AUERBACH COMPUTER NOTEBOOK INTERNATIONAL

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AUERBACH COMPUTER NOTEBOOK INTERNATIONAL

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JAPAN

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MONETARY CONVERSION TABLE

Country	Currency Unit	Par Value of Unit, U. S. $	U. S. A. Selling Price of Unit on October 24, 1969, U.S. $
Denmark	Krone	0.1335	0.133075
France	Franc, F	0.18004	0.178975
Israel	Pound	0.2900	0.2875
Japan	Yen, ¥	0.00277778	0.002798
Netherlands	Guilder	0.276243	0.2785
United Kingdom	Pound, £	2.40	2.3921
West Germany	Deutschmark, DM	0.25	0.2715

USERS' GUIDE

AUERBACH
COMPUTER
NOTEBOOK
INTERNATIONAL

AUERBACH
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Printed in U.S.A.

USERS' GUIDE

.1 INTRODUCTION

AUERBACH Computer Notebook International is a looseleaf reference service that provides the facts and insights you need to understand digital computer systems manufactured throughout the world and to make straightforward, objective comparisons of their capabilities and costs. Monthly supplements keep the Notebook comprehensive and up-to-date — and keep you informed of significant new developments in the computer field.

AUERBACH Computer Notebook International consists of five major sections:

- Users' Guide (this section)
- Glossary
- Special Reports
- Comparison Charts
- Computer Descriptions and Price Lists (behind the tabs labeled BURROUGHS through UNIVAC and Denmark through West Germany).

The contents and purpose of each of these sections are explained in the paragraphs that follow. Next, beginning on page 4:001.800, you'll find straightforward guidelines for using the information in this Notebook to solve various types of problems that are often encountered in evaluating and using computers and in auditing their operations.

AUERBACH Computer Notebook International is a uniquely useful tool for everyone who needs to understand and use digital computer systems. Like most tools, it will be of some value to nearly everyone who uses it, but it will be of far greater value to those who are willing to invest a little time and effort in learning how to use it most effectively. To ensure that all of the information in this Notebook can be effectively employed in solving your data processing problems, we strongly recommend a thorough reading of the remainder of this Users' Guide.

.2 GLOSSARY

Everyone who is called upon to participate in the selection, application, or auditing of digital computer systems needs to develop an understanding of the meaning and significance of a large number of technical terms. The Glossary in this Notebook has been specifically designed to fill that need.

Approximately 700 terms related to digital computers and their applications are listed in straightforward alphabetical order. The terms are not merely defined; their significance, implications, and interrelationships are discussed, and examples and cross-references are liberally employed to clarify the presentation. Thus, this Glossary can serve not only as a reference tool, but also as a tutorial guide to many aspects of the computer field.

The first page of the Glossary (page 7:001.001) contains brief instructions for using it effectively.

.3 SPECIAL REPORTS

This section of the Notebook contains tutorial papers and state-of-the-art reports on timely topics in computer technology and applications. These reports will help you keep informed on developments and trends in the data processing field. The Special Reports have been extracted from AUERBACH Standard EDP Reports and will be revised and updated when necessary to maintain their value as up-to-date reference sources.

.4 COMPARISON CHARTS

The Comparison Charts in this volume are divided into four basic categories:

Configuration Rentals

.4 COMPARISON CHARTS (Contd.)

- Hardware Characteristics
- Software
- System Performance.

The Quick Reference Index on page 11:001.002 will guide you quickly to all of the Comparison Chart entries that pertain to any specific computer system.

The organization of the comparison charts can be seen by looking at the Table of Contents for the Comparison charts on page 11:001.101. The Introductions identified in the Table of Contents present the structure of the Charts and the meaning of each entry.

.5 COMPUTER DESCRIPTIONS AND PRICE LISTS

The largest section of this Notebook contains Computer Descriptions and Price Lists. These are extracted from the detailed Computer System Reports for the commercially important U.S.-manufactured digital computer systems, and are especially prepared for this Notebook for non-U.S.-manufactured computer systems.

The U.S. Computer Descriptions and Price Lists are arranged alphabetically by manufacturer, with certain exceptions as indicated in the Table of Contents on page 1:001.001. Non-U.S. Computer Descriptions and Price Lists are arranged alphabetically by manufacturer within country of manufacture. Divider tabs for the major U.S. computer manufacturers, from BURROUGHS to UNIVAC, and for countries, from DENMARK to WEST GERMANY, make it easy to locate the information you need.

Each Computer Description summarizes the general scale and orientation of the system, its degree of compatibility with other equipment, the capabilities of the central processor and peripheral devices, the optional features, the capabilities for simultaneous operations, the available software (compilers, assemblers, operating systems, etc.), and the principal advantages and drawbacks relative to competitive systems. Unlike the other sections of this volume, the Computer Descriptions do not conform to a rigidly standardized format. The aim is to summarize and interpret the important features of each system in a concise, readable report.

Unless otherwise noted, the Price List for each system contains single-shift monthly rental prices, purchase prices, and monthly maintenance charges for each hardware component and optional feature. (Remember that the total monthly rentals for several representative configurations of each U.S. system can be found in the Configuration Rentals Comparison Chart on Page 11:010.101.)

.6 REGULAR SUPPLEMENTS

Your copy of AUERBACH Computer Notebook International will be kept comprehensive and up to date by means of monthly supplements. Each supplement contains new reports on recently announced equipment and/or revised versions of previously published reports that reflect changes in equipment characteristics and in the state of the art. These supplements serve an important current-awareness function by keeping you informed of significant new developments in the computer field.

A cover sheet containing a summary of the new information and easy-to-follow filing instructions accompanies each supplement. We recommend that you set up a standard procedure to ensure that each new supplement will be filed promptly in your binder. (Note that the page numbering system is far simpler than it may appear to be at first glance; all page numbers are arranged in strict numerical sequence, although there are many "gaps," or omitted page numbers, to facilitate the insertion of new material in the most appropriate places.)

.7 DERIVATION AND RELIABILITY

AUERBACH Computer Notebook International is prepared and edited by experienced computer system analysts. Most of the material on U.S. computers in this Notebook is extracted from AUERBACH Standard EDP Reports, an 8-volume analytical reference service that for more than five years has served as an authoritative source of information on computer equipment, software, and performance for computer users, manufacturers, and consultants.

In gathering, analyzing, and evaluating material for these reports, our staff starts with the specifications and manuals issued by the equipment manufacturers and other reliable sources.

.7 DERIVATION AND RELIABILITY (Contd.)

Advance information from the manufacturers frequently enables us to publish a detailed analysis immediately after the official announcement of a new computer system. Extensive amplification and clarification of the generally-available specifications are usually obtained through visits to or correspondence with the manufacturers. Users of the equipment are also interviewed whenever practical.

Every report describing a specific manufacturer's equipment or services is sent to the manufacturer for review prior to publication. We invite the manufacturer's comments regarding the completeness and accuracy of the report. Where differences of opinion exist between a manufacturer and our staff, however, the published material always reflects the opinion of our staff.

Comments and suggestions from our subscribers are always welcome because they help us to make this publication even more effective in meeting the needs of its users. We welcome notification of any errors or omissions, as well as suggestions for additions to the Notebook or improvements in its clarity or balance.

.8 HOW TO USE THIS NOTEBOOK EFFECTIVELY

The information in this volume can meet many different needs, and you will probably find new uses nearly every time you open it. There are many possibilities for casual yet rewarding "browsing" that will enrich your overall understanding of computers and their applications. Most of your computer information problems, however, will probably fall within one of the following three classes:

(1) Details are needed on certain characteristics or capabilities of one or more specific computer systems. How can they be found most efficiently?

(2) The required equipment configuration and price range for a computer system are known. Which computers fit into this class, and what are their capabilities?

(3) The performance requirements for a computer system are known. Which computers can meet these requirements, and how much will they cost?

Suggested procedures for using the information in this Notebook to solve each of these three types of problems are described in the following paragraphs.

.81 When Details on a Specific Computer System Are Needed:

Use the Table of Contents on page 1:001.001 to guide you to the appropriate Computer Description and Price List. Here you will find a concise report covering the system's design orientation, software, features, and limitations, plus detailed cost data. Also, be sure to check the appropriate columns in the Hardware Characteristics Comparison Charts for details on the central processor, storage devices, and input/output equipment; use the Quick Reference Index on page 11:001.002 to guide you to all the pertinent pages. For standardized measurements of overall processing speeds for U. S. computers, the System Performance Comparison Charts, beginning on page 11:400.101, are the place to turn.

.82 When the Required Configuration and Rental Range Are Known (for U. S. Computers):

Turn first to the Introduction to the Configuration Rentals Comparison Charts on page 11:010.101. There you will find the specifications for each of our 13 standard configurations. Find the standard configuration (identified by a Roman numeral) that most closely matches your needs. Now turn to the Configuration Rentals Comparison Chart on page 11:010.101. The column corresponding to your standard configuration contains the monthly rentals for a number of computer systems that are suitable for use in the type of equipment configuration you need. Those systems that fall within the allowable rental range can now be further investigated in any or all of the following ways:

- Use the System Performance Comparison Charts (for U. S. systems), beginning on page 11:400.101, to check each system's overall performance on typical business and scientific problems.

- Use the Hardware Characteristics Charts, beginning on page 11:210.101, to compare the important characteristics of the central processors and peripheral devices available for each system. Use the Quick Index beginning on page 11:001.002 to locate the specific information you want.

.82 When the Required Configuration and Rental Range Are Known (for U.S. Computers): (Contd.)

- Turn to the individual Computer Descriptions and Price Lists (using the Table of Contents on page 1:001.001) for a summary of the important features and drawbacks of each system plus detailed pricing information.

.83 When the Performance Requirements are Known:

First, relate the specific performance requirements for U.S. computers to one or more of the five standard benchmark problems described beginning on page 11:400.100 of the Comparison Charts. If your workload consists mainly of commercial data processing applications, this should not be difficult because most of the runs will probably be basically similar to the File Processing or Sorting standard problems. For scientific applications, check the descriptions of the Matrix Inversion and Generalized Mathematical Processing problems to see which one(s) are most like your principal applications.

When you have determined which standard problem, or appropriately-weighted combination of problems, best approximates your requirements, turn to the System Performance Comparison Charts, beginning on page 11:400.104. From the listed processing times for the standard problems, find which computer systems appear to be able to do the job within the allowable time, and their monthly rentals.

The systems that survive this "screening" process can now be further investigated by turning to either the Hardware Characteristics Comparison Charts (using the Quick Reference Index on page 11:001.002) or the individual Computer Descriptions and Price Lists (using the Table of Contents on page 1:001.001).

.9 WHAT THIS NOTEBOOK CAN — AND CANNOT — DO FOR YOU

The facts, evaluations, and insights in this Notebook can:

- Provide the background information you need to understand and apply digital computers.
- Serve as a ready reference to answer specific questions posed by your associates or your clients.
- Keep you informed of new developments in the fast-moving computer field.
- Provide useful indications of the prices and performance of competitive computer systems in applications similar to your own or your clients'.
- Help to narrow the range of choices and aid in the decision-making process whenever computer equipment must be selected.
- Assist you in preparing requests for proposals and in evaluating proposals from computer manufacturers.
- Allow you to compare computer systems on an international basis.

It is important to remember, however, that it would be impossible to include all of the pertinent information about computers in a compact volume such as this, or to ensure that all of the published information is completely up-to-date at all times. One important aspect that cannot feasibly be included in a generalized publication such as this is the availability and quality of local support — both maintenance service and programming assistance — for each computer system.

Therefore, you should keep in mind, and utilize when necessary, other sources of information about computer systems. The possibilities include: computer manufacturers' representatives, documentation published by the manufacturers, users of the computers being investigated, independent computer consultants, and more detailed computer reference services such as AUERBACH Standard EDP Reports.

No matter which of these alternative sources of information you decide to utilize, you'll find that your AUERBACH Computer Notebook International will give you a good "head start," so that you can efficiently gather the remaining information you need to solve the problem or complete the evaluation.

GLOSSARY

AUERBACH
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Printed in U.S.A.

GLOSSARY

.1 PURPOSE AND SCOPE

This Glossary has been compiled with three main objectives in mind:

(1) To define, in a precise and consistent manner, the meanings of more than 700 words and phrases as used in the AUERBACH Computer Technology Reference Services.

(2) To aid the novice in understanding what he reads and hears about the data processing field by providing clearcut, up-to-date explanations of the terminology, with liberal use of illustrative examples and cross-references.

(3) To guide the expert in choosing the correct term to express a given concept by clarifying the distinctions and similarities among related terms.

Although a number of other glossaries of data processing terms have been prepared (see the Annotated Bibliography in Paragraph .3), none of them was found to be satisfactory to meet the objectives stated above. Therefore, this Glossary was compiled through careful analysis of the definitions in previous glossaries and of current usage in the data processing field; it contains many terms, examples, comments, and cross-references that are not included in any of the glossaries listed in the Bibliography.

With respect to scope, this Glossary defines more than 700 terms whose meanings in the data processing field are different from their meanings in the general U.S. vocabulary. It does not include terms whose meanings are obvious or are the same as in the everyday, nontechnical vocabulary. Also excluded, in general, are specialized terms that have been arbitrarily coined by individual computer manufacturers or users and have not found widespread acceptance.

.2 ORGANIZATION AND USE

In compiling a Glossary, it is necessary to choose one of two basic forms of organization: dictionary form, in which the entries are arranged alphabetically, or thesaurus form, in which the entries are arranged in logical groups to keep related terms close together. Although the thesaurus form has certain advantages, it has one major disadvantage: to locate the definition of a particular term, one must first consult an alphabetical index. Therefore, to facilitate rapid references, we have chosen the dictionary form, with all terms arranged in straightforward alphabetical order.

All multi-word phrases are listed in their natural order (e.g., "absolute address" rather than "address, absolute").

In the case of terms with two or more distinct meanings, the meanings are numbered sequentially, and the first meaning listed is the most common or most general one.

Numerous examples and comments follow the formal definitions to clarify the meanings, usage, and significance of the concepts and entities that are defined in this Glossary.

Several different types of cross-references are used. Their meanings are as follows:

- Same as — indicates that the referenced term has the same meaning as (i.e., is synonymous with) the term containing the reference, and that the referenced term is the preferred one.
- Synonymous with — indicates that the referenced term has the same meaning as the term containing the reference, and that the term containing the reference is the preferred term.
- Contrast with — indicates that the referenced term is a related term that has a meaning significantly different from that of the term containing the reference.
- See also — indicates that the referenced term is a related term whose definition will provide additional background or clarification.
- See — indicates that the referenced term is an alternative or qualified form of the term containing the reference.
- Underline — indicates that the underlined term is significant in the definition and is defined elsewhere in the Glossary.

Because of its straightforward alphabetical arrangement, this Glossary can be used in the same way as a dictionary: simply turn to the term of interest and read its definition. All of the underlined terms used in the definition are defined elsewhere in the Glossary, and if you are not sure of their precise meanings, you may want to turn to their definitions.

.2 ORGANIZATION AND USE (Contd.)

In this way, a "chain" of cross-references can guide you in learning all the important terms and concepts that are associated with some particular aspect of the data processing field.

Thus, the many cross-references, coupled with the examples and comments, make this a Glossary that can serve not only as a reference work, but as an educational guide to many aspects of computers and data processing.

.3 ANNOTATED BIBLIOGRAPHY

The principal sources of input for this Glossary are listed below, along with brief comments about their format, content, and usefulness. It should be noted that numerous other glossaries and dictionaries were studied, but the others were found to be either highly specialized or significantly less precise and authoritative than the sources listed below.

(1) AUERBACH Corporation, "Glossary," AUERBACH Standard EDP Reports, May 1962.

This earlier version of the AUERBACH Glossary served as the principal basis for the new edition because of the importance of maintaining consistency with the terminology that has been used in AUERBACH Standard EDP Reports throughout its five-year history. However, the earlier version was in thesaurus form, contained no cross-references, had fewer examples and comments, and, of course, did not include the many important terms that have been introduced since 1962.

(2) AUERBACH Corporation, "Users' Guide," AUERBACH Standard EDP Reports, May 1962.

This 162-page Users' Guide, though not a glossary, contains expanded definitions and practical examples of many of the important terms and concepts. As such, it served as a valuable reference in the compilation of this Glossary.

(3) Bureau of the Budget, Automatic Data Processing Glossary, U.S. Government Printing Office, Washington, D.C., December 1962 (also published as the Datamation ADP Glossary).

This 62-page glossary, arranged in dictionary form, was compiled in 1962 to serve as a U.S. Government reference on data processing terminology. Although the coverage is quite broad, many of the definitions are somewhat imprecise and inconsistent, there are few cross-references, and many terms of current significance are not included.

(4) Honeywell, Inc., Glossary of Data Processing and Communications Terms, Third Edition, April 1966.

This 88-page publication combines selected definitions from references (3) and (6) with original, none-too-precise definitions of terms related to the communications field. It uses the dictionary form.

(5) IFIP/ICC (International Federation for Information Processing and International Computation Centre), IFIP/ICC Vocabulary of Information Processing, North-Holland Publishing Company, Amsterdam, 1966.

This 208-page hardbound volume probably represents the most impressive and successful effort to date to develop a truly definitive glossary of data processing terminology. Its definitions are quite precise, and examples and explanatory comments are liberally employed. The thesaurus format permits clear distinctions among related or contrasting terms. For our purposes, however, the volume has three major drawbacks: (1) the thesaurus format requires use of an index to locate specific terms; (2) the distinctly British flavor of the language, terminology, and usage can distract — and in some cases mislead — American readers; and (3) terms describing specific languages, codes, and applications (e.g., COBOL, ASCII, message switching) are conspicuously absent.

(6) U.S.A. Standards Institute, American Standard Vocabulary for Information Processing, U.S.A. Standard X3.12-1966, New York, 1966.

This 32-page vocabulary was prepared by ASA (now USASI) Subcommittee X3.5, Terminology and Glossary, and approved as a U.S.A. Standard on June 14, 1966. Its purpose is to define current usage and encourage standardization of terms and their meanings. The dictionary form is used, with enough cross-references to clarify most of the interrelationships among terms. Several significant drawbacks, however, detract from the usefulness of the American Standard Vocabulary: (1) most of the definitions are brief, with relatively few examples and explanatory notes; (2) many of the definitions are so terse that they are totally unsatisfactory; e.g., "COBOL. (Common Business Oriented Language.) A business data processing language"; and (3) numerous terms of considerable current importance have been omitted; e.g., background program, EAM, emulator, integrated circuit, PL/I, privileged instruction, systems analysis, virtual address, etc.

(Contd.)

A

absolute address
An address that is permanently assigned by the machine designer to a particular storage location. For example, the addresses 0000, 0001, and 0002 might be assigned to the first three locations in a computer's working storage.

absolute coding
Coding that uses machine instructions and absolute addresses; therefore, it can be directly executed by a computer without prior translation to a different form. Contrast with relative coding and symbolic coding.

access mode
A technique used to obtain a specific record from, or to place a specific record into, a specific file. See random access and serial access.

access time
The time interval between the instant when a computer or control unit calls for a transfer of data to or from a storage device and the instant when this operation is completed. Thus, access time is the sum of the waiting time and transfer time. Note: In some types of storage, such as disc and drum storage, the access time depends upon the location specified and/or upon preceding events; in other types, such as core storage, the access time is essentially constant.

accounting machine
(1) A keyboard-actuated machine used to prepare accounting records. (2) Same as tabulator.

accumulator
A register that holds one operand, with means for performing various arithmetic and/or logical operations involving that operand and (where appropriate) another operand; usually, the result of the operation is formed in the accumulator, replacing the original operand. Note: Among computers currently in use, some have a single accumulator, others have multiple accumulators, and still others (especially those that use two-address or three-address instructions) have no accumulator as such; in the latter case, the results of arithmetic and logical results are usually formed in programmer-specified locations in the computer's main storage.

accuracy
The degree of freedom from error; a measure of the smallness of error or the range of error. Thus, high accuracy implies small error. Note: Accuracy should be carefully distinguished from precision, which is the degree of discrimination with which a quantity is stated. For example, a 6-digit numeral is more precise than a 4-digit numeral, but a properly computed 4-digit result may be more accurate than an improperly computed 6-digit result.

acronym
A word formed from the initial letter or letters of the words in a name or phrase; e.g., ALGOL from ALGOrithmic Language, COBOL from COmmon Business Oriented Language.

activity
The degree of frequency with which individual records in a file are used, modified, or referred to. For example, an "activity factor" of 0.10 (or 10 per cent) denotes that an average of 1 of every 10 master-file records is referenced or affected by a transaction during a run.

adder
A device capable of forming a representation of the sum of two or more numbers whose representations are supplied as inputs.

address
A name, numeral, or other reference that designates a particular location in a store or some other data source or destination. Note: Numerous types of addresses are employed in computer programming; see, for example: absolute address, base address, direct address, effective address, immediate address, indirect address, relative address, symbolic address.

address format
The arrangement of the address parts of an instruction. Among the commonly-used address formats are one-address, one-plus-one, two-address, and three-address. Note: In some computers all of the instructions employ the same address format, while in other computers two or more different address formats are used with the various types of instructions.

address modification
An operation that causes an address to be altered in a prescribed way by a stored-program computer. Note: The address upon which modification is performed is called the presumptive address, and the address that results is called the effective address. See also index and indirect address — the two most common forms of address modification.

address register
A register capable of holding the address of a location in a store or of some other data source or destination.

ADP (Automatic Data Processing)
Data processing performed largely by automatic means; i.e., by a system of electronic or electrical machines which require little human assistance or intervention.

alarm
A signal that warns a human operator of an equipment fault or some other abnormal condition; e.g., a warning lamp or buzzer.

ALGOL (ALGOrithmic Language)
A process oriented language developed as a result of international cooperation to develop a standard language for expressing computational algorithms. ALGOL is designed to serve as a means for communicating computational procedures among humans, as well as to facilitate the preparation of such procedures for execution on any computer for which a suitable ALGOL compiler exists. Note: The basic elements of ALGOL are arithmetic expressions containing numbers, variables, and functions. These are

combined to form self-contained units called assignment statements. Declarations are non-computational instructions which inform the compiler of characteristics such as the dimensions of an array or the class of a variable. A sequence of declarations followed by a sequence of statements, all enclosed within "begin" and "end" instructions, constitute an ALGOL program block. ALGOL is not widely used in the United States, but is very popular in Europe.

algorithm
A set of well-defined rules for the solution of a problem in a finite number of steps; e.g., a full statement of an arithmetic procedure for evaluating the sine of an angle to a stated precision, or a full statement of a procedure for computing a rate of return. Contrast with heuristic.

allocation
The assignment of specific portions of storage devices or specific input-output devices to hold specific programs and/or data files. Note: Allocation of storage and input-output devices may be performed: (1) by the programmer, when he writes a program; (2) by the operator, when he loads a program for execution; or (3) automatically, by an operating system.

alphabet
An ordered set of characters used for the representation of sounds in a spoken language; in English, the 26 letters A through Z.

alphameric
Same as alphanumeric.

alphanumeric
Pertaining to a character set that includes both alphabetic characters (letters) and numeric characters (digits). Note: Most alphanumeric character sets also contain special characters.

analog
Pertaining to data represented in the form of continuously variable physical quantities (e.g., voltage or angular position). Contrast with digital.

analog computer
A computer that operates on analog data by performing physical processes on the data. Contrast with digital computer.

analyst
A person skilled in defining problems and developing algorithms or other systematic procedures for their solution. See also programmer.

AND
(1) A logical operator which has the property that if P is a statement and Q is a statement, then "P AND Q" is true if both P and Q are true, and false if either P or Q, or both P and Q, are false. "P AND Q" is often represented by $P \wedge Q$, $P \cdot Q$, or PQ. (2) The logical operation that uses the AND operator; also called logical product, logical multiplication, and conjunction.

application
The problem or system to which a computer (or other processing equipment or technique) is applied.

application package
A computer routine or set of routines designed for a specific application (e.g., inventory control, on-line savings accounting, linear programming, etc.) Note: In most cases, the routines in the application packages are necessarily written in a generalized way and will need to be modified to meet each user's own specific needs.

argument
An independent variable. For example, in table look-up operations, the arguments are the numbers that are used to identify the locations of the desired items in the table.

arithmetic unit
A section of a computer in which arithmetic, logical, and/or shift operations are performed.

array
A group of items arranged in a meaningful pattern.
Example 1: A one-dimensional array (i.e., a list) of one-word items:

Adams
Baker
Collins
Dorsey

Example 2: A two-dimensional array (i.e., a matrix) of one-digit items:

7	2	5	4
3	8	0	9
6	9	1	6
4	7	3	8

artificial intelligence
The capability of computers or other devices to perform functions that are normally associated with human intelligence, such as reasoning, learning, adapting to environmental changes, and self-improvement.

ASCII (American Standard Code for Information Interchange)
A 7-bit code adopted as a U.S.A. Standard in order to facilitate the interchange of data among various types of data processing and data communications equipment. Note: Because of the very large investment in equipment and programs which use earlier codes, ASCII has not been widely used to date, but a steady trend toward its usage may be expected.

assemble
To prepare a machine language program from a program written in symbolic coding by substituting absolute operation codes for symbolic operation codes and absolute or relocatable addresses for symbolic addresses. For example, the symbolic instruction ADD TAX might be assembled into the machine instruction 24 1365, where 24 is the operation code for addition and 1365 is the address of the storage location labeled TAX. Contrast with compile and generate.

assembler
A computer program that assembles programs written in symbolic coding to produce machine language programs. Note: Assemblers are an important part of the basic software for most computers; their use can greatly reduce the human effort required to prepare

(Contd.)

and debug computer programs by enabling the coder to use a symbolic language which is simpler and more meaningful to him than the computer's machine language.

associative memory
A storage device whose storage locations are identified by their contents (rather than by names or positions, as in most computer storage devices). Synonymous with content-addressable memory. Note: Associative memories can facilitate programming and increase computer efficiencies by eliminating the need for item-by-item search operations, but the high cost of implementing such memories limits their current use to specialized functions such as holding small, frequently-referenced tables.

asynchronous computer
A computer in which each operation starts as a result of a signal generated by the completion of the previous operation or by the availability of the equipment required for the next operation. Contrast with synchronous computer.

attribute
A characteristic of an entity; e.g., the attributes of a file might include its name, use, creation date, record length, record format, and the device to which it is currently assigned.

audio response unit
Same as voice response unit.

audit trail
A means for systematically tracing the progress of specific items of data through the steps of a process (particularly from a machine-generated report or other output back to the original source document) in order to verify the validity and accuracy of the process.

automatic check
A check performed by a facility that is built into equipment specifically for checking purposes. Also called a "built-in check" or "hardware check." Contrast with programmed check.

automatic data processing
See ADP.

automatic programming
(1) The use of a computer to perform some stages of the work involved in preparing programs. (2) In particular, the use of a computer to translate programs expressed in a process oriented language into machine language or a machine oriented language (i.e., to compile).

automation
The theory, art, or technique of making processes more automatic, thereby reducing or eliminating the need for human intervention.

auxiliary storage
Storage that supplements a computer's working storage. Synonymous with backup storage, mass storage, and secondary storage. Note: In general, the auxiliary storage has a much larger capacity but a longer access time than the working storage. Usually, the computer cannot access auxiliary storage directly for instructions or instruction operands; instead, data is transferred in blocks between auxiliary and working storage. Disc storage and drum storage are the most common types of auxiliary storage.

availability
The period of time, usually quoted by an equipment manufacturer, that can be expected to elapse between placement of a non-priority order for a particular type of equipment and delivery of the equipment to the user.

available time
Same as uptime.

B

B box
Same as index register.

background program
A program, usually of the batch processing type, that is not subject to any real-time constraints and can be executed whenever the facilities of a multiprogramming computer system are not required by real-time programs or other programs of higher priority. Contrast with foreground program.

backspace
To move an input or output medium backward for a distance of one unit; e.g., one character position on a typewriter, one row on punched tape, or one block on magnetic tape.

backup
Pertaining to equipment or procedures that are available for use in the event of failure or overloading of the normally-used equipment or procedures. Note: The provision of adequate backup facilities is an important factor in the design of every data processing system, and is especially vital in the design of real-time systems, where a system failure may bring the total operations of a business to a virtual standstill.

backup storage
Same as auxiliary storage.

band
(1) A group of tracks (usually in a disc storage or drum storage unit) which are associated for some specific purpose; e.g., a group of 8 tracks which are read and recorded upon in parallel to permit high-speed transfers of 8-bit bytes of data. (2) The range of frequencies between two defined limits.

base
(1) A reference value.
(2) Same as radix.

base address
A specified address (often held in a "base address register") which is combined with a relative address (usually contained in an instruction) to form the absolute address of a particular storage location. Synonymous with origin.

batch processing
A technique in which items to be processed are collected into groups (i.e., "batched") to permit convenient and efficient processing. Note: Most business

applications are of the batch processing type; the records of all transactions affecting a particular master file are accumulated over a period of time (e.g., one day), then they are arranged in sequence and processed against the master file.

batch total
A sum of a set of items which is used to check the accuracy of operations on a particular batch of records.

baud
A unit of signalling speed equal to the number of discrete conditions or signal events per second. Note: In the case of a train of binary signals, and therefore in most data communications applications, one baud equals one bit per second.

Baudot code
A 5-bit code used in telegraphy for more than 100 years and still widely used in data communications and punched tape. Note: The Baudot code has two significant disadvantages: the limitation to 5 bits per character (i.e., 32 code combinations) requires frequent shifts between the "letters" and "figures" cases, and there is no provision for a parity check. The Baudot code is gradually being replaced by ASCII and other codes.

BCD (Binary Coded Decimal)
Pertaining to a method of representing each of the decimal digits 0 through 9 by a distinct group of binary digits. For example, in the "8-4-2-1" BCD notation, which is used in numerous digital computers, the decimal number 39 is represented as 0011 1001 (whereas in pure binary notation it would be represented as 100111).

benchmark problem
A precisely defined problem that is coded and timed for a number of computers in order to measure their performance in a meaningful and directly comparable manner. Note: The benchmark problem may be one of the user's own specific applications, or (as in the case of the AUERBACH System Performance comparisons) it may be representative of a class of typical computer applications.

binary
Pertaining to the number system with a radix of two, or to a characteristic or property involving a choice or condition in which there are two possibilities. Note: The binary number system is widely used in digital computers because most computer components (e.g., vacuum tubes, transistors, flip-flops, and magnetic cores) are essentially binary in that they have two stable states. Example: The binary numeral 1101 means: $(1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$ which is equivalent to decimal 13.

binary coded decimal
See BCD.

binary search
A search technique in which a set of items is divided into two parts, one of the parts is rejected, and the process is repeated on the accepted part until the item or items with the desired property are found; also called "dichotomizing search."

bit
A binary digit; a digit (0 or 1) in the representation of a number in binary notation.

blank
A character used to produce a character space (i.e., no mark) on an output medium.

block
A group of words, characters, or digits that are held in one section of an input/output medium or store and handled as a unit; e.g., the data recorded on a punched card, or the data recorded between two inter-block gaps on a magnetic tape.

block diagram
A diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines. Note: A flowchart is a special type of block diagram that shows the structure and general sequence of operations of a program or process.

blocking
Combining two or more records into one block. Note: The principal purpose of blocking is to increase the efficiency of computer input and output operations. For example, the effective data transfer rates of most magnetic tape units can be greatly increased by reducing the need for frequent tape stops and starts through combining multiple short records into blocks which are several thousand characters in length.

Boolean operation
A logical operation on single bits. Note: The term "Boolean" refers to the processes used in a special type of algebra formulated by George Boole.

bootstrap
(1) A form of loader whose first few instructions are sufficient to bring the rest of itself into the computer's storage from an input device. (2) More generally, a technique or device designed to bring itself into a desired state by means of its own action.

branch
(1) Same as conditional transfer. (2) A set of instructions that are executed between two successive conditional transfer instructions.

breakpoint
A specified point in a program where the program may be interrupted by manual intervention or by a monitor routine. Note: Breakpoints are usually used as an aid in testing and debugging programs; they facilitate halting a computer or triggering a printout at a particular point so that specific conditions can be examined.

brush
An electrical conductor used to sense the presence or absence of holes in a punched card.

buffer
A storage device used to compensate for differences in the rates of flow of data or in the times of occurrence of events when transmitting data from one device to another. For example, a buffer holding one line is associated with most line printers to compensate for the large difference between the high speed at which the computer can transmit data to the printer and the relatively low speed of the printing operation itself.

bug
A mistake in the design of a program or a computer system, or an equipment fault.

(Contd.)

bus
A major path used to transmit signals from one or more sources to one or more destinations. Synonymous with trunk.

byte
A group of adjacent bits operated upon as a unit and usually shorter than a word. Note: In a number of important current computer systems, the term "byte" has been assigned the more specific meaning of a group of eight adjacent bits, which can represent one alphanumeric character or two decimal digits.

C

calculator
A device capable of performing arithmetic operations. Note: This term is generally applied only to devices that require frequent intervention by a human operator; contrast with computer.

call
(1) In computer programming, to transfer control to a subroutine, usually by supplying the required parameters and executing a jump to the entry point of the subroutine. (2) In communications, the actions performed by the party initiating a connection, or the effective use that is made of a temporary connection between two stations.

calling sequence
A specified set of instructions and data necessary to call a given subroutine.

card
Usually same as punched card; see also edge-notched card, edge-punched card, magnetic card.

card field
In a punched card, a group of columns (or parts of columns) whose punchings represent one item. For example, a three-column field might hold an item representing order quantity, whose value ranges from 000 to 999.

card image
A direct, one-to-one representation of the contents of a punched card; e.g., a matrix, in core storage or on magnetic tape, in which a "1" bit represents a punched hole and a "0" bit represents the absence of a hole.

card punch
A machine that punches holes in punched cards. Note: The data to be punched in the cards may be transmitted to the punch by a computer, by EAM equipment, or by an operator's keystrokes (see keypunch).

card reader
A machine that senses the holes in punched cards to provide input to a computer or EAM equipment.

carry
(1) A signal that arises when the sum or product of two or more digits in one digit position equals or exceeds the radix of the number system in use; the carry is forwarded to the next more significant digit position for processing there. (2) To forward a carry as defined in (1).

cartridge
A unit of a storage medium which can be conveniently removed from the storage device and replaced by other similar cartridges, without loss of the data recorded in it. Note: A variety of interchangeable-cartridge storage devices are now in use. They permit rapid random access to their on-line contents, while providing economical off-line storage for virtually unlimited volumes of data. The cartridges usually consist of single or multiple magnetic discs or multiple magnetic cards.

cathode ray tube
An electronic vacuum tube containing a screen on which information can be stored or displayed. The abbreviation CRT is frequently used. Note: Cathode ray tubes served as the principal storage medium in some of the early digital computers; they now serve as the basic component of most display units.

cell
See storage cell.

central processor
The unit of a computer system that includes the circuits which control the interpretation and execution of instructions. Synonymous with CPU (central processing unit) and main frame.

chad
A piece of material that is removed in the process of forming a hole or notch in a medium such as punched cards or punched tape.

chadless
Pertaining to the punching of tape in such a way that no chad results because each hole is only partially perforated. Note: Chadless perforation makes the full surface of a punched tape available for interpreting (i.e., printing) the characters represented by the punching; but many high-speed punched tape readers cannot read chadless tape.

chain printer
A line printer in which the type slugs are mounted on a chain that moves horizontally past the printing positions. Note: Chain printers generally provide more accurate vertical registration than the more commonly used drum printers, and interchangeable chains often permit rapid changes in the size or make-up of the character set.

chaining
(1) The linking together of a sequence of instructions or commands, usually for the purpose of simplifying the coding process or reducing execution time and/or storage requirements. (2) The division of a program into a number of sequential segments, only one of which resides in working storage at a time; each segment uses the output from the previous segment as its input.

channel
A path or group of parallel paths for carrying signals between a source and a destination. See also input-output channel.

character
A member of a set of mutually distinct marks or signals used to represent data. Each member has one

or more conventional representations on paper (e. g., a letter of the ordinary alphabet) and/or in data processing equipment (e. g., a particular configuration of 0 and 1 bits).

character recognition
The identification of graphic characters by automatic means. See MICR and OCR.

character set
A set of mutually distinct marks or signals used to represent data; e. g., a typical character set for a printer might include the digits 0 through 9, the letters A through Z, and the common punctuation marks.

characteristic
Same as exponent.

check
A general term meaning a partial or complete test for the absence of certain classes of errors or for the correct performance of a process. Note: A check may be either an automatic check or a programmed check. Among the types of checking commonly performed in computers are echo checks, parity checks, read-after-write checks, residue checks, summation checks, and validity checks.

check bit
A binary check digit. Note: A parity check usually involves appending a check bit of the appropriate value to an array of bits.

check digit
A digit associated with a word or part of a word for the purpose of checking for the absence of certain classes of errors.

check problem
A problem whose correct results are known, and which is used to determine whether a computer and/or a program are operating correctly.

check protection
The insertion of a character, most commonly an asterisk, in place of one or more suppressed zeros to guard against tampering with the amount printed on a check. For example, the amount $ 9. 98 with check protection added becomes $****9. 98.

check sum
See summation check.

checkpoint
(1) A place in a program where the results of one or more checks are examined. (2) Same as rerun point.

circuit
(1) A system of conductors and related elements through which electrical current flows. (2) A communications link between two or more points.

clear
To "erase" (i. e., delete) the data in a storage location or device by bringing all of the storage cells involved to a prescribed state — usually to the state denoting zero or blank.

clock
(1) A timing device that generates the basic periodic signal used to control the timing of all operations in a synchronous computer. (2) A device that records the progress of real time, or some approximation of it, and whose contents are available to a computer program (frequently in a special register); the clock may also be capable of initiating a program interrupt when a specified period of time has elapsed.

closed loop
(1) A loop from which there is no exit other than by intervention from outside the program; such a loop is usually the result of a programming error or machine fault. (2) Pertaining to a process control system that utilizes feedback (i. e., information about the conditions being controlled) in order to exert self-correcting influences upon its own operation.

closed shop
A computer installation that may be operated (and, in some cases, programmed) only by personnel on the staff of the associated computer department. Contrast with open shop.

closed subroutine
A subroutine that can be stored in one place and connected to a program by means of linkages at one or more points in the program. Contrast with open subroutine. Note: The use of closed subroutines tends to save storage space whenever a particular subroutine must be used at two or more different points in a program.

clutch point
In a clutch-operated input or output device (e. g., most card readers and punches), one of the instants at which it is possible to engage the clutch. For example, in a card reader which has a 3-point clutch and a 600-millisecond clutch cycle, the clutch points occur at intervals of 200 milliseconds. Therefore, it is possible to engage the clutch (and thereby initiate the feeding of a card) every 600, 800, 1000, 1200, or 1400 . . . milliseconds.

COBOL (COmmon Business Oriented Language)
A process oriented language developed to facilitate the preparation and interchange of programs to perform business data processing functions. Note: Designed in 1959 by a committee representing the U.S. Government and several computer manufacturers, COBOL has evolved through several versions (e. g., COBOL-60, COBOL-61, COBOL-61 Extended, COBOL-65). COBOL-65 forms the basis for a proposed standard version of the language which will probably soon be adopted as an official U. S. A. Standard. Every COBOL source program has four divisions, whose names and functions are as follows: (1) Identification Division — identifies the source program and the output of a compilation. (2) Environment Division — specifies those aspects of a data processing problem that are dependent upon the physical characteristics of a particular computer. (3) Data Division — describes the data that the object program is to accept as input, manipulate, create, or produce as output. (4) Procedure Division — specifies the procedures to be performed by the object program, by means of English-like statements such as:
SUBTRACT TAX FROM GROSS-PAY GIVING NET-PAY.
PERFORM PROC-A THRU PROC-B UNTIL X IS GREATER THAN Y.

code
A set of unambiguous rules that specifies the exact manner in which data is to be represented by the characters of a character set; e. g., ASCII, Hollerith code.

(Contd.)

code translation
The act of converting data from one code to another.

coder
A person who prepares coding for a computer. See also programmer.

coding
(1) An ordered list or lists of the successive instructions which will cause a computer to perform a particular process. See also absolute coding, relative coding, skeletal coding, symbolic coding. (2) The act of preparing coding as defined in (1) above.

collate
Same as merge (i. e., to form a single sequenced file by combining two or more similarly sequenced files).

collating sequence
The ranking, or precedence with respect to each other, of all the characters in a character set that can be used to constitute a key used for sequencing purposes. Note: Most collating sequences are arranged so that the digits 0 through 9 and the letters A through Z fall into their natural sequences. However, either the digits or letters may come first, and the handling of special characters varies widely.

collator
A machine that feeds and compares two or more files of punched cards or other documents in order to match or merge them or to check their sequence. Note: The cards that match can be separated from those that do not match, making it possible to select specific cards as well as to file cards automatically.

column
(1) A vertical arrangement of characters or other symbols. (2) A location capable of holding one digit or character, especially in a punched card; e. g., one of the 80 groups of 12 punch positions in a standard 80-column card.

column binary
Pertaining to a method for representing binary data on punched cards in which adjacent positions in a card column correspond to adjacent bits of data. For example, in a standard 80-column, 12-row card, each column may be used to represent 12 consecutive bits of a 36-bit word. Sometimes called "Chinese binary." Contrast with row binary.

command
(1) A control signal, especially one transmitted from a computer to a peripheral device or input-output channel. (2) Loosely, an instruction.

comment
An explanation or identification, for human use, of a step in a routine; the comment has no effect upon the operations of the computer that executes the routine.

common language
(1) A programming language that can be used to prepare programs for a number of different computer systems; examples include ALGOL, COBOL, and FORTRAN. (2) Loosely, an input-output medium and code that can be read or recorded upon by a variety of business machines, thereby facilitating intercommunication among them.

communication
The transfer of information from one person, place, or device to another. See also data communications.

communications link
The physical means of connecting one location to another for the purpose of transmitting information between them; e. g., a telegraph, telephone, radio, or microwave circuit.

compare
To examine two words or items to discover whether they are identical, or to discover their relative magnitudes or relative order in a sequence.

compatibility
The characteristic that enables one device to accept and process data prepared by another device without prior code translation, data transcription, or other modifications. Thus, one computer system is "data compatible" with another if it can read and process the punched cards, magnetic tape, etc., produced by the other computer system. See also program compatibility.

compile
To prepare a machine language program (or a program expressed in symbolic coding) from a program written in another programming language (usually a process oriented language such as COBOL or FORTRAN). The compilation process usually involves examining and making use of the overall structure of the program, or generating more than one object program instruction for each source program statement, or both. Contrast with assemble and generate.

compiler
A computer program that compiles. Note: Compilers are an important part of the basic software for most computers; they permit the use of process oriented languages which can greatly reduce the human effort required to prepare computer programs. However, the computer time required to perform the compilation process may be excessive, and the object programs produced by the compiler usually require more execution time and more storage space than programs written in machine language or symbolic coding.

complement
A number whose representation is derived from the representation of another number by one of the following rules (or by some equivalent process): (1) To derive the "radix complement" or "true complement," subtract each digit from one less than the radix, then add 1 to the least significant digit, executing all carries required. Thus, 830 is the "tens complement" of 170 in decimal notation using three digits. (2) To derive the "radix-minus-one" complement, subtract each digit from one less than the radix. Thus, 829 is the "nines complement" of 170 in decimal notation using three digits, while 01110 is the "ones complement" of 10001 in five-digit binary notation. Note: In many computers, the absolute value of a negative number is represented as a complement of the corresponding positive number.

computer
A device capable of solving problems by accepting data, performing prescribed operations on the data,

and supplying the results of these operations, all without intervention by a human operator. See also analog computer, digital computer, general-purpose computer, special-purpose computer, stored-program computer.

concatenate
To unite in a series; to link together.

conditional transfer
An instruction that may or may not cause a jump (i.e., a departure from the normal sequence of executing instructions) depending upon the result of some operation, the contents of some register, or the setting of some indicator. Contrast with unconditional transfer. Note: Conditional transfer instructions are the basic means for implementing decision-making processes in stored-program computers.

configuration
A specific set of equipment units which are interconnected and (in the case of a computer) programmed to operate as a system. Thus, a computer configuration consists of one or more central processors, one or more storage devices, and one or more input-output devices. Synonymous with system configuration.

connector
In a flowchart, a means of representing the convergence of two or more paths into one, the divergence of one path into two or more paths, or a "break" in a single path which is continued in another area.

console
A portion of a computer that is used for communication between operators or maintenance engineers and the computer, usually by means of displays and manual controls.

constant
A quantity whose value does not vary. Contrast with variable.

constant-ratio code
A code in which all of the valid characters have the same number of 1 bits, thereby facilitating the performance of a validity check. For example, in the "4-of-8" code, frequently used in data communications, each of the valid characters is represented by a combination of four 1 bits and four 0 bits.

content-addressable memory
Same as associative memory.

contents
A general term for the data contained in any storage device, location, or medium.

control card
A punched card that contains input data required for a specific application of a general routine such as a generator or operating system; e.g., one of a series of cards that direct an operating system to load and initiate execution of a particular program.

control counter
Same as sequence counter.

control panel
(1) A part of a computer console that contains manual controls such as switches, buttons, and dials.
(2) Same as plugboard.

control program
A routine, usually contained within an operating system, that aids in controlling the operations and managing the resources of a computer system.

control sequence
The normal order of selection of instructions for execution. See also sequential control.

control unit
(1) A section of a computer that effects the retrieval of instructions in the proper sequence, interprets each instruction, and stimulates the proper circuits to execute each instruction. (2) A device that controls the operation of one or more units of peripheral equipment under the overall direction of the central processor.

conversational mode
A mode of operation that implies a "dialogue" between a computer and its user, in which the computer program examines the input supplied by the user and formulates questions or comments which are directed back to the user.

convert
To transform data according to some criteria while preserving its information content; e.g., radix conversion from decimal to binary, code translation from Hollerith to EBCDIC, data transcription from punched cards to magnetic tape, conversion from analog to digital representation, etc.

converter
A device that converts data from one form to another in order to make it available or acceptable to another device; e.g., a "card-to-tape" converter that transcribes data from punched cards to magnetic tape so that the data can be read into a computer system at high speed.

copy
To reproduce data in a new location, leaving the original data unchanged.

core storage
A type of storage that uses an array of magnetic cores, each capable of storing one bit of data. Note: Most current computers use magnetic core storage as their main working storage. This widespread acceptance is due to the fact that magnetic cores require no power while storing data, can be switched rapidly from one state to the other by relatively small currents, and can tolerate adverse environmental conditions.

corrective maintenance
Maintenance that is carried out to correct a fault. Contrast with preventive maintenance.

counter
A device, such as a register or storage location, that holds a number, permits this number to be increased by one or by an arbitrary constant, and is often capable of being reset to zero. See also sequence counter.

CPU (Central Processing Unit)
Same as central processor.

CRT
See cathode ray tube.

(Contd.)

cryogenics
The study and use of devices which utilize the properties assumed by materials at temperatures near absolute zero. Note: Certain materials become "superconductive" at very low temperatures; i.e., their resistance falls to zero, so they can maintain (i.e., store) a current indefinitely. Cryogenic techniques have found little practical application in computer design to date, but they represent a promising area for research and development.

cybernetics
The science of exploring analogies between organic and machine processes. Emphasis is upon comparative study of control and communication in machines and in the nervous systems of animals and man.

cycle
(1) An interval of time or space in which one set of events or phenomena is completed. (2) A set of operations that is repeated regularly in the same sequence; the operations may be subject to variations during each repetition.

cycle time
The minimum time interval between the starts of successive accesses to a storage location. Contrast with access time. For example, if it takes 2 microseconds to read a word out of a core storage unit and 3 more microseconds to rewrite the word before another read operation can be initiated, then the unit has a read access time of 2 microseconds and a cycle time of 2 + 3 = 5 microseconds.

cylinder
A collective term for the group of locations that can be accessed without physical movement of the read/write heads in a random access storage device. Note: In a storage device in which all of the heads move in unison, there will normally be one cylinder corresponding to each discrete position of the head mechanism.

D

data
Any representation of a fact or idea in a form capable of being communicated or manipulated by some process. The representation may be more suitable for interpretation either by humans (e.g., printed text) or by equipment (e.g., punched cards or electrical signals). Note: Information, a closely related term, is the meaning that humans assign to data by means of the known conventions used in its representation.

data communications
The transmission of data from one point to another.

data management
The development and implementation of systematic techniques for defining and structuring files and other data sets, storing them within a computer system, and retrieving specific data upon request.

Data-Phone
A trademark for the Bell System's line of data communications equipment that utilizes the facilities of the public (dialed) telephone network.

data processing
A systematic sequence of operations performed upon data; e.g., handling, computing, merging, sorting, or any other transformation or rearrangement whose object is to extract information, revise the data, or alter its representation.

data reduction
The process of transforming masses of raw data from tests or experiments, usually gathered by automatic recording equipment, into a condensed or simplified form that will convey useful information to humans.

data set
(1) A collection of data items in a prescribed arrangement; often synonymous with file. (2) A device that provides the appropriate interface between a communications link and a data processing machine or system (usually by serving as a modulator and/or demodulator, in which case the term is synonymous with modem).

data structure
The manner in which data is represented and stored in a computer system or program.

data transcription
Conversion of data from one medium to another without alteration of its information content. Note: The conversion may be performed by a manual keystroke operation, by a computer system, or by a specialized converter, and may or may not involve changes in the format of the data.

data transfer
The movement of data from a source to a destination (e.g., from one storage location or device to another).

debug
To trace and eliminate mistakes in a program or faults in equipment. The process is often assisted by a diagnostic routine. Synonymous with troubleshoot.

decimal
Pertaining to the number system with a radix of 10, or to a characteristic or property involving a choice or condition in which there are 10 possibilities. Note: the decimal number system is the one generally used by humans; therefore, it is also used in many digital computers, even though the binary number system is simpler and more efficient to implement. Example: The decimal numeral 6754 means: $(6 \times 10^3) + (7 \times 10^2) + (5 \times 10^1) + (4 \times 10^0)$.

decision
A choice of one of two or more alternative courses of action. Note: In computer programs, conditional transfer instructions are the basic means for implementing decision-making processes.

decision table
A table that lists all the contingencies to be considered in the description of a problem, together with the corresponding actions to be taken. Note: Decision tables permit complex decision-making criteria to be expressed in a concise and logical format. They are sometimes used in place of flowcharts for problem definition and documentation. Moreover, compilers have been written to convert decision tables into programs that can be executed by computers.

deck
A collection of punched cards, usually bearing data for a particular run.

decode
To reverse some previous encoding process; see encode.

decrement
The quantity by which a variable (frequently the contents of an index register) is decreased.

delay
The amount of time by which an event is retarded; e.g., the length of time after the close of a reporting period before information pertaining to that period becomes available to management.

delay line
A component or circuit designed specifically to introduce a desired delay in the transmission of a signal. Note: Delay lines using various types of waves (e.g., sonic, electromagnetic) and various propagating media (e.g., mercury, nickel, quartz) have been used as computer storage devices. In all cases, the delay line's output is regenerated and fed back to its input, so that the stored data recirculates continually and can be read out or recorded when desired.

delimiter
A character or item that marks the end of a string of characters or items, and is used to facilitate processing of the string and to separate it from other strings.

demand on processor
A quantitative measure of the delay imposed upon a central processor or its working storage by the operation of a particular peripheral device, usually expressed as a percentage. Synonymous with interference and processor demand. For example, if a magnetic tape unit requires 25 out of every 100 cycles of a core storage unit to store the data which it is reading from tape, it imposes a demand of 25%; four such magnetic tape operations proceeding simultaneously would "saturate" the core storage, resulting in a demand of 100% and (in most systems) a halt in the execution of instructions by the processor.

demodulator
A device that receives signals transmitted over a communications link and converts them into electrical pulses, or bits, that can serve as inputs to a data processing machine. Contrast with modulator.

density
See recording density.

descriptor
An elementary term (i.e., a word or brief phrase) used to identify a subject or concept, especially in information retrieval.

designator
In a programming language, a convention or rule that permits a certain type of entity to be recognized by some property of its name; e.g., use of names beginning with the letters I through N for fixed-point variables.

destructive readout
A reading process that inherently erases (i.e., destroys the record of) the data which has been read. Contrast with nondestructive readout. Note: Most core storage units are of the destructive readout type; therefore, read operations are followed by automatic rewrite operations which restore the data that was erased from each core.

detail file
A file containing information that is relatively transient, such as records of individual transactions that occurred during a particular period of time. Synonymous with transaction file. Contrast with master file.

diagnostic
Pertaining to the detection and isolation of mistakes in programs or faults in equipment.

diagnostic routine
A routine designed to perform diagnostic functions. See also dump, postmortem routine, snapshot, and trace routine (all of which are commonly-used types of diagnostic routines).

digit
A single numeric character used to represent an integer; e.g., in binary notation, the character 0 or 1; in decimal notation, one of the characters 0 through 9.

digital
Pertaining to data represented in the form of digits. Contrast with analog.

digital computer
A computer that operates on digital data by performing arithmetic and logical operations on the data. Contrast with analog computer.

diode
An electronic component that permits the flow of current in one direction and inhibits the flow in the other.

direct access
Same as random access.

direct address
An address that specifies the storage location of an operand. Contrast with indirect address.

directive
Same as pseudo instruction.

directory
(1) A list of addresses used as reference points in a program, particularly in connection with relative coding. (2) A list of the locations of specific items or records in a file contained in a storage device.

disable
To put a device (e.g., an input-output unit or an interrupt facility) into a condition in which it is unable to respond to signals from its control unit.

disc storage
A type of magnetic storage that uses one or more rotating flat circular plates with a magnetic surface on which data can be stored by selective magnetization of portions of the surface.

display unit
An output device that provides a visual representation of data for human viewing, usually on the screen of a cathode ray tube.

(Contd.)

document
(1) A medium and the data recorded on it for human use (e.g., a check, report sheet, or book). (2) By extension, any record that has permanence and can be read by man and/or machine.

documentation
The collecting, organizing, storing, citing, and disseminating of documents or the information recorded in documents. Note: Complete, up-to-date documentation of all programs and their associated operating procedures is a necessity for efficient operation of a computer installation and maintenance of its programs.

double precision
Pertaining to the use of two computer words to represent a number in order to gain increased precision. Note: Double precision arithmetic operations may be implemented, in various computers, by means of standard instructions, optional hardware facilities, or subroutines.

downtime
The period of time during which a computer or other equipment is unavailable for productive use because of a mechanical or electronic fault or malfunction. Downtime includes: time wasted on runs spoiled by faults, time lost while awaiting repairs, and the repair time itself. Contrast with uptime.

drum printer
A line printer in which the type slugs are mounted on a rotating drum that contains a full character set for each printing position. Note: Drum printers are the most widely used type of line printer at present, though chain printers offer certain advantages.

drum storage
A type of magnetic storage that uses a rotating cylinder with a magnetic surface on which data can be stored by selective magnetization of portions of the surface.

dump
(1) To copy the contents of a set of storage locations, usually from an internal storage device (such as core storage) to an external storage medium (such as magnetic tape), and usually for diagnostic or rerun purposes. (2) The data that results from a process as defined in (1). See also postmortem routine, selective dump, snapshot.

duplex
(1) Pertaining to a twin, a double, or a "two-in-one" situation; e.g., the provision of a second set of equipment to be used in the event of failure of the primary set. (2) In communications, same as full duplex.

dynamic relocation
The movement of part or all of an active (i.e., currently operating) program from one region of storage to another, with all necessary address references being adjusted to enable proper execution of the program to continue in its new location. Note: Dynamic relocation helps to ensure effective utilization of working storage in a multiprogramming environment.

E

EAM (Electrical Accounting Machine)
Pertaining to data processing equipment that is predominantly electromechanical, such as keypunches, collators, mechanical sorters, and tabulators. Note: EAM equipment is still widely used in lieu of, or in support of, electronic digital computers. (The computers themselves are classified as "EDP equipment" rather than "EAM equipment").

EBCDIC (Extended Binary Coded Decimal Interchange Code)
An 8-bit code that represents an extension of a 6-bit "BCD" code that was widely used in computers of the first and second generations. Note: EBCDIC can represent up to 256 distinct characters and is the principal code used in many of the current computers.

echo check
A check upon the accuracy of a data transfer operation in which the data that was received (typically, by an output device) is transmitted back to the source (typically, a control unit) and compared with the original data. Note: An echo check on an output operation usually can only verify that, for example, the proper print hammers or punch pins were actuated at the proper instants; it cannot ensure that the proper marks were actually recorded on the output medium.

edge-notched card
A card of any size provided with a series of holes near one or more of its edges for use in coding information for a simple mechanical search technique. By notching away the edge of the card into a particular hole, the card can be coded to represent a particular item. Cards containing desired information can be selected from a deck by inserting a long needle into the appropriate hole position and lifting the deck, allowing notched cards to fall from the deck while unnotched cards remain.

edge-punched card
A card in which data can be recorded by punching holes, in patterns and codes similar to those used for punched tape, near one edge. Note: Many punched tape readers and punches can be equipped to utilize edge-punched cards as well. Unit records can be stored and selectively retrieved more conveniently on edge-punched cards than on punched tape.

edit
To modify the form or format of data. Editing may involve the rearrangement of data, the addition of data (e.g., insertion of dollar signs and decimal points), the deletion of data (e.g., suppression of leading zeros), code translation, and the control of layouts for printing (e.g., provision of headings and page numbers).

EDP (Electronic Data Processing)
Data processing performed largely by electronic equipment, such as electronic digital computers.

effective address
The address that is derived by performing any specified address modification operations (e.g., indexing

or indirect addressing) upon a specified address (called the presumptive address) and that is actually used to identify the current operand.

effective speed
The average speed that can be maintained by a device over a sustained period of time. Because of unavoidable factors such as start times, stop times, and interblock gaps, a device's effective speed may be far lower than its peak speed as quoted in the manufacturer's specifications.

effective transfer rate
The average rate at which data can be transferred from one device or storage location to another when large quantities of data are transferred and optimum coding techniques are employed.

eighty-column card
A punched card containing 80 vertical columns, each capable of holding one character, and 12 rows, which are designated (from the top): 12 (or Y), 11 (or X), 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Note: The usual dimensions of an 80-column card are: 3.25 inches high, 7.375 inches long, and 0.070 inch thick. This type of card, with data recorded in the Hollerith code, is by far the most widely used. Contrast with ninety-column card.

electrical accounting machine
See EAM.

electronic data processing
See EDP.

electrostatic storage
A storage device that uses electric charges for the representation of data. Examples are cathode ray tubes and capacitors.

emulator
A device, usually used in conjunction with special routines, that enables a computer to execute machine language programs written for another computer of dissimilar design, without prior translation. Note: Emulation is an important technique for achieving program compatibility between certain current computers and earlier computers produced by the same or different manufacturers. The emulator usually consists of stored logic, in a read-only storage unit, that interprets and simulates the functions of each instruction in the original computer's programs. Functions that cannot be handled conveniently by the stored logic, such as input-output operations, are performed by the associated special routines.

enable
To put a device (e.g., an input-output unit or an interrupt facility) into a condition in which it is able to respond to signals from its control unit.

encode
To convert data into a particular code.

end-of-file mark
A special character or symbol that denotes the end of a file, or the completion of a quantity of data; frequently abbreviated EOF.

entry
(1) A statement in a programming language; in many cases, each entry is written on one line of a coding form and punched on one card. (2) An item in a list or table. (3) A message entered into a computer system, usually from a manual keyboard or control panel.

entry point
A point in a routine (especially a subroutine) to which control can be transferred; i.e., the first instruction to be executed when the routine is entered. Note: A subroutine may have a number of different entry points, each of which corresponds to a different function of the subroutine.

erasable storage
A storage device or medium whose contents can conveniently be changed by deleting the stored data and recording new data in its place. For example, magnetic tape and core storage are normally erasable, while punched cards are not. Contrast with nonerasable storage.

error
A discrepancy between a computed, measured, or observed quantity and the true, specified, or theoretically correct value or condition. Note: an error may result from an equipment fault or a human mistake, but errors also arise from insufficient precision which is foreseen and accepted.

error correcting code
An error detecting code that uses additional code elements (e.g., additional bits), so that if certain types of errors occur, the mutilated representation will resemble the original more closely than any other valid representation; thus, the error can be corrected. Note: When an error occurs which the code has not been designed to correct, an erroneous "correction" may result.

error detecting code
A code in which each representation of a character conforms to specific rules of construction, so that if certain types of errors occur, the mutilated representation will not conform to the rules of construction; thus, the presence of errors can be detected without reference to the original message. Synonymous with self-checking code. Note: The most common types of error detecting codes append a parity bit to each array of bits and utilize a parity check.

escape character
A character used to indicate that the character(s) which follow are expressed in a code or case different from the one currently in use. Examples are the "letters" and "figures" shift characters in the Baudot code, which indicate that the succeeding characters are members of the letters or figures case, respectively. Use of escape characters allows a limited code to represent a wide range of characters by assigning more than one meaning to each character representation.

even parity
See parity bit.

(Contd.)

excess-three code
A BCD representation (often abbreviated XS-3) in which each decimal digit N is represented by the binary equivalent of N + 3:

Decimal Digit	XS-3 Code	Binary Value
0	0011	3
1	0100	4
2	0101	5
3	0110	6
4	0111	7
5	1000	8
6	1001	9
7	1010	10
8	1011	11
9	1100	12

exclusive OR
(1) A logical operator which has the property that if P and Q are two statements, then "P exclusive OR Q" is true if either P or Q (but not both) are true, and false if both P and Q are true or if both are false. "P exclusive OR Q" is often represented by $P \oplus Q$ or $P \veebar Q$. Contrast with inclusive OR. (2) The logical operation that uses the exclusive OR operator; also called non-equivalence.

execute
To carry out an instruction or an operation, or to run a program.

execution time
The time required to execute a particular instruction, operation, or program. Note: The execution time for an instruction (sometimes called the "instruction time") includes the time required to select, prepare, and carry out one instruction and to step on to the next instruction, including the necessary accesses to storage for both the instruction and data.

executive routine
A routine designed to organize and regulate the flow of work in a computer system by initiating and controlling the execution of other programs. Synonymous with supervisory routine and "supervisor." Note: An executive routine is a principal component of most operating systems.

exponent
The numeral that indicates the position of the radix point in a floating-point number.

expression
A symbol representing a quantity, or a group of symbols representing a group of quantities, possibly combined by symbols representing operators according to prescribed rules.

external storage
A storage device or medium that is not permanently linked to a computer but can hold data in a form acceptable to it. Thus, external storage may or may not be made accessible to a computer during a given run, as the operator chooses. For example, magnetic tape, punched cards, and punched tape. Contrast with internal storage.

extract
To choose from a set of items a subset including all those that meet some specified criterion; e.g., to obtain certain specified characters or bits from a machine word, as controlled by an instruction or mask.

F

fault
A physical condition that causes a device, component, or element to fail to perform in the required manner. Synonymous with malfunction. Note: A fault may be either sporadic (intermittent) or permanent. Moreover, a fault may escape immediate detection if it does not result in failure to perform a particular task, or if the failure is not noticed. Equipment faults should be carefully distinguished from human mistakes.

feedback
Information that enables a system to exert self-correcting influences upon its own operation; e.g., information about the conditions being controlled by a process control system of the closed loop type.

fetch
To obtain data from a storage location.

field
(1) In a punched card, a group of columns whose punchings represent one item. (2) A subdivision of a computer word or instruction; e.g., a group of bit positions within an instruction that hold an address. (3) A subdivision of a record; thus, an item.

file
A collection of related records, usually (but not necessarily) arranged in sequence according to a key contained in each record. Note: A record, in turn, is a collection of related items, while an item is an arbitrary quantity of data that is treated as a unit. Thus, in payroll processing, an employee's pay rate forms an item, all of the items relating to one employee form a record, and the complete set of employee records forms a file.

file maintenance
The updating of a file to reflect the effects of nonperiodic changes by adding, altering, or deleting data; e.g., the addition of new programs to a program library on magnetic tape.

file processing
The periodic updating of a master file to reflect the effects of current data, often transaction data contained in a detail file; e.g., a weekly payroll run.

fixed-length record
A record that always contains the same number of characters. The restriction to a fixed length may be deliberate, in order to simplify and speed processing, or it may be dictated by the characteristics of the equipment used. Contrast with variable-length record.

fixed-point
Pertaining to a number system in which each number is represented by a single set of digits and the position of the radix point is implied by the manner in which the numbers are used. Contrast with floating-point. Note: Fixed-point representation is usually used in business data processing, while floating-point representation is frequently used in scientific applications because it allows convenient representation of a wide range of magnitudes — though usually at a higher cost in equipment complexity and execution times.

fixed-point part
The numeral that represents the significant digits of a floating-point number. Note: "Fixed-point part" is recommended as the least unsatisfactory of several alternative terms; others in common use — but liable to cause confusion — are "fractional part" and "mantissa."

fixed storage
Same as read-only storage.

fixed word-length
Pertaining to a machine word or operand that always has the same number of bits or characters. Contrast with variable word-length. Note: Most scientific computers are of the fixed word-length type for maximum computational speeds, while many business-oriented computers have variable word-lengths to permit efficient handling of items and records of varying sizes.

flag
A character or symbol that signals the occurrence of some condition, such as the end of a word or file. Synonymous with mark and sentinel.

floating-point
Pertaining to a number system in which each number is represented by two numerals (i.e., two sets of digits), of which one (the fixed-point part) represents the significant digits and the other (the exponent) indicates the position of the radix point. The number represented is equal to the fixed-point part multiplied by the radix raised to the power of the exponent. Algebraically, the relationship is: $x = a(r^b)$ where x is the number represented, a is the fixed-point part, b is the exponent, and r is the radix (a positive integer which is usually not represented explicitly). Contrast with fixed-point. Note: Floating-point allows the representation of a wide range of magnitudes to a given precision using a limited number of digits; therefore, it is frequently used in scientific applications. Floating-point arithmetic operations may be implemented by means of either standard instructions, optional hardware facilities, or subroutines.

flowchart
A diagram that shows the structure and general sequence of operations of a program or process by means of symbols and interconnecting lines which represent operations, data, flow, and equipment.

font
A family or assortment of graphic character representations (i.e., a character set) of a particular size and style; e.g., Font E-13B, the MICR font adopted as a standard by the American Bankers' Association, and the U.S.A. Standard Optical Font for OCR.

foreground program
A program that requires real-time responses or has a high priority, and which therefore takes precedence over other concurrently-operating programs in a computer system using multiprogramming techniques. Contrast with background program.

form
(1) A printed or typed document, usually containing blank spaces for the insertion of specific data items. (2) Stationery on which data is printed for human use by automatic data processing equipment (e.g., by a line printer or tabulator).

format
The predetermined arrangement of data (e.g., characters, items, and lines), usually on a form or in a file. See also address format.

FORTRAN (FORmula TRANslating system)
A process oriented language designed to facilitate the preparation of computer programs to perform mathematical computations. Note: Designed by IBM in the 1950's to use symbols and expressions similar to those of algebra, FORTRAN was not originally intended to be a common language. However, it has evolved through several basic versions (e.g., FORTRAN I, FORTRAN II, FORTRAN IV) plus numerous dialects, has become largely machine-independent, and has recently been approved as a U.S.A. Standard programming language in two versions (FORTRAN and Basic FORTRAN). FORTRAN is now by far the most widely used process oriented language in the U.S., and is being effectively employed in certain business as well as scientific applications. The essential element of the FORTRAN language is the assignment statement; e.g., Z = X + Y causes the current values of the variables X and Y to be added together and causes their sum to replace the previous value of the variable Z.

fractional part
Same as fixed-point part.

full duplex
Pertaining to the simultaneous, independent transmission of data in both directions over a communications link. Synonymous with duplex. Contrast with half-duplex and simplex.

function
(1) A specific purpose or characteristic action of an entity. (2) In mathematics, a magnitude so related to another magnitude that for each value of the latter there is a corresponding value of the former. (3) In a process oriented language, a particular type of subroutine that is given a name which can be used as a variable in a statement; e.g., whenever the statement Z = Y + SIN(X) is executed, the subroutine SIN will be entered and used to compute the sine of the current value of the variable X.

G

gang punch
A punched card machine that has a single card feed path with a punching station followed by a sensing station. It is used to copy data from the first card of a deck into all the succeeding cards. Note: Some gang punches can also be used as summary punches.

gap
See interblock gap.

gather-write
Pertaining to an output operation in which the data to be written is gathered from a number of specified, noncontiguous regions of internal storage rather than from a series of consecutive locations. See also scatter-read.

general-purpose computer
A computer designed to solve a wide variety of problems. Note: Most of the current digital computers fall into the general-purpose category because their

(Contd.)

stored-program capability, and the inherent flexibility it provides, make them suitable for a wide range of diverse applications in both business and scientific data processing. Contrast with special-purpose computer.

generate
: To construct a computer program through the use of a generator. Contrast with assemble and compile.

generator
: A computer program designed to construct other programs for performing particular types of operations; e.g., a report program generator or a generator of data transcription routines. Based upon parameters supplied to it, the generator typically selects from among various alternatives the most suitable method for performing the specified task, and adjusts the details of the selected method to produce a program matched to the characteristics of the data to be handled by the generated program.

group mark
: A special character used in some computers to designate the end of a record in internal storage.

H

half-duplex
: Pertaining to the alternate, independent transmission of data in both directions — but in only one direction at a time — over a communications link. Contrast with full duplex and simplex.

hard copy
: Pertaining to documents containing data printed by data processing equipment in a form suitable for permanent retention (e.g., printed reports, listings, and logs), as contrasted with "volatile" output such as data displayed on the screen of a cathode ray tube.

hardware
: Physical equipment, such as mechanical, magnetic, electrical, and electronic devices. Contrast with software.

head
: A device that reads, records, or erases data on a storage medium; e.g., a small electromagnet used to read, write, or erase data on magnetic tape or drum storage, or a device that perforates or senses holes in punched tape.

heuristic
: Pertaining to exploratory methods of problem-solving in which solutions are discovered by evaluating the progress made toward the final result; i.e., a guided trial-and-error approach. Contrast with algorithm.

hexadecimal
: Pertaining to the number system with a radix of 16, or to a characteristic or property involving a choice or condition in which there are 16 possibilities. Synonymous with sexadecimal. Note: Hexadecimal numerals are frequently used as a "shorthand" representation for binary numerals, with each hexadecimal digit representing a group of four bits (binary digits); e.g., the binary numeral 1001 0111 0100 can be represented as hexadecimal 974.

high-order
: Pertaining to the digit or digits of a number that have the greatest weight or significance; e.g., in the number 53276, the high-order digit is 5. Contrast with low-order.

Hollerith code
: A widely used code for representing alphanumeric data on punched cards, named after Herman Hollerith, the originator of punched card tabulating. Each card column holds one character, and each decimal digit, letter, and special character is represented by one, two, or three holes punched into designated row positions of the column.

hopper
: A part of a machine where punched cards or other documents are placed immediately prior to being fed into the machine.

housekeeping
: Pertaining to operations in a program or computer system which do not contribute directly to the solution of users' problems, but which are necessary in order to maintain control of the situation; e.g., the recording of the locations used by different parts of a program to ensure that data is not overwritten unless it is no longer required.

hub
: A socket on a plugboard into which a wire can be inserted to carry signals to one or more other hubs.

I

identifier
: A thing by which an entity can be identified; this may be a unique name, a location in which the entity can be found, or an indirect address that will lead to the entity.

idle time
: The time during which a computer or other equipment is available but not in use; e.g., the period between the end of one run and the start of the subsequent run, or any period when no work is scheduled.

IDP (Integrated Data Processing)
: Data processing by a system that coordinates a number of previously unconnected processes in order to improve overall efficiency by reducing or eliminating redundant data entry or processing operations. An example of IDP is a system in which data describing orders, production, and purchases is entered into a single processing scheme that combines the functions of scheduling, invoicing, inventory control, etc. See also SDA.

immediate access
: An imprecise term referring to storage whose access time is negligible in comparison with the times required for other operations in a computer system.

immediate address
: Pertaining to an instruction whose address part contains the value of an operand rather than its address. Thus, an "immediate address" is not an address at all, but an operand supplied as part of an instruction. Note: The capability to use "immediate addressing" is available only in certain computers, and usually only with certain types of instructions.

inclusive OR
(1) A logical operator which has the property that if P and Q are two statements, then "P inclusive OR Q" is true if either P or Q, or both P and Q, are true, and false if both P and Q are false. "P inclusive OR Q" is often represented by $P + Q$ or $P \vee Q$. Contrast with exclusive OR. (2) The logical operation that uses the inclusive OR operator; also called logical sum, union, and disjunction.

increment
The quantity by which a variable (frequently the contents of an index register) is increased.

index
(1) An ordered list of the contents of a document, file, or storage device, together with keys that can be used to locate or identify those contents. (2) To modify an address by adding or subtracting the contents of an index register..

index register
A register whose contents can be added to or subtracted from an address prior to or during the execution of an instruction. Note: Indexing (i.e., the use of index registers) is the most common form of address modification used in stored-program computers. Indexing can greatly simplify programming by facilitating the handling of loops, arrays, and other repetitive processes. Some computers have many index registers, some have only one, and others have none.

indexed address
An address that will be or has been modified by addition or subtraction of the contents of an index register.

indicator
(1) A device that can be set into a prescribed state, often according to the results of a previous process, and which can subsequently be used by a control unit to determine a selection from alternative processes; e.g., an overflow indicator is set whenever an overflow occurs. (2) A device (e.g., a lamp) that informs an operator of the existence of a particular condition; e.g., power on, stacker full, hopper empty.

indirect address
An address that specifies a storage location that contains either a direct address (i.e., an address that specifies the location of an operand) or another indirect address. Note: Indirect addressing (also called "multilevel addressing") is a form of address modification possible in many, but not all, digital computers; it can simplify programming and increase execution speeds in certain applications by permitting the effective addresses of many instructions to be modified by changing the contents of a single storage location.

information
The meaning that humans assign to data by means of the known conventions used in its representation.

information retrieval
The methods, procedures, and equipment for recovering specific information from stored data, especially from collections of documents or other graphic records.

information theory
A branch of mathematics that is concerned with the factors affecting the transmission of information, such as transmission rate, channel width, noise, distortion, and the probabilities of errors.

initialize
To set the variable items of a process at initial values before the process is started; e.g., to set counters, indicators, and addresses to the appropriate starting values at the beginning or other prescribed points of a computer program.

in-line subroutine
Same as open subroutine.

input
(1) The process of transferring data from external storage or peripheral equipment to internal storage (e.g., from punched cards or magnetic tape to core storage). (2) Data that is transferred by an input process. (3) Pertaining to an input process (e.g., input channel, input medium). (4) To perform an input process. (5) A signal received by a device or component. Note: As the above definitions indicate, "input" is the general term applied to any technique, device, or medium used to enter data into data processing equipment, and also to the data so entered.

input area
An internal storage area used for the receipt of input data which is transmitted as the immediate result of execution of an input instruction.

input-output
A general term for the techniques, devices, and media used to communicate with data processing equipment and for the data involved in these communications. Depending upon the context, the term may mean either "input and output" or "input or output." Synonymous with I/O.

input-output channel
A channel that transmits input data to, or output data from, a computer. Note: Usually a given channel can transmit data to or from only one peripheral device at a time. However, some current computers have multiplexor channels, each of which can service a number of simultaneously operating peripheral devices.

input-output control system
See IOCS.

inquiry station
An input-output device that permits a human operator to interrogate a computer system and receive prompt replies in a convenient form. Note: Frequently, the inquiries are entered from a keyboard and the computer-generated replies are typed and/or displayed. Inquiry stations may be located remotely from the computer. An airline reservation system, for example, usually includes multiple inquiry stations in widely scattered locations.

inscribe
To read the data recorded on a document (e.g., a check) and write the same data on the same document, but in a form that makes the document suitable for processing by automatic character recognition equipment.

(Contd.)

instruction
A set of characters that specifies an operation to be performed and, usually, the values or locations of one or more of its operands. Note: In this context, the term instruction is preferable to the terms command and order, which are sometimes used synonymously.

instruction code
Same as operation code.

instruction counter
Same as sequence counter.

instruction format
The allocation of the characters comprising an instruction between the component parts of the instruction (e.g., the operation part and one or more address parts). See also address format.

instruction register
A register that stores the current instruction of a computer's program so that it can be interpreted by the control unit.

instruction repertoire
The set of all the different types of instructions that can be executed by a particular computer or used in a particular programming language. Synonymous with "instruction repertory" and "instruction set."

instruction time
See execution time.

integrated circuit
A complete, complex electronic circuit, capable of performing all the functions of a conventional circuit containing numerous discrete transistors, diodes, capacitors, and/or resistors, all of whose component parts are fabricated and assembled in a single integrated process. The resultant assembly cannot be disassembled without destroying it. Note: Integrated circuits, now coming into widespread use in commercially available computers, promise dramatic improvements in speed, economy, reliability, and compactness.

integrated configuration
A computer configuration in which input-output functions such as card reading and printing are performed by peripheral equipment connected directly to the central processor. Contrast with paired configuration.

integrated data processing.
See IDP.

interblock gap
The distance between the end of one block and the beginning of the next block on a magnetic tape. The tape can be stopped and brought up to normal speed again in this distance, and no reading or writing is permitted in the interblock gap because the tape speed may be changing. Synonymous with inter-record gap and record gap (but use of these two terms is not recommended because of the important distinction between blocks and records).

interchangeable-cartridge storage
A storage device that uses cartridges which can be conveniently removed from the device and replaced by other similar cartridges.

interface
A shared boundary; e.g., the boundary between two systems, or between a computer and one of its peripheral devices.

interference
Same as demand on processor.

interleave
(1) To assign successive addresses to locations separated physically or in time by other locations. (2) To allocate digits to storage cells on a track so that cells allocated to successive digits of a particular word are separated by a specific number of intermediate cells which may be allocated similarly to the digits of other words.

interlock
A protective facility that prevents one device or operation from interfering with another; e.g., by locking the keys of a console typewriter to prevent manual entry of data while the computer is transferring data to the typewriter.

internal storage
A storage device that is permanently linked to a computer and directly controlled by it; e.g., core storage and drum storage. Contrast with external storage.

interpret
(1) To translate, explain, or tell the meaning of.
(2) To print on a punched card the data already punched in the card.

interpreter
(1) A punched card machine that is capable of sensing the data punched into a card and printing it on the card. (2) Same as interpretive routine.

interpretive routine
A routine that deals with the execution of a program by translating each instruction of the source language into a sequence of machine instructions and executing them before translating the next instruction. Thus, each instruction must be translated every time it is to be executed — an inherently inefficient process. See also simulator.

inter-record gap
Same as interblock gap.

interrupt
A signal, condition, or event that causes an interruption; e.g., completion of an input or output operation, detection of incorrect parity, or an attempt to execute an illegal instruction or to write in a protected location.

interruption
A temporary suspension of the execution of a sequence of instructions as a result of the occurrence of some prescribed event or condition. Note: The interrupt usually triggers an unconditional transfer to a predetermined location, where a special routine (usually part of an operating system) determines the cause of the interruption, takes the appropriate action, and then transfers control back to the point where the program was interrupted — or, in some cases, to another program of higher priority. Effective interruption facilities are a vital ingredient of computers that are to operate in a multiprogramming or real-time mode.

I/O
Same as input-output.

IOCS (Input/Output Control System)
A standard routine or set of routines designed to initiate and control the input and output processes of a computer system, thereby making it unnecessary for users to prepare detailed coding for these processes.

item
An arbitrary quantity of data that is treated as a unit. Note: a record, in turn, is a collection of related items, while a file is a collection of related records. Thus, in payroll processing, an employee's pay rate forms an item, all of the items relating to one employee form a record, and the complete set of employee records forms a file.

iterative
Pertaining to a process in which a sequence of operations is executed repeatedly until some condition is satisfied (e.g., until all items have been processed, or until a certain variable reaches a specified value). Note: In computer programs, iterative processes are normally implemented by means of loops.

J

job
A unit of work for a data processing system, especially from the standpoint of installation scheduling and accounting.

jump
A departure from the normal sequence of executing instructions in a computer. See also conditional transfer and unconditional transfer.

justify
(1) To adjust the position of words on a printed page so that the left-hand or right-hand margin is regular. (2) By extension, to shift an item in a register so that the most or least significant digit is at some specified position in the register.

K

key
One or more characters associated with a particular item or record and used to identify that item or record, especially in sorting or collating operations. Note: The key may or may not be attached to the record or item it identifies. Contrast label and tag.

keypunch
A keyboard-actuated card punch. The punching in each column is determined by the key depressed by the operator.

L

label
A name that is attached to or written alongside the entity it identifies; e.g., a key that is attached to the item or record it identifies, or a name written alongside a statement on a coding sheet.

language
A defined set of symbols and of rules or conventions governing the manner and sequence in which the symbols may be combined into a meaningful communication. Note: An unambiguous language used to express computer programs is called a programming language.

latency
Same as waiting time.

lateral parity check
Synonymous with row parity check.

leader
(1) A blank or unused length of tape at the beginning of a reel of tape. (2) A record that precedes a group of "detail records" and contains data about the group which is not contained in the individual detail records.

letter
An alphabetic character used for the representation of sounds in a spoken language; in English, one of the 26 characters A through Z.

library
An organized collection of information for study and reference purposes. See also program library.

library routine
A tested routine that is maintained in a program library (in contrast to a routine written especially for a particular job).

line printer
A printer that prints all the characters comprising one line during each cycle of its action. Synonymous with "line-at-a-time printer." Note: Two widely used types of line printers are chain printers and drum printers.

linear programming
An operations research technique that involves locating the maximum or minimum of a linear function of variables which are subject to linear constraints and inequalities. Note: Linear programming (often abbreviated "LP") is useful for solving certain problems involving many variables whose optimum values must be found (e.g., many distribution, blending, and resource allocation problems).

linkage
Coding that connects two separately-coded routines; e.g., the coding that links a subroutine to the program with which it is to be used. See also calling sequence.

list
(1) An ordered set of items. (2) To print the items and records that comprise a file or the instructions that comprise a program.

listing
A printed list of the instructions or statements that comprise a program.

literal
(1) In a programming language, an item whose representation in characters remains essentially unaltered during the operation of the appropriate compiler. (2) In a machine language, a numeral that is embedded within an instruction and used directly as an operand of that instruction.

(Contd.)

load
(1) The quantity of data transferred in a single input or output operation. (2) To read a program into internal storage in preparation for its execution. (3) To insert a supply of an input or output medium (e.g., punched cards or a reel of magnetic tape) into a peripheral device.

load-and-go
An operating technique in which the loading and execution phases of a program are performed in one continuous run. The "loading" phase frequently includes performance of the functions of an assembler, compiler, or generator. Note: The load-and-go technique is especially effective when a program must be compiled or generated for a one-time application, such as the production of a special report.

loader
A service routine designed to read programs into internal storage in preparation for their execution.

location
(1) A part of a store which can be explicitly and uniquely specified by means of an address, and which holds a word or part of a word. (2) Loosely, any place in which data can be stored.

lockout
The inhibition of all or certain types of references to a particular part of a computer system (e.g., a magnetic tape unit, or certain areas of core storage). Lockout may be effected by means of either instructions or manual switches. Note: A "write lockout" inhibits writing in specific areas of storage while permitting reading of data stored in those areas. See also storage protection.

log
A record of the operations of data processing equipment, which lists each job or run, the time it required, operator actions, and other pertinent data.

logical operation
(1) An operation whose operands and result are single digits. (2) By extension, an operation with operands and result of any length in which each digit of the result depends on not more than one digit of any one operand. Usually the same operation is performed on all corresponding digits of the operands. The most common logical operations are AND, exclusive OR, inclusive OR, NOR, and NOT.

logical record
Same as record; contrast with physical record, which is synonymous with block.

longitudinal parity check
A parity check performed on the bits in each track of magnetic tape or punched tape. At the end of each block, the parity bits that have been generated for each of the tracks are recorded simultaneously in the form of a "longitudinal check character," which is regenerated and checked when the block is read. Synonymous with track parity check.

look-up
See table look-up.

loop
A sequence of instructions that can be executed repetitively, usually with modified addresses or modified data values. Each repetition is called a cycle. Cycling continues until a specified criterion is satisfied (e.g., until a counter reaches a predetermined value). Note: The use of loops greatly facilitates the coding of any iterative process.

low-order
Pertaining to the digit or digits of a number that have the least weight or significance; e.g., in the number 53276, the low-order digit is 6. Contrast with high-order.

M

machine address
Same as absolute address.

machine instruction
An instruction that a computer can directly recognize and execute.

machine language
A language that is used directly by a computer. Thus, a "machine language program" is a set of instructions which a computer can directly recognize and execute, and which will cause it to perform a particular process.

machine oriented language
A language in which there is a general (though not necessarily strict) one-to-one correspondence between the statements of the source program and the instructions of the object program (which will normally be a machine language program ready for execution on a particular computer). Note: The input to an assembler is usually expressed in a machine oriented language. Contrast with process oriented language.

machine-readable
Pertaining to data represented in a form that can be sensed by a data processing machine (e.g., by a card reader, magnetic tape unit, or optical character reader).

machine word
Same as word (i.e., a group of bits or characters treated as a unit and capable of being stored in one storage cell).

macro instruction
An instruction written in a machine oriented language that has no equivalent operation in the computer, and is replaced in the object program by a predetermined set of machine instructions. Note: Macro instruction facilities can ease the task of coding in a machine oriented language by precluding the need for detailed coding of input and output operations, blocking, format control, checking for errors, etc.

magazine
See cartridge, hopper, stacker; "magazine" is sometimes used as a synonym for any of these three terms.

magnetic card
A thin, flexible card with a magnetic surface upon which data can be stored. Note: Some large-capacity auxiliary storage devices use a large number of magnetic cards, contained in interchangeable cartridges. One card at a time is extracted from the cartridge, transported to a read/write station where data is read and/or recorded, and then returned to the cartridge.

magnetic core
A small piece of magnetic material, often toroidal in shape (i.e., doughnut-shaped), whose magnetic properties make it suitable for storing one bit of data. See also core storage.

magnetic ink character recognition
See MICR.

magnetic storage
A storage device that uses the magnetic properties of materials to store data. Note: Most of the storage devices currently used with computers fall into this broad category. Magnetic storage embraces two distinct types of storage devices: those in which there is relative movement between the heads and the magnetic medium (e.g., drum storage and disc storage), and those in which no such movement occurs (e.g., core storage).

magnetic tape
A tape with a magnetic surface on which data can be stored by selective polarization of portions of the surface. Note: The magnetic tape currently in widest use with computers is made of a polyester plastic, is one-half inch in width, is supplied in 2400-foot reels with a diameter of 10.5 inches, and is recorded with 7 or 9 tracks across the tape at a recording density of 200, 556, 800, or 1600 rows per inch.

magnetic tape unit
A device, used to read data from or record data on magnetic tape, that contains a tape transport mechanism, reading and writing heads, and associated controls.

main frame
(1) Same as central processor. (2) That portion of a computer system which is not considered peripheral equipment.

main storage
Same as working storage.

maintenance
Tests, measurements, adjustments, repairs, and replacements intended to keep equipment in satisfactory working order. Note: All maintenance can be classified as either corrective maintenance or preventive maintenance.

malfunction
Same as fault.

management information system
A system designed to supply the managers of a business with the information they need to keep informed of the current status of the business, to understand its implications, and to make and implement the appropriate operating decisions.

mantissa
Same as fixed-point part.

manual input
(1) The entry of data into a device by manual means at the time of processing. (2) Data entered into a device by manual means at the time of processing; e.g., data entered by means of a keyboard, or by setting switches, dials, or levers.

map
A list that indicates the areas of storage occupied by various elements of a program and its data.

mark
Same as flag. See also group mark, word mark.

mark sensing
A technique for detecting pencil marks entered by hand in prescribed places on punched cards or other documents. The marked data may be converted into punched holes in the same cards, recorded on another medium, or transmitted directly to a computer.

mask
A machine word containing a pattern of characters or bits that is used to extract or select parts of other machine words by controlling the retention or elimination of selected characters or bits.

mass storage
Same as auxiliary storage.

master file
A file containing relatively permanent information which is used as a source of reference and (usually) is periodically updated. Contrast with detail file.

matrix
(1) In mathematics, a two-dimensional rectangular array of quantities that is manipulated according to defined rules. (2) By extension, an array of any number of dimensions.

medium
Any agency or means for representing data; usually, a material on which data is recorded. Note: Among the most widely used media are punched cards, punched tape, magnetic tape, and printed forms.

memory
Same as store (i.e., a device into which data can be inserted and retained, and from which the data can be obtained at a later time).

merge
To form a single sequenced file by combining two or more similarly sequenced files. Note: Merging may be performed manually, by a collator, or by a computer system for which a "merge routine" is available. Repeated merging, splitting, and remerging of strings of records can be used to arrange the records in sequence; this process, called a "merging sort," is frequently used as the basis for sorting operations on computer systems.

message
An arbitrary amount of information (e.g., a group of characters or words) that is transmitted as a unit.

message switching
A technique for controlling the traffic within a data communications network that involves: the reception of messages from various sources at a switching center, the storage of each message until the proper outgoing communications link is available, and the ultimate retransmission of each message to its destination or destinations.

(Contd.)

MICR (Magnetic Ink Character Recognition)
The automatic reading by machine of graphic characters printed with magnetic ink.

microprogramming
A method of operation of the control unit of a computer in which each instruction, instead of being used to initiate control signals directly, starts the execution of a sequence of "microinstructions" at a more elementary level. The microinstructions are usually stored in a special read-only storage unit. Note: The instruction repertoire of a microprogrammed computer can be altered to suit particular requirements by simply changing the stored microinstructions.

microsecond
One millionth of a second, abbreviated μsec or μs.

millisecond
One thousandth of a second, abbreviated msec or ms.

minimum-latency coding
A method of coding used for those computers (no longer in common use) in which the waiting time for a word in working storage depends upon its location; locations for both instructions and operands are so chosen that access times are reduced or minimized. Synonymous with optimum coding.

misfeed
The failure of a punched card or other document to pass through a machine in the prescribed manner.

mistake
The failure of a human to carry out an operation in the required manner (e.g., in writing a program or in operating equipment). Contrast with fault. See also error.

mnemonic
Pertaining to a technique used to assist human memory. Note: Most symbolic assembly languages use mnemonic operation codes, which are typically abbreviations such as MPY for multiply and SUB for subtract.

mode
(1) A system of data representation used in a computer; e.g., binary mode, decimal mode. (2) See access mode.

modem (modulator-demodulator)
A device that provides the appropriate interface between a communications link and a data processing machine or system by serving as a modulator and/or as a demodulator.

modify
To alter an instruction or address in a prescribed way. See also address modification.

modulator
A device that receives electrical pulses, or bits, from a data processing machine and converts them into signals suitable for transmission over a communications link. Contrast with demodulator.

module
(1) An incremental block of storage or some other "building block" that can be used to expand the capacity of a computer system. (2) An interchangeable, plug-in unit containing electronic components.

modulo N check
Same as residue check.

monitor
To observe the state of a system or the execution of a program and indicate significant departures from the normal or expected conditions.

monitor routine
(1) A routine designed to indicate the progress of work in a computer system. (2) Formerly, same as executive routine.

Monte Carlo method
A trial-and-error technique of repeated calculations, based on the concept of randomness, that can be used to solve problems containing a large number of variables with interrelationships so complex that a straightforward analytical solution is impossible or impractical.

multi-precision
Pertaining to the use of two or more computer words to represent a number in order to gain increased precision.

multiple address
Pertaining to an instruction containing more than one address; e.g., one-plus-one address, two-address, three-address.

multiplex
To transmit two or more messages simultaneously over a single channel or other transmission facility. This can be accomplished either by splitting the channel's frequency band into two or more narrower bands ("frequency-division multiplexing") or by interleaving the bits, characters, or words that make up the various messages ("time-division multiplexing").

multiplexor
A device that makes it possible to transmit two or more messages simultaneously over a single channel or other transmission facility.

multiplexor channel
A special type of input-output channel that can transmit data between a computer and a number of simultaneously operating peripheral devices.

multiprocessing
The simultaneous execution of two or more sequences of instructions in a single computer system. This may be accomplished through the use of either two or more central processors (i.e., a multiprocessor system) or a single central processor with several instruction registers and several sequence counters. Synonymous with parallel processing.

multiprocessor
Pertaining to a computer system that contains two or more central processors.

multiprogramming
A technique for handling two or more independent programs simultaneously by overlapping or interleaving their execution. The overlapping or interleaving of the execution of the various programs is usually controlled by an operating system which attempts to optimize the overall performance of the computer system in accordance with the priority requirements of the various jobs.

multisequencing
The simultaneous execution of two or more parts of a program by separate central processors.

N

name
A word or phrase that constitutes the distinctive designation of an entity and is generally used in referring to that entity; e.g., a person's name, or a symbol used to identify a particular data item.

nanosecond
One billionth of a second (i.e., 10^{-9} second), abbreviated nsec or ns.

NDRO
Same as nondestructive readout.

nest
(1) To embed a structure (such as a subroutine or block of data) within another structure of the same form. (2) To evaluate a polynomial of the Nth degree by an algorithm that consists of (N-1) multiply operations and (N-1) add operations in succession.

ninety-column card
A punched card containing 45 vertical columns and 12 rows. Each column is divided into an upper and a lower half, and each half-column is capable of holding one character. Thus, the card is logically equivalent to a 90-column card, which accounts for its name. Note: In each half-column, the digits 0, 1, 3, 5, 7, or 9 can be represented by a single punched hole in the appropriate position; the digits 2, 4, 6, or 8 or other characters are represented by a combination of two or more punched holes. The popularity of 90-column cards has been declining steadily in recent years. Contrast with eighty-column card.

noise
(1) Random variations of one or more characteristics of any entity such as voltage, current, or data. (2) Loosely, any disturbance that tends to interfere with the normal operation of a device or system.

nondestructive readout
A reading process that does not erase the data which has been read. Contrast with destructive readout.

nonerasable storage
A storage device or medium whose contents are not erasable; i.e., the stored data can only be changed by replacing the storage medium with new medium bearing the new data. Contrast with erasable storage. See also read-only storage.

NOR
A logical operator which has the property that if P and Q are statements, then the NOR of P and Q is true if both P and Q are false, and false if either P or Q, or both, are true. "P NOR Q" is often represented by $\overline{P \vee Q}$. (2) The logical operation that uses the NOR operator.

normalize
To adjust the exponent and fixed-point part of a number in floating-point representation so that the new fixed-point part lies within a prescribed standard range.

NOT
(1) A logical operator which has the property that if P is a statement, then the NOT of P is true if P is false, and false if P is true. "NOT P" is often represented by $\overline{P}$, $\sim$ P, or $\neg$P. (2) The logical operation that uses the NOT operator; also called "negation."

number
(1) A mathematical entity that may indicate a quantity or amount of units. (2) Loosely, a numeral.

number system
A system for the representation of numbers according to an agreed set of rules. Note: All number systems used in data processing utilize "radix notation," which means that there is a fixed ratio between the significance of each digit position and the significance of the previous digit position. This ratio is called the radix or base of the number system, and the significances of successive digit positions are successive integral powers of the radix. For example, in the decimal number system, the radix is 10, and the numeral 5762 means:

$$(5 \times 10^3) + (7 \times 10^2) + (6 \times 10^1) + (2 \times 10^0).$$

The decimal number system is generally used by humans, whereas computers frequently employ the binary (radix 2), octal (radix 8), decimal (radix 10), and hexadecimal (radix 16) number systems.

numeral
A representation of a number, usually by means of one or more digits.

numerical analysis
The study of methods of obtaining useful quantitative solutions to problems that have been expressed mathematically, including the study of the errors and bounds on errors in obtaining such solutions.

numerical control
The automatic control of operations (such as those of milling or boring machines) wherein the control is applied at discrete points in the operation through proper interpretation of numerical data. Contrast with process control.

O

object language
A language that is an output from a translation process. Contrast with source language.

object program
A program expressed in an object language (e.g., a machine language program that can be directly executed by a particular computer.

OCR (Optical Character Recognition)
The automatic reading by machine of graphic characters through use of light-sensitive devices.

(Contd.)

octal
Pertaining to the number system with a radix of eight, or to a characteristic or property involving a choice or condition in which there are eight possibilities. Note: Octal numerals are frequently used as a "shorthand" representation for binary numerals, with each octal digit representing a group of three bits (binary digits); e.g., the binary numeral 110 101 010 can be represented as octal 652.

odd-even check
Same as parity check.

odd parity
See parity bit.

off-line
Pertaining to equipment or devices which are not in direct communication with the central processor of a computer system. Contrast with on-line. Note: Off-line devices cannot be controlled by a computer except through human intervention.

one-address
Pertaining to an address format in which each instruction contains one address part, which normally specifies the location of an operand.

one-plus-one
Pertaining to an address format in which each instruction contains two address parts, one of which normally specifies the location of an operand while the other (the "plus-one" address) specifies the location of the next instruction to be executed in the normal sequence. Contrast with two-address. Note: One-plus-one addressing was commonly used in computers which used magnetic drums for working storage.

on-line
Pertaining to equipment or devices which are in direct communication with the central processor of a computer system. Contrast with off-line. Note: On-line devices are usually under the direct control of the computer with which they are in communication.

on-the-fly printer
A printer in which the type remains in motion during the printing process; at the appropriate instants during its movement, the paper and type are forced together to cause the desired characters to be printed. Note: Most high-speed chain printers and drum printers are of the on-the-fly type.

open-ended
Pertaining to a process or system that can conveniently be augmented or improved.

open shop
A computer installation that may be programmed and operated by any qualified employee of the organization. Contrast with closed shop.

open subroutine
A subroutine that must be inserted directly into a program at each point where it is to be used. Synonymous with in-line subroutine. Contrast with closed subroutine.

operand
A unit of data upon which an operation is performed. Note: The operand of a computer instruction may also be an equipment item such as an indicator, switch, or peripheral device.

operating environment
A collective term for all of the facilities that contribute to the efficient and convenient execution of programs in a computer system.

operating system
An organized collection of routines and procedures for operating a computer. These routines and procedures will normally perform some or all of the following functions: (1) Scheduling, loading, initiating, and supervising the execution of programs. (2) Allocating storage, input-output units, and other facilities of the computer system. (3) Initiating and controlling input-output operations. (4) Handling errors and restarts. (5) Coordinating communications between the human operator and the computer system. (6) Maintaining a log of system operations. (7) Controlling operations in a multiprogramming, multiprocessing, or time-sharing mode. Note: Among the facilities frequently included within an operating system are an executive routine, a scheduler, an IOCS, utility routines, and monitor routines.

operation
(1) A general term for any well-defined action. (2) The derivation of a unit of data (the "result") from one or more given units of data (the "operands") according to rules that completely specify the result for any permissible combination of values of the operands. (3) A program step undertaken or executed by a computer (e.g., addition, multiplication, comparison, shift, transfer).

operation code
A code used to represent the specific operations of a computer.

operations research
The use of analytical techniques to solve operational problems in order to provide management with a sound, logical basis for making decisions and predictions. Among the common techniques of operations research are linear programming, Monte Carlo methods, information theory, and queueing theory.

operator
(1) A person who operates a machine. (2) A symbol that indicates an action to be performed on one or more operands (e.g., the logical operators AND and OR).

optical character recognition
See OCR.

optical scanner
A device that scans printed or written data, using optical techniques, and converts the data into digital representation.

optimum coding
Same as minimum-latency coding.

OR
See exclusive OR and inclusive OR.
Note: When OR is used without qualification, "inclusive OR" is implied.

order
(1) To arrange items in a specified sequence. (2) Loosely, an instruction.

origin
Same as base address.

output
(1) The process of transferring data from internal storage to external storage or to peripheral equipment (e. g. , from core storage to magnetic tape or a printer). (2) Data that is transferred by an output process. (3) Pertaining to an output process (e. g. , output channel, output medium). (4) To perform an output process. (5) A signal transmitted from a device or component. Note: As the above definitions indicate, "output" is the general term applied to any technique, device, or medium used to take data out of data processing equipment, and also to the data so transferred.

output area
An internal storage area used for the release of output data; the area occupied by output data at the time when execution of an output instruction is initiated.

overflow
In an arithmetic operation, the generation of a quantity beyond the capacity of the register or storage location which is to receive the result.

overhead
A collective term for the factors which cause the performance of a device or program to be lower then it would be in the ideal case; e. g. , the start and stop times which can cause a magnetic tape unit's effective speed to be far lower than its rated speed; and the time and storage space required by an operating system to perform its functions.

overlay
To transfer segments of programs from auxiliary storage into working storage for execution, so that two or more segments occupy the same working storage locations at different times. Note: This technique makes it possible to execute programs which are too large to fit into the computer's working storage at one time; it is also of great importance in multiprogramming and time-sharing operations.

overpunch
To change the data represented in a punched card column or punched tape row by punching one or more additional holes into the column or row.

own coding
Coding supplied by the user that causes a generalized program to perform a function tailored to the user's specific needs; e. g. , coding which alters the output format of a manufacturer-supplied sort routine to conform with a user's file format.

P

pack
To store several short units of data in a single storage cell in such a way that the individual units can later be recovered; e. g. , to store two 4-bit BCD digits in one 8-bit storage location or one magnetic tape row.

packing density
Same as recording density.

padding
Dummy characters, items, or records used to fill out a fixed-length block of information.

page
A segment of a program or data, usually of fixed length, that has a fixed virtual address but can in fact reside in any region of the computer's working storage. Note: The division of every program and its data into pages can facilitate the control of time-sharing operations by permitting straightforward "swapping" of pages belonging to various programs between working storage and auxiliary storage.

page printer
(1) A printer in which the pattern of characters for an entire page is determined prior to printing. Synonymous with "page-at-a-time printer." (2) A widely-used but misleading term for teleprinters (i. e. , the character-at-a-time printers commonly used in low-speed communications networks).

paired configuration
A computer configuration that includes two central processors: a "main" processor all of whose input and output is from and to magnetic tape (or some other high-speed medium), and a "satellite" processor equipped to perform the necessary data transcription functions (e. g. , punched cards to magnetic tape, magnetic tape to printer).

paper tape
Same as punched tape.

parallel
Dealing with the elements of a word or message (e. g. , the bits or characters) simultaneously, each element in a different device. Contrast with serial.

parallel processing
Same as multiprocessing.

parameter
A variable that is assigned a constant value for a particular purpose or process; e. g. , the re-order level for a particular item in an inventory control program, the matrix size in a generalized matrix inversion program, the record length in a sort program generator.

parity bit
A bit (binary digit) that is appended to an array of bits to make the sum of all the "1" bits in the array either always even ("even parity") or always odd ("odd parity"). For example:

	Even Parity			Odd Parity		
Data bits	0	1	1	0	1	1
	0	1	0	0	1	0
	0	1	0	0	1	0
	0	1	1	0	1	1
	0	1	1	0	1	1
	1	1	0	1	1	0
Parity bit	1	0	1	0	1	0

parity check
A check that tests whether the number of "1" bits in an array is either even ("even parity check") or odd ("odd parity check"). Synonymous with odd-even check. See also row parity check and longitudinal parity check.

pass
One complete cycle of input, processing, and output in the execution of a computer program. For example, a "one-pass compiler" reads the source program,

(Contd.)

compiles it, and writes the object program without intermediate input-output operations or human intervention.

patch
: To correct or modify a program in a rough or expedient way by adding new sections of coding.

pattern recognition
: The identification of shapes, forms, configurations, or sounds by automatic means; e.g., optical character recognition (OCR), machine recognition of human speech.

peak speed
: The maximum instantaneous speed which a device is capable of achieving when no allowances are made for factors such as start times, stop times, interblock gaps, etc. This is the speed usually quoted in manufacturers' specifications, but it may differ substantially from the device's effective speed in typical applications.

perforated tape
: Same as punched tape.

performance
: The execution of the functions required of a device or system; the degree of speed or effectiveness with which these required functions are carried out. See also system performance.

peripheral equipment
: All of the input-output units and auxiliary storage units of a computer system. Note: The central processor and its associated working storage and control units are the only parts of a computer system which are not considered peripheral equipment.

physical characteristics
: The dimensions, weight, heat dissipation, and electrical power requirements of each unit of a computer system.

physical record
: Same as block; contrast with logical record. Note: To avoid the need for distinguishing between physical records and logical records, use of the alternative terms "block" and "record", respectively, is recommended.

picosecond
: One thousandth of a nanosecond (i.e., 10^{-12} second), abbreviated psec.

pinboard
: A perforated board used to control the operation of some automatic data processing equipment through manual insertion of cordless pins in the appropriate holes. See also plugboard.

pitch
: The distance between corresponding points of adjacent characters, rows, tracks, etc.; e.g., most high-speed line printers have a character pitch (i.e., horizontal spacing) of 10 characters per inch and a line pitch (i.e., vertical spacing) of 6 or 8 lines per inch.

PL/I (Programming Language I)
: A process oriented language designed to facilitate the preparation of computer programs to perform both business and scientific functions. Note: Developed jointly by IBM and the SHARE users' organization between 1964 and 1966, PL/I represents an attempt to combine the best features of existing programming languages (such as ALGOL, COBOL, and FORTRAN) with a number of facilities not available in previous languages. However, it has not yet been demonstrated that an efficient compiler for the PL/I language can be developed, and PL/I has to date made only limited inroads upon the popularity of other programming languages.

plotter
: A device that produces a graphical representation of a dependent variable, as a function of one or more other variables, by means of an automatically controlled pen or pencil. See also XY plotter.

plugboard
: A perforated board used to control the operation of some automatic data processing equipment. The holes in the board (called "hubs" or "sockets") are manually interconnected, in a manner appropriate to the job to be performed, by means of wires terminating in plugs (called "patchcords"). Synonymous with control panel (2). See also pinboard.

pocket
: Same as stacker.

postmortem routine
: A diagnostic routine, often a dump, that is used after a program has failed to operate as intended.

precision
: The degree of discrimination with which a quantity is stated. For example, a three-decimal-digit numeral permits discrimination among 1000 possible values. Precision should be carefully distinguished from accuracy, which is the degree of freedom from error. For example, a 6-digit numeral is more precise than a 4-digit numeral, but a properly computed 4-digit result may be more accurate than an improperly computed 6-digit result.

preset
: Pertaining to a condition or variable whose value is established prior to the initiation of a run.

presumptive address
: An address that is altered through address modification to form an effective address which is actually used to identify an operand.

preventive maintenance
: Maintenance that is carried out to keep equipment in proper operating condition and to prevent faults from occurring during subsequent operations Contrast with corrective maintenance.

printer
: A machine that produces a printed record of the data with which it is fed, usually in the form of discrete graphic characters that can be conveniently read by humans. See also chain printer, drum printer, line printer, page printer.

print position
: In a line printer, a position in which any one of the members of the printer's character set can be printed in each line. Note: Most of the current line

printers have between 80 and 160 print positions; i.e., they can print between 80 and 160 characters per line.

priority
A preferential rating that specifies the relative urgency or importance of a particular job or task. Note: In some operating systems, the entry of a high-priority job can cause immediate suspension of the processing of jobs of lower priority.

privileged instruction
A computer instruction that is not available for use in ordinary programs written by users; its use is restricted to the routines of the operating system. Note: Input-output, priority control, and storage protection instructions are in the "privileged" category in many of the current computers.

problem oriented facilities
A collective term for the standard software other than assemblers, compilers, and operating systems that is available for a particular computer system. Included are utility routines (such as simulators, sort and merge routines, report program generators, data transcription routines, and file maintenance routines) plus application packages and problem oriented languages.

problem oriented language
A language whose design is oriented toward the specification of a particular class of problems, such as numerical control of machine tools. Contrast with process oriented language.

procedure
The course of action taken to solve a problem

procedure oriented language
Same as process oriented language

process
A system of operations designed to solve a problem or lead to a particular result.

process control
The automatic regulation of a process (such as the production of chemicals or the generation of power) wherein the control is applied continuously and adjustments are made to keep the values of one or more controlled variables (such as temperature or flow rate) constant. Contrast with numerical control.

process oriented language
A language designed to permit convenient specification, in terms of procedural or algorithmic steps, of data processing or computational processes. Examples include ALGOL, COBOL, and FORTRAN. Contrast with problem oriented language and machine oriented language.

processor
A device or system capable of performing operations upon data Note: The term may refer to either hardware (see central processor) or software (an assembler or compiler is sometimes referred to as a "language processor").

processor demand
Same as demand on processor.

program
(1) A plan for solving a problem. (2) To devise a plan for solving a problem. (3) A computer routine; i.e., a set of instructions arranged in proper sequence to cause a computer to perform a particular process. (4) To write a computer routine.

program compatibility
The characteristic that enables one computer system to execute programs written for another computer system and obtain identical results. See also compatibility. Note: Program compatibility can be achieved through the use of two computer systems with similar instruction repertoires and facilities; or — between dissimilar computers — through emulators, simulators, translators, or coding in a common language.

program interrupt
See interrupt.

program library
An organized collection of tested programs, together with sufficient documentation to permit their use by users other than their authors.

program step
A single instruction or operation in a program.

programmed check
A check that is carried out by a series of instructions in a program. Contrast with automatic check.

programmer
A person who devises programs. Note: The term "programmer" is most suitably applied to a person who is mainly involved in formulating programs, particularly at the level of flowchart preparation. A person mainly involved in the definition of problems is called an analyst, while a person mainly involved in converting programs into coding suitable for entry into a computer system is called a coder. In many organizations, all three of these functions are performed by "programmers."

programming language
An unambiguous language used to express programs for a computer.

protected location
A location whose contents are protected against accidental or improper alteration. See also storage protection.

pseudocode
A programming language whose instructions are not directly executable by a computer.

pseudo instruction
An instruction that has the same general form as a machine instruction but is not directly executable by a computer. Pseudo instructions are commonly used in machine oriented languages to control the operation of a translator. Synonymous with directive.

pulse
A sudden, significant change of short duration in the value of some variable (most commonly the voltage in an electrical circuit).

(Contd.)

punch
(1) To form a hole by forcing a sharp-edged tool through a medium and into a die. (2) A hole resulting from a punch operation as defined in (1) above. (3) A device used to punch holes into a medium such as cards or paper tape. See also card punch and keypunch.

punched card
A card of defined dimensions that can be punched with a pattern of holes in defined positions for the purpose of representing data. Note: The punching positions are defined in terms of columns and rows, and different types of punched cards are designated according to the number of columns they contain; e.g., eighty-column card, ninety-column card.

punched tape
A tape of defined dimensions that can be punched with a pattern of holes in defined positions for the purpose of representing data. Note: Punched tapes in common use are made of paper, oiled paper, or polyester plastic. Tapes are usually designated according to the number of holes that can be punched across them; e.g., an 8-track tape can have up to 8 code holes (plus a smaller feed hole) punched across the width of the tape. Synonymous with paper tape, perforated tape. See also chad, chadless.

pushdown list
A set of items that is constructed and maintained in such a way that the next item to be retrieved is always the item which was most recently stored in the list; i.e., last in, first out (LIFO). Synonymous with stack.

pushup list
A set of items that is constructed and maintained in such a way that the next item to be removed is always the oldest item still in the list; i.e., first in, first out (FIFO).

Q

qualified name
In a programming language, a name which has been qualified to pinpoint a specific data item. For example, if there are two items named PRICE, one in a master file and one in a detail file, they could be qualified as MASTER-PRICE and DETAIL-PRICE, or as PRICE-IN-MASTER and PRICE-IN-DETAIL.

quantity
An entity that is capable of being measured or expressed in numbers.

queueing theory
An operations research technique that is especially useful in studying delays or line-ups at servicing points such as tollbooths, checkout counters, and message switching systems.

R

radix
In a number system, the quantity whose successive integral powers are the implicit multipliers of the sequence of digits that represents a number. For example, in the decimal number system, the radix is 10, and the numeral 5762 means:
$(5 \times 10^3) + (7 \times 10^2) + (6 \times 10^1) + (2 \times 10^0)$.

radix point
In a number system, the character (usually a dot) or implied character that separates the integral part of a numeral from the fractional part; e.g., decimal point, binary point.

random access
Pertaining to a storage device in which the access time is not significantly affected by the location of the data to be accessed; thus, any item of data which is stored on-line can be accessed within a relatively short time (usually less than one second). Synonymous with direct access. Contrast with serial access.

random numbers
A sequence of numbers that satisfies various statistical tests which are thought to be appropriate tests of randomness. Note: Sequences of random numbers which closely approximate numbers obtained entirely by chance can be generated by certain arithmetic processes; they are useful in many types of calculations, especially those involving an element of uncertainly, such as Monte Carlo methods.

read
To obtain data from a store or medium. See also input.

read-after-write check
A check upon the accuracy of an output operation in which the data recorded on the output medium is read back and compared with the data that was supposed to be recorded. Note: Read-after-write checking is one of the most positive types of error checking; it may be performed automatically, as in most of the current magnetic tape units, or as a separately programmed operation, as in many disc storage units.

read-only storage.
A storage device into which data cannot be written by the computer with which it is used. Note: In some computers, portions of the core storage or drum storage can be made "read-only" by temporarily effecting manual or programmed write lockouts. Permanent read-only storage (ROS) is used in many current computers to implement emulators and microprogramming.

read/write head
A head used to read or write data on a storage medium.

real-time
(1) Pertaining to the actual time during which a physical process takes place. (2) Pertaining to a mode of operation in which the instants of occurrence of certain events in the system must satisfy restrictions determined by the occurrence of events in some other independent system. For example, real-time operation is essential in computers associated with process control systems, message switching systems, and reservation systems.

record
A collection of related items of data. Note: a file, in turn, is a collection of related records. Thus, in payroll processing, an employee's pay rate forms an item, all of the items relating to one employee form a record, and the complete set of employee

records forms a file. Synonymous with logical record. See also fixed-length record and variable-length record.

record gap
Same as interblock gap.

record mark
A special character used in some computers either to limit the number of characters in a data transfer operation or to separate blocked records on tape.

recording density
The number of useful storage cells per unit of length or area; e. g. , the number of rows (or characters) per inch on a magnetic tape or punched tape, or the number of bits per inch on a single track of a tape or drum. Synonymous with packing density. Note: The most common recording densities in current use are 10 rows per inch for punched tape and 200, 556, 800, or 1600 rows per inch for magnetic tape.

recursive
Pertaining to a process that contains itself as a part of itself; e. g. , a recursive subroutine is a subroutine that contains a call to itself.

redundancy check
A check based on the transfer of more bits or characters than the minimum number required to express the message itself, with the added bits or characters inserted systematically for checking purposes. Note: The most common type of redundancy check is a parity check.

re-entrant
Pertaining to a routine that can be used by two or more independent programs at the same time. This means that the re-entrant routine cannot modify the contents of any of its own locations, and that any required temporary storage must be supplied along with each program using the re-entrant routine. Note: Re-entrant routines have two significant advantages in multiprogramming or time-sharing environments: (1) they conserve storage space because only one copy of a routine needs to be present regardless of the number of programs which are simultaneously using it; (2) since they are never modified, they do not need to be rewritten in auxiliary storage when displaced from working storage by another program.

register
A device capable of storing a specified amount of data, such as one word, and usually intended for some special purpose. Note: Among the registers included in many computers are an accumulator, index registers, instruction register, and sequence counter. Each register may be an individual store or a reserved location within a larger store (e. g , a reserved core storage location).

registration
The accuracy of positioning relative to some reference (e. g. , of the holes in a punched card or the forms in a printer).

relative address
An address (usually contained in an instruction) that is combined with a base address to form the absolute address of a particular storage location.

relative coding
Coding that uses machine instructions with relative addresses. Contrast with absolute coding and symbolic coding.

reliability
(1) The ability of a device to perform a specified function when required, without remedial action.
(2) In quantitative terms, the probability that a device will perform to a specified standard throughout a specified period of time or amount of usage.

relocatable coding
Coding existing in a form that permits it to be loaded and executed in any available region of a computer's working storage. Note: The object programs produced by most of the current assemblers and compilers are in relocatable form to permit flexibility in storage allocation.

relocate
To move a program from one region of storage to another, adjusting all necessary address references so that the program can be properly executed in its new location.

reperforator (receiving perforator)
A tape punch that automatically converts coded electrical signals into perforations in paper tape.

report file
A file containing records which constitute a report of the transactions and/or results of a data processing job.

report program generator
A generator designed to construct programs to perform routine report-writing functions; e. g. , to accept input data from punched cards or magnetic tape and produce printed reports, often with headings, subtotals, etc.

reproducer
A punched card machine that has two separate card feed paths, one equipped with a sensing station and the other with a punching station. Its basic function is to copy data from one deck of cards into another deck of cards in card-by-card fashion.

rerun
To make another attempt to complete a job by executing all or part of the process again with the same or corrected inputs

rerun point
A place in a program where its execution can be re-established after an equipment failure or some other interruption. Note: At a rerun point, sufficient data has been recorded to permit a restart from that point in the event of a subsequent interruption. Thus, the provision of rerun points at reasonable intervals can save computer time by making it unnecessary to rerun a program from the beginning whenever a run is interrupted.

reset
To restore a counter, indicator, switch, or storage location to a prescribed initial state.

(Contd.)

residue check
A check of numeric data or arithmetic operations in which each number, A, is divided by the modulus, N, and the remainder, B, accompanies A as a check digit or digits. For example, in a modulo 4 check, B will be either 0, 1, 2, or 3; if the remainder formed when A is divided by 4 does not equal B, an error is indicated. Note: The well-known arithmetic method of "casting out nines" is a modulo 9 check. Synonymous with modulo N check.

restart
To re-establish the execution of a program whose execution has been interrupted, using the data recorded at a rerun point.

rewind
To return a magnetic tape, punched tape, or film to its beginning (or to some passed location).

rewrite
In a storage device of the destructive readout type, to restore the data into the same position from which it has just been read. Note: In most core storage units, every read operation is automatically followed by a rewrite operation which restores the data that was erased from each core.

roll in
To transfer a program or segment of a program from auxiliary storage to a computer's working storage.

roll out
To transfer a program or segment of a program from a computer's working storage (e.g., core storage) to auxiliary storage (e.g., a disc file or drum), usually to allow another program of higher priority to occupy the same region of working storage.

round off
To delete the least significant digit or digits from a numeral and adjust the part retained in accordance with some rule. Note: The purpose of round-off operations is to reduce the bias introduced when numerals are truncated; e.g., to round off the last digit to be retained of a result, one-half of the radix is often added to the next (less significant) digit position before truncation.

routine
A set of instructions arranged in proper sequence to cause a computer to perform a particular process. Note: In this context, the term "routine" is somewhat more precise than the more general (and more commonly used) term program.

row
(1) A series of characters or other entities in a continued (usually horizontal) line. (2) One of several divisions running parallel to the longer edges of a punched card; e.g., one of the 12 rows of 80 punch positions in a standard 80-column card. (3) One of several divisions running perpendicular to the edges of a punched tape or magnetic tape; usually, each tape row holds one character and constitutes the number of bits read or recorded simultaneously. A tape row is sometimes called a "frame."

row binary
Pertaining to a method for representing binary data on punched cards in which adjacent positions in a card row correspond to adjacent bits of data. For example, each row of an 80-column card may be used to represent the 80 bits of two consecutive 40-bit words Contrast with column binary.

row parity check
A parity check performed on the bits in each row of magnetic tape or punched tape. Synonymous with lateral parity check.

run
A performance of a specific process by a computer on a given set of data; i.e., the execution of one routine or of several routines which are linked to form one operating unit, during which little or no human intervention is required.

S

scale
To multiply a quantity by a factor in order to bring its range within the limits prescribed for the equipment or method being used. See also normalize.

scale factor
A number used as a multiplier to scale one or more quantities so that they will fall within a prescribed range of values. For example, to scale the values 96, 43.2, -9, and -75.6 to fall between + 1 and -1, a scale factor of 1/100 could be used, resulting in the scaled values 0.96, 0.432, -0.09, and -0.756, respectively.

scan
To examine sequentially, part by part.

scanner
A device that automatically samples a physical condition or the state of a process and transfers the data obtained to a recorder or control device. See also optical scanner.

scatter-read
Pertaining to an input operation in which the data that is read is stored in a number of specified, noncontiguous regions of internal storage rather than in a series of consecutive locations. See also gather-write.

scheduler
A routine, usually part of an operating system, that controls the scheduling of jobs and allocation of the physical facilities of a computer system.

SDA (Source Data Automation)
The capture, in machine-readable form, ot data describing events or transactions at the time and place where each event or transaction occurs. Note: SDA can greatly improve the overall efficiency of data processing operations by reducing the need for manual data transcription operations and decreasing the incidence of errors. See also IDP.

search
To examine a set of items in order to locate those (if any) that have a desired property. See also binary search.

secondary storage
Same as auxiliary storage.

seek
(1) To look for data, making use of known information regarding its location (especially by moving the access mechanism of a random access storage device so that a read/write head is positioned over the track where the desired data is located). (2) Loosely, same as search.

segment
One of the parts into which a program is divided by a segmentation process. See also overlay.

segment mark
A special character written on magnetic tape to separate one section of a tape file from another.

segmentation
The division of a program into parts so that each part can be stored within a computer's working storage and contains the necessary linkages to other parts. Each part thus formed is called a segment. Note: Segmentation makes it possible to execute programs which exceed the capacity of a computer's working storage; it is performed automatically by some compilers.

selective dump
A dump of the contents of a set of storage locations specified by the user; e. g. , of the storage locations occupied by a particular program and/or its data.

selector channel
A term used in certain computer systems for an input-output channel that can transfer data to or from only one peripheral device at a time. Contrast with multiplexor channel.

self-adapting
Pertaining to the ability of a system to change its performance characteristics in response to its environment.

self-checking code
Same as error detecting code.

self-checking number
A numeral that contains redundant information (such as an appended check digit) which permits the numeral to be checked for accuracy after it has been transferred from one medium or device to another (e. g. , by means of a residue check).

semantics
The relationships between symbols and their meanings; i. e. , the study of the meanings jointly assigned to the constructions in a language by its users, by other statements in the language, or by the context. Contrast with syntax.

semiconductor
A solid whose electrical conductivity lies between the high conductivities of metals and the low conductivities of insulators. Note: Transistors and crystal diodes are semiconductor circuit elements which are used in many computers.

sense
(1) To read punched holes or other marks. (2) To determine the condition or setting of some element of hardware, especially a manually-set switch (i. e. , a "sense switch").

sentinel
Same as flag.

sequence
To arrange items so that they are in the order defined by some criterion of their keys. Note: Often the keys are groups of numbers or letters, and the items are arranged so that the keys of successive items are in numerical or alphabetical order.

sequence counter
A register from whose contents the address of the next instruction is derived. Synonymous with control counter and instruction counter. Note: In computers that use sequential control, the sequence counter arranges for successive instructions to be accessed from successive storage locations, except when a jump or other special instruction is encountered.

sequential control
A method of computer operation that permits instructions to be stored in the sequence in which they are normally executed. Note: This is the method of operation employed in most of the current digital computers; exceptions are the computers that use one-plus-one addressing, in which one of the addresses in each instruction specifies the location of the next instruction to be executed.

sequential processing
Same as batch processing.

serial
Dealing with the elements of a word or message (e. g. , the bits or characters) one after another, in the same device. Contrast with parallel.

serial access
Pertaining to a storage device in which there is a sequential relationship between the access times to successive locations, as in the case of magnetic tape. Contrast with random access.

service routine
Same as utility routine

set-up time
The time between computer runs or other machine operations that is devoted to such tasks as changing reels of tape and moving cards, forms, and other supplies to and from the equipment.

sexadecimal
Same as hexadecimal

shift
To move all the bits, digits, or characters of a word a specified number of positions toward either the left or right. Note: An "arithmetic shift" corresponds to multiplication or division by an integral power of the radix; usually the sign is given special treatment, and round-off may be performed. In a "logical shift" all digit positions are treated alike; digits shifted beyond the end of the word or register may be lost, or (in a "cyclic shift") they may be returned to the other end of the word or register in circular fashion.

shift register
A register in which shift operations can be performed.

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sign
A character that indicates whether a number is positive or negative. Note: In many computers that use binary representation, the left-most bit of each word serves as the sign of the word. In decimal computers, the sign may be represented by the left-most digit of each field or by a particular zone bit configuration.

signal
An event or phenomenon that conveys data from one point to another; it can be initiated and controlled at the source and recognized at one or more destinations (e.g., an electrical impulse).

significant digit
A digit that contributes to the accuracy or precision of a numeral.
Example 1: If the last two digits are considered inaccurate or irrelevant, the representation 73524 may be replaced with 73500 to three significant digits.
Example 2: In a system where all numbers are carried to only two significant digits, the product of 12 and 0.12 is 1.4.

simplex
Pertaining to a communications link that is capable of transmitting data in only one direction. Contrast with full duplex and half-duplex.

simulate
To represent certain features of the behavior or functioning of one system by means of actions of another; e.g., to represent one computer by another, or to represent physical phenomena by the actions of a computer.

simulator
A device or computer program designed to simulate the behavior or functioning of a system.

simultaneity
The capability of a computer system to perform multiple operations (input-output and/or internal processing) during the same period of time Note: Simultaneity is usually provided through the use of multiple input-output channels and automatic multiplexing of the data transfers between the various channels and the computer's working storage. The degree of simultaneity is a vital factor in determining a computer system's overall effectiveness in many applications.

simultaneous operations
Operations which can take place during the same period of time in a computer system (e.g., one input or output operation on each input-output channel plus execution of instructions in the central processor).

single-step
Pertaining to a mode of computer operation, usually used for test purposes, in which each program step is performed in response to a single manual operation, such as depression of a particular console button.

skeletal coding
Sets of instructions in which certain addresses and other parts are left unspecified. Note: Skeletal coding often serves as the framework for programs produced by a generator.

skew
The angular displacement of an individual printed character, a group of characters, a magnetic tape row, or other data from its intended or ideal placement.

skip
(1) To move paper in a printer, without printing, through a distance greater than the normal line spacing, usually at a higher speed than in a single-line advance. Synonymous with slew. (2) In a card punch, to pass rapidly over fields in which no punching is required. (3) To ignore one or more instructions in a sequence of instructions.

slew
Same as skip (1).

snapshot
A dynamic dump of the contents of specified storage locations and/or registers that is performed at specified points or times during the running of a program.

software
The collection of programs and routines associated with a computer (such as assemblers, compilers, utility routines, and operating systems) which facilitate the programming and operation of the computer. Contrast with hardware.

solid state
Pertaining to electronic components whose operation depends on the control of electric or magnetic phenomena in solids; e.g., transistors, crystal diodes, ferrite cores.

sort
To arrange items in sequence or segregate them into groups according to some criterion of their keys or some definite rules. Note: Often the keys are groups of numbers or letters (e.g., account numbers or employee names), and the sorting operation involves arranging the items so that the keys of successive items are in numerical or alphabetical sequence. Sorting is one of the most common data processing operations; it may be performed manually, by a punched card sorter, or by a computer system for which a "sort routine" is available.

sorter
(1) A person, device or computer routine that sorts.
(2) A machine that has sensing facilities and several stackers or pockets. According to the data sensed from a document (e.g., a punched card or MICR-encoded check), the document is routed to a particular stacker or pocket. Thus, a sorting operation can be accomplished in one or more passes of the documents through the machine.

source data automation
See SDA.

source document
A document from which data is extracted; e.g., a document that contains typed or handwritten data to be keypunched.

source language
A language that is an input to a translation process. Contrast with object language.

source program
A program written in a source language (e.g., a program written in COBOL, FORTRAN, or symbolic coding for input to a compiler or assembler).

special character
A character that is neither a letter nor a digit; it may be a punctuation mark (e.g., comma) or a character that causes a particular operation to be performed (e.g., carriage return).

special-purpose computer
A computer designed to solve a restricted class of problems; e.g., a computer designed specifically for use in a specialized application such as process control, message switching, or missile guidance. Contrast with general-purpose computer.

sprocket holes
Holes punched in a paper tape or in one or both longitudinal margins of a continuous form to facilitate feeding of the tape or form.

stack
(1) A group of heads which are used together to read, record, or erase one band at a time. (2) Same as pushdown list.

stacker
A part of a machine where punched cards or other documents are deposited after passing through the machine. Synonymous with pocket. Note: Some machines, such as collators and sorters, are equipped with multiple stackers. Frequently, documents containing detected errors can be routed to a separate "reject stacker."

start time
The time that elapses between the issuance of an instruction to read or write on tape and the initiation of the transfer of data to or from the tape. Also called "acceleration time."

statement
In computer programming, a meaningful expression or generalized instruction in a programming language.

step
(1) One operation in a computer routine. (2) To cause a computer to execute one operation; see also single-step.

stop time
The time that elapses between the completion of reading or writing of data on tape and the time when the tape stops moving. Also called "deceleration time."

storage
(1) The retention of data for subsequent reference. (2) Loosely, synonymous with store: a device into which data can be inserted and retained, and from which the data can be obtained at a later time. Note: Various types of storage are used in current computer systems; see, for example, core storage, disc storage, drum storage, read-only storage. See also external storage and internal storage.

storage allocation
The assignment of specific programs, program segments, and/or blocks of data to specific portions of a computer's storage. See also allocation and dynamic relocation.

storage capacity
The amount of data that can be contained in a storage device, usually expressed in words or characters.

storage cell
An elementary unit of storage, capable of holding one bit, one character, or one word.

storage dump
Same as dump.

storage protection
Prevention of unauthorized writing in and/or reading from all or part of a storage device. This may be achieved by manually-set switches or by automatic hardware facilities, usually in connection with an operating system. Note: Effective storage protection is a vital element in multiprogramming and time-sharing systems to ensure privacy and prevent concurrently operating programs from interfering with one another.

store
(1) A device into which data can be inserted and retained, and from which the data can be obtained at a later time. (2) To insert or retain data in a storage device.

stored-program computer
A computer that, under control of instructions held in an internal store, can synthesize, alter, and store instructions as if they were data and can subsequently execute these new instructions. Thus, a stored-program computer is capable of modifying its own programs — a feature that permits great flexibility and responsiveness to changing problem conditions.

straight-line coding
Coding in which the use of loops and/or closed subroutines is avoided by repetition of parts of the coding when required.

string
(1) A connected sequence of entities such as characters, bits, or items. (2) In sorting, a set of records which is in ascending (or descending) sequence according to a key contained in each record.

stroke
In character recognition, a straight line or arc that forms part of a graphic character.

subprogram
A part of a larger program; usually, the subprogram can be converted into machine language independently of the remainder of the program.

subroutine
A routine that can be part of another routine. See also closed subroutine and open subroutine. Note: A great deal of coding effort can be saved through judicious use of subroutines to handle tasks which are encountered repetitively. Examples include the control of input-output operations, the evaluation of mathematical functions, and the handling of checking and error recovery procedures.

(Contd.)

summary punch
A card punch which is directly connected to and controlled by a tabulator, and which punches certain data processed by the tabulator.

summation check
A check in which the sum of a group of digits is formed, usually without regard to overflow, and the result is compared with a previously-computed value called the "check sum."

supervisory routine
Same as executive routine.

suppression
In a printing operation, the elimination (i.e., non-printing) of certain characters or groups of characters. Note: Suppression may be either programmed or performed by automatic hardware facilities. See also zero suppression.

switch
(1) In a program, an instruction or parameter that causes selection of one of two or more alternative paths (i.e., sequences of instructions). The selection, once made, persists until it is altered. (2) In hardware, a device that can be placed in one of two or more distinct settings by a human operator or an instruction; see also indicator.

symbol
A character, group of characters, or ideograph that serves as a representation of something else by reason of relationship, association, or convention.

symbolic address
An address expressed in symbols convenient to the programmer, which must be translated into an absolute address (usually by an assembler) before it can be interpreted by a computer. For example, the storage location that holds an employee's gross pay might be assigned the symbolic address GPAY.

symbolic coding
Coding that uses machine instructions with symbolic addresses. Contrast with absolute coding and relative coding. Note: The input to most assemblers is expressed in symbolic coding. Mnemonic operation codes are usually employed along with the symbolic addresses to further simplify the coding process. For example, a two-address instruction that subtracts an employee's taxes from his gross pay might be written SUB TAX GPAY.

synchronization check
A check that determines whether a particular event or condition occurred at the proper instant; e.g., whether the print hammers in a drum printer were activated at the instants when the appropriate character slugs on the drum were in the proper position.

synchronous computer
A computer in which each operation starts as a result of a signal generated by a clock. Contrast with asynchronous computer.

syntax
In a language, the rules for the formation of permissible constructions (e.g., sentences, expressions) without regard to their meanings. Contrast with semantics.

system
A set or arrangement of entities that forms, or is considered as, an organized whole. Note: This term is a very general one that is applied to both hardware and software entities; therefore, it must be carefully qualified to be meaningful (e.g., computer system, management information system, number system, operating system).

system configuration
(1) Same as configuration. (2) The rules for interconnecting the available equipment units which collectively define the range of possible configurations for a particular computer system.

system analysis
The examination of an activity, procedure, method, technique or business to determine what needs to be done and how it can best be accomplished.

T

table
A collection of data, each item of which is directly and uniquely identifiable by means of one or more arguments. The arguments may be listed explicitly or implied by the positions of the entries in the table.

table look-up
A procedure for using a known value (the argument) to locate an unknown value in a table. Note: Special instruction for table look-up operations are provided in some computers; in others, the procedure must be programmed.

tabulate
(1) To arrange data in the form of a table. (2) In punched card equipment, to print totals, differences, or like data on the general basis of one line of print per group of input cards.

tabulating equipment
The data processing machines that use punched cards and are predominantly electromechanical, such as tabulators, collators, gang punches, interpreters, reproducers, and sorters. Note: The name "tabulating equipment" resulted from the fact that the main function of these machines for many years prior to the introduction of electronic computers was to produce tabulations of information by sorting, listing, selecting, and totaling data on punched cards.

tabulator
A machine that reads data from external storage media, such as punched cards or tape, and automatically produces lists, tables, or totals, usually on continuous forms. Synonymous with accounting machine (but "tabulator" is the preferred term because "accounting machine" has another, different meaning).

tag
One or more characters attached to a particular item or record and used to identify that item or record. Note: The tag can be removed from the item or record by a simple operation, but it then loses its significance. Contrast with key.

tape transport
A mechanism that moves tape past one or more heads in a controlled manner, as in a magnetic tape unit.

tape unit
A device containing a tape transport, reading and writing heads, and associated controls.

target computer
The computer configuration on which a particular object program is to be executed.

task
(1) A logical part of a problem. (2) In some operating systems, a unit of work for the central processor.

telecommunications
The transmission of signals over long distances, such as by radio or telegraph. See also data communications.

Teleprocessing
A trademark for IBM's line of data communications equipment.

temporary storage
Storage locations used by a program to store intermediate results which are generated and must be temporarily retained.

terminal
A point or device in a system or communications network at which data can either enter or leave.

test routine
A routine designed to show whether or not a computer is operating properly.

thin film
A layer of magnetic material, usually less than one millionth of an inch in thickness and deposited by a vacuum process on some" substrate" such as a flat plate or wire. Note: Magnetic thin films are being used for both storage and logic elements.

three-address
Pertaining to an address format in which each instruction contains three address parts. Thus, a single three-address instruction can cause the contents of two storage locations to be added and the result stored in a third location.

throughput
The total amount of useful work performed by a data processing system during a given period of time.

time-sharing
(1) The use of a given device by a number of other devices, programs, or human users, one at a time and in rapid succession. (2) A technique or system for furnishing computing services to multiple users simultaneously, while providing rapid responses to each of the users. Note: Time-sharing computer systems usually employ multiprogramming and/or multiprocessing techniques, and they are often capable of serving users at remote locations via a data communications network.

trace routine
A diagnostic routine designed to check or demonstrate the operation of a program; its output usually includes some or all of the instructions in the program being checked and the immediate results of those instructions, arranged in the sequence in which the instructions are executed.

track
That part of a data storage medium that is influenced by (or influences) one head; e.g., the ring-shaped portion of the surface of a drum associated with one nonmovable head, or one of several divisions (most commonly 7 or 9) running parallel to the edges of a magnetic tape.

track parity check
Same as longitudinal parity check.

trailer record
A record that follows another record or group of records and contains pertinent data related to that record or group of records.

transaction code
One or more characters that form part of a record and signify the type of transaction represented by the record (e.g., in inventory control, the types of transactions would include deliveries to stock, disbursements from stock, orders, etc.)

transaction file
Same as detail file.

transcribe
To convert data from one medium to another without altering its information content; i.e., to perform a data transcription operation.

transfer
See conditional transfer, unconditional transfer, data transfer.

transfer load size
The quantity of data that can be transferred in a single read or write operation.

transfer time
The time required to effect the actual movement of data from source to destination in a data transfer operation. See also access time.

transistor
An electronic device that uses semiconductor properties to control the flow of currents.

translate
(1) To transform statements from one language (the source language) to another (the object language) without significantly changing the meaning or information content, as in an assembler or compiler.
(2) To convert data from one code to another.

translator
A device or computer program that performs translations from one language or code to another; e.g., an assembler or compiler.

transliterate
To convert the characters of one character set to the corresponding characters of another character set with which they are, for the most part, in one-to-one correspondence.

transmit
To send data from one device or location to another.

(Contd.)

trap
An unprogrammed jump to a preset location, activated automatically upon the occurrence of a particular condition (e.g., upon an attempt to execute an instruction that is not in the computer's instruction repertoire). The location from which the jump occurred is recorded, so that normal execution of the program can be resumed after the condition that activated the trap has been dealt with.

troubleshoot
Same as debug.

truncate
To omit terms of an expression, digits of a numeral, or symbols of a string after a certain point. For example, the numeral 123.45678, truncated to five digits, would become 123.45. See also round off.

trunk
Same as bus.

Turing machine
A mathematical model of a device that can change its internal state and can read from, write on, and move a potentially infinite tape, all in accordance with its present state, thereby constituting a model for computer-like behavior.

turnaround time
The time required to reverse the direction of transmission in a half-duplex communications channel.

two-address
Pertaining to an address format in which each instruction contains two address parts, both of which normally specify the locations of operands. Contrast with one-plus-one.

two-out-of-five code
A code in which each decimal digit is represented by a group of five bits of which two are ones and three are zeros (or vice versa).

type font
See font.

U

unconditional transfer
An instruction that always causes a jump (i.e., a departure from the normal sequence of executing instructions). Contrast with conditional transfer.

underflow
In an arithmetic operation (especially of the floating-point type), the generation of a nonzero result that is smaller than the smallest nonzero quantity that can be represented in the register or storage location which is to receive the result.

underpunch
A punch in one of the nine lower rows (rows 1 through 9) of an 80-column, 12-row punched card. Contrast with zone punch.

unit record
(1) A record that is similar in form and content to other records but is physically separate; e.g., a record on a punched card. (2) Pertaining to equipment or techniques for dealing with unit records as described in (1), especially to punched card equipment.

unpack
To separate short units of data that have previously been packed; i.e., to reverse a packing operation.

update
To incorporate into a master file the changes required to reflect recent transactions or other events.

uptime
The period of time during which a computer or other equipment is available for productive use, in that it has the power turned on, is not undergoing maintenance work, and is known or believed to be operating correctly. Synonymous with available time. Contrast with downtime.

user
A person, department, or organization that utilizes the facilities of a data processing system, either directly (in an open shop) or in connection with the services of a staff of data processing specialists.

utility routine
A standard routine used to assist in the operation of a computer by performing some frequently-required process such as sorting, merging, report program generation, data transcription, file maintenance, etc. Synonymous with service routine. Note: Utility routines are important components of the software supplied by the manufacturers of most computers.

V

validity check
(1) In hardware, a check that determines whether or not a particular character is a legitimate member of the permissible character set. (2) In programming, a check that determines whether or not the value of a particular data item falls within the permissible limits (e.g., a man cannot work 800 hours in a month, and no month can have a day 32).

variable
A quantity that can assume any of a given set of values. Contrast with constant.

variable address
An address that is subject to alteration through some form of address modification.

variable-length record
A record that may contain a variable number of characters. Contrast with fixed-length record. Note: In many cases where the equipment would permit the use of variable-length records, the records are nonetheless held to a fixed length to facilitate both programming and processing.

variable word-length
Pertaining to a machine word or operand that may consist of a variable number of bits or characters. Contrast with fixed word-length. Note: Many business-oriented computers are of the variable word-length type for efficient processing of items and records of varying sizes.

verifier
A machine used to verify the accuracy of a data transcription operation. Note: The most commonly used type of verifier checks the accuracy of keypunch operations through manual rekeying of the same data and comparison with the data punched in the cards.

verify
To determine whether a data transcription or data transfer operation has been accomplished accurately.

virtual address
An address in a machine instruction that refers to a particular page which may be located in any region of the computer's working storage; thus, every time the instruction is executed, the virtual address must be translated to the proper absolute address, usually through the use of an associative memory and/or a page directory. Note: Virtual addresses are used in many time-sharing computer systems.

virtual storage
Storage that can be directly addressed by the machine instructions of a computer, but which may not actually be installed in a particular configuration; i. e., the storage that can be addressed by virtual addresses.

vocabulary
The total set of words available for use in a language or in a device such as a voice response unit.

voice response unit
A device that accepts digitally-coded input (usually from a computer) and converts it into machine-generated human-voice messages which can be transmitted over telephone lines. Usually the human-voice messages are replies to digital inquires entered via pushbutton telephones. Synonymous with audio response unit.

volatile storage
A storage device whose contents may be lost or altered when its power supply is switched off or otherwise disconnected. Note: There are different degrees of storage volatility. In some stores, the data will not be lost if the power is turned off in the normal way, but may be lost if there is a power failure.

W

waiting time
The time interval between the instant when a computer or control unit calls for a transfer of data to or from a storage device and the instant when the actual movement of data can begin; e. g., the time required to reposition moveable read/write heads, to transport a magnetic card to a read/write station, and/or to wait for a specific item on a drum to pass under a read/write head. Synonymous with latency. See also access time.

word
A group of bits or characters treated as a unit and capable of being stored in one storage cell. Note: Within a word, each location that may be occupied by a bit or character is called a "position."

word length
The number of bits or characters in a word.

word mark
A symbol (e. g., a special character or a single bit) used in some variable word-length computers to indicate the beginning or end of a word or item.

word time
The time interval between the appearance or occurrence of corresponding parts of successive words, especially in storage devices that provide serial access to the stored data.

working storage
The storage locations in a computer that can be accessed directly for instructions and/or operands used in arithmetic and logical operations; thus, those locations that can be designated by the addresses in arithmetic and logical instructions. Synonymous with main storage. Contrast with auxiliary storage.

write
To record data in a store or medium. See also output.

X

X-punch
A punch in the X row (or 11 row) of an 80-column punched card, often used to indicate a negative number or for control or selection purposes.

xerography
A copying or printing process that involves the photoelectric discharge of an electrostatically-charged plate.

XY plotter
A device that plots coordinate points (i. e., the relationships between two variables) by means of an automatically controlled pen or pencil or by a non-impact printing technique. Note: The input data to an XY plotter may come from a directly-connected computer or from punched cards, magnetic tape, etc., prepared by a computer.

Y

Y-punch
A punch in the Y row (or 12 row) of an 80-column punched card, often used to indicate a positive number or for control or selection purposes.

yoke
Several stacks of heads which are rigidly connected to one another and move in unison whenever one of the stacks is to read or record data in a particular band of a storage device.

Z

zero compression
A technique for reducing the number of locations required to hold a record by eliminating the storage of nonsignificant zeros.

zero suppression
The suppression (i. e., elimination) of nonsignificant zeros in a numeral, usually before or during a printing operation. For example, the numeral 0006304, with zero suppression, would be printed as 6304.

zone bit
(1) One of the two leftmost bits in a widely-used code that uses six bits to represent each character. (2) A bit in one of a group of bit positions used to indicate a specific class of items; e. g., digits, letters, special characters.

zone punch
A punch in one of the three upper rows (row 0, X, or Y) of an 80-column, 12-row punched card. Contrast with underpunch.

COMPARISON CHARTS

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COMPARISON CHARTS

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QUICK REFERENCE INDEX TO ALL THE COMPARISON CHARTS

The following table will guide you quickly to the exact pages on which you will find all the entries describing the characteristics of any of the computer systems currently included in the AUERBACH Computer Notebook International Comparison Charts. Note that the Configuration Rentals given for the U. S. A. systems are on Pages 11:010.102 and 11:010.103, and that the standard software provided with each of the U. S. A. systems is on Pages 11:300.102 and 11:300.103.

System Identity	Central Processor and Working Storage	Auxiliary Storage and Magnetic Tape	Punched Card and Punched Tape Input-Output	Printers and Specialized Input-Output Equipment	System Performance Comparisons
U. S. A.					
Burroughs B 100/200/300	11:210.104	11:220.104	11:230.102	11:240.102	11:400.104
Burroughs B 2500/3500	11:210.105	11:220.105	11:230.102	11:240.103	11:400.104
Burroughs B 5500	11:210.105	11:220.105	11:230.102	11:240.103	11:400.104
Burroughs B 6500/7500	11:210.106	11:220.106	11:230.103	11:240.103	—
CDC 160 & 160-A	11:210.107	11:220.107	11:230.103	11:240.104	—
CDC 1604 & 1604-A	11:210.107	11:220.107	11:230.104	11:240.104	—
CDC 3000 Series	11:210.108	11:220.108	11:230.104	11:240.104	11:400.104
CDC 6000 Series	11:210.110	11:220.109	11:230.105	11:240.105	11:400.104
GE-115	11:210.111	11:220.110	11:230.105	11:240.106	—
GE-130	11:210.111	11:220.110	11:230.105	11:240.106	—
GE-200 Series	11:210.112	11:220.111	11:230.106	11:240.107	11:400.104
GE-400 Series	11:210.113	11:220.111	11:230.106	11:240.107	11:400.104
GE-600 Series	11:210.114	11:220.112	11:230.106	11:240.108	11:400.106
Honeywell Series 200	11:210.115	11:220.113	11:230.107	11:240.108	11:400.106
Honeywell 400/1400	11:210.117	11:220.114	11:230.108	11:240.109	11:400.106
Honeywell 800/1800	11:210.117	11:220.114	11:230.108	11:240.109	11:400.106
IBM 360, Models 25-85	11:210.118	11:220.115	11:230.109	11:240.110	11:400.108
IBM 360, Model 20	11:210.118	11:220.116	11:230.109	11:240.110	11:400.108
IBM 360, Model 44	11:210.119	11:220.115	11:230.110	11:240.111	11:400.108
IBM 360, Model 67	11:210.119	11:220.115	11:230.109	11:240.110	—
IBM 1400 Series	11:210.120	11:220.117	11:230.111	11:240.112	11:400.108
IBM 1620	11:210.121	11:220.118	11:230.112	11:240.114	—
IBM 7010	11:210.122	11:220.118	11:230.113	11:240.114	11:400.110
IBM 7040/7044	11:210.122	11:220.118	11:230.113	11:240.114	11:400.110
IBM 7070/7072/7074	11:210.123	11:220.119	11:230.113	11:240.115	11:400.110
IBM 7080	11:210.124	11:220.119	11:230.114	11:240.115	11:400.110
IBM 7090/7094	11:210.124	11:220.119	11:230.114	11:240.115	11:400.110
NCR Century Series	11:210.125	11:220.120	11:230.114	11:240.116	—
NCR 315 Series	11:210.126	11:220.120	11:230.115	11:240.116	11:400.110
RCA Spectra 70	11:210.127	11:220.121	11:230.116	11:240.117	11:400.110
RCA 301/3301	11:210.128	11:220.122	11:230.116	11:240.117	11:400.112
UNIVAC III	11:210.129	11:220.122	11:230.117	11:240.118	11:400.112
UNIVAC SS 80/90	11:210.129	11:220.123	11:230.117	11:240.118	—
UNIVAC 418	11:210.129	11:220.124	11:230.117	11:240.119	11:400.112
UNIVAC 490 Series	11:210.130	11:220.125	11:230.118	11:240.119	11:400.112
UNIVAC 1004	11:210.131	11:220.126	11:230.118	11:240.120	11:400.112
UNIVAC 1050	11:210.131	11:220.126	11:230.119	11:240.120	11:400.112
UNIVAC 1107	11:210.131	11:220.126	11:230.119	11:240.120	—
UNIVAC 1108	11:210.132	11:220.127	11:230.119	11:240.121	11:400.112
UNIVAC 9200/9300	11:210.132	11:220.128	11:230.120	11:240.121	11:400.112
UNIVAC 9400	11:210.132	11:220.128	11:230.120	11:240.121	—
France					
Bull-GE Gamma 10	11:510.102	11:520.102	11:530.102	11:540.102	—
General Electric GE-55	11:510.103	11:520.102	11:530.102	11:540.102	—
Japan					
Hitachi HITAC 3010	11:510.104	11:520.104	11:530.104	—	—
Hitachi HITAC 8000 Series	11:510.103	11:520.103	11:530.103	11:540.103	—
Nippon NEAC-Series 2200	11:510.105	11:520.105	11:530.104	11:540.104	—
Netherlands					
Philips P1000 Series	11:510.102	11:520.102	11:530.102	11:540.105	—
United Kingdom					
ICL System 4	11:510.107	11:520.107	11:530.106	11:540.105	—
ICL 1900 Series	11:510.108	11:520.109	11:530.107	11:540.106	—

CONFIGURATION RENTALS COMPARISON CHARTS

INTRODUCTION

The charts on the following pages show the single-shift monthly rental prices for nearly 100 U. S. -manufactured digital computer systems arranged in various standardized equipment configurations. These charts, organized in alphabetical order by manufacturer, enable you to make direct, meaningful comparisons of the costs of competitive systems with similar capabilities. Furthermore, the standard equipment configurations form a meaningful basis for accurate comparisons of the overall performance of computer systems, as presented in the System Performance Comparison Charts.

Table I summarizes the nominal specifications for each of the 13 standard equipment configurations. Each configuration is identified by a Roman numeral and a brief title that describes its size and orientation.

TABLE I: THE STANDARD EQUIPMENT CONFIGURATIONS

CONFIGURATION NAMES / NOMINAL SPECIFICATIONS	Card System	4-Tape Business System	6-Tape Business System	5-Million-Byte Random Access System	12-Tape Business System	20-Million-Byte Random Access System	6-Tape Auxiliary Storage System	6-Tape Business/ Scientific System	10-Tape General-Purpose System — Integrated	10-Tape General-Purpose System — Paired		20-Tape General-Purpose System — Integrated	20-Tape General-Purpose System — Paired		100-Million-Byte Random Access System
	I	II	III	IIIR	IV	IVR	V	VI	VIIA	VIIB		VIIIA	VIIIB		VIIIR
										Main	Sat. (1)		Main	Sat. (1)	
WORKING (CORE) STORAGE															
One-address instructions (or equivalent) plus	1,000	1,000	2,000	2,000	4,000	4,000	2,000	8,000	12,000	8,000	500	24,000	16,000	1,000	24,000
Characters (or bytes) of data	4,000	4,000	8,000	8,000	16,000	16,000	8,000	32,000	48,000	32,000	2,000	96,000	64,000	4,000	96,000
RANDOM ACCESS STORAGE															
Millions of characters	0	0	0	5	0	20	20	0	0	0	0	0	0	0	100
MAGNETIC TAPE															
Simultaneous transfers while computing	--	0	1	1	2	2	1	1	2	2	0	5	4	1	4
Units	0	4	6	0 or 1*	12	4	6	6	10	8	2	20	16	4	4
Nominal speed, char/sec.	--	15,000	30,000	30,000	60,000	60,000	30,000	30,000	60,000	60,000	30,000	120,000	120,000	60,000	120,000
PRINTER															
Nominal speed, lines/min.	1,000	500	500	500	1,000	1,000	500	500	500	--	500	1,000	--	1,000	1,000
CARD READER															
Nominal speed, cards/min.	1,000	500	500	500	1,000	1,000	500	500	500	100	500	1,000	100	1,000	1,000
CARD PUNCH															
Nominal speed, cards/min.	200	100	100	100	200	200	100	100	100	--	100	200	--	200	200
OTHER FEATURES															
Simultaneous transfers (other than magnetic tape)	1	0	1	1	2	2	1	1	2	0	0	3	0	2	4
Floating-point arithmetic	No	No	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Index registers	1	No	3	1	10	10	3	3	6	6	0	10	10	3	10
Console typewriter	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes

*No tape unit is required if the random access storage uses interchangeable cartridges (e.g., Disk Packs).
(1)"Satellite" computer equipped to perform card-to-tape and tape-to-printer data transcriptions.

The storage capacities and input-output speeds specified in Table I are nominal ones. They have been carefully chosen to result in balanced equipment configurations that will perform effectively in applications of the types indicated by their titles. In general, the equipment available for use in a particular computer system will not exactly match our nominal specifications. Therefore, in evaluating the price and performance of a particular computer arranged in a particular standard configuration, our analysts select, from among the available storage capacities and peripheral devices, those whose characteristics most closely conform to the nominal specifications in Table I. (For example, if a manufacturer offered three card reader models, rated at 200, 600, and 1200 cards per minute, the 600-card-per-minute model would be chosen for Configuration III, which calls for a nominal card reader speed of 500 cards per minute.)

As you can see, the 13 standard configurations cover a wide range of storage capacities, input-output facilities, and computational features. It would be unrealistic, and often impossible, to evaluate the rental prices of every computer system in all of these configurations. Instead each, system is evaluated in those configurations (usually from three to six) that represent the sizes and types of applications for which it is best suited.

As Table I indicates, large-scale Configurations VII and VIII may be arranged in either an "Integrated" version (VIIA or VIIIA), which includes on-line card reading and printing equipment, or in a "Paired" version (VIIB or VIIIB), in which the magnetic tape-oriented main computer is supported by a small "satellite" computer equipped to perform card-to-tape and tape-to-printer data transcriptions.

Standard Configurations IIIR, IVR, and VIIIR are equipped with varying amounts of on-line random access storage (disc files, drums, etc.). Thus, they are oriented toward real-time applications in which large files must be stored on-line so that their contents are readily accessible at all times. Where there are two or more random access devices that could satisfy the specified capacity requirements, our choice is based upon considerations of economy, system throughput, software support, and reliability. Therefore, disc files will normally be chosen in preference to drums (which are relatively expensive) or magnetic strip devices (which tend to be relatively slow and of lower reliability).

You'll find the Configuration Rental charts particularly useful when you need to know which computers fall into a particular price range. All of the prices in any one column are the rental prices of systems which include — as nearly as possible — the same storage capacity, input-output facilities, and optional features. Keep in mind, however, that comparisons based solely on considerations of configuration and cost overlook the vital matter of <u>performance</u> — and the overall performance of similarly-priced computer systems can vary significantly, as shown in the System Performance Comparison Charts.

CONFIGURATION RENTALS, DOLLARS PER MONTH

System Identity	Card System I	4-Tape Business System II	6-Tape Business System III	5-Mega-Byte Random Access System IIIR	12-Tape Business System IV	20 Mega-Byte Random Access System IVR	6-Tape Business/ Scientific System V	6-Tape Auxiliary Storage System VI	10-Tape General Purpose System—Integrated VIIA	10-Tape General Purpose System—Paired VIIB	20-Tape General Purpose System—Integrated VIIIA	20-Tape General Purpose System—Integrated VIIIB	100 Mega-Byte Random Access System VIIIR
Burroughs B 100	2,510	4,590	–	–	–	–	–	–	–	–	–	–	–
Burroughs B 200	4,525	5,895	8,840	–	–	–	12,260	–	–	–	–	–	–
Burroughs B 300	–	–	10,070	–	–	–	–	–	–	–	–	–	–
Burroughs B 2500	–	4,910	6,415	–	–	10,130	–	–	–	–	–	–	–
Burroughs B 3500	–	–	–	–	–	11,630	–	–	15,480	–	–	–	19,680
Burroughs B 5500	–	–	23,340	–	–	–	25,250	–	30,995	28,705	–	–	–
Burroughs B 6500	–	–	–	–	–	23,410	–	–	29,960	–	–	–	–
Burroughs B 7500	–	–	–	–	–	–	–	–	–	–	–	–	46,910
CDC 3100	–	–	–	9,390	–	14,250	–	14,610	20,375	–	–	–	–
CDC 3300	–	–	–	–	–	15,980	–	16,240	22,025	–	–	–	–
CDC 3400	–	–	–	–	–	32,520	–	16,640	22,110	23,511	–	39,045	–
CDC 3600	–	–	–	–	–	48,400	–	33,800	40,118	40,671	–	57,045	–
CDC 3800	–	–	–	–	–	53,180	–	35,840	42,190	42,711	–	59,125	–
CDC 6400/6500	–	–	–	–	–	–	33,895	40,225	42,100	–	54,540	–	–
CDC 6600	–	–	–	–	–	–	–	–	64,100	–	76,625	–	–
CDC 6800	–	–	–	–	–	–	–	–	57,740	–	70,885	–	–
GE-115	2,615	3,760	4,400	3,795	–	8,655	–	–	–	–	–	–	–
GE-130	3,630	–	5,595	–	–	–	7,660	–	–	–	–	–	–
GE-215	4,905	6,250	7,375	–	–	–	10,205	8,325	–	–	–	–	–
GE-225	5,085	6,450	9,155	–	15,620	–	11,985	11,825	–	–	–	–	–
GE-235	–	–	11,870	–	18,385	–	14,700	15,120	–	–	–	–	–
GE-405	4,800	5,760	7,920	–	13,615	–	–	–	–	–	–	–	–
GE-415	5,135	6,955	8,255	–	13,950	–	10,955	–	15,245	–	–	–	–
GE-425	6,120	7,940	9,240	–	14,035	–	11,550	–	16,545	–	–	–	–
GE-435	–	–	13,400	–	19,095	–	15,710	–	19,975	–	–	–	–
GE-625	–	–	–	–	–	–	–	–	39,505	–	54,275	–	–
GE-635	–	–	–	–	–	–	–	–	40,630	–	55,400	–	–
Honeywell 110	2,405	2,855	–	4,520	–	–	–	–	–	–	–	–	–
Honeywell 120	3,835	3,465	6,180	5,070	–	–	–	–	–	–	–	–	–
Honeywell 125	–	4,075	–	5,240	–	–	–	–	–	–	–	–	–
Honeywell 200	4,185	4,995	7,415	6,285	14,640	–	–	–	–	–	–	–	–
Honeywell 1200	5,060	5,870	7,875	7,665	14,945	11,765	–	10,985	16,195	15,805	–	–	–
Honeywell 1250	–	–	–	–	–	11,995	–	–	–	–	–	–	–
Honeywell 2200	–	–	8,935	–	16,095	13,425	–	–	18,330	17,685	–	–	–
Honeywell 4200	–	–	–	–	25,805	21,995	–	–	23,345	24,170	–	36,425	28,225
Honeywell 8200	–	–	–	–	–	–	–	–	39,120	–	51,360	–	40,670
Honeywell 400	–	7,695	9,815	–	–	–	12,305	11,015	–	–	–	–	–
Honeywell 1400	–	10,750	12,290	–	20,980	–	–	14,530	–	–	–	–	–
Honeywell 800	–	–	–	–	–	–	23,329	19,329	35,679	27,975	53,600	46,325	–
Honeywell 1800	–	–	–	–	–	–	–	27,150	36,650	34,725	54,950	53,575	–
IBM 360, Model 20	2,776	3,558	–	3,630	–	8,078	–	–	–	–	–	–	–
IBM 360, Model 25	3,555	4,945	6,445	5,280	–	9,635	–	–	–	–	–	–	–
IBM 360, Model 30	4,097	4,714	6,956	6,111	–	11,656	–	–	–	–	–	–	–

CONFIGURATION RENTALS, DOLLARS PER MONTH (Cont'd)

System Identity	Card System	4-Tape Business System	6-Tape Business System	5-Mega-Byte Random Access System	12-Tape Business System	20 Mega-Byte Random Access System	6-Tape Business/ Scientific System	6-Tape Auxiliary Storage System	10-Tape General Purpose System—Integrated	10-Tape General Purpose System—Paired	20-Tape General Purpose System—Integrated	20-Tape General Purpose System—Integrated	100 Mega-Byte Random Access System
	I	II	III	IIIR	IV	IVR	V	VI	VIIA	VIIB	VIIIA	VIIIB	VIIIR
IBM 360, Model 40	–	7,221	8,208	7,343	–	13,032	–	11,601	-	–	–	–	–
IBM 360, Model 44	–	–	–	–	–	–	11,723	10,802	14,531	–	–	–	–
IBM 360, Model 50	–	–	15,400	–	21,564	18,399	–	–	19,720	21,837	–	–	26,773
IBM 360, Model 65	–	–	–	–	–	–	–	–	34,585	35,187	–	51,944	43,388
IBM 360, Model 75	–	–	–	–	–	–	–	–	47,298	47,900	–	64,657	56,101
IBM 360, Model 85	–	–	–	–	–	–	–	–	–	–	–	92,177	87,736
IBM 1401	4,320	5,920	10,810	–	11,485	–	13,310	–	–	–	–	–	–
IBM 1401-H	1,335	–	–	–	–	–	–	–	–	–	–	–	–
IBM 1410	6,115	8,415	12,240	–	19,060	–	15,365	15,790	–	23,560	–	–	–
IBM 1440	3,295	4,050	5,920	–	–	–	7,970	–	–	–	–	–	–
IBM 1460	–	–	11,735	–	–	–	13,975	–	–	–	–		–
IBM 7010	–	–	19,175	–	27,225	–	22,220	22,175	–	28,355	–		–
IBM 7740	–	–	–	–	–	–	–	20,715	27,190	–	–	47,145	–
IBM 7044	–	–	–	–	–	–	–	–	36,690	–	–	56,645	–
IBM 7070	–	–	19,400	–	–	–	24,785	23,450	–	29,755	–	45,030	–
IBM 7072	–	–	–	–	–	–	–	–	–	32,915	–	49,890	–
IBM 7074	–	–	24,700	–	–	–	29,860	34,175	–	40,465	–	72,840	–
IBM 7080	–	–	–	–	–	–	–	–	–	51,745	–	79,325	–
IBM 7090	–	–	–	–	–	–	64,060	–	–	66,770	–	89,215	–
IBM 7094-I	–	–	–	–	–	–	69,960	–	–	72,395	–	95,065	–
NCR 315	5,450	4,775	7,695	–	19,040	12,445	9,795	–	–	–	–	–	–
NCR 315-100	4,750	3,975	–	–	19,140	–	–	–	–	–	–	–	–
NCR 315 RMC	–	–	9,970	–	19,140	13,820	12,995	–	–	–	–	–	–
NCR Century 100	–	4,300	–	2,700	–	–	–	–	–	–	–	–	–
NCR Century 200	–	–	–	4,350	–	7,750	–	–	–	–	–	–	–
RCA 301	4,271	5,084	9,687	–	20,290	–	12,777	12,880	–	–	–	–	–
RCA 3301	–	–	11,390	–	18,940	–	14,865	14,265	21,265	21,604	–	–	–
RCA Spectra 70/15	3,470	4,815	–	–	–	–	–	–	–	–	–	–	–
RCA Spectra 70/25	–	5,990	6,610	–	12,585	–	–	–	–	–	–	–	–
RCA Spectra 70/35	5,420	6,896	7,616	8,336	–	10,791	–	9,286	13,022	–	–	–	–
RCA Spectra 70/45	–	–	8,712	9,351	14,402	12,421	–	10,567	14,156	16,142	–		–
RCA Spectra 70/55	–	–	13,845	15,569	18,915	17,425	–	13,850	17,345	19,425	–	33,975	–
UNIVAC III	–	–	19,000	–	20,400	–	–	–	25,000	–	–	38,730	–
UNIVAC 418	–	–	7,125	–	–	–	11,425	–	17,875	–	–	–	–
UNIVAC 490	–	–	19,780	–	–	–	25,830	–	31,270	–	48,120	–	–
UNIVAC 491/492	–	–	14,290	–	–	–	19,620	–	25,085	–	43,755	–	–
UNIVAC 494	–	–	32,270	–	–	–	37,600	–	39,405	–	49,555	–	–
UNIVAC 1004	1,800	2,725	–	–	–	–	–	–	–	–		–	–
UNIVAC 1050	3,470	5,030	6,600	–	18,720	–	12,500	–	–	–	47,165	–	–
UNIVAC 1107	1,800	2,725	–	–	–	–	–	–	–	–	41,915	–	–
UNIVAC 1108	–	–	–	–	–	50,805	–	–	50,365	–	65,075	–	53,990
UNIVAC 9200	1,290	–	–	–	–	–	–	–	–	–	–	–	–
UNIVAC 9300	1,740	3,610	4,545	–	7,810	–	–	–	–	–	–	–	–
UNIVAC 9400	–	5,880	6,705	6,295	11,550	10,520	–	–	–	–	–	–	–

HARDWARE CHARACTERISTICS COMPARISON CHARTS CENTRAL PROCESSORS AND WORKING STORAGE

INTRODUCTION

The Hardware Characteristics Comparison Charts list the important characteristics of the central processor, storage units, and peripheral devices for nearly 100 digital computer systems. The systems are arranged in alphabetical order by manufacturer, and all entries are presented in a standardized format that permits quick, meaningful comparisons.

Because of the physical limitations upon the amount of information a printed page can hold, the Hardware Characteristics charts are divided into four subsections containing the specifications for the following classes of equipment:

- Central Processors and Working Storage: word length, arithmetic speeds, processing facilities, I/O channels, core storage capacity, cycle time, and other characteristics.
- Auxiliary Storage and Magnetic Tape: disc, drum, or magnetic strip storage capacities and access times, maximum number of tape units, tape speeds, and other characteristics.
- Punched Card and Punched Tape Input-Output: speeds, error checks, and other relevant characteristics.
- Printers and Specialized Input-Output Equipment: specifications of the available line printers, optical readers, MICR readers, data communications controllers, display units, plotters, and other input-output devices.

The Quick Reference Index will guide you directly to all the entries pertaining to a particular computer system.

The charts on the following pages deal specifically with the data structure, central processor, and working (main) storage unit for each computer system. Explanations of the entries on these charts follow.

DATA STRUCTURE

Word Length	Size of each computer word, expressed in terms of the number of binary bits, decimal digits, and/or alphanumeric characters it can accommodate. (For variable-word-length computers, the number of bits, digits, and characters comprising each byte or position are indicated.)
Floating-Point Representation	Radix (binary or decimal) and the number of bits or digits used to represent both the fractional part and the exponent (or mantissa) of a floating-point number. (Blanks indicate that there is no standard mode for representing floating-point numbers.)

CENTRAL PROCESSOR

Model Number	Manufacturer's identifying number for this processor.
Arithmetic Radix	Number system (usually binary or decimal) employed for arithmetic computations.
Operand Length, Words	Number of words comprising each fixed-point arithmetic operand, expressed in terms of the word length specified under "DATA STRUCTURE."

Instruction Length, Words	Number of words comprising each instruction.
Addresses per Instruction	Number of operand locations or other addresses specified in each instruction.
Likely Fixed-Point Execution Times, μsec	Number of microseconds normally required to perform addition (c = a + b), multiplication (c = ab), and division (c = a/b) tasks upon fixed-point operands at least five decimal digits (or an equivalent number of bits) in length. All listed execution times include the time required to access both operands from working storage and store the result in working storage. This ensures valid comparisons between computers with one-address, two-address, and three-address instruction formats.
Likely Floating-Point Execution Times, μsec	Number of microseconds normally required to perform addition (c = a + b), multiplication (c = ab), and division (c = a/b) tasks upon operands expressed in the standard floating-point representation listed under "DATA STRUCTURE." All listed execution times include the time required to access both operands from working storage and store the result in working storage.
Checking of Data Transfers	Type of checking, if any, that is performed to help ensure the accuracy of data transferred to or from the central processor.
Program Interrupt Facility	Availability of a hardware facility that can be used to initiate the execution of a new sequence of instructions upon the occurrence of a specific signal or condition, such as completion of an I/O operation.
Number of Index Registers	Number of special registers, if any, whose contents can be added to the address portion of an instruction prior to or during its execution. Indexing and indirect addressing (next entry) are the principal techniques used for address modification, which can greatly simplify programming.
Indirect Addressing	Availability and number of levels of indirect addressing. An indirect address is an address that specifies a storage location that contains either a direct address (i.e., the address of an operand) or another indirect address.
Special Editing Capabilities	Specialized processing facilities, such as an Edit instruction, that facilitate the coding of operations that modify the format of data fields. Answers range from "None", for computers with no special editing facilities, to "Excellent", for computers that can handle character insertions, zero suppression, and floating dollar signs by means of a single instruction.

Boolean Operations	Availability of instructions to perform any or all of the following Boolean or logical operations upon single bits: AND, INClusive OR, EXClusive OR.
Table Look-Up	Availability of specialized instructions to facilitate the coding of procedures that use a known value to locate an associated unknown value in a table.
Console Typewriter	Availability (standard or optional) of an on-line typewriter for communications between the console operator and the computer system.
Input-Output Channels	Number and type of channels available to transmit data between the computer and its peripheral equipment. In most cases a given channel can transmit data to or from only one peripheral device at a time. Some computers, however, have multiplexor channels, each of which can service a number of simultaneously operating devices.
Features and Comments	Noteworthy additional features or facilities, compatibility relationships, or amplification of one or more of the preceding entries.

WORKING STORAGE

Model Number	Manufacturer's identifying number.
Type of Storage	Storage medium used in this unit; usually ferrite cores, but occasionally thin-film or magnetic drum.
Number of Words	Minimum and maximum working storage capacity, expressed in terms of the word length specified under "DATA STRUCTURE."
Maximum Total Storage	Maximum working storage capacity, expressed in terms of both decimal digits and alphanumeric characters.
Cycle Time, μsec	Minimum time interval, in microseconds, between the starts of two successive accesses to a particular storage location.
Effective Transfer Rate, char/sec	The average rate, expressed in alphanumeric characters per second, at which large blocks of data can be transferred from one area of working storage to another.
Checking	Type of checking, if any, that is performed to help ensure the accuracy of data transferred to or from working storage.
Storage Protection	Facilities for prevention, under program control, of unauthorized writing in and/or reading from specified areas of working storage.
Features and Comments	Noteworthy additional features or facilities.

System Identity			Burroughs B 100/200 Series 10-μsec Processor	Burroughs B 200/300 Series 6-μsec Processor	
DATA STRUCTURE	Word Length	Binary Bits	6 + parity	6 + parity	
		Decimal Digits	1	1	
		Characters	1	1	
	Floating Point Representation	Radix	---	---	
		Fraction Size	---	---	
		Exponent Size	---	---	
CENTRAL PROCESSOR	Model Number		B 160, B 170, B 180, B 250, B 251, B 260, B 270, B 280	B263, B 273, B 275, B 283, B 300	
	Arithmetic Radix		Decimal	Decimal	
	Operand Length, Words		1 to 12 char	1 to 12 char	
	Instruction Length, Words		12 char	12 char	
	Addresses per Instruction		3	3	
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	690	414	
		c = ab	6, 270	3, 762	
		c = a/b	14, 630	8, 802	
	Likely Floating Point Execution Times, μsec	c = a + b	---	---	
		c = ab	---	---	
		c = a/b	---	---	
	Checking of Data Transfers		Parity	Parity	
	Program Interrupt Facility		None	None	
	Number of Index Registers		None	None	
	Indirect Addressing		None	None	
	Special Editing Capabilities		Good	Good	
	Boolean Operations		None	None	
	Table Look-up		None	None	
	Console Typewriter		None	Optional	
	Input-Output Channels		1 integrated non-simultaneous channel	1 integrated non-simultaneous channel	
	Features and Comments		Most input-output units are buffered	Most input-output units are buffered	
WORKING STORAGE	Model Number		B 160, B 170, B 180, B 250, B 251, B 260, B 270, B 280	B 263, B 273 B 275, or B 283	B 300
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	4, 800	4, 800	4, 800
		Maximum	4, 800	19, 200	19, 200
	Maximum Total Storage	Decimal Digits	4, 800	19, 200	28, 800
		Characters	4, 800	19, 200	19, 200
	Cycle Time, μsec		10	6	6
	Effective Transfer Rate, char/sec		48,000	80, 000	80, 000
	Checking		Parity	Parity	Parity
	Storage Protection		None	None	
	Features and Comments			B 300 uses optional Data Compress Instruction to pack decimal digits	

* With optional equipment.
(s) Using subroutine.

Burroughs B 2500 & B 3500		Burroughs B 5500		System Identity		
16 + parity	16 + parity	48 + parity		Binary Bits	Word Length	DATA STRUCTURE
4	4	14		Decimal Digits	Word Length	DATA STRUCTURE
2	2	8		Characters	Word Length	DATA STRUCTURE
Decimal	Decimal	Binary		Radix	Floating Point Representation	DATA STRUCTURE
1 to 100 digits	1 to 100 digits	39 bits + sign		Fraction Size	Floating Point Representation	DATA STRUCTURE
2 digits + sign	2 digits + sign	6 bits + sign		Exponent Size	Floating Point Representation	DATA STRUCTURE
B 2501	B 3501	B 5281		Model Number		CENTRAL PROCESSOR
Decimal	Decimal	Binary, decimal		Arithmetic Radix		CENTRAL PROCESSOR
1 to 100 digits or bytes	1 to 100 digits or bytes	1 or 2 words, or 1 to 63 char		Operand Length, Words		CENTRAL PROCESSOR
6 to 24 digits	6 to 24 digits	1/4		Instruction Length, Words		CENTRAL PROCESSOR
0, 1, 2, or 3	0, 1, 2, or 3	1 or 0		Addresses per Instruction		CENTRAL PROCESSOR
75	37.5	17		c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
416	208	44		c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
1, 810	905	76		c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
102*	51*	17		c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
462*	231*	44		c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
1, 860*	930*	76		c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity	Parity	Parity		Checking of Data Transfers		CENTRAL PROCESSOR
Yes, for many conditions	Yes, for many conditions	Yes, with priority scheme		Program Interrupt Facility		CENTRAL PROCESSOR
3 per program	3 per program	3 (non-conventional)		Number of Index Registers		CENTRAL PROCESSOR
Yes, recursive	Yes, recursive	One level		Indirect Addressing		CENTRAL PROCESSOR
Good	Good	Good		Special Editing Capabilities		CENTRAL PROCESSOR
AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR		Boolean Operations		CENTRAL PROCESSOR
Yes, Scan Instruction	Yes, Scan instruction	Good		Table Look-up		CENTRAL PROCESSOR
Optional	Optional	Yes		Console Typewriter		CENTRAL PROCESSOR
4 standard (2 low-speed Type A and 2 high-speed Type B); 6 channels max.	6 standard (3 Type A and 3 Type B); 20 maximum (10 A, 10 B)	1 to 4 "floating" among peripheral device control units		Input-Output Channels		CENTRAL PROCESSOR
Type A I/O channels transfer 1 character at a time. Type B I/O channels transfer 2 characters in parallel.		B 5500 is faster, expanded version of original B 5000		Features and Comments		CENTRAL PROCESSOR
200X	300X	B460	B 461	Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		WORKING STORAGE
5, 000	5, 000	4, 096	4, 096	Minimum	Number of Words	WORKING STORAGE
30, 000	250, 000	32, 768	32, 768	Maximum	Number of Words	WORKING STORAGE
120, 000	1, 000, 000	458, 752	458, 752	Decimal Digits	Maximum Total Storage	WORKING STORAGE
60, 000	500, 000	262, 144	262, 144	Characters	Maximum Total Storage	WORKING STORAGE
2	1	6	4	Cycle Time, μsec		WORKING STORAGE
500, 000	1, 000, 000	353, 000	444, 000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Parity	Checking		WORKING STORAGE
Yes, using limit register	Yes, using limit register	Yes, using limit registers		Storage Protection		WORKING STORAGE
Core storage is addressable by 4-bit digit positions; the first 1, 200 digit positions are reserved for use by the processor		Each of up to eight 4, 096-word modules operates independently of the others		Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			Burroughs B 6500 & B 7500		
DATA STRUCTURE	Word Length	Binary Bits	48 + parity + 3 control bits		
		Decimal Digits	12		
		Characters	6 or 8		
	Floating Point Representation	Radix	Binary		
		Fraction Size	39 or 78 bits + sign		
		Exponent Size	6 or 15 bits + sign		
CENTRAL PROCESSOR	Model Number		B 6503, B 6504, B 6506, B 7504, B 7506		
	Arithmetic Radix		Binary		
	Operand Length, Words		1 or 2 words		
	Instruction Length, Words		1 to 18 eight-bit syllables		
	Addresses per Instruction		1 or 0		
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	?		
		c = ab	?		
		c = a/b	?		
	Likely Floating Point Execution Times, μsec	c = a + b	?		
		c = ab	?		
		c = a/b	?		
	Checking of Data Transfers		Parity		
	Program Interrupt Facility		Yes; multi-level		
	Number of Index Registers		3 (non-conventional)		
	Indirect Addressing		One level		
	Special Editing Capabilities		Good		
	Boolean Operations		AND, INC OR, EXC OR		
	Table Look-up		Good		
	Console Typewriter		Yes; also CRT display		
	Input-Output Channels		1 or 2 I/O multiplexors, each with 4 to 10 "floating" I/O channels		
	Features and Comments		1 or 2 processors can be used in a system; instruction times not released to date		
WORKING STORAGE	Model Number		B 6503	B 6504, B 7504,	B 6506, B 7506
	Type of Storage		Core	Core	Thin-film
	Number of Words	Minimum	16,384	16,384	16,384
		Maximum	131,072	524,288	524,288
	Maximum Total Storage	Decimal Digits	1,572,864	6,291,456	6,291,456
		Characters	786,432	3,145,728	3,145,728
	Cycle Time, μsec		1.2	1.2	0.6
	Effective Transfer Rate, char/sec		?		
	Checking		Parity		
	Storage Protection		Yes		
	Features and Comments		16,384-word memory modules are functionally independent		

* With optional equipment.
(s) Using subroutine.

CDC 160	CDC 160-A	CDC 1604 and 1604-A	System Identity		
12	12	48	Binary Bits	Word Length	DATA STRUCTURE
3.3	3.3	14	Decimal Digits		
2	2	8	Characters		
Binary or decimal	Binary or decimal	Binary	Radix	Floating Point Representation	
Varies (s)	Varies (s)	36 bits + sign	Fraction Size		
Varies (s)	Varies (s)	11 bits	Exponent Size		
160	160-A	1604, 1604-A	Model Number		CENTRAL PROCESSOR
Binary	Binary	Binary	Arithmetic Radix		
1	1	1 or 2	Operand Length, Words		
1 or 2	1 or 2	1 or 2	Instruction Length, Words		
1	1	1	Addresses per Instruction		
480 (s) or 145*	480 (s) or 145*	21.6	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
7,700 (s) or 250*	7,700 (s) or 250*	39.6 to 77.2	c = ab		
10,200 (s) or 330*	10,200 (s) or 330*	82.6	c = a/b		
4,350 (s)	4,350 (s) or 1,000*	33.2	c = a + b	Likely Floating Point Execution Times, μsec	
14,200 (s)	14,200 (s) or 1,500*	50.4	c = ab		
19,200 (s)	19,200 (s) or 1,500*	70.4	c = a/b		
None	None	Tolerances on pulse size	Checking of Data Transfers		
None	Yes; multi-level	Yes; multi-level	Program Interrupt Facility		
1	1	6	Number of Index Registers		
Yes, non-recursive	Yes; non-recursive	Yes; recursive	Indirect Addressing		
None	None	None	Special Editing Capabilities		
AND, EXC OR	AND, EXC OR	AND, INC OR	Boolean Operations		
None	None	Good	Table Look-up		
Optional	Optional	Yes	Console Typewriter		
1 integrated non-simultaneous channel	2, one of which is integrated and non-simultaneous	6 —3 input and 3 output	Input-Output Channels		
Fixed-point execution times are based on 2-word operands	Fixed-point execution times are based on 2-word operands		Features and Comments		
160	160-A and 169	1604, 1604-A	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		
4,096	8,192	8,192	Minimum	Number of Words	
4,096	32,768	32,768	Maximum		
13,500	108,000	458,752	Decimal Digits	Maximum Total Storage	
8,192	65,536	262,144	Characters		
6.4	6.4	6.4	Cycle Time, μsec		
44,600	44,600	371,200 to 555,552	Effective Transfer Rate, char/sec		
None	None	Tolerance on pulse size	Checking		
None	None	None	Storage Protection		
		Two independent banks are used to reduce access times	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			CDC 3100	CDC 3300	CDC 3500
DATA STRUCTURE	Word Length	Binary Bits	24 + parity	24 + parity	24 + parity
		Decimal Digits	6.9 or 4	6.9 or 4	6.9 or 4
		Characters	4	4	4
	Floating Point Representation	Radix	Binary (double-length)	Binary (double-length)	Binary (double-length)
		Fraction Size	36 bits + sign	36 bits + sign	36 bits + sign
		Exponent Size	11 bits	11 bits	11 bits
CENTRAL PROCESSOR	Model Number		3114	3304	3504-1
	Arithmetic Radix		Binary (decimal*)	Binary (decimal*)	Binary (decimal)
	Operand Length, Words		1 or 2	1 or 2	1 or 2
	Instruction Length, Words		1, 2, or 3	1, 2, or 3	1, 2, or 3
	Addresses per Instruction		1, 2, or 3	1, 2, or 3	1, 2, or 3
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	10.5	8.25	5.9
		c = ab	18.5 to 22	13.75 to 16.75	9.93 to 12.08
		c = a/b	22	19.63	14.13
	Likely Floating Point Execution Times, μsec	c = a + b	27.4*	14.23 to 15.63*	10.25 to 11.45
		c = ab	32.8 to 39.8*	25.38*	18.27
		c = a/b	41.9*	28.38*	20.43
	Checking of Data Transfers		Parity	Parity	Parity
	Program Interrupt Facility		Yes, multi-level	Yes, multi-level	Yes, multi-level
	Number of Index Registers		3	3	3
	Indirect Addressing		Yes, recursive	Yes, recursive	Yes, recursive
	Special Editing Capabilities		Yes*	Yes*	Yes
	Boolean Operations		AND, EXC OR	AND, EXC OR	AND, EXC OR
	Table Look-up		Good	Good	Good
	Console Typewriter		Yes	Yes	Yes
	Input-Output Channels		1 to 4	1 to 8	1 to 8
	Features and Comments		A binary processor with optional features for business applications.	A faster version of the 3100 with a multiprogramming option.	Includes standard features for multiprogramming, floating-point, and decimal arithmetic.
WORKING STORAGE	Model Number		3113; 3119	3302; 3309	3502-2; 3502-3
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	8,192	16,384	32,768
		Maximum	32,768	262,144	262,144
	Maximum Total Storage	Decimal Digits	131,072	262,144	131,072
		Characters	131,072	1,048,576	1,048,576
	Cycle Time, μsec		1.75	1.25	0.9
	Effective Transfer Rate, char/sec		571,000	3,200,000	4,444,444
	Checking		Parity	Parity	Parity
	Storage Protection		Yes	Yes	Yes
	Features and Comments		Uses same peripheral equipment as CDC 3300 and 3500	64-word Register File has 0.5-microsecond cycle time	64-word Register File has 0.4-microsecond cycle time

* With optional equipment.
(s) Using subroutine.

CDC 3400	CDC 3600	CDC 3800	System Identity		
48 + parity	48 + parity	48 + parity	Binary Bits	Word Length	DATA STRUCTURE
14	14	14	Decimal Digits		
8	8	8	Characters		
Binary	Binary	Binary	Radix	Floating Point Representation	
36 bits + sign	36 or 84 bits + sign	36 or 84 bits + sign	Fraction Size		
11 bits	11 bits	11 bits	Exponent Size		
3404	3604	3804	Model Number		CENTRAL PROCESSOR
Binary	Binary	Binary	Arithmetic Radix		
1	1 or 2	1 or 2	Operand Length, Words		
1/2 or 1	1/2 or 1	1/2 or 1	Instruction Length, Words		
1 or 2	1 or 2	1 or 2	Addresses per Instruction		
9	6.0	3.0	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
24	10.3	7.3	c = ab		
24	20.0	11.3	c = a/b		
12*	8.4	4.5	c = a + b	Likely Floating Point Execution Times, μsec	
20*	10.3	7.0	c = ab		
20*	19.0	9.9	c = a/b		
Parity	Parity	Parity	Checking of Data Transfers		
Yes, identity must be tested	Yes	Yes	Program Interrupt Facility		
6	6	6	Number of Index Registers		
Yes; recursive	Yes; recursive	Yes; recursive	Indirect Addressing		
None	None	None	Special Editing Capabilities		
AND, INC OR, EXC OR	AND, INC OR, Special	AND, INC OR, EXC OR	Boolean Operations		
Good	Good	Good	Table Look-up		
Yes	Yes	Yes	Console Typewriter		
1 to 4	1 to 32, attached 8 per Communication Module	1 to 32, attached 8 per I/O Module	Input-Output Channels		
Double indexing; largely compatible with CDC 3600		Double indexing; overlapping access of data and instructions	Features and Comments		
3409	3609	3803	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		
16,384	32,768	32,768	Minimum	Number of Words	
32,768	262,144	262,144	Maximum		
458,752	3,670,016	3,670,016	Decimal Digits	Maximum Total Storage	
262,144	2,097,152	2,097,152	Characters		
1.5	1.5	0.9	Cycle Time, μsec		
1,050,000	2,610.00	500,000	Effective Transfer Rate, char/sec		
Parity	Parity	Parity	Checking		
Yes, using "bounds" registers	Yes, using "bounds" registers	Yes, using relocation wds.	Storage Protection		
Single-bank storage	Dual-bank storage	Look-ahead feature reads next instruction during execution of current instruction	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			CDC 6400/6500	CDC 6600
DATA STRUCTURE	Word Length	Binary Bits	60	60
		Decimal Digits	18	18
		Characters	10	10
	Floating Point Representation	Radix	Binary	Binary
		Fraction Size	48 or 96 bits	48 or 96 bits
		Exponent Size	11 bits + sign	11 bits + sign
CENTRAL PROCESSOR	Model Number		6413, 6414, 6415, 6513, 6514	6613, 6614, 6615
	Arithmetic Radix		Binary	Binary
	Operand Length, Words		1	1
	Instruction Length, Words		1/4 or 1/2	1/4 or 1/2
	Addresses per Instruction		3	3
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	2.1	1.0
		c = ab	---	---
		c = a/b	---	---
	Likely Floating Point Execution Times, μsec	c = a + b	2.0	1.0
		c = ab	7.1	1.2
		c = a/b	7.1	3.1
	Checking of Data Transfers		None	None
	Program Interrupt Facility		Yes	Yes
	Number of Index Registers		8	8
	Indirect Addressing		None	None
	Special Editing Capabilities		None	None
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None	None
	Console Typewriter		Yes	Yes
	Input-Output Channels		12 standard; up to 156*	12 standard; up to 156*
	Features and Comments		CDC 6500 systems use two 6400-style processors	Can execute up to 10 instructions concurrently
WORKING STORAGE	Model Number		Central memory	
	Type of Storage		Core	
	Number of Words	Minimum	32,768	
		Maximum	131,072	
	Maximum Total Storage	Decimal Digits	2,359,116	
		Characters	1,310,620	
	Cycle Time, μsec		1.0	
	Effective Transfer Rate, char/sec		100,000,000	
	Checking		None	
	Storage Protection		Yes, for each program	
	Features and Comments		Each of 10 Peripheral Processors has 4,096 12-bit words of 1-microsecond core memory; CDC 6500 systems can have 65K- or 131K-word core storage	

* With optional equipment.
(s) Using subroutine.

GE-115	GE-130	System Identity		
8 + parity	8 (+ parity) per octet	Binary Bits	Word Length	DATA STRUCTURE
2 (packed)	1 or 2 per octet	Decimal Digits		
1	1 per octet	Characters		
Binary	---	Radix	Floating Point Representation	
---	---	Fraction Size		
---	---	Exponent Size		
GE-115	GE-130	Model Number		CENTRAL PROCESSOR
Decimal	Decimal or binary	Arithmetic Radix		
1 to 16 digits	1 to 16 octets	Operand Length, Words		
2, 4, or 6 char	2, 4 or 6 octets	Instruction Length, Words		
0, 1, or 2	0, 1, or 2	Addresses per Instruction		
216	62	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
(s)	550	c = ab		
(s)	864	c = a/b		
---	---	c = a + b	Likely Floating Point Execution Times, μsec	
---	---	c = ab		
---	---	c = a/b		
Parity	Parity	Checking of Data Transfers		
None	Yes; one-level	Program Interrupt Facility		
AND, INC OR, EXC OR	8	Number of Index Registers		
None	None	Indirect Addressing		
None	Good	Special Editing Capabilities		
None	AND, INC OR, EXC OR	Boolean Operations		
None	Search instructions	Table Look-up		
Good	None	Console Typewriter		
2 data channels with 4 device outlets; data transfer locks out processor	3 channels and 4 device connectors; channel and connector assignments are controlled by program	Input-Output Channels		
Logical operands can be up to 256 characters long	Logical operands can be up to 256 octets long. Program-compatible with GE-115	Features and Comments		
GE-115	GE-130	Model Number		WORKING STORAGE
Core	Core	Type of Storage		
4, 096	16, 384 octets	Minimum	Number of Words	
16, 384	32, 768 octets	Maximum		
16, 384	65, 536	Decimal Digits	Maximum Total Storage	
16, 384	32, 768	Characters		
6.5	2.0	Cycle Time, μsec		
46, 090	250, 000	Effective Transfer Rate, char/sec		
Parity	Parity	Checking		
None	None	Storage Protection		
		Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			GE-215	GE-225	GE-235
DATA STRUCTURE	Word Length	Binary Bits	20 + parity	20 + parity	20 + parity
		Decimal Digits	5.7 + sign	5.7 + sign	5.7 + sign
		Characters	3	3	3
	Floating Point Representation	Radix	Binary	Binary	Binary
		Fraction Size	30 bits + sign	30 bits + sign	30 bits + sign
		Exponent Size	8 bits + sign	8 bits + sign	8 bits + sign
CENTRAL PROCESSOR	Model Number		215	225	235
	Arithmetic Radix		Binary (decimal*)	Binary (decimal*)	Binary (decimal*)
	Operand Length, Words		1 or 2	1 or 2	1 or 2
	Instruction Length, Words		1	1	1
	Addresses per Instruction		1	1	1
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	216	108	36
		c = ab	594	414	126
		c = a/b	675	567	189
	Likely Floating Point Execution Times, μsec	c = a + b	724*	580*	69*
		c = ab	1,068*	874*	87*
		c = a/b	1,322*	1,178*	111*
	Checking of Data Transfers		Parity	Parity	Parity
	Program Interrupt Facility		Yes*, external only	Yes*, external only	Yes*, external only
	Number of Index Registers		3; 32*	3; 32*	3; 32*
	Indirect Addressing		None	None	None
	Special Editing Capabilities		Good	Good	Good
	Boolean Operations		AND, OR	AND, OR	AND, OR
	Table Look-up		None	None	None
	Console Typewriter		Optional	Optional	Yes
	Input-Output Channels		6, permitting a maximum of 5 simultaneous data transfers	11, 8 of which are multiplexed by a Controller Selector	10, 7 of which are multiplexed by a Controller Selector
	Features and Comments		GE-215, GE-225, GE-235, all program compatible	GE-225 + DATANET 30 = GE 255 time shared system	GE-235 + DATANET 30 = GE 265 time shared system
WORKING STORAGE	Model Number		215	225	MM235
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	4,096	4,096	4,096
		Maximum	16,384	16,384	16,384
	Maximum Total Storage	Decimal Digits	93,388	93,388	93,388
		Characters	48,852	48,852	48,852
	Cycle Time, μsec		36	18/14*	6
	Effective Transfer Rate, char/sec		12,000/41,700*	24,000/83,400*	84,000/249,999*
	Checking		Parity	Parity	Parity
	Storage Protection		None	None	None
	Features and Comments				

* With optional equipment.
(s) Using subroutine.

GE-415	GE-425	GE-435	System Identity		
24 + parity	24 + parity	24 + parity	Binary Bits	Word Length	DATA STRUCTURE
4 + sign	4 + sign	4 + sign	Decimal Digits		
4	4	4	Characters		
Binary	Binary	Binary	Radix	Floating Point Representation	
38 bits + sign	38 bits + sign	38 bits + sign	Fraction Size		
8 bits + sign	8 bits + sign	8 bits + sign	Exponent Size		
GE-415	GE-425	GE-435	Model Number		CENTRAL PROCESSOR
Decimal, binary	Decimal, binary	Decimal, binary	Arithmetic Radix		
1 to 4	1 to 4	1 to 4	Operand Length, Words		
1 or 2	1 or 2	1 or 2	Instruction Length, Words		
1 or 2	1 or 2	1 or 2	Addresses per Instruction		
63.8	42.9	29.9	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
480.1	377.5	310.1	c = ab		
848.8	657.1	522.4	c = a/b		
70.6	47.2	32.8	c = a + b	Likely Floating Point Execution Times, μsec	
74.0	53.4	39.8	c = ab		
83.9	63.3	49.8	c = a/b		
Parity	Parity	Parity	Checking of Data Transfers		
Yes, priority system	Yes, priority system	Yes, priority system	Program Interrupt Facility		
6	6	6	Number of Index Registers		
Yes	Yes	Yes	Indirect Addressing		
Very good	Very good	Very good	Special Editing Capabilities		
AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		
None	None	None	Table Look-up		
Yes	Yes	Yes	Console Typewriter		
8 channels standard, 4 additional channels optional	8 channels standard, 4 additional channels optional	8 channels standard, 4 additional channels optional	Input-Output Channels		
All three models, plus newly-announced GE-405 and GE-420, are program compatible			Features and Comments		
GE-415	GE-425	GE-435	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		
8,192	8,192	16,384	Minimum	Number of Words	
32,768	131,072	131,072	Maximum		
131,072	524,288	524,288	Decimal Digits	Maximum Total Storage	
131,072	524,288	524,288	Characters		
5.8	3.9	2.7	Cycle Time, μsec		
344,000	512,800	740,800	Effective Transfer Rate, char/sec		
Parity	Parity	Parity	Checking		
Yes*, using limits registers	Yes*, using limits registers	Yes*, using limits registers	Storage Protection		
	GE-427 is GE-425 with cycle time increase of 0.7 μsec	GE-437 is GE-435 with cycle time increase of 0.7 μsec	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			GE-625	GE-635
DATA STRUCTURE	Word Length	Binary Bits	36 + parity	36 + parity
		Decimal Digits	10.5	10.5
		Characters	6 or 9 bits	6 or 9 bits
	Floating Point Representation	Radix	Binary	Binary
		Fraction Size	28 or 64 bits	28 or 64 bits
		Exponent Size	8 bits	8 bits
CENTRAL PROCESSOR	Model Number		CP 8030 (GE-625)	CP 8030 (GE-635)
	Arithmetic Radix		Binary	Binary
	Operand Length, Words		1 or 2	1 or 2
	Instruction Length, Words		1	1
	Addresses per Instruction		1	1
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	9.5 (long or short)	6.1 (short); 6.8 (long)
		c = ab	13.5 (short)	11.3 (short)
		c = a/b	21.0 (short)	18.5 (short)
	Likely Floating Point Execution Times, μsec	c = a + b	9.5 (short); 10.0 (long)	7.0 (short); 7.6 (long)
		c = ab	12.5 (short); 19.0 (long)	10.2 (short); 16.6 (long)
		c = a/b	21.0 (short); 30.5 (long)	18.5 (short); 28.1 (long)
	Checking of Data Transfers		Parity	Parity
	Program Interrupt Facility		Yes, with priority levels	Yes, with priority levels
	Number of Index Registers		8	8
	Indirect Addressing		Yes	Yes
	Special Editing Capabilities		None	None
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None	None
	Console Typewriter		Yes	Yes
	Input-Output Channels		8 to 16 channels per I/OC; up to 40 I/OC's per system	8 to 16 channels per I/OC; up to 40 I/OC's per system
	Features and Comments		Program-compatible. Master/slave modes of operation facilitate multiprogramming	
WORKING STORAGE	Model Number		MM 8031	MM 8030
	Type of Storage		Core	Core
	Number of Words	Minimum	32,768	32,768
		Maximum	262,144	262,144
	Maximum Total Storage	Decimal Digits	2,097,152	2,097,152
		Characters	1,572,864	1,572,864
	Cycle Time, μsec		2.0 per 72 bits	1.0 per 72 bits
	Effective Transfer Rate, char/sec		2,400,000	3,330,000
	Checking		Parity	Parity
	Storage Protection		Yes, using bounds registers	Yes, using bounds registers
	Features and Comments		Models 627 & 637 are 625 & 635 with 0.7 μ cycle time increase Multiple processors can access a storage module	

* With optional equipment.
(s) Using subroutine.

AUERBACH

Honeywell Series 200				System Identity		
Model 110	Model 120	Model 125	Model 200			
6 + parity	6 + parity + 2 punctuation	6 + parity + 2 punctuation	6 + parity + 2 punctuation	Binary Bits	Word Length	DATA STRUCTURE
1	1	1	1	Decimal Digits	Word Length	DATA STRUCTURE
1	1	1	1	Characters	Word Length	DATA STRUCTURE
?	---	---	---	Radix	Floating Point Representation	DATA STRUCTURE
?	---	---	---	Fraction Size	Floating Point Representation	DATA STRUCTURE
?	---	---	---	Exponent Size	Floating Point Representation	DATA STRUCTURE
111-1 to 111-8	121	126	201-2	Model Number		CENTRAL PROCESSOR
Decimal, binary	Decimal, binary	Decimal, binary	Decimal, binary	Arithmetic Radix		CENTRAL PROCESSOR
1 to N char	1 to N char	1 to N char	1 to N char	Operand Length, Words		CENTRAL PROCESSOR
1 to 10	1 to 10	1 to 10	1 to 12	Instruction Length, Words		CENTRAL PROCESSOR
1 or 2	2	2	2	Addresses per Instruction		CENTRAL PROCESSOR
164	123	102.5	84	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
?	3,100(s)	2,600(s)	480	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
?	3,700(s)	2,500(s)	1,148	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
?	---	---	---	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
?	---	---	---	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
?	---	---	---	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity	Parity	Parity	Parity	Checking of Data Transfers		CENTRAL PROCESSOR
Yes	Yes, I/O only	Yes, I/O only	Yes, I/O only	Program Interrupt Facility		CENTRAL PROCESSOR
6*	6*	6*	6* or 15*	Number of Index Registers		CENTRAL PROCESSOR
Yes*	Optional	Optional	Optional	Indirect Addressing		CENTRAL PROCESSOR
Yes	Poor; excellent*	Poor; excellent*	Poor; excellent*	Special Editing Capabilities		CENTRAL PROCESSOR
No	AND, EXC OR	AND, EXC OR	AND, EXC OR	Boolean Operations		CENTRAL PROCESSOR
No	None	None	None	Table Look-up		CENTRAL PROCESSOR
Yes	Yes	Yes	Yes	Console Typewriter		CENTRAL PROCESSOR
3	2 or 3*	2, 3*, or 4*	3 or 4*	Input-Output Channels		CENTRAL PROCESSOR
	120 Processor includes built-in I/O control	Use of 4 simultaneous I/O Channels	IBM 1401—compatible through software	Features and Comments		CENTRAL PROCESSOR
111-1 to 111-8	121	126	201-2	Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		WORKING STORAGE
4,096	2,048	4,096	4,096	Minimum	Number of Words	WORKING STORAGE
32,768	32,768	32,768	65,536	Maximum	Number of Words	WORKING STORAGE
32,768	32,768	32,768	65,536	Decimal Digits	Maximum Total Storage	WORKING STORAGE
32,768	32,768	32,768	65,536	Characters	Maximum Total Storage	WORKING STORAGE
4.0 per char	3.0 per char	2.5 per char	2.0 per char	Cycle Time, μsec		WORKING STORAGE
125,000	167,000	167,000	250,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Parity	Checking		WORKING STORAGE
None	None	None	None	Storage Protection		WORKING STORAGE
	48-character control memory	48-character control memory	48-character control memory has 0.5-μsec cycle	Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			Honeywell Series 200 Model 1200	Model 1250	Model 2200	Model 4200	Model 8200**
DATA STRUCTURE	Word Length	Binary Bits	6 + parity + 2 punctuation	6 + parity + 2 punctuation	6 + parity + 2 punctuation	6 + parity + 2 punctuation	48 + parity + 16 punctuation
		Decimal Digits	1	1	1	1	12
		Characters	1	1	1	1	8
	Floating Point Representation	Radix	Binary	Binary	Binary	Binary	Decimal, binary
		Fraction Size	36 bits	36 bits	36 bits	36 bits	10 dig. 40 dig.
		Exponent Size	12 bits	12 bits	12 bits	12 bits	7 bits 7 bits
CENTRAL PROCESSOR	Model Number		1201	1251	2201	4201	8201
	Arithmetic Radix		Decimal, binary	Decimal, binary	Decimal, binary	Decimal, binary	Decimal, binary
	Operand Length, Words		1 to N char	1 to N char	1 to N char	1 to N Char	1
	Instruction Length, Words		1 to 12	1 to 12	1 to 12	1 to 12	1
	Addresses per Instruction		2	2	2	2	3
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	63	63	51	25	1.8 to 3.0
		c = ab	360	360	244	85	5.3
		c = a/b	900	900	600	99	14.0
	Likely Floating Point Execution Times, μsec	c = a + b	84*	84*	56*	19*	2.3 to 9.3*
		c = ab	120*	120*	81*	29*	<7.5
		c = a/b	149*	149*	99*	35*	<14.0
	Checking of Data Transfers		Parity	Parity	Parity	Parity	Parity
	Program Interrupt Facility		Yes	Yes	Yes	Yes	Yes, multi-level
	Number of Index Registers		15 or 30*	15 or 30*	15 or 30*	15 or 30*	64
	Indirect Addressing		Yes	Yes	Yes	Yes	Yes
	Special Editing Capabilities		Excellent	Excellent	Excellent	Excellent	None
	Boolean Operations		AND, EXC OR	AND, EXC OR	AND, EXC OR	AND, EXC OR	AND, INC OR, EXC OR
	Table Look-up		Optional	Optional	Optional	Yes	No
	Console Typewriter		Yes	Yes	Yes	Yes	Yes
	Input-Output Channels		4*	8*	4 or 8*	8 or 16*	16 or 32*
	Features and Comments		IBM/1401/1410/ 7010-compatible through software	IBM 1401/1410/ 7010 compatible through software	IBM 1401/1410/ 7010-compatible through software	IBM 1401/1410/ 7010-compatible through software	Program compatible with H-800, H-1800, and Series 200
WORKING STORAGE	Model Number		1201	1251	2201	4201	8201
	Type of Storage		Core	Core	Core	Core	Core
	Number of Words	Minimum	8,192	32,768	16,384	131,072	32,768
		Maximum	131,072	262,144	262,144	524,288	131,072
	Maximum Total Storage	Decimal Digits	131,072	262,144	262,144	524,288	1,572,864
		Characters	131,072	262,144	262,144	524,288	1,048,576
	Cycle Time, μsec		1.5 per char	1.5 per char	1.0 per char	0.75 per 4 chars	0.75 per 4 or 8 chars
	Effective Transfer Rate, char/sec		333,000	333,000	500,000	1,333,000	8,000,000
	Checking		Parity	Parity	Parity	Parity	Parity
	Storage Protection		Yes*	Yes*	Yes*	Yes*	Yes, using locks & keys
	Features and Comments		48 or 96-character control memory has 0.5-μsec cycle	48 or 96-character control memory has 0.5-μsec cycle	48 or 96-character control memory has 0.5-μsec cycle	96-character control memory has 0.3-μsec cycle	Used by 8200 Word and Character Processors

* With optional equipment.
(s) Using subroutine.

** All entries refer to 8200's Word Processor; Model 8200 also contains a Character Processor similar to the Honeywell 4200 Processor.

Honeywell 400	Honeywell 1400	Honeywell 800 and 1800		System Identity		
48 + parity	48 + parity	48		Binary Bits	Word Length	DATA STRUCTURE
12 including optional sign	12 including optional sign	12		Decimal Digits		
8	8	8		Characters		
---	Decimal	Decimal	Binary	Radix	Floating Point Representation	
---	9 digits	10 digits	40 bits + sign	Fraction Size		
---	2 digits	6 bits + sign	6 bits + sign	Exponent Size		
401A	1401	801 (H-800)	1801 (H-1800)	Model Number		CENTRAL PROCESSOR
Decimal, binary	Decimal, binary	Decimal, binary		Arithmetic Radix		
1	1	1		Operand Length, Words		
1	1	1		Instruction Length, Words		
3	3	3		Addresses per Instruction		
114	78	24	8	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
1, 580*	1, 085*	200	67	c = ab		
2, 140*	1, 470*	272	30	c = a/b		
---	140*	42*	10*	c = a + b	Likely Floating Point Execution Times, μsec	
---	1, 210*	100*	12*	c = ab		
---	2, 760*	400*	32*	c = a/b		
Parity	Parity	Parity		Checking of Data Transfers		
Yes	Yes	Yes, limited I/O sensing		Program Interrupt Facility		
3	3	64		Number of Index Registers		
None	None	One level		Indirect Addressing		
Good	Good	None		Special Editing Capabilities		
AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR		Boolean Operations		
None	None	No		Table Look-up		
Yes	Yes	Yes		Console Typewriter		
1 integrated non-simultaneous channel	1 integrated non-simultaneous channel; buffered I/O units are available	8 input and 8 output		Input-Output Channels		
Two magnetic tape operations can be performed simultaneously	Program-compatible with Honeywell 400	H-800 and 1800 are program-compatible; each can run up to 8 programs concurrently		Features and Comments		
402	1402	802 (H-800)	1802 (H-1800)	Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		
1, 024	4, 096	4, 096	8, 192	Minimum	Number of Words	
4, 096	32, 768	28, 672	65, 536	Maximum		
49, 152	393, 216	345, 144	786, 432	Decimal Digits	Maximum Total Storage	
32, 768	262, 144	229, 376	524, 288	Characters		
9. 25 per 24 bits	6. 5 per 24 bits	6	2	Cycle Time, μsec		
210, 000	310, 000	533, 333	1, 600, 000	Effective Transfer Rate, char/sec		
Parity	Parity	Parity	Parity	Checking		
None	None	None		Storage Protection		
		A 256-word control memory is also utilized		Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			IBM System/360 Model 20		Model 25	Model 30	Model 40
DATA STRUCTURE	Word Length	Binary Bits	8 per byte		8 per byte	8 per byte	8 per byte
		Decimal Digits	2 per byte		2 per byte	2 per byte	2 per byte
		Characters	1 per byte		1 per byte	1 per byte	1 per byte
	Floating Point Representation	Radix	---		Binary	Binary	Binary
		Fraction Size	---		24 or 56 bits	24 or 56 bits	24 or 56 bits
		Exponent Size	---		7 bits	7 bits	7 bits
CENTRAL PROCESSOR	Model Number		2020 Mdls 1&2	2020 Mdls 3&4	2025	2030	2040
	Arithmetic Radix		Decimal		Binary or decimal	Binary (decimal*)	Binary (decimal*)
	Operand Length, Words		Variable		Variable	Variable	Variable
	Instruction Length, Words		2, 4, or 6 bytes		2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes
	Addresses per Instruction		0, 1 or 2		0, 1, or 2	0, 1, or 2	0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	675	1,207	113 or 182	78 or 96	36 or 64
		c = ab	7,000	7,530	616 or 645	296 or 395	113 or 178
		c = a/b	10,810	11,340	805 or 1,308	481 or 767	216 or 349
	Likely Floating Point Execution Times, μsec	c = a + b	---	---	303 or 369*	107 or 161*	43 or 62*
		c = ab	---	---	730 or 1,154*	295 or 874	105 or 294*
		c = a/b	---	---	664 or 1,839*	350 or 1,717	157 or 511
	Checking of Data Transfers		Parity		Parity	Parity	Parity
	Program Interrupt Facility		Yes, I/O only		Yes, 5 classes	Yes, 5 classes	Yes, 5 classes
	Number of Index Registers		8 max.		16 max.	16 max.	16 max.
	Indirect Addressing		None		None	None	None
	Special Editing Capabilities		Good		Good	Good	Good
	Boolean Operations		AND, INC OR		AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None		None	None	None
	Console Typewriter		None		Yes	Optional	Optional
	Input-Output Channels		Integrated channels permit sharing of core storage models		1 selector channel or 1 multiplexor channel	0 to 2 selector channels; 1 multiplexor channel	0 to 2 selector channels; 1 multiplexor channel
	Features and Comments		Limited program compatibility with other System/360 models		These models have a high degree of program compatibility		
WORKING STORAGE	Model Number		2020		2025	2030	2040
	Type of Storage		Core		Core	Core	Core
	Number of Words	Minimum	4,096 bytes		16,384 bytes	8,192 bytes	16,384 bytes
		Maximum	16,384 bytes		49,152 bytes	65,536 bytes	262,144 bytes
	Maximum Total Storage	Decimal Digits	32,768		98,304	131,072	524,288
		Characters	16,384		49,152	65,536	262,144
	Cycle Time, μsec		3.6 per half-byte		0.9 per 1 or 2 bytes	1.5 per 1 byte	2.5 per 2 bytes
	Effective Transfer Rate, char/sec		62,500 max.		185,000 max.	321,000 max.	390,000 max.
	Checking		Parity		Parity	Parity	Parity
	Storage Protection		None		Write only*	Write only*	Write only*
	Features and Comments				Certain I/O units can be connected without their usual control units or channels		

* With optional equipment.
(s) Using subroutine.

IBM System/360				System Identity		
Model 44	Model 50	Model 65	Model 67			
32 + 4 parity	8 per byte	8 per byte	8 per byte	Binary Bits	Word Length	DATA STRUCTURE
9.2	2 per byte	2 per byte	2 per byte	Decimal Digits		
4	1 per byte	1 per byte	1 per byte	Characters		
Binary	Binary	Binary	Binary	Radix	Floating Point Representation	
24, 32, 40, 48 or 56 bits	24 or 56 bits	24 or 56 bits	24 or 56 bits	Fraction Size		
7 bits	7 bits	7 bits	7 bits	Exponent Size		
2044	2050	2065	2067	Model Number		CENTRAL PROCESSOR
Binary (decimal*)	Binary or decimal	Binary or decimal	Binary, decimal	Arithmetic Radix		
1 or 1/2 word	Variable	Variable	Variable	Operand Length, Words		
1 or 1/2 word	2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	Instruction Length, Words		
2	0, 1, or 2	0, 1, or 2	0, 1, or 2	Addresses per Instruction		
13.0; 7.0*	12 or 35	3.5 or 9.0	4.2 or 9.7	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
26.3; 20.5*	40 or 86	7.0 or 32	7.7 or 33	c = ab		
41.0; 33.8*	44 or 97	11 or 47	12 or 48	c = a/b		
18.8 or 11.6*	14 or 21	4.7 or 4.8	5.4 or 5.5	c = a + b	Likely Floating Point Execution Times, μsec	
73.6 or 21.8*	29 or 49	6.1 or 9.7	6.8 or 10.4	c = ab		
137.5 or 31.0	30 or 81	9.3 or 16	10.0 or 16.9	c = a/b		
Parity	Parity	Parity	Parity	Checking of Data Transfers		
Yes, 5 classes	Yes, 5 classes	Yes, 5 classes	Yes, 5 classes	Program Interrupt Facility		
16	16 max.	16 max.	25 max.	Number of Index Registers		
None	None	None	Yes; 8-register associative memory	Indirect Addressing		
Restricted	Good	Good	Good	Special Editing Capabilities		
AND, INC OR, EXC OR	AND, INC OR EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		
None	None	None	None	Table Look-up		
Standard	Optional	Optional	Optional	Console Typewriter		
1 multiplexor channel with 64 subchannels; 1* or 2* high-speed multiplexor channels	0 to 3 selector channels; 1 multiplexor channel	0 to 6 selector channels; 0 or 1 multiplexor channel	1 or 2 Channel Controllers; up to 7 channels per controller	Input-Output Channels		
Limited program compatibility with other System/360 models			Special hardware facilitates time-sharing operations	Features and Comments		
2044	2050	2065	2067	Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		
8,192 4-byte words	65,536 bytes	131,072 bytes	262,144 bytes	Minimum	Number of Words	
65,536 4-byte words	524,288 bytes	1,048,576 bytes	2,097,152	Maximum		
524,288	524,288	2,097,152	4,194,304	Decimal Digits	Maximum Total Storage	
262,144	262,144	1,048,576	2,097,152	Characters		
1.0 per 4-byte word	2.0 per 4 bytes	0.75 per 8 bytes	0.75 per 8 bytes	Cycle Time, μsec		
121,200 max.	851,000 max.	4,760,000 max.	4,760,000 max.	Effective Transfer Rate, char/sec		
Parity	Parity	Parity	Parity	Checking		
Read* and write*	Write only	Read and write	Read and write	Storage Protection		
Standard general registers are in extended core storage; High-Speed Registers are optional		Interleaving improves sequential access rate	1 or 2 central processors and 1 to 8 independent 262K modules per system	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			IBM System/360 Model 75	IBM System/360 Model 85	IBM 1401	IBM 1410
DATA STRUCTURE	Word Length	Binary Bits	8 per byte	8 per byte	6 + parity + word mark	6 + parity + word mark
		Decimal Digits	2 per byte	2 per byte	1	1
		Characters	1 per byte	1 per byte	1	1
	Floating Point Representation	Radix	Binary	Binary	Decimal	Decimal
		Fraction Size	24 or 56 bits	24, 56, or 112 bits	8 digits(s)	8 digits(s)
		Exponent Size	7 bits	7 bits	2 digits(s)	2 digits(s)
CENTRAL PROCESSOR	Model Number		2075	2085	1401	1411
	Arithmetic Radix		Binary or decimal	Binary, Decimal	Decimal	Decimal
	Operand Length, Words		Variable	Variable	1 to N char	1 to N char
	Instruction Length, Words		2, 4, or 6 bytes	2, 4, or 6 bytes	1 to 8 char	1 to 12 char
	Addresses per Instruction		0, 1 or 2	0, 1 or 2	2	2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	2.3 or 7.3	0.64 or 2.84	437	226
		c = ab	5.1 or 25	1.80 or 9.82	21,216(s); 2,280*	1,206
		c = a/b	9.0 or 33	2.84 or 13.0	27.730(s); 2,784*	2,440
	Likely Floating Point Execution Times, μsec	c = a + b	2.4	0.86 or 0.78	8,800(s)	3 999(s)
		c = ab	3 6 or 5.6	1.84 or 2.56	8,600(s)	5,430(s)
		c = a/b	5.4 or 8.6	2.12 or 3.13	12,700(s)	8,790(s)
	Checking of Data Transfers		Parity	Parity	Parity, char validity	Parity, char validity
	Program Interrupt Facility		Yes, 5 classes	Yes, 5 classes	None	Yes,* with priority scheme
	Number of Index Registers		16 max.	16 max.	3*	15
	Indirect Addressing		None	None	None	None
	Special Editing Capabilities		Good	Good	Good; excellent*	Excellent
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR	None	None
	Table Look-up		None	None	None	Good
	Console Typewriter		Optional	Optional	Optional	Yes
	Input-Output Channels		0 to 6 selector channels; 0 or 1 multiplexor channel	0 to 6 selector channels; 0 or 1 multiplexor channel	1 integrated non-simultaneous channel; buffered printing*	1 integrated non-simultaneous channel is standard; a second is optional, as is Processing Overlap
	Features and Comments			Upward-compatible with System/360 Models 25-75	Processing Overlap* Feature permits 1 I/O operation while computing	Speeds are about 23% higher with Accelerator feature
WORKING STORAGE	Model Number		2075	2085	1401 & 1406	1411
	Type of Storage		Core	Core	Core	Core
	Number of Words	Minimum	262,144 bytes	524,288 bytes	1,400	10,000
		Maximum	1,048,576 bytes	4,194,304 bytes	16,000	80,000
	Maximum Total Storage	Decimal Digits	2,097,152	8,388,608	16,000	80,000
		Characters	1,048,576	4,194,304	16,000	80,000
	Cycle Time, μsec		0.75 per 8 bytes	0.96 or 1.04 per 16 bytes	11.5 (19.3 in Model H)	4.5; 4.0*
	Effective Transfer Rate, char/sec		5,857,000 max.	35,000,000 max.	43,500	111,000
	Checking		Parity	Parity, error correction	Parity	Parity
	Storage Protection		Read and write	Read and write	None	None
	Features and Comments		Interleaving improves sequential access rate	80-nanosecond buffer memory holds 16K to to 32K bytes		

* With optional equipment.
(s) Using subroutine.

IBM 1440	IBM 1460	IBM 1620 Model 1	IBM 1620 Model 2	System Identity		
6 + parity + word mark	6 + parity + word mark	4 + Parity + flag		Binary Bits	Word Length	DATA STRUCTURE
1	1	1		Decimal Digits	Word Length	DATA STRUCTURE
1	1	0.5		Characters	Word Length	DATA STRUCTURE
Decimal	Decimal	Decimal		Radix	Floating Point Representation	DATA STRUCTURE
8 digits (s)	8 digits (s)	2 to 100 digits		Fraction Size	Floating Point Representation	DATA STRUCTURE
2 digits (s)	2 digits (s)	2 digits		Exponent Size	Floating Point Representation	DATA STRUCTURE
1441A	1441B	1620 Model 1	1620 Model 2	Model Number		CENTRAL PROCESSOR
Decimal	Decimal	Decimal	Decimal	Arithmetic Radix		CENTRAL PROCESSOR
1 to N char	1 to N char	2 to N digits	2 to N digits	Operand Length, Words		CENTRAL PROCESSOR
1 to 8 char	1 to 8 char	12 digits	12 digits	Instruction Length, Words		CENTRAL PROCESSOR
2	2	2	2	Addresses per Instruction		CENTRAL PROCESSOR
422	228	920	280	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
20,500 (s); 2,200*	11,100(s); 1,190*	5320	1,350	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
26,800 (s); 2,690*	14,500(s); 1,450*	66,900(s); 17,700*	3,628	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
8,500 (s)	4,600(s)	28,500(s); 1,760*	541*	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
8,300 (s)	4,500(s)	36,000(s); 13,100*	3,295*	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
12,250 (s)	6,600(s)	88,700(s); 41,700*	8,960*	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity, char validity	Parity, char validity	Parity		Checking of Data Transfers		CENTRAL PROCESSOR
Only for 1448 Transmission Control Unit	Only for 1448 Transmission Control Unit	None		Program Interrupt Facility		CENTRAL PROCESSOR
3*	3*	None		Number of Index Registers		CENTRAL PROCESSOR
None	None	Yes		Indirect Addressing		CENTRAL PROCESSOR
Good; execellent*	Good; excellent*	None		Special Editing Capabilities		CENTRAL PROCESSOR
None	None	None		Boolean Operations		CENTRAL PROCESSOR
None	None	None		Table Look-up		CENTRAL PROCESSOR
Optional	Optional	Yes		Console Typewriter		CENTRAL PROCESSOR
1 integrated non-simultaneous channel; buffered printing*	1 non-simultaneous channel; Processing Overlap and buffered printing*	1 integrated non-simultaneous channel		Input-Output Channels		CENTRAL PROCESSOR
	Program-compatible with IBM 1401			Features and Comments		CENTRAL PROCESSOR
1441A	1441B	1620, 1623	1625	Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		WORKING STORAGE
2,000	8,000	20,000	20,000	Minimum	Number of Words	WORKING STORAGE
16,000	16,000	60,000	60,000	Maximum	Number of Words	WORKING STORAGE
16,000	16,000	60,000	60,000	Decimal Digits	Maximum Total Storage	WORKING STORAGE
16,000	16,000	30,000	30,000	Characters	Maximum Total Storage	WORKING STORAGE
11.1	6.0	20	10	Cycle Time, μsec		WORKING STORAGE
45,000	83,300	12,500	33,300	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Parity	Checking		WORKING STORAGE
None	None	None	None	Storage Protection		WORKING STORAGE
		2 digits represent 1 alphameric character		Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			IBM 7010	IBM 7040	IBM 7044
DATA STRUCTURE	Word Length	Binary Bits	6 + parity + word mark	36 + parity	36 + parity
		Decimal Digits	1	10.5	10.5
		Characters	1	6	6
	Floating Point Representation	Radix	Decimal	Binary	Binary
		Fraction Size	8 digits (s)	27 or 54 bits	27 or 54 bits
		Exponent Size	2 digits (s)	8 bits	8 bits
CENTRAL PROCESSOR	Model Number		7114	7106	7107
	Arithmetic Radix		Decimal	Binary	Binary
	Operand Length, Words		1 to N char	1	1
	Instruction Length, Words		1 to 12 char	1	1
	Addresses per Instruction		2	1	1
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	56	48	12
		c = ab	431	72	32
		c = a/b	925	94	48
	Likely Floating Point Execution Times, μsec	c = a + b	1,590 (s)	56*	19*
		c = ab	2,175 (s)	67*	28*
		c = a/b	3,495 (s)	88*	44*
	Checking of Data Transfers		Parity, char validity	Parity	Parity
	Program Interrupt Facility		Yes, with priority scheme	Yes, with fixed priorities	Yes, with fixed priorities
	Number of Index Registers		15	3*	3*
	Indirect Addressing		None	One level	One level
	Special Editing Capabilities		Excellent	None	None
	Boolean Operations		None	AND, INC OR, EXC OR, NOT	AND, INC OR, EXC OR, NOT
	Table Look-up		Good	None	None
	Console Typewriter		Yes	No	No
	Input-Output Channels		1 channel is standard; a second is optional	0 to 4; most low-speed I/O devices operate in buffered mode	0 to 4; most low-speed I/O devices operate in buffered mode
	Features and Comments		Program-compatible with IBM 1410	Can be directly coupled to an IBM 7090 or 7094	Program-compatible with IBM 7040
WORKING STORAGE	Model Number		7114	7106	7107
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	40,000	4,096	8,192
		Maximum	100,000	32,768	32,768
	Maximum Total Storage	Decimal Digits	100,000	344,064	344,064
		Characters	100,000	196,608	196,608
	Cycle Time, μsec		2.4 (per 2 characters)	8.0	2.0
	Effective Transfer Rate, char/sec		356,000	375,000	1,200,000
	Checking		Parity	Parity	Parity
	Storage Protection		None	Yes*	Yes*
	Features and Comments				Cycle time was 2.5 μsec prior to April 1, 1964

* With optional equipment.
(s) Using subroutine.

IBM 7070	IBM 7072	IBM 7074	System Identity		
50 + 3 sign	50 + 3 sign	50 + 3 sign	Binary Bits	Word Length	DATA STRUCTURE
10 + sign	10 + sign	10 + sign	Decimal Digits	Word Length	DATA STRUCTURE
5	5	5	Characters	Word Length	DATA STRUCTURE
Decimal	Decimal	Decimal	Radix	Floating Point Representation	DATA STRUCTURE
8 digits	8 digits	8 digits	Fraction Size	Floating Point Representation	DATA STRUCTURE
2 digits	2 digits	2 digits	Exponent Size	Floating Point Representation	DATA STRUCTURE
7601	7105	7104	Model Number		CENTRAL PROCESSOR
Decimal	Decimal	Decimal	Arithmetic Radix		CENTRAL PROCESSOR
1 to 10 digits	1 to 10 digits	1 to 10 digits	Operand Length, Words		CENTRAL PROCESSOR
1	1	1	Instruction Length, Words		CENTRAL PROCESSOR
1	1	1	Addresses per Instruction		CENTRAL PROCESSOR
156	36	24	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
660	84	72	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
1,820	115	103	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
324*	44	32*	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
1,150*	84	72*	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
2,540*	110	98*	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Fixed count	Fixed count	Fixed count	Checking of Data Transfers		CENTRAL PROCESSOR
Yes, with priority scheme	Yes, with priority scheme	Yes, with priority scheme	Program Interrupt Facility		CENTRAL PROCESSOR
99	99	99	Number of Index Registers		CENTRAL PROCESSOR
None	None	None	Indirect Addressing		CENTRAL PROCESSOR
Fair	Fair	Fair	Special Editing Capabilities		CENTRAL PROCESSOR
None	None	None	Boolean Operations		CENTRAL PROCESSOR
Excellent	Excellent	Excellent	Table Look-up		CENTRAL PROCESSOR
Yes	Yes	Yes	Console Typewriter		CENTRAL PROCESSOR
0 to 4; most low-speed devices operate in buffered mode	1 or 2; typewriter and card reader are not buffered	0 to 4; most low-speed devices operate in buffered mode	Input-Output Channels		CENTRAL PROCESSOR
Floating point optional; three accumulators	Floating point standard; program-compatible with IBM 7070	Floating point optional; program-compatible with IBM 7070	Features and Comments		CENTRAL PROCESSOR
7301	7301	7301	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		WORKING STORAGE
5,000	5,000	5,000	Minimum	Number of Words	WORKING STORAGE
9,990	30,000	30,000	Maximum	Number of Words	WORKING STORAGE
99,900	300,000	300,000	Decimal Digits	Maximum Total Storage	WORKING STORAGE
49,950	150,000	150,000	Characters	Maximum Total Storage	WORKING STORAGE
6.0	6.0	4.0	Cycle Time, μsec		WORKING STORAGE
209,000	416,500	625,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Fixed count	Fixed count	Fixed count	Checking		WORKING STORAGE
None	None	None	Storage Protection		WORKING STORAGE
			Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			IBM 7080	IBM 7090	IBM 7094	
DATA STRUCTURE	Word Length	Binary Bits	6 + parity	36	36	
		Decimal Digits	1	10.5	10.5	
		Characters	1	6	6	
	Floating Point Representation	Radix	Decimal	Binary	Binary	
		Fraction Size	8 digits (s)	27 bits + sign	27 or 54 bits + sign	
		Exponent Size	2 digits (s)	8 bits	8 bits	
CENTRAL PROCESSOR	Model Number		7102 & 7305	7108 & 7109	Model I	Model II
	Arithmetic Radix		Decimal	Binary	Binary	
	Operand Length, Words		1 to 255 char	1	1 or 2	
	Instruction Length, Words		5 char	1	1	
	Addresses per Instruction		1	1	1	
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	32	13.08	10	7.0
		c = ab	134	34.01	16	9.8
		c = a/b	285	39.24	20	14.0
	Likely Floating Point Execution Times, μsec	c = a + b	---	22.67	12	8.4
		c = ab	---	32.70	16	11.2
		c = a/b	---	37.06	22	14.0
	Checking of Data Transfers		Parity	None	None	
	Program Interrupt Facility		Yes	Yes, with priority levels	Yes, with priority levels	
	Number of Index Registers		None	3	7	
	Indirect Addressing		One level	One level	One level	
	Special Editing Capabilities		Good	None	None	
	Boolean Operations		None	AND, INC OR, EXC OR, NOT	AND, INC OR, EXC OR, NOT	
	Table Look-up		None	None	None	
	Console Typewriter		Yes	None	None	
	Input-Output Channels		0 to 10, 4 of which can be used only by low-speed devices	1 to 5; also a special data communications channel with 32 subchannels	1 to 5; also a special data communications channel with 32 subchannels	
	Features and Comments		Can operate in IBM 705-compatible mode			
WORKING STORAGE	Model Number		7302	7302	Model I	Model II
	Type of Storage		Core	Core	Core	
	Number of Words	Minimum	80,000	32,768	32,768	
		Maximum	160,000	32,768	32,768	
	Maximum Total Storage	Decimal Digits	160,000	344,064	344,064	
		Characters	160,000	196,608	196,608	
	Cycle Time, μsec		2.0	2.18	2.00	1.40
	Effective Transfer Rate, char/sec		2,500,000 max.	1,380,000 max.	3,000,000 max.	4,300,000 max.
	Checking		Parity	None	None	None
	Storage Protection		None	Limited, using ESNT instruction	Limited, using ESNT instruction	
	Features and Comments		Can access 1, 5 or 10 characters per cycle		Single bank	Dual banks with over-lapped access

* With optional equipment.
(s) Using subroutine.

NCR Century Series		System Identity		
Century 100	Century 200			
8(+ parity) per byte	8 (+ parity) per byte	Binary Bits	Word Length	DATA STRUCTURE
1 or 2 per byte	1 or 2 per byte	Decimal Digits	Word Length	DATA STRUCTURE
1 per byte	1 per byte	Characters	Word Length	DATA STRUCTURE
---	Binary	Radix	Floating Point Representation	DATA STRUCTURE
---	24 or 56 bits + sign	Fraction Size	Floating Point Representation	DATA STRUCTURE
---	7 bits	Exponent Size	Floating Point Representation	DATA STRUCTURE
615-100	615-200	Model Number		CENTRAL PROCESSOR
Decimal or binary	Decimal or binary	Arithmetic Radix		CENTRAL PROCESSOR
1 to 256 bytes	1 to 256 bytes	Operand Length, Words		CENTRAL PROCESSOR
4 or 8 bytes	4 or 8 bytes	Instruction Length, Words		CENTRAL PROCESSOR
1 or 2	1 or 2	Addresses per Instruction		CENTRAL PROCESSOR
82.4 (dec. or bin.)	22.9 (dec. or bin.)	$c = a + b$	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
3,780 (s)	278.3 (dec.)	$c = ab$	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
9,930 (s)	(s)	$c = a/b$	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
---	30 (short); 52 (long)	$c = a + b$	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
---	124 (short); 416 (long)	$c = ab$	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
---	189 (short); 752 (long)	$c = a/b$	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity	Parity	Checking of Data Transfers		CENTRAL PROCESSOR
Yes; 4 types	Yes; 4 types	Program Interrupt Facility		CENTRAL PROCESSOR
63	63	Number of Index Registers		CENTRAL PROCESSOR
None	Yes; up to 5 levels	Indirect Addressing		CENTRAL PROCESSOR
None	Good	Special Editing Capabilities		CENTRAL PROCESSOR
None	Optional	Boolean Operations		CENTRAL PROCESSOR
None	Scan instructions	Table Look-up		CENTRAL PROCESSOR
Optional	Standard	Console Typewriter		CENTRAL PROCESSOR
2 I/O trunks (channels)	4 I/O trunks (channels) are standard; 4 more are optional	Input-Output Channels		CENTRAL PROCESSOR
Instruction repertoire is a subset of the Century 200 repertoire	Optional features include NCR 315 and IBM 1401/1440/1460 compatibility	Features and Comments		CENTRAL PROCESSOR
615-100	615-200	Model Number		WORKING STORAGE
Short-rod thin-film	Short-rod thin-film	Type of Storage		WORKING STORAGE
16,384 bytes	32,768 bytes	Minimum	Number of Words	WORKING STORAGE
32,768 bytes	524,288 bytes	Maximum	Number of Words	WORKING STORAGE
65,536	1,048,576	Decimal Digits	Maximum Total Storage	WORKING STORAGE
32,768	524,288	Characters	Maximum Total Storage	WORKING STORAGE
0.8 per 1 byte	0.8 per 2 bytes	Cycle Time, μsec		WORKING STORAGE
156,000	625,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Checking		WORKING STORAGE
None	Optional	Storage Protection		WORKING STORAGE
Dual-spindle disc unit is required in every Century 100 system; all software is disc-oriented	Dual-spindle disc unit is required in every Century 200 system; all software is disc-oriented	Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			NCR 315 & 315-100	NCR 315 RMC
DATA STRUCTURE	Word Length	Binary Bits	12 + parity	12 + parity
		Decimal Digits	3	3
		Characters	2	2
	Floating Point Representation	Radix	Decimal	Decimal
		Fraction Size	11 digits	11 digits
		Exponent Size	3 digits	3 digits
CENTRAL PROCESSOR	Model Number		315-3 thru 315-5, 315-101	315-501
	Arithmetic Radix		Decimal	Decimal
	Operand Length, Words		1 to 8	1 to 8
	Instruction Length, Words		2 or 4	2 or 4
	Addresses per Instruction		1	1
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	138	19.5
		c = ab	568	97.2
		c = a/b	1,414	458.4
	Likely Floating Point Execution Times, μsec	c = a + b	1,232 (s)	48.2
		c = ab	3,132 (s)	261.2
		c = a/b	3,332 (s)	523.2
	Checking of Data Transfers		Parity	Parity
	Program Interrupt Facility		Yes, I/O only; processor malfunction*	Yes, I/O only; processor malfunction*
	Number of Index Registers		30	30
	Indirect Addressing		None	None
	Special Editing Capabilities		Good	Good
	Boolean Operations		None	None
	Table Look-up		Fair	Fair
	Console Typewriter		Yes	Yes
	Input-Output Channels		1 integrated non-simultaneous channel; optional tape read/write/ compute facility	1 integrated non-simultaneous channel; optional tape read/write/compute facility
	Features and Comments		Multiply/divide is standard in 315, optional in 315-100	Program compatible with NCR 315 and 315-100
WORKING STORAGE	Model Number		316	316-502, 316-504
	Type of Storage		Core	Thin film
	Number of Words	Minimum	5,000	20,000
		Maximum	40,000	80,000
	Maximum Total Storage	Decimal Digits	120,000	240,000
		Characters	80,000	160,000
	Cycle Time, μsec		6	0.8
	Effective Transfer Rate, char/sec		83,000	1,244,000
	Checking		Parity	Parity
	Storage Protection		None	None
	Features and Comments			Entire working storage is thin-film "Rod Memory"

* With optional equipment.
(s) Using subroutine.

RCA Spectra 70					System Identity		
70/15	70/25	70/35	70/45	70/55			
8 per byte	8 per byte	8 per byte	8 per byte	8 per byte	Binary Bits	Word Length	DATA STRUCTURE
2 per byte	2 per byte	2 per byte	2 per byte	2 per byte	Decimal Digits		
1 per byte	1 per byte	1 per byte	1 per byte	1 per byte	Characters		
---	---	Binary	Binary	Binary	Radix	Floating Point Representation	
---	---	24 or 56 bits	24 or 56 bits	24 or 56 bits	Fraction Size		
---	---	7 bits	7 bits	7 bits	Exponent Size		
70/15	70/25	70/35	70/45	70/55	Model Number		CENTRAL PROCESSOR
Binary, decimal	Binary, decimal	Binary, decimal	Binary, decimal	Binary, decimal	Arithmetic Radix		
Variable	Variable	Variable	Variable	Variable	Operand Length, Words		
4 or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	Instruction Length, Words		
0, 1, or 2	0, 1, or 2	0, 1, or 2	0, 1, or 2	0, 1, or 2	Addresses per Instruction		
62	23 or 49	51 or 80	25 or 42	7.8 or 20	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
(s)	406	163 or 276	82 or 126	18 or 58	c = ab		
(s)	469	243 or 487	111 or 209	25 or 46	c = a/b		
---	---	81 or 116	37 or 53	13.4 or 19.0	c = a + b	Likely Floating Point Execution Times, μsec	
---	---	203 or 536	68 or 212	24.2 or 53.1	c = ab		
---	---	446 or 1282	101 or 305	28.6 or 83.8	c = a/b		
Parity	Parity	Parity	Parity	Parity	Checking of Data Transfers		
Yes, limited	Yes, 4-level	Yes, multi-level	Yes, multi-level	Yes, multi-level	Program Interrupt Facility		
None	15 max.	16 max.	16 max.	16 max.	Number of Index Registers		
None	None	None	None	None	Indirect Addressing		
Fair	Fair	Good	Good	Good	Special Editing Capabilities		
AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		
None	None	None	None	None	Table Look-up		
Optional	Optional	Optional	Optional	Optional	Console Typewriter		
1 with 6 sub-channels, 3 of which can operate simultaneously	4 to 8 selector channels; 0 or 1 multiplexor channel	0 to 2 selector channels; 1 multiplexor channel	0 to 3 selector channels; 1 multiplexor channel	0 to 6 selector channels; 1 multiplexor channel	Input-Output Channels		
No multiply or divide instructions	Multiply-divide in decimal radix only	Program compatible with IBM System/360; uses integrated circuits	Program compatible with IBM System/360; uses integrated circuits	Program compatible with IBM System/360; uses integrated circuits	Features and Comments		
70/15	70/25	70/35	70/45	70/55	Model Number		WORKING STORAGE
Core	Core	Core	Core	Core	Type of Storage		
4,096 bytes	16,384 bytes	16,384 bytes	16,384 bytes	65,536 bytes	Minimum	Number of Words	
8,192 bytes	65,536 bytes	65,536 bytes	262,144 bytes	524,288 bytes	Maximum		
16,384	131,072	131,072	524,288	1,048,576	Decimal Digits	Maximum Total Storage	
8,192	65,536	65,536	262,144	524,288	Characters		
2.0 per 1 byte	1.5 per 4 bytes	1.44 per 2 bytes	1.44 per 2 bytes	0.84 per 4 bytes	Cycle Time, μsec		
250,000	1,333,333	695,000	695,000	1,136,000	Effective Transfer Rate, char/sec		
Parity	Parity	Parity	Parity	Parity	Checking		
None	None	Write only*	Write only*	Write only*	Storage Protection		
No general-purpose registers	15 general-purpose registers in core storage	16 general-purpose registers in core storage	16 general-purpose registers in fast scratchpad memory	16 general-purpose registers in fast scratchpad memory	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			RCA Spectra 70/46	RCA 301		RCA 3301	
DATA STRUCTURE	Word Length	Binary Bits	8 per byte	6 + parity		6 + parity	
		Decimal Digits	2 per byte	1		1	
		Characters	1 per byte	1		1	
	Floating Point Representation	Radix	Binary	Decimal		Decimal	
		Fraction Size	24 or 56 bits	8 digits		8 digits	
		Exponent Size	7 bits	2 digits		2 digits	
CENTRAL PROCESSOR	Model Number		70/46	303, 304, 305	354, 355	3303	3304
	Arithmetic Radix		Binary, decimal	Decimal	Decimal	Decimal	
	Operand Length, Words		Variable	1 to 44 char	8 or 1 to 44 char	1 to 44 char	
	Instruction Length, Words		2,4, or 6 bytes	10 char	10 char	10 char	
	Addresses per Instruction		0,1, or 2	2	2	2	
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	25 or 42	294	166	45	13
		c = ab	82 or 127	8,400(s)	434	562	25
		c = a/b	111 or 210	18,000(s)	441	1,650	41
	Likely Floating Point Execution Times, μsec	c = a + b	37 or 53	35,000(s)	196	---	13
		c = ab	68 or 212	9,200(s)	476	---	26
		c = a/b	101 or 305	18,800(s)	483	---	41
	Checking of Data Transfers		Parity	Parity		Parity	
	Program Interrupt Facility		Yes, multi-level	None		Yes, flexible	
	Number of Index Registers		16 max.	3		3	
	Indirect Addressing		None	Yes		Yes; recursive	
	Special Editing Capabilities		Good	Fair		Good	
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR		AND, INC OR, EXC OR	
	Table Look-up		None	Single char only		None	
	Console Typewriter		Optional	No input; output optional		Yes	
	Input-Output Channels		0 to 4 high-speed selector channels; 1 multiplexor channel	1 integrated non-simultaneous channel; 2 additional simultaneous operations*		2 standard, a 3rd optional; also, 1 Communications Control for up to 160 devices	
	Features and Comments		Time-sharing capabilities for up to 48 remote terminals	Models 354 and 355 contain high speed arithmetic circuits		Model 3304 processes 10-character operands very efficiently	
WORKING STORAGE	Model Number		70/46	303, 304, 305		3361	
	Type of Storage		Core	Core		Core	
	Number of Words	Minimum	262, 144 bytes	10,000		40,000	
		Maximum	262, 144 bytes	40,000		160,000	
	Maximum Total Storage	Decimal Digits	524, 288	40,000		160,000	
		Characters	262, 144	40,000		160,000	
	Cycle Time, μsec		1.44 per 2 bytes	7.0		1.5 or 1.93	
	Effective Transfer Rate, char/sec		1,388,888	67,600		1,290,000	
	Checking		Parity	Parity		Parity	
	Storage Protection		Read and write	None		None	
	Features and Comments		Fast read-only memory facilitates time-shared operations	Optional 4.8 μsec memory reduces execution times by 31%		200-character control memory has 0.214 μsec cycle time	

* With optional equipment.
(s) Using subroutine.

UNIVAC III	UNIVAC SS 80/90 Model I	UNIVAC SS 80/90 Model II	UNIVAC 418 I & II	System Identity		
25 + 2 check	41 + parity	44 + parity	18 + parity	Binary Bits	Word Length	DATA STRUCTURE
6	10	11	5.3	Decimal Digits		
4	10 char. per 2 words	20 char. per 3 words	3	Characters		
---	---	---	---	Radix	Floating Point Representation	
---	---	---	---	Fraction Size		
---	---	---	---	Exponent Size		

UNIVAC III	UNIVAC SS 80/90 Model I	UNIVAC SS 80/90 Model II	UNIVAC 418 Mod I	UNIVAC 418 Mod II			
4121	Model I	Model II	418 Mod I	418 Mod II	Model Number		CENTRAL PROCESSOR
Decimal	Decimal	Decimal	Binary	Binary	Arithmetic Radix		
1 to 4	1	1	1	1	Operand Length, Words		
1	1	1	1	1	Instruction Length, Words		
1	1 + 1	1 + 1	1	1	Addresses per Instruction		
24	833	136	24	12	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
92 to 140	1,800	979	54	27	c = ab		
88 to 164	1,800	979	72	36	c = a/b		
---	---	---	561(s)	280(s)	c = a + b	Likely Floating Point Execution Times, μsec	
---	---	---	775(s)	387(s)	c = ab		
---	---	---	795(s)	397(s)	c = a/b		
Modulo 3 check	Parity	Parity	Parity	Parity	Checking of Data Transfers		
Yes, with priorty scheme	Yes, I/O only	Yes, I/O only	Yes, with priority scheme		Program Interrupt Facility		
15	3	9	8	8	Number of Index Registers		
Yes, recursive	None	None	None	None	Indirect Addressing		
None	Zero suppress	Zero suppress	None	None	Special Editing Capabilities		
AND, INC OR	AND, INC OR	AND, INC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		
None	None	None	None	None	Table Look-up		
Yes	Numeric only	Numeric only	Optional	Optional	Console Typewriter		
13, 5 of which are reserved for magnetic tape operations	1 for tape and drum	2 for tape and drum	8, 12, or 16		Input-Output Channels		
Four accumulators	I/O devices other than tape and drum are buffered		Models I and II are program-compatible; primarily for real-time applications		Features and Comments		

UNIVAC III	UNIVAC SS 80/90			UNIVAC 418 Mod I	UNIVAC 418 Mod II			
4122				418 Mod I	418 Mod II	Model Number		WORKING STORAGE
Core	Drum	Core	Drum	Core	Core	Type of Storage		
8,192	2,400	1,280	2,400	4,096	4,096	Minimum	Number of Words	
32,768	9,200	1,280	8,800	16,384	65,536	Maximum		
196,608	92,000	14,080	96,800	86,835	347,340	Decimal Digits	Maximum Total Storage	
131,072	46,000	9,386	64,566	49,152	196,608	Characters		
4.0	3,400	17	3,400	4.0	2.0	Cycle Time, μsec		
400,000	4,600 or 18,500	53,944	Up to 73,000	62,500	125,000	Effective Transfer Rate, char/sec		
Modulo 3 check	Parity	Parity	Parity	Parity	Parity	Checking		
None	None	None	None	None	None	Storage Protection		
						Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			UNIVAC 490 Series		
			UNIVAC 490	UNIVAC 491/492	UNIVAC 494
DATA STRUCTURE	Word Length	Binary Bits	30	30	30 + parity
		Decimal Digits	8.7	8.7	8.7
		Characters	5	5	5
	Floating Point Representation	Radix	---	---	Binary
		Fraction Size	---	---	48 bits + sign
		Exponent Size	---	---	11 bits
CENTRAL PROCESSOR	Model Number		8188 thru 8199	8187-88 thru 8187-99	3012-99
	Arithmetic Radix		Binary	Binary	Binary
	Operand Length, Words		1	1	1 or 2
	Instruction Length, Words		1	1	1
	Addresses per Instruction		1	1	1
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	36/29*	29.0	2.3
		c = ab	85/68*	68.2	8.7
		c = a/b	110/88*	88.3	8.7
	Likely Floating Point Execution Times, μsec	c = a + b	---	---	9.6
		c = ab	---	---	18.1
		c = a/b	---	---	18.4
	Checking of Data Transfers		None	None	None
	Program Interrupt Facility		Yes, multi-level	Yes, multi-level	Yes, multi-level
	Number of Index Registers		7	7	7
	Indirect Addressing		None	None	None
	Special Editing Capabilities		None	None	None
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		Good, via repeat mode	Good, via repeat mode	Good, via repeat mode
	Console Typewriter		Yes	Yes	Yes
	Input-Output Channels		8 or 14	491 has 8; 492 has 14	12, 16, 20, or 24 general-purpose channels
	Features and Comments				
WORKING STORAGE	Model Number		8188 thru 8199	8187-88 thru 8187-99	7005-95 thru 7005-99
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	16,384	16,384	16,384
		Maximum	32,768	65,536	131,072
	Maximum Total Storage	Decimal Digits	245,760	491,520	983,040
		Characters	163,840	327,680	655,360
	Cycle Time, μsec		6.0	4.8	0.750
	Effective Transfer Rate, char/sec		415,000	520,000	2,222,000
	Checking		None	None	Parity check
	Storage Protection		None	Yes, in 1,024-word blocks	Yes, in 64-word blocks
	Features and Comments		Accelerator feature reduces cycle time to 4.8 μsec		

* With optional equipment.
(s) Using subroutine.

UNIVAC 1004		UNIVAC 1050		UNIVAC 1107		System Identity		
6		6 + parity		36		Binary Bits	Word Length	DATA STRUCTURE
1		1		10.5		Decimal Digits	Word Length	DATA STRUCTURE
1		1		6		Characters	Word Length	DATA STRUCTURE
---		---		Binary		Radix	Floating Point Representation	DATA STRUCTURE
---		---		27 bits + sign		Fraction Size	Floating Point Representation	DATA STRUCTURE
---		---		8 bits		Exponent Size	Floating Point Representation	DATA STRUCTURE
1004 I	1004 II, 1004 III	Model III Processor	Model IV Processor	Type 7200		Model Number		CENTRAL PROCESSOR
Decimal		Decimal		Binary		Arithmetic Radix		CENTRAL PROCESSOR
1 to N char		1 to 16 char		1		Operand Length, Words		CENTRAL PROCESSOR
Plugboard wired		5 char		1		Instruction Length, Words		CENTRAL PROCESSOR
2		1		1		Addresses per Instruction		CENTRAL PROCESSOR
224	182	337	94	12.0		c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
3,800(s)	3,100(s)	1,566*	563*	20.0		c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
7,100(s)	6,000(s)	2,912*	753*	39.3		c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
---		---		22.0		c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
---		---		21.3		c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
---		---		34.7		c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
None		Parity		None		Checking of Data Transfers		CENTRAL PROCESSOR
None		Yes, 3 priority levels		Yes, multi-level		Program Interrupt Facility		CENTRAL PROCESSOR
None		7		15		Number of Index Registers		CENTRAL PROCESSOR
None		None		Yes; recursive		Indirect Addressing		CENTRAL PROCESSOR
Good		Excellent		None		Special Editing Capabilities		CENTRAL PROCESSOR
INC OR		AND, INC OR		AND. INC OR, EXC OR		Boolean Operations		CENTRAL PROCESSOR
None		None		Good		Table Look-up		CENTRAL PROCESSOR
None		Optional		Yes		Console Typewriter		CENTRAL PROCESSOR
1 integrated channel permits some I/O overlapping		3 to 8 fixed-purpose	3 to 8 general-purpose	16, 1 of which is reserved for the system console device		Input-Output Channels		CENTRAL PROCESSOR
Programmed by plugboard wiring		Model III and IV Processors are program-compatible		16 arithmetic registers; partial word capabilities		Features and Comments		CENTRAL PROCESSOR
1004 I	1004 II, 1004 III	Model III Processor	Model IV Processor	7230-7234	7200	Model Number		WORKING STORAGE
Core		Core	Core	Core	Thin-film	Type of Storage		WORKING STORAGE
961		4,096	8,192	16,384	128	Minimum	Number of Words	WORKING STORAGE
1,922		32,768	65,536	65,536	128	Maximum	Number of Words	WORKING STORAGE
1,922		32,768	65,536	688,128	1,344	Decimal Digits	Maximum Total Storage	WORKING STORAGE
1,922		32,768	65,536	393,216	768	Characters	Maximum Total Storage	WORKING STORAGE
8.0	6.5	4.5	2.0 per 2 characters	4.0	0.667	Cycle Time, μsec		WORKING STORAGE
62,400	76,700	222,000	1,000,000 max.	750,000	750,000	Effective Transfer Rate, char/sec		WORKING STORAGE
None		Parity		None	None	Checking		WORKING STORAGE
None		Only by software		Yes, write only	Yes, write only	Storage Protection		WORKING STORAGE
Core storage is used only for data				Overlapped access to each bank	Used for index, arithmetic, and I/O registers	Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			UNIVAC 1108	UNIVAC 9200 & 9300		UNIVAC 9400
DATA STRUCTURE	Word Length	Binary Bits	36 bits + parity bits	8 per byte		8 (+ parity) per byte
		Decimal Digits	10.5	2 per byte		1 or 2 per byte
		Characters	6	1 per byte		1 per byte
	Floating Point Representation	Radix	Binary	---		---
		Fraction Size	27 or 60 bits ÷ sign	---		---
		Exponent Size	8 or 11 bits	---		---
CENTRAL PROCESSOR	Model Number		3011-99	9200	9300	9400
	Arithmetic Radix		Binary	Decimal		Decimal or binary
	Operand Length, Words		1 or 2	1 to 31 digits + sign		1 to 256 bytes
	Instruction Length, Words		1	4 or 6 bytes		2, 4, or 6 bytes
	Addresses per Instruction		1	0, 1, or 2		0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	2.3	187.2	93.6	54 (dec.) or 16.8 (bin.)
		c = ab	3.9	2,980	1,490	347 (dec.)
		c = a/b	11.6	2,152	1,076	127 (dec.)
	Likely Floating Point Execution Times, μsec	c = a + b	3.3	---	---	---
		c = ab	4.1	---	---	---
		c = a/b	9.8	---	---	---
	Checking of Data Transfers		None	Parity	Parity	Parity
	Program Interrupt Facility		Yes, multi-level	Yes, I/O & processor errors		Yes; 7 levels
	Number of Index Registers		15	8	8	32 max.
	Indirect Addressing		Yes; recursive	None	None	None
	Special Editing Capabilities		None	Good*	Good	Good
	Boolean Operations		AND, INC OR, EXC OR	AND, OR	AND, OR	AND, INC OR, EXC OR
	Table Look-up		Good	None	None	None
	Console Typewriter		Yes	None	None	Standard
	Input-Output Channels		Up to 5 1108 Processors and I/O Controllers in an 1108-II; up to 16 I/O channels in each Processor and I/O Controller	Integrated controls for simultaneous operation of basic card reader, punch, and printer; 1 8-way multiplexor channel*		1 multiplexor channel with 8 subchannels; 0 to 2 selector channels
	Features and Comments		A single-processor 1108 can contain 8, 12, or 16 I/O channels	Multiply, divide, and edit instructions are optional features with the 9200 Processor		Two sets of 16 general registers; largely program-compatible with UNIVAC 9200/9300
WORKING STORAGE	Model Number		7005	9200	9300	9400
	Type of Storage		Core	Plated-wire	Plated-wire	Plated-wire thin-film
	Number of Words	Minimum	65,536	8,192 bytes	8,192 bytes	24,576 bytes
		Maximum	262,144	16,384 bytes	32,768 bytes	131,072 bytes
	Maximum Total Storage	Decimal Digits	2,752,512	32,768	65,536	262,144
		Characters	1,572,864	16,384	32,768	131,072
	Cycle Time, μsec		0.75	1.2/byte	0.60/byte	0.6 per 2 bytes
	Effective Transfer Rate, char/sec		4,000,000	59,000	118,000	416,000
	Checking		Parity check on each half-word	Parity	Parity	Parity
	Storage Protection		Read and write, in 512 word blocks	None	None	Optional
	Features and Comments		Up to 8 independent memory modules	Data structure and most instructions are IBM System/360-compatible		

* With optional equipment.
(s) Using subroutine.

HARDWARE CHARACTERISTICS COMPARISON CHARTS AUXILIARY STORAGE AND MAGNETIC TAPE

INTRODUCTION

The charts on the following pages summarize the important characteristics of the auxiliary storage and magnetic tape units for each computer system. Explanations of the entries on these charts follow. (To find all the information pertaining to a particular computer system, please refer to the Quick Reference Index.)

AUXILIARY STORAGE

Model Number	Manufacturer's identifying number for this auxiliary storage device.
Type of Storage	Storage medium used in this unit; most commonly magnetic discs, drum, or strips.
Maximum Number	Configuration restrictions as to : (1) maximum number of units that can be connected on-line, (2) maximum number of simultaneous read and/or write operations, and (3) maximum number of simultaneous seek operations. (A seek operation usually involves the repositioning of a movable access mechanism to a particular track or cylinder.)
Number of Words per Unit	Maximum and minimum data capacity of each physical unit of auxiliary storage, expressed in computer words.
Maximum Total Storage	Total on-line data capacity when the maximum number of units of this type are connected, expressed in terms of both decimal digits and alphanumeric characters.
Rotational Time, msec	Period of time required for the rotating unit (drum or disc) to complete one revolution. In general, this time represents the minimum time between successive accesses to a particular location.
Waiting Time, msec	Minimum, average, and maximum time interval, in milliseconds, between the instant when the the computer calls for a transfer of data to or from the storage device and the instant when the actual movement of data can begin. This includes the time required to reposition movable read/write heads, to transport a magnetic strip to a read/write drum, and/or to wait for a specific item on a drum or disc to pass under a read/write head.
Effective Transfer Rate, char/sec	Average rate, expressed in alphanumeric characters per second, at which data can be transferred between auxiliary storage and the computer's working storage when large blocks of data are transferred and optimum coding techniques are employed.

Sector Size, char	Minimum unit of data that can be addressed, expressed in characters or bytes. Auxiliary storage units are frequently constructed so that a variable-length field of data can be transferred by terminating the transfer after a specified number of characters, but the location of the first character transferred must be a multiple of the sector size.
Transfer Load Size, char	Number of alphanumeric characters of data that can be transferred to or from the auxiliary storage device in a single read or write operation.
Checking	Type of checking, if any, that is performed to help ensure the accuracy of data transferred to or from auxiliary storage.
Features and Comments	Noteworthy additional features or facilities, such as the use of removable disc packs; or amplification of one or more of the preceding entries.

MAGNETIC TAPE

Model Number	Manufacturer's identifying number for this magnetic tape unit.
Maximum Number of Units	Configuration restrictions as to: (1) maximum number of units that can be connected on-line, (2) maximum number of simultaneous tape read and/or write operations, (3) maximum number of units (if any) that can simultaneously search for a specified record or class of records, and (4) maximum number of tape rewind operations that can proceed simultaneously.
Demands on Processor, %	Quantitative measure of the delay imposed upon the central processor or its working (main) storage unit by data transfer operations to or from the magnetic tape unit. For example, if a tape unit requires 25 out of every 100 cycles of a core storage unit to store the data which it is reading from tape, it imposes a demand of 25%; four such tape read or write operations proceeding simultaneously would "saturate" the core storage, resulting (in most systems) in a total suspension of the execution of instructions by the processor. Demands on the processor, if any, during tape starting (acceleration) and stopping (deceleration) are also shown.
Transfer Rate, Kilochar/sec	Speeds, expressed in thousands of alphanumeric characters (or bytes) per second, at which data is transferred between magnetic tape and the computer's working (main) storage under three conditions: (1) peak speed -- the instantaneous data transfer rate when no allowances are made for tape start times, stop times, or interblock gaps; (2) effective (average) speed when reading or writing data in blocks of 1000 data characters; and (3) effective speed upon blocks of 100 data

	characters. For tape units that can read or write at two or more recording densities (Data Rows per Inch), Transfer Rates are shown for all densities.
Data Tracks	Number of tracks (divisions running parallel to the edges of the tape) in which information bits (as distinguished from checking or timing bits) are recorded; therefore, the number of information bits recorded in each row or frame of the tape. (Note that the commonly-used "7-track tape" and "9-track tape" have 6 and 8 data tracks, respectively, plus a parity track.)
Tape Speed, inches/sec	Speed with which the tape passes the read/write heads. The tape speed multiplied by the recording density in characters per inch gives the peak transfer rate in characters per second.
Data Rows per Block	Number of rows (frames) of information that can be recorded in each physical block (i.e., the section of tape between two interblock gaps). Most current tape units record one character or byte per row and can record a variable number of rows per block.
Data Rows per Inch	Recording density, expressed in terms of the number of rows of information that can be recorded in a 1-inch length of tape. Many current units offer a choice of two or more densities.
IBM 729 Compatible	Capability to read tapes written by one of the IBM 729 Series Magnetic Tape Units, which effectively established format standards for 7-track tape recording: 1/2-inch wide tape, usually in 2400-foot reels, recorded at 200, 556, or 800 rows per inch with 6 data tracks and 1 parity track and in variable block lengths with 0.75-inch interblock gaps.
IBM 2400 Compatible	Capability to read tapes written by one of the IBM 2400 Series Magnetic Tape Units, which effectively established standards for 9-track tape recording: 1/2-inch wide tape, usually in 2400-foot reels, recorded at 800 or 1600 rows per inch with 8 data tracks and 1 parity track and in variable block lengths with 0.6-inch interblock gaps.
Checking	Type of checking, if any, that is performed to help ensure the accuracy of both magnetic tape reading and writing operations.
Read Reverse	Capability to read a tape in the reverse direction and fill an input area backwards starting with the last location. This feature is of particular value in reducing the time to perform sorts.
Features and Comments	Noteworthy additional features or facilities, or amplification of one or more of the preceding entries.

System Identity			Burroughs B 100/200 Series 10-μsec Processor	Burroughs B 200 Series 6-μsec Processor	(Burroughs B 300)
AUXILIARY STORAGE	Model Number			B 475	B 475
	Type of Storage			Discs	Discs
	Maximum Number	Units On-Line		10	10
		Read/Write Operations		1	1
		Seek Operations		0	0
	Number of Words per Unit	Minimum		9,600,000	9,600,000
		Maximum		48,000,000	48,000,000
	Maximum Total Storage	Decimal Digits		480,000,000	720,000,000
		Characters		480,000,000	480,000,000
	Rotational Time, msec			40	40
	Waiting Time, msec	Minimum		0	0
		Average (Random)		20	20
		Maximum		40	40
	Effective Transfer Rate, char/sec			62,000	62,000
	Sector Size, char			96, 240, or 480	96, 240, or 480
	Transfer Load Size, char			1 to 19,200 by 96 or 240, or 480	1 to 19,200 by 96 or 240, or 480
	Checking			Multiple character check	Multiple character check
	Features and Comments		No auxiliary storage is available for these processor models		Optional Data Compress instruction permits packing of decimal digits.

System Identity			Burroughs B 100/200 Series 10-μsec Processor		Burroughs B 200 Series 6-μsec Processor		(Burroughs B 300)
MAGNETIC TAPE	Model Number		B 421	B 423	B 422	B 424	B 425
	Maximum Number of Units	On-Line	6	6	6	6	6
		Reading/Writing	1	1	1	1	1
		Searching	1	1	1	1	1
		Rewinding	6	6	6	6	6
	Demands on Processor, %	Reading/Writing	100	100	100	100	100
		Starting/Stopping	100/0	100/0	100/0	100/0	100/0
	Transfer Rate, Kilo-char/sec	Peak	50.0	24.0	66.0	66.0	72.0
		1,000-char blocks	29.6	19.0	38.5	39.8	41.9
		100-char blocks	6.3	6.6	8.0	8.7	8.8
	Tape Speed, inches/sec		90	120	120	83	90
	Data Tracks		6	6	6	6	6
	Data Rows per Block		Variable	Variable	Variable	Variable	Variable
	Data Rows per Inch		200/556	200	200/556	800	200/556/800
	IBM 729 Compatible		Yes	Yes	Yes	Yes	Yes
	IBM 2400 Compatible		No	No	No	No	No
	Checking	Reading	Track and row parity	Track and row parity	Track and row parity	Track and row parity	Track and row parity
		Writing	Read after write	Read after write	Read after write	Read after write	Read after write
	Read Reverse		No	No	No	No	No
	Features and Comments		A maximum of 4 tape units can be attached to a B 100 Series processor		B 200 Series 6-μsec processor can also use B 421 and B 423 tape units		B 300 Processor can utilize all B 400 Series tape units.

*With optional equipment.

Burroughs B 2500 & B 3500			Burroughs B 5500		System Identify		
B 9370 Series	B 9372 Series	B 9375 Series	B 430	B 475	Model Number		AUXILIARY STORAGE
Disc	Disc	Disc	Drum	Discs	Type of Storage		
2/channel	25/channel	25/channel	2	100	Units on-Line	Maximum Number	
1/channel	1/channel	1/channel	2	2	Read/Write Operations		
2/channel	5/channel	5/channel	2	2	Seek Operations		
1,000,000	10,000,000	100,000,000	32,768	1,200,000	Minimum	Number of Words per Unit	
2,000,000	50,000,000	500,000,000	32,768	6,000,000	Maximum		
8,000,000/ch	500 x 10^6/ch	500 x 10^7/ch	917,504	1,680 x 10^6	Decimal Digits	Maximum Total Storage	
4,000,000/ch	250 x 10^6/ch	250 x 10^7/ch	524,288	960 x 10^6	Characters		
34	40	46, 80, or 120	16.7	40	Rotational Time, msec		
0	0	0	0	0	Minimum	Waiting Time, msec	
17	20	23, 40, or 60	8.3	20	Average (Random)		
34	40	46, 80, or 120	16.7	40	Maximum		
291,000	218,000	216,000 to 395,000	122,880	80,000	Effective Transfer Rate, char/sec		
100	100	100	8	240	Sector Size, char		
100 to 10,000	100 to 10,000	100 to 10,000	8 to 8,124	240 to 15,120	Transfer Load Size, char		
Multiple char.	Multiple char.	Multiple char.	Parity	Multiple Char.	Checking		
Fixed heads, one per track; called "Systems Memory"	Fixed heads, one per track	Access time depends on model selected; fixed heads, 1/track		Fixed heads, one per track	Features and Comments		

B 9381	B 9382	B 9390	B 9391	B 9392	B 9393	B 422	B 423	B 424	B 425	Model Number		MAGNETIC TAPE
4/channel		10/channel				16	16	16	16	On-Line	Maximum Number of Units	
1/channel		1/channel				4	4	4	4	Reading/Writing		
0		0				0	0	0	0	Searching		
4/channel		10/channel				16	16	16	16	Rewinding		
Varies		Varies				0 to 3.3	0 to 3.2	0 to 3.3	0 to 3.6	Reading/Writing	Demands on Processor, %	
Varies		Varies				0	0	0	0	Starting/Stopping		
36.0	72.0	50.0	72.0	72.0	144.0	66.0	24.0	66.0	72.0	Peak	Transfer Rate, Kilo-char/sec	
24.0	30.2	35.5	44.6	49.0	73.4	64.4	63.5	64.4	68.9	1,000-char blocks		
6.5	7.2	9.5	10.1	12.2	13.0	14.8	32.3	14.8	18.0	100-char blocks		
45	45	90	90	90	90	120	120	83	90	Tape Speed, inches/sec		
8;6*	8;6*	6	6	8	8	6				Data Tracks		
Variable		Variable				Variable				Data Rows per Block		
200/800	200/800/1600	200/556	200/556/800	200/800	200/800/1600	220/556	200	800	200/556/800	Data Rows per Inch		
Yes*	Yes*	Yes	Yes	No	No	Yes				IBM 729 Compatible		
Yes	Yes	No	No	Yes	Yes	No				IBM 2400 Compatible		
Track and row parity		Track and row parity				Track and row parity				Reading	Checking	
Read after write		Read after write				Read after write				Writing		
Yes		Yes				Yes				Read Reverse		
Optional 7-channel recording										Features and Comments		

*With optional equipment.

System Identity			Burroughs B 6500 & B 7500		
AUXILIARY STORAGE	Model Number		B 9375-0	B 9375-2	B 9375-3
	Type of Storage		Discs	Discs	Discs
	Maximum Number	Units on-Line	10/control	10/control	10/control
		Read/Write Operations	1/control	1/control	1/control
		Seek Operations	---	---	---
	Number of Words per Unit	Minimum	100 x 10^6 bytes	100 x 10^6 bytes	100 x 10^6 bytes
		Maximum	100 x 10^6 bytes	100 x 10^6 bytes	100 x 10^6 bytes
	Maximum Total Storage	Decimal Digits	Up to 2 x 10^9 bytes/control		
		Characters	Up to 1 x 10^9 bytes/control		
	Rotational Time, msec		46	46	120
	Waiting Time, msec	Minimum	0	0	0
		Average (Random)	23	40	60
		Maximum	46	80	120
	Effective Transfer Rate, char/sec		377,000	216,000	395,000
	Sector Size, char		100	100	100
	Transfer Load Size, char		?		
	Checking		Longitudinal check characters		
	Features and Comments		Fixed heads, one per track; storage capacities are highly modular; "exchange" units permit 2-way or 4-way read/write simultaneity within one bank of disc modules		

MAGNETIC TAPE	Model Number		B 9381	B 9382	B 9392	B 9393	B 9394-2
	Maximum Number of Units	On-Line	8/control		6/control		
		Reading/Writing	1/control		1/control		
		Searching	0		0		
		Rewinding	All		All		
	Demands on Processor, %	Reading/Writing	Varies		Varies		
		Starting/Stopping	Varies		Varies		
	Transfer Rate, Kilo-char/sec	Peak	36.0	72.0	72.0	144	96.0
		1,000-char blocks	24.0	30.2	49.0	73.4	64.2
		100-char blocks	6.5	7.2	12.2	13.0	16.2
	Tape Speed, inches/sec		45	45	90	90	120
	Data Tracks		8		8		
	Data Rows per Block		Variable		Variable		
	Data Rows per Inch		800/200*	1600	800/200*	1600	800/200*
	IBM 729 Compatible		Yes*		Yes*		
	IBM 2400 Compatible		Yes		Yes		
	Checking	Reading	Parity		Parity		
		Writing	Read after write		Read after write		
	Read Reverse		Yes		Yes		
	Features and Comments		2, 3, or 4 tape drives in a single cabinet.		Free-standing tape drives; "exchange" units permit up to 4 controls to serve up to 16 drives.		

*With optional equipment.

CDC 160 & 160-A	CDC 1604	CDC 1604-A	System Identify		
8951	818	818	Model Number		AUXILIARY STORAGE
Drum	Discs	Discs	Type of Storage		
1	28	28	Units on-Line	Maximum Number	
1	1	6	Read/Write Operations		
1	6	6	Seek Operations		
32,864	4,194,304	4,194,304	Minimum	Number of Words per Unit	
32,864	4,194,304	4,194,304	Maximum		
108,400	938×10^6	938×10^6	Decimal Digits	Maximum Total Storage	
65,728	938×10^6	938×10^6	Characters		
---	---	---	Rotational Time, msec		
---	0	0	Minimum	Waiting Time, msec	
---	146	146	Average (Random)		
---	226	226	Maximum		
32,000 max	98,000 max	98,000 max	Effective Transfer Rate, char/sec		
---	---	---	Sector Size, char		
32,768	8 to 32,768	8 to 32,768	Transfer Load Size, char		
---	Check characters	Check characters	Checking		
	Individually positionable access arm serves each disc	Individually positionable access arm serves each disc	Features and Comments		

603	606	1607	IBM 729 II	IBM 729 IV	606	Model Number		MAGNETIC TAPE
8	8	24	24	24	48	On-Line	Maximum Number of Units	
1 (2* in 160-A)	1 (2* in 160-A)	6	2	2	6	Reading/Writing		
0	0	0	0	0	0	Searching		
8	8	24	24	24	48	Rewinding		
100 (80* in 160-A)	100 (83* in 160-A)	5.4	7.8 max	11.3 max	3.3 max	Reading/Writing	Demands on Processor, %	
---	---	0	0	0	0	Starting/Stopping		
41.7	83.3	30.0	41.7	62.5	83.3	Peak	Transfer Rate, Kilo-char/sec	
24.7	49.0	27.4	27.3	40.3	49.0	1,000-char blocks		
5.4	10.4	10.2	6.7	9.6	10.4	100-char blocks		
75	150	150	75	112.5	150	Tape Speed, inches/sec		
6	6	6	6	6	6	Data Tracks		
Variable	Variable	Variable	Variable	Variable	Variable	Data Rows per Block		
200/556	200/556	200	200/556	200/556	200/556	Data Rows per Inch		
Yes	Yes	Yes	Yes	Yes	Yes	IBM 729 Compatible		
No	No	No	No	No	No	IBM 2400 Compatible		
Track and row parity		Row parity	Row parity		Row parity	Reading	Checking	
Read after write		Row parity	Read after write		Read after write	Writing		
No	No	Yes	No	No	No	Read Reverse		
						Features and Comments		

*With optional equipment.

System Identity			CDC 3100, 3300, & 3500					CDC 3400, 3600, & 3800	
AUXILIARY STORAGE	Model Number		852	853	854	813 & 814	863	813 & 814	863
	Type of Storage		Discs	Discs	Discs	Discs	Drum	Discs	Drum
	Maximum Number	Units on-Line	5/ch	8/ch	8/ch	8/ch	8/ch	8/ch	8/ch
		Read/Write Operations	1/ch	1/ch	1/ch	1/ch	1/ch	1/ch	1/ch
		Seek Operations	1	1	1	2	1	2	1
	Number of Words per Unit	Minimum	0.5×10^6	1.1×10^6	2.0×10^6	50.3×10^6	1.0×10^6	50.3×10^6	1.0×10^6
		Maximum	0.7×10^6	1.1×10^6	2.0×10^6	50.3×10^6	1.0×10^6	50.3×10^6	1.0×10^6
	Maximum Total Storage	Decimal Digits	14.9×10^6	32.7×10^6	65.5×10^6	1.6×10^9	33.5×10^6	1.6×10^9	33.5×10^6
		Characters	14.9×10^6	32.7×10^6	65.5×10^6	1.6×10^9	33.5×10^6	1.6×10^9	33.5×10^6
	Rotational Time, msec		40	25	25	50.9	50.9	50.9	50.9
	Waiting Time, msec	Minimum	0	0	0	0	0	0	0
		Average (Random)	67.5	67.5	67.5	65	16.7	65	16.7
		Maximum	165	165	165	110	33.4	110	33.4
	Effective Transfer Rate, char/sec		69,840	193,750	193,750	160,000	1,308,104	160,000	1,308,104
	Sector Size, char		100	256	256	256	100	256	100
	Transfer Load Size, char		1 to 40,960	1 to 40,960	1 to 40,960	1 to 4,096	2 to 131,072	1 to 4,096	2 to 131,072
	Checking		Parity	Parity	Parity	Parity	Parity	Parity	Parity
	Features and Comments		Compatible with IBM 1311	Removable Disc Packs	Removable Disc Packs	Dual-channel controllers are standard	Various interlacing factors can be selected	Dual-channel controllers are standard	Various interlacing factors can be selected

			600 Series			
MAGNETIC TAPE	Model Number		7-Track Units	9-Track Units	604	607
	Maximum Number of Units	On-Line	16/ch	2/ch	512	512
		Reading/Writing	8	8	4	4
		Searching	0	0	0	0
		Rewinding	All	All	512	512
	Demands on Processor, %	Reading/Writing	Varies	Varies	4.5	8.9
		Starting/Stopping	0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak	120.0	30.0	60.0	120.0
		1,000-char blocks	74.4	20.3	36.0	64.0
		100-char blocks	16.8	5.2	6.8	12.4
	Tape Speed, inches/sec		150	150	75	150
	Data Tracks		6	8	6	
	Data Rows per Block		Variable	Variable	Variable	
	Data Rows per Inch		200/556/800	200/800	200/556/800	
	IBM 729 Compatible		Yes	No	Yes	
	IBM 2400 Compatible		No	No	No	
	Checking	Reading	Track and row parity	Track and row parity	Track and row parity	
		Writing	Read after write	Read after write	Read after write	
	Read Reverse		Yes	Yes	No	Yes
	Features and Comments				1, 2, 3, and 4-channel controllers available	

*With optional equipment.

Control Data 6000 Series					System Identify		
6400/6600/ 6800 Extended Core Storage	6603	6638	853	854	Model Number		AUXILIARY STORAGE
Core	Disc	Disc	Disc	Disc	Type of Storage		
1, 2, 4, 8, or 16 modules	8	8	8	8	Units on-Line	Maximum Number	
1	1/ch	1/ch	1/ch	1/ch	Read/Write Operations		
---	1/ch	1/ch	1/ch	1/ch	Seek Operations		
125,952	8×10^6	84×10^6	2.048×10^6	4.086×10^6	Minimum	Number of Words per Unit	
2,015,232	8×10^6	84×10^6	2.048×10^6	4.086×10^6	Maximum		
37,028,736	144×10^6	294×10^6	7.168×10^6	14.3×10^6	Decimal Digits	Maximum Total Storage	
20,971,520	80×10^6	168×10^6	32.768×10^6	65.536×10^6	Characters		
---	63.2	52.6	25	25	Rotational Time, msec		
.0032	0	0	0	0	Minimum	Waiting Time, msec	
.0032	153	25	70	70	Average (Random)		
.0032	186	110	170	170	Maximum		
25×10^6 to 100×10^6	2 to 1,195,297	1,666,666	193,750	193,750	Effective Transfer Rate, char/sec		
---	704	256	256	256	Sector Size, char		
10 to 1,200,000	2 to 88,376	2 to 40,956	2 to 40,960	2 to 40,960	Transfer Load Size, char		
None	Parity	Parity	Parity	Parity	Checking		
			Removable Disc Packs	Removable Disc Packs	Features and Comments		

607-7 Track	Model Number		MAGNETIC TAPE
6/ch	On-Line	Maximum Number of Units	
1/ch	Reading/Writing		
1/ch	Searching		
All	Rewinding		
0	Reading/Writing	Demands on Processor, %	
0	Starting/Stopping		
120.0	Peak	Transfer Rate, Kilo-char/sec	
74.4	1,000-char blocks		
16.8	100-char blocks		
150	Tape Speed, inches/sec		
7	Data Tracks		
Variable	Data Rows per Block		
200/556/800	Data Rows per Inch		
Yes	IBM 729 Compatible		
No	IBM 2400 Compatible		
Track and row parity	Reading	Checking	
Read after write	Writing		
Yes	Read Reverse		
	Features and Comments		

*With optional equipment.

System Identity			GE-115		GE-130	
AUXILIARY STORAGE	Model Number		DSS130		DSU160	
	Type of Storage		Disc		Discs	
	Maximum Number	Units on-Line	5/controller		8/controller	
		Read/Write Operations	1		1/controller	
		Seek Operations	1		8/controller	
	Number of Words per Unit	Minimum	2,000,000 chars		192,000	
		Maximum	4,470,000 digits		192,000	
	Maximum Total Storage	Decimal Digits	89.4 x 10^6 controller		92 x 10^6/controller	
		Characters	59.6 x 10^6 controller		6.14 x 10^6/controller	
	Rotational Time, msec		40		25	
	Waiting Time, msec	Minimum	0		0	
		Average (Random)	95		85	
		Maximum	185		165	
	Effective Transfer Rate, char/sec		50,000		111,000	
	Sector Size, char		100		384	
	Transfer Load Size, char		1 to 1,024		1 to 38,400	
	Checking		Parity; synchronization		Parity check char.	
	Features and Comments		Changeable "Disk Pack" storage medium		Compatible with IBM 1316	
MAGNETIC TAPE	Model Number		MTH103	MTH106	MTH103	MTH106
	Maximum Number of Units	On-Line	6/controller	6/controller	6/controller	6/controller
		Reading/Writing	1	1	1/controller	1/controller
		Searching	0	0	0	0
		Rewinding	All	All	All	All
	Demands on Processor, %	Reading/Writing	100.0	100.0	?	?
		Starting/Stopping	100.0	100.0	?	?
	Transfer Rate, Kilo-char/sec	Peak	30.0	60.0	30.0	60.0
		1,000-char blocks	20.3	40.5	20.3	40.5
		100-char blocks	5.2	10.3	5.2	10.3
	Tape Speed, inches/sec		37.5	75	37.5	75
	Data Tracks		8 or 6*	8 or 6*	8 or 6*	8 or 6*
	Data Rows per Block		Variable	Variable	Variable	Variable
	Data Rows per Inch		800/556*/200*	800/556*/200*	800/556*/200*	800/566*/200*
	IBM 729 Compatible		Yes*	Yes*	Yes*	Yes*
	IBM 2400 Compatible		Yes	Yes	Yes	Yes
	Checking	Reading	Track, row, and diagonal parity		Track, row, and diagonal parity	
		Writing	Read after write		Read after write	
	Read Reverse		Yes		Yes	
	Features and Comments		Up to four controllers can be connected to the central processor			

*With optional equipment.

GE-200 Series	GE-400 Series		System Identify		
DSU204	DSU270	MSU388	Model Number		AUXILIARY STORAGE
Discs	Discs	Magnetic cards	Type of Storage		
4 or 32	4/channel	4/channel	Units on-Line	Maximum Number	
1	1/channel	4/channel	Read/Write Operations		
4 or 32	4/channel	4/channel	Seek Operations		
6,290,000	3.8×10^6	84.8×10^6	Minimum	Number of Words per Unit	
6,290,000	3.8×10^6	84.8×10^6	Maximum		
138.4×10^6 to $1,107 \times 10^6$	94×10^6/ch	$1,356 \times 10^6$/ch	Decimal Digits	Maximum Total Storage	
75.5×10^6 to 604×10^6	307.2×10^6/ch	$1,356 \times 10^6$/ch	Characters		
50	31	—	Rotational Time, msec		
0	0	0	Minimum	Waiting Time, msec	
225	26	550	Average (Random)		
357	52	600	Maximum		
60,000	324,000	35,000/42,000	Effective Transfer Rate, char/sec		
192	384	6	Sector Size, char		
192 to 3,072 by 192	1 to max core	1 to max core	Transfer Load Size, char		
Parity	Parity; check char	Parity; read after write	Checking		
Capacity varies with 200 Series processor model		Changeable storage	Features and Comments		

MTH680	MTH690	MT Series (7-track)	MT Series (9-track)	Model Number		MAGNETIC TAPE
8, 56, or 64	64 or 56	8/channel	8/channel	On-Line	Maximum Number of Units	
1, 7, or 8	2 or 4	1/channel	1/channel	Reading/Writing		
0	0	0	0	Searching		
8, 56, or 64	64 or 56	All	All	Rewinding		
18, 3, or 9	25 or 8.3	3.5 to 23.2	4.8 to 31.0	Reading/Writing	Demands on Processor, %	
0	0	0	0	Starting/Stopping		
15.0	41.6	20.9 to 120	28 to 160	Peak	Transfer Rate, Kilo-char/sec	
12.7	29.0	14.6 to 73.5	17.7 to 86.6	1,000-char blocks		
5.3	6.9	3.9 to 16.3	4.1 to 16.8	100-char blocks		
75	75	37.5; 75; 150	37.5; 75; 150	Tape Speed, inches/sec		
6	6	6	8	Data Tracks		
Variable	Variable	Variable	Variable	Data Rows per Block		
200	200/556	200/556/800	200/556/800	Data Rows per Inch		
Yes		Yes	No	IBM 729 Compatible		
No		No	Yes	IBM 2400 Compatible		
Track and row parity		Track and row parity	3-way parity	Reading	Checking	
Read after write		Read after write	Read after write	Writing		
Yes	Yes	No	No	Read Reverse		
Capacity varies with 200 Series processor model		6 models, varying in tape speeds and densities	6 models, varying in tape speeds and densities	Features and Comments		

*With optional equipment.

System Identity			GE - 600 Series			
AUXILIARY STORAGE	Model Number		DSU200	DSU270	MDS200	MSU338
	Type of Storage		Discs	Discs	Drum	Magnetic cards
	Maximum Number	Units on-Line	4/channel	4/channel	1/channel	4/controller
		Read/Write Operations	1/channel	1/channel	1/channel	1/unit
		Seek Operations	1/unit	4/channel	1/unit	1/unit
	Number of Words per Unit	Minimum	983,000	3.8×10^6	768,432	56.6×10^6
		Maximum	3,925,000	3.8×10^6	768,432	113.2×10^6
	Maximum Total Storage	Decimal Digits	94×10^6/ch	94×10^6/ch	7.90×10^6/ch	2.7×10^9
		Characters	94×10^6/ch	307.2×10^6/ch	4.55×10^6/ch	2.7×10^9
	Rotational Time, msec		50	31	33.3	---
	Waiting Time, msec	Minimum	0	0	0	0
		Average (Random)	225	26	16.7	375
		Maximum	357	52	33.3	573
	Effective Transfer Rate, char/sec		69,500	324,000	372,000	35,000/42,000
	Sector Size, char		1 to 240	384	6	---
	Transfer Load Size, char		240 to 7,680	6 to 1.57×10^6	6 to 262,144	648 to 262,144
	Checking		Parity, check character	Parity, check character	Parity	Parity
	Features and Comments		Optional fast access feature uses fixed access arms		An adaptation of the UNIVAC FH-880 Drum	MMS-388 is manufactured by RCA as model 3488 RACE

MAGNETIC TAPE	Model Number		MT Series (7-track)	MT Series (9-track)
	Maximum Number of Units	On-Line	16/channel	16/channel
		Reading/Writing	1/channel	1/channel
		Searching	0	0
		Rewinding	All	All
	Demands on Processor, %	Reading/Writing	0.35 to 4.0	0.47 to 5.4
		Starting/Stopping	0	0
	Transfer Rate, Kilo-char/sec	Peak	20.9 to 120	28 to 160
		1,000-char blocks	14.5 to 70	17.7 to 86.5
		100-char blocks	3.9 to 14.7	4.1 to 16.8
	Tape Speed, inches/sec		37.5; 75; 150	37.5; 75; 150
	Data Tracks		6	8
	Data Rows per Block		Variable	Variable
	Data Rows per Inch		200/556/800	200/556/800
	IBM 729 Compatible		Yes	No
	IBM 2400 Compatible		No	Yes
	Checking	Reading	Track & row parity	Track & row parity
		Writing	Read after write, Track & row parity	Read after write
	Read Reverse		No	No
	Features and Comments		6 models, varying in tape speed and densities	6 models, varying in tape speed and densities

*With optional equipment.

Honeywell Series 200				System Identify		
258B	258/259/259A	261/262	270A	Model Number		AUXILIARY STORAGE
Disc	Discs	Discs	Drum	Type of Storage		
2	8/control	261: 8/control 262: 4/control	8/control	Units on-Line	Maximum Number	
1	1/channel	1/control	1/control	Read/Write Operations		
7	1/disc drive	261: 1/disc drive 262: 2/disc drive	0	Seek Operations		
4.6×10^6	258: 4.6×10^6 char 259: 9.2×10^6 char	261: 150 x 106 char 262: 300 x 10^6 char	2.6×10^6 char	Minimum	Number of Words per Unit	
4.6×10^6	258: 4.6 x 106 char 259: 9.2 x 106 char	261: 150 x 106 char 262: 300 x 10^6 char	2.6×10^6 char	Maximum		
4.6×10^6	73.6×10^6/control	1.2×10^9/control	20.8×10^6/control	Decimal Digits	Maximum Total Storage	
4.6×10^6	73.6×10^6/control	1.2×10^9/control	20.8×10^6/control	Characters		
25	25	35.3	50.8	Rotational Time, msec		
0	0	0	0	Minimum	Waiting Time, msec	
107.5	92.0/92.1/97.0	78	31	Average (Random)		
142.5	175/175/185	120	57.3	Maximum		
80,800	258: 35,929; 259: 35,810; 259A: 32,000	189,393	111,000	Effective Transfer Rate, char/sec		
Variable	Variable	Variable	128	Sector Size, char		
32,768	1 to 4,602	1 to 9,216	1 to N	Transfer Load Size, char		
Validity	Parity	Parity	Parity	Checking		
For Model 110 only				Features and Comments		

204B-17	204B-18	204A Series	204B Series	204C Series	Model Number		MAGNETIC TAPE
1	3	8/controller	8/controller	2/controller	On-Line	Maximum Number of Units	
1*		1 per device	1 per device	1 per device	Reading/Writing		
1*		0	0	0	Searching		
1*		All	All	All	Rewinding		
11.55		Varies widely	Varies widely	Varies widely	Reading/Writing	Demands on Processor, %	
0		0	0	0	Starting/Stopping		
8.896		32.0 to 88.8	4.8 to 144.0	28.8	Peak	Transfer Rate, Kilo-char/sec	
8.79		23.7 to 59.7	4.2 to 77.7	19.4	1,000-char blocks		
7.06		7.1 to 15.1	1.92 to 15.8	5.0	100-char blocks		
26		60/120	26	36/60/120	Tape Speed, inches/sec		
6		8	6	8	Data Tracks		
Variable		Variable	Variable	Variable	Data Rows per Block		
556/200*		533/740	200/556/800/1200*	800	Data Rows per Inch		
Yes*		No	Yes*	No	IBM 729 Compatible		
No		No	No	Yes	IBM 2400 Compatible		
Parity		Track & row parity, plus Orthotronic sys.	Track & row parity, plus Orthotronic sys.	Track & row parity, plus Orthotronic sys.	Reading	Checking	
Parity		None	Read after write	Read after write	Writing		
Yes		No	Yes	No	Read Reverse		
Cannot be used on 110-2 Disc system		Compatible with H-400/1400/800/1800 tapes	Model 204B-9 units can be modified to handle 1200 bpi tape		Features and Comments		

*With optional equipment.

System Identity			Honeywell Series 200			Honeywell 400 & 1400	Honeywell 800 & 1800
AUXILIARY STORAGE	Model Number		265	266	267	460	860
	Type of Storage		Drum			Discs	Discs
	Maximum Number	Units on-Line	4/control			1	8
		Read/Write Operations	1/control			1	1/unit
		Seek Operations	4/control			1	1/unit
	Number of Words per Unit	Minimum	4200	4200	16,425	1,572,864	6,291,456
		Maximum	4200	4200	16,425	12,582,912	100,663,296
	Maximum Total Storage	Decimal Digits	2.1×10^6	4.2×10^6	4.2×10^6	150×10^6	$1,208 \times 10^6$
		Characters	2.1×10^6	4.2×10^6	4.2×10^6	10×10^6	805×10^6
	Rotational Time, msec		17.2	17.2	17.2	67	67
	Waiting Time, msec	Minimum	0	0	0	0	0
		Average (Random)	8.6	8.6	8.6	129	40
		Maximum	17.2	17.2	17.2	197	197
	Effective Transfer Rate, char/sec		300,000	300,000	1.2×10^6	27,800 to 75,000	85,000
	Sector Size, char		?	?	?	512	512
	Transfer Load Size, char		1 to 4200	1 to 4200	1 to 16,425	512	512
	Checking		Write-read check code			Parity	Parity
	Features and Comments						

			Honeywell Series 200	Honeywell 400 & 1400			Honeywell 800 & 1800			
MAGNETIC TAPE	Model Number			404-3	404-1	404-2	804-1	804-2	804-3	804-4
	Maximum Number of Units	On-Line		8 (16 on H-1400)	8 (16 on H-1400)	8 (16 on H-1400)	64	64	64	64
		Reading/Writing		2	2	2	8+8	8+8	8+8	8+8
		Searching		0	0	0	0	0	0	0
		Rewinding		8 (16 on H-1400)	8 (16 on H-1400)	8 (16 on H-1400)	64	64	64	64
	Demands on Processor, %	Reading/Writing		100	100	100	1.6 to 15.0	2.2 to 20.0	0.8 to 7.5	3.3 to 30.0
		Starting/Stopping		100/0	100/0	100/0	0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak		32.0	64.0	89.0	64.0	89.0	32.0	124.0
		1,000-char blocks		23.5	47.0	59.0	47.0	59.0	23.5	83.0
		100-char blocks		6.8	13.6	14.5	13.6	14.5	6.8	20.6
	Tape Speed, inches/sec			60	120	120	120	120	60	120
	Data Tracks			8	8	8	8			
	Data Rows per Block			18 to N	18 to N	18 to N	Variable			
	Data Rows per Inch			400	400	555	400	555	400	777
	IBM 729 Compatible			No			No			
	IBM 2400 Compatible			No			No			
	Checking	Reading		Track & row parity, plus Orthotronic system			Track & row parity, plus Orthotronic system			
		Writing		None			None			
	Read Reverse			No			Yes			
	Features and Comments									

*With optional equipment.

AUXILIARY STORAGE

System Identify		IBM System /360				
Model Number		2301	2302	2303	2311 Model 1	2314
Type of Storage		Drum	Disk	Drum	Discs	Discs
Maximum Number	Units on-Line	8/channel	8/channel	8/channel	64/channel	8/channel
	Read/Write Operations	1/channel	1/channel	1/channel	1/channel	1/channel
	Seek Operations	1/channel	1/channel	1/channel	64/channel	64/channel
Number of Words per Unit	Minimum	4.10 x 10^6 bytes	28 x 10^6 ch	3.9 x 10^6 bytes	7.25 x 10^6 bytes	7.3 x 10^6 bytes
	Maximum	4.10 x 10^6 bytes	28 x 10^6 ch	3.9 x 10^6 bytes	7.25 x 10^6 bytes	58.4 x 10^6 bytes
Maximum Total Storage	Decimal Digits	66 x 10^6/ch	1,794 x 10^6/ch	125x10^6/ch	928 x 10^6/ch	466 x 10^6/ch
	Characters	33 x 10^6/ch	897x10^6/ch	62.4 x 10^6/ch	464 x 10^6/ch	233 x 10^6/ch
Rotational Time, msec		17.2	34	17.5	25	25
Waiting Time, msec	Minimum	0	0	0	0	0
	Average (Random)	8.6	165	8.75	97.5	87.5
	Maximum	17.2	180	17.5	160	160
Effective Transfer Rate, char/sec		1,134,000	132,000	276,000	104,000	277,000
Sector Size, char		Variable	Variable	Variable	Variable	Variable
Transfer Load Size, char		1 to 20,483	1 to 4,984	1 to 4,892	1 to 36,250	1 to 145,880
Checking		Cyclic check code	Cyclic check code	Cyclic check code	Cyclic check code	Cyclic check code
Features and Comments		For Models 50—75 only	For Models 30—75 only	For Models 40—85 only; replaces IBM 7320	Changeable "Disk Pack" storage medium	8 on-line disc drives per 2314

MAGNETIC TAPE

Model Number		2400 Series Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6
Maximum Number of Units	On-Line	64 per channel			64 per channel		
	Reading/Writing	1 per channel			1 per channel		
	Searching	0			0		
	Rewinding	64 per channel			64 per channel		
Demands on Processor, %	Reading/Writing	Varies with processor model			Varies with processor model		
	Starting/Stopping	Varies with processor model			Varies with processor model		
Transfer Rate, Kilo-char/sec	Peak	30.0	60.0	90.0	60.0	120.0	180.0
	1,000-char blocks	20.3	40.5	60.8	30.6	61.2	91.8
	100-char blocks	5.2	10.3	15.5	5.6	11.3	16.9
Tape Speed, inches/sec		37.5	75.0	112.5	37.5	75.0	112.5
Data Tracks		8 (6 with Compatibility option)			8 (6 with Compatibility option)		
Data Rows per Block		Variable			Variable		
Data Rows per Inch		800 (200/556)*			1600 (800/556/200)*		
IBM 729 Compatible		Yes*			Yes*		
IBM 2400 Compatible		Yes			Yes		
Checking	Reading	Track, row, and diagonal parity			Row parity		
	Writing	Read after write			Read after write		
Read Reverse		Yes			Yes		
Features and Comments		Dual-channel controllers and tape switching units are available.					

*With optional equipment.

System Identity			IBM System/360		IBM System/360 Model 20	
AUXILIARY STORAGE	Model Number		2321	2361	2311 Model 11	2311 Model 12
	Type of Storage		Mag. strips	Core	Discs	Discs
	Maximum Number	Units on-Line	64/channel	4	2	2
		Read/Write Operations	1/channel	1	1	1
		Seek Operations	64/channel	---	1	1
	Number of Words per Unit	Minimum	40×10^6 bytes	1.05×10^6 bytes	5.4×10^6/ch	2.7×10^6/ch
		Maximum	400×10^6 bytes	2.10×10^6 bytes	5.4×10^6/ch	2.7×10^6/ch
	Maximum Total Storage	Decimal Digits	$51,200 \times 10^6$/ch	16.78×10^6	21.6×10^6	10.4×10^6
		Characters	$25,600 \times 10^6$/ch	8.39×10^6	10.8×10^6	5.4×10^6
	Rotational Time, msec		50	---	25	25
	Waiting Time, msec	Minimum	0	0.008	0	0
		Average (Random)	550	0.008	75	60
		Maximum	600	0.008	135	90
	Effective Transfer Rate, char/sec		25,800	500,000	81,000	82,080
	Sector Size, char		Variable	---	Variable	Variable
	Transfer Load Size, char		1 to 40,000	1 to 255	1 to 270	1 to 270
	Checking		Cyclic check code	Parity	Cyclic check code	Cyclic check code
	Features and Comments		10 changeable "Data Cells" per drive	Directly addressable; for Models 50—75 only	Changeable storage medium	Changeable storage medium
MAGNETIC TAPE	Model Number		2415 Series	7340 Model 3	2415 Series	
	Maximum Number of Units	On-Line	48/channel	64/channel	6 drives	
		Reading/Writing	1/channel	1/channel	1	
		Searching	0	0	1	
		Rewinding	48/channel	64/channel	6	
	Demands on Processor, %	Reading/Writing	Varies	Varies	Varies	
		Starting/Stopping	Varies	Varies	Varies	
	Transfer Rate, Kilo-char/sec	Peak	15.0 or 30.0	340.0	15.0 or 30.0	
		1,000-char blocks	10.1 or 15.3	160	10.1 or 15.3	
		100-char blocks	2.6 or 2.8	27	2.6 or 2.8	
	Tape Speed, inches/sec		18.75	112.5	18.75	
	Data Tracks		8 or 6*	8	8 or 6*	
	Data Rows per Block		Variable	Variable	Variable	
	Data Rows per Inch		800 or 1600 (200/556)*	1,511 or 3,022	800 or 1600 (200/556)*	
	IBM 729 Compatible		Yes*	No	Yes*	
	IBM 2400 Compatible		Yes	No	Yes	
	Checking	Reading	Same as 2400's	Dual-row parity	Same as 2400's	
		Writing	Read after write	Read after write	Read after write	
	Read Reverse		Yes	Yes	Yes	
	Features and Comments		Models 1, 2, and 3 lack the error correction feature	Cartridge-loaded	Models 1, 2, and 3 lack the error correction feature	

*With optional equipment.

IBM 1401 & 1460		IBM 1410		IBM 1440		System Identify		
1311	1405	1301 Mod. 1, 2	1311	1301 Mod. 11, 12, 21, 22	1311	Model Number		AUXILIARY STORAGE
Discs	Discs	Discs	Discs	Discs	Discs	Type of Storage		
5	1	5	10	5	5	Units on-Line	Maximum Number	
1	1	2	2	1	1	Read/Write Operations		
1 or 5*	1 or 3*	10	2 or 10*	5	1 or 5*	Seek Operations		
2,000,000	10,000,000	28,000,000	2,000,000	20,000,000	2,000,000	Minimum	Number of Words per Unit	
2,980,000*	20,000,000	56,000,000	2,980,000*	40,000,000	2,980,000*	Maximum		
14.9×10^{6}	20×10^{6}	280×10^{6}	29.8×10^{6}	100×10^{6}	14.9×10^{6}*	Decimal Digits	Maximum Total Storage	
14.9×10^{6}	20×10^{6}	280×10^{6}	29.8×10^{6}	100×10^{6}	14.9×10^{6}*	Characters		
40	50	33.5	40	33.5	40	Rotational Time, msec		
0	0	0	0	0	0	Minimum	Waiting Time, msec	
270 or 170*	600	177	170	177	270 or 174*	Average (Random)		
432 or 288*	800	214	288	214	432 or 288*	Maximum		
36,500 or 41,300*	7,530	42,000 or 82,300*	36,500 or 41,300*	41,500	38,200*	Effective Transfer Rate, char/sec		
100	200	100	100	100	100	Sector Size, char		
100 to max core by 100 (3)	200 or 1,000	1 to 2,800	100 to 20,000 by 100	100 to max core by 100 (3)	100 to max core by 100 (3)	Transfer Load Size, char		
Parity, write check	Parity, write check	Parity, write check	Parity, write check	Parity, write check	Parity, write check	Checking		
Changeable storage medium	Not available with 1460 systems	1302 can also be used	Changeable storage medium	Also usable in IBM 1401 and 1460 systems	Changeable storage medium	Features and Comments		

7330	729 Series	7340 Mod. 2	7330	729 Series	7335	Model Number		MAGNETIC TAPE
6	6	4	20	20	2	On-Line	Maximum Number of Units	
1	1	1	2	2	1	Reading/Writing		
0	0	0	0	0	0	Searching		
6	6	4	20	20	2	Rewinding		
100 or 23*	100	100	100 or 11*	100 to 22*	100	Reading/Writing	Demands on Processor, %	
38 or 0*	83 to 0*	100/0	54 or 0*	83 to 0*	100/0	Starting/Stopping		
20.0	41.6 to 90.0	34.0	20.0	41.6 to 90.0	20.0	Peak	Transfer Rate, Kilo-char/sec	
14.2	27.3 to 40.0	20.2	14.2	6.7 to 50.2	14.2	1,000-char blocks		
4.0	6.7 to 9.6	4.4	4.0	6.7 to 10.1	4.0	100-char blocks		
36	75 or 112.5	22.5	36	75 or 112.5	36	Tape Speed, inches/sec		
6	6	6 or 8	6	6	6	Data Tracks		
Variable	Variable	Variable	Variable	Variable	Variable	Data Rows per Block		
200/556	200/556/800	1511	200/556	200/556/800	556	Data Rows per Inch		
Yes		No	Yes		Yes	IBM 729 Compatible		
No		No	No		No	IBM 2400 Compatible		
Track & row parity		Dual-row parity	Track & row parity		Track & row parity	Reading	Checking	
Read after write			Read after write		Read after write	Writing		
No		Yes	No		No	Read Reverse		
7340 (Hypertape) is cartridge-loaded						Features and Comments		

*With optional equipment.

		System Identity	IBM 1620	IBM 7010		IBM 7040 & 7044	
AUXILIARY STORAGE	Model Number		1311	1301 Mod. 1, 2	1311	1301 Mod. 1, 2	
	Type of Storage		Discs	Discs	Discs	Discs	
	Maximum Number	Units on-Line	4	5	10	5	
		Read/Write Operations	1	2	2	2	
		Seek Operations	1	10	2 or 10*	10	
	Number of Words per Unit	Minimum	2,000,000 char	28,000,000	2,000,000	4,650,000	
		Maximum	2,000,000 char	56,000,000	2,980,000*	9,300,000	
	Maximum Total Storage	Decimal Digits	8.0×10^6	280×10^6	29.8×10^6	279×10^6	
		Characters	8.0×10^6	280×10^6	29.8×10^6	279×10^6	
	Rotational Time, msec		40	33.5	40	33.5	
	Waiting Time, msec	Minimum	0	0	0	0	
		Average (Random)	250	177	170	177	
		Maximum	400	214	288	214	
	Effective Transfer Rate, char/sec		77,000 max	82,000	38,200	83,700	
	Sector Size, char		100	100	100	100	
	Transfer Load Size, char		100 to 20,000 by 100	1 to 112,000	100 to 20,000 by 100	1 to 111,600	
	Checking		Parity	Parity, write check	Parity, write check	Parity, write check	
	Features and Comments		Changeable storage medium	1302 can also be used	Changeable storage medium		
MAGNETIC TAPE	Model Number			7330	729 Series	7330	729 Series
	Maximum Number of Units	On-Line		20	20	50	50
		Reading/Writing		2	2	5	5
		Searching		0	0	0	0
		Rewinding		20	20	50	50
	Demands on Processor, %	Reading/Writing		2.4	10.8 max	5.3 max	24.0 max
		Starting/Stopping		0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak		20.0	41.6 to 90.0	20.0	41.6 to 90.0
		1,000-char blocks		14.2	27.3 to 50.2	14.2	27.3 to 50.2
		100-char blocks		4.0	6.7 to 10.0	4.0	6.7 to 10.1
	Tape Speed, inches/sec			36	75 or 112.5	36	75 or 112.5
	Data Tracks			6	6	6	6
	Data Rows per Block			Variable	Variable	Variable	Variable
	Data Rows per Inch			200/556	200/556/800	200/556	200/556/800
	IBM 729 Compatible			Yes	Yes	Yes	Yes
	IBM 2400 Compatible			No		No	
	Checking	Reading		Track & row parity		Track & row parity	
		Writing		Read after write		Read after write	
	Read Reverse			No		No	
	Features and Comments		7330 and 729 II Magnetic Tape Units available on a special-order basis				

*With optional equipment.

IBM 7070, 7072, & 7074		IBM 7080		IBM 7090 & 7094		System Identify		
7300	1301	1301	1302	1301	7320	Model Number		AUXILIARY STORAGE
Discs	Discs	Discs	Discs	Discs	Drum	Type of Storage		
4	5	5	5	5	10	Units on-Line	Maximum Number	
2	2	2	2	2	2	Read/Write Operations		
12	10	10	20	10	0	Seek Operations		
600,000	2,780,000	28×10^6	117×10^6	4,650,000	212,000	Minimum	Number of Words per Unit	
1,200,000	5,560,000	56×10^6	234×10^6	9,300,000	212,000	Maximum		
48×10^6	278×10^6	433×10^6	$1,813 \times 10^6$	279×10^6	12.7×10^6	Decimal Digits	Maximum Total Storage	
24×10^6	278×10^6	280×10^6	$1,170 \times 10^6$	279×10^6	12.7×10^6	Characters		
50	33.5	33.5	33.5	33.5	17.5	Rotational Time, msec		
38	0	0	0	0	0	Minimum	Waiting Time, msec	
760	177	177	177	177	8.6	Average (Random)		
940	214	214	214	214	17.5	Maximum		
2,580	83,000*	82,300*	158,000*	83,700	203,000 max	Effective Transfer Rate, char/sec		
60	100	100	Variable	100	100	Sector Size, char		
300	1 to 111,200	1 to 112,000	1 to 234,000	1 to 111,600	Variable	Transfer Load Size, char		
Fixed count, write compare	Check characters	Check characters		Parity, write check	Parity, write check	Checking		
Not usable with 7072	Not usable with 7072; 7074 can also use the 1302			1302 can also be used; see IBM 7040 & 7044		Features and Comments		

IBM 7070, 7072, & 7074			IBM 7080		IBM 7090 & 7094				
7330	729 Series	7340 Mod. 1	729 Series	7340 Mod. 1	729 Series	7340 Mod. 1	Model Number		MAGNETIC TAPE
20	40	20	40	20	80	20	On-Line	Maximum Number of Units	
2	4	2	4	2	8	2	Reading/Writing		
0	0	0	0	0	0	0	Searching		
20	40	20	40	20	80	20	Rewinding		
2.4	11 max	14 max	2.4 to 14.5	27.0	3.3 max	6.2 max	Reading/Writing	Demands on Processor, %	
0	0	0	0	0	0	0	Starting/Stopping		
20.0	41.6 to 90.0	170.0	41.6 to 90.0	170.0	41.6 to 90.0	170.0	Peak	Transfer Rate, Kilo-char/sec	
14.2	27.3 to 50.2	100.0	27.3 to 50.2	100.0	27.3 to 50.2	100.0	1,000-char blocks		
4.0	6.7 to 10.1	22.0	6.7 to 10.1	22.0	6.7 to 10.1	22.0	100-char blocks		
36	75 or 112.5	22.5	75 or 112.5	22.5	75 or 112.5	22.5	Tape Speed, inches/sec		
6	6	6 or 8	6	6 or 8	6	6 or 8	Data Tracks		
Variable	Variable	Variable	Variable	Variable	Variable	Variable	Data Rows per Block		
200/556	200/556/800	1511	200/556/800	1511	200/556/800	1511	Data Rows per Inch		
Yes	Yes	No	Yes	No	Yes	No	IBM 729 Compatible		
No	No	No	No	No	No	No	IBM 2400 Compatible		
Track & row parity		Dual-row parity	Track & row parity	Dual-row parity	Track & row parity	Dual-row parity	Reading	Checking	
Read after write			Read after write	Read after write	Read after write	Read after write	Writing		
No		Yes	No	Yes	No	Yes	Read Reverse		
Usable with 7072 only	Usable with 7070 or 7074	Usable with 7074 only		Cartridge-loaded		Cartridge-loaded	Features and Comments		

*With optional equipment.

System Identity			NCR Century Series			NCR 315,315-100, 315 RMC		
AUXILIARY STORAGE	Model Number		655-101,-102	655-201	655-202	353-1	353-3	353-5
	Type of Storage		Discs	Discs	Discs	Magnetic cards	Magnetic cards	Magnetic cards
	Maximum Number	Units on-Line	2	4/controller	4/controller	16	16	16
		Read/Write Operations	1	1/controller	1/controller	1	1	1
		Seek Operations	4	8/controller	8/controller	16	16	16
	Number of Words per Unit	Minimum	8,388,608	8,388,608	8,388,608	2.8×10^6	8.0×10^6	41.4×10^6
		Maximum	8,388,608	8,388,608	8,388,608	2.8×10^6	8.0×10^6	41.4×10^6
	Maximum Total Storage	Decimal Digits	33.6×10^6	67.2×10^6/ controller	67.2×10^6 controller	133×10^6	385×10^6	1.9×10^9
		Characters	16.8×10^6	33.6×10^6/ controller	33.6×10^6/ controller	89×10^6	256×10^6	1.3×10^9
	Rotational Time, msec		41.6	41.6	25	---	---	---
	Waiting Time, msec	Minimum	0	0	0	3	3	3
		Average (Random)	65	65	57	235	235	125
		Maximum	102	102	85	235	235	125
	Effective Transfer Rate, char/sec		81,000	96,700	159,700	36,500	20,350	29,030
	Sector Size, char		512	512	512	3,100	1,120	1,120
	Transfer Load Size, char		262,144 max.			2 to 3,100	2 to 1,120	2 to 1,500
	Checking		Parity			Parity, read after write		
	Features and Comments		655-101 and -102 used with Century 100; 655-201 and -202 used with Century 200; each unit has two independent disc drives; each removable disc pack has 3 discs			Model 353-2 has half the storage capacity of the similar Model 353-3 unit		
MAGNETIC TAPE	Model Number		633-111, -121	633-211, -221	633-311	332-204	333 Series	334 Series
	Maximum Number of Units	On-Line	8/controller	8/controller	8/controller	16	16	16
		Reading/Writing	1/controller	1/controller	1/controller	2	2	2
		Searching	0	0	0	0	0	0
		Rewinding	All	All	All	16	16	16
	Demands on Processor, %	Reading/Writing	10 to 38	18 to 69	31	100 or 26.7*	100 or 48.0*	100 or 13.3*
		Starting/Stopping	0	0	0	100 or 0*	100 or 0*	100 or 0*
	Transfer Rate, Kilo-char/sec	Peak	80	144	240	66.7	120.0	33.4
		1,000-char blocks	41	74	124	40.8	55.0	20.0
		100-char blocks	7.5	14	23	9.2	8.9	4.6
	Tape Speed, inches/sec		50	90	150	120	150	60
	Data Tracks		8	8	8	6	6	6
	Data Rows per Block		Variable	Variable	Variable	Variable		
	Data Rows per Inch		1600	1600	1600	200/556	200/556 or 800	200/556
	IBM 729 Compatible		Yes*			Yes		
	IBM 2400 Compatible		Yes*			No		
	Checking	Reading	Row parity			Track and row parity		
		Writing	Read after write			Read after write		
	Read Reverse		No			No		
	Features and Comments							

*With optional equipment.

RCA Spectra 70				System Identify		
70/564	70/565	70/568-11	70/567	Model Number		AUXILIARY STORAGE
Discs	Drum	Magnetic cards	Drum	Type of Storage		
8/trunk	4/trunk	8/trunk	1/trunk	Units on-Line	Maximum Number	
1/channel	1/channel	1/channel	1/channel	Read/Write Operations		
1/unit	1/channel	1/unit	1/unit	Seek Operations		
7.25 x 10^6 bytes	1.6 x 10^6 bytes	536 x 10^6 bytes	1.033 x 10^6 bytes	Minimum	Number of Words per Unit	
7.25 x 10^6 bytes	1.6 x 10^6 bytes	536 x 10^6 bytes	4.130 x 10^6 bytes	Maximum		
116 x 10^6/trunk	12.8 x 10^6/trunk	8,516 x 10^6/trunk	4.130 x 10^6/trunk	Decimal Digits	Maximum Total Storage	
58 x 10^6/trunk	6.4 x 10^6/trunk	4,258 x 10^6/trunk	8.260 x 10^6/trunk	Characters		
25	16.7	---	16.7	Rotational Time, msec		
0	0	0	0	Minimum	Waiting Time, msec	
97.5	8.6	500	8.6	Average (Random)		
170	17.2	550	17.9	Maximum		
156,000	210,000	70,000	267,900	Effective Transfer Rate, char/sec		
Variable	Variable	2,048	Variable	Sector Size, char		
1 to 36,250	1 to 24,424	1 to 16,384	1 to 31,078	Transfer Load Size, char		
Cyclic check code	Cyclic check code	Cyclic check code	Cyclic check code	Checking		
Changeable "Disk Packs" (IBM 2311 Disk Storage Drive)		Changeable cartridges hold 256 cards each	Single or dual-drum models; currently available only with RCA Spectra 70/46 systems	Features and Comments		
70/432	70/442	70/445	70/441	Model Number		MAGNETIC TAPE
16/trunk	16/trunk	16/trunk	16/trunk	On-Line	Maximum Number of Units	
1/channel	1/channel	1/channel	1/channel	Reading/Writing		
0	0	0	0	Searching		
All	All	All	All	Rewinding		
Varies	Varies	Varies	Varies	Reading/Writing	Demands on Processor, %	
Varies	Varies	Varies	Varies	Starting/Stopping		
30.0	60.0	120.0	25.0	Peak	Transfer Rate, Kilo-char/sec	
20.4	40.0	81.3	19.5	1,000-char blocks		
5.2	10.3	20.8	6.4	100-char blocks		
37.5	75	150	50	Tape Speed, inches/sec		
8 (6 with optional 7-Channel Tape Feature)			6 plus parity	Data Tracks		
Variable			Variable	Data Rows per Block		
800 (200 556 or 800 with 7-Channel Feature)			333 or 500	Data Rows per Inch		
Only when 7-Channel Tape Feature is installed			No	IBM 729 Compatible		
Yes			No	IBM 2400 Compatible		
Track, row, and diagonal parity			Track parity	Reading	Checking	
Read after write			Read after write	Writing		
Yes			Yes	Read Reverse		
Dual-channel controllers are available			Dual-channel controllers are available; compatible with RCA 381 and 581	Features and Comments		

*With optional equipment.

System Identity			RCA 301		RCA 3301		UNIVAC III
AUXILIARY STORAGE	Model Number		366	3488	3465	3488	Fastrand
	Type of Storage		Discs	Mag. cards	Drum	Mag. cards	Drum
	Maximum Number	Units on-Line	2	8	1	8	16
		Read/Write Operations	2	2	1	2	2
		Seek Operations	2	8	1	8	16
	Number of Words per Unit	Minimum	22,118,400	42×10^6	32,768	42×10^6	16,515,072
		Maximum	88,473,600	681×10^6	262,144	681×10^6	16,515,072
	Maximum Total Storage	Decimal Digits	177×10^6	$5,452 \times 10^6$	2.62×10^6	$5,452 \times 10^6$	$1,584 \times 10^6$
		Characters	177×10^6	$5,452 \times 10^6$	2.62×10^6	$5,452 \times 10^6$	$1,056 \times 10^6$
	Rotational Time, msec		50	---	17.1	---	68.9
	Waiting Time, msec	Minimum	0	0	0	0	5
		Average (Random)	105	500	8.6	300	92
		Maximum	150	640	17.2	1,000	156
	Effective Transfer Rate, char/sec		25,400	80,000 max	149,000	42,000 (80,000 max)	156.000 max
	Sector Size, char		160	650	320	650	168
	Transfer Load Size, char		1 to 1,600	1 to 40,000	1 to 160,000	1 to 160,000	4 to 131,072
	Checking		Parity	Parity	Parity	Parity	Check character
	Features and Comments			Changeable storage medium		Changeable storage medium	Can store either 24 bits or all 27 bits of each word

			RCA 301			RCA 3301			UNIVAC III		
MAGNETIC TAPE	Model Number		381,382	581	582	681	3485	3487	Uni-servo IIA	Uni-servo IIIA	Uni-servo IIIC
	Maximum Number of Units	On-Line	12	14	14	24	24	24	6	32	8
		Reading/Writing	2	2	2	2 (3*)	2 (3*)	2 (3*)	1	4	1
		Searching	0	0	0	0	0	0	0	0	0
		Rewinding	12	14	14	24	24	24	6	32	8
	Demands on Processor %	Reading/Writing	100 (7 or 21)*	100 (23*)	100 (46*)	11.5	11.5	6.0	1.9 max	13.3	6.3 max
		Starting/Stopping	100 (0*)	100 (0*)	100 (0*)	0	0	0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak	10.0 or 30.0	33.3	66.7	120.0	120.0	60.0	25.0	133.0	62.5
		1,000-char blocks	9.0 or 25.0	30.0	47.0	64.0	75.0	37.5	18.3	74.0	36.4
		100-char blocks	5.0 or 15.0	15.0	15.0	12.0	17.0	8.5	Not possible	17.0	7.7
	Tape Speed, inches/sec		60	100	100	225	150	75	100	100	112
	Data Tracks		6	6 (2 bands)	6 (2 bands)	6	6	6	6	9	6
	Data Rows per Block		Variable			Variable			720	Variable	
	Data Rows per Inch		333/500	333	667	800	200/556/800	200/556/800	125/250	1000	200/256
	IBM 729 Compatible		No	No	No	No	Yes	Yes	No	No	Yes
	IBM 2400 Compatible		No	No	No	No	No	No	No	No	No
	Checking	Reading	Row parity	Row parity	Row parity	Row parity	Track & row parity		Row parity	Row parity	2-way parity
		Writing	Echo parity	Echo parity	Read after write	Read after write			None	Read after write	
	Read Reverse		Yes			Yes			Yes	Yes	
	Features and Comments					581 and 582 can also be used (see RCA 301); dual-channel tape controllers are standard					

*With optional equipment.

UNIVAC SS 80/90 Model 1	UNIVAC SS 80/90 Model 2	System Identify		
Randex	Randex	Model Number		AUXILIARY STORAGE
Drum	Drum	Type of Storage		AUXILIARY STORAGE
10	10	Units on-Line	Maximum Number	AUXILIARY STORAGE
1	1	Read/Write Operations	Maximum Number	AUXILIARY STORAGE
1	1	Seek Operations	Maximum Number	AUXILIARY STORAGE
1,152,000	1,152,000	Minimum	Number of Words per Unit	AUXILIARY STORAGE
2,304,000	2,304,000	Maximum	Number of Words per Unit	AUXILIARY STORAGE
230 x 10^6	230 x 10^6	Decimal Digits	Maximum Total Storage	AUXILIARY STORAGE
144 x 10^6	154 x 10^6	Characters	Maximum Total Storage	AUXILIARY STORAGE
3.4	3.4	Rotational Time, msec		AUXILIARY STORAGE
0	0	Minimum	Waiting Time, msec	AUXILIARY STORAGE
375	375	Average (Random)	Waiting Time, msec	AUXILIARY STORAGE
624	624	Maximum	Waiting Time, msec	AUXILIARY STORAGE
4.350	4,640	Effective Transfer Rate, char/sec		AUXILIARY STORAGE
10	10	Sector Size, char		AUXILIARY STORAGE
300	320	Transfer Load Size, char		AUXILIARY STORAGE
Parity	Parity	Checking		AUXILIARY STORAGE
		Features and Comments		AUXILIARY STORAGE
Uniservo II	Uniservo II	Model Number		MAGNETIC TAPE
10	10	On-Line	Maximum Number of Units	MAGNETIC TAPE
1	2	Reading/Writing	Maximum Number of Units	MAGNETIC TAPE
0	0	Searching	Maximum Number of Units	MAGNETIC TAPE
10	20	Rewinding	Maximum Number of Units	MAGNETIC TAPE
5.7	5.7	Reading/Writing	Demands on Processor, %	MAGNETIC TAPE
0	0	Starting/Stopping	Demands on Processor, %	MAGNETIC TAPE
25.0	25.0	Peak	Transfer Rate, Kilo-char/sec	MAGNETIC TAPE
16.4	16.4	1,000-char blocks	Transfer Rate, Kilo-char/sec	MAGNETIC TAPE
Not possible	Not possible	100-char blocks	Transfer Rate, Kilo-char/sec	MAGNETIC TAPE
100	100	Tape Speed, inches/sec		MAGNETIC TAPE
6	6	Data Tracks		MAGNETIC TAPE
720 or 1100	720 or 1100	Data Rows per Block		MAGNETIC TAPE
125/250	125/250	Data Rows per Inch		MAGNETIC TAPE
No	No	IBM 729 Compatible		MAGNETIC TAPE
No	No	IBM 2400 Compatible		MAGNETIC TAPE
Row parity	Row parity	Reading	Checking	MAGNETIC TAPE
None	None	Writing	Checking	MAGNETIC TAPE
Yes	Yes	Read Reverse		MAGNETIC TAPE
		Features and Comments		MAGNETIC TAPE

*With optional equipment.

System Identity			UNIVAC 418 I & II			
AUXILIARY STORAGE	Model Number		FH-432	FH-330	FH-880	Fastrand II
	Type of Storage		Drum	Drum	Drum	Drum
	Maximum Number	Units on-Line	8	80	64	64
		Read/Write Operations	418-I: 8 418-II: 16	418-I: 2 418-II: 4	418-I: 1 418-II: 3	418-I: 1 418-II: 3
		Seek Operations	8	80	64	64
	Number of Words per Unit	Minimum	262,144	262,144	1,572,864	44,040,192
		Maximum	262,144	262,144	1,572,864	44,040,192
	Maximum Total Storage	Decimal Digits	$17,796 \times 10^6$	63×10^6	302×10^6	$8,456 \times 10^6$
		Characters	$17,796 \times 10^6$	63×10^6	302×10^6	$8,456 \times 10^6$
	Rotational Time, msec		35.2	10.7	33.3	68.9
	Waiting Time, msec	Minimum	0	0	0	0
		Average (Random)	9.25	8.5	16.7	92
		Maximum	8.5	17.0	33.3	155
	Effective Transfer Rate, char/sec		1,200,000	90,000 max	180,000 max	158,000 max
	Sector Size, char		3	3	3	168
	Transfer Load Size, char		5 to 20,480	3 to 196,608	3 to 196,608	3 to 196,608
	Checking		Word Parity	Parity	Parity	Parity
	Features and Comments					Fastrand I is the same except for halved data capacity
MAGNETIC TAPE	Model Number		Uniservo IIA	Uniservo IIIA	Uniservo IVC	Uniservo VIC
	Maximum Number of Units	On-Line	96	128	192	256
		Reading/Writing	8	418-I: 2 418-II: 5	418-I: 2 418-II: 4	418-I: 5 418-II: 11
		Searching	8	8	0	0
		Rewinding	All	All	All	All
	Demands on Processor, %	Reading/Writing	418-I: 8.0 418-II: 4.0	418-I: 40.0 418-II: 20.0	418-I: 48.4 418-II: 24.2	418-I: 18.4 418-II: 9.2
		Starting/Stopping	0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak	25.0	120.0	90.0	34.1
		1,000-char blocks	19.8	54.9	39.5	21.3
		100-char blocks	6.9	10.9	6.5	4.9
	Tape Speed, inches/sec		100	100	112.5	42.7
	Data Tracks		6	8	6	6
	Data Rows per Block		Variable	Variable	Variable	Variable
	Data Rows per Inch		125/250	1000	200/556/800	200/556/800
	IBM 729 Compatible		No	No	Yes	Yes
	IBM 2400 Compatible		No	No	No	Yes
	Checking	Reading	Row parity	Row parity	Track & row parity	Track & row parity
		Writing	None	Read after write	Read after write	Read after write
	Read Reverse		Yes	Yes	No	Yes
	Features and Comments					

*With optional equipment.

UNIVAC 490 Series				System Identify		
Fastrand II	FH-432	FH-880	FH-1782	Model Number		AUXILIARY STORAGE
Drum	Drum	Drum	Drum	Type of Storage		
8/channel	9/channel	8/channel	8/channel	Units on-Line	Maximum Number	
1/channel	1/channel	1/channel	1/channel	Read/Write Operations		
8/channel	1/channel	1/channel	1/channel	Seek Operations		
25,952,256	262,144	786,432	2,097,152	Minimum	Number of Words per Unit	
25,952,256	262,144	786,432	2,097,152	Maximum		
1,038 x 10^6/ch	11,796 x 10^6/ch	31.5 x 10^6/ch	83.9 x 10^6/ch	Decimal Digits	Maximum Total Storage	
1.038 x 10^6/ch	11,796 x 10^6/ch	31.5 x 10^6/ch	83.9 x 10^6/ch	Characters		
68.9	35.2	33.3	33.8	Rotational Time, msec		
5	0	0	0	Minimum	Waiting Time, msec	
92	4.25	16.7	17	Average (Random)		
155	8.5	33.3	34	Maximum		
125,000	1.200,000	300.000 max	1,200,000	Effective Transfer Rate, char/sec		
168	3	3	3	Sector Size, char		
5 to 163, 835 or 20,480 (494)	5 to 20,480	5 to 163, 835 or 20,480 (494)	5 to 20,480	Transfer Load Size, char		
Parity, phase	Word parity	Word parity	Word parity	Checking		
Dual-channel controller available	With 494 only		With 494 only; can be intermixed with FH-432 on same controller	Features and Comments		
Uniservo IIA	Uniservo IIIA	Uniservo VIC	Uniservo VIIIC	Model Number		MAGNETIC TAPE
12/ch	16/ch	16/ch	16/ch	On-Line	Maximum Number of Units	
1/ch	1/ch	1/ch	1/ch	Reading/Writing		
1/ch	1/ch	1/ch	1/ch	Searching		
All	All	All	All	Rewinding		
0.63 to 5.0	3.3 to 25.0	0.21 to 6.8	0.6 to 19.2	Reading/Writing	Demands on Processor, %	
0	0	0	0	Starting/Stopping		
25.0	125.0	8.5 to 34.0	24.0 to 96.0	Peak	Transfer Rate, Kilo-char/sec	
19.8	65.9	7.4 to 21.1	19.9 to 59.5	1,000-char blocks		
6.9	12.5	3.4 to 4.7	9.6 to 13.4	100-char blocks		
100	100	42.7	120	Tape Speed, inches/sec		
6	8	6		Data Tracks		
5 to 163,835 or 20,480 (494)	5 to 135,068 or 16,384 (494)	5 to 163,835 or 20,480 (494)		Data Rows per Block		
125,250	1000	200/556/800		Data Rows per Inch		
No	No	Yes		IBM 729 Compatible		
No	No	Yes*		IBM 2400 Compatible		
Row parity	Row parity	Track and row parity		Reading	Checking	
None	Read after write	Read after write		Writing		
Yes	Yes	Yes		Read Reverse		
			Dual-channel controllers available	Features and Comments		

*With optional equipment.

System Identity			UNIVAC 1004	UNIVAC 1050		UNIVAC 1107	
AUXILIARY STORAGE	Model Number			Fastrand I	Fastrand II	FH-880	Fastrand
	Type of Storage			Drum (movable heads)		Drum	Drum
	Maximum Number	Units on-Line		8 per I/O channel		120	120
		Read/Write Operations		1		2	5
		Seek Operations		1		0	15
	Number of Words per Unit	Minimum		66×10^6	132×10^6	786,432	12,976,128
		Maximum		66×10^6	132×10^6	786,432	12,976,128
	Maximum Total Storage	Decimal Digits		528×10^6	$1,056 \times 10^6$	566×10^6	$9,340 \times 10^6$
		Characters		528×10^6	$1,056 \times 10^6$	566×10^6 *	$9,340 \times 10^6$
	Rotational Time, msec			68.9		33.3	68.9
	Waiting Time, msec	Minimum		5		0	5
		Average (Random)		93		16.7	92
		Maximum		155		33.3	155
	Effective Transfer Rate, char/sec			154,000		360,000	150,000
	Sector Size, char			168		3	3
	Transfer Load Size, char			1 to 65,536		6 to 393,210	6 to 393,210
	Checking			Parity, phase		Parity	Check character
	Features and Comments			Search capability; can recover up to 11 bits of missed data			

System Identity			UNIVAC 1004	UNIVAC 1050			UNIVAC 1107		
MAGNETIC TAPE	Model Number		Model 0857 Uniservo	Uniservo IIIA	Uniservo IVC	Uniservo VIC	Uniservo IIA	Uniservo IIIA	Uniservo IIIC
	Maximum Number of Units	On-Line	2	12	12	32	180	240	180
		Reading/Writing	1	1	1	4	15	6	12
		Searching	0	0	0	0	15	15	15
		Rewinding	2	12	12	32	180	240	180
	Demands on Processor, %	Reading/Writing	100	60 max	44 max	16 max	1.7 max	8.0	4.2 max
		Starting/Stopping	100/0	0	0	0	0	0	0
	Transfer Rate, Kilo-char/sec	Peak	33.7	133.0	90.0	34.1	25.0	120.0	62.5
		1,000-char blocks	20.7	43.2	39.4	21.3	19.8	63.2	42.2
		100-char blocks	4.7	7.2	7.0	4.9	6.9	12.0	10.8
	Tape Speed, inches/sec			100	112.5	42.7	100	100	112
	Data Tracks		6	9	6	6	6	8	6
	Data Rows per Block		Variable	Variable	Variable	Variable	Variable	Variable	Variable
	Data Rows per Inch		200/556/800	1000	200/556/800		125/250	1000	200/556
	IBM 729 Compatible		Yes	No	Yes	Yes	No	No	Yes
	IBM 2400 Compatible		No	No	No	Yes	No	No	No
	Checking	Reading	Track & row parity	Row parity	Track & row parity		Row parity	Row parity	Row parity
		Writing	Read after write	Read after write			None	Read after write	
	Read Reverse		No	Yes	No	Yes	Yes	Yes	
	Features and Comments		Can be connected to 1004 III systems only	1050 IV Processor can control twice as many tape units as indicated					

*With optional equipment.

UNIVAC 1108			System Identify		
Fastrand II	FH-432	FH-1782	Model Number		AUXILIARY STORAGE
Drum	Drum	Drum	Type of Storage		
8/channel	9/channel	8/channel	Units on-Line	Maximum Number	
1/channel	1/channel	1/channel	Read/Write Operations		
8/channel	1/channel	1/channel	Seek Operations		
22,020,096	262,144	2,097,152	Minimum	Number of Words per Unit	
176,160,768	2,097,152	16,778,216	Maximum		
1 057 x 10^6/ch	12.6 x 10^6/ch	99.7 x 10^6/ch	Decimal Digits	Maximum Total Storage	
1,057 x 10^6/ch	12.6 x 10^6/ch	99.7 x 10^6/ch	Characters		
68.9	35.2	33.8	Rotational Time, msec		
5.0	0	0	Minimum	Waiting Time, msec	
93.0	4.25	17.0	Average (Random)		
155.0	8.5	34.0	Maximum		
148.200	1.422,000	1,362,000	Effective Transfer Rate, char/sec		
168	3	3	Sector Size, char		
6 to 393.204	6 to 393.204	6 to 393,204	Transfer Load Size, char		
Parity, phase	Word parity	Word parity	Checking		
Dual-channel controller available	Dual-channel controller available	Can be intermixed with FH-432 on same controller	Features and Comments		
Uniservo VIC	Uniservo VIIIC		Model Number		MAGNETIC TAPE
16/channel	16/channel		On-Line	Maximum Number of Units	
1/channel	1/channel		Reading/Writing		
1/channel	1/channel		Searching		
All	All		Rewinding		
0.43 max	1.2 max		Reading/Writing	Demands on Processor, %	
0	0		Starting/Stopping		
8.5 to 34.0	24.0 to 96.0		Peak	Transfer Rate, Kilo-char/sec	
21.1 to 29.6	59.5 to 79.7		1,000-char blocks		
4.76 to 13.6	13.4 to 38.4		100-char blocks		
42.7	120		Tape Speed, inches/sec		
6			Data Tracks		
6 to 393,204			Data Rows per Block		
200/556/800			Data Rows per Inch		
Yes			IBM 729 Compatible		
Yes*			IBM 2400 Compatible		
Track and row parity			Reading	Checking	
Read after write			Writing		
Yes			Read Reverse		
Dual-channel controllers available			Features and Comments		

*With optional equipment.

System Identity			UNIVAC 9200 & 9300	UNIVAC 9400
AUXILIARY STORAGE	Model Number			8411
	Type of Storage			Discs
	Maximum Number	Units on-Line		8/controller
		Read/Write Operations		1/controller
		Seek Operations		8/controller
	Number of Words per Unit	Minimum		7,250,000 bytes
		Maximum		7,250,000 bytes
	Maximum Total Storage	Decimal Digits		116×10^6/controller
		Characters		58×10^6/controller
	Rotational Time, msec			50
	Waiting Time, msec	Minimum		0
		Average (Random)		92
		Maximum		160
	Effective Transfer Rate, char/sec			156,000
	Sector Size, char			Variable
	Transfer Load Size, char			36,250 max.
	Checking			Cyclic check code
	Features and Comments		No auxiliary storage equipment announced to date	Removable disc packs have 6 discs each and are IBM 1316-compatible

System Identity			UNIVAC 9200 & 9300		UNIVAC 9400		
MAGNETIC TAPE	Model Number		Uniservo VIC 0858-99	Uniservo VIC 0858-98	Uniservo VIC	Uniservo 12	Uniservo 16
	Maximum Number of Units	On-Line	16	16	8/controller	16/controller	16/controller
		Reading/Writing	2	2	1/controller	2/controller*	2/controller*
		Searching	0	0	0	0	0
		Rewinding	16	16	All	All	All
	Demands on Processor, %	Reading/Writing	33	33	2.1	4.2 max.	11.6 max.
		Starting/Stopping	?	?	0	0	0
	Transfer Rate, Kilo-char/sec	Peak	34.1	34.1	34.2	68.3/34.2*	192/96*
		1,000-char blocks	21.5	21.5	22.9	34.8/22.9*	98/64*
		100-char blocks	5.1	5.1	5.8	6.4/5.8*	18/16*
	Tape Speed, inches/sec		42.7	42	42.7	42.7	120
	Data Tracks		8	6	8	8	8
	Data Rows per Block		Variable	Variable	Variable	Variable	Variable
	Data Rows per Inch		800	200/556/800	800	1600/800*	1600/800*
	IBM 729 Compatible		No	Yes	Yes*		
	IBM 2400 Compatible		Yes	No	Yes		
	Checking	Reading	Track and row parity		Parity		
		Writing	Read after write		Read after write		
	Read Reverse		Yes		Yes		
	Features and Comments		Available only with UNIVAC 9300				

*With optional equipment.

HARDWARE CHARACTERISTICS COMPARISON CHARTS PUNCHED CARD AND PUNCHED TAPE INPUT-OUTPUT

INTRODUCTION

The charts on the following pages summarize the important characteristics of the punched card and punched tape input-output units for each computer system. The entries which are used to describe all four categories of equipment covered in these charts are explained below. (To find all the information pertaining to a particular computer system, be sure to use the Quick Reference Index.)

PUNCHED CARD AND PUNCHED TAPE INPUT-OUTPUT

Model Number	Manufacturer's identifying number for the input or output unit.
Maximum Number On-Line	Configuration restrictions as to maximum number of units of each type that can be connected on-line.
Number of Channels	Number of parallel channels or tracks of information on punched tape. The most common are 5, 6, 7, and 8 channels. The capability for accommodating tapes with different numbers of channels implies the accommodation of different tape widths: 11/16-inch (5 channel), 7/8-inch (6 channel), and 1-inch (7 and 8 channel).
Peak Speed, cards/min or char/sec	Maximum speed as rated by the manufacturer, expressed in terms of standard 80-column cards per minute for punched card units, and in terms of characters (i.e., tape rows) per second for punched tape units.
Demands on Processor, %	Quantitative measure of the delay imposed upon the central processor or its working (main) storage unit by data transfer operations to or from the input or output device. For example, if a card reader requires 2 out of every 100 cycles of a core storage unit to store the data which it is reading, it imposes a demand of 2%.
Code Translation	Technique used to perform any required conversions between the data code used on punched cards or tape and the computer's internal code. "Automatic" means that standard hardware facilities perform the code translation.
Checking	Type of checking, if any, that is performed to help ensure the accuracy of the input or output operations.
Features and Comments	Noteworthy additional features or facilities, or amplification of one or more of the preceding entries.

System Identity		Burroughs B 100, B 200, & B 300 Series				Burroughs B 2500 & B 3500			Burroughs B 5500			
PUNCHED CARD INPUT	Model Number	B 122	B 123	B 124	B 129	B 9110	B 9111	B 9112	B 122	B 123	B 124	B 129
	Maximum Number On-Line	2	2	2	2	1/ch	1/ch	1/ch	2	2	2	2
	Peak Speed, cards/min	200	475	800	1400	200	800	1400	200	475	800	1400
	Demands on Processor, %	0.7	2.5	4.3	7.5	Less than 1.0			0.04	0.16	0.16	0.16
	Code Translation	Automatic				Automatic			Automatic			
	Checking	Validity				Validity			Validity			
	Features and Comments	Maximum of 1 reader with B 100 Series; B 200/300 6-μsec processor is necessary for use of B 129				Reads Hollerith or column binary code			Reads Hollerith or column binary code			

System Identity		Burroughs B 100, B 200, & B 300 Series		Burroughs B 2500 & B 3500		Burroughs B 5500	
PUNCHED CARD OUTPUT	Model Number	B 303	B 304	B 9210	B 9211	B 303	B 304
	Maximum Number On-Line	1	1	1/ch	1/ch	1	1
	Peak Speed, cards/min	100	300	100	300	100	300
	Demands on Processor, %	2.5	7.4	0.03 (B 2500); 0.01 (B 3500)	0.08 (B 2500); 0.04 (B 3500)	0.01	0.03
	Code Translation	Automatic	Automatic	Automatic		Automatic	
	Checking	Read compare	Read compare	Read compare		Read compare	
	Features and Comments	Binary card punching is possible with B 300 Series processor only		Punches Hollerith or binary code		Punches Hollerith or binary code	

System Identity		Burroughs B 100, B 200, & B 300 Series	Burroughs B 2500 & B 3500	Burroughs B 5500
PUNCHED TAPE INPUT	Model Number	B 141	B 9120	B 141
	Maximum Number On-Line	2	1/channel	2
	Number of Channels	5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8
	Peak Speed, char/sec	500 or 1,000	500 or 1,000	500 or 1,000
	Demands on Processor, %	1.5 or 3.1	0.2 (B 2500); 0.1 (B 3500)	0.02 or 0.05
	Code Translation	Automatic	Automatic	Programmed; automatic*
	Checking	Parity	Parity	Parity
	Features and Comments	Available for use only with B 200/300 6-μsec processor	Optional Input Code Translator provides full code translation capability	

System Identity		Burroughs B 100, B 200, & B 300 Series	Burroughs B 2500 & B 3500	Burroughs B 5500
PUNCHED TAPE OUTPUT	Model Number	B 341	B 9220	B 341
	Maximum Number On-Line	1	1/channel	2
	Number of Channels	5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8
	Peak Speed, char/sec	100	100	100
	Demands on Processor, %	0.3	Negligible	<.01
	Code Translation	Automatic	Automatic	Programmed; automatic*
	Checking	None	None	None
	Features and Comments	Available for use only with B 200/300 6-μsec processor	Optional Output Code Translator provides full code translation capability	

*With optional equipment.

Burroughs B 6500 & B 7500		CDC 160 & 160-A		System Identity	
B 9111	B 9112	405	167	Model Number	PUNCHED CARD INPUT
1/control	1/control	1	1	Maximum Number On-Line	
800	1400	1200	250	Peak Speed, cards/min	
Less than 1.0	Less than 1.0	160: 100; 160-A: 1.1*		Demands on Processor, %	
Automatic	Automatic	Automatic		Code Translation	
Validity, photocells	Validity, photocells	Dual read*	None	Checking	
Reads EBCDIC, BCL, Hollerith, or binary code		Full-card buffer and dual read controls optional		Features and Comments	
B 9213		415	IBM 523	Model Number	PUNCHED CARD OUTPUT
1/control		1		Maximum Number On-Line	
300		250	100	Peak Speed, cards/min	
Less than 1.0		160: 100; 160-A: 1.0*		Demands on Processor, %	
Automatic		Automatic		Code Translation	
Echo		Optional; depends on controller		Checking	
Punches EBCDIC, BCL, Hollerith, or binary code		Full card buffer and dual write controls optional		Features and Comments	
B 9210		350		Model Number	PUNCHED TAPE INPUT
1/control		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 7, or 8		Number of Channels	
500 or 1000		350		Peak Speed, char/sec	
Less than 1.0		100		Demands on Processor, %	
Automatic		Programmed		Code Translation	
Parity		None		Checking	
				Features and Comments	
B 9220		BRPE-11		Model Number	PUNCHED TAPE OUTPUT
1/control		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 7, or 8		Number of Channels	
100		120		Peak Speed, char/sec	
Less than 1.0		100		Demands on Processor, %	
Automatic		Programmed		Code Translation	
None		None		Checking	
		Model 350 and the Teletype BRPE-11 form the CDC 3691 Paper Tape Reader/Punch		Features and Comments	

*With optional equipment.

System Identity		CDC 1604 & 1604-A		CDC 3100, 3300, & 3500		CDC 3400, 3600, & 3800	
PUNCHED CARD INPUT	Model Number	405	1617	405	3142	405	3142
	Maximum Number On-Line	3	3	1/channel	1/channel	1/channel	1/channel
	Peak Speed, cards/min	1200	250	1,200	100	1200	100
	Demands on Processor, %	0.4 Max.		<0.1	<0.1	<0.1	<0.1
	Code Translation	Automatic		Automatic	Automatic	Automatic	Automatic
	Checking	Dual read*	None	Dual read*	None	Dual read*	None
	Features and Comments	Full-card buffer and dual read controls optional		Full-card buffer and dual read controls optional		Full-card buffer and dual read controls optional	
PUNCHED CARD OUTPUT	Model Number	1609 (IBM 521)		415	IBM 523	415	IBM 523
	Maximum Number On-Line	3		1/channel		1/channel	
	Peak Speed, cards/min	100		250	100	250	100
	Demands on Processor, %	0.06 max.		<0.1		<0.1	
	Code Translation	Matched or instruction		Automatic		Automatic	
	Checking	None		Optional; depends on controller		Optional; depends on controller	
	Features and Comments	A number of other IBM units can be used		Full card buffer and dual write controls optional		Full card buffer and dual write controls optional	
PUNCHED TAPE INPUT	Model Number	350		350		350	
	Maximum Number On-Line	1		1/channel		1/channel	
	Number of Channels	5, 7 or 8		5, 7 or 8		5, 7 or 8	
	Peak Speed, char/sec	350		350		350	
	Demands on Processor, %	0.06 max.		<0.1		<0.1	
	Code Translation	Matched		Programmed		Programmed	
	Checking	None		Parity		Parity	
	Features and Comments						
PUNCHED TAPE OUTPUT	Model Number	BRPE-11		BRPE-11		BRPE-11	3694
	Maximum Number On-Line	1		1/channel		1/channel	Many
	Number of Channels	5,7 or 8		5, 7 or 8		5, 7 or 8	5, 7 or 8
	Peak Speed, char/sec	120		120		120	110
	Demands on Processor, %	0.16 max.		<0.1		<0.1	<0.1
	Code Translation	Matched		Programmed		Programmed	Programmed
	Checking	None		None		None	None
	Features and Comments	Model 350 and the Teletype BRPE-11 form the CDC 3691 Paper Tape Reader/Punch					

*With optional equipment.

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Control Data 6000 Series	GE-115			GE-130			System Identity

PUNCHED CARD INPUT

Control Data 6000 Series	GE-115			GE-130			System Identity
405	CRZ100	CRP100	CRZ120	CRZ111	CRZ120	CRP100	Model Number
Many	1	67	1	34	34	34	Maximum Number On-Line
1,200	300	300	600	400	600	300	Peak Speed, cards/min
0	80 max.	54 max.	54 max.	?	?	?	Demands on Processor, %
Automatic	Automatic			Automatic	Automatic	Automatic	Code Translation
Dual read*	Parity; column count			Photo-cells	Photo cells	Card synch.	Checking
Full-card buffer and dual read controls are optional	CRP100 can also punch 300 cards per minute			Reads Hollerith or binary code; CRP100 reads and/or punches at 300 cpm			Features and Comments

PUNCHED CARD OUTPUT

Control Data 6000 Series	GE-115		GE-130		System Identity
415	CPZ101	CPZ103	CPZ101	CRP100	Model Number
Many	67	67	34	34	Maximum Number On-Line
250	60 to 200	300	60 to 200	300	Peak Speed, cards/min
0	56	<1	?	?	Demands on Processor, %
Automatic	Automatic	Automatic	Automatic	Automatic	Code Translation
Optional; depends on controller	Echo	Echo	Echo	Read compare	Checking
Full-card buffer and dual write controls are optional	Speed depends upon no. of columns punched per card	1,200-card input hopper and output stacker	Punches 100 columns/second; buffered	Reads and/or punches at 300 cpm; buffered	Features and Comments

PUNCHED TAPE INPUT

Control Data 6000 Series		GE-115	GE-130	System Identity
3691	3694	PTR100	PTR100	Model Number
Many	Many	67	34	Maximum Number On-Line
5,7, or 8	5,7, or 8	5,6,7, or 8	5,7, or 8	Number of Channels
350	1,000	500	500	Peak Speed, char/sec
0	0	100	?	Demands on Processor, %
Programmed	Programmed	Programmed	Programmed	Code Translation
None	Character parity	Parity or read compare	Parity	Checking
		Reads square-hole or round-hole tape		Features and Comments

PUNCHED TAPE OUTPUT

Control Data 6000 Series		GE-115	GE-130	System Identity
3691	3694			Model Number
Many	Many			Maximum Number On-Line
5,7, or 8	5,7, or 8			Number of Channels
120	110			Peak Speed, char/sec
0	0			Demands on Processor, %
Programmed	Programmed			Code Translation
None	None			Checking
				Features and Comments

*With optional equipment.

System Identity		GE 200 Series			GE 400 Series		GE 600 Series	
PUNCHED CARD INPUT	Model Number	D225B	D225C	CRD125	CR-21		CRZ201	
	Maximum Number On-Line	1	1	1	7		10 per I/O Controller	
	Peak Speed, cards/min	400	1,000	360	900		900	
	Demands on Processor, %	0.3 to 2.0	1.3 to 7.5	0.3 to 2.0	0.8 to 1.4		0.72 max.	
	Code Translation	Automatic	Automatic	Automatic	Automatic		Automatic	
	Checking	None	Read check	Validity	Validity, photocells		Validity, photocells	
	Features and Comments	Decimal or 10- or 12-row binary formats; slight variations under different model nos.			Can read intermixed Hollerith and binary cards		Can read intermixed Hollerith and binary cards	
PUNCHED CARD OUTPUT	Model Number	E225K	E225M		CP-10	CP-20	CPZ100	CPZ201
	Maximum Number On-Line	1	1		7	7	10 per I/O Controller	
	Peak Speed, cards/min	100	300		100	300	100	300
	Demands on Processor, %	1.0 to 5.8	2.9 to 17.3		1.1 to 1.8	0.29 to 0.42	0.96 max.	0.24 max.
	Code Translation	Automatic			Automatic	Automatic	Automatic	Automatic
	Checking	Double punch, blank col.	Hole count		Hole count	Hole count	Hole count	Hole count
	Features and Comments	Decimal or 10- or 12-row binary formats; slight variations under different model nos.			Row buffer only	Full card-image buffer		Full card-image buffer
PUNCHED TAPE INPUT	Model Number	Paper Tape System			TS-20		PTS200	
	Maximum Number On-Line	1			7		10 per I/O Controller	
	Number of Channels	5, 6, 7, or 8			5, 6, 7, or 8		5, 6, 7, or 8	
	Peak Speed, char/sec	250 or 1,000			500		500	
	Demands on Processor, %	0.9 to 11.0			0.34 to 0.56		0.30 max.	
	Code Translation	Programmed			Programmed		Programmed	
	Checking	Parity			Parity		Parity	
	Features and Comments				Combination reader/punch unit; can be used off-line		Combination reader/punch unit; can be used off-line	
PUNCHED TAPE OUTPUT	Model Number	Paper Tape System			TS-20		PTS200	
	Maximum Number On-Line	1			7		10 per I/O Controller	
	Number of Channels	5, 6, 7, or 8			5, 6, 7, or 8		5, 6, 7, or 8	
	Peak Speed, char/sec	110			110		150	
	Demands on Processor, %	0.4 to 2.4			0.07 to 0.12		0.07 max.	
	Code Translation	Programmed			Programmed		Programmed	
	Checking	None			None		None	
	Features and Comments							

*With optional equipment.

Honeywell Series 200		Honeywell Series 200 Model 110		System Identity	
214-2	223:223-2	123		Model Number	PUNCHED CARD INPUT
1/address assignment	1/address assignment	1		Maximum Number On-Line	
400	800; 1050	400		Peak Speed, cards/min	
Varies	Varies	1		Demands on Processor, %	
Automatic	Automatic	Automatic		Code Translation	
Validity	Validity	Validity		Checking	
Hollerith and 'Special' code conversion Binary optional	Binary and 51- and 90-column reading optional			Features and Comments	
214-1, 2	224	214-1	214-2	Model Number	PUNCHED CARD OUTPUT
1/address assignment	1/address assignment	1		Maximum Number On-Line	
100 to 400	50 to 270 or 91 to 360	400		Peak Speed, cards/min	
Varies	Varies	1		Demands on Processor, %	
Automatic	Automatic	Automatic		Code Translation	
Check on punching dies activated	Hole count & physical oper. of punch	Punch activation	Illegal punch; punch activation	Checking	
Speed depends upon position of last column punched	Speed depends upon no. of columns punched		Can read and punch on same pass.	Features and Comments	
209-2		209-2		Model Number	PUNCHED TAPE INPUT
1/address assignment		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 6, 7, or 8		Number of Channels	
600		600		Peak Speed, char/sec	
Varies		1		Demands on Processor, %	
Programmed		Programmed		Code Translation	
Parity (by program)		Frame parity		Checking	
Can perform rewind, runout, and advance operations off-line				Features and Comments	
210		210		Model Number	PUNCHED TAPE OUTPUT
1/address assignment		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 6, 7, or 8		Number of Channels	
120		120		Peak Speed, char/sec	
Varies		1		Demands on Processor, %	
Programmed		Programmed		Code Translation	
None		Frame parity		Checking	
				Features and Comments	

*With optional equipment.

System Identity		Honeywell 400 & 1400			Honeywell 800 & 1800
PUNCHED CARD INPUT	Model Number	427	423-2		827
	Maximum Number On-Line	1	1		64
	Peak Speed, cards/min	800	650		800
	Demands on Processor, %	60 or 2*	57		0.1 max.
	Code Translation	Automatic	Instruction		Automatic
	Checking	Hole count, validity	Hole count		Hole count, validity
	Features and Comments	IBM 1402 Card Read Punch	IBM 088 collator		
PUNCHED CARD OUTPUT	Model Number	427	424-1	424-2	827
	Maximum Number On-Line	1	1	1	64
	Peak Speed, cards/min	250	100	250	250
	Demands on Processor, %	70 or 2*	83	74	0.03 max.
	Code Translation	Automatic	Instruction		Automatic
	Checking	Hole count	Echo		Hole count
	Features and Comments	IBM 1402 Card Read Punch	Usable for off-line gang punching		
PUNCHED TAPE INPUT	Model Number	409			809
	Maximum Number On-Line	3			8
	Number of Channels	5, 6, 7, or 8			5, 6, 7, or 8
	Peak Speed, char/sec	1,000			1,000
	Demands on Processor, %	100			2.0 max.
	Code Translation	Programmed			Programmed
	Checking	Parity			Parity
	Features and Comments				
PUNCHED TAPE OUTPUT	Model Number	410			810
	Maximum Number On-Line	2			8
	Number of Channels	5, 6, 7, or 8			5, 6, 7, or 8
	Peak Speed, char/sec	110			110
	Demands on Processor, %	100			0.66 max.
	Code Translation	Programmed			Programmed
	Checking	None			None
	Features and Comments				

*With optional equipment.

IBM System/360 Model 20				IBM System/360 Models 30 thru 85					System Identity	
2501 Model A1	2501 Model A2	2520 Model A1	2560 MFCM	1442 Mdl N1	2501 Mdl B1	2501 Mdl B2	2520 Mdl B1	2540 Mdl 1	Model Number	PUNCHED CARD INPUT
1	1	1	1	8/ channel	8/ channel	8/ channel	8/ channel	8/ channel	Maximum Number On-Line	
600	1,000	500	500	400	600	1,000	500	1,000	Peak Speed, cards/min	
12.0	20.0	10.0	4.1	Varies	Varies		Varies	Varies	Demands on Processor, %	
Automatic				Automatic	Automatic		Automatic	Automatic	Code Translation	
Validity, circuit checks				Dual read	Dual read		Validity	Dual read	Checking	
All use solar cells and read serially by column; 2520 A1 is a combination reader/punch unit; 2560 is a combination reader/punch/interpreter/collator unit.				Reader-punch has single feed	Single-access clutch		Reader-punch has single feed	Reader and punch are inde-pendent	Features and Comments	
1442 Model 5	2520 Mdl A1, -A2	2520 Model A3	2560 MFCM	1442 Mdl 5, N2	2520 Mdl B1, B2	2520 Mdl B3	2540 Model 1		Model Number	PUNCHED CARD OUTPUT
1	1	1	1	8/ channel	8/ channel	8/ channel	8/ channel		Maximum Number On-Line	
91 to 360	500	300	91 to 360	91 to 360	500	300	300		Peak Speed, cards/min	
Varies	7.5	9.5	3.1	Varies	Varies		Varies		Demands on Processor, %	
Automatic				Automatic	Automatic		Automatic		Code Translation	
Echo				Echo	Echo		Hole count		Checking	
1442 punches serially by column, others by row; 2520 A1 is a combination reader/punch unit; 2560 is a combination reader/punch/interpreter/collator unit.				Serial by column punching	Row-by-row parallel punching		Column Binary and Punch Feed Read options available		Features and Comments	
				2671					Model Number	PUNCHED TAPE INPUT
				8/channel					Maximum Number On-Line	
				5,6,7, or 8					Number of Channels	
				1,000					Peak Speed, char/sec	
				Varies					Demands on Processor, %	
				Programmed					Code Translation	
				Parity					Checking	
				Spooling facilities are optional					Features and Comments	
									Model Number	PUNCHED TAPE OUTPUT
									Maximum Number On-Line	
									Number of Channels	
									Peak Speed, char/sec	
									Demands on Processor, %	
									Code Translation	
									Checking	
									Features and Comments	

*With optional equipment.

	System Identity	IBM System/360 Model 44			
PUNCHED CARD INPUT	Model Number	1442 Model N1	2501 Models B1, B2	2520 Model B1	2540 Model 1
	Maximum Number On-Line	8/channel	8/channel	8/channel	8/channel
	Peak Speed, cards/min	400	600/1,000	500	1,000
	Demands on Processor, %	Varies	Varies	Varies	Varies
	Code Translation	Autcmatic	Automatic	Automatic	Automatic
	Checking	Dual read	Dual read	Validity	Dual read
	Features and Comments	Reader-punch has single feed	Single-access clutch	Reader-punch has single feed	Reader and punch are independent
PUNCHED CARD OUTPUT	Model Number	1442 Models N1, N2	2520 Models B1, B2	2520 Model B3	2540 Model 1
	Maximum Number On-Line	8/channel	8/channel	8/channel	8/channel
	Peak Speed, cards/min	91 to 360	500	300	300
	Demands on Processor, %	Varies	Varies		Varies
	Code Translation	Automatic	Automatic		Automatic
	Checking	Echo	Echo		Hole count
	Features and Comments	Serial-by-column punching	Row-by-row parallel punching		Column Binary and Punch Feed Read options available
PUNCHED TAPE INPUT	Model Number	2671			
	Maximum Number On-Line	8/channel			
	Number of Channels	5, 6, 7, or 8			
	Peak Speed, char/sec	1,000			
	Demands on Processor, %	Varies			
	Code Translation	Programmed			
	Checking	Parity			
	Features and Comments	Spooling facilities are optional			
PUNCHED TAPE OUTPUT	Model Number				
	Maximum Number On-Line				
	Number of Channels				
	Peak Speed, char/sec				
	Demands on Processor, %				
	Code Translation				
	Checking				
	Features and Comments				

*With optional equipment.

IBM 1401 & 1460	IBM 1401-G	IBM 1401-H	System Identity	
1402 Model 1	1402 Models 4 or 5	1402 Model 6	Model Number	PUNCHED CARD INPUT
1	1	1	Maximum Number On-Line	
800	450	450	Peak Speed, cards/min	
87 to 16*	84 or 58*	100	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Hole count, validity	Hole count, validity	Hole count, validity	Checking	
Column binary format is optional; three stackers	Three stackers	Three stackers	Features and Comments	
1402 Model 1	1402 Models 4 or 5	1402 Model 6	Model Number	PUNCHED CARD OUTPUT
1	1	1	Maximum Number On-Line	
250	250	250	Peak Speed, cards/min	
91 to 7*	91 or 75*	100	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Hole count	Hole count	Hole count	Checking	
Column binary format is optional; three stackers	Three stackers; optional read station	Three stackers; optional read station	Features and Comments	
1011	1011		Model Number	PUNCHED TAPE INPUT
1	1		Maximum Number On-Line	
5,6,7, or 8	5,6,7, or 8		Number of Channels	
500	500		Peak Speed, char/sec	
100 or 0.6*	100		Demands on Processor, %	
Plugboard	Plugboard		Code Translation	
Parity	Parity		Checking	
			Features and Comments	
1012	1012		Model Number	PUNCHED TAPE OUTPUT
1	1		Maximum Number On-Line	
5,6,7, or 8	5,6,7, or 8		Number of Channels	
150	150		Peak Speed, char/sec	
100	100		Demands on Processor, %	
Programmed	Programmed		Code Translation	
Read compare	Read compare		Checking	
			Features and Comments	

*With optional equipment.

	System Identity	IBM 1410	IBM 1440			IBM 1620
PUNCHED CARD INPUT	Model Number	1402 Model 2	1442 Mod. 1	1442 Mod. 2,4		1622
	Maximum Number On-Line	2	2	2		1
	Peak Speed, cards/min	800	300	400		250
	Demands on Processor, %	1	21 to 73	21 to 73		1.4
	Code Translation	Automatic	Automatic			Automatic
	Checking	Hole count, validity	Dual read			Dual read, parity
	Features and Comments	Three stackers	Models 1 and 2 are combination read/punch units			
PUNCHED CARD OUTPUT	Model Number	1402 Model 2	1442 Mod. 1	1442 Mod. 2	1444	1622
	Maximum Number On-Line	2	2	2	1	1
	Peak Speed, cards/min	250	50 to 270	88 to 360	250	125
	Demands on Processor, %	0.4	83	76	91	0.7
	Code Translation	Automatic	Automatic			Automatic
	Checking	Hole count	Echo		Hole count	Read compare
	Features and Comments	Three stackers	1442 speed depends on number of columns punched			
PUNCHED TAPE INPUT	Model Number	1011	1011			1621 Models 1 or 2
	Maximum Number On-Line	2	1			1
	Number of Channels	5, 6, 7, or 8	5,6,7, or 8			8
	Peak Speed, char/sec	500	500			150
	Demands on Processor, %	0.5	100			100
	Code Translation	Plugboard	Plugboard			Automatic
	Checking	Parity	Parity			Parity
	Features and Comments					
PUNCHED TAPE OUTPUT	Model Number		1012			1621 Model 2
	Maximum Number On-Line		1			1
	Number of Channels		5,6,7, or 8			8
	Peak Speed, char/sec		150			15
	Demands on Processor, %		100			100
	Code Translation		Programmed			Automatic
	Checking		Read compare			None
	Features and Comments					

*With optional equipment.

IBM 7010	IBM 7040 & 7044		IBM 7070, 7072, & 7074		System Identity	
1402 Model 2	1402 Model 2	1622	7501	7500	Model Number	PUNCHED CARD INPUT
2	1	1	1	3	Maximum Number On-Line	
800	800	250	60	500	Peak Speed, cards/min	
0.32	0.4 max.	0.2 max.	100	5 max.	Demands on Processor, %	
Automatic	Automatic	Automatic	Automatic	Automatic	Code Translation	
Hole count, validity	Hole count	Dual read	Double punch, blank column	Read compare, char. validity	Checking	
Three stackers	Reads binary images or BCD		Reads numeric codes only	Not usable on 7072	Features and Comments	
1402 Model 2	1402 Model 2	1622	7550		Model Number	PUNCHED CARD OUTPUT
2	1	1	3		Maximum Number On-Line	
250	250	125	250		Peak Speed, cards/min	
0.1	0.3 max.	0.1 max.	2.5 max.		Demands on Processor, %	
Automatic	Automatic	Automatic	Automatic		Code Translation	
Hole count	Hole count	Read compare	Double punch, blank column		Checking	
Three stackers	Punches BCD or binary image		Not usable on 7072		Features and Comments	
1011	1011		1011		Model Number	PUNCHED TAPE INPUT
2	5		1		Maximum Number On-Line	
5,6,7, or 8	5,6,7, or 8		5,6,7, or 8		Number of Channels	
500	500		500		Peak Speed, char/sec	
0.144 min.	0.1 max.		0.1 max.		Demands on Processor, %	
Plugboard	Plugboard		Plugboard		Code Translation	
Parity	Parity		Parity		Checking	
					Features and Comments	
					Model Number	PUNCHED TAPE OUTPUT
					Maximum Number On-Line	
					Number of Channels	
					Peak Speed, char/sec	
					Demands on Processor, %	
					Code Translation	
					Checking	
					Features and Comments	

*With optional equipment.

System Identity		IBM 7080		IBM 7090 & 7094	NCR Century Series	
PUNCHED CARD INPUT	Model Number	714	7502	711	682-100	686-101, 686-201
	Maximum Number On-Line	10	1	1	1	8/trunk
	Peak Speed, cards/min	250	60	250	300	800
	Demands on Processor, %	100	100	<1	0.3 max.	0.7 max.
	Code Translation	Automatic	Automatic	Automatic	Automatic	Automatic
	Checking	Hole count	Validity	Can be programmed	Photocells	Photocells
	Features and Comments			Reads binary image of 72 out of 80 columns		686-101 is a read/punch unit; 686-201 is a reader only
PUNCHED CARD OUTPUT	Model Number	722		721	686-101, 686-301	
	Maximum Number On-Line	10		1	8/trunk	
	Peak Speed, cards/min	100		100	82 to 240	
	Demands on Processor, %	100		<1	0.1 max	
	Code Translation	Automatic		Automatic	Automatic	
	Checking	Hole count, validity		None	Echo	
	Features and Comments			Can be used to gang punch	Speed varies with number of columns punched; 686-101 is a read/punch unit; 686-301 is a punch only	
PUNCHED TAPE INPUT	Model Number				662-100	660-101
	Maximum Number On-Line				1	8/trunk
	Number of Channels				5,7, or 8	5,7, or 8
	Peak Speed, char/sec				1000	1500
	Demands on Processor, %				0.5 max.	0.7 max.
	Code Translation				Programmed	Programmed
	Checking				None	Parity
	Features and Comments					
PUNCHED TAPE OUTPUT	Model Number				665-101	
	Maximum Number On-Line				8/trunk	
	Number of Channels				5,7, or 8	
	Peak Speed, char/sec				200	
	Demands on Processor, %				0.1 max.	
	Code Translation				Programmed	
	Checking				Echo	
	Features and Comments					

*With optional equipment.

NCR 315, 315-100, 315 RMC				System Identity	
376-7	376-8	380-3	472-3	Model Number	PUNCHED CARD INPUT
2	2	1	1	Maximum Number On-Line	
300	400	2,000	400	Peak Speed, cards/min	
73 max.	73 max.	80 max.	84 max.	Demands on Processor, %	
Automatic		Automatic	Programmed	Code Translation	
Dual read		Validity	None	Checking	
IBM 1442 Card Read Punch units; not available with 315 RMC systems			Not available with 315 RMC systems	Features and Comments	
376-7	376-8	376-2	376-101	Model Number	PUNCHED CARD OUTPUT
2	2	4	4	Maximum Number On-Line	
50 to 270	88 to 360	100	250	Peak Speed, cards/min	
83 max.	77 max.	<1	<1	Demands on Processor, %	
Automatic		Automatic	Automatic	Code Translation	
Echo		Echo	Echo	Checking	
IBM 1442 Card Read Punch units; not available with 315 RMC systems				Features and Comments	
472-1, 472-3		361-201		Model Number	PUNCHED TAPE INPUT
1		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 7, or 8		Number of Channels	
1,000		600		Peak Speed, char/sec	
100		100		Demands on Processor, %	
Programmed		Programmed		Code Translation	
Parity		Parity		Checking	
Code translation can be performed during time between characters		Code translation can be performed during time between characters		Features and Comments	
472-1, 472-3		371-201		Model Number	PUNCHED TAPE OUTPUT
1		1		Maximum Number On-Line	
5, 6, 7, or 8		5, 7, or 8		Number of Channels	
110		120		Peak Speed, char/sec	
100		100		Demands on Processor, %	
Programmed		Programmed		Code Translation	
None		None		Checking	
Code translation can be performed during time between characters		Code translation can be performed during time between characters		Features and Comments	

*With optional equipment.

System Identity		RCA Spectra 70		RCA 301		RCA 3301	
PUNCHED CARD INPUT	Model Number	70/237		323		324	329
	Maximum Number On-Line	1/trunk		2		2	2
	Peak Speed, cards/min	1,435		600		900	1,470
	Demands on Processor, %	Varies		80 to 13*		0.1	0.2
	Code Translation	Automatic*		Automatic		Automatic	
	Checking	Circuit checks; validity check in Translate mode		Hole count, validity		Validity	
	Features and Comments	Optional mark reading feature		Reject stacker		Photocells are tested during each card cycle	
PUNCHED CARD OUTPUT	Model Number	70/234	70/236	334		3436	
	Maximum Number On-Line	1/trunk	1/trunk	1		2	
	Peak Speed, cards/min	100	300	100		300	
	Demands on Processor, %	Varies	Varies	100 to 1*		<0.1	
	Code Translation	Automatic	Automatic	Automatic		Automatic	
	Checking	Hole count	Hole count	Hole count, validity		Hole count	
	Features and Comments	Single stacker	Two stackers; Read/punch option			Punches Hollerith or column binary code	
PUNCHED TAPE INPUT	Model Number	70/221	70/224	321	322	321	322
	Maximum Number On-Line	1/trunk	1/trunk	1	1	2	2
	Number of Channels	5,6,7, or 8	5,6,7, or 8	5 or 7	5,6,7, or 8	5 or 7	5,6,7, or 8
	Peak Speed, char/sec	200	1,000	100	500 or 1,000	100	1,000
	Demands on Processor, %	Varies	Varies	100 to 0.1*	100 to 0.4*	<0.1	0.2
	Code Translation	Automatic*	Automatic*	Matched		Programmed	
	Checking	Parity	Parity	Parity		Parity	
	Features and Comments	Combination reader and punch	Synchronous or asynchronous reading				
PUNCHED TAPE OUTPUT	Model Number	70/221		321, 331		321, 331	332
	Maximum Number On-Line	1/trunk		1		2	2
	Number of Channels	5,6,7, or 8		5 or 7		5 or 7	
	Peak Speed, char/sec	100		100		100	300
	Demands on Processor, %	Varies		100 to 0.1*		<0.1	<0.1
	Code Translation	Automatic*		Matched		Programmed	
	Checking	Echo		None		Echo	
	Features and Comments						

*With optional equipment.

UNIVAC III	UNIVAC SS 80/90	UNIVAC 418 I & II	System Identity	
4133, 4182	7935, 7945	UNIVAC 1004 Card Reader	Model Number	PUNCHED CARD INPUT
8	1	16	Maximum Number On-Line	
700	600	400 or 615	Peak Speed, cards/min	
29	3.5	0.1 to 0.4	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Hole count	Programmed	Circuit checks	Checking	
Three stackers	80 or 90-column card models	1004 is used on-line with 418 to handle card I/O	Features and Comments	
4127, 4183	7936, 7946	UNIVAC 1004 Card Punch	Model Number	PUNCHED CARD OUTPUT
8	1	16	Maximum Number On-Line	
300	150	200	Peak Speed, cards/min	
0.48	1.8	<0.1	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Hole count	Programmed	Hole count	Checking	
Two stackers	Can also be used as a card reader; 80 or 90-column card models	1004 is used on-line with 418 to handle card I/O	Features and Comments	
Punched Tape Unit	Paper Tape System	Paper Tape Subsystem	Model Number	PUNCHED TAPE INPUT
8	1	1	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
500	500	200	Peak Speed, char/sec	
1.0 max.	5	<0.1	Demands on Processor, %	
Programmed	Plugboard	Programmed	Code Translation	
Parity	Parity (odd or even)	Parity	Checking	
Reads up to 2,500 char/sec. in "non-stop" mode		Combination reader/punch unit	Features and Comments	
Punched Tape Unit	Paper Tape System	Paper Tape Subsystem	Model Number	PUNCHED TAPE OUTPUT
8	1	1	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
110	100	110	Peak Speed, char/sec	
0.004	0.1	<0.1	Demands on Processor, %	
Programmed	Plugboard	Programmed	Code Translation	
None	None	None	Checking	
			Features and Comments	

*With optional equipment.

System Identity		UNIVAC 490 Series	UNIVAC 1004	
PUNCHED CARD INPUT	Model Number	490 Punched Card Subsystem	1004 I	1004 II, 1004 III
	Maximum Number On-Line	1/channel	1	1
	Peak Speed, cards/min	800/900	400	615
	Demands on Processor, %	0.032 to 0.25	100	94
	Code Translation	Automatic on 80-column models	Automatic	
	Checking	Hole count	Proper photocell functioning only	
	Features and Comments	Higher rate when reading only 72 columns; row and column binary optional	Auxiliary 400 cpm reader can be added to any 1004 system	
PUNCHED CARD OUTPUT	Model Number	490 Punched Card Subsystem	2009, 2011	
	Maximum Number On-Line	1/channel	1	
	Peak Speed, cards/min	300	200	
	Demands on Processor, %	0.011 to 0.084	<1	
	Code Translation	Automatic on 80-column models	Automatic	
	Checking	Hole count	Hole count	
	Features and Comments	Binary card images can be punched (240 holes max.)	Available for 80 or 90-column cards; read station is optional	
PUNCHED TAPE INPUT	Model Number	490 Paper Tape Subsystem	0902	
	Maximum Number On-Line	1/channel	1	
	Number of Channels	5, 6, 7, or 8	5, 6, 7, or 8	
	Peak Speed, char/sec	400	400	
	Demands on Processor, %	0.06 to 0.48	100	
	Code Translation	Programmed	Programmed	
	Checking	None	Parity	
	Features and Comments	Parity check can be programmed		
PUNCHED TAPE OUTPUT	Model Number	490 Paper Tape Subsystem	F0606	
	Maximum Number On-Line	1/channel	1	
	Number of Channels	5, 6, 7, or 8	5, 6, 7, or 8	
	Peak Speed, char/sec	110	110	
	Demands on Processor, %	0.016 to 0.13	<1	
	Code Translation	Programmed	Programmed	
	Checking	Verify punch activation	None	
	Features and Comments			

*With optional equipment.

UNIVAC 1050		UNIVAC 1107		UNIVAC 1108	System Identity	
0706-00	0706-01	Type 7223		1108 Punched Card Subsystem	Model Number	PUNCHED CARD INPUT
4 or 8	4 or 8	15		1/channel	Maximum Number On-Line	
800/900	600	600		900	Peak Speed, cards/min	
0.6 max.	0.3 max.	0.15 max.		0.016 max.	Demands on Processor, %	
Automatic on 80-column models		Automatic (or matched)		Automatic	Code Translation	
Hole count		Dual read		Hole count	Checking	
900 cpm rate is attained when only 72 columns per card are read				Row binary and column binary reading optional	Features and Comments	
0600-00	0600-12	Type 7224	Type 7266	1108 Punched Card Subsystem	Model Number	PUNCHED CARD OUTPUT
4 or 8	4 or 8	15	15	1/channel	Maximum Number On-Line	
300	200	150	300	300	Peak Speed, cards/min	
5.1 max.	3.4 max.	0.04 max.	0.08 max.	0.005 max.	Demands on Processor, %	
Automatic on 80-column models		Automatic (or matched)		Automatic	Code Translation	
Hole count		Read compare		Full card image check	Checking	
Can punch binary images		Only Type 7266 is suitable for binary punching		Binary card images can be punched (240 holes max.)	Features and Comments	
0903-00	0903-01	Type 7423		1108 Paper Tape Subsystem	Model Number	PUNCHED TAPE INPUT
3 or 8	3 or 8	15		1/channel	Maximum Number On-Line	
5, 6, 7, or 8		5, 6, 7, or 8		5, 6, 7, or 8	Number of Channels	
1,000	500	400		400	Peak Speed, char/sec	
0.5 max.	0.3 max.	0.16		0.03 max.	Demands on Processor, %	
Programmed		Programmed		Programmed	Code Translation	
Parity		None		None	Checking	
		Parity check can be programmed		Parity check can be programmed	Features and Comments	
0606-1		Type 7423		1108 Paper Tape Subsystem	Model Number	PUNCHED TAPE OUTPUT
3 or 8		15		1/channel	Maximum Number On-Line	
5, 6, 7, or 8		5, 6, 7, or 8		5, 6, 7, or 8	Number of Channels	
110		110		110	Peak Speed, char/sec	
0.05 max.		0.04		0.008 max.	Demands on Processor, %	
Programmed		Programmed		Programmed	Code Translation	
None		Verify punch activation		Verify punch activation	Checking	
					Features and Comments	

*With optional equipment.

System Identity		UNIVAC 9200 & 9300			UNIVAC 9400
PUNCHED CARD INPUT	Model Number	0711-00	0711-02	1001 Card Controller	0711-05
	Maximum Number On-Line	1	1	1	7
	Peak Speed, cards/min	400	600	2,000	600
	Demands on Processor, %	<1	1	1.6	Less than 1.0
	Code Translation	Automatic	Automatic	Automatic	Automatic
	Checking	Proper photocell functioning	Proper photocell functioning	Proper photocell functioning	Photocells, registration
	Features and Comments	Used with UNIVAC 9200 only	Used with UNIVAC 9300 only	Two card feeds and seven stackers permit collating can be used off-line	Can read 51- or 66-column cards*
PUNCHED CARD OUTPUT	Model Number	0603-04	0604-00		0604-99
	Maximum Number On-Line	1	1		7
	Peak Speed, cards/min	75 to 200	200		250
	Demands on Processor, %	< 1	<1		Less than 1.0
	Code Translation	Automatic	Automatic		Automatic
	Checking	Echo	Hole count		Echo
	Features and Comments	Punches serially by column; has 2 850-card stackers	Punches serially by row; has 2 1,000-card stackers		Read/punch feature allows prepunched cards to be read prior to punching*
PUNCHED TAPE INPUT	Model Number				
	Maximum Number On-Line				
	Number of Channels				
	Peak Speed, char/sec				
	Demands on Processor, %				
	Code Translation				
	Checking				
	Features and Comments				
PUNCHED TAPE OUTPUT	Model Number				
	Maximum Number On-Line				
	Number of Channels				
	Peak Speed, char/sec				
	Demands on Processor, %				
	Code Translation				
	Checking				
	Features and Comments				

*With optional equipment.

HARDWARE CHARACTERISTICS COMPARISON CHARTS PRINTERS AND SPECIALIZED INPUT-OUTPUT EQUIPMENT

INTRODUCTION

The charts on the following pages summarize the important characteristics of the line printers and specialized I/O equipment (optical readers, MICR readers, data communications controllers, display units, plotters, etc.) for each computer system. Explanations of the entries on these charts follow. (To find all the information pertaining to a particular computer system, please refer to the Quick Reference Index.)

PRINTED OUTPUT

Model Number	Manufacturer's identifying number.
Maximum Number On-Line	Configuration restriction as to the maximum number that can be connected on-line.
Speed, lines/min.	Performance of the printer, expressed in terms of the maximum number of alphanumeric lines per minute that can be printed under two conditions: (1) single-spaced printing, and (2) printing with an average spacing of 1 inch between consecutive printed lines. (The difference between the two figures is a measure of the printer's facilities for high-speed skipping.)
Demands on Processor, %	Quantitative measure of the delay imposed upon the central processor or its working (main) storage unit by data transfer operations to the printer.
Number of Print Positions	Number of printing positions; i.e., the maximum number of printed characters per line.
Character Set Size	Number of different symbols that can be printed.
Checking	Type of checking, if any, that is performed to help ensure the accuracy of the printing operation.
Features and Comments	Noteworthy additional features or facilities, or amplification of one or more of the preceding entries.

SPECIALIZED INPUT-OUTPUT EQUIPMENT

Model Number	Manufacturer's identifying number and formal name of the device.
Peak Speed	Maximum rated speed, or other meaningful information describing the unit's performance or capacity.
Features and Comments	Noteworthy additional features or facilities, or amplification of one or more of the preceding entries.

System Identity			Burroughs B 100, B 200, & B 300					Burroughs B 2500 & B 3500			
PRINTED OUTPUT	Model Number		B 320	B 321	B 328	B 325	B 329	B 9240	B 9241	B 9242	B 9243
	Maximum Number On-Line		2	2	2	2	2	1/channel			
	Speed, lines/min	Single Spacing	475	700	1040	700	1040	700	1040	815	1040
		1-inch Spacing	370	500	595	500	595	540	648	620	648
	Demands on Processor, %		1.0	1.5	2.2	1.5	2.2	<1.0			
	Number of Print Positions		120			120/132*		120/132*			
	Character Set Size		64			64		64			
	Checking		Parity			Parity		Parity			
	Features and Comments		B 100 Series can use only 1 printer			132 print positions are standard on B 300 Series		9240 and 9241 buffered; 9242 and 9243 unbuffered			
MICR READER	Model Number		B 106, B 107		B 102, B 103 B 104, B 116			B 9130, B 9131, B 9132			
	Peak Speed, documents/min		1,200		1,560			1,565			
	Features and Comments										
OPTICAL CHARACTER READER	Model Number										
	Peak Speed, documents/min										
	Features and Comments										
DATA COMMUNI-CATIONS CONTROLLER	Model Number		B 248 Control Unit					B 2353		B 2351	
	Peak Speed, bits/sec		180,000					2,400/line		2,400	
	Features and Comments		Can service large number of remote terminals					36 lines		One line	
CRT DISPLAY	Model Number							B 9351			
	Capacity, char							2,000			
	Features and Comments							Multi-station unit			
PLOTTER	Model Number										
	Peak Speed, points/sec										
	Features and Comments										
OTHER INPUT-OUTPUT DEVICES	Model Number		B 401			B322, B323, B326, B332, B333		B 9244-1, B 9244-2			
	Name		Record Processor			Multiple Tape Listers		Multiple Tape Listers			
	Features and Comments		44 Active ledgers/min.			1600 lpm		1565 lpm			

*With optional equipment.

Burroughs B 5500					Burroughs B 6500 & B 7500		System Identity	
B 320	B 321	B 322	B 325	B 329	B 9242	B 9243	Model Number	PRINTED OUTPUT
2					1/control		Maximum Number On-Line	
475	700	1040	700	1040	815	1040	Speed, lines/min: Single Spacing	
370	540	648	540	648	620	648	Speed, lines/min: 1-inch Spacing	
0.1					<1.0		Demands on Processor, %	
120			132		120/132*		Number of Print Positions	
64					64		Character Set Size	
Parity					Parity		Checking	
							Features and Comments	
							Model Number	MICR READER
							Peak Speed, documents/min	
							Features and Comments	
							Model Number	OPTICAL CHARACTER READER
							Peak Speed, documents/min	
							Features and Comments	
B 5480 Control Unit					B 6350 DCP		Model Number	DATA COMMUNI-CATIONS CONTROLLER
180,000					>15,000		Peak Speed, bits/sec	
Handles large number of remote terminals					64 lines		Features and Comments	
					B 9351		Model Number	CRT DISPLAY
					2,000		Capacity, char	
					Multi-station unit		Features and Comments	
							Model Number	PLOTTER
							Peak Speed, points/sec	
							Features and Comments	
							Model Number	OTHER INPUT-OUTPUT DEVICES
							Name	
							Features and Comments	

*With optional equipment.

System Identity			CDC 160 & 160-A		CDC 1604 & 1604-A			CDC 3100, 3300, & 3500		
PRINTED OUTPUT	Model Number		1612 G	166G-2	1612 G	505	501	501	505	3152
	Maximum Number On-Line		1	1	24	24	24	8/ch	8/ch	1/ch
	Speed, lines/min	Single Spacing	1000	150	1000	500	1000	1000	500	150
		1-inch Spacing	500	130	500	375	571	571	375	150
	Demands on Processor, %		1	0.2	2.8 Max.	2.8 Max.	2.8 Max.	<0.1	<0.1	<0.1
	Number of Print Positions		120	120	120	136	136	136	136	120
	Character Set Size		64	64	64	64	64	64	64	64
	Checking		None	None	None	Echo	Echo	Echo	Echo	Echo
	Features and Comments		Higher speeds possible when restricted character sets are used.		Increased speed is possible with restricted character set; Dual-channel controller provided with 501 and 505.			Dual channel controller provided		
MICR READER	Model Number									
	Peak Speed, documents/min									
	Features and Comments									
OPTICAL CHARACTER READER	Model Number							Page Reader		915
	Peak Speed, documents/min							370 char/sec		
	Features and Comments									
DATA COMMUNICATIONS CONTROLLER	Model Number							3266-A	3274	3275
	Peak Speed, bits/sec							2400/ line	2,500,000	230,400
	Features and Comments							Multi-line	Multiple lines, 1 at a time	
CRT DISPLAY	Model Number							210	217	
	Capacity, char							1,000	1,000	
	Features and Comments							Multi-station	Single station	
PLOTTER	Model Number							3293		
	Peak Speed, points/sec							300		
	Features and Comments							Incremental		
OTHER INPUT-OUTPUT DEVICES	Model Number									
	Name									
	Features and Comments									

*With optional equipment.

CDC 3400, 3600, & 3800		CDC 6000 Series		System Identity	
501	505	501	512	Model Number	PRINTED OUTPUT
8/ch	8/ch	8/ch	8/ch	Maximum Number On-Line	
1000	500	1000	1200	Speed, lines/min: Single Spacing	
571	375	571	685	Speed, lines/min: 1-inch Spacing	
<0.1		0	0	Demands on Processor, %	
136		136	136	Number of Print Positions	
64		64	48	Character Set Size	
Echo		Echo	Echo	Checking	
Dual channel controller provided				Features and Comments	

CDC 3400, 3600, & 3800	CDC 6000 Series	System Identity	
		Model Number	MICR READER
		Peak Speed, documents/min	
		Features and Comments	

CDC 3400, 3600, & 3800	CDC 6000 Series	System Identity	
915 Page Reader		Model Number	OPTICAL CHARACTER READER
370 char/sec		Peak Speed, documents/min	
		Features and Comments	

CDC 3400, 3600, & 3800			CDC 6000 Series						System Identity	
3266-A	3274	3275	3266-A	3276	6671	6673	6674	6676	Model Number	DATA COMMUNI-CATIONS CONTROLLER
2400/line	2,500,000	230,400	2400/line	2400/line	2400/line	40,800	40,800	110	Peak Speed, bits/sec	
Multi-line	Multiple lines 1 at a time		Multi-line controllers		Handles multiple lines 1 at a time				Features and Comments	

CDC 3400, 3600, & 3800		CDC 6000 Series	System Identity	
210	217		Model Number	CRT DISPLAY
1,000	1,000		Capacity, char	
Multi-station	Single station		Features and Comments	

CDC 3400, 3600, & 3800	CDC 6000 Series	System Identity	
3293		Model Number	PLOTTER
300 steps/sec		Peak Speed, points/sec	
Incremental		Features and Comments	

CDC 3400, 3600, & 3800	CDC 6000 Series	System Identity	
	6411 & 6416	Model Number	OTHER INPUT-OUTPUT DEVICES
	I/O Buffer & Control	Name	
	Doubles I/O Capability	Features and Comments	

*With optional equipment.

System Identity			GE-115			GE-130		
PRINTED OUTPUT	Model Number		PRT 100	PRT 110	PRT 120	PRT 100	PRT 110	PRT 120
	Maximum Number On-Line		1	1	67	1/channel	1/channel	34/system
	Speed, lines/min	Single Spacing	300	600	780	300	600	780
		1-inch Spacing	220	220	500	220	220	500
	Demands on Processor, %		80 max	80 max	80 max	?	?	?
	Number of Print Positions		104, 120, or 136			104, 120, or 136		
	Character Set Size		64			64		
	Checking		Echo			Echo		
	Features and Comments							
MICR READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
OPTICAL CHARACTER READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
DATA COMMUNI-CATIONS CONTROLLER	Model Number		DATANET-10			DATANET-10		DATANET-12
	Peak Speed, bits/sec		2,400			2,400		50,000
	Features and Comments		Single line controller			Single line controllers		
CRT DISPLAY	Model Number							
	Capacity, char							
	Features and Comments							
PLOTTER	Model Number							
	Peak Speed, points/sec							
	Features and Comments							
OTHER INPUT-OUTPUT DEVICES	Model Number							
	Name							
	Features and Comments							

*With optional equipment.

GE-200 Series		GE-400 Series			System Identity		
P215E (GE-215)	P225A (GE-225 & 235)	PR-21			Model Number		PRINTED OUTPUT
3	8	7			Maximum Number On-Line		
450	900	1,200			Single Spacing	Speed, lines/min	
360	601	665			1-inch Spacing		
2	2 max	1.9 to 3.1			Demands on Processor, %		
120	120	136			Number of Print Positions		
64	64	64			Character Set Size		
Echo	Echo	Validity			Checking		
	On/off line models available	Listed speed is based on a restricted, 48-character set			Features and Comments		
S12A (GE-215)	S12B, S12C (GE-225 & 235)	MR-20 Magnetic Reader/Sorter			Model Number		MICR READER
750 (550 on demand)	1200 (600 on demand)	1,155			Peak Speed, documents/min		
12 stackers; usable for off-line sorting	12 stackers; usable for off-line sorting	12 stackers; usable for off-line sorting			Features and Comments		
					Model Number		OPTICAL CHARACTER READER
					Peak Speed, documents/min		
					Features and Comments		
DATANET-15		DATANET-					DATA COMMUNI-CATIONS CONTROLLER
		20	21	30	Model Number		
2,400		1,200	2,400	250,000	Peak Speed, bits/sec		
Single-line controller		Async.	Sync.	Independent Computer	Features and Comments		
					Model Number		CRT DISPLAY
					Capacity, char		
					Features and Comments		
					Model Number		PLOTTER
					Peak Speed, points/sec		
					Features and Comments		
		ML-20			Model Number		OTHER INPUT-OUTPUT DEVICES
		Multiple Tape Lister			Name		
		2000 lpm			Features and Comments		

*With optional equipment.

<table>
<tr><td colspan="3">System Identity</td><td>GE-600 Series</td><td colspan="3">Honeywell Series 200</td></tr>
<tr><td rowspan="9">PRINTED OUTPUT</td><td colspan="2">Model Number</td><td>PRT 201</td><td colspan="2">222 Series</td><td>122-1</td></tr>
<tr><td colspan="2">Maximum Number On-Line</td><td>10 per I/O Controller</td><td colspan="2">1/address assignment</td><td>1</td></tr>
<tr><td rowspan="2">Speed, lines/min</td><td>Single Spacing</td><td>949/1,200</td><td colspan="2">650/950/450</td><td>300</td></tr>
<tr><td>1-inch Spacing</td><td>640</td><td colspan="2">437/605/355</td><td>50</td></tr>
<tr><td colspan="2">Demands on Processor, %</td><td>1.3 max</td><td colspan="2">Varies</td><td>12</td></tr>
<tr><td colspan="2">Number of Print Positions</td><td>136</td><td colspan="2">96,108,120, or 132*</td><td>132*</td></tr>
<tr><td colspan="2">Character Set Size</td><td>64</td><td colspan="2">63</td><td>63</td></tr>
<tr><td colspan="2">Checking</td><td>Echo</td><td colspan="2">Echo</td><td>Echo</td></tr>
<tr><td colspan="2">Features and Comments</td><td>1,200-1 pm speed is based on use of 46 of the 64 printable characters</td><td colspan="2">Speeds are lower when full 63-character sets are used.</td><td>Data protection-stops and indicator sets if incorrect response to control unit; Module 110 only</td></tr>
<tr><td rowspan="3">MICR READER</td><td colspan="2">Model Number</td><td></td><td>233-2</td><td>232</td><td>Burroughs B103</td></tr>
<tr><td colspan="2">Peak Speed, documents/min</td><td></td><td>3,200 char/sec</td><td>600</td><td>1,560</td></tr>
<tr><td colspan="2">Features and Comments</td><td></td><td></td><td>Reader-Sorter and Control</td><td>Reader-Sorter</td></tr>
<tr><td rowspan="3">OPTICAL CHARACTER READER</td><td colspan="2">Model Number</td><td></td><td colspan="2">Honeywell 235 (NCR 420)</td><td>Honeywell 238 (IBM 1287)</td></tr>
<tr><td colspan="2">Peak Speed, documents/min</td><td></td><td colspan="2">1,664 char/sec</td><td>420 char/sec</td></tr>
<tr><td colspan="2">Features and Comments</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">DATA COMMUNI-CATIONS CONTROLLER</td><td colspan="2">Model Number</td><td>DATANET - 30</td><td colspan="2">281 Series</td><td>286 Series</td></tr>
<tr><td colspan="2">Peak Speed, bits/sec</td><td>250,000</td><td colspan="2">40,800</td><td>2,400/line</td></tr>
<tr><td colspan="2">Features and Comments</td><td>Up to 128 lines; independent computer</td><td colspan="2">Single-line controller</td><td>Controls 13 to 63 lines</td></tr>
<tr><td rowspan="3">CRT DISPLAY</td><td colspan="2">Model Number</td><td></td><td>303,304,311, 312,317</td><td>331,332</td><td>355</td></tr>
<tr><td colspan="2">Capacity, char</td><td></td><td colspan="3">32 to 768 characters</td></tr>
<tr><td colspan="2">Features and Comments</td><td></td><td>Display station</td><td>Communication module</td><td>Polling module</td></tr>
<tr><td rowspan="3">PLOTTER</td><td colspan="2">Model Number</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Peak Speed, points/sec</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Features and Comments</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">OTHER INPUT-OUTPUT DEVICES</td><td colspan="2">Model Number</td><td></td><td>285-8C,D,F,G, J,K</td><td>082-1,2</td><td>083-1,2,3,4,5</td></tr>
<tr><td colspan="2">Name</td><td></td><td>Audio Unit</td><td>Answer Back Feature</td><td>Voice Cylinders</td></tr>
<tr><td colspan="2">Features and Comments</td><td></td><td colspan="3">31, 63 or 189 vocabulary elements at 0.533 second per word; used with 286 series</td></tr>
</table>

*With optional equipment.

Honeywell 400 & 1400	Honeywell 800 & 1800	System Identity		
422-3, 422-4	822	Model Number		PRINTED OUTPUT
1	8	Maximum Number On-Line		
900	900	Single Spacing	Speed, lines/min	
560	560	1-inch Spacing		
79 or 2*	0.3 max	Demands on Processor, %		
120	120	Number of Print Positions		
56	56	Character Set Size		
Echo	Echo	Checking		
422-4 can print in any 120 or 160 print positions	Prints 120 of 160 positions, as selected by plugboard	Features and Comments		
		Model Number		MICR READER
		Peak Speed, documents/min		
		Features and Comments		
		Model Number		OPTICAL CHARACTER READER
		Peak Speed, documents/min		
		Features and Comments		
		Model Number		DATA COMMUNICATIONS CONTROLLER
		Peak Speed, bits/sec		
		Features and Comments		
		Model Number		CRT DISPLAY
		Capacity, char		
		Features and Comments		
		Model Number		PLOTTER
		Peak Speed, points/sec		
		Features and Comments		
		Model Number		OTHER INPUT-OUTPUT DEVICES
		Name		
		Features and Comments		

*With optional equipment.

System Identity			IBM System/360 Model 20			IBM System/360 Models 25-85			
PRINTED OUTPUT	Model Number		1403 Models 2, 7	1403 Model N1	2203 Model A1	1403 Model 2, 7	1403 Model 3	1403 Model N1	1404 Model 2
	Maximum Number On-Line		1	1	1	8/channel			
	Speed, lines/min	Single Spacing	600	1, 100	350	600	1, 100	1, 100	600
		1-inch Spacing	480	755	265	480	755	755	480
	Demands on Processor, %		2.0	3.6	21.5 max.	Varies			
	Number of Print Positions		Mdl 2-132 Mdl 7-120	120	120/144*	Mdl 2-132 Mdl 7-120	132	120	132
	Character Set Size		48	48	13/39/52/63	48			
	Checking		Echo	Echo	Print synch.	Echo			
	Features and Comments		Horiz. chain printer	Uses train of type slugs	Horiz. typebar	Horiz. chain printer	Horiz. train of type slugs	Has acoustical cover	Can print on punched cards
MICR READER	Model Number		1259 Model 1	1419 Model 1		1259 Models 1, 2	1412	1419	
	Peak Speed, documents/min		600	1, 600		600	950	1200	
	Features and Comments								
OPTICAL CHARACTER READER	Model Number					1418 Models 1, 2, 3	1428 Models 1, 2, 3	1285	1287
	Peak Speed, documents/min					560 char/sec	532 char/sec	1042 char/sec	420 char/sec
	Features and Comments						Alphameric		
DATA COMMUNICATIONS CONTROLLER	Model Number		2074 Adapter			2701	2702	2703	
	Peak Speed, bits/sec		2, 400			460, 800	9, 000	115, 200	
	Features and Comments		Binary Synchronous			4 lines max.	31 lines max.	176 lines max.	
CRT DISPLAY	Model Number					2250		2260	
	Capacity, char					3, 848		960	
	Features and Comments					Vector type display		Alphanumeric display	
PLOTTER	Model Number								
	Peak Speed, points/sec								
	Features and Comments								
OTHER INPUT-OUTPUT DEVICES	Model Number					7770	7772	1231 Model N1	
	Name					Audio Response Unit	Audio Response Unit	Optical Mark Page Reader	
	Features and Comments					Vocab. 32/48/64/128 words	Disk based vocabulary	2000 doc/hr. contin. 1600 doc/hr. demand	

*With optional equipment.

IBM System/360 Models 30-85			IBM System/360 Model 44				System Identity	
1443 Model N1	1445 Model N1	2203 Model A1	1403 Models 2, 7	1403 Model 3	1403 Model N1	1443 Model N1	Model Number	PRINTED OUTPUT
8/channel			8/channel				Maximum Number On-Line	
240	190	350	600	1,100	1,100	240	Speed, lines/min: Single Spacing	
190	150	265	480	755	755	190	Speed, lines/min: 1-inch Spacing	
Varies			Varies				Demands on Processor, %	
120; 144*	113	120; 144*	Mdl 2-132 Mdl 7-120	132	120	120; 144*	Number of Print Positions	
13/39/52/63	56	13/39/52/63	48			13/39/52/63	Character Set Size	
Print synch.			Echo			Print synch.	Checking	
Horiz. typebar	Can print MICR chars.	Horiz. typebar	Horiz. chain printer	Horiz. train of type slugs	Has acoustical cover	Horiz. typebar	Features and Comments	
1288							Model Number	MICR READER
764 char/sec							Peak Speed, documents/min	
Page Reader							Features and Comments	
							Model Number	OPTICAL CHARACTER READER
							Peak Speed, documents/min	
							Features and Comments	
							Model Number	DATA COMMUNICATIONS CONTROLLER
							Peak Speed, bits/sec	
							Features and Comments	
			2250		2260		Model Number	CRT DISPLAY
			3,848		960		Capacity, char	
			Vector type display		Alphanumeric display		Features and Comments	
							Model Number	PLOTTER
							Peak Speed, points/sec	
							Features and Comments	
							Model Number	OTHER INPUT-OUTPUT DEVICES
							Name	
							Features and Comments	

*With optional equipment.

	System Identity	IBM 1401			IBM 1401-G			IBM 1401-H
PRINTED OUTPUT	Model Number	1403 Models 1, 2	1404 Model 2	1445 Model N1	1403 Mod. 4 or 5	1445 Model N1		1403 Mod 6
	Maximum Number On-Line	1	1	1	1	1		1
	Speed, lines/min: Single Spacing	600	600	190	465	190 (525 numeric)		340
	Speed, lines/min: 1-inch Spacing	480	480	150	390	150		300
	Demands on Processor, %	84 to 2*	?	?	87	?		?
	Number of Print Positions	100 or 132	132	113	100 or 132	113		120
	Character Set Size	48	?	56	48	56		48
	Checking	Echo; validity	Echo	Echo	Echo; validity	Echo		Echo: validity
	Features and Comments	Horizontal-chain print mechanism	Can print on punched cards	Can print MICR characters	Horizontal-chain print mechanism	Can print MICR characters		
MICR READER	Model Number	#1419 Model 1	#1412 Model		1412 Model 1			
	Peak Speed, documents/min	1,600	950		950			
	Features and Comments							
OPTICAL CHARACTER READER	Model Number	1418	1428	1285	1418	1428	1285	
	Peak Speed, documents/min	560	533	800	560 char/sec	533 char/sec	800 char/sec	
	Features and Comments							
DATA COMMUNICATIONS CONTROLLER	Model Number	1009	7710	7740	1009			
	Peak Speed, bits/sec	2,400	40,800	350,000	2,400			
	Features and Comments	4-of-8 code		Independent computer	Uses 4-of-8 code			
CRT DISPLAY	Model Number							
	Capacity, char							
	Features and Comments							
PLOTTER	Model Number							
	Peak Speed, points/sec							
	Features and Comments							
OTHER INPUT-OUTPUT DEVICES	Model Number	1231 Model 1	7770		1231 Model 1			
	Name	Optical Mark Page Reader	Audio Response Unit		Optical Mark Page Reader			
	Features and Comments	2,000 doc/hr max.	32- to 128-word vocabulary		2,000 doc/hr max.			

*With optional equipment.

IBM 1410		IBM 1440		IBM 1460		System Identity	
1403 Mod. 1,2	1403 Mod. 3	1443 Model 1	1443 Model 2	1403 Model 2	1403 Model 3	Model Number	PRINTED OUTPUT
2	2	1	1	3	3	Maximum Number On-Line	PRINTED OUTPUT
600 (1,285 numeric*)	1,100	150 (430 numeric)	240 (600 numeric)	600 (1,285 numeric*)	1,100	Speed, lines/min: Single Spacing	PRINTED OUTPUT
480 (838 numeric*)	750	132	196	480 (838 numeric*)	750	Speed, lines/min: 1-inch Spacing	PRINTED OUTPUT
1 to 3	2.6	94 or 0.6*	90 or 1.0*	84 to 1*	1.8	Demands on Processor, %	PRINTED OUTPUT
100 or 132	132	120 or 144*		132		Number of Print Positions	PRINTED OUTPUT
48	48	13,39,52, or 63 characters*		48		Character Set Size	PRINTED OUTPUT
Echo; validity	Echo; validity	Echo		Echo; validity		Checking	PRINTED OUTPUT
		Interchangeable horizontal typebar				Features and Comments	PRINTED OUTPUT
1419 Model 1	1412 Model 1			1412	1419	Model Number	MICR READER
1600	950			950	1,600	Peak Speed, documents/min	MICR READER
						Features and Comments	MICR READER
				1418	1428	Model Number	OPTICAL CHARACTER READER
				560 chars/sec	533 chars/sec	Peak Speed, documents/min	OPTICAL CHARACTER READER
						Features and Comments	OPTICAL CHARACTER READER
1009	7750	1448	7740	1009		Model Number	DATA COMMUNI-CATIONS CONTROLLER
2,400	22,400	420	350,000	2,400		Peak Speed, bits/sec	DATA COMMUNI-CATIONS CONTROLLER
4-of-8 code	Independent computer		Independent computer			Features and Comments	DATA COMMUNI-CATIONS CONTROLLER
						Model Number	CRT DISPLAY
						Capacity, char	CRT DISPLAY
						Features and Comments	CRT DISPLAY
						Model Number	PLOTTER
						Peak Speed, points/sec	PLOTTER
						Features and Comments	PLOTTER
		1231 Model	7770			Model Number	OTHER INPUT-OUTPUT DEVICES
		Optical Mark Page Reader	Audio Response Unit			Name	OTHER INPUT-OUTPUT DEVICES
		2,000 doc/hr max.	32- to 128-word vocab.			Features and Comments	OTHER INPUT-OUTPUT DEVICES

*With optional equipment.

System Identity			IBM 1620 Models 1 & 2		IBM 7010		IBM 7040 & 7044	
PRINTED OUTPUT	Model Number		1443 Mod. 1	1443 Mod. 2	1403 Models 1, 2	1403 Model 3	1403 Models 1, 2	1403 Model 3
	Maximum Number On-Line		1	1	2	2	2	2
	Speed, lines/min	Single Spacing	150 (430 numeric)	240 (600 numeric)	600	1100	600	1100
		1-inch Spacing	132	196	480	750	480	750
	Demands on Processor, %		94 or 0.6*	90 or 1.0*	0.3 to 0.84	0.73	0.7 max.	1.3 max.
	Number of Print Positions		120 or 144*		100 or 132	132	100 or 132	132
	Character Set Size		13, 39, 52 or 63 characters*		48		48	
	Checking		Echo		Echo, validity		Echo, validity	
	Features and Comments		Interchangeable horizontal typebar					
MICR READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
OPTICAL CHARACTER READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
DATA COMMUNI-CATIONS CONTROLLER	Model Number				1009	7750	1009	
	Peak Speed, bits/sec				2,400	22,400	2,400	
	Features and Comments				4-of-8 code	Independent computer; up to 112 lines	Uses 4-of-8 code; synchronous	
CRT DISPLAY	Model Number							
	Capacity, char							
	Features and Comments							
PLOTTER	Model Number		1627					
	Peak Speed, points/sec		200 or 300					
	Features and Comments		Incremental					
OTHER INPUT-OUTPUT DEVICES	Model Number							
	Name							
	Features and Comments							

*With optional equipment.

IBM 7070.7072. & 7074	IBM 7080		IBM 7090 & 7094	System Identity		
7400	717	720	716	Model Number		PRINTED OUTPUT
3	10	10	1	Maximum Number On-Line		
150	150	500	75 to 150	Single Spacing	Speed, lines/min	
150	150	400	75 to 150	1-inch Spacing		
1.5 max.	100	100	< 1	Demands on Processor, %		
120	120	120	120	Number of Print Positions		
48	48	48	48	Character Set Size		
Validity,	Echo	Echo	Programmed echo	Checking		
Not usable with 7072			Maximum of 72 characters per print cycle	Features and Comments		
				Model Number		MICR READER
				Peak Speed, documents/min		
				Features and Comments		
				Model Number		OPTICAL CHARACTER READER
				Peak Speed, documents/min		
				Features and Comments		
	1009	7750	1009	Model Number		DATA COMMUNI-CATIONS CONTROLLER
	2,400	22,400	2,400	Peak Speed, bits/sec		
	4-of-8 code	Independent computer	Uses 4-of-8 code; synchronous	Features and Comments		
				Model Number		CRT DISPLAY
				Capacity, char		
				Features and Comments		
				Model Number		PLOTTER
				Peak Speed, points/sec		
				Features and Comments		
				Model Number		OTHER INPUT-OUTPUT DEVICES
				Name		
				Features and Comments		

*With optional equipment.

System Identity			NCR Century Series				NCR 315, 315-100, & 315-RMC			
PRINTED OUTPUT	Model Number		640-102	640-200	640-210	640-300	340-3	340-502 340-512	340-503	340-601, -632, -644
	Maximum Number On-Line		8/trunk				4	4	4	4
	Speed, lines/min	Single Spacing	450/ 900	1500/ 3000	1500/ 3000	600/ 1200	690/ 940	650/ 805	805	1000
		1-inch Spacing	300/ 450	820/ 1180	820/ 1180	?	407	400	400	520
	Demands on Processor, %		8 Max.	17 Max.	21 Max.	?	1.4 Max.	81 Max.	81 Max.	1.5 Max.
	Number of Print Positions		132	132	160	132	120	120	120	120 or 132
	Character Set Size		64 or 51	64 or 51	64 or 51	Up to 128				
	Checking		Echo				Validity	Validity	Validity	Validity
	Features and Comments		One 640-102 is "integrated" into every Century 100 system; one 640-200, 210 or 300 is "integrated" into every Century 200 system; other printers are connected via buffer controls; higher speeds are for all-numeric printing				340-512 can operate as a 24-position numeric lister at 1850 lpm.		Listed speeds are based on use of a restricted 42-character set	Model 340-644 can function as a 2000 lpm numeric lister
MICR READER	Model Number		670-101	671-101			402-3, 402-4		407-1	
	Peak Speed, documents/min		600	1,200			750		1,200	
	Features and Comments						Usable off-line		Usable off-line	
OPTICAL CHARACTER READER	Model Number		420-2 Optical Reader				420-2 Optical Reader			
	Peak Speed, documents/min		1,664 char/sec				1,664 char/sec			
	Features and Comments		Reads journal tapes				Reads journal tapes			
DATA COMMUNICATIONS CONTROLLER	Model Number		621-101		621-201		321-1(315); 327-3 (315-RMC)			
	Peak Speed, bits/sec		50,000/ line		50,000/ line		40,800/line			
	Features and Comments		Controls up to 15 lines		Controls up to 255 lines		Controls up to 99 lines			
CRT DISPLAY	Model Number		795							
	Capacity, char		256, 512, or 1,024							
	Features and Comments		Extensive editing controls							
PLOTTER	Model Number									
	Peak Speed, points/sec									
	Features and Comments									
OTHER INPUT-OUTPUT DEVICES	Model Number									
	Name									
	Features and Comments									

*With optional equipment.

RCA SPECTRA 70			RCA 301		System Identity	
70/242	70/243	70/248	333	335	Model Number	PRINTED OUTPUT
1/Trunk			2	2	Maximum Number On-Line	
625	1,250	600	800 to 1,000	835 to 1,075	Speed lines/min: Single Spacing	
508	715	480	500	572	Speed lines/min: 1-inch Spacing	
Varies			85/22*	84/32*	Demands on Processor, %	
132/160*	132	132	120	160	Number of Print Positions	
64	64	48	47; 64		Character Set Size	
Timing	Timing	None	None		Checking	
"Quietized" versions are available	Versions are available with 96-character print drums	Can print on punched cards	1000 lpm with 47 character character sets.		Features and Comments	
			Burroughs B102		Model Number	MICR READER
			1,560		Peak Speed, documents/min	
					Features and Comments	
70/251			5820 VIDEOSCAN		Model Number	OPTICAL CHARACTER READER
1,300			1,500		Peak Speed, documents/min	
					Features and Comments	
70/627	70/653	70/668	378 CMC		Model Number	DATA COMMUNI-CATIONS CONTROLLER
320,000 bytes/sec	5100 char/sec	6000 bytes/sec	2,400 per line		Peak Speed, bits/sec	
Direct computer line	Single line	48 lines	Up to 80 lines		Features and Comments	
70/252 Video Data Terminal					Model Number	CRT DISPLAY
1,080					Capacity, char	
Single-station unit; can be multiplexed via 70/755 Video Data Switch					Features and Comments	
					Model Number	PLOTTER
					Peak Speed, points/sec	
					Features and Comments	
70/510	70/630		328	338	Model Number	OTHER INPUT-OUTPUT DEVICES
Voice Response Unit	Data Gathering System		Interrogating Typewriter	Monitor Printer	Name	
189-word vocabulary	120 char/sec		10 char/sec	10 char/sec	Features and Comments	

*With optional equipment.

System Identity		RCA 3301			UNIVAC III	UNIVAC S.S. 80/90
PRINTED OUTPUT	Model Number	333	335		4152	7912
	Maximum Number On-Line	2	2		8	1
	Speed, lines/min — Single Spacing	800	800		700/922	600
	Speed, lines/min — 1-inch Spacing	540	540		480/670	430
	Demands on Processor, %	<0.1	<0.1		0.16 to 0.22	14
	Number of Print Positions	120	160		128	100 to 130
	Character Set Size	64			54	57
	Checking	None			None	Echo
	Features and Comments	1,000 lpm with restricted (47 characters) character set			No form control loop	No form control loop
MICR READER	Model Number					
	Peak Speed, documents/min					
	Features and Comments					
OPTICAL CHARACTER READER	Model Number					
	Peak Speed, documents/min					
	Features and Comments					
DATA COMMUNI-CATIONS CONTROLLER	Model Number	3376	3377	3378		
	Peak Speed, bits/sec	40,800	276,000	2,400/line		
	Features and Comments	Single line	Computer link	Up to 160 lines		
CRT DISPLAY	Model Number					
	Capacity, char					
	Features and Comments					
PLOTTER	Model Number					
	Peak Speed, points/sec					
	Features and Comments					
OTHER INPUT-OUTPUT DEVICES	Model Number					
	Name					
	Features and Comments					

*With optional equipment.

UNIVAC 418 Series			UNIVAC 490 Series			System Identity	
0755	0758		0751, 0755, 8121	0758-00		Model Number	PRINTED OUTPUT
16	8		1/ch	1/ch		Maximum Number On-Line	PRINTED OUTPUT
400	700/922 Numeric		700/922	1600		Speed lines/min: Single Spacing	PRINTED OUTPUT
340	472/563 Numeric		472/484	900		Speed lines/min: 1-inch Spacing	PRINTED OUTPUT
0.2 to 0.7	0.2 to 0.7		0.051 to 0.41			Demands on Processor, %	PRINTED OUTPUT
132			132			Number of Print Positions	PRINTED OUTPUT
63			63			Character Set Size	PRINTED OUTPUT
None			None			Checking	PRINTED OUTPUT
			Higher speeds can be obtained with restricted character set			Features and Comments	PRINTED OUTPUT
						Model Number	MICR READER
						Peak Speed, documents/min	MICR READER
						Features and Comments	MICR READER
						Model Number	OPTICAL CHARACTER READER
						Peak Speed, documents/min	OPTICAL CHARACTER READER
						Features and Comments	OPTICAL CHARACTER READER
CTMC	WTS	CTS	CTMC	WTS	CTS	Model Number	DATA COMMUNI-CATIONS CONTROLLER
Up to 4,800 per line	40,800	40,800	Up to 4,800 per line	40,800	40,800	Peak Speed, bits/sec	DATA COMMUNI-CATIONS CONTROLLER
Up to 32 lines	Synchronous	Asynchronous	Up to 32 lines	Synchronous	Asynchronous	Features and Comments	DATA COMMUNI-CATIONS CONTROLLER
						Model Number	CRT DISPLAY
						Capacity, char	CRT DISPLAY
						Features and Comments	CRT DISPLAY
						Model Number	PLOTTER
						Peak Speed, points/sec	PLOTTER
						Features and Comments	PLOTTER
						Model Number	OTHER INPUT-OUTPUT DEVICES
						Name	OTHER INPUT-OUTPUT DEVICES
						Features and Comments	OTHER INPUT-OUTPUT DEVICES

*With optional equipment.

System Identity			UNIVAC 1004		UNIVAC 1050		UNIVAC 1107	
PRINTED OUTPUT	Model Number		1004 I	1004 II, III	0755-01	0755-02	7400	7418
	Maximum Number On-Line		1		4 or 8		15	
	Speed, lines/min	Single Spacing	400	600	600/750	700/922	700 to 922	600
		1-inch Spacing	340	380	422	468	475	424
	Demands on Processor, %		100		0.6 max.	0.7 max.	0.12 max.	0.09
	Number of Print Positions		132		128		100 to 130	128
	Character Set Size		63		63		63	51
	Checking		None		Validity		None	
	Features and Comments				Higher rates obtainable with restricted character sets		No form control loop	
MICR READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
OPTICAL CHARACTER READER	Model Number							
	Peak Speed, documents/min							
	Features and Comments							
DATA COMMUNICATIONS CONTROLLER	Model Number		DLT Series		Standard Communications Subsystem		Standard Communications Subsystem	
	Peak Speed, bits/sec		Varies widely; many models		Up to 4,800 per line		Up to 4,800 per line	
	Features and Comments		Single-line		Up to 32 lines		Up to 32 lines	
CRT DISPLAY	Model Number							
	Capacity, char							
	Features and Comments							
PLOTTER	Model Number							
	Peak Speed, points/sec							
	Features and Comments							
OTHER INPUT-OUTPUT DEVICES	Model Number							
	Name							
	Features and Comments							

*With optional equipment.

UNIVAC 1108			UNIVAC 9200 & 9300		UNIVAC 9400		System Identity	
0758-00	7299-03		3030-00	3030-02	768-00	768-99	Model Number	PRINTED OUTPUT
4/channel			1	1	7		Maximum Number On-Line	
1200/1600	700/922		250/500*	600/1200*	900/1100	1200/1600	Speed lines/min: Single Spacing	
800/834	472/484		220	451	652/670	800/810	Speed lines/min: 1-inch Spacing	
0.025 max.			13	31	<1.0		Demands on Processor, %	
132			96/132*	120/132*	132		Number of Print Positions	
63			63	63	63		Character Set Size	
None			Echo	Echo	Echo		Checking	
			For use on 9200	For use on 9300			Features and Comments	
							Model Number	MICR READER
							Peak Speed, documents/min	
							Features and Comments	
							Model Number	OPTICAL CHARACTER READER
							Peak Speed, documents/min	
							Features and Comments	
CTMC	WTS	CTS	DCS-1		DCS-1	DCS-4, -16	Model Number	DATA COMMUNI-CATIONS CONTROLLER
4,800 per line	40,800	40,800	50,000		50,000	230,400 per line	Peak Speed, bits/sec	
32 lines	Synchro-nous	Asyn-chronous	Single-line		Single-line	For 4 or 16 lines	Features and Comments	
							Model Number	CRT DISPLAY
							Capacity, char	
							Features and Comments	
							Model Number	PLOTTER
							Peak Speed, points/sec	
							Features and Comments	
							Model Number	OTHER INPUT-OUTPUT DEVICES
							Name	
							Features and Comments	

*With optional equipment.

SOFTWARE COMPARISON CHARTS
INTRODUCTION

The charts on the following pages show the principal software facilities available from the manufacturers for use on nearly 100 U. S.-manufactured digital computer systems. These charts, arranged in alphabetical order by manufacturer, enable you to make direct comparisons of the type and extent of software support facilities furnished by the manufacturers of competitive computers. Moreover, the charts provide valuable indications of the age of each computer system and the type of circuitry it employs.

In the Software Comparison Charts, a "bulls-eye" (large black dot) denotes the availability or use of a particular facility, while a blank space denotes its absence. Explanations of the specific chart entries follow.

SYSTEM CHARACTERISTICS

Identity — Manufacturer and model number of the computer system.

Date of First Customer Delivery — Month and year in which the first successful installation was made or is scheduled to be made.

Solid State — Uses electronic components whose operation depends on the control of electric or magnetic phenomena in solids (e. g., transistors, crystal diodes, ferrite cores), as distinguished from the earlier vacuum-tube technology.

Integrated Circuits — Uses complete, miniaturized electronic circuits, all of whose component parts are fabricated and assembled in a single integrated process, so that the resultant assembly cannot be disassembled without destroying it.

LANGUAGE PROCESSORS

These are specialized computer routines which translate programs written in languages designed for programming convenience into machine-language programs suitable for execution by computers.

Language processors can be grouped into two major categories, assemblers and compilers, depending upon the type of source language they accept as input. An assembler accepts programs written in a symbolic code that is closely related to the computer's own machine language. A compiler accepts programs written in a "process oriented language" such as COBOL or FORTRAN, which permits convenient specification of data processing or computational processes in terms of procedural or algorithmic steps rather than specific computer operations.

Assembler — Assembles programs written in a symbolic language that is similar to machine language but simpler and more meaningful, thereby greatly reducing the human effort required to prepare and debug programs.

ALGOL Compiler — Compiles programs written in ALGOL, an international language designed for convenient expression of computational procedures. ALGOL is very popular in Europe but is not as widely used in the United States.

COBOL Compiler — Compiles programs written in COBOL, the COmmon Business Oriented Language designed in 1959 and accepted as a USA Standard. COBOL uses English-like procedural statements and is by far the most widely used process oriented language for business applications.

FORTRAN Compiler	Compiles programs written in FORTRAN, a language designed to facilitate the preparation of scientific programs through the use of expressions and symbols similar to those of algebra. FORTRAN has been accepted as a USA Standard language in two versions (FORTRAN and Basic FORTRAN), and is by far the most popular scientific programming language.
PL/I Compiler	Compiles programs written in PL/I, a multipurpose language developed jointly by IBM and the SHARE users' organization between 1964 and 1966. PL/I represents an attempt to combine the best features of ALGOL, COBOL, and FORTRAN with a number of facilities not available in previous languages.

OPERATING SYSTEMS

An operating system is an organized collection of routines and/or procedures for operating a computer. It will normally handle some or all of the following functions: (1) scheduling, loading, initiating, and supervising the execution of programs; (2) allocating storage, input-output units, and other facilities of the computer system; (3) initiating and controlling input-output operations; (4) handling error conditions and restarts; (5) coordinating communications between operator and computer; (6) maintaining a log of system operations; and (7) controlling operations in a multiprogramming, multiprocessing, time-sharing, or data communications mode.

Tape Operating System	Resides on magnetic tape and performs some or all of functions (1) through (6) above; random-access storage devices are not required.
Disc Operating System	Resides on a random-access storage medium (disc, drum, or magnetic strip) and performs some or all of functions (1) through (6) above; usually more efficient than an equivalent tape operating system.
Multiprogramming	Support for handling two or more independent programs simultaneously by overlapping or interleaving their execution.
Multiprocessing	Support for controlling the simultaneous execution of two or more sequences of instructions in a single computer system, usually through the use of two or more central processors.
Time-Sharing	Support for furnishing computing services to multiple simultaneous users at remote terminals, while providing rapid responses to each of the users.
Data Communications	Support for controlling the transmission of digital data between the computer site and one or more remote locations, usually via a communications medium such as a telephone, telegraph, or microwave circuit.

In addition a column is included to indicate the presence or absense of a Report Generator, a routine that constructs programs, based upon problem parameters supplied as input, to perform routine report-writing functions.

SOFTWARE COMPARISON CHART

SYSTEM CHARACTERISTICS				LANGUAGE PROCESSORS					OPERATING SYSTEMS						
IDENTITY	Date of First Customer Delivery	Solid State	Integrated Circuits	Assembler	ALGOL Complier	COBOL Complier	FORTRAN Complier	PL/I Complier	Tape Operating System	Disc Operating System	Multiprogramming	Multiprocessing	Time-Sharing	Data Communications	Report Generator
Burroughs B 100	12/63	●		●											●
Burroughs B 200	10/62	●		●		●			●	●	●			●	●
Burroughs B 300	5/65	●		●		●			●	●	●			●	●
Burroughs B 2500	5/67	●	●	●		●	●			●	●			●	●
Burroughs B 3500	5/67	●	●	●		●	●			●	●			●	●
Burroughs B 5500	12/64	●			●	●	●			●	●	●	●	●	
Burroughs B 6500	3/69	●	●		●	●	●	●		●	●	●		●	
Burroughs B 7500	3/69	●	●		●	●	●	●		●	●	●		●	
CDC 160/160A	5/60	●		●			●								
CDC 1604/1604A	1/60	●		●	●	●	●		●						
CDC 3100	1/65	●		●	●	●	●		●	●	●			●	●
CDC 3300	3/66	●		●	●	●	●		●	●	●		●	●	●
CDC 3500	7/68	●		●	●	●	●		●	●	●		●	●	
CDC 3400	11/64	●		●		●	●		●		●		●	●	
CDC 3600	6/63	●		●	●	●	●		●		●		●	●	
CDC 3800	2/66	●		●	●	●	●		●		●		●	●	
CDC 6400	3/66	●		●	●	●	●			●	●	●	●	●	●
CDC 6500	7/67	●		●	●	●	●			●	●	●	●	●	●
CDC 6600	8/64	●		●	●	●	●			●	●	●	●	●	●
GE-115	12/65	●		●		●			●	●				●	
GE-130	4/69	●		●		●	●		●	●				●	
GE-200 Series	4/61	●		●		●	●		●	●		●	●	●	●
GE-400 Series	5/64	●		●		●	●		●	●	●	●	●	●	●
GE-600 Series	4/65	●		●	●	●	●		●	●	●	●	●	●	●
Honeywell 110	8/68	●	●			●			●	●	●	●		●	●
Honeywell 120	2/66	●	●	●		●			●	●	●	●		●	●
Honeywell 125	3/68	●	●	●		●			●	●	●	●		●	●
Honeywell 200	7/64	●		●		●	●		●	●	●	●		●	●
Honeywell 1200	1/66	●		●		●	●		●	●	●	●		●	●
Honeywell 1250	7/68	●		●		●	●		●	●	●	●		●	●
Honeywell 2200	12/65	●		●		●	●		●	●	●	●		●	●
Honeywell 4200	3/68	●	●	●		●	●		●	●	●	●		●	●
Honeywell 8200	6/68	●	●	●		●	●		●		●	●		●	●
Honeywell 400	12/61	●		●		●	●		●						●
Honeywell 1400		●		●		●	●		●					●	●
Honeywell 800	1960	●		●		●	●		●		●				●
Honeywell 1800	1963	●		●		●			●		●				●
IBM 360, Model 20	12/65	●(1)		●											●
IBM 360, Model 25	1/68	●(1)		●		●	●	●	●	●	●			●	●
IBM 360, Model 30	5/65	●(1)		●	●	●	●	●	●	●	●			●	●
IBM 360, Model 40	4/65	●(1)		●	●	●	●	●	●	●	●			●	●
IBM 360, Model 44	7/66	●(1)		●						●					
IBM 360, Model 50	8/65	●(1)		●	●	●	●	●	●	●	●			●	●
IBM 360, Model 65	11/65	●(1)		●	●	●	●	●	●	●	●	●		●	●
IBM 360, Model 67	10/66	●(1)		●			●			●	●	●	●	●	●

(1) IBM uses "hybrid" electronic circuitry in the System/360; this is a compromise between solid-state and integrated circuitry.

SOFTWARE COMPARISON CHART (Cont'd)

SYSTEM CHARACTERISTICS				LANGUAGE PROCESSORS					OPERATING SYSTEMS						
IDENTITY	Date of First Customer Delivery	Solid State	Integrated Circuits	Assembler	ALGOL Complier	COBOL Complier	FORTRAN Complier	PL/I Complier	Tape Operating System	Disc Operating System	Multiprogramming	Multiprocessing	Time-Sharing	Data Communications	Report Generator
IBM 360, Model 75	2/66	●(1)		●	●	●	●	●	●	●	●			●	
IBM 360, Model 85	-		●	●	●	●	●	●	●	●	●			●	●
IBM 1401	9/60	●		●		●	●							●	●
IBM 1410	11/61	●		●		●	●							●	
IBM 1440	4/63	●		●		●	●								●
IBM 1460	10/63	●		●		●	●								●
IBM 1620 Model 1	9/60			●			●								
IBM 1620 Model 2	10/62			●			●								
IBM 7010	10/63	●		●		●	●							●	●
IBM 7040	7/62	●		●			●							●	●
IBM 7044	7/62	●		●			●							●	●
IBM 7070	3/60	●		●		●	●								●
IBM 7072	6/62	●		●		●	●							●	●
IBM 7074	11/61	●		●		●	●							●	●
IBM 7080	8/61	●		●		●	●								●
IBM 7090	7/62	●		●		●	●							●	
IBM 7094	10/62	●		●			●							●	
NCR 315	2/62	●		●		●	●		●	●				●	●
NCR 315-100	12/64	●		●		●	●		●	●				●	●
NCR 315 RMC	9/65	●		●		●	●		●	●	●			●	●
NCR Century 100	9/68	●	●	●		●	●			●	●			●	●
NCR Century 200	3/69	●	●	●		●	●			●	●			●	●
RCA Spectra 70/15	9/65	●	●	●											●
RCA Spectra 70/25	12/65	●	●	●											●
RCA Spectra 70/35	2/27	●	●	●		●	●		●	●	●			●	●
RCA Spectra 70/45	2/66	●	●	●		●	●		●	●	●			●	●
RCA Spectra 70/46	1/69	●	●	●		●	●		●	●	●		●	●	●
RCA Spectra 70/55	9/66	●	●	●		●	●		●	●	●			●	●
RCA 301	2/61	●		●		●	●							●	●
RCA 3301	7/64	●		●		●	●				●		●	●	●
UNIVAC III	8/62	●		●		●	●		●		●				
UNIVAC SS 80/90 I	8/58	●		●											
UNIVAC SS 80/90 II	6/62	●		●											
UNIVAC 418 I	6/63	●		●			●		●	●(2)	●		●	●	
UNIVAC 418 II	?/64	●		●			●		●	●(2)	●		●	●	
UNIVAC 418 III	6/69	●		●		●	●			●(2)	●		●	●	
UNIVAC 490	12/61	●		●		●	●			●(2)	●		●	●	
UNIVAC 491/492	12/65	●		●		●	●			●(2)	●		●	●	
UNIVAC 494	6/66	●		●		●	●			●(2)	●		●	●	
UNIVAC 1004	1/63	●												●	●
UNIVAC 1050	6/63	●		●		●	●		●		●			●	●
UNIVAC 1107	9/62	●		●	●	●	●			●(2)	●	●		●	
UNIVAC 1108	12/65	●		●	●	●	●			●(2)	●	●	●	●	
UNIVAC 9200	6/67		●	●										●	●
UNIVAC 9300	9/67		●	●		●	●		●		●			●	●
UNIVAC 9400	6/69		●	●		●	●		●		●		●	●	●

(2) Drum oriented.

SYSTEM PERFORMANCE COMPARISON CHARTS

INTRODUCTION

These unique charts list the total processing times for five standard "benchmark" problems which represent typical computer workloads in both business and scientific applications. Each line on the System Performance charts shows the cost and calculated performance of a particular computer system arranged in a particular standard equipment configuration. (The standard configurations are defined in Table I of the Configuration Rentals Comparison Charts section.)

The System Performance charts are particularly useful when you need to make comparisons of the performance and cost of competitive computer systems (or different configurations of the same system) in applications similar to your own or your client's.

Each of the standard benchmark problems has been coded and timed in detail by experienced programmer/analysts. Each computer system's central processor speeds, input-output speeds, and capabilities for simultaneous operations have been carefully considered to determine the overall time required to process each problem.

To minimize subjective errors and ensure valid performance comparisons, the input, output, and basic computational procedure for each benchmark problem are rigidly specified. Conversely, the details of the computational procedure are left flexible so that useful features of specific computer systems can be effectively utilized.

All of the processing times shown in the System Performance charts are idealized times, with no allowance for set-up times, equipment failures, inefficient coding, software inefficiencies, operator errors, or idle time. The degrading effects of these factors are difficult to estimate and tend to vary widely from installation to installation, but it is important to note that they can cause a computer system's overall throughput to be substantially lower than our published processing times for individual runs might seem to indicate.

Processing times are listed for the following standard benchmark problems:

(1) Generalized File Processing Problem A

The essence of most business data processing applications is the updating of files to reflect the effects of various types of transactions. This benchmark problem is a file processing run in which transaction data in a detail file is used to update a master file, and a record of each transaction is written in a report file or journal (Figure 1). This type of run forms the bulk of the workload for many computer systems, in diverse applications such as billing, payroll, and inventory control.

The listed "Activity" factors of 0.0, 0.1, and 1.0 refer to cases in which an average of 0, 0.1, and 1.0 transaction record, respectively, must be processed for each record in the master file. Low activities are characteristic of applications such as inventory control, whereas a payroll run might well have an activity factor of 1.0. All calculated processing times are reported in terms of the number of minutes required to process 10,000 master-file records.

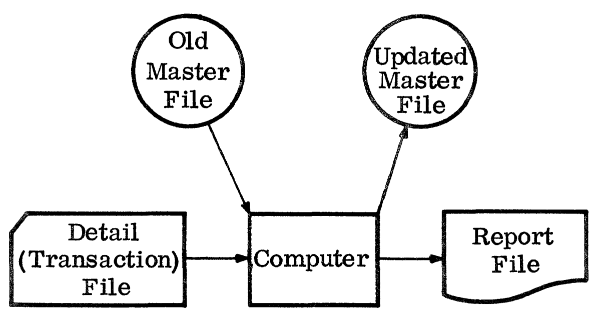

Figure 1. Run Diagram for Generalized File Processing Problem A

Figure 2 is a general flowchart that summarizes the computational process. Both the master file and detail file are sequentially arranged, and conventional batch processing techniques are employed. Record lengths are 108 characters for the master file, 80 characters (1 card) for the detail file, and 120 characters (1 line) for the report file. Record layouts are fixed for the detail and report files, but are left flexible for the master file in order to take advantage of the specific capabilities of each computer system.

Card reading and printing are performed on-line in all standard configurations except paired configurations VIIB and VIIIB, in which card-to-tape and tape-to-printer transcriptions are performed off-line, usually by a separate small-scale computer. The master file is on magnetic tape in all standard configurations except Configuration I, where it is on punched cards.

(2) Random Access File Processing Problem

This benchmark problem represents a wide range of real-time computer applications in which an on-line master file is accessed to answer inquiries and/or updated to reflect various types of transactions. Figure 3 shows the basic run diagram. Examples of this type of processing include real-time inventory control, credit checking, airline and hotel reservations, on-line savings systems, etc.

In contrast to Generalized File Processing Problem A, described above, this problem uses random access storage to hold the entire master file on-line, and processes all transactions as they occur, without prior sorting. All calculated times are reported in terms of the time in milliseconds required to process each transaction and the total time in minutes required to process 10,000 transactions.

This problem is evaluated for one or more of the three Random Access standard configurations (IIIR, IVR, and VIIIR). Where there are two or more random access devices that could satisfy the specified capacity requirements, our choice is based upon considerations of economy, system throughput, software support, and reliability. Therefore, disc files will normally be chosen in preference to drums (which are relatively expensive) or magnetic strip devices (which tend to be relatively slow and of lower reliability).

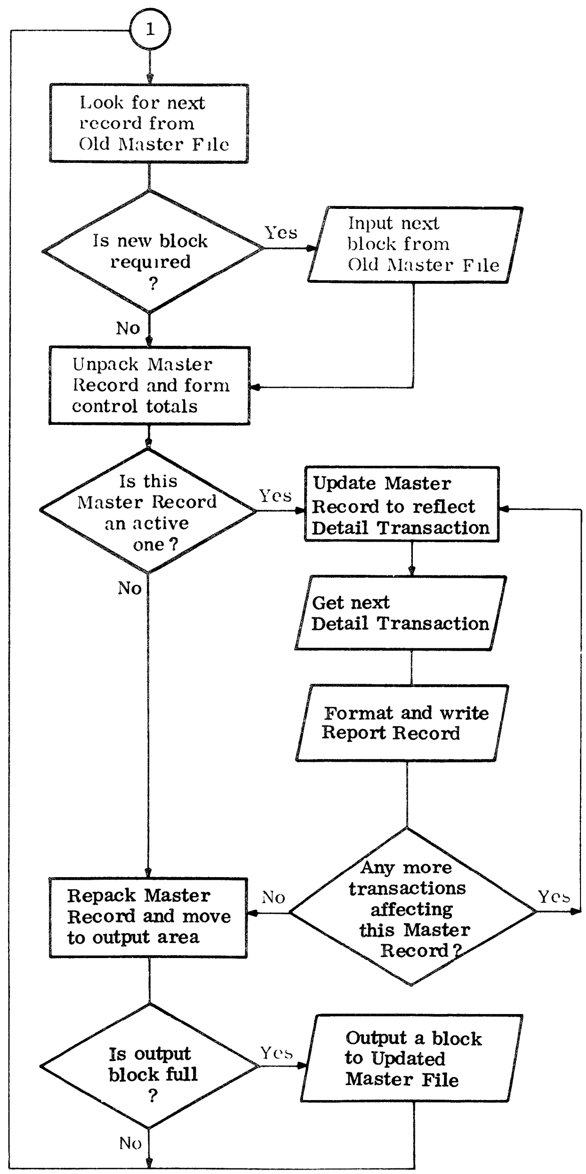

Figure 2. General Flowchart for Generalized File Processing Problem A

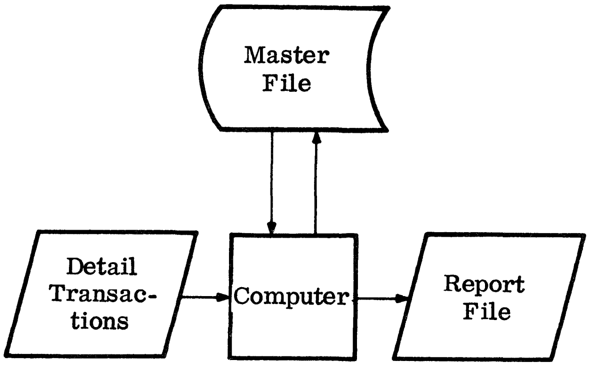

Figure 3. Run Diagram for Random Access File Processing Problem

Figure 4 is a general flowchart that summarizes the computational process. The master file is sequentially arranged in random access storage, and a two-stage indexing procedure is used to determine the location of each master-file record that needs to be accessed. Record lengths are 108 characters for the master file, 80 characters (1 card) for the detail transactions, and 120 characters (1 line) for the report file. Record layouts are fixed for the detail and report files, but are left flexible for the master file so that the specific features of each computer system can be advantageously utilized.

The detail transactions (e.g., inquiries, orders, or deposits) are assumed to be arriving in a random sequence and at a continuous rate that is high enough to ensure that one or more transactions are always waiting to be processed. Therefore, it makes no difference whether the transactions enter the system via an on-line card reader, a simple remote inquiry terminal, or a multi-terminal data communications network. This assumption means that the Random Access File Processing Problem does not attempt the highly complex and variable task of measuring the efficiency of real-time data communications networks; it simply measures the central computer system's ability to locate and update randomly-addressed master-file records.

The report file is written on either magnetic tape or a random access device, presumably for printing at some later time. Each report record is also made available for optional transmission back to the remote terminal that initiated the transaction (though the processor time required to effect this transaction is not included in the published timing figures).

(3) Sorting

Because conventional data processing techniques usually require all records to be arranged in a particular sequence, sorting operations are an important and time-consuming part of the workload in most business computer installations. This benchmark problem requires that a file consisting of 10,000 records, each 80 characters in length, be arranged sequentially according to an 8-digit key, such as an account number.

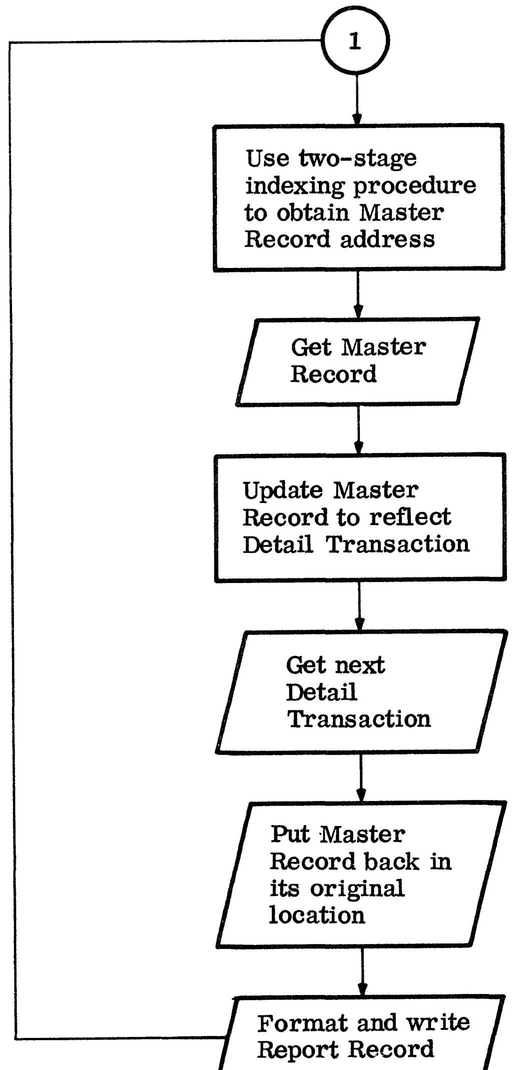

Figure 4. General Flowchart for Random Access File Processing Problem

The "Standard Estimate" column lists the estimated sorting times calculated by our analysts for sorting operations that use straightforward magnetic tape merging techniques. Two-way tape merging is used in the four-tape Standard Configuration II and three-way merging in all of the larger systems.

Whenever timing data is available for a standard, manufacturer-supplied sort routine, the time required to perform the same 10,000-record sort is listed in the "Available Routines" column. Because most manufacturer-supplied sort routines now use internal sorting and merging techniques which are more sophisticated than those used to prepare our estimates, the "Available Routines" sort time will often be substantially less than the "Standard Estimate" time for a given configuration. Nevertheless, the Standard Estimates provide useful, directly comparable indications of each computer system's basic capabilities to perform magnetic tape input-output operations.

(4) Matrix Inversion

In many scientific and operations research applications, such as multiple regression, linear programming, and the solution of simultaneous equations, the bulk of the central processor's time is spent in inverting large matrices. This benchmark problem involves the inversion of 10-by-10 and 40-by-40 matrices. It measures the speed of the central processor on floating-point calculations; no input or output operations are involved. All matrix elements are held within the system's main storage unit in floating-point form with a precision equivalent to at least eight decimal digits.

The "Standard Estimate" columns list the matrix inversion times calculated by our analysts through a simple estimating procedure that uses the system's floating-point arithmetic speeds. Whenever timing data is available for a standard, manufacturer-supplied matrix inversion routine, it is reported in the "Available Routines" columns.

(5) Generalized Mathematical Problem A

Another frequently-encountered scientific problem involves the evaluation of polynomial equations of the type $Y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5$. This benchmark problem includes the following basic steps:

- Read an input record consisting of 10 eight-digit numbers.
- Perform a floating-point calculation that consists of evaluating five 5th-order polynomials, executing five division operations, and evaluating one square root.
- For every 10 input records, form and print one output record consisting of 10 eight-digit numbers.

The "Computation Factors" of 1, 10, and 100 mean that the standard calculation described above is performed 1, 10, or 100 times, respectively, for each input record to show the effects of varying ratios of computation to input-output volume. Processing times are listed in terms of milliseconds per input record.

SYSTEM PERFORMANCE COMPARISONS

SYSTEM IDENTITY	STANDARD CONFIGU- RATION NUMBER	MONTHLY RENTAL, $	GENERALIZED FILE PROCESSING PROBLEM A			RANDOM ACCESS BENCHMARK PROBLEM		SORTING	
			Activity			Timing Summary		10,000 80-Char. Records	
			0.0	0.1	1.0	Time per Transaction	Time per 10,000 Records	Standard Estimate	Available Routines
			Minutes per 10,000 Records			Milliseconds	Minutes	Minutes	
Burroughs B 200	I	4,525	-	-	67.	-	-	-	-
	II	5,895	2.2	2.9	26.	-	-	22.	-
	III	8,840	1.4	2.8	26.	-	-	9.5	14.
Burroughs B 2500	II	4,910	0.95	1.9	18.	-	-	7.5	-
	III	6,415	0.75	1.8	18.	-	-	5.0	-
	IVR	10,130	-	-	-	125.	21.	-	-
Burroughs B 3500	IVR	11,630	-	-	-	125.	21.	-	-
	VIIA	15,480	0.37	2.0	18.	-	-	2.5	-
	VIIIR	19,680	-	-	-	301.	50.	-	-
Burroughs B 5500	III	23,340	1.2	2.0	19.	-	-	-	-
	V	25,250	1.2	2.0	19.	-	-	-	-
	VIIA	30,995	0.55	1.7	17.	-	-	2.9	2.8
	VIIB	28,705	0.55	0.69	1.8	-	-	2.9	2.8
CDC 3100	IIIR	9,390	-	-	-	-	-	-	-
	IVR	14,250	-	-	-	-	-	-	-
	VI	14,610	0.94	2.0	20.	-	-	6.1	-
	VIIA	20,375	0.36	2.0	20.	-	-	2.7	-
CDC 3300	IVR	15,980	-	-	-	-	-	-	-
	VI	16,240	0.94	2.0	20.	-	-	6.1	-
	VIIA	22,025	0.36	2.0	20.	-	-	2.7	-
CDC 3400	VI	16,640	0.56	1.96	16.	-	-	3.7	-
	VIIA	22,110	0.56	1.62	16.	-	-	3.7	-
	VIIB	23,511	0.56	0.77	2.6	-	-	3.7	-
	VIIIB	39,045	0.29	0.33	1.0	-	-	1.8	-
CDC 3600	VIB	40,110	0.19	0.28	1.2	-	-	1.4	-
	VIIB	40,671	0.19	0.28	1.2	-	-	2.0	-
	VIIIB	57,045	0.19	0.19	1.0	-	-	1.4	-
CDC 6400	VIIA	42,100	0.38*	0.38*	2.0*	-	-	2.5	-
	VIIIA	54,540	0.19*	0.19*	1.0*	-	-	1.3	-
CDC 6600	VIIA	64,100	0.38*	0.38*	2.0*	-	-	2.5	-
	VIIIA	76,625	0.19*	0.19*	1.0*	-	-	1.3	-
GE 215	I	4,905	-	-	67.	-	-	-	-
	II	6,250	3.7	5.4	28.	-	-	37.	-
	III	7,375	3.7	3.7	28.	-	-	25.	-
	VI	8,325	3.7	3.7	28.	-	-	25.	-
GE 225	I	5,085	-	-	67.	-	-	-	-
	II	6,450	3.7	3.7	25.	-	-	37.	24.
	III	9,155	1.6	2.5	25.	-	-	10.	14.
	IV	15,620	0.80	1.8	18.	-	-	5.3	8.5
	VI	11,985	1.6	2.5	25.	-	-	10.	14.
GE 235	III	11,870	1.5	2.5	25.	-	-	10.	-
	IV	18,385	0.77	1.7	17.	-	-	5.	-
	VI	15.120	1.5	2.5	25.	-	-	10.	-
GE 415	I	5,135	-	-	75.	-	-	-	-
	II	6,955	2.4	2.4	15.	-	-	24.	-
	III	8,255	1.8	1.8	15.	-	-	13.	-
	IV	13,950	0.47	1.5	15.	-	-	3.	-
	VIIA	15,245	0.47	1.5	15.	-	-	3.	-
GE 425	I	6,120	-	-	61.	-	-	-	-
	II	7,940	2.4	2.4	15.	-	-	25.	-
	III	9,240	1.8	1.8	15.	-	-	13.	-
	IV	14,935	0.47	1.4	15.	-	-	3.1	-
	VIIA	16,545	0.47	1.4	15.	-	-	3.1	-

*Indicated time is for the tape-to-tape main processing run only; it is assumed that the required on-line card-to-tape and tape-to-printer transcriptions will be performed with these or other programs.

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	MATRIX INVERSION				GENERALIZED MATHEMATICAL PROBLEM A		
			Standard Estimate		Available Routines				
			Array Size				Computation Factor for 10% Output		
			10	40	10	40	1	10	100
			Minutes				Milliseconds		
Burroughs B 200	I	4,525	-	-	-	-	-	-	-
	II	5,895	-	-	-	-	-	-	-
	III	8,840	-	-	-	-	-	-	-
Burroughs B 2500	II	4,910	-	-	-	-	-	-	-
	III	6,415	0.026	1.5	-	-	78.	700.	6,900.
	IVR	10,130	-	-	-	-	-	-	-
Burroughs B 3500	IVR	11,630	-	-	-	-	-	-	-
	VIIA	15,480	0.013	0.75	-	-	78.	350.	3,500.
	VIIIR	19,680	-	-	-	-	-	-	-
Burroughs B 5500	III	23,340	0.0025	0.14	0.006	0.25	74.	74.	330.
	V	25,250	0.0025	0.14	0.006	0.25	74.	74.	330.
	VIIA	30,995	0.0025	0.14	0.006	0.25	74.	74.	330.
	VIIB	28,705	0.0025	0.14	0.006	0.25	9.5*	39.*	330.
CDC 3100	IIIR	9,390	-	-	-	-	-	-	-
	IVR	14,250	-	-	-	-	-	-	-
	VI	14,610	0.0013	0.08	-	-	50.	50.	330.
	VIIA	20,375	0.0013	0.08	-	-	50.	50.	330.
CDC 3300	IVR	15,980	-	-	-	-	-	-	-
	VI	16,240	0.0008	0.046	-	-	50.	50.	265.
	VIIA	22,025	0.0008	0.046	-	-	50.	50.	265.
CDC 3400	VI	16,640	0.0004	0.026	-	-	65.	65.	145.
	VIIA	22,110	0.0004	0.026	-	-	65.	65.	145.
	VIIB	23,511	0.0004	0.026	-	-	12.	23.	145.
	VIIIB	39,045	0.0004	0.026	-	-	9.9	23.	145.
CDC 3600	VIB	40,110	0.0003	0.017	-	-	6.0	6.5	61.
	VIIB	40,671	0.0003	0.017	-	-	6.0	6.5	61.
	VIIIB	57,045	0.0003	0.017	-	-	6.0	6.5	61.
CDC 6400	VIIA	42,100	0.00022	0.011	-	-	13.*	13.*	13.*
	VIIIA	54,540	0.00022	0.011	-	-	6.2*	6.2*	6.2*
CDC 6600	VIIA	64,100	0.00003	0.0014	-	-	13.*	13.*	13.*
	VIIIA	76,625	0.00003	0.0014	-	-	6.2*	6.2*	6.2*
GE 215	I	4,095	0.70	33.	-	-	-	-	-
	II	6,250	0.70	33.	-	-	-	-	-
	III	7,375	0.70	33.	-	-	-	-	-
	VI	8,325	0.07	3.2	-	-	-	-	-
GE 225	I	5,085	0.31	15.	0.60	38.	-	-	-
	II	6,450	0.31	15.	0.60	38.	-	-	-
	III	9,155	0.31	15.	0.60	38.	-	-	-
	IV	15,620	0.31	15.	0.60	38.	-	-	-
	VI	11,985	0.033	1.7	0.030	1.9	-	-	-
GE 235	III	11,870	0.07	3.5	-	-	-	-	-
	IV	18,385	0.07	3.5	-	-	-	-	-
	VI	15,120	0.005	0.22	-	-	-	-	-
GE 415	I	5,135	-	-	-	-	-	-	-
	II	6,955	-	-	-	-	-	-	-
	III	8,255	-	-	-	-	-	-	-
	IV	13,980	-	-	-	-	-	-	-
	VIIA	15,245	0.0029	0.17	-	-	120.	280.	1,800.
GE 425	I	6,120	-	-	-	-	-	-	-
	II	7,940	-	-	-	-	-	-	-
	III	9,240	-	-	-	-	-	-	-
	IV	14,935	-	-	-	-	-	-	-
	VIIA	16,545	0.0021	0.12	-	-	100.	240.	1,400.

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	GENERALIZED FILE PROCESSING PROBLEM A			RANDOM ACCESS BENCHMARK PROBLEM		SORTING	
			Activity			Timing Summary		10,000 80-Char. Records	
			0.0	0.1	1.0	Time per Transaction	Time per 10,000 Records	Standard Estimate	Available Routines
			Minutes per 10,000 Records			Milliseconds	Minutes	Minutes	
GE 435	III	13,400	1.8	1.8	15.	-	-	13.	-
	IV	19,095	0.47	1.4	15.	-	-	3.1	-
	VIIA	19,975	0.47	1.4	15.	-	-	3.1	-
GE 625	VIIA	39,505	0.47*	0.70*	2.8*	-	-	3.1	-
	VIIIA	54,275	0.26*	0.26*	1.4*	-	-	1.7	-
GE 635	VIIA	40,630	0.47*	0.70*	2.8*	-	-	3.1	-
	VIIIA	55,400	0.26*	0.26*	1.4*	-	-	1.7	-
Honeywell 110	I	2,405	-	-	-	-	-	-	-
	II	2,855	-	-	-	-	-	-	-
	IIIR	4,520	-	-	-	-	-	-	-
Honeywell 120	I	3,835	-	-	190.	-	-	-	-
	II	3,465	4.0	6.4	28.	-	-	41.	-
	III	6,180	2.1	4.7	27.	-	-	14.	-
	IIIR	5,070	-	-	-	148.6	24.7	-	-
Honeywell 200	I	4,185	-	-	160.	-	-	-	-
	II	4,995	3.4	3.4	21.	-	-	33.	-
	III	7,415	0.9	2.1	21.	-	-	6.8	7.9
	IIIR	6,285	-	-	-	148.6	24.7	-	-
	IV	14,640	0.39	1.7	17.	-	-	2.5	2.8
Honeywell 1200	I	5,060	-	-	160.	-	-	-	-
	II	5,870	3.4	3.4	21.	-	-	33.	-
	III	7,875	0.9	2.1	21.	-	-	6.8	-
	IIIR	7,665	-	-	-	148.6	24.7	-	-
	IV	14,945	0.39	1.7	17.	-	-	2.5	-
	IVR	11,765	-	-	-	111.1	18.5	-	-
	VI	10,985	0.9	2.1	21.	-	-	6.8	-
	VIIA	16,195	0.39	2.1	21.	-	-	2.5	-
	VIIB	15,805	0.39	0.5	2.	-	-	2.5	-
Honeywell 2200	III	8,935	0.9	2.1	21.	-	-	6.8	7.1
	IV	16,095	0.39	1.7	17.	-	-	2.5	2.7
	IVR	13,435	-	-	-	111.1	18.5	-	-
	VIIA	18,330	0.39	2.1	21.	-	-	2.5	2.8
	VIIB	17,685	0.39	0.5	2.	-	-	2.5	2.8
Honeywell 4200	IV	25,805	0.39	1.7	17.	-	-	6.8	-
	IVR	21,995	-	-	-	111.1	18.5	-	-
	VIIA	23,345	0.39	2.1	21.	-	-	2.5	-
	VIIB	24,170	0.39	0.49	2.	-	-	2.5	-
	VIIIB	36,425	0.30	0.30	1.1	-	-	2.1	-
	VIIIR	28,225	-	-	-	226.3	37.7	-	-
Honeywell 8200	VIIA	39,120	0.35*	0.35*	0.43*	-	-	2.3	-
	VIIIA	51,360	0.28*	0.28*	0.33*	-	-	1.8	-
	VIIIR	40,670	-	-	-	226.3	37.7	-	-
Honeywell 400	II	7,695	2.0	4.0	24.	-	-	12.	-
	III	9,815	2.0	3.0	20.	-	-	8.9	-
	IV	15,590	1.1	2.4	20.	-	-	5.2	-
	VI	11,015	2.0	3.0	20.	-	-	8.9	-
Honeywell 1400	II	10,750	1.6	3.7	24.	-	-	9.5	-
	III	12,290	1.6	2.8	20.	-	-	8.0	-
	IV	20,980	0.57	1.9	20.	-	-	4.4	-
	VI	14,530	1.6	2.8	20.	-	-	8.0	-
Honeywell 800	VI	19,329	0.60	2.0	17.	-	-	6.3	-
	VIIA	36,679	0.34	2.0	17.	-	-	2.4	-
	VIIB	27,795	0.30	0.42	3.1	-	-	2.4	-
	VIIIA	53,600	0.20	2.0	17.	-	-	1.5	-
	VIIIB	46,325	0.20	0.42	3.1	-	-	1.5	-

*Indicated time is for the tape-to-tape main processing run only; it is assumed that the required on-line card-to-tape and tape-to-printer transcriptions will be performed with these or other programs.

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	MATRIX INVERSION Standard Estimate, Array Size 10 (Minutes)	MATRIX INVERSION Standard Estimate, Array Size 40 (Minutes)	MATRIX INVERSION Available Routines, Array Size 10 (Minutes)	MATRIX INVERSION Available Routines, Array Size 40 (Minutes)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 1 (Milliseconds)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 10 (Milliseconds)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 100 (Milliseconds)
GE 435	III	13,400	-	-	-	-	-	-	-
	IV	19,095	-	-	-	-	-	-	-
	VIIA	19,975	0.0016	0.09	-	-	74.	190.	1,300.
GE 625	VIIA	39,505	0.0005	.028	-	-	13.*	18.*	149.*
	VIIIA	54,275	0.0005	.028	-	-	8.*	18.*	149.*
GE 635	VIIA	40,630	0.0004	.021	-	-	13.*	14.*	113.*
	VIIIA	55,400	0.0004	.021	-	-	8.*	14.*	113.*
Honeywell 110	I	2,405	-	-	-	-	-	-	-
	II	2,855	-	-	-	-	-	-	-
	IIIR	4,520	-	-	-	-	-	-	-
Honeywell 120	I	3,835	-	-	-	-	-	-	-
	II	3,465	-	-	-	-	-	-	-
	III	6,180	-	-	-	-	-	-	-
	IIIR	5,070	-	-	-	-	-	-	-
Honeywell 200	I	4,185	-	-	-	-	-	-	-
	II	4,995	-	-	-	-	-	-	-
	III	7,415	-	-	-	-	-	-	-
	IIIR	6,285	-	-	-	-	-	-	-
	IV	14,640	-	-	-	-	-	-	-
Honeywell 1200	I	5,060	-	-	-	-	-	-	-
	II	5,870	-	-	-	-	-	-	-
	III	7,875	-	-	-	-	-	-	-
	IIIR	7,665	-	-	-	-	-	-	-
	IV	14,945	-	-	-	-	-	-	-
	IVR	11,765	-	-	-	-	-	-	-
	VI	10,985	0.0043	0.23	-	-	88.	88.	720.
	VIIA	16,195	0.0043	0.23	-	-	88.	88.	720.
	VIIB	15,805	0.0043	0.23	-	-	18.	80.	720.
Honeywell 2200	III	8,935	-	-	-	-	-	-	-
	IV	16,095	-	-	-	-	-	-	-
	IVR	13,435	-	-	-	-	-	-	-
	VIIA	18,330	0.0028	0.17	-	-	88.	88.	490.
	VIIB	17,685	0.0028	0.17	-	-	15.	58.	490.
Honeywell 4200	IV	25,805	-	-	-	-	-	-	-
	IVR	21,995	-	-	-	-	-	-	-
	VIIA	23,345	-	-	-	-	88.	88.	200.
	VIIB	24,170	0.002	0.10	-	-	5.1	21.	200.
	VIIIB	36,425	0.002	0.10	-	-	-	-	-
	VIIIR	28,225	-	-	-	-	-	-	-
Honeywell 8200	VIIA	39,120	0.0002	0.012	-	-	75.	75.	75.
	VIIIA	51,360	0.0002	0.012	-	-	75.	75.	75.
	VIIIR	40,670	-	-	-	-	-	-	-
Honeywell 400	II	7,695	0.15	8.0	-	-	-	-	-
	III	9,815	0.15	8.0	-	-	-	-	-
	IV	15,590	0.15	8.0	-	-	-	-	-
	VI	11,015	0.15	8.0	-	-	-	-	-
Honeywell 1400	II	10,750	0.16	8.5	-	-	-	-	-
	III	12,290	0.16	8.5	-	-	-	-	-
	IV	20,980	0.16	8.5	-	-	-	-	-
	VI	14,530	0.035	2.0	-	-	-	-	-
Honeywell 800	VI	19,329	0.003	0.17	-	-	90.	90.	600.
	VIIA	36,679	0.003	0.17	-	-	90.	90.	600.
	VIIB	27,975	0.003	0.17	-	-	-	-	-
	VIIIA	53,600	0.003	0.17	-	-	72.	90.	600.
	VIIIB	46,325	0.003	0.17	-	-	-	-	-

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	GENERALIZED FILE PROCESSING PROBLEM A — Activity 0.0 (Minutes per 10,000 Records)	Activity 0.1 (Minutes per 10,000 Records)	Activity 1.0 (Minutes per 10,000 Records)	RANDOM ACCESS BENCHMARK PROBLEM — Timing Summary: Time per Transaction (Milliseconds)	Time per 10,000 Records (Minutes)	SORTING — 10,000 80-Char. Records: Standard Estimate (Minutes)	Available Routines (Minutes)
Honeywell 1800	VI	27,150	-	-	-	-	-	-	-
	VIIA	36,650	0.33	1.8	18.	-	-	-	-
	VIIB	34,725	0.33	0.33	1.5	-	-	-	-
	VIIIA	54,950	0.22	1.8	18.	-	-	-	-
	VIIIB	53,575	0.22	0.22	1.5	-	-	-	-
IBM 360, Model 20	I	2,776	-	-	67.	-	-	-	-
	II	3,558	6.0	7.0	21.	-	-	61.	27.
	IIIR	3,630	-	-	-	186.	32.	-	10.
IBM 360, Model 25	I	3,555	-	-	67.	-	-	-	-
	II	4,945	2.8	2.8	21.	-	-	30.	-
	III	6,445	1.4	2.1	21.	-	-	9.5	-
	IIIR	5,280	-	-	-	148.	25.	-	-
	IVR	9,635	-	-	-	109.	18.	-	-
IBM 360 Model 30	I	4,097	-	-	67.	-	-	-	-
	II	4,714	3.7	3.7	20.	-	-	40.	25.
	III	6,956	1.5	2.0	20.	-	-	9.7	9.2
	IIIR	6,111	-	-	-	148.	25.	-	5.0
	IVR	11,656	-	-	-	109.	18.	-	3.0
IBM 360, Model 40	II	7,221	1.5	2.0	20.	-	-	13.	10.4
	III	8,208	1.5	2.0	20.	-	-	9.7	8.6
	IIIR	7,343	-	-	-	148.	25.	-	4.0
	IVR	13,032	-	-	-	109.	18.	-	3.0
	VI	11,601	1.5	2.0	20.	-	-	9.7	3.8
IBM 360, Model 44	V	11,723	1.5	2.0	20.	-	-	55.	-
	VI	10,802	1.5	2.0	20.	-	-	55.	-
	VIIA	14,531	0.38	2.0	20.	-	-	28.	-
	XI	9,717	1.5	5.0	50.	-	-	55.	-
IBM 360, Model 50	III	15.400	1.5	2.0	20.	-	-	9.7	-
	IV	21,564	0.38	1.5	15.	-	-	2.3	2.7
	IVR	18.399	-	-	-	109.	18.	-	2.1
	VIIA	19,720	0.38	2.0	20.	-	-	2.3	2.7
	VIIB	21,837	0.38	0.58	2.0	-	-	2.3	2.7
	VIIIR	26,773	-	-	-	117.	20.	-	1.9
IBM 360, Model 65	VIIA	34,585	-	-	-	-	-	-	-
	VIIB	35,187	0.40	0.59	2.0	-	-	2.4	2.0
	VIIIB	51,944	0.22	0.22	1.1	-	-	1.8	1.8
	VIIIR	43,388	-	-	-	117.	20.	-	1.7
IBM 360. Model 75	VIIA	47,298	-	-	-	-	-	-	-
	VIIB	47,900	0.40	0.59	2.0	-	-	2.4	1.8
	VIIIB	64,657	0.22	0.22	1.1	-	-	1.8	1.7
	VIIIR	56,101	-	-	-	117.	20.	-	1.4
IBM 360, Model 85	VIIIB	92,177	0.23	0.23	1.5	-	-	1.6	-
	VIIIR	87,736	-	-	-	117.	20.	-	-
IBM 1401	I	4,320	-	-	100.	-	-	-	-
	II	5,920	3.7	7.5	40.	-	-	41.	35.
	III	10,810	2.4	4.2	26.	-	-	15.	13.
	IV	11,485	2.0	2.6	20.	-	-	12.	10.
IBM 1401-G	I	2,270	-	-	139.	-	-	-	-
IBM 1410	I	6,115	-	-	80.	-	-	-	-
	II	8,415	2.7	3.2	20.	-	-	30.	-
	III	12,240	1.4	2.0	20.	-	-	9.0	9.7
	IV	19,060	1.0	2.0	20.	-	-	6.0	6.0
	VI	15,790	1.4	2.0	20.	-	-	9.0	7.0
	VIIB	23,560	0.85	1.2	3.3	-	-	-	7.0

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	MATRIX INVERSION				GENERALIZED MATHEMATICAL PROBLEM A		
			Standard Estimate		Available Routines				
			Array Size				Computation Factor for 10% Output		
			10	40	10	40	1	10	100
			Minutes				Milliseconds		
Honeywell 1800	VI	27,150	0.0013	0.066	-	-	-	-	-
	VIIA	36,650	0.0013	0.066	-	-	75.	75.	130.
	VIIB	34,725	0.0013	0.066	-	-	6.7	14.	130.
	VIIIA	54,950	0.0013	0.066	-	-	75.	75.	130.
	VIIIB	53,575	0.0013	0.066	-	-	5.9	14.	130.
IBM 360, Model 20	I	2,776	-	-	-	-	-	-	-
	III	3,558	-	-	-	-	-	-	-
	IIIR	3,630	-	-	-	-	-	-	-
IBM 360, Model 25	I	3,555	0.032	1.7	-	-	130.	1,200.	12,000.
	II	4,945	0.032	1.7	-	-	130.	1,200.	12,000.
	III	6,445	0.032	1.7	-	-	130.	1,200.	12,000.
	IIIR	5,280	0.032	1.7	-	-	-	-	-
	IVR	9,635	0.032	1.7	-	-	-	-	-
IBM 360, Model 30	I	4,097	0.025	1.2	-	-	100.	480.	4,230.
	II	4,714	0.025	1.2	-	-	100.	480.	4,230.
	III	6,956	0.025	1.2	-	-	100.	480.	4,230.
	IIIR	6,111	-	-	-	-	-	-	-
	IVR	11,656	-	-	-	-	-	-	-
IBM 360, Model 40	II	7,221	0.0071	0.39	-	-	100.	150.	2,000.
	III	8,208	0.0071	0.39	-	-	100.	150.	2,000.
	IIIR	7,343	-	-	-	-	-	-	-
	IVR	13,032	-	-	-	-	-	-	-
	VI	11,601	0.0071	0.39	-	-	100.	150.	2,000.
IBM 360, Model 44	V	11,723	0.0017	0.10	-	-	100.	100.	280.
	VI	10,802	0.0017	0.10	-	-	100.	100.	280.
	VIIA	14,531	0.0017	0.10	-	-	100.	100.	280.
	XI	9,717	0.0017	0.10	-	-	100.	100.	280.
IBM 360, Model 50	III	15,400	0.0017	0.07	-	-	100.	100.	400.
	IV	21,564	0.0017	0.07	-	-	100.	100.	400.
	IVR	18,399	-	-	-	-	-	-	-
	VIIA	21,720	0.0017	0.07	-	-	100.	100.	400.
	VIIB	21,837	0.0017	0.07	-	-	9.7	31.	280.
	VIIIR	26,773	-	-	-	-	-	-	-
IBM 360, Model 65	VIIA	34,585	-	-	-	-	-	-	-
	VIIB	35,187	0.00022	0.012	-	-	9.7	9.7	64.
	VIIIB	51,944	0.00022	0.012	-	-	6.5	6.5	64.
	VIIIR	43,388	-	-	-	-	-	-	-
IBM 360, Model 75	VIIA	47,298	-	-	-	-	-	-	-
	VIIB	47,900	0.00016	0.0089	-	-	9.7	9.7	35.
	VIIIB	64,657	0.00016	0.0089	-	-	6.5	6.5	35.
	VIIIR	56,101	-	-	-	-	-	-	-
IBM 360, Model 85	VIIIB	92,177	0.00007	0.0036	-	-	8.7	8.7	20.
	VIIIR	87,736	0.00007	0.0036	-	-	-	-	-
IBM 1401	I	4,320	0.33	-	-	-	520.	5,000.	50,000.
	II	5,920	0.33	-	-	-	-	-	-
	III	10,810	0.33	-	-	-	520.	5,000.	50,000.
	IV	11,485	0.33	-	-	-	-	-	-
IBM 1401-G	I	2,270	-	-	-	-	-	-	-
IBM 1410	I	6,115	0.17	9.0	-	-	-	-	-
	II	8,415	0.17	9.0	-	-	-	-	-
	III	12,240	0.17	9.0	-	-	-	-	-
	IV	19,060	0.17	9.0	-	-	-	-	-
	VI	15,790	0.17	9.0	-	-	-	-	-
	VIIB	23,560	0.17	9.0	-	-	-	-	-

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	GENERALIZED FILE PROCESSING PROBLEM A			RANDOM ACCESS BENCHMARK PROBLEM		SORTING	
			Activity			Timing Summary		10,000 80-Char. Records	
			0.0	0.1	1.0	Time per Transaction	Time per 10,000 Records	Standard Estimate	Available Routines
			Minutes per 10,000 Records			Milliseconds	Minutes	Minutes	
IBM 1440	I	3,295	-	-	135.	-	-	-	-
	II**	4,050	3.8	10.7	73.	-	-	40.	-
	III**	5,920	2.9	5.1	48.	-	-	19.	-
IBM 1460	III	11,735	1.4	3.6	26.	-	-	9.1	-
IBM 7010	III	19,175	1.4	2.0	20.	-	-	8.5	-
	IV	27,225	0.56	1.3	13.	-	-	3.8	-
	VI	22,175	1.4	2.0	20.	-	-	8.5	-
	VIIB	28,355	0.64	0.96	3.2	-	-	4.8	-
IBM 7040	VI	20,715	1.4	2.3	20.	-	-	15.	-
	VIIA	27,190	-	-	-	-	-	3.8	-
	VIIIB	47,145	0.33	0.75	5.5	-	-	2.2	-
IBM 7044	VIIA	36,690	-	-	-	-	-	2.7	-
	VIIIB	56,645	0.39	0.39	1.9	-	-	1.9	-
IBM 7070	III	19,400	1.3	6.7	67.	-	-	8.5	5.7
	VIIB	29,775	0.45	0.80	4.5	-	-	3.0	2.0
	VIIIB	45,030	0.38	0.80	4.5	-	-	2.4	2.0
IBM 7072	VIIB	32,915	1.2	1.7	5.7	-	-	8.3	-
	VIIIB	49,890	1.2	1.7	5.7	-	-	8.3	-
IBM 7074	VIIB	40,465	0.45	0.6	2.2	-	-	3.0	1.5
	VIIIB	72,840	0.18	0.18	1.7	-	-	1.2	1.2
IBM 7080	VIIB	51,745	0.42	0.58	2.	-	-	2.6	1.2
	VIIIB	79,325	0.18	0.2	1.4	-	-	1.3	0.12
IBM 7090	VIIB	66,770	0.47	0.61	1.9	-	-	3.2	-
	VIIIB	89,215	0.21	0.21	1.6	-	-	1.5	-
IBM 7094-I	VIIB	72,395	0.47	0.61	1.9	-	-	3.2	-
	VIIIB	95,065	0.21	0.21	0.96	-	-	1.5	-
NCR 315	I	5,450	-	-	80.	-	-	-	-
	II	4,775	3.3	5.1	29.	-	-	20.	26.
	III	7,695	1.5	3.0	26.	-	-	5.8	7.9
	IIIC	7,800	1.3	3.7	24.	-	-	-	-
	IV	19,040	0.4	1.9	18.	-	-	3.8	2.6
	IVR	12,445	-	-	-	235.	39.	-	-
NCR 315-100	I	4,750	-	-	80.	-	-	-	-
	II	3,975	3.6	7.8	41.	-	-	-	-
	IIIC	7,300	1.6	3.8	25.	-	-	-	-
NCR 315 RMC	III	9,970	1.7	1.7	19.	-	-	4.	-
	IIIC	10,175	1.7	1.7	19.	-	-	-	-
	IV	19,140	0.35	1.9	19.	-	-	2.7	-
	IVR	13,820	-	-	-	77.	39.	-	-
RCA Spectra 70/15	I	3,470	-	-	66.	-	-	-	-
	II	4,815	1.8	2.2	22.	-	-	19.	15.
RCA Spectra 70/25	II	5,990	1.4	2.2	22.	-	-	15.	15.
	III	6,610	1.4	2.2	22.	-	-	10.	10.
	IV	12,585	0.7	1.3	13.	-	-	2.5	2.5
RCA Spectra 70/35	I	5,420	-	-	64.	-	-	-	-
	II	6,896	1.4	2.2	22.	-	-	15.0	-
	III	7,616	1.4	2.2	22.	-	-	10.0	-
	IIIR	8,336	-	-	-	149.5	26.0	-	-
	IVR	10,791	-	-	-	109.5	18.0	-	-
	VI	9,046	1.4	2.2	22.	-	-	10.0	-
	VIIA	13,022	0.7	1.3	13.	-	-	10.0	-

**Using 1311 Disk Storage Drives in place of magnetic tape.

SYSYTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	MATRIX INVERSION				GENERALIZED MATHEMATICAL PROBLEM A		
			Standard Estimate		Available Routines				
			Array Size				Computation Factor for 10% Output		
			10	40	10	40	1	10	100
			Minutes				Milliseconds		
IBM 1440	I	3,295	-	-	-	-	-	-	-
	II*	4,050	-	-	-	-	-	-	-
	III*	5,920	-	-	-	-	-	-	-
IBM 1460	III	11,735	0.17	-	-	-	-	-	-
IBM 7010	III	19,175	0.06	3.5	-	-	-	-	-
	IV	27,225	0.06	3.4	-	-	-	-	-
	VI	22,175	0.06	3.4	-	-	-	-	-
	VIIB	28,355	0.06	3.4	-	-	-	-	-
IBM 7040	VI	20,715	0.002	0.10	-	-	100.	150.	1,300.
	VIIA	27,190	0.002	0.10	-	-	17.	150.	1,300.
	VIIIB	47,145	0.002	0.10	-	-	16.	150.	1,300.
IBM 7044	VIIA	36,690	0.001	0.068	-	-	13.	47.	450.
	VIIIB	56,645	0.0010	0.068	-	-	7.7	47.	400.
IBM 7070	III	19,400	0.037	2.1	0.055	3.6	-	-	-
	VIIB	29,755	0.037	2.1	0.055	3.6	63.	600.	6,000.
	VIIIB	45,030	0.037	2.1	0.055	3.6	63.	600.	6,000.
IBM 7072	VIIB	32,915	0.0037	0.24	-	-	25.	45.	400.
	VIIIB	49,890	0.0037	0.24	-	-	25.	45.	400.
IBM 7074	VIIB	40,465	0.003	0.17	-	-	11.	37.	350.
	VIIIB	72,840	0.003	0.17	-	-	11.	37.	350.
IBM 7080	VIIB	51,745	-	-	-	-	-	-	-
	VIIIB	79,325	-	-	-	-	-	-	-
IBM 7090	VIIB	66,770	0.001	0.062	-	-	8.5	30.	270.
	VIIIB	89,215	0.001	0.062	-	-	7.7	30.	270.
IBM 7094-I	VIIB	72,395	0.0004	0.029	-	-	7.7	17.	140.
	VIIIB	95,065	0.0004	0.029	-	-	7.7	17.	140.
NCR 315	I	5,450	0.09	-	0.077	-	23.	190.	2,000.
	II	4,775	0.09	-	0.077	-	32.	200.	2,000.
	III	7,695	0.09	-	0.077	-	32.	200.	2,000.
	IIIC	7,800	0.09	-	0.077	-	32.	200.	2,000.
	IV	19,040	0.09	5.	0.077	4.	23.	190.	2,000.
	IVR	12,445	-	-	-	-	-	-	-
NCR 315-100	I	4,750	0.09	-	-	-	-	-	-
	II	3,975	0.09	-	-	-	-	-	-
	IIIC	7,300	0.09	-	-	-	-	-	-
NCR 315 RMC	III	9,970	-	0.4	-	-	45.0	230.	2,000.
	IIIC	10,175	-	0.4	-	-	45.0	230.	2,000.
	IV	19,140	-	0.4	-	-	45.0	230.	2,000.
	IVR	13,820	-	-	-	-	-	-	-
RCA Spectra 70/15	I	3,470	-	-	-	-	-	-	-
	II	4,815	-	-	-	-	-	-	-
RCA Spectra 70/25	II	5,990	-	-	-	-	-	-	-
	III	6,610	-	-	-	-	-	-	-
	IV	12,585	-	-	-	-	-	-	-
RCA Spectra 70/35	I	5,420	0.014	0.70	-	-	47.	350.	3,300.
	II	6,896	0.014	0.70	-	-	47.	350.	3,300.
	III	7,616	0.014	0.70	-	-	47.	350.	3,300.
	IIIR	8,336	-	-	-	-	-	-	-
	IVR	10,791	-	-	-	-	-	-	-
	VI	9,046	0.014	0.70	-	-	47.	350.	3,300.
	VIIA	13,022	0.014	0.70	-	-	47.	350.	3,300.

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU-RATION NUMBER	MONTHLY RENTAL, $	GENERALIZED FILE PROCESSING PROBLEM A			RANDOM ACCESS BENCHMARK PROBLEM		SORTING	
			Activity			Timing Summary		10,000 80-Char. Records	
			0.0	0.1	1.0	Time per Transaction	Time per 10,000 Records	Standard Estimate	Available Routines
			Minutes per 10,000 Records			Milliseconds	Minutes	Minutes	
RCA Spectra 70/45	III	8,712	1.4	2.2	22.	-	-	9.4	-
	IIIR	9,351	-	-	-	149.5	26.0	-	-
	IV	14,402	0.36	1.3	12.	-	-	2.4	-
	IVR	12,421	-	-	-	109.5	18.0	-	-
	VI	10,567	1.4	2.2	22.	-	-	9.4	-
	VIIA	14,156	0.36	2.2	22.	-	-	2.4	-
	VIIB	16,142	0.36	0.52	2.1	-	-	2.4	-
RCA Spectra 70/55	III	13,840	1.4	2.2	22.	-	-	9.4	-
	IIIR	15,564	-	-	-	149.5	26.0	-	-
	IV	18,915	0.36	1.3	13.	-	-	2.4	-
	IVR	17,425	-	-	-	109.5	18.0	-	-
	VI	13,845	1.4	2.2	22.	-	-	9.4	-
	VIIA	17,345	0.36	2.2	22.	-	-	2.4	-
	VIIB	19,425	0.36	0.52	2.1	-	-	2.4	-
	VIIIB	33,975	0.18	0.18	0.85	-	-	1.2	-
RCA 301	I	4,271	-	-	200.	-	-	-	-
	II	5,084	5.7	10.1	49.	-	-	60.	-
	III	9,687	1.5	4.3	32.	-	-	15.	-
	IV	20,290	1.5	4.3	32.	-	-	13.	-
	VI	12,880	1.5	4.3	32.	-	-	15.	-
RCA 3301	III	11,390	0.61	1.9	18.	-	-	4.0	-
	IV	18,940	0.37	1.9	18.	-	-	2.7	-
	VI	14,265	0.61	1.9	18.	-	-	4.0	-
	VIIA	21,265	0.29	1.9	18.	-	-	1.9	-
	VIIB	21.604	0.29	0.29	1.3	-	-	1.9	-
UNIVAC III	III	19,000	0.19	2.1	20.	-	-	1.7	1.2
	VI	20,400	0.19	2.1	20.	-	-	1.7	1.2
	VIIA	25,000	0.19	2.1	20.	-	-	1.2	1.2
	VIIB	38,730	0.19	0.19	1.5	-	-	1.2	1.2
UNIVAC 418	III	7,125	1.6	2.4	24.	-	-	11.	-
	VIIA	17,875	0.42*	0.68*	3.7	-	-	2.8	-
UNIVAC 490	III	19,780	2.3	2.3	21.	-	-	15.	-
	VIIA	31,270	0.27*	0.42*	2.4*	-	-	1.7	-
	VIIIA	48,120	0.27*	0.42*	2.4*	-	-	1.7	-
UNIVAC 491/492	III	14,290	0.82	2.2	22.	-	-	5.1	-
	VIIA	25,085	0.32*	0.50*	2.2*	-	-	2.1	-
	VIIIA	43,755	0.32*	0.34*	2.2*	-	-	2.1	-
UNIVAC 494	III	32,270	0.82	2.2	20.	-	-	5.1	-
	VIIA	39,405	0.32*	0.50*	1.9*	-	-	2.1	-
	VIIIA	49,555	0.32*	0.34*	1.7*	-	-	2.1	-
UNIVAC 1004	I	1,800	-	-	100.	-	-	-	-
	II	2,725	3.2	5.3	27.	-	-	-	-
UNIVAC 1050	I	3,470	-	-	100.	-	-	-	-
	II	5,030	1.0	2.9	24.	-	-	10.	-
	III	6,660	0.82	2.4	24.	-	-	5.5	-
	IV	18,720	0.53	2.1	21.	-	-	3.6	-
UNIVAC 1108	VIIA	50,365	0.27*	0.43*	1.5*	-	-	1.9	-
	VIIIA	65,075	0.27*	0.27*	1.3*	-	-	1.9	-
UNIVAC 9200	I	1,290	-	-	206.	-	-	-	-
UNIVAC 9300	I	1,740	-	-	206.	-	-	-	-
	II	3,610	-	2.1	21.2	-	-	6.5	-
	III	4,545	-	2.1	21.2	-	-	4.7	-
	IV	7,810	-	2.1	21.2	-	-	4.7	-

*Indicated time is for the tape-to-tape main processing run only; it is assumed that the required on-line card-to-tape and tape-to-printer transcriptions will be performed with these or other programs.

SYSTEM PERFORMANCE COMPARISONS (Contd.)

SYSTEM IDENTITY	STANDARD CONFIGU- RATION NUMBER	MONTHLY RENTAL, $	MATRIX INVERSION Standard Estimate, Array Size 10 (Minutes)	MATRIX INVERSION Standard Estimate, Array Size 40 (Minutes)	MATRIX INVERSION Available Routines, Array Size 10 (Minutes)	MATRIX INVERSION Available Routines, Array Size 40 (Minutes)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 1 (Milliseconds)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 10 (Milliseconds)	GENERALIZED MATHEMATICAL PROBLEM A, Computation Factor for 10% Output 100 (Milliseconds)
RCA Spectra 70/45	III	8,712	0.0053	0.30	-	-	47.	100.	1,150.
	IIIR	9,351	-	-	-	-	-	-	-
	IV	14,402	0.0053	0.30	-	-	42.	100.	1,150.
	IVR	12,421	-	-	-	-	-	-	-
	VI	10,567	0.0053	0.30	-	-	47.	100.	1,150.
	VIIA	14,156	0.0053	0.30	-	-	47.	100.	1,150.
	VIIB	16,142	0.0053	0.30	-	-	9.5	100.	1,150.
RCA Spectra 70/55	III	13,840	0.0015	0.08	-	-	47.	47.	280.
	IIIR	15,564	-	-	-	-	-	-	-
	IV	18,915	0.0015	0.08	-	-	42.	42.	280.
	IVR	17,425	-	-	-	-	-	-	-
	VI	13,845	0.0015	0.08	-	-	47.	47.	280.
	VIIA	17,345	0.0015	0.08	-	-	47.	47.	280.
	VIIB	19,425	0.0015	0.08	-	-	9.5	29.	280.
	VIIIB	33,975	0.0015	0.08	-	-	4.8	29.	280.
RCA 301	I	4,271	0.37	20.	0.19	11.	-	-	-
	II	5,084	0.37	20.	0.19	11.	-	-	-
	III	9,687	0.37	20.	0.19	11.	-	-	-
	IV	20,290	0.37	20.	0.19	11.	-	-	-
	VI	12,880	0.020	1.0	-	-	300.	590.	3,700.
RCA 3301	III	11,390	-	-	-	-	-	-	-
	IV	18,940	-	-	-	-	-	-	-
	VI	14,265	0.0010	0.040	-	-	65.	65.	210.
	VIIA	21,265	0.0010	0.040	-	-	65.	65.	210.
	VIIB	21,604	0.0010	0.040	-	-	8.3	26.	210.
UNIVAC III	III	19,000	0.024	1.4	-	-	25.	250.	2,500.
	VI	20,400	0.024	1.4	-	-	25.	250.	2,500.
	VIIA	25,000	0.024	1.4	-	-	25.	250.	2,500.
	VIIIB	38,730	0.024	1.4	-	-	-	-	-
UNIVAC 418	III	7,125	-	-	-	-	-	-	-
	VIIA	17,875	-	-	-	-	-	-	-
UNIVAC 490	III	19,780	0.023	1.0	-	-	100.	290.	3,400.
	VIIA	31,270	0.023	1.0	-	-	55.	290.	3,400.
	VIIIA	48,120	0.023	1.0	-	-	55.	290.	3,400.
UNIVAC 491/492	III	14,290	0.018	0.8	-	-	75.	290.	2,700.
	VIA	25,085	0.018	0.8	-	-	45.	290.	2,700.
	VIIIA	43,755	0.018	0.8	-	-	45.	290.	2,700.
UNIVAC 494	III	32,270	0.001	0.05	-	-	75.	75.	75.
	VIIA	39,405	0.001	0.05	-	-	7.3*	7.3*	58.*
	VIIIA	49,555	0.001	0.05	-	-	7.3*	7.3*	58.*
UNIVAC 1004	I	1,800	-	-	-	-	-	-	-
	II	2,725	-	-	-	-	-	-	-
UNIVAC 1050	I	3,470	-	-	-	-	-	-	-
	II	5,030	-	-	-	-	-	-	-
	III	6,600	-	-	-	-	-	-	-
	IV	18,720	-	-	-	-	-	-	-
UNIVAC 1108	VIIA	50,365	0.00017	0.0089	-	-	7.0*	7.0*	21.*
	VIIIA	65,075	0.00017	0.0089	-	-	7.0*	7.0*	21.*
UNIVAC 9200	I	1,290	-	-	-	-	-	-	-
UNIVAC 9300	I	1,740	-	-	-	-	-	-	-
	II	3,610	-	-	-	-	-	-	-
	III	4,545	-	-	-	-	-	-	-
	IV	7,810	-	-	-	-	-	-	-

COMPARISON CHARTS — NON-U.S.A. COMPUTERS
CENTRAL PROCESSORS AND WORKING STORAGE

An introduction to the Central Processor and Working Storage Section of the Comparison Charts, giving the precise meaning of each entry, can be found on Page 11:210.101.

System Identity			A/S Regnecentralen RC 4000 (Denmark)	Bull-GE GAMMA 10 (France)	GE-55 (France)
DATA STRUCTURE	Word Length	Binary Bits	24 plus 1 parity and 3 protection	6	8 + 1 parity per byte
		Decimal Digits	6	1	2
		Characters	3	1	1
	Floating Point Representation	Radix	Binary	-	Decimal
		Fraction Size	36	-	7 decimal digits
		Exponent Size	12	-	2 hexadecimal digits
CENTRAL PROCESSOR	Model Number		RC 4005	GAMMA 10	GE-55
	Arithmetic Radix		Binary	Decimal	Decimal, binary
	Operand Length, Words		1/2, 1, 2	Variable	Variable
	Instruction Length, Words		1	3	1 to 8 bytes
	Addresses per Instruction		1	2	0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	?	?	?
		c = ab	?	?	?
		c = a/b	?	?	(s)
	Likely Floating Point Execution Times, μsec	c = a + b	?	-	(s)
		c = ab	?	-	(s)
		c = a/b	?	-	(s)
	Checking of Data Transfers		Yes	Yes	Parity
	Program Interrupt Facility		Yes	No	Yes
	Number of Index Registers		3 or 4	None	10
	Indirect Addressing		Yes	Yes	No
	Special Editing Capabilities		None	?	?
	Boolean Operations		AND, OR, EXC OR	?	AND, INC OR, EXC OR
	Table Look-up		Yes	None	None
	Console Typewriter		Yes	None	None
	Input-Output Channels		2, maximum 64 controllers	?	Up to 3
	Features and Comments		High-speed (max 16 controllers simultaneously) and low-speed input/output channels		Selected configurations marketed in some U.S.A. areas
WORKING STORAGE	Model Number		RC 4081	GAMMA 10	GE-55
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	16,384	1024	2,500
		Maximum	131,072	4096	10,000
	Maximum Total Storage	Decimal Digits	786,432	4096	20,000
		Characters	393,216	4096	10,000
	Cycle Time, μsec		1.5	7	7.9
	Effective Transfer Rate, char/sec		1,500,000	?	?
	Checking		Parity	Yes	Parity
	Storage Protection		Yes	No	None
	Features and Comments				

* With optional equipment.
(s) Using subroutine.

Elbit 100 (Israel)	Fujitsu FACOM 270 Series (Japan)			System Identity		
	270-10	270-20	270-30			
12	16 + parity	16 + parity + memory	Protect bit	Binary Bits	Word Length	DATA STRUCTURE
3	4.6			Decimal Digits		
2	2			Characters		
Binary	—	Binary	Binary	Radix	Floating Point Representation	
5 or 8 digits	—	24 or 56 bits	24 or 56 bits	Fraction Size		
1 digit	—	7 bits	7 bits	Exponent Size		
100				Model Number		CENTRAL PROCESSOR
Hexadecimal	Binary	Binary	Binary	Arithmetic Radix		
1	0.5 or 1	1, 2, or 4	1, 2, or 4	Operand Length, Words		
1	1	1 or 2	1 or 2	Instruction Length, Words		
1	1	1	1	Addresses per Instruction		
14.0	312	21.6	8.1	c = a + b	Likely Fixed Point Execution Times, µsec (5 Digits Min. Precision)	
—	(s) 15,000	37.2	16.2	c = ab		
—	(s) 15,000	55.8	22	c = a/b		
—	—	*43.2	*15.7	c = a + b	Likely Floating Point Execution Times, µsec	
—	—	*76.8	*27.9	c = ab		
—	—	*117.6	*43.2	c = a/b		
None	Parity	Parity	Parity	Checking of Data Transfers		
1 level	1 level	12 levels	12 levels	Program Interrupt Facility		
None	3	3	3	Number of Index Registers		
1 level	No	Yes	Yes	Indirect Addressing		
None	(s) none	(s) none	(s) none	Special Editing Capabilities		
None	AND, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		
No	None	None	None	Table Look-up		
Yes	Standard	Standard	Standard	Console Typewriter		
Maximum of 256	1 direct channel	1 direct channel 3 selector channels	1 direct channel multiplexor 7 selector channels	Input-Output Channels		
				Features and Comments		
				Model Number		WORKING STORAGE
Core	Core	Core	Core	Type of Storage		
1,024	1,048	4,096	8,192	Minimum	Number of Words	
8,192	4,096	32,768	65,536	Maximum		
24,576	4.6 x 4,096	147×10^3	299×10^3	Decimal Digits	Maximum Total Storage	
16,384	8,192	65,536	131,072	Characters		
2.0	2/word	2.4/word	.9/word	Cycle Time, µsec		
	10×10^5	833×10^3	$2,222 \times 10^3$	Effective Transfer Rate, char/sec		
None	Parity	Parity	Parity	Checking		
None	None	Write only	Write only	Storage Protection		
		Includes a drum (131×10^3 words, 20 msec access)	Includes a drum (262×10^3 words, 10 msec access)	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			Fujitsu FACOM 230 Series (Japan)		
			230-10	230-20	230-30
DATA STRUCTURE	Word Length	Binary Bits	8 + W.M. + P	4 + W.M. + P	4 + W.M. + P
		Decimal Digits	2/byte	1	1
		Characters	1/byte	0.5	0.5
	Floating Point Representation	Radix	(s) decimal	Hexadecimal	*Hexadecimal
		Fraction Size	1-20 digits	Variable 2-123 digits	Variable 2-123 digits
		Exponent Size	(s) 2 digits	2 digits	2 digits
CENTRAL PROCESSOR	Model Number				
	Arithmetic Radix		Binary & decimal	Hexadecimal & decimal	Hexadecimal & decimal
	Operand Length, Words		Variable	Variable	Variable
	Instruction Length, Words		1, 2, 3, 4, 5, 6 bytes	4, 8, or 12 digits	4, 8, or 12 digits
	Addresses per Instruction		0, 1, or 2	0, 1, or 2	0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	96	98.1	80.3
		c = ab	7100 (s)	639.0	263.3
		c = a/b	8500 (s)	1308.15	553.8
	Likely Floating Point Execution Times, μsec	c = a + b	8300 (s)	917.1	155.9
		c = ab	7900 (s)	1703.25	425.3
		c = a/b	11,000 (s)	2421.0	696.2
	Checking of Data Transfers		Parity	Parity	Parity
	Program Interrupt Facility		Yes	Yes	Yes
	Number of Index Registers		—	2	2
	Indirect Addressing		None	Yes	Yes
	Special Editing Capabilities		(s)	Yes	Yes
	Boolean Operations		None	Yes	Yes
	Table Look-up		None	None	None
	Console Typewriter		*optional	*optional	*optional
	Input-Output Channels		1 direct 2 data	1 direct 4 { selector x 4 multiplexor	1 direct 4 { selector x 4 multiplexor
	Features and Comments		W.M. = Word mark P = Parity check		
WORKING STORAGE	Model Number				
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	4×10^3 bytes	4×10^3 bytes	4×10^3 bytes
		Maximum	8×10^3 bytes	32×10^3 bytes	32×10^3 bytes
	Maximum Total Storage	Decimal Digits	16×10^3	65×10^3	65×10^3
		Characters	8×10^3	32×10^3	32×10^3
	Cycle Time, μsec		2/byte	1.8/byte	2.2/byte
	Effective Transfer Rate, char/sec		125×10^3	277×10^3	455×10^3
	Checking		Parity	Parity	Parity
	Storage Protection		None	Yes, write only	Yes, write only
	Features and Comments		Including a drum (65×10^3 bytes 15 msec)		

* With optional equipment.
(s) Using subroutine.

Fujitsu FACOM 230 Series (Japan) 230-50	230-60	System Identity		
36 + 4 + 2 (P)	36 + 4 + 2 (P)	Binary Bits	Word Length	DATA STRUCTURE
10.5	10.5	Decimal Digits		
6	6	Characters		
Binary	Binary	Radix	Floating Point Representation	
27 or 62 bits	27 or 62 bits	Fraction Size		
9 bits	9 bits	Exponent Size		
		Model Number		CENTRAL PROCESSOR
Binary	Binary	Arithmetic Radix		
1 or 2	1 or 2	Operand Length, Words		
1	1	Instruction Length, Words		
1	1	Addresses per Instruction		
13.2	3.92	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	
23.7	6.72	c = ab		
44	12.84	c = a/b		
23.7	4.93	c = a + b	Likely Floating Point Execution Times, μsec	
39.6	6.34	c = ab		
48.4	7.78	c = a/b		
Parity	Parity	Checking of Data Transfers		
Yes, 8 classes	Yes, 5 classes	Program Interrupt Facility		
8	8	Number of Index Registers		
Yes	Yes	Indirect Addressing		
Good	Good	Special Editing Capabilities		
AND, INC OR NOT, EXC OR	AND, INC OR NOT, EXC OR	Boolean Operations		
Good	Good	Table Look-up		
*Optional	*Optional	Console Typewriter		
7 data channels selector or multiplexor	18 channels { selector or multiplexor	Input-Output Channels		
	Multiprocessor capability	Features and Comments		
		Model Number		WORKING STORAGE
Core	Core	Type of Storage		
16×10^3	32×10^3	Minimum	Number of Words	
65×10^3	262×10^3	Maximum		
682.5×10^3	2.3×10^6	Decimal Digits	Maximum Total Storage	
390×10^3	1.57×10^6	Characters		
2.2/word	.92/bank	Cycle Time, μsec		
2.7×10^6	40×10^6	Effective Transfer Rate, char/sec		
Parity	Parity	Checking		
Yes, write only	Yes, good	Storage Protection		
	Multi-Bank memory optional	Features and Comments		

* With optional equipment.
(s) Using subroutine.

System Identity			Hitachi HITAC 8000 Series (Japan)		
			H-8210	H-8200	H-8300
DATA STRUCTURE	Word Length	Binary Bits	8 per byte	8 per byte	8 per byte
		Decimal Digits	2	2	2
		Characters	1	1	1
	Floating Point Representation	Radix	-	-	Binary
		Fraction Size	-	-	24 or 56
		Exponent Size	-	-	7
CENTRAL PROCESSOR	Model Number		H-8210	H-8200	H-8300
	Arithmetic Radix		Binary, decimal	Binary, decimal	Binary, decimal
	Operand Length, Words		Variable	Variable	Variable
	Instruction Length, Words		4 or 6	4 or 6	2, 4, or 6
	Addresses per Instruction		1 or 2	1 or 2	0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	63	88	51
		c = ab	416	(s)	141
		c = a/b	648	(s)	232
	Likely Floating Point Execution Times, μsec	c = a + b	-	-	79 or 114
		c = ab	-	-	182 or 465
		c = a/b	-	-	394 or 1218
	Checking of Data Transfers		Parity	Parity	Parity
	Program Interrupt Facility		Yes	Yes	Yes. multilevel
	Number of Index Registers		0	0	16 max
	Indirect Addressing		None	None	None
	Special Editing Capabilities		Good	Good	Good
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None	None	None
	Console Typewriter		Optional	Optional	Optional
	Input-Output Channels		1 selector; 1 multiplexor	1 with 6 trunks	0 to 2 selector; 1 multiplexor
	Features and Comments				Program compatible with IBM System/360
WORKING STORAGE	Model Number		H-8210	H-8200	H-8300
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	8192	8192	32,768
		Maximum	32,768	16,384	65,536
	Maximum Total Storage	Decimal Digits	65,536	32,768	131,072
		Characters	32,768	16,384	65,536
	Cycle Time, μsec		1.4 per byte	2.0/byte	1.44/2 bytes
	Effective Transfer Rate, char/sec		750,000	250,000	695,000
	Checking		Parity	Parity	Parity
	Storage Protection		None	None	Write only
	Features and Comments				16 general-purpose registers in core storage

* With optional equipment.
(s) Using subroutine.

Hitachi HITAC 8000 Series (Japan) H-8400	Hitachi HITAC 8000 Series (Japan) H-8500	Hitachi HITAC 3010 (Japan)	System Identity		
8 per byte	8 per byte	6 + parity	Binary Bits	Word Length	DATA STRUCTURE
2	2	1	Decimal Digits	Word Length	DATA STRUCTURE
1	1	1	Characters	Word Length	DATA STRUCTURE
Binary	Binary	Decimal	Radix	Floating Point Representation	DATA STRUCTURE
24 or 56 bits	24 or 56 bits	8 digits	Fraction Size	Floating Point Representation	DATA STRUCTURE
7 bits	7 bits	2 digits	Exponent Size	Floating Point Representation	DATA STRUCTURE
H-8400	H-8500	H-3045, 3055	Model Number		CENTRAL PROCESSOR
Binary, decimal	Binary, decimal	Decimal	Arithmetic Radix		CENTRAL PROCESSOR
Variable	Variable	1 to 44 char	Operand Length, Words		CENTRAL PROCESSOR
2, 4, or 6	2, 4, or 6	10 char	Instruction Length, Words		CENTRAL PROCESSOR
0, 1, or 2	0, 1, or 2	2	Addresses per Instruction		CENTRAL PROCESSOR
25	5.9	147	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
82	11.9	4200 (s)	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
111	15.8	9000 (s)	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
37 or 53	8.6 or 11.3	(s)	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
68 or 212	13.4 or 26.9	(s)	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
101 or 305	17.0 or 42.9	(s)	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity	Parity	Parity	Checking of Data Transfers		CENTRAL PROCESSOR
Yes, multilevel	Yes, multilevel	None	Program Interrupt Facility		CENTRAL PROCESSOR
16 max	16 max	3*	Number of Index Registers		CENTRAL PROCESSOR
None	None	Yes	Indirect Addressing		CENTRAL PROCESSOR
Good	Good	Fair	Special Editing Capabilities		CENTRAL PROCESSOR
AND, INC OR, EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR	Boolean Operations		CENTRAL PROCESSOR
None	None	Single char only	Table Look-up		CENTRAL PROCESSOR
Optional	Optional	None	Console Typewriter		CENTRAL PROCESSOR
0 to 3 selector; 1 multiplexor	0 to 6 selector; 1 multiplexor	1 simultaneous channel*	Input-Output Channels		CENTRAL PROCESSOR
Program compatible with IBM System/360		High-speed arithmetic circuits optional	Features and Comments		CENTRAL PROCESSOR
H-8400	H-8500	H-3045, 3055	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		WORKING STORAGE
32,768	65,536	20,000	Minimum	Number of Words	WORKING STORAGE
262,144	524,288	40,000	Maximum	Number of Words	WORKING STORAGE
524,288	1,048,576	40,000	Decimal Digits	Maximum Total Storage	WORKING STORAGE
262,144	524,288	40,000	Characters	Maximum Total Storage	WORKING STORAGE
1.44 per 2 bytes	0.84/4 bytes	3.5/2 char	Cycle Time, μsec		WORKING STORAGE
510,000	1,058,000	135,200	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Checking		WORKING STORAGE
Write only*	Write only*	None	Storage Protection		WORKING STORAGE
16 general-purpose registers in fast scratchpad memory		Other models have 7-microsecond cycle time per 2 characters	Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			Nippon Electric NEAC Series 2200 (Japan)		
			2200/50	2200/100	2200/200
DATA STRUCTURE	Word Length	Binary Bits	6 + 2 punctuation + parity		
		Decimal Digits	1		
		Characters	1		
	Floating Point Representation	Radix	Binary		
		Fraction Size	36 bits		
		Exponent Size	12 bits		
CENTRAL PROCESSOR	Model Number		E050	N100	N200
	Arithmetic Radix		Decimal	Decimal	Decimal
	Operand Length, Words		1 to N	1 to N	1 to N
	Instruction Length, Words		1 to N	1 to N	1 to N
	Addresses per Instruction		2	0, 1, or 2	0, 1, or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	123	123	84
		c = ab	3100 (s)	3100 (s)	500
		c = a/b	3700 (s)	3700 (s)	1134
	Likely Floating Point Execution Times, μsec	c = a + b	-	-	-
		c = ab	-	-	-
		c = a/b	-	-	-
	Checking of Data Transfers		Parity	Parity	Parity
	Program Interrupt Facility		Yes	Yes	Yes
	Number of Index Registers		6	6	6, 15*
	Indirect Addressing		Optional	Optional	Yes
	Special Editing Capabilities		Poor; excellent*	Poor; excellent*	Excellent
	Boolean Operations		AND, EXC OR	AND, EXC OR	AND, EXC OR
	Table Look-up		None	None	None
	Console Typewriter		None	Yes	Yes
	Input-Output Channels		2; 3*	2; 3*	3; 4*
	Features and Comments			Includes built-in I/O control	IBM 1401/1410/7010 compatible through software
WORKING STORAGE	Model Number		E050M	N100M	N200M
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	4096	2048	4096
		Maximum	16,384	32,768	65,536
	Maximum Total Storage	Decimal Digits	16,384	32,768	65,536
		Characters	16,384	32,768	65,536
	Cycle Time, μsec		2.0/char	2.0/char	2.0/char
	Effective Transfer Rate, char/sec		167,000	167,000	250,000
	Checking		Parity	Parity	Parity
	Storage Protection		None	None	None
	Features and Comments				

* With optional equipment.
(s) Using subroutine.

Nippon Electric NEAC Series 2200 (Japan)			System Identity		
2200/300	2200/400	2200/500			
6 + 2 punctuation + parity			Binary Bits	Word Length	DATA STRUCTURE
1			Decimal Digits	Word Length	DATA STRUCTURE
1			Characters	Word Length	DATA STRUCTURE
Binary			Radix	Floating Point Representation	DATA STRUCTURE
36 bits			Fraction Size	Floating Point Representation	DATA STRUCTURE
12 bits			Exponent Size	Floating Point Representation	DATA STRUCTURE
N300	N400	N500	Model Number		CENTRAL PROCESSOR
Decimal, binary			Arithmetic Radix		CENTRAL PROCESSOR
1 to N			Operand Length, Words		CENTRAL PROCESSOR
1 to N			Instruction Length, Words		CENTRAL PROCESSOR
0, 1, or 2			Addresses per Instruction		CENTRAL PROCESSOR
61.5	43	12	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
363	216	96	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
850	612	196	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
34.5*	26*	6	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
46.5*	32*	12	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
51*	45*	21	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity	Parity	Parity	Checking of Data Transfers		CENTRAL PROCESSOR
Yes	Yes	Yes	Program Interrupt Facility		CENTRAL PROCESSOR
15; 30*	15; 30*	15 + 15 per program	Number of Index Registers		CENTRAL PROCESSOR
Yes	Yes	Yes	Indirect Addressing		CENTRAL PROCESSOR
Excellent	Excellent	Excellent	Special Editing Capabilities		CENTRAL PROCESSOR
AND, EXC OR	AND, EXC OR	AND, EXC OR	Boolean Operations		CENTRAL PROCESSOR
Optional	Yes	Yes	Table Look-up		CENTRAL PROCESSOR
Yes	Yes	Yes	Console Typewriter		CENTRAL PROCESSOR
4	4; 8*	8, 16*	Input-Output Channels		CENTRAL PROCESSOR
IBM 1401/1410/7010 compatible through software			Features and Comments		CENTRAL PROCESSOR
N300M	N400M	N500M	Model Number		WORKING STORAGE
Core	Core	Core	Type of Storage		WORKING STORAGE
16,384	16,384	65,536	Minimum	Number of Words	WORKING STORAGE
131,072	262,144	524,288	Maximum	Number of Words	WORKING STORAGE
131,072	262,144	524,288	Decimal Digits	Maximum Total Storage	WORKING STORAGE
131,072	262,144	524,288	Characters	Maximum Total Storage	WORKING STORAGE
1.5/char	1/char	1.5/8 char	Cycle Time, μsec		WORKING STORAGE
333,000	500,000	1,777,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Checking		WORKING STORAGE
Yes*	Yes*	Yes*	Storage Protection		WORKING STORAGE
			Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			Philips P1000 Series (Netherlands)		
DATA STRUCTURE	Word Length	Binary Bits	8		
		Decimal Digits	2		
		Characters	1		
	Floating Point Representation	Radix	Binary		
		Fraction Size	24 or 56 bits		
		Exponent Size	7 bits		
CENTRAL PROCESSOR	Model Number		P1100	P1200	P1400
	Arithmetic Radix		Binary or decimal		
	Operand Length, Words		Up to 204		
	Instruction Length, Words		4 or 8		
	Addresses per Instruction		1 or 2		
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	53.5	17.5	7.5
		c = ab	167.5	69.5	17.0
		c = a/b	217	?	16.5
	Likely Floating Point Execution Times, μsec	c = a + b	67	26	9
		c = ab	138	59	17
		c = a/b	182	96	19
	Checking of Data Transfers		Parity		
	Program Interrupt Facility		Yes		
	Number of Index Registers		14		
	Indirect Addressing		Yes		
	Special Editing Capabilities		Excellent		
	Boolean Operations		AND, EXC OR		
	Table Look-up		Yes		
	Console Typewriter		Yes		
	Input-Output Channels		3	5	7
	Features and Comments		Special hardware for automatic alignment, rounding-off, and truncation of decimal numbers		
WORKING STORAGE	Model Number		1100	1200	1400
	Type of Storage		Core	Core	Core
	Number of Words	Minimum	16,384	65,536	131,072
		Maximum	65,536	262,144	524,288
	Maximum Total Storage	Decimal Digits	131,072	524,288	1,048,576
		Characters	65,536	262,144	524,288
	Cycle Time, μsec		1	1	1
	Effective Transfer Rate, char/sec		?	?	?
	Checking		Parity	Parity	Parity
	Storage Protection		Yes	Yes	Yes
	Features and Comments			1200 and 1400 can be extended with 2.5-μsec core storage up to 14,680,064 bytes in modules of 2,097,152	

* With optional equipment.
(s) Using subroutine.

ICL System 4 (United Kingdom)					System Identity		
4-30	4-40	4-50	4-70	4-75			
8 + 1 parity per byte					Binary Bits	Word Length	DATA STRUCTURE
2					Decimal Digits	Word Length	DATA STRUCTURE
1					Characters	Word Length	DATA STRUCTURE
Binary fraction, hexadecimal exponent					Radix	Floating Point Representation	DATA STRUCTURE
24 or 56 bits					Fraction Size	Floating Point Representation	DATA STRUCTURE
7 bits					Exponent Size	Floating Point Representation	DATA STRUCTURE
4-30	4-40	4-50	4-70	4-75	Model Number		CENTRAL PROCESSOR
Binary, decimal					Arithmetic Radix		CENTRAL PROCESSOR
Variable					Operand Length, Words		CENTRAL PROCESSOR
2, 4, or 6					Instruction Length, Words		CENTRAL PROCESSOR
0, 1, or 2					Addresses per Instruction		CENTRAL PROCESSOR
50	33.8	25.2	4.82	6.12	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
673	119.4	82.0	9.17	10.5	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
691	162.1	111.2	14.1	15.4	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
-	40.3 or 55.5	37.4 or 52.6	6.82 or 8.68	8.17 or 10.0	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
-	70.5 or 214	67.7 or 211	9.90 or 16.4	11.2 or 17.7	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
-	104 or 308	101 or 305	13.7 or 23.6	15.0 or 25.0	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity					Checking of Data Transfers		CENTRAL PROCESSOR
Yes, multilevel					Program Interrupt Facility		CENTRAL PROCESSOR
16/processor state					Number of Index Registers		CENTRAL PROCESSOR
None					Indirect Addressing		CENTRAL PROCESSOR
Good					Special Editing Capabilities		CENTRAL PROCESSOR
AND, INC OR, EXC OR					Boolean Operations		CENTRAL PROCESSOR
None					Table Look-up		CENTRAL PROCESSOR
Yes					Console Typewriter		CENTRAL PROCESSOR
2 to 8 selector; 1 multiplexor	2 or 3 selectors; 1 multiplexor		1 to 16 channels; combination of selector, and 1 or 2 multiplexors		Input-Output Channels		CENTRAL PROCESSOR
Multiply/divide decimal only	Program compatible with IBM System/360; 4-75 same as 4-70, but has special paging hardware				Features and Comments		CENTRAL PROCESSOR
4-30	4-40	4-50	4-70	4-75	Model Number		WORKING STORAGE
Core	Core	Core	Core	Core	Type of Storage		WORKING STORAGE
32,192	65,536	65,536	65,536	65,536	Minimum	Number of Words	WORKING STORAGE
65,536	131,072	262,144	1,048,576	1,048,576	Maximum	Number of Words	WORKING STORAGE
131,072	262,144	524,288	2,097,152	2,097,152	Decimal Digits	Maximum Total Storage	WORKING STORAGE
65,536	131,072	262,144	1,048,576	1,048,576	Characters	Maximum Total Storage	WORKING STORAGE
1.5/2 bytes	1.5/2 bytes	1.44/2 bytes	0.9/4 bytes	0.9/4 bytes	Cycle Time, μsec		WORKING STORAGE
513,000	465,000	694,000	2,222,000	1,900,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity	Parity	Parity	Parity	Parity	Checking		WORKING STORAGE
None	Write only*	Write only*	Write only	Write only	Storage Protection		WORKING STORAGE
			Effective cycle time is 0.65 per 4 bytes with full interleaving		Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			ICL 1900 Series (United Kingdom) 1901A	1902A	1903A	1904A
DATA STRUCTURE	Word Length	Binary Bits	24 + parity			
		Decimal Digits	6.9			
		Characters	4			
	Floating Point Representation	Radix	Binary			
		Fraction Size	37 bits			
		Exponent Size	8 bits			
CENTRAL PROCESSOR	Model Number		2010	2020	2030	2040
	Arithmetic Radix		Binary			
	Operand Length, Words		1 or 2			
	Instruction Length, Words		1			
	Addresses per Instruction		0, 1, or 2			
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	57	23	11	5.9
		c = ab	128*	64*	32*	16.5
		c = a/b	133*	70*	35*	21.6
	Likely Floating Point Execution Times, μsec	c = a + b	103*	83*	41*	11*
		c = ab	203*	180*	90*	17*
		c = a/b	233*	208*	104*	32*
	Checking of Data Transfers		Parity			
	Program Interrupt Facility		Yes	Yes, multilevel		
	Number of Index Registers		3			
	Indirect Addressing		No			
	Special Editing Capabilities		Good			
	Boolean Operations		AND, INC OR, EXC OR			
	Table Look-up		None			
	Console Typewriter		Optional	Yes		
	Input-Output Channels		4; 7*	4; 8*	4; 12*	10; 31*
	Features and Comments					
WORKING STORAGE	Model Number		2010	2020	2030	2040
	Type of Storage		Core	Core	Core	Core
	Number of Words	Minimum	4,096	8,192	16,384	65,536
		Maximum	16,384	32,768	65,536	262,144
	Maximum Total Storage	Decimal Digits	113,049	226,099	452,198	1,808,793
		Characters	65,536	131,072	262,144	1,048,576
	Cycle Time, μsec		4.0	3.0	1.5	0.75
	Effective Transfer Rate, char/sec		37,000	615,000	1,230,000	2,220,000
	Checking		Parity			
	Storage Protection					
	Features and Comments					

* With optional equipment.
(s) Using subroutine.

ICL 1900 Series (United Kingdom)				System Identity		
1904, 5E	1904, 5F	1906E, 1907E	1906F, 1907F			
24 + parity				Binary Bits	Word Length	DATA STRUCTURE
6.9				Decimal Digits	Word Length	DATA STRUCTURE
4				Characters	Word Length	DATA STRUCTURE
Binary				Radix	Floating Point Representation	DATA STRUCTURE
38 bits + sign				Fraction Size	Floating Point Representation	DATA STRUCTURE
8 bits + sign				Exponent Size	Floating Point Representation	DATA STRUCTURE
2040, 2050	2042, 2052	2060, 2070	2062, 2072	Model Number		CENTRAL PROCESSOR
Binary				Arithmetic Radix		CENTRAL PROCESSOR
1 or 2				Operand Length, Words		CENTRAL PROCESSOR
1				Instruction Length, Words		CENTRAL PROCESSOR
0, 1 or 2				Addresses per Instruction		CENTRAL PROCESSOR
11.8	7.2	14.4	9.4	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
29.9	23.6	31.8	26.3	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
36	28.2	39.5	32.1	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
31.6	15	37.6	21	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
47.6	22	53.6	28	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
69.6	36	75.6	42	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
Parity				Checking of Data Transfers		CENTRAL PROCESSOR
Multilevel				Program Interrupt Facility		CENTRAL PROCESSOR
3				Number of Index Registers		CENTRAL PROCESSOR
Yes				Indirect Addressing		CENTRAL PROCESSOR
Good				Special Editing Capabilities		CENTRAL PROCESSOR
AND, EXC OR, INC OR				Boolean Operations		CENTRAL PROCESSOR
None				Table Look-up		CENTRAL PROCESSOR
Standard				Console Typewriter		CENTRAL PROCESSOR
6 to 30*		12 to 60*		Input-Output Channels		CENTRAL PROCESSOR
2050 and 2052 have autonomous floating point unit; multiprogramming; program compatible.		Dual processor systems. 2070 & 2072 have autonomous floating point unit on each processor.		Features and Comments		CENTRAL PROCESSOR
2040, 2050	2042, 2052	2060, 2070	2062, 2072	Model Number		WORKING STORAGE
Core				Type of Storage		WORKING STORAGE
32,768	32,768	65,536	65,536	Minimum	Number of Words	WORKING STORAGE
262,144	262,144	262,144	262,144	Maximum	Number of Words	WORKING STORAGE
1,808,793	1,808,793	1,808,793	1,808,793	Decimal Digits	Maximum Total Storage	WORKING STORAGE
1,048,576	1,048,576	1,048,576	1,048,576	Characters	Maximum Total Storage	WORKING STORAGE
1.8	0.75	1.8	0.75	Cycle Time, μsec		WORKING STORAGE
1,110,000	1,700,000	830,000	1,140,000	Effective Transfer Rate, char/sec		WORKING STORAGE
Parity				Checking		WORKING STORAGE
Variable datum and limit registers				Storage Protection		WORKING STORAGE
		Dual processor systems sharing common core store		Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

System Identity			Siemens System 4004 (West Germany) 4004/15	4004/25	4004/35	4004/45	4004/55
DATA STRUCTURE	Word Length	Binary Bits	8/byte	8/byte	8/byte	8/byte	8/byte
		Decimal Digits	2/byte	2/byte	2/byte	2/byte	2/byte
		Characters	1/byte	1/byte	1/byte	1/byte	1/byte
	Floating Point Representation	Radix	—	—	Binary	Binary	Binary
		Fraction Size	—	—	24 or 56 bits	24 or 56 bits	24 or 56 bits
		Exponent Size	—	—	7 bits	7 bits	7 bits
CENTRAL PROCESSOR	Model Number		4004/15	4004/25	4004/35	4004/45	4004/55
	Arithmetic Radix		Binary, decimal	Binary, decimal	Binary, decimal	Binary, decimal	Binary, decimal
	Operand Length, Words		Variable	Variable	Variable	Variable	Variable
	Instruction Length, Words		4 or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes	2, 4, or 6 bytes
	Addresses per Instruction		0, 1 or 2	0, 1 or 2	0, 1 or 2	0, 1 or 2	0, 1 or 2
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	76	49	51 or 80	25 or 42	7, 8 or 20
		c = ab	(5)	445	163 or 287	82 or 134	18 or 62
		c = a/b	(5)	185	243 or 206	106 or 111	23 or 25
	Likely Floating Point Execution Times, μsec	c = a + b	—	—	81 or 116	37 or 53	13 or 18
		c = ab	—	—	203 or 536	68 or 212	23 or 50
		c = a/b	—	—	445 or 1282	101 or 305	28 or 84
	Checking of Data Transfers		Parity	Parity	Parity	Parity	Parity
	Program Interrupt Facility		Yes, limited	Yes, 4 levels	Yes, multilevel	Yes, multilevel	Yes, multilevel
	Number of Index Registers		None	15 max	16 max	16 max	16 max
	Indirect Addressing		None	None	None	None	None
	Special Editing Capabilities		Fair	Fair	Good	Good	Good
	Boolean Operations		AND, INC OR EXC OR,	AND, INC OR EXC OR,	AND, INC OR EXC OR	AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None	None	None	None	None
	Console Typewriter		Optional	Optional	Optional	Optional	Optional
	Input-Output Channels		1 with 6 sub-channels, 2 simultaneous	4408 selector channels, 0 or 1 multiplexor	0 to 2 selector channels; 1 multiplexor	0 to 3 selector channels; 1 multiplexor	0 to 6 selector channels; 1 multiplexor
	Features and Comments						
WORKING STORAGE	Model Number		4004/15	4004/25	4004/35	4004/45	4004/55
	Type of Storage		Core	Core	Core	Core	Core
	Number of Words	Minimum	4,096 bytes	16,384 bytes	16,384 bytes	16,384 bytes	65,536 bytes
		Maximum	16,384 bytes	65,536 bytes	65,563 bytes	262,144 bytes	524,288 bytes
	Maximum Total Storage	Decimal Digits	32,768	131,072	131,072	524,288	1,048,576
		Characters	16,384	65,536	65,536	262,144	524,288
	Cycle Time, μsec		2.0/byte	1.5/4 bytes	1.44/2 bytes	1.44/2 bytes	.84/4 bytes
	Effective Transfer Rate, char/sec		250,000	1,333,333	507,000	679,000	1,201,000
	Checking		Parity	Parity	Parity	Parity	Parity
	Storage Protection		None	None	Write only*	Write only*	Write only*
	Features and Comments		No general-purpose registers	15 general-purpose registers in core storage	16 general-purpose registers in core storage	16 general-purpose registers in core storage	16 general-purpose registers in core storage

* With optional equipment.
(s) Using subroutine.

Siemens System 300 (West Germany)						System Identity		
301	302	303	304	305	306			
24	24	24	24	24	24	Binary Bits	Word Length	DATA STRUCTURE
4/word	4/word	4/word	4/word	4/word	4/word	Decimal Digits	Word Length	DATA STRUCTURE
4/word	4/word	4/word	4/word	4/word	4/word	Characters	Word Length	DATA STRUCTURE
—	—	—	—	Binary	Binary	Radix	Floating Point Representation	DATA STRUCTURE
—	—	—	—	24 bits	24 or 34 bits	Fraction Size	Floating Point Representation	DATA STRUCTURE
—	—	—	—	10 bits	10 bits	Exponent Size	Floating Point Representation	DATA STRUCTURE
301	302	303	304	305	306	Model Number		CENTRAL PROCESSOR
Binary	Binary	Binary	Binary	Binary	Binary	Arithmetic Radix		CENTRAL PROCESSOR
1	1	1	1	1	1	Operand Length, Words		CENTRAL PROCESSOR
1	1	1	1	1	1	Instruction Length, Words		CENTRAL PROCESSOR
1	1	1	1	1	1	Addresses per Instruction		CENTRAL PROCESSOR
11	9	30	8	8	4	c = a + b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
—	—	29	23	23	13	c = ab	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
—	—	—	23	23	13	c = a/b	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	CENTRAL PROCESSOR
—	—	—	—	29	14 or 15	c = a + b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
—	—	—	—	26	14 or 18	c = ab	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
—	—	—	—	26	11 or 13	c = a/b	Likely Floating Point Execution Times, μsec	CENTRAL PROCESSOR
None	None	None	None	None	Parity	Checking of Data Transfers		CENTRAL PROCESSOR
Yes, 2 levels	Yes, multilevel	Yes, multilevel	Yes, multilevel	Yes, multilevel	Yes, multilevel	Program Interrupt Facility		CENTRAL PROCESSOR
None	None	None	None	None	16	Number of Index Registers		CENTRAL PROCESSOR
Yes	Yes	Yes	Yes	Yes	Yes	Indirect Addressing		CENTRAL PROCESSOR
None	None	None	None	None	None	Special Editing Capabilities		CENTRAL PROCESSOR
AND, OR	AND, OR	AND, OR	AND, OR	AND, OR	AND, OR	Boolean Operations		CENTRAL PROCESSOR
None	None	None	None	None	None	Table Look-up		CENTRAL PROCESSOR
Optional	Standard	Standard	Standard	Standard	Standard	Console Typewriter		CENTRAL PROCESSOR
1 integrated channel, 1 high-speed channel	1 multiplexor channel with 5 trunks	1 multiplexor-channel with 6 trunks	1 multiplexor-channel with 10 trunks, 1 high-speed channel with 5 trunks			Input-Output Channels		CENTRAL PROCESSOR
						Features and Comments		CENTRAL PROCESSOR
301	302	303	304	305	306	Model Number		WORKING STORAGE
Core	Core	Core	Core	Core	Core	Type of Storage		WORKING STORAGE
4,096	8,192	4,096	8,192	8,192	16,384	Minimum	Number of Words	WORKING STORAGE
16,384	16,384	16,384	16,384	16,384	65,536	Maximum	Number of Words	WORKING STORAGE
65,536	65,536	65,536	65,536	65,536	262,144	Decimal Digits	Maximum Total Storage	WORKING STORAGE
65,536	65,536	65,536	65,536	65,536	262,144	Characters	Maximum Total Storage	WORKING STORAGE
1.6/word	1.5/word	8.3/6-bits	1.5/word	1.5/word	0.6/word	Cycle Time, μsec		WORKING STORAGE
2,600,000	668,000	120,000	2,668,000	2,668,000	2,220,000	Effective Transfer Rate, char/sec		WORKING STORAGE
None	None	None	None	None	Parity	Checking		WORKING STORAGE
None	None	Yes, write only	Yes, write only	Yes, write only	Yes, write only	Storage Protection		WORKING STORAGE
						Features and Comments		WORKING STORAGE

* With optional equipment.
(s) Using subroutine.

COMPARISON CHARTS — NON–U.S.A. COMPUTERS
AUXILIARY STORAGE AND MAGNETIC TAPE

An introduction to the Auxiliary Storage and Magnetic Tape Section of the Comparison Charts, giving the precise meaning of each entry, can be found on Page 11:220.101.

System Identity			A/S Regnecentralen RC 4000 (Denmark)			
AUXILIARY STORAGE	Model Number		RC 4320		RC 433	
	Type of Storage		Drum		Disc	
	Maximum Number	Units On-Line	16		6/controller	
		Read/Write Operations	16		1/controller (max 15)	
		Seek Operations				
	Number of Words per Unit	Minimum	65, 536		2, 048, 000	
		Maximum	524, 288		12, 288, 000	
	Maximum Total Storage	Decimal Digits				
		Characters				
	Rotational Time, msec					
	Waiting Time, msec	Minimum			13	
		Average (Random)	10.5		94	
		Maximum			163	
	Effective Transfer Rate, char/sec		150, 000		120, 000	
	Sector Size, char		256 plus 1 parity word			
	Transfer Load Size, char					
	Checking		Parity plus status word			
	Features and Comments					
MAGNETIC TAPE	Model Number		RC 707		RC 709	
	Maximum Number of Units	On-Line	1/controller (max 64 controllers)			
		Reading/Writing	Maximum 16			
		Searching				
		Rewinding	All			
	Demands on Processor, %	Reading/Writing				
		Starting/Stopping				
	Transfer Rate, kilo-char/sec	Peak	36	25	9	36
		1,000-char blocks	22.5	17.5	7.8	22.5
		100-char blocks	5.1	4.8	3.6	5.1
	Tape Speed, inches/sec		45			
	Data Tracks		6		8	
	Data Rows per Block		4 to 65, 538		4 to 87, 380	
	Data Rows per Inch		800	556	200	800
	IBM 729 Compatible		Yes			
	IBM 2400 Compatible					
	Checking	Reading	Parity			
		Writing	Parity, read after write			
	Read Reverse					
	Features and Comments					

*With optional equipment.

Bull Gamma 10 (France)	Bull-GE-GE-55 (France)	Elbit 100 (Israel)	System Identity		
	GE-55	CLC-1	Model Number		AUXILIARY STORAGE
	Drum	Magnetic drum	Type of Storage		
	2		Units On-Line	Maximum Number	
	1	1/trunk	Read/Write Operations		
	2	1/unit	Seek Operations		
	89,600	50,000	Minimum	Number of Words per Unit	
	89,600	100,000	Maximum		
	358,400	300,000	Decimal Digits	Maximum Total Storage	
	179,200	200,000	Characters		
	30		Rotational Time, msec		
	0		Minimum	Waiting Time, msec	
	15		Average (Random)		
	30		Maximum		
	70,000		Effective Transfer Rate, char/sec		
	1,400	Variable	Sector Size, char		
	?		Transfer Load Size, char		
	?		Checking		
No auxiliary storage devices as yet			Features and Comments		

Bull Gamma 10 (France)	Bull-GE-GE-55 (France)	Elbit 100 (Israel)		System Identity		
MFU 35		Kennedy 1400/360	Peripheral Equipment	Model Number		MAGNETIC TAPE
2				On-Line	Maximum Number of Units	
2		1/unit	1/unit	Reading/Writing		
0		1/unit	1/unit	Searching		
2		1/unit	1/unit	Rewinding		
?				Reading/Writing	Demands on Processor, %	
?				Starting/Stopping		
34		500 bytes/sec	25 inches/sec	Peak	Transfer Rate, kilo-char/sec	
				1,000-char blocks		
				100-char blocks		
4			25	Tape Speed, inches/sec		
		9	7 or 9	Data Tracks		
		Variable		Data Rows per Block		
100		800	800	Data Rows per Inch		
No		Yes	No	IBM 729 Compatible		
No		No	No	IBM 2400 Compatible		
		Parity	Parity	Reading	Checking	
		Parity	Parity	Writing		
		No	No	Read Reverse		
	No magnetic units announced as yet			Features and Comments		

*With optional equipment.

System Identity			Fujitsu FACOM 270 Series (Japan)		
AUXILIARY STORAGE	Model Number		F627A	F631A	F631B
	Type of Storage		Drum	Disc	Disc
	Maximum Number	Units On-Line	8/channel	8/channel	8/channel
		Read/Write Operations	1/channel	1/channel	1/channel
		Seek Operations	1/channel	1/channel	1/channel
	Number of Words per Unit	Minimum	524 x 18^3 bytes	33.5 x 10^6 bytes	67.1 x 10^6 bytes
		Maximum	524 x 18^3 bytes	33.5 x 10^6 bytes	67.1 x 10^6 bytes
	Maximum Total Storage	Decimal Digits	1,048 x 8 x 10^3/channel	67.1 x 10^6 x 8/channel	134 x 10^6 x 8/channel
		Characters	524 x 8 x 10^3/channel	33.5 x 10^6 x 8/channel	67.1 x 10^6 x 8/channel
	Rotational Time, msec				
	Waiting Time, msec	Minimum	0	0	0
		Average (Random)	8.4	150	150
		Maximum	17	290	290
	Effective Transfer Rate, char/sec		150 x 10^3	56 x 10^3	In 95 x 10^3 Out 120 x 10^3
	Sector Size, char				
	Transfer Load Size, char		16 — 65 x 10^3 bytes	256 — 131 x 10^3 bytes	256 — 262 x 10^3 bytes
	Checking		Check bytes	Check bytes	Check bytes
	Features and Comments		Floating head		
MAGNETIC TAPE	Model Number		F603D	F603E	F603F
	Maximum Number of Units	On-Line	8/controller	8/controller	8/controller
		Reading/Writing	1/controller	1/controller	1/controller
		Searching	1/controller	1/controller	1/controller
		Rewinding	8/controller	8/controller	8/controller
	Demands on Processor, %	Reading/Writing	CPU dependent		
		Starting/Stopping	CPU dependent		
	Transfer Rate, kilo-char/sec	Peak	41.7/60	66.7/96	60
		1,000-char blocks	28.9/36.7	46.4/59	39.5
		100-char blocks	7.67/8.12	12.4/13.2	9.7
	Tape Speed, inches/sec		75	120	5
	Data Tracks		7	7	9
	Data Rows per Block		Variable		
	Data Rows per Inch		556/800	556/800	800
	IBM 729 Compatible		Yes	Yes	No
	IBM 2400 Compatible		Yes		Yes
	Checking	Reading	Lateral and longitudinal parity		
		Writing	Read-after-write parity		
	Read Reverse		Yes	Yes	
	Features and Comments		Cross call	Cross call	

*With optional equipment.

Fujitsu FACOM 270 Series (Japan)		System Identity		
F631K	F461K	Model Number		AUXILIARY STORAGE
Disc	Disc pack	Type of Storage		
4/channel	4/channel	Units On-Line	Maximum Number	
1/channel	1/channel	Read/Write Operations		
1/channel	1/channel	Seek Operations		
90 x 10^6 bytes	7.25 x 10^6 bytes	Minimum	Number of Words per Unit	
90 x 10^6 bytes	7.25 x 10^6 bytes	Maximum		
180 x 10^6 x 8/channel	14.5 x 10^6 x 8/channel	Decimal Digits	Maximum Total Storage	
90 x 10^6 x 8/channel	7.25 x 10^6 x 8/channel	Characters		
		Rotational Time, msec		
0	0	Minimum	Waiting Time, msec	
130	87.5	Average (Random)		
270	160	Maximum		
130 x 10^3 bytes	156 x 10^3 bytes	Effective Transfer Rate, char/sec		
		Sector Size, char		
Variable	Variable	Transfer Load Size, char		
Check bytes	Check bytes	Checking		
		Features and Comments		
F603G	F401A	Model Number		MAGNETIC TAPE
8/controller	3/controller	On-Line	Maximum Number of Units	
1/controller	1/controller	Reading/Writing		
1/controller	None	Searching		
8/controller	None	Rewinding		
CPU dependent		Reading/Writing	Demands on Processor, %	
CPU dependent		Starting/Stopping		
96	1.67	Peak	Transfer Rate, kilo-char/sec	
63.7	1.18	1,000-char blocks		
15.8	0.32	100-char blocks		
120	30	Tape Speed, inches/sec		
9	4	Data Tracks		
Variable	Variable	Data Rows per Block		
800	333	Data Rows per Inch		
No	None	IBM 729 Compatible		
Yes	None	IBM 2400 Compatible		
Lateral, longitudinal and diagonal parity	Track parity	Reading	Checking	
Read-after-write parity	Double write	Writing		
		Read Reverse		
		Features and Comments		

*With optional equipment.

System Identity			Fujitsu FACOM 270 Series (Japan)		
AUXILIARY STORAGE	Model Number		F622D	F623A	F624B
	Type of Storage		Drum	Drum	Drum
	Maximum Number	Units On-Line	8/channel	8/channel	8/channel
		Read/Write Operations	1/channel	1/channel	1/channel
		Seek Operations	1/channel	1/channel	1/channel
	Number of Words per Unit	Minimum	131 x 10^3 bytes	262 x 10^3 bytes	2,096 x 10^3 bytes
		Maximum	131 x 10^3 bytes	262 x 10^3 bytes	2,096 x 10^3 bytes
	Maximum Total Storage	Decimal Digits	262 x 8 x 10^3/channel	524 x 8 x 10^3/channel	4,192 x 8 x 10^3/channel
		Characters	131 x 8 x 10^3/channel	262 x 8 x 10^3/channel	2,096 x 8 x 10^3/channel
	Rotational Time, msec				
	Waiting Time, msec	Minimum	0	0	0
		Average (Random)	10	20	17
		Maximum	20	40	34
	Effective Transfer Rate, char/sec		25 x 10^3 bytes	27 x 10^3 bytes	120 x 10^3 bytes
	Sector Size, char				
	Transfer Load Size, char		1 — 16 x 10^3 bytes	256 — 262 x 10^3 bytes	256 — 131 x 10^3 bytes
	Checking		Parity	Parity	Check bytes
	Features and Comments		Fixed head	Fixed head	Floating head
MAGNETIC TAPE	Model Number		F606A	F603B	F603C
	Maximum Number of Units	On-Line	6/controller	8/controller	8/controller
		Reading/Writing	1/controller	1/controller	1/controller
		Searching	1/controller	1/controller	1/controller
		Rewinding	6/controller	8/controller	8/controller
	Demands on Processor, %	Reading/Writing	CPU dependent	CPU dependent	CPU dependent
		Starting/Stopping	CPU dependent	CPU dependent	CPU dependent
	Transfer Rate, kilo-char/sec	Peak	15/25	15/41.7	24/66.7
		1,000-char blocks	11.8/15.6	12.9/28.9	20.7/46.4
		100-char blocks	3.26/3.57	5.77/7/67	9.33/12.4
	Tape Speed, inches/sec		45	75	120
	Data Tracks		7	7	7
	Data Rows per Block		Variable	Variable	Variable
	Data Rows per Inch		333/556	200/556	200/556
	IBM 729 Compatible		Yes	Yes	Yes
	IBM 2400 Compatible		Yes	Yes	Yes
	Checking	Reading	Lateral and longitudinal parity		
		Writing	Read-after-write parity		
	Read Reverse		Yes	Yes	Yes
	Features and Comments			Cross call	Cross call

*With optional equipment.

Fujitsu FACOM 230 Series (Japan)			System Identity		
F624B	F627A	F631A	Model Number		AUXILIARY STORAGE
Drum	Drum	Disc	Type of Storage		
8/channel	8/channel	8/channel	Units On-Line	Maximum Number	
1/channel	1/channel	1/channel	Read/Write Operations		
1/channel	1/channel	1/channel	Seek Operations		
2,096 x 10^3 bytes	524 x 18^3 bytes	33.5 x 10^6 bytes	Minimum	Number of Words per Unit	
2,096 x 10^3 bytes	524 x 10^3 bytes	33.5 x 10^6 bytes	Maximum		
4,192 x 8 x 10^3/channel	1,048 x 8 x 10^3/channel	67.1 x 10^6 x 8/channel	Decimal Digits	Maximum Total Storage	
2,096 x 8 x 10^3/channel	524 x 8 x 10^3/channel	33.5 x 10^6 x 8/channel	Characters		
			Rotational Time, msec		
0	0	0	Minimum	Waiting Time, msec	
17	8.4	150	Average (Random)		
34	17	290	Maximum		
120 x 10^3 bytes	150 x 10^3 bytes	56 x 10^3 bytes	Effective Transfer Rate, char/sec		
			Sector Size, char		
256 — 131 x 10^3 bytes	16 — 65 x 10^3 bytes	256 — 131 x 10^3 bytes	Transfer Load Size, char		
Check bytes	Check bytes	Check bytes	Checking		
Floating head	Floating head		Features and Comments		

F603D	F603E	F603F	Model Number		MAGNETIC TAPE
8/controller	8/controller	8/controller	On-Line	Maximum Number of Units	
1/controller	1/controller	1/controller	Reading/Writing		
1/controller	1/controller	1/controller	Searching		
8/controller	8/controller	8/controller	Rewinding		
CPU dependent			Reading/Writing	Demands on Processor, %	
CPU dependent			Starting/Stopping		
41.7/60	66.7/96	60	Peak	Transfer Rate, kilo-char/sec	
28.9/36.7	46.4/59	39.5	1,000-char blocks		
7.67/8.12	12.4/13.2	9.7	100-char blocks		
75	120	5	Tape Speed, inches/sec		
7	7	9	Data Tracks		
Variable			Data Rows per Block		
556/800	556/800	800	Data Rows per Inch		
Yes	Yes	No	IBM 729 Compatible		
Yes			IBM 2400 Compatible		
Lateral and longitudinal parity			Reading	Checking	
Read-after-write parity			Writing		
Yes	Yes		Read Reverse		
Cross call	Cross call		Features and Comments		

*With optional equipment.

System Identity			Fujitsu FACOM 230 Series (Japan)		
AUXILIARY STORAGE	Model Number		F631B	F631K	F461K
	Type of Storage		Disc	Disc	Disc pack
	Maximum Number	Units On-Line	8/channel	4/channel	8/channel
		Read/Write Operations	1/channel	1/channel	1/channel
		Seek Operations	1/channel	1/channel	1/channel
	Number of Words per Unit	Minimum	67.1 x 10^6 bytes	90 x 10^6 bytes	7.25 x 10^6 bytes
		Maximum	67.1 x 10^6 bytes	90 x 10^6 bytes	7.25 x 10^6 bytes
	Maximum Total Storage	Decimal Digits	134 x 10^6 x 8/channel	180 x 10^6 x 8/channel	14.5 x 10^6 x 8/channel
		Characters	67.1 x 10^6 x 8/channel	90 x 10^6 x 8/channel	7.25 x 10^6 x 8/channel
	Rotational Time, msec				
	Waiting Time, msec	Minimum	0	0	0
		Average (Random)	150	130	87.5
		Maximum	290	270	160
	Effective Transfer Rate, char/sec		In 95 x 10^3 bytes Out 120 x 10^3 bytes	130 x 10^3 bytes	156 x 10^3 bytes
	Sector Size, char				
	Transfer Load Size, char		256 to 262 x 10^3 bytes	Variable	Variable
	Checking		Check bytes	Check bytes	Check bytes
	Features and Comments				

MAGNETIC TAPE	Model Number		F603G	F401A
	Maximum Number of Units	On-Line	8/controller	3/controller
		Reading/Writing	1/controller	1/controller
		Searching	1/controller	None
		Rewinding	8/controller	None
	Demands on Processor, %	Reading/Writing	CPU dependent	
		Starting/Stopping	CPU dependent	
	Transfer Rate, kilo-char/sec	Peak	96	1.67
		1,000-char blocks	63.7	1.18
		100-char blocks	15.8	0.32
	Tape Speed, inches/sec		120	30
	Data Tracks		9	4
	Data Rows per Block		Variable	Variable
	Data Rows per Inch		800	333
	IBM 729 Compatible		No	None
	IBM 2400 Compatible		Yes	None
	Checking	Reading	Lateral, longitudinal and diagonal parity	Track parity
		Writing	Read-after-write parity	Double write
	Read Reverse			
	Features and Comments			

*With optional equipment.

Fujitsu FACOM 230 Series (Japan)			System Identity		
	F622D	F623A	Model Number		AUXILIARY STORAGE
Core	Drum	Drum	Type of Storage		
3	8/channel	8/channel	Units On-Line	Maximum Number	
6	1/channel	1/channel	Read/Write Operations	Maximum Number	
—	1/channel	1/channel	Seek Operations	Maximum Number	
262×10^3	131×10^3 bytes	262×10^3 bytes	Minimum	Number of Words per Unit	
262×10^3	131×10^3 bytes	262×10^3 bytes	Maximum	Number of Words per Unit	
$262 \times 9 \times 3 \times 10^3$	$262 \times 8 \times 10^3$/channel	$524 \times 8 \times 10^3$/channel	Decimal Digits	Maximum Total Storage	
$262 \times 6 \times 3 \times 10^3$	$131 \times 8 \times 10^3$/channel	$262 \times 8 \times 10^3$/channel	Characters	Maximum Total Storage	
			Rotational Time, msec		
6 μsec	0	0	Minimum	Waiting Time, msec	
6 μsec	10	20	Average (Random)	Waiting Time, msec	
6 μsec	20	40	Maximum	Waiting Time, msec	
6×10^6 bytes	25×10^3 bytes	27×10^3 bytes	Effective Transfer Rate, char/sec		
			Sector Size, char		
Variable	$1 - 16 \times 10^3$ bytes	$256 - 262 \times 10^3$ bytes	Transfer Load Size, char		
Parity	Parity	Parity	Checking		
	Fixed head	Fixed head	Features and Comments		
F606A	F603B	F603C	Model Number		MAGNETIC TAPE
6/controller	8/controller	8/controller	On-Line	Maximum Number of Units	
1/controller	1/controller	1/controller	Reading/Writing	Maximum Number of Units	
1/controller	1/controller	1/controller	Searching	Maximum Number of Units	
6/controller	8/controller	8/controller	Rewinding	Maximum Number of Units	
CPU dependent	CPU dependent	CPU dependent	Reading/Writing	Demands on Processor, %	
CPU dependent	CPU dependent	CPU dependent	Starting/Stopping	Demands on Processor, %	
15/25	15/41.7	24/66.7	Peak	Transfer Rate, kilo-char/sec	
11.8/15.6	12.9/28.9	20.7/46.4	1,000-char blocks	Transfer Rate, kilo-char/sec	
3.26/3.57	5.77/7.67	9.33/12.4	100-char blocks	Transfer Rate, kilo-char/sec	
45	75	120	Tape Speed, inches/sec		
7	7	7	Data Tracks		
Variable	Variable	Variable	Data Rows per Block		
333/556	200/556	200/556	Data Rows per Inch		
Yes	Yes	Yes	IBM 729 Compatible		
Yes	Yes	Yes	IBM 2400 Compatible		
Lateral and longitudinal parity			Reading	Checking	
Read-after-write parity			Writing	Checking	
Yes	Yes	Yes	Read Reverse		
	Cross call	Cross call	Features and Comments		

*With optional equipment.

System Identity			Hitachi HITAC 3010 (Japan)					
AUXILIARY STORAGE	Model Number		H-366					
	Type of Storage		Disc					
	Maximum Number	Units On-Line	2					
		Read/Write Operations	2					
		Seek Operations	2					
	Number of Words per Unit	Minimum	22,118,400					
		Maximum	88,473,600					
	Maximum Total Storage	Decimal Digits	177×10^6					
		Characters	177×10^6					
	Rotational Time, msec		50					
	Waiting Time, msec	Minimum	0					
		Average (Random)	105					
		Maximum	150					
	Effective Transfer Rate, char/sec		25,400					
	Sector Size, char		160					
	Transfer Load Size, char		1 to 1,600					
	Checking		Parity					
	Features and Comments							
MAGNETIC TAPE	Model Number		H-381	H-382	H-197	H-581	H-582	H-3485
	Maximum Number of Units	On-Line	12	12	14			14
		Reading/Writing	2	2	2			2
		Searching	0	0	0			0
		Rewinding	All	All	All			All
	Demands on Processor, %	Reading/Writing	Varies	Varies	Varies			Varies
		Starting/Stopping	Varies	Varies	Varies			Varies
	Transfer Rate, kilo-char/sec	Peak	10.0	30.0	55.0	33.3	66.7	120
		1,000-char blocks	9.0	25.0	41.6	30.0	42.0	75
		100-char blocks	5.0	15.0	12.8	15.0	15.0	17
	Tape Speed, inches/sec		30	60	100	100	100	150
	Data Tracks		6	6	6 (2 bands)			6
	Data Rows per Block		Variable	Variable	Variable			Variable
	Data Rows per Inch		333	500	555	333	667	800
	IBM 729 Compatible		No	No	No			Yes
	IBM 2400 Compatible		No	No	No			No
	Checking	Reading	Row parity					
		Writing	Read-after-write					
	Read Reverse		Yes					
	Features and Comments							

*With optional equipment.

Hitachi HITAC 8000 Series (Japan)							System Identity		
H-8564	H-8564-12	H-8564-11	H-8564-21	H-8566	H-8577	H-8568-11	Model Number		AUXILIARY STORAGE
Disc	Disc	Disc	Disc	Drum	Disc	Magnetic cards	Type of Storage		
8/trunk	2/trunk	2/trunk	1/trunk	16/trunk	8/channel	32/trunk	Units On-Line	Maximum Number	
1/channel	1/channel	1/channel	1/channel	1/channel	1/channel	1/channel	Read/Write Operations		
1/unit	1/unit	1/unit	1/unit	10/unit	8/unit	1/unit	Seek Operations		
7.25×10^6	2.56×10^6	5.12×10^6	5.12×10^6	1.6×10^6	29.2×10^6	537×10^6	Minimum	Number of Words per Unit	
7.25×10^6	2.56×10^6	5.12×10^6	5.12×10^6	1.6×10^6	233.4×10^6	537×10^6	Maximum		
116×10^6	10.2×10^6	20.5×10^6	10.2×10^6	51.2×10^6	3.7×10^9	34.4×10^9	Decimal Digits	Maximum Total Storage	
58×10^6	5.12×10^6	10.2×10^6	5.12×10^6	25.6×10^6	1.9×10^9	17.2×10^9	Characters		
25	25	25	25	17.2	25	60	Rotational Time, msec		
0	0	0	0	0	0	0	Minimum	Waiting Time, msec	
87.5	72.5	87.5	87.5	8.6	87.5	500	Average (Random)		
160	115	160	160	17.2	160	550	Maximum		
156,000	156,000	156,000	156,000	210,000	312,000	70,000	Effective Transfer Rate, char/sec		
Variable	200	200	200	Variable	Variable	Variable	Sector Size, char		
1 to 36,250	200	200	200	1 to 36,250	1 to 146,880	1 to 16,384	Transfer Load Size, char		
Cyclic check code							Checking		
H-8564 series uses changeable disc packs (similar to IBM 2311); H-8564-21 has 2 disc drives per unit; H-8568-11 uses changeable cartridges holding 256 cards each; all maximum storage capacities are based on 1 trunk.							Features and Comments		

H-8422	H-8432	H-8442	H-8445	H-8451	H-8453	Model Number		MAGNETIC TAPE
8/trunk	16/trunk			16/trunk		On-Line	Maximum Number of Units	
1/channel	1/channel			1/channel		Reading/Writing		
0	0			0		Searching		
All	All			All		Rewinding		
Varies	Varies			Varies		Reading/Writing	Demands on Processor, %	
Varies	Varies			Varies		Starting/Stopping		
15.0	30.0	60.0	120	60.0	120	Peak	Transfer Rate, kilo-char/sec	
12.7	20.4	40.0	81.3	30.6	61.2	1,000-char blocks		
5.4	5.2	10.3	20.8	5.6	11.3	100-char blocks		
37.5	37.5	75	150	37.5	75	Tape Speed, inches/sec		
8	8 or 6*			8		Data Tracks		
Variable	Variable			Variable		Data Rows per Block		
400	800 (200, 556 or 800)*			1,600		Data Rows per Inch		
No	Yes*			No		IBM 729 Compatible		
No	Yes			Yes		IBM 2400 Compatible		
Track, row parity	Tracks, row and diagonal			Row parity		Reading	Checking	
Read-after-write						Writing		
Yes						Read Reverse		
						Features and Comments		

*With optional equipment.

System Identity			Nippon Electric NEAC Series-2200 (Japan)				
AUXILIARY STORAGE	Model Number		N271B	N274A-1	N274A-2	E271	E261
	Type of Storage		Drum	Disc	Disc	Drum	Disc
	Maximum Number	Units On-Line	4/control	1/control	1/control	4/controller	4/controller
		Read/Write Operations	1/control	1/control	1/control	1/controller	1/controller
		Seek Operations	—	16/control	8/control	—	1/unit
	Number of Words per Unit	Minimum	1.7×10^6	294×10^6	147×10^6	82,000	820,000
		Maximum	1.7×10^6	294×10^6	147×10^6	82,000	820,000
	Maximum Total Storage	Decimal Digits	6.8×10^6/cont.	294×10^6/cont.	147×10^6/cont.	$.34 \times 10^6$/cont.	3.3×10^6/cont.
		Characters	6.8×10^6/cont.	294×10^6/cont.	147×10^6/cont.	$.34 \times 10^6$/cont.	3.3×10^6/cont.
	Rotational Time, msec		34	25		16.7	34
	Waiting Time, msec	Minimum	0	0		0	0
		Average (Random)	17	62.5		8.3	?
		Maximum	34	135		16.7	534
	Effective Transfer Rate, char/sec		900,000	208,330		103,000	83,333
	Sector Size, char		Variable	Variable		128	100
	Transfer Load Size, char		Variable	Variable		1 to N	1 to N
	Checking		Cyclic	Cyclic		Parity	Parity
	Features and Comments		For 2200/700 only	16 drives per N274A-1; 8 drives per N274A-2		E261 uses changeable disc packs; both units for 2200/50 only	

			N204A Series			N204C Series		
MAGNETIC TAPE	Model Number		-1	-2	-3	-13	-15	E204
	Maximum Number of Units	On-Line	4/controller			4/controller		4/controller
		Reading/Writing	1/controller			1/controller		1/controller
		Searching	0			0		0
		Rewinding	All			All		All
	Demands on Processor, %	Reading/Writing	Varies widely			Varies widely		2 max
		Starting/Stopping	0			0		0
	Transfer Rate, kilo-char/sec	Peak	32	64	88.8	28.8	64	8.9
		1,000-char blocks	23.5	47	65.3	19.4	43.2	7.1
		100-char blocks	7	14	19.4	5.0	11	2.54
	Tape Speed, inches/sec		60	120	120	36	80	16
	Data Tracks		8			8		6
	Data Rows per Block		Variable			Variable		Variable
	Data Rows per Inch		400	400	556	800		556
	IBM 729 Compatible		No			No		Yes
	IBM 2400 Compatible		No			Yes		No
	Checking	Reading	Track and row parity; Orthotronic system			Track and row parity; cyclic redundancy		Track and row parity
		Writing	None			Read-after-write		Read-after-write
	Read Reverse		Yes			No		Yes
	Features and Comments							For 2200/50 only

*With optional equipment.

Nippon Electric NEAC Series-2200 (Japan)					System Identity		
N259	N261	N262	N271	N271A	Model Number		AUXILIARY STORAGE
Disc	Disc	Disc	Drum	Drum	Type of Storage		
8/control	8/control	4/control	8/control	8/control	Units On-Line	Maximum Number	
1/control	1/control	1/control	1/control	1/control	Read/Write Operations		
1/unit	1/unit	2/unit	—	—	Seek Operations		
9.2×10^6	134×10^6	268×10^6	2.6×10^6	327,700	Minimum	Number of Words per Unit	
9.2×10^6	134×10^6	268×10^6	2.6×10^6	327,700	Maximum		
73.6×10^6/cont.	1.07×10^9/cont.	1.07×10^9/cont.	20.8×10^6/cont.	2.6×10^6/cont.	Decimal Digits	Maximum Total Storage	
73.6×10^6/cont.	1.07×10^9/cont.	1.07×10^9/cont.	20.8×10^6/cont.	2.6×10^6/cont.	Characters		
25	51.4	51.4	50	16.7	Rotational Time, msec		
0	0	0	0	0	Minimum	Waiting Time, msec	
?	104	104	27.5	8.3	Average (Random)		
190	171	125	55	16.7	Maximum		
208,000	188,000	188,000	106,000	103,000	Effective Transfer Rate, char/sec		
1 to N	1 to N	1 to N	128	?	Sector Size, char		
1 to N	1 to N	1 to N	1 to N	1 to N	Transfer Load Size, char		
Cyclic	Cyclic	Cyclic	Cyclic	Parity	Checking		
Uses changeable disc pack					Features and Comments		

N204 B Series							Model Number		
-1, -2	-2, -4	-5	-7	-8	-9	-11, -12			MAGNETIC TAPE
8/controller							On-Line	Maximum Number of Units	
1/controller							Reading/Writing		
0							Searching		
All							Rewinding		
Varies widely							Reading/Writing	Demands on Processor, %	
0							Starting/Stopping		
20	44	67	29	64	96	13.3	Peak	Transfer Rate, kilo-char/sec	
16	33.4	48	21.2	43.2	61.5	10.7	1,000-char blocks		
5.7	10.3	13.6	6.3	11	14.6	3.8	100-char blocks		
36	80	120	36	80	120	24	Tape Speed, inches/sec		
6							Data Tracks		
Variable							Data Rows per Block		
200, 556			200, 556, 800			556	Data Rows per Inch		
Yes*							IBM 729 Compatible		
No							IBM 2400 Compatible		
Track and row parity							Reading	Checking	
Read-after-write							Writing		
Yes (optional on N204B-11/-12)							Read Reverse		
N103 with characteristics similar to N204B-11/-12 available for 2200/100 only							Features and Comments		

*With optional equipment.

System Identity			Philips P1000 Series (Netherlands)	ICL System 4 (United Kingdom)	
AUXILIARY STORAGE	Model Number		P1041	4425	
	Type of Storage		Disc	Disc	Disc
	Maximum Number	Units On-Line	8/control	8/trunk	4/trunk
		Read/Write Operations	1	1/trunk	1/trunk
		Seek Operations	8	1/unit	1/unit
	Number of Words per Unit	Minimum	7,250,000	7.25×10^6	5.84×10^6
		Maximum	7,250,000	7.25×10^6	5.85×10^6
	Maximum Total Storage	Decimal Digits	116×10^6/control	116×10^6/trunk	46.7×10^6/trunk
		Characters	58×10^6/control	58×10^6/trunk	23.4×10^6/trunk
	Rotational Time, msec		25	25	25
	Waiting Time, msec	Minimum	25	6	0
		Average (Random)	107.5	112.5	112.5
		Maximum	175	170	170
	Effective Transfer Rate, char/sec		156,000	156,000	156,000
	Sector Size, char		Variable record length	3,600	3,600
	Transfer Load Size, char		?	1 to 36,890	1 to 320
	Checking		Check characters	Cyclic	
	Features and Comments		Removable disc pack; Model P1041-002 has reduced seek time (775 msec average access time)	Uses changeable disc pack; Model 4-30 only	Uses changeable disc pack; 4-40 and higher numbered models

MAGNETIC TAPE	Model Number		P1061-1, -2, -3			P1064-1, -2, -3			4450	4452	4453	4454
	Maximum Number of Units	On-Line	8/control			8/control			8/trunk			
		Reading/Writing	2/control			2/control			1/trunk			
		Searching	2/control			2/control			0			
		Rewinding	8/control			8/control			All			
	Demands on Processor, %	Reading/Writing	Varies			Varies			Varies			
		Starting/Stopping	None			None			Varies			
	Transfer Rate, kilo-char/sec	Peak	30	60	90	60	120	180	60	60	120	30
		1,000-char blocks	20	40	61	30	62	97	57.5	40.5	81.1	20.2
		100-char blocks							8.6	10.3	20.7	5.2
	Tape Speed, inches/sec		37.5	75	112.5	37.5	75	112.5	75	75	150	37.5
	Data Tracks		8 or 6*			8 or 6*			6	8	8	8
	Data Rows per Block		Varies			Varies			18–65K			
	Data Rows per Inch		800			1,600			200, 556, or 800	800	800	800
	IBM 729 Compatible		Yes*			Yes*			Yes	No	No	No
	IBM 2400 Compatible		Yes			Yes			No	Yes	Yes	Yes
	Checking	Reading	Cyclic redundancy						Track and row parity; cyclic redundancy for 8-track			
		Writing	Read-after-write						Read-after-write			
	Read Reverse		Yes						Yes			
	Features and Comments											

*With optional equipment.

ICL System 4 (United Kingdom)				System Identity		
4440	4441	4442	4443	Model Number		AUXILIARY STORAGE
Disc	Disc	Disc	Disc	Type of Storage		
4/trunk	8/trunk	4/trunk	8/trunk	Units On-Line	Maximum Number	
1/trunk	1/trunk	1/trunk	1/trunk	Read/Write Operations		
1/unit	1/unit	1/unit	1/unit	Seek Operations		
600 x 10^6	300 x 10^6	600 x 10^6	300 x 10^6	Minimum	Number of Words per Unit	
600 x 10^6	300 x 10^6	600 x 10^6	300 x 10^6	Maximum		
5.6 x 10^9/trunk				Decimal Digits	Maximum Total Storage	
2.8 x 19^9/trunk				Characters		
41.1				Rotational Time, msec		
0				Minimum	Waiting Time, msec	
80				Average (Random)		
100				Maximum		
530,000	530,000	265,000	265,000	Effective Transfer Rate, char/sec		
21,142	21,142	10,567	10,567	Sector Size, char		
1 to 338,000 (one cylinder)				Transfer Load Size, char		
Cyclic check				Checking		
For 4-70 and 4-75 only		For all models except 4-30		Features and Comments		

4458	4460	4461	4462	Model Number		MAGNETIC TAPE
8/trunk				On-Line	Maximum Number of Units	
1/trunk				Reading/Writing		
0				Searching		
All				Rewinding		
Varies				Reading/Writing	Demands on Processor, %	
Varies				Starting/Stopping		
60	60	120	200	Peak	Transfer Rate, kilo-char/sec	
37.5	30	61	102	1,000-char blocks		
8.6	5.6	11.3	19	100-char blocks		
75	37.5	75	125	Tape Speed, inches/sec		
6	8	8	8	Data Tracks		
18-65, 536				Data Rows per Block		
800	1600			Data Rows per Inch		
Yes	No			IBM 729 Compatible		
No	Yes			IBM 2400 Compatible		
Track and row parity; cyclic redundancy for 8-track				Reading	Checking	
Read-after-write				Writing		
Yes				Read Reverse		
4460, 4461, and 4462 utilize phase encoded recording (NRZ recording optional)				Features and Comments		

*With optional equipment.

System Identity			ICL 1900 Series (United Kingdom)				
AUXILIARY STORAGE	Model Number		2801	2802	2820	2821	2805 Series
	Type of Storage		Disc	Disc	Disc	Disc	Disc
	Maximum Number	Units On-Line	8/control	8/control	4	4	14/control
		Read/Write Operations	1/control	1/control	1	1	1/control
		Seek Operations	8/control	8/control	4	4	14/control
	Number of Words per Unit	Minimum	1, 048, 576	2, 097, 152	409, 600	819, 200	26, 214, 400
		Maximum	1, 048, 576	2, 097, 152	409, 600	819, 200	104, 857, 600
	Maximum Total Storage	Decimal Digits	57, 881, 395	115, 762, 790	11, 304, 960	22, 609, 920	10, 129, 244, 160
		Characters	33, 554, 432	67, 108, 864	6, 553, 600	13, 107, 200	5, 872, 025, 600
	Rotational Time, msec						
	Waiting Time, msec	Minimum	0	0	0	0	0
		Average (Random)	102.5	102.5	195	195	150
		Maximum	180	180	325	325	240
	Effective Transfer Rate, char/sec		208, 000	208, 000	208, 000	208, 000	76, 000 to 190, 000
	Sector Size, char						
	Transfer Load Size, char		512 to 2, 097, 152	512 to 2, 097, 152	512 to 40, 960	512 to 40, 960	512 to 1, 638, 400
	Checking		Check characters	Check characters	Check characters	Check characters	Cyclic check code
	Features and Comments		Exchangeable disc packs	Exchangeable disc packs	Twin exchangeable disc stores		2806 Series is same but has about double the data capacities

MAGNETIC TAPE	Model Number		1971	1972	1973
	Maximum Number of Units	On-Line	6/control	6/control	6/control
		Reading/Writing	1/control	1/control	1/control
		Searching	0	0	0
		Rewinding	6/control	6/control	6/control
	Demands on Processor, %	Reading/Writing	Varies with processor model		
		Starting/Stopping	Varies with processor model		
	Transfer Rate, kilo-char/sec	Peak	20.8	41.7	60.0
		1,000-char blocks	15.1/13.6	28.0/26.4	33.4
		100-char blocks	4.3/3.3	7.0/6.1	6.7
	Tape Speed, inches/sec		37.5	75	75
	Data Tracks		6	6	6
	Data Rows per Block		Variable		
	Data Rows per Inch		200, 556		200, 556, 800
	IBM 729 Compatible		Yes		
	IBM 2400 Compatible		No		
	Checking	Reading	Track and row parity		
		Writing	Read-after-write		
	Read Reverse				
	Features and Comments		Short gap facility		

*With optional equipment.

ICL 1900 Series (United Kingdom)				System Identity		
1962	1963	1964	2851	Model Number		AUXILIARY STORAGE
Drum	Drum	Drum	Drum	Type of Storage		
4/control	4/control	4/control	8/control	Units On-Line	Maximum Number	
1/control	1/control	1/control	1/control	Read/Write Operations		
—	—	—	—	Seek Operations		
32,768	131,072	524,288	524,288	Minimum	Number of Words per Unit	
32,768	131,288	524,288	524,288	Maximum		
904,396	3,617,587	14,470,348	29,940,697	Decimal Digits	Maximum Total Storage	
524,288	2,097,152	8,388,608	16,777,216	Characters		
				Rotational Time, msec		
0	0	0	0	Minimum	Waiting Time, msec	
10	10	20	6.5	Average (Random)		
20	20	40	13	Maximum		
50,000	100,000	100,000	1,400,000	Effective Transfer Rate, char/sec		
				Sector Size, char		
4 to 131,072	4 to 524,288	4 to 2,097,152	512 to 2,097,152	Transfer Load Size, char		
Character parity	Character parity	Character parity	Cyclic check code	Checking		
				Features and Comments		

2501	2504	2505	2506	2507	Model Number		MAGNETIC TAPE
4/control	4/control				On-Line	Maximum Number of Units	
1/control	1/control				Reading/Writing		
0	0				Searching		
No rewind	4/control				Rewinding		
16.3	Varies with processor model				Reading/Writing	Demands on Processor, %	
—	Varies with processor model				Starting/Stopping		
20.0	80.0	160.0	40.0	80.0	Peak	Transfer Rate, kilo-char/sec	
8.8	48.0/30.8	88.3/53.2	30.4/22.4	58.5/40.6	1,000-char blocks		
4.5	10.5/4.8	17.5/7.7	9.6/4.5	17.1/7.5	100-char blocks		
150	37.5	75	37.5	75	Tape Speed, inches/sec		
8	8				Data Tracks		
—	Variable				Data Rows per Block		
—	1600			800	Data Rows per Inch		
No	No				IBM 729 Compatible		
No	Yes				IBM 2400 Compatible		
Cyclic check code	Vertical redundancy check		Vertical redundancy check, Cyclic redundancy & longitudinal check chars		Reading	Checking	
Read-after-write	Read-after-write				Writing		
					Read Reverse		
Bit serial recording. Cassette loaded. No longer marketed	Read reverse and error correction facilities are standard. Run-on-facility				Features and Comments		

*With optional equipment.

System Identity			Siemens System 4004 (West Germany)			
AUXILIARY STORAGE	Model Number		4004/564		4004/568-11	
	Type of Storage		Disc		Magnetic cards	
	Maximum Number	Units On-Line	8/trunk		4/trunk	
		Read/Write Operations	1/channel		1/channel	
		Seek Operations	1/unit		1/unit	
	Number of Words per Unit	Minimum	7.25×10^6 bytes		536×10^6 bytes	
		Maximum	7.25×10^6 bytes		536×10^6 bytes	
	Maximum Total Storage	Decimal Digits	116×10^6/trunk		$4,288 \times 10^6$/trunk	
		Characters	58×10^6/trunk		$2,144 \times 10^6$/trunk	
	Rotational Time, msec		?		?	
	Waiting Time, msec	Minimum	0		0	
		Average (Random)	87.5		523	
		Maximum	160		557	
	Effective Transfer Rate, char/sec		156,000		70,000	
	Sector Size, char		?		?	
	Transfer Load Size, char		1 — 36,260		1 — 16,384	
	Checking		Cyclic check		Cyclic cneck	
	Features and Comments		Changeable "Disc Packs" (IBM 2311 Disk Storage Drive)		Changeable cartridges hold 256 cards each	
MAGNETIC TAPE	Model Number		4004/432	4004/4443	4004/4446	4004/441
	Maximum Number of Units	On-Line	16/trunk	16/trunk	16/trunk	16/trunk
		Reading/Writing	1/channel	1/channel	1/channel	1/channel
		Searching	0	0	0	0
		Rewinding	All	All	All	All
	Demands on Processor, %	Reading/Writing	Varies	Varies	Varies	Varies
		Starting/Stopping	Varies	Varies	Varies	Varies
	Transfer Rate, kilo-char/sec	Peak	30.0	60.0	120.0	25.0
		1,000-char blocks	20.4	40.5	81.1	20.7
		100-char blocks	5.2	10.3	20.7	8.1
	Tape Speed, inches/sec		?	?	?	?
	Data Tracks		8 (6 Optional)			6
	Data Rows per Block		Variable			Variable
	Data Rows per Inch		800 (200, 556, or 800 with 7-channel feature)			333 or 500
	IBM 729 Compatible		Only when 7-channel tape feature is installed			No
	IBM 2400 Compatible		Yes	Yes	Yes	No
	Checking	Reading	Track, row, and diagonal parity			Track parity
		Writing	Read-after-write			Read-after-write
	Read Reverse		Yes	Yes	Yes	?
	Features and Comments		Dual channel controllers are available; backward reading is standard; compatible with IBM 2400 Series Tape Units			

*With optional equipment.

Siemens System 300 (West Germany)					System Identity		
2013	2014	2015	2027	2051	Model Number		AUXILIARY STORAGE
Drum	Drum	Drum	Core	Disc	Type of Storage		
4/trunk	4/trunk	4/trunk	1/trunk	1/trunk	Units On-Line	Maximum Number	
1/channel	1/channel	1/channel	1/channel	1/channel	Read/Write Operations		
1/unit	1/unit	1/unit	1/unit	1/unit	Seek Operations		
65, 536	131, 072	262, 144	16, 384	1, 792, 000	Minimum	Number of Words per Unit	
65, 536	131, 072	262, 144	16, 384	1, 792, 000	Maximum		
262, 144	524, 288	1, 048, 576	65, 536	1, 168, 000	Decimal Digits	Maximum Total Storage	
262, 144	524, 288	1, 048, 576	65, 536	1, 168, 000	Characters		
62	62	62	—	25	Rotational Time, msec		
0	0	0	—	0	Minimum	Waiting Time, msec	
32	32	32	—	87.5	Average (Random)		
64	64	64	—	147.5	Maximum		
72, 000	72, 000	72, 000	2, 668, 000	208, 000	Effective Transfer Rate, char/sec		
64	64	64		256	Sector Size, char		
1 — 4, 096	1 — 4, 096	1 — 4, 096		1 — 35, 840	Transfer Load Size, char		
Cyclic check code	Cyclic check code	Cyclic check code	Parity	Cyclic check	Checking		
—	—	—	—	—	Features and Comments		

	Model Number		MAGNETIC TAPE
	On-Line	Maximum Number of Units	
	Reading/Writing		
	Searching		
	Rewinding		
	Reading/Writing	Demands on Processor, %	
	Starting/Stopping		
	Peak	Transfer Rate, kilo-char/sec	
	1,000-char blocks		
	100-char blocks		
	Tape Speed, inches/sec		
	Data Tracks		
	Data Rows per Block		
	Data Rows per Inch		
	IBM 729 Compatible		
	IBM 2400 Compatible		
	Reading	Checking	
	Writing		
	Read Reverse		
	Features and Comments		

*With optional equipment.

COMPARISON CHARTS — NON-U.S.A. COMPUTERS
PUNCHED CARD AND PUNCHED TAPE INPUT-OUTPUT

An introduction to the Punched Card and Punched Tape Input-Output Section of the Comparison Charts, giving the precise meaning of each entry, will be found on Page 11:230.101.

System Identity		A/S Regnecentralen RC 4000 (Denmark)	Bull Gamma-10 (France)	Bull-GE GE-55 (France)
PUNCHED CARD INPUT	Model Number	RC 405	300	L617
	Maximum Number On-Line	1/controller (maximum 64 controllers)	1	1
	Peak Speed, cards/min	1200 for 80 columns, 1500 for 51 columns	300	150
	Demands on Processor, %		?	?
	Code Translation	Yes	Automatic	Automatic
	Checking	Dual read comparison	?	Character validity
	Features and Comments			Reads cards column by column
PUNCHED CARD OUTPUT	Model Number		300	P540
	Maximum Number On-Line		1	1
	Peak Speed, cards/min		300	60
	Demands on Processor, %		?	?
	Code Translation		Yes	Automatic
	Checking		?	Hole check
	Features and Comments			Punches cards column by column, can interpret
PUNCHED TAPE INPUT	Model Number	RC 2000	300	PTR055
	Maximum Number On-Line	1/controller (maximumum 64 controllers)	1	
	Number of Channels	5, 6, 7, or 8	5, 7, or 8	
	Peak Speed, char/sec	2000	300	
	Demands on Processor, %		?	
	Code Translation		Programmed	
	Checking		?	
	Features and Comments		Can handle 6-channel Olivetti tape	
PUNCHED TAPE OUTPUT	Model Number	RC 150		PTP 55
	Maximum Number On-Line	1/controller (maximum 64 controllers)		
	Number of Channels	5, 6, 7, or 8		5, 7, or 8
	Peak Speed, char/sec	150		105
	Demands on Processor, %			
	Code Translation			Automatic
	Checking			
	Features and Comments			

*With optional equipment.

Elbit 100 (Israel)		System Identity	
		Model Number	PUNCHED CARD INPUT
		Maximum Number On-Line	
		Peak Speed, cards/min	
		Demands on Processor, %	
		Code Translation	
		Checking	
		Features and Comments	
		Model Number	PUNCHED CARD OUTPUT
		Maximum Number On-Line	
		Peak Speed, cards/min	
		Demands on Processor, %	
		Code Translation	
		Checking	
		Features and Comments	
ASR 33/620	Digitronics 2500	Model Number	PUNCHED TAPE INPUT
256	256	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
10		Peak Speed, char/sec	
		Demands on Processor, %	
Automatic	Automatic	Code Translation	
Parity	Parity	Checking	
		Features and Comments	
Tally P120	ASR 33/620	Model Number	PUNCHED TAPE OUTPUT
256	256	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
120	10	Peak Speed, char/sec	
		Demands on Processor, %	
Automatic	Automatic	Code Translation	
Parity	Parity	Checking	
		Features and Comments	

*With optional equipment.

System Identity		Fujitsu FACOM 230 Series and 270 Series (Japan)			
PUNCHED CARD INPUT	Model Number	F664A			
	Maximum Number On-Line	8/channel + 2 direct channels			
	Peak Speed, cards/min	800			
	Demands on Processor, %	0.5			
	Code Translation	Yes			
	Checking	Dual read			
	Features and Comments				
PUNCHED CARD OUTPUT	Model Number	F683A			
	Maximum Number On-Line	8/channel + 2 Direct Channels			
	Peak Speed, cards/min	250			
	Demands on Processor, %	0.2			
	Code Translation	Yes			
	Checking	Read after punch			
	Features and Comments				
PUNCHED TAPE INPUT	Model Number	F749A	F749E	F750A	F748A
	Maximum Number On-Line	8/channel + 2 Direct Channels			
	Number of Channels				
	Peak Speed, char/sec	200/400	600/1,200	240	1,000
	Demands on Processor, %				
	Code Translation	None	None	None	None
	Checking	Dual read	Dual read	Dual read	Dual read
	Features and Comments	Console type	Console type	Free-standing type	Free-standing type
PUNCHED TAPE OUTPUT	Model Number	F766A		F767A	
	Maximum Number On-Line	8/channel + 2 Direct Channels			
	Number of Channels				
	Peak Speed, char/sec	200		100	
	Demands on Processor, %				
	Code Translation	None		None	
	Checking	Feed check*		Feed check	
	Features and Comments				

*With optional equipment.

Hitachi HITAC 8000 Series (Japan)			System Identity	
H-8239-11, -21	H-8233	H-8238	Model Number	PUNCHED CARD INPUT
1/trunk	1/trunk	1/trunk	Maximum Number On-Line	
400	750	1,470	Peak Speed, cards/min	
Varies	Varies	Varies	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Hole count	Validity; echo check	Validity; echo check	Checking	
	Mark reading feature optional	Mark reading feature optional	Features and Comments	

H-8239-11, -31	H-8234	H-8235	Model Number	PUNCHED CARD OUTPUT
1 per trunk	1/trunk	1/trunk	Maximum Number On-Line	
91 (160 col/sec)	100	250	Peak Speed, cards/min	
Varies	Varies	Varies	Demands on Processor, %	
Automatic	Automatic	Automatic	Code Translation	
Echo check	Hole count	Hole count	Checking	
			Features and Comments	

H-8226-1	H-8229-22	H-8221	H-8222	Model Number	PUNCHED TAPE INPUT
1/trunk	1/trunk	1/trunk	1/trunk	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
500	200	200	1,000	Peak Speed, char/sec	
Varies	Varies	Varies	Varies	Demands on Processor, %	
Automatic	Automatic	Automatic	Automatic	Code Translation	
Parity	Parity	Parity	Parity	Checking	
For H-8210 Processor only		Combination reader and punch	Combination reader and punch	Features and Comments	

H-8227-1	H-8229-22	H-8221	H-8222	Model Number	PUNCHED TAPE OUTPUT
1/trunk	1/trunk	1/trunk	1/trunk	Maximum Number On-Line	
5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	5, 6, 7, or 8	Number of Channels	
110	100	100	100	Peak Speed, char/sec	
Varies	Varies	Varies	Varies	Demands on Processor, %	
Automatic	Automatic	Automatic	Automatic	Code Translation	
None	None	Echo check	Echo check	Checking	
		Combination reader and punch	Combination reader and punch	Features and Comments	

*With optional equipment.

System Identity		Hitachi HITAC 3010 (Japan)		Nippon Electric 2200/50 (Japan)
PUNCHED CARD INPUT	Model Number	H-323	H-329B	E214
	Maximum Number On-Line	2	2	8
	Peak Speed, cards/min	600	1,470	400
	Demands on Processor, %	6.72	Varies	0.1 max
	Code Translation	Automatic	Automatic	Automatic
	Checking	Hole count; character validity	Echo check; character validity	Character validity
	Features and Comments			
PUNCHED CARD OUTPUT	Model Number	H-334	H-336	E214
	Maximum Number On-Line	1	1	1/address assignment
	Peak Speed, cards/min	100	200	100 to 400
	Demands on Processor, %	Varies	Varies	0.1 max
	Code Translation	Automatic	Automatic	Automatic
	Checking	Hole count	Hole count	Punch die activation
	Features and Comments			
PUNCHED TAPE INPUT	Model Number	H-322	H-176	E209
	Maximum Number On-Line	1	1	1/address assignment
	Number of Channels	5, 6, 7, or 8	8	5, 6, 7, or 8
	Peak Speed, char/sec	1,000	200	300
	Demands on Processor, %	Varies	Varies	0.1 max
	Code Translation	Matched codes	Matched codes	Programmed
	Checking	Parity	Parity	Parity; dual-read compare
	Features and Comments			
PUNCHED TAPE OUTPUT	Model Number	H-331		E209
	Maximum Number On-Line	1		1/address assignment
	Number of Channels	5, 6, or 7		5, 6, 7, or 8
	Peak Speed, char/sec	100		110
	Demands on Processor, %	Varies		0.1 max
	Code Translation	Matched codes		Programmed
	Checking	None		None
	Features and Comments			

*With optional equipment.

NEAC Series 2200/100, 200, 300, 400, 500 (Japan)				System Identity	
N223	N214-2	N223-2	N123**	Model Number	PUNCHED CARD INPUT
1/address assignment			1/system	Maximum Number On-Line	
800	400	1, 050	400	Peak Speed, cards/min	
Varies			0.2 max	Demands on Processor, %	
Automatic				Code Translation	
Validity cycle				Checking	
Direct transcription feature	Reader/punch, direct transcription feature	Direct transcription feature		Features and Comments	
N224A-1	N214-1	N214-2	N224A-2	Model Number	PUNCHED CARD OUTPUT
1/address assignment				Maximum Number On-Line	
				Peak Speed, cards/min	
Varies				Demands on Processor, %	
Automatic				Code Translation	
				Checking	
Direct transcription	Reader/punch; Direct transcription feature	Direct transcription feature		Features and Comments	
N109A-1**	N209A-1	N209A-2		Model Number	PUNCHED TAPE INPUT
1/system	1/address assignment			Maximum Number On-Line	
5, 6, 7, and 8				Number of Channels	
300	300	1000		Peak Speed, char/sec	
0.2 max	Varies			Demands on Processor, %	
Programmed				Code Translation	
Parity; dual-read compare				Checking	
Special code detecting	Special code detecting, ISO code processing feature			Features and Comments	
N110A-1**	N110A-3**	N210A-1	N210A-3	Model Number	PUNCHED TAPE OUTPUT
1/system		1/address assignment		Maximum Number On-Line	
5, 6, 7, and 8				Number of Channels	
60	110	60	110	Peak Speed, char/sec	
0.1 max		Varies		Demands on Processor, %	
Programmed				Code Translation	
None				Checking	
				Features and Comments	

*With optional equipment.

System Identity		Philips P1000 (Netherlands)			ICL System 4 (United Kingdom)	
PUNCHED CARD INPUT	Model Number	P1010	P1011	P1012	4512	4514
	Maximum Number On-Line	1/controller			1/trunk	1/trunk
	Peak Speed, cards/min	400/500	800/1000	1,500/2000	800	1435
	Demands on Processor, %	Less than 1			Varies	Varies
	Code Translation	Automatic			Automatic	Automatic
	Checking	Character validity			Validity	Validity
	Features and Comments	Higher speed is for 51-column cards; lower for 80-column cards			By column on demand	By column on demand
PUNCHED CARD OUTPUT	Model Number	P1015	P1016		4521	
	Maximum Number On-Line	1/controller			1/trunk	
	Peak Speed, cards/min	100	300/400		100	
	Demands on Processor, %	Less than 1			Varies	
	Code Translation	Automatic			Automatic	
	Checking	Character validity			Read after punch	
	Features and Comments	Higher speed for P1016 is for 51-column cards			By rows	
PUNCHED TAPE INPUT	Model Number	P1020			4580, 4581	
	Maximum Number On-Line	1/controller			4/trunk	
	Number of Channels	5, 6, 7, and 8			5, 7 and 8	
	Peak Speed, char/sec	1,000			1500	
	Demands on Processor, %	Less than 1			Varies	
	Code Translation	None			Automatic	
	Checking	None			Parity, validity	
	Features and Comments					
PUNCHED TAPE OUTPUT	Model Number	P1025			4585	
	Maximum Number On-Line	1/controller			1/trunk	
	Number of Channels	5, 6, 7, and 8			5, 7, and 8	
	Peak Speed, char/sec	150			150	
	Demands on Processor, %	Less than 1			Varies	
	Code Translation	None			Automatic	
	Checking	Echo			Parity, validity	
	Features and Comments					

*With optional equipment.

ICL 1900 Series (United Kingdom)					System Identity	
2101	2103	2104	2105	2106	Model Number	PUNCHED CARD INPUT
Varies			1	1	Maximum Number On-Line	
1600	600	600	300	600	Peak Speed, cards/min	
Varies according to processor model			0.6	1.2	Demands on Processor, %	
Automatic					Code Translation	
Proper photocell functioning and correct registration					Checking	
Optical binary image feature	60-column cards		1901A only	1901A only; optional binary image feature	Features and Comments	

1920	1922	2151	Model Number	PUNCHED CARD OUTPUT
Varies			Maximum Number On-Line	
100	33	300	Peak Speed, cards/min	
Varies according to processor			Demands on Processor, %	
Automatic			Code Translation	
Hole count	Echo check	Hole count	Checking	
Row punch	Column punch	Row punch	Features and Comments	

1915	1916	2601	2602	Model Number	PUNCHED TAPE INPUT
Varies				Maximum Number On-Line	
5, 6, 7, and 8				Number of Channels	
300	1000	250	1000	Peak Speed, char/sec	
Varies according to processor model				Demands on Processor, %	
Format board				Code Translation	
Parity				Checking	
	Combined reader and punch using one I/O channel; for 1901A, 1902A, 1903A only			Features and Comments	

1925	2601	2602	Model Number	PUNCHED TAPE OUTPUT
Varies			Maximum Number On-Line	
5, 6, 7, and 8			Number of Channels	
110			Peak Speed, char/sec	
Varies according to processor model			Demands on Processor, %	
Format board			Code Translation	
None			Checking	
	Combined reader and punch using one I/O channel: for 1901A, 1902A, 1903A only		Features and Comments	

*With optional equipment.

System Identity		Siemens System 4004 (West Germany)	
PUNCHED CARD INPUT	Model Number	4004/237	4004/4235
	Maximum Number On-Line	1/trunk	1/trunk
	Peak Speed, cards/min	1435	666
	Demands on Processor, %	Varies	Varies
	Code Translation	Automatic*	Automatic*
	Checking	Circuit checks; validity check in translate mode	
	Features and Comments	Optional mark reading feature	90-column verified cards feature
PUNCHED CARD OUTPUT	Model Number	4004/234	4004/236
	Maximum Number On-Line	1/trunk	1/trunk
	Peak Speed, cards/min	100	300
	Demands on Processor, %	Varies	Varies
	Code Translation	Automatic	Automatic
	Checking	Hole count	Hole count
	Features and Comments	Single stacker	Two stackers; Read/punch option
PUNCHED TAPE INPUT	Model Number	4004/4226	4004/4227
	Maximum Number On-Line	1/trunk	1/trunk
	Number of Channels		
	Peak Speed, char/sec	400	1, 000
	Demands on Processor, %	Varies	Varies
	Code Translation	Automatic*	Atutomatic*
	Checking	Parity	Parity
	Features and Comments		
PUNCHED TAPE OUTPUT	Model Number	4004/4225	
	Maximum Number On-Line	1/trunk	
	Number of Channels		
	Peak Speed, char/sec	100	
	Demands on Processor, %	Varies	
	Code Translation	Automatic*	
	Checking	Parity	
	Features and Comments		

*With optional equipment.

Siemens System 300 (West Germany)				System Identity	
2009	2010			Model Number	PUNCHED CARD INPUT
1/channel	1/channel			Maximum Number On-Line	
33	600			Peak Speed, cards/min	
Varies	Varies			Demands on Processor, %	
Automatic	Automatic			Code Translation	
	Validity check in translate mode			Checking	
Combined reader/punch	Column binary feature			Features and Comments	
2021				Model Number	PUNCHED CARD OUTPUT
1/channel				Maximum Number On-Line	
245				Peak Speed, cards/min	
Varies				Demands on Processor, %	
Automatic				Code Translation	
Echo				Checking	
Column binary feature				Features and Comments	
0001 Console Tape Input only for Mod. 303	0016 Console Tape Input for Mod.: 302, 304, 305, 306	2006	2008	Model Number	PUNCHED TAPE INPUT
1/channel	1/channel	1/channel	1/channel	Maximum Number On-Line	
5 and 6 channels	5 and 6 channels	5, 6, 7, 8 channels	5, 6, 7, 8 channels	Number of Channels	
30	200	400	400 input-max 150	Peak Speed, char/sec	
Varies	Varies	Varies	Varies	Demands on Processor, %	
Automatic	Automatic	Automatic	Automatic	Code Translation	
Second read station	Second read station	Parity	Parity	Checking	
			Combined input/output	Features and Comments	
2007				Model Number	PUNCHED TAPE OUTPUT
1/channel				Maximum Number On-Line	
5, 6, 7, 8 channels				Number of Channels	
150 max				Peak Speed, char/sec	
Varies				Demands on Processor, %	
Automatic				Code Translation	
Parity				Checking	
				Features and Comments	

*With optional equipment.

COMPARISON CHARTS — NON—U.S.A. COMPUTERS
PRINTERS AND SPECIALIZED INPUT/OUTPUT EQUIPMENT

An introduction to the Printers and Specialized Input/Output Equipment Section of the Comparison Charts, giving the precise meaning of each entry, can be found on Page 11:240.101.

System Identity			A/S Regnecentralen RC 4000 (Denmark)		Bull Gamma 10 (France)
PRINTED OUTPUT	Model Number		RC 610		—
	Maximum Number On-Line		1/controller (maximum 64 controllers)		1
	Speed, lines/min	Single Spacing	1000	667	300
		1-inch Spacing	1350		
	Demands on Processor, %				
	Number of Print Positions		132		120 or 144
	Character Set Size		64	96	
	Checking				Yes
	Features and Comments		One line buffer		Dual feed carriage
MICR READER	Model Number				—
	Peak Speed, documents/min				600
	Features and Comments				CMC7 characters
OPTICAL CHARACTER READER	Model Number				
	Peak Speed, documents/min				
	Features and Comments				
DATA COMMUNI-CATIONS CONTROLLER	Model Number				
	Peak Speed, bits/sec				
	Features and Comments				
CRT DISPLAY	Model Number		RC 4195		
	Capacity, char				
	Features and Comments				
PLOTTER	Model Number		RC 4193 Controller		
	Peak Speed, points/sec		6400 (160 mm/sec)	200, 300, 350, or 450	
	Features and Comments		Resolution: 0.025 mm	Incremental plotter	
OTHER INPUT-OUTPUT DEVICES	Model Number		RC 450		
	Name		Strip Printer		
	Features and Comments				

*With optional equipment.

Bull-GE GE-55 (France)						Elbit 100 (Israel)	System Identity	
PRT 051	PRT 052	PRT 055	PRT 056	PRT 050	PRT 057	Shepard 880	Model Number	PRINTED OUTPUT
						256	Maximum Number On-Line	
Typically 140		Typically 83		50 char/sec		600	Speed lines/min: Single Spacing	
							Speed lines/min: 1-inch Spacing	
							Demands on Processor, %	
96	128	96	128	128		80	Number of Print Positions	
						64	Character Set Size	
						Parity	Checking	
Speed is given for 48-character set; lower speeds for 64-character set				Serial printers			Features and Comments	
							Model Number	MICR READER
							Peak Speed, documents/min	
							Features and Comments	
							Model Number	OPTICAL CHARACTER READER
							Peak Speed, documents/min	
							Features and Comments	
							Model Number	DATA COMMUNI-CATIONS CONTROLLER
							Peak Speed, bits/sec	
							Features and Comments	
							Model Number	CRT DISPLAY
							Capacity, char	
							Features and Comments	
							Model Number	PLOTTER
							Peak Speed, points/sec	
							Features and Comments	
							Model Number	OTHER INPUT-OUTPUT DEVICES
							Name	
							Features and Comments	

*With optional equipment.

System Identity			Fujitsu FACOM 230 Series and FACOM 270 Series (Japan)		
PRINTED OUTPUT	Model Number		F642A	F643A	F643C
	Maximum Number On-Line		8/channel + 2 direct channels	1	1
	Speed, lines/min	Single Spacing	1,500/1,000/500	480/240	480/240
		1-inch Spacing	750/500	320/200	320/200
	Demands on Processor, %		0.8		
	Number of Print Positions		136	80	136
	Character Set Size		64/128	50/100	50/100
	Checking		Parity, validity	Parity, timing, paper feed	
	Features and Comments		With buffer memory Flag bit control	Unbuffered control	
MICR READER	Model Number				
	Peak Speed, documents/min				
	Features and Comments				
OPTICAL CHARACTER READER	Model Number				
	Peak Speed, documents/min		440	360 lines/min	440 lines/min
	Features and Comments		Document scanner	Page scanner	Roll paper reader
DATA COMMUNICATIONS CONTROLLER	Model Number				
	Peak Speed, bits/sec				
	Features and Comments				
CRT DISPLAY	Model Number				
	Capacity, char				
	Features and Comments				
PLOTTER	Model Number		F6201B		
	Peak Speed, points/sec		400		
	Features and Comments				
OTHER INPUT-OUTPUT DEVICES	Model Number				
	Name		Electronic Printer		
	Features and Comments		10,000 lines/min		

*With optional equipment.

Hitachi HITAC 8000 Series (Japan)						System Identity	
8244-31	8244-32	8245-11	8245-12	8246-11	8246-12	Model Number	PRINTED OUTPUT
1/trunk						Maximum Number On-Line	
300	150	600	300	1250	625	Speed lines/min — Single Spacing	
252	148	435	252	769	476	Speed lines/min — 1-inch Spacing	
Varies						Demands on Processor, %	
132	132	132 or 160*	132 or 160*	132 or 160*	132 or 160*	Number of Print Positions	
63	110	63	110	63	110	Character Set Size	
None						Checking	
	Includes Kama characters		Includes Kama characters		Includes Kama characters	Features and Comments	
						Model Number	MICR READER
						Peak Speed, documents/min	
						Features and Comments	
						Model Number	OPTICAL CHARACTER READER
						Peak Speed, documents/min	
						Features and Comments	
						Model Number	DATA COMMUNI-CATIONS CONTROLLER
						Peak Speed, bits/sec	
						Features and Comments	
						Model Number	CRT DISPLAY
						Capacity, char	
						Features and Comments	
						Model Number	PLOTTER
						Peak Speed, points/sec	
						Features and Comments	
8212-1						Model Number	OTHER INPUT-OUTPUT DEVICES
Input/Output typewriter						Name	
500 char/min peak speed						Features and Comments	

*With optional equipment.

System Identity			Hitachi HITAC 3010 (Japan)		Nippon NEAC Series 2200 (Japan)	
PRINTED OUTPUT	Model Number		H-333	H-333C	E206	
	Maximum Number On-Line		2		1/Address assignment	
	Speed, lines/min	Single Spacing	800 to 1000	521 to 600	333	
		1-inch Spacing	500	405	310	
	Demands on Processor, %		Varies		0.8 maximum	
	Number of Print Positions		120 or 160*	120 or 160*	120 or 132*	
	Character Set Size		63	96	60	
	Checking		None		Cycle check, printer check	
	Features and Comments			Includes Kama characters		
MICR READER	Model Number					
	Peak Speed, documents/min					
	Features and Comments					
OPTICAL CHARACTER READER	Model Number		H-5820		N240D-1	
	Peak Speed, documents/min		1500		1100	
	Features and Comments		Videoscan document reader		407 Font	
DATA COMMUNI-CATIONS CONTROLLER	Model Number				N284A	N292
	Peak Speed, bits/sec					
	Features and Comments				64 lines max.	256 lines max.
CRT DISPLAY	Model Number					
	Capacity, char					
	Features and Comments					
PLOTTER	Model Number				N244A-1	N244A-2
	Peak Speed, points/sec				300	200
	Features and Comments					
OTHER INPUT-OUTPUT DEVICES	Model Number					
	Name					
	Features and Comments					

*With optional equipment.

Philips P1000 Series (Netherlands)			ICL System 4 (United Kingdom)				System Identity	
P1030-001	P1030-002	P1030-003	4554	4555	4560	4561	Model Number	PRINTED OUTPUT
1/control unit			1/trunk				Maximum Number On-Line	PRINTED OUTPUT
360	600	1000	1350		750		Speed lines/min: Single Spacing	PRINTED OUTPUT
270	380	600	779*		667		Speed lines/min: 1-inch Spacing	PRINTED OUTPUT
Less than 1			Varies				Demands on Processor, %	PRINTED OUTPUT
132			160	132	160	132	Number of Print Positions	PRINTED OUTPUT
64			64				Character Set Size	PRINTED OUTPUT
Validity			Validity				Checking	PRINTED OUTPUT
			Speeds based on restricted 48-character set				Features and Comments	PRINTED OUTPUT
							Model Number	MICR READER
							Peak Speed, documents/min	MICR READER
							Features and Comments	MICR READER
			2				Model Number	OPTICAL CHARACTER READER
			150				Peak Speed, documents/min	OPTICAL CHARACTER READER
							Features and Comments	OPTICAL CHARACTER READER
P1080							Model Number	DATA COMMUNI-CATIONS CONTROLLER
640,000							Peak Speed, bits/sec	DATA COMMUNI-CATIONS CONTROLLER
For up to 16 teletypewriters							Features and Comments	DATA COMMUNI-CATIONS CONTROLLER
							Model Number	CRT DISPLAY
							Capacity, char	CRT DISPLAY
							Features and Comments	CRT DISPLAY
P1035							Model Number	PLOTTER
300							Peak Speed, points/sec	PLOTTER
							Features and Comments	PLOTTER
			2				Model Number	OTHER INPUT-OUTPUT DEVICES
			Lector				Name	OTHER INPUT-OUTPUT DEVICES
			9000 documents/hour				Features and Comments	OTHER INPUT-OUTPUT DEVICES

*With optional equipment.

System Identity			ICL 1900 Series					
PRINTED OUTPUT	Model Number		1933	2401	2402	2404	2405	
	Maximum Number On-Line		Varies			1	1	
	Speed, lines/min	Single Spacing	1100 or 1350	300	600	300	600	
		1-inch Spacing	630	231	333	163	326	
	Demands on Processor, %		Varies according to processor model			8.1	16.2	
	Number of Print Positions		96, 120 or 160	96 or 120		96 or 120		
	Character Set Size		64	64		64		
	Checking		Print synchronization and hammer count					
	Features and Comments		Automatic write feature			1901A only		
MICR READER	Model Number		8500					
	Peak Speed, documents/min		1200					
	Features and Comments		Endorser; zero kill; 18 stackers; 6-pocket pull-out; usable off line					
OPTICAL CHARACTER READER	Model Number		8101/8201/8301					
	Peak Speed, documents/min		600					
	Features and Comments		Control is 8101; character reader is 8201; mark reader is 8301					
DATA COMMUNI-CATIONS CONTROLLER	Model Number		7007/2 Multiplexor	7900 System	7070/1 Single Channel	7070/2 Data Terminals	7070/3	7010/3
	Peak Speed, bits/sec		50/line to 2400/line	50/line to 4800/line	110	110	1200	2400
	Features and Comments		Up to 63 lines	Up to 252 lines	5-bit code	8-bit code	For 7152 CRT	For telephone
CRT DISPLAY	Model Number		7152					
	Capacity, char		520 or 1040					
	Features and Comments		Local or remote					
PLOTTER	Model Number		1934					
	Peak Speed, points/sec		200 or 300					
	Features and Comments		1004					
OTHER INPUT-OUTPUT DEVICES	Model Number		1004 link					
	Name		Link to UNIVAC 1004 plugboard computer					
	Features and Comments							

*With optional equipment.

Siemens System 4004 (West Germany)				System Identity	
4247	243			Model Number	PRINTED OUTPUT
1/trunk	1/trunk			Maximum Number On-Line	
750	1,250			Speed lines/min — Single Spacing	
535	715			Speed lines/min — 1-inch Spacing	
Varies	Varies			Demands on Processor, %	
132	132 or 160			Number of Print Positions	
64	64			Character Set Size	
Timing	Timing			Checking	
				Features and Comments	
				Model Number	MICR READER
				Peak Speed, documents/min	
				Features and Comments	
4250	4251	4252	4253	Model Number	OPTICAL CHARACTER READER
1,600	1,600	750	750	Peak Speed, documents/min	
				Features and Comments	
653	668	4666		Model Number	DATA COMMUNI-CATIONS CONTROLLER
300 char/sec	6,000 bytes/sec	8,000 char/sec		Peak Speed, bits/sec	
				Features and Comments	
				Model Number	CRT DISPLAY
				Capacity, char	
				Features and Comments	
				Model Number	PLOTTER
				Peak Speed, points/sec	
				Features and Comments	
752				Model Number	OTHER INPUT-OUTPUT DEVICES
Video Data Terminal				Name	
				Features and Comments	

*With optional equipment.

System Identity			Siemens System 300 (West Germany)	
PRINTED OUTPUT	Model Number		2022	2023
	Maximum Number On-Line		1/channel	1/channel
	Speed, lines/min	Single Spacing	750	600
		1-inch Spacing	535	378
	Demands on Processor, %		Varies	Varies
	Number of Print Positions		120	104
	Character Set Size		48	48
	Checking		Echo/timing	Timing
	Features and Comments			Extension print drum of 104 to 120 columns Extension print drum of 120 to 136 columns
MICR READER	Model Number			
	Peak Speed, documents/min			
	Features and Comments			
OPTICAL CHARACTER READER	Model Number			
	Peak Speed, documents/min			
	Features and Comments			
DATA COMMUNI-CATIONS CONTROLLER	Model Number			
	Peak Speed, bits/sec			
	Features and Comments			
CRT DISPLAY	Model Number			
	Capacity, char			
	Features and Comments			
PLOTTER	Model Number			
	Peak Speed, points/sec			
	Features and Comments			
OTHER INPUT-OUTPUT DEVICES	Model Number		Console Typewriter 2017	Typewriter T 100
	Name		69 and 104 char/line	10 char/sec 200 bits/sec
	Features and Comments			

*With optional equipment.

SPECIAL REPORTS

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COMPUTER
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AUERBACH SPECIAL REPORT:

COMPUTER RENTAL CONTRACTS AND PROPOSALS— A SURVEY AND ANALYSIS

PREPARED BY

THE TECHNICAL STAFF OF
AUERBACH CORPORATION

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COMPUTER RENTAL CONTRACTS AND PROPOSALS— A SURVEY AND ANALYSIS

.1 INTRODUCTION

The acquisition of an electronic data processing system is a major expenditure for any company. Therefore, the prospective user should carefully weigh all of the factors which could have either a direct or indirect influence on determining which system meets his requirements at the lowest overall cost. The difficulty faced by the user in accurately assessing the merits of various systems offered by competitive manufacturers is compounded by many intangible factors, such as equipment reliability, availability, competence of the manufacturer's support personnel, software performance, and programming difficulty. Even the true cost of the computer hardware itself can be hard to pin down because of the effects of varying extra-use charges, downtime credits, discounts, and purchase options.

An accurate analysis of relative equipment costs involves projections of the monthly use of each system throughout the contract period, plus a study of the implications of all the clauses in each contract. The evaluation of such a study is difficult because most of the standard computer rental contracts fail to cover certain major cost factors. Often the contracts do not define potentially important points such as whether or not set-up time is to be included in chargeable machine usage time. Extra-usage charges are often established by individual branch managers rather than by specific terms in the standard contracts. Equipment rentals during the first decade of the computer era have often been handled in a surprisingly informal way, perhaps because the essential question often was "Will it ever work?" rather than "Will it always work?"

Now that computers are a vital cog in most business organizations, rental contracts are more important than ever. A well-prepared contract should show what costs the user will need to bear during the installation period and exactly how much help he can count on from the manufacturer. It should show how much computer time is allowed under the basic rental charge, how operational time is to be computed, the cost of extra time, and the discount, if any, that is applicable when the equipment is not fully utilized. It should show what the user can expect when a breakdown occurs: how soon the service engineer should arrive and what credits are allowed for time lost due to the breakdown. A well-prepared computer rental contract should cover all these and numerous other points that may involve major expenditures by one of the contracting parties.

Unfortunately, although contract terms are becoming increasingly important, objective comparisons between the terms offered by different manufacturers are still very difficult to make. Differences in terminology and frequent omissions of important factors from the standard contracts continue to make it hard for the prospective user to evaluate all of the alternatives.

The objectives of this Special Report are:

(1) To identify the major considerations in contracting for the rental of a data processing system; and

(2) To present a clearcut analysis and comparison of the terms and provisions of the standard commercial and government rental contracts currently being offered by nine major U.S. manufacturers.

A knowledge of the terms that all nine manufacturers are prepared to offer can clearly strengthen the prospective user's bargaining position when negotiating with any one manufacturer.

.2 CONTRACT FACTORS AND CONSIDERATIONS

In analyzing the costs of competing equipment, it is desirable to use an indentical specification base and to examine all manufacturers' equipment suitable for the application against this common base. The U.S. Government, by employing such a technique through its yearly "Invitations to Bid," is able to elicit responses which are clear in detail and highly conducive to comparative analysis. In contrast, the commercial lease agreements offered by the major computer manufacturers tend to have a somewhat nebulous quality in that they neglect to specify certain contract details that are included in government contracts as a matter of course. Since most manufacturers are willing to negotiate on specific terms, it is desirable for the user to obtain statements covering all of the pertinent points discussed in this Special Report as a means of defining the exact equipment and services to be provided by the manufacturer.

.2 CONTRACT FACTORS AND CONSIDERATIONS (Contd.)

It should be noted that this report does not attempt to cover all of the numerous legal considerations involved in a contract of the complexity required for a computer system. Legal counsel should always be obtained for thorough analysis of a specific contract. The balance of this section, however, indicates the nature of the contract and proposal terms which the user should attempt to have clarified.

.21 Specifications

.211 Equipment

The manufacturer should provide detailed specifications of the equipment units at contract initiation. These detailed specifications will permit the user to begin effective preparation for the arrival of the system. If specifications are not complete, programmers may be unable to complete effective, detailed coding. (This is less critical, however, if a firm, process-oriented language is available.) The hardware unit specifications should be carefully determined to insure obtaining an expected level of performance.

.212 Software

In addition to the specification of the equipment configuration, it is reasonable to expect a complete delineation of the specific program "packages" which are to be made available.

Perhaps the one area that will be most difficult to specify is the software to be provided by the manufacturer. Software includes program translators (compilers, assemblers, generators, etc.) as well as utility routines. The ideal objective would be to have all languages and routines fully documented, completely free of errors, easy to learn and easy to use. At the present state-of-the-art, provision should be made for additional manufacturer's assistance in utilization and implementation of these techniques.

The user should determine whether process oriented (compiler) languages will be useful. Experienced programmers often prefer assemblers. The user should determine that the translators for the languages to be used are readily available and fully tested. It may be found that the sort routines, report program generators, debugging routines, etc., will not fit within the conceptual ideas of the user's intended operational practices. The manufacturer may, therefore, be asked to modify them as necessary.

The user should assure himself that all of the software he is obtaining will operate on the equipment configuration he is to receive.

.213 Method of payment

The method of payment should be specified in the contract. Apart from outright purchase and normal rental contracts, it is also possible to obtain a rental contract which includes a purchase option (usually exercisable within a fixed time period). With a purchase option, a major portion of the rental charges can be applied to subsequent purchase. The use of a computer leasing company as a second or third party should also be investigated. See paragraph .268.

Before a decision is made relative to the type of payment, the user should determine whether his expected amortization schedule is acceptable to the Internal Revenue Service so that some evaluation can be made of the various alternatives in the light of corporate profits. In some cases, the manufacturer will pass on to the customer the 7% Investment Tax Credit, as outlined in paragraph .267.

The term of the contract should be established. Rental contracts are usually renewable on a year-to-year basis and cancellable (after an initial period) on 30 to 90 days' notice. One year is the minimum acceptable time by manufacturers as an initial period in conventional contracts The user can in some cases obtain reduced rentals or additional services by agreeing to a minimum term which is longer than one year.

The responsibility for personal property and sales and use taxes should also be specified in the contract.

.214 Amount of chargeable time

Rental contracts should clearly define the amount of chargeable time included in the basic rental fee. Some of the more common definitions of the amount of chargeable time are:

(a) Any 176 hours per month.

(b) Any 200 hours per month.

(c) Any 9 hours per day.

(d) The time during a specific period such as: 9 am to 5 pm, or 8 am to 5 pm (with the lunch hour available to the user).

(e) Unlimited use.

(Contd.)

.214 Amount of Chargeable Time (Contd.)

Additional charges beyond the amount included in the basic rental fee should also be defined. These charges are usually a stated percentage of the basic hourly rental rate, 10 to 50 percent being common. Charges for time beyond the basic time are usually based directly on the actual time used on each unit or subsystem.

.215 Chargeable time

The time to be counted as chargeable time is usually defined similarly to operational use time. This is the time during which the system is productive or could have been productive if the user operated efficiently. It is not unusual to declare rerun time as nonchargeable, provided it is caused by equipment malfunction rather than operator error. Such credit is usually limited to a maximum of 20 minutes per rerun. Most manufacturers exclude set-up time from the accrual of rental time; however, a clear statement of the manufacturer's concept of "set-up time" should be obtained in writing by the user. Some manufacturers, for example, consider tape rewinding and program loading as operational use time, and charge accordingly, while others charge only for program running time.

.216 Assurance of serviceable time

The manufacturer guarantees (at least implicitly) a certain number of serviceable hours per day (or month). In some cases, when the number of serviceable hours is less than the guarantee, the user can reduce his rental pro rata; e.g., if 176 hours per month are agreed upon and 6 hours of that time are unavailable, the rental fee can be reduced by 6/176. In case of major failures, a backup facility should be provided.

.22 Acceptance

.221 Shipping and installation charges

Payment for these services should be mutually agreed upon during contract negotiations. It is customary for shipping charges to be borne by the prospective user; however, the costs of in-transit insurance, physical installation and final test of the hardware are absorbed by the manufacturer.

The site preparation for the equipment is the user's responsibility, but should be designed in accordance with the manufacturer's recommendations in order to insure proper installation and operating conditions. The manufacturer will usually be most cooperative in supplying physical installation data and advice. Complete environmental details should be specified by the manufacturer's site-installation engineering staff and should include: air conditioning, power, equipment layout, cable lengths, floor loads, special power outlets, and service area layout. Manufacturers sometimes overstate floor space requirements (systems can be operated in "crowded" conditions if necessary), but otherwise, provide good assistance in site design (see Paragraph .23).

In cases where the manufacturer delivers equipment which differs from that specified and requires site changes, the manufacturer may then be held responsible for such changes.

.222 Delivery and acceptance dates

Delivery and acceptance dates should be established. The user can normally postpone the delivery date with as little as 30 days notice without penalty. Should the equipment be delivered before program preparations are completed, a considerable amount of money can be wasted unnecessarily. Therefore, the delivery date should be carefully reviewed as the implementation of the system progresses, and postponed if necessary.

Any program packages specified in the contract should be available at their promised date. Software should be delivered several months earlier than hardware to permit time for familiarization and use.

In some cases, penalties may be agreed upon for failure to meet hardware or software schedules, if the user sustains a loss attributable to the delay. The time lapse between the placing of an order and the delivery of equipment often runs between 6 and 24 months. Most manufacturers have done a good job of meeting delivery schedules for production-model equipment, but have often had problems when the system includes novel or advanced components or new software.

Quite commonly, users experience difficulties in meeting their own system design and programming schedules, leading to a lack of readiness on the proposed installation date. As a protective measure, manufacturers are beginning to include contract clauses specifying damages to be paid by the user in the event his unpreparedness delays the shipping schedule.

The actual delivery date is not as important as the acceptance date, which is the date before which the acceptance tests should have been passed. In some cases, manufacturers have agreed to penalty clauses should the acceptance date be delayed. This is not common, but penalty clauses as high as $1,000.00 per day have been negotiated.

.223 Acceptance tests

Acceptance tests should be specified and should include additional tests of the system after it has passed the diagnostic and engineering program tests used by the manufacturer's installation team.

It is important in any new system to test all components and their interactions as part of the overall system. A system should operate without serious equipment failure for a mutually agreed-upon period (usually 40 to 80 hours) before being considered for final acceptance tests.

The final acceptance test procedures should be explicit. Good acceptance procedures involve these factors:

(a) The schedule for the acceptance test period should be clearly defined. This schedule should show how the time throughout the day should be allocated to periods of operation, idleness, preventive maintenance, etc. The acceptance test period should last at least 30 days in order to obtain a good estimate of both the mean time between failures (MTBF) and mean time to repair (MTTR).

(b) During each of the operating periods, the nature of the work which the computer is to be doing should be clearly defined. The work which the computer should do during the operating period might be divided into cycles. In each cycle the following should be performed:

(1) Process actual, but tested, data for key applications.

(2) Process special data designed to test all of the special features of the equipment and any program packages supplied. (Experience has shown that a selection of actual data will not begin to test all of the possible conditions; therefore, a special input is desirable. Conversely, a set of special data can never be developed to predict all the unusual conditions which occur in practice; therefore, a large section of actual data is also desirable).

(3) Use diagnostic routines which exercise all parts of the equipment, including peripheral units.

By repeating this cycle of tests throughout an operating period, a good test of the system can be obtained. Of course, each program should be designed to check its own operation so that any errors which the system makes are promptly reported. Any output should be checked against specified standard results. The minimum performance level required for acceptability during the test period must be agreed upon in advance. This agreement might include minimum mean time between failures, maximum mean repair time, maximum repair time, and minimum percentage operating time out of total on-time. Estimated performance speeds (as listed in AUERBACH Standard EDP Reports) can be used as a basis to establish anticipated performance times.

Rental charges for the equipment should not be effective until the system components have passed the stipulated acceptance tests.

For well-established equipment with many prior satisfactory installations, the acceptance testing may be considerably simplified. A method often used is to operate the system for a continuous period of one month on the normal work, loaded to the expected schedule. Rent is then paid retroactively to the beginning of the period, provided a ratio of 0.90 (or better) chargeable time to scheduled operating time has been achieved.

.23 Environment

The minimum environmental conditions under which the manufacturer's equipment will perform satisfactorily should be stated. Allowable variations in the following requirements should be specified:

(a) Temperature and humidity

(1) Equipment — in use and on standby.

(2) Magnetic tape — in use and in storage.

In these two areas, the specification will help determine the amount of air conditioning that the user will have to install.

(b) Power

(1) Voltage requirements and permissible variation.

(2) Frequency requirements and permissible variation.

(3) Waveform variations allowable.

Advance specification of these factors will help determine requirements for power transformers and/or a motor-generator set.

(Contd.)

.23 Environment (Contd.)

(c) Space

(1) Free floor space around each equipment unit to permit access for maintenance.

(2) Space to be devoted to the maintenance engineers, equipment, and spare parts.

.24 Maintenance

.241 Reliability

Reliability is measured as a ratio of serviceable time to the sum of serviceable time and downtime (time when faults are awaiting repair or are being repaired, or fault-caused rerun time). It is frequently quoted as a percentage and often called percentage "uptime" (values of 95 to 98 percent are generally expected). In general, only time that had been scheduled for work by the user is considered in this calculation. A guaranteed uptime should be negotiated at least in the form of minimum serviceable hours per day (usually equal to the time required by the user for his basic jobs, ranging from 8 to 20 hours).

A more technical method of specifying acceptable reliability is to indicate the mean time between failures and the mean time to repair equipment failures. Proportions of uptime and downtime can be estimated from these figures.

Under certain conditions, the importance of the data or of the workload situation will not permit delays due to equipment (or any other) failure. In such cases, it is desirable to specify that an emergency or "backup" facility be available. Charges incurred under such circumstances are usually absorbed by the equipment manufacturer if the emergency is caused by system failure.

.242 Maintenance responsibility

The contract should define maintenance requirements and procedures, describing the types of maintenance: fully attended, resident, non-resident, unattended, or emergency. In connection with a purchase agreement, there may be a need for a separate maintenance and spare parts contract. In most rental contracts, the equipment manufacturer guarantees a minimum percentage of uptime or other assurance of usable time. The responsibility for reliability then rests with the manufacturer. For both rental and separate maintenance contracts, the level of skill, number of people, and their location (e.g., user's installation or manufacturer's office) can be considered as discussion points. In the case of on-site maintenance personnel, facilities such as space, power, and furniture are usually supplied by the user.

Duration of scheduled maintenance should be specified in the contract after the level of acceptable reliability has been agreed upon. The user should have the right to establish his operating hours and the manufacturer should adjust scheduled maintenance times accordingly. Attention should be given to the availability of maintenance services during scheduled extra shift operation and also during occasional unscheduled overtime requirements. The maximum time between the call for maintenance and the arrival of maintenance personnel might also be specified.

The method of scheduling and charging the time required to make any changes to equipment and/or engineering improvements should be stipulated. These items are usually a matter of mutual agreement at the time of occurrence. For rental contracts, however, these usually include modifications or substitutions to maintain the equipment equivalent to the "current product-line." In any case, an agreement should be reached on those types of improvements which will be installed at no cost and those which will be paid for by the user. When improvements for increased reliability are necessary (e.g., marginal components or units to be replaced) to maintain the percentage of uptime, they should be made at no cost to the user.

.25 User's Rights

In the case of rental contracts, the conditions under which the user can modify and/or maintain the equipment (if any) should be specified. Usually the user may rent time on his own system to outside users in order to utilize slack periods. Sometimes the manufacturer will agree to buy time. In this case, rates and procedures should be established.

.26 Additional Factors

.261 Special equipment

If any unit of the system is being constructed especially for the user, the contract should include complete technical performance specifications. If the unit involves the interconnection of equipment from two manufacturers, the individual responsibilities for performance and maintenance should be carefully defined.

.261 Special Equipment (Contd.)

Price, delivery, and acceptance conditions for special units should be stated within the terms of the contract. The policies adopted for regular equipment can usually be modified for special equipment.

.262 System design

Often the user's system is based on a design outlined in the manufacturer's proposal. In this case, the detailing of the system design and the extension of the system concept should be accomplished with assistance from the manufacturer. The degree and level of system design assistance is a point of negotiation. The number, level, and type of skill of personnel assigned, the assignment of specific individuals, the responsibility of the manufacturer's personnel, as well as their qualifications, are points which should be considered. The tenure of their assignment should also be agreed upon, in addition to the availability of additional manufacturer's support personnel for specific needs such as writing special programs, debugging, or design of difficult parts of the procedures.

.263 Training

Training courses may be specified to be held on the user's premises and/or at the manufacturer's training centers. The programming language to be used should be decided upon early in the implementation program, and this language should be used in the training courses. The choice of a programming language is dependent on the availability of an operational translator prior to the delivery date.

A "reasonable" number of programmers and systems analysts should be trained (usually as many as the user actually intends to employ in these positions). Training is also necessary for console operators. Advanced programming courses and orientation programs to be presented to top management personnel should be considered. If good systems courses (as opposed to programming and coding) can be made available, they are especially desirable for training new analysts.

As part of the training program, it is usual for the manufacturer to provide complete training materials and reference manuals. Manuals and training materials should apply to the equipment and the languages to be used, not to earlier systems.

.264 Program testing

Ideally, the user's first applications should be pre-tested. This might be accomplished on equipment provided by the manufacturer at another site. Usually no charge is made for a limited number of machine hours for this purpose. The exact number of hours is subject to negotiation.

.265 Special programs

In some cases the user may wish to contract with the manufacturer to supply specific operational programs (in addition to software packages). In this case, there should be a firm mutual understanding of: the form of documentation of the programs provided; delivery date; acceptance date; how changes and improvements will be made after the program is accepted; how the user can train his own people on the program; and the maximum permissible processing time or other measure of efficiency. The user will have to provide firm specifications for the program early in the schedule and will not have the same flexibility in changing requirements as he might have if his own group were doing the programming. Attention should be given to the acceptance tests for such programs. In general, manufacturers avoid negotiating penalty clauses for late software delivery, or for software that does not "perform as expected."

An industry trend toward the development of highly specialized, "canned" application packages lends a great deal of sales appeal to some manufacturers' offerings. The user, however, should not be over-impressed by the quantity and range of such offerings, unless the packages can directly benefit his particular needs.

.266 Conversion credits

Where possible, the user should obtain, either in the contract or in a separate agreement, terms specifying credits for operation of the system in parallel with a replacement system if, at some future date, conversion to a larger system becomes necessary. Typically, coversion credit periods last for thirty days.

.267 Investment tax credit

The Investment Tax Credit applies to the lease or sale of data processing equipment, with the manufacturers granted the 7% credit by the U.S. Government. The manufacturers retain the option to use the credit themselves or to pass it on to the users. Since this 7% can represent a significant amount of money, the user should determine what the manufacturer's present investment tax credit policies are, and what they are likely to be in the future.

(Contd.)

.268 Purchase-leaseback

The emergence of computer leasing companies within the past three years offers a third alternative to the purchase or rental of data processing systems. By depreciating equipment over longer time periods, leasing companies can often give their customers lower rental rates than can the original manufacturers.

The most common leasing arrangement is purchase-leaseback, which involves a three-way exchange. The user buys the equipment from the manufacturer and subsequently sells it to the leasing company. The lessor then leases it to the user at lower rates than he originally had been paying or would have paid to the manufacturer. In other cases, the manufacturer sells the equipment directly to the leasing company, which in turn leases it to the user.

Purchase-leaseback should be investigated prior to the acquisition of a data processing system because in many cases savings ranging from 10 to 30 per cent of the normal rental rates can result. Some flexibility, however, is sacrificed, since leasing companies generally require longer-term leases.

.27 Summary of Considerations

As the preceding paragraphs have pointed out, there are many significant factors to be considered in contracting for an electronic data processing system. These factors are recapitulated below, in a form that may be used as a checklist in negotiating a contract.

- Basic Specifications

  Equipment — the manufacturer should provide detailed specifications of the equipment units.

  Software — specifications should indicate the software to be provided. The user should assure himself that the software provided will operate on the equipment configuration selected.

  Type of payment — the user should be aware of the various types of payments possible, aside from outright purchases and rental contracts. The user should also investigate the tax implications involved with a particular agreement.

  Amount of chargeable time — rental agreements should clearly define the amount of chargeable time included in the basic rental fee. In addition, a definition of the "amount of chargeable time" should be stated.

  Chargeable time — a definition should be provided for the time that is to be counted as chargeable time.

  Assurance of serviceable time — this time should be specified by the manufacturer; and in the event of a major failure, what backup facilities are available.

- Acceptance

  Shipping and installation — payment for these services should be mutually agreed upon during contract negotiations. Some charges are undertaken by the user while others are absorbed by the manufacturer.

  Delivery and acceptance dates — these dates, and associated penalties, should be established during contract negotiations. Software packages should be delivered before equipment to allow for familiarization and use.

  Acceptance tests — these tests should be specified and the test procedures made explicit. The amount of time that tests should run satisfactorily before the equipment is considered acceptable should be stipulated in the contract.

- Environment — the minimum environmental conditions under which the manufacturer's equipment will perform satisfactorily should be stated.

- Maintenance

  Reliability — the minimum level of reliability and methods of maintaining reliable operation should be agreed upon at contract negotiation.

  Maintenance responsibility — maintenance of equipment responsibility and the types of maintenance provided should be specified.

- User's Rights — conditions under which the user can modify and/or maintain the equipment and rent time to others should be agreed upon.

- Additional Factors

  Special equipment — price, delivery, acceptance conditions, and vendor responsibilities should be specified.

.27 Summary of Considerations (Contd.)

System design — support from the manufacturer may be desirable in detailing system design and system concepts.

Training — training courses should be provided by the manufacturer, and the location of the training center be specified.

Program testing — initial programs should be pre-tested, perhaps on equipment provided by the manufacturer at another site.

Special programs — the user may contract with the manufacturer to supply specific operational programs other than the software packages provided.

Conversion credits — the user should arrange for credit for parallel operation in the event conversion to a larger system takes place at some subsequent date.

Investment tax credit — the manufacturer's present and future Investment Tax Credit policies should be considered to determine whether a saving to the customer is applicable.

Purchase-leaseback — computer leasing arrangements should be considered for possible savings to the user.

.3 ORGANIZATION OF THE SURVEY

The foregoing considerations should be clearly specified by the manufacturer in the form of contracts, supplementary agreements, proposals, or letters of intent. To aid the prospective user in negotiations, the AUERBACH staff has made a survey in which the standard terms offered by the manufacturers to commercial and government users were analyzed and summarized.

The arrangement of the tables which summarize the results of this survey is based upon the U.S. Government's Invitation for Bids to manufacturers of data processing equipment (General Services Administration Solicitation No. FPNN-E-27332-N-11-22-65. The General Services Administration issues such an Invitation for Bids each year; then it negotiates a one-year contract, running from July 1 to June 30, with each computer manufacturer. This contract, which in some cases is not finally negotiated until after July 1, then forms the standard contract between all Federal agencies and the manufacturer concerned.

Because the U.S. Government is such an important computer user, the aims of its negotiators and the contracts which they negotiate are extremely influential in setting computer marketing trends. The aims of the negotiators are clearly indicated in the Invitation for Bids, which forms the basic framework for each round of contract negotiations, and the contracts themselves are part of the public records.

The tables summarize the contract terms that were sought by the U.S. Government negotiators for the currently existing contracts, with references to the particular section of the Invitation for Bids that provides a detailed explanation of each point. Alongside the terms sought by the U.S. Government for each contract factor, the tables summarize the terms currently offered in the standard government and commercial computer rental contracts of each of the following manufacturers: Burroughs, Control Data, General Electric, Honeywell, IBM, NCR, RCA, SDS, and UNIVAC. The tables were prepared by obtaining, analyzing, and summarizing a copy of each manufacturer's Authorized Federal Supply Schedule Price List and (where available) a standard commercial contract form. The material to be published was submitted to each manufacturer for prepublication review and was discussed with the manufacturers' designated representatives for verification and clarification where necessary.

The U.S. Government's Invitation to Bid for fiscal year 1968, covering the period from July 1, 1967 to June 30, 1968, closely parallels last year's solicitation, with the following notable changes:

(1) The government may terminate the contract after giving 30 days' notice. Previously, 90 days' notice was required for terminating a contract involving the removal of an entire system.

(2) Liquidated damages for failure to deliver software on schedule is the lesser of the basic daily rental rate or $100 per day per item of software delayed, including all software inoperable as a direct result of the delay. Previously, the liability equaled the greater of $100 per day per item of software delayed or the basic daily rental rate.

(3) Acceptance tests require satisfactory performance at a 95% effectiveness level instead of the former 90% level.

(4) A liability credit equal to the pro-rated basic rental for service call response time in excess of one hour has been incorporated into the solicitation.

(Contd.)

.3 ORGANIZATION OF THE SURVEY (Contd.)

(5) The government may exercise its option to have equipment replaced when downtime exceeds 5% (formerly 10%) of the total operational use time per month over a period of three months.

.4 CONCLUSIONS

In compiling and analyzing the tables of computer rental terms, the AUERBACH Standard EDP Reports staff arrived at four significant conclusions:

(1) Commercial contracts tend to omit many of the user safeguards that U.S. Government contracts include.

(2) Terms in the standard contracts, both commercial and government, vary widely enough so that they may well constitute a decisive factor in the decision to rent a specific computer system.

(3) Most manufacturers are willing, in varying degrees, to alter the terms of their standard contracts through clauses which are added during contract negotiations.

(4) From the user's viewpoint, standard contracts as presently written are inadequate in a number of important respects.

.41 Omission of User Safeguards

Among the subjects that simply are not specified in most of the standard commercial contracts are: firm delivery dates for hardware and software, standards for acceptance tests (or even the existence of such tests), and guidelines for assessing penalties for nonperformance. It would be nice to believe that all the equipment will be deliverd on time, that all the required software will be available when needed, and that both the hardware and software will always perform according to expectations; but these are assumptions that no businessman can afford to make without some clearly-specified assurance — such as the terms requested by the U.S. Government negotiators.

.42 Variations Among the Manufacturers

Areas where the standard contract terms vary among the different manufacturers seem to be more prevalent than areas where the terms are in agreement. Extra-time charges (for operation beyond the time allowed by the basic monthly rental) can effectively double the rental cost of some computer systems, while involving no extra cost on others. Purchase options, by crediting some portion of the previously-paid rental charges, can reduce the purchase price of a system 75% or more in some cases, or by a maximum of only 20% in others; the options are free in some cases, but involve an extra cost in others. Discounts for users who cannot keep their equipment busy throughout a full shift now appear in some contracts, but not in others.

.43 Possibilities for Negotiations

Most of the standard commercial contracts are far from sacred, so the user is likely to find it worthwhile to engage in some bargaining before signing the contract. During the preparation of this survey, we received comments from manufacturers' representatives which indicated that they are in a position to offer varying degrees of flexibility in their contract terms, depending upon the particular user's needs, the competitive situation, the potential for additional business, and other variable factors. This flexibility of terms applies to various manufacturers' policies regarding delivery, extra-time charges, acceptance tests, performance standards, program testing time, purchase option credits, and nearly every other item in the standard contracts except the basic monthly rental. Checks among computer users confirmed that contracts currently in force do vary significantly from one another as a result of clauses added during negotiations.

Most manufacturers are willing to negotiate contract terms with the user until an agreeable settlement has been reached. While IBM tends to hold firmly to its standard contract, it is often possible to negotiate certain terms with the branch manager in a letter of intent. Although the strict legality and enforceability of such a document are questionable, IBM has tended to honor these as gentlemen's agreements. There are reliable indications that, when dealing with IBM, negotiations at the branch manager's level usually produce the best results. When dealing with other firms, however, negotiations at higher levels seem to maximize the user's benefits.

.44 Inadequacies of the Standard Contracts

Most of the current standard contracts do not offer the computer user as much protection as he might reasonably expect. None of the standard contracts reviewed in this survey offers assurance that the program run times or software performance promised in the manufacturer's proposal will actually be achieved, nor is any penalty specified for failure to achieve the anticipated throughput in the user's installation. Even where damages are specified in the standard contracts, the liability rates are generally in-

.44 Inadequacies of the Standard Contracts (Contd.)

adequate to compensate for the actual losses; hence, the user generally remains "locked in" and must try to make the best of a less-than-satisfactory situation. Despite the current emphasis on "integrated product lines," none of the current standard contracts assures the user that a faster, program-compatible system will actually be available to him when he needs it. Such assurance would help the user to formulate his future expansion plans with far greater confidence.

.5 SURVEY COMPARISON CHARTS

The survey tables that follow summarize the standard contract terms that are currently applicable when computer systems are rented. The information contained in this Special Report should be well worth studying at an early stage in every computer procurement program, and enlightened use of this information (together with appropriate legal counsel) should help to ensure that the resulting contract will be a reasonably comprehensive and satisfactory one.

COMPUTER RENTAL TERMS

SUBJECT MATTER	TERMS SOUGHT BY U.S. GOV'T (From GSA Solicitation of 10/28/65).	BURROUGHS STANDARD TERMS		CONTROL DATA STANDARD TERMS		GENERAL ELECTRIC STANDARD TERMS		HONEYWELL STANDARD TERMS	
	PERIOD: July 1, 1966 to June 30, 1967	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)
What is the minimum rental period?	One year or less (Sect. A-1, 1(a).)	1 year	As GSA requests. (See 2nd col.)	1 year.	As GSA requests. (See 2nd col.)	1 year.	As GSA requests. (See 2nd col.)	6 months (200 Series). 1 year (400 and 800)	As GSA requests (See 2nd col)
How much notice is needed to cancel the contract?	90 days for a complete computer system, or 30 days for any component thereof. (Section A-1, 1(a).)	90 days, after minimum rental period.	As GSA requests. (See 2nd col.)	90 days, after minimum rental period.	As GSA requests. (See 2nd col.)	90 days, after minimum rental period.	As GSA requests. (See 2nd col.)	90 days, after minimum rental period.	As GSA requests (See 2nd col)
What software is to be supplied, and when?	As written into the contract, plus future work developed by the manufacturer for general use. (Section A-1, 2(b).)	As GSA requests. (See 2nd col.)	As GSA requests. (See 2nd col.)	As written into the contract.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified	As GSA requests (See 2nd col)
What damages will be paid if the hardware is not delivered on time?	Basic pro-rated rental of the system, with a minimum of $100 per day delayed. (Sect. A-1, 3(a).)	None.	As GSA requests. (See 2nd col.)	None.	As GSA requests. (See 2nd col.)	None.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col)
What damages will be paid if the software is not delivered on time?	Lesser of pro-rated basic monthly rental or $100 per day per item of software delayed, including software facilities rendered unusable as a result of the delay of supporting facilities. (Section A-1, 3(b).)	None.	As GSA requests. (See 2nd col.)	None.	$100 per day total maximum liability.	None.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col)
What is the minimum acceptable performance during acceptance tests?	90% good time throughout 30 days' running, with at least 100 hours used during the period. (Section A-1, 4)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests (See 2nd col)
How many hours of operational use are allowed in the basic monthly rental (under GSA Option B)?	200 hours per month. (Section A-1, 5(b).)	176 hours.	176 hrs.: B2500, B3500 200 hrs.: B100, B200, B300, B220, B5500	CPU — 176 hours; most peripherals — unlimited use.	CPU — 176 hours; most peripherals — unlimited use.	200 hours.	200 hours.	400, 1400, 800, 1800—176 hours if on 1 yr contract; otherwise, 200 hours/month. 200—200 hours/month.	As GSA requests. (See 2nd col.)
What is the extra usage rate expressed as a percentage of the basic rental rate?	This is not mentioned in the Invitation to Bid.	25%: B200, B300, B5500 7½%: B2500, B3500	25%: B200, B300, B500 40%: B100, B200 7½%: B2500, B3500	Approximately 20%; no extra-use charge for most peripherals	Approximately 20%; no extra-use charge for most peripherals.	20%.	20%.	As mutually agreed upon in rental contract.	As mutually agreed upon in rental contract
What is the standard rate for unlimited usage (GSA Option A), expressed in terms of the basic monthly rental? • 5-day week: • 6-day week: • 7-day week:	This is not mentioned in the Invitation to Bid.	B5500—115% Others — unspecified. (7-day week)	B5500—115% Others — unspecified. (7-day week)	120% of items subject to extra use charge. (7-day week)	120% of items subject to extra use charge. (7-day week)	108%. 110%. 111%.	108%. 110%. 111%.	Unspecified	Unspecified.
How is the amount of central processing time used computed for establishing the rental due?	Only that time between program START and program STOP, measured either by meters or by user's estimates. (Sect. A-1, 5(a).)	Power on time less user maintenance and idle time.	As GSA requests. (See 2nd col.)	As GSA requests. (See 2nd col.)	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests (See 2nd col.)
How is the usage time of peripheral units computed for establishing the rental due?	This is not mentioned by the Invitation to Bid.	Power on time less user maintenance and idle time.	Direct usage where this is easily measurable; otherwise, as for central processor, if the peripheral is actually used in the run.	Based on CPU time for equipment subject to extra use charge.	No extra charge.	Unspecified.	Unspecified.	Unspecified.	Direct usage where this is easily measurable; otherwise, as for central processor, if the peripheral is actually used in the run.
How long will it take a serviceman to respond to an emergency service call?	One hour maximum. (Section A-1, 6)	Unspecified.	No specific amount of time.	Unspecified.	No definite commitment, but CDC "shall always be responsive to the needs of the Govt."	Unspecified.	2 hours.	Unspecified.	As GSA requests. (See 2nd col.)
What credit is allowed to a user when a system is down?	Credit at basic rental rates for each machine inoperative as a result of the malfunction, whenever the downtime period exceeds 12 hours. (Section A-1, 6)	None.	As GSA requests. (See 2nd col.)	As GSA requests. (See 2nd col.), except when period exceeds 24 hours	As GSA requests. (See 2nd col.)	Unspecified.	Option B— As GSA requests. (See 2nd col.) Options A and C — varies.	Unspecified.	As GSA requests. (See 2nd col.)
How much equipment downtime before the user may, at his option, elect to have the faulty equipment replaced?	Whenever machine-failure downtime exceeds 10% of total operational use time for three consecutive months. (Sect. A-1, 6(a).)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)

SUBJECT MATTER	IBM STANDARD TERMS		NCR STANDARD TERMS		RCA STANDARD TERMS		SDS STANDARD TERMS		UNIVAC STANDARD TERMS	
	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)
What is the minimum rental period?	1 year	As GSA requests. (See 2nd col.)	1 year.	As GSA requests. (See 2nd col)	1 year.	As GSA requests. (See 2nd col.)	1 year.	As GSA requests. (See 2nd col)	1 year	As GSA requests (See 2nd col)
How much notice is needed to cancel the contract?	90 days, after minimum rental period.	As GSA requests. (See 2nd col.)	90 days, after minimum rental period.	As GSA requests. (See 2nd col.)	90 days, after minimum rental period	As GSA requests. (See 2nd col.)	90 days after minimum period of rental	As GSA requests. (See 2nd col)	90 days, after minimum rental period.	As GSA requests (See 2nd col)
What software is to be supplied, and when?	Unspecified.	As GSA requests. (See 2nd col.)	As stated in contract. *	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests (See 2nd col.)	Unspecified	As GSA requests. (See 2nd col)	Unspecified.	As GSA requests (See 2nd col)
What damages will be paid if the hardware is not delivered on time?	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	None.	As GSA requests. (See 2nd col.)	None	As GSA requests (See 2nd col.)
What damages will be paid if the software is not delivered on time?	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	$100 per day total maximum liability.	None.	As GSA requests. (See 2nd col.)	None.	As GSA requests (See 2nd col)
What is the minimum acceptable performance during acceptance tests?	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests (See 2nd col)	Unspecified	As GSA requests (See 2nd col)	Unspecified	As GSA requests (See 2nd col)
How many hours of operational use are allowed in the basic monthly rental (under GSA Option B)?	176 hours.	176 hours.	176 hours.	As GSA requests for all systems except NCR 304, which is 176 hrs.	Unlimited use option only.	Unlimited use.	Unlimited use option only.	Unlimited use option only.	Unlimited use option only.	Unlimited use option only
What is the extra usage rate expressed as a percentage of the basic rental rate?	IBM-established billable rates, which generally vary from 10% to 30%.	Either 10% or 30% depending on equipment.	40%, based on each individual component.	No extra charge.	None	None.	Not applicable.	Not applicable.	Not applicable	Not applicable
What is the standard rate for unlimited usage (GSA Option A), expressed in terms of the basic monthly rental? • 5-day week: • 6-day week: • 7-day week:	Unspecified.	Option unavailable.	Approximately 10%. (7-day week)	Not applicable.	No extra charge.	No extra charge.	No extra charge.	No extra charge.	No extra charge	No extra charge.
How is the amount of central processing time used computed for establishing the rental due?	As GSA requests (See 2nd col.)	As GSA requests. (See 2nd col.)	As GSA requests (See 2nd col.)	As GSA requests. (See 2nd col.)	Not applicable.	Not applicable.	Unspecified.	Not applicable.	Not applicable.	Not applicable
How is the usage time of peripheral units computed for establishing the rental due?	Direct usage where practicable; otherwise as for CPU, if the peripheral is actually used in the run.	Direct usage where practicable; otherwise, as for CPU, if the peripheral is actually used in the run.	From relation to time measured for CPU.	Direct usage where practicable; otherwise, as for CPU, if the peripheral is actually used in the run.	Not applicable.	Not applicable.	Unspecified.	Not applicable.	Not applicable.	Not applicable
How long will it take a serviceman to respond to an emergency service call?	Unspecified.	No definite commitment, but IBM "shall always be responsive to the needs of the Govt."	Best effort. *	Response will be initiated within one hour.	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Best effort. *	No definite time specified, shall be responsive to needs of Govt
What credit is allowed to a user when a system is down?	Unspecified.	As GSA requests. (See 2nd col.)	Usage time credit equivalent to downtime.	As GSA requests (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	When fault continues for 48 hours after notification, at a mutually agreed upon rate.	As GSA requests (See 2nd col.)	None	As GSA requests. (See 2nd col.), except credit of 0 5% of basic monthly rental per hour.
How much equipment downtime before the user may, at his option, elect to have the faulty equipment replaced?	Unspecified.	IBM retains option to: (1) provide backup equipment; (2) provide on-site customer engineer; or (3) replace the equipment.	Unspecified.	NCR retains option to: (1) provide on-site maintenance; (2) provide backup equipment; or (3) make every effort to replace the equipment.	Unspecified.	As GSA requests. (See 2nd col.)	Unspecified.	As GSA requests. (See 2nd col.)	Never at customer option. *	As GSA requests. (See 2nd col.)

*Unspecified in standard contract, but stated by company to be present policy.

COMPUTER RENTAL TERMS (Contd.)

SUBJECT MATTER	TERMS SOUGHT BY U. S. GOV'T (From G. S. A. Solicitation of 10/28/65) PERIOD: July 1, 1966 to June 30, 1967	BURROUGHS STANDARD TERMS		CONTROL DATA STANDARD TERMS		GENERAL ELECTRIC STANDARD TERMS		HONEYWELL STANDARD TERMS	
		Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)
How much computer time is provided free of charge prior to installation?	Enough time to allow successful operation of all specified applications on installation day. (Section A-1, 10)	B5500, B100, 200, 300 — 40 hours. B2500, 3500 — 6 hours/$1,000 of basic monthly rental, to a maximum of 60 hours	B2500 and B3500 — 6 hours/ $1,000 of basic monthly rental with a maximum of 60 hours. B5500 — 3 hours/ $1,000. B100, 200, 300 – 6 hours/$1,000.	50 hours maximum, or 2 hrs/ $1,000 of basic monthly rental, whichever is less.	100 hrs, or 2 hrs/$1,000 of basic monthly rental, whichever is less.	Greater of 40 hours or 3 hours per $1,000 of basic monthly rental.	As GSA requests. (See 2nd col.)	Unspecified	6 hours/$1,000 of basic monthly rental
How much computer time is provided free of charge after installation?	All available time outside basic rental period for the first 90 days, plus COBOL, FORTRAN, and ALGOL compilation time as required (Section A-1, 10)	As GSA requests. (See 2nd col.)	As GSA requests. (See 2nd col.)	All available time for 90 days without paying extra-use charges.	All available time for 180 days without paying extra-use charges.	Unspecified.	As mutually agreed upon, or twice the unused pre-installation time.		Series 200 — 60 days. All others — 90 days. 200 hours max
What charge is made for machine time needed for program testing after free time allowance has been exhausted?	This is not mentioned by the Invitation to Bid	7 ½ % of basic rental rate — B2500 and B3500, 25% of basic rental rate — B200, B300, B5500	Basic rental rate	Basic rental rate.	Basic rental rate.	Unspecified.	Unspecified	Honeywell Data Center rates	Basic rental rate.
What reduction in monthly rental is allowed if full utilization is not achieved?	Some definite reduction is required (Section A-1, 5(d))	None.	None	None.	None.	None.	None.	None.	None.
What discounts in the rental rate are applicable in special situations?	Discounts are requested for: • Multiple systems	None.	Unspecified.	None.	None.	None.	None.	Unspecified.	None.
	• Educational use	None	None	None.	20%, plus unlimited usage is permitted.	Unspecified.	50% of basic rental rate, applicable only to equipment installed prior to June 30, 1965.	Unspecified.	120-10%, 200-25%, 400-50%, 800-25%
	• Hospitals	None.	None	None.	20%, plus unlimited usage is permitted.	None.	None.	Unspecified.	Unspecified.
What rental adjustments may come into force?	A rental adjustment is requested in each of the following circumstances: • When the rental paid exceeds the purchase price of the equipment	None.	None	None.	None.	None.	None.	Unspecified.	None.
	• Whenever the purchase price of the equipment is reduced.	None.	None.	None.	None.	None.	None.	Unspecified.	None.
	• As soon as the equipment has become obsolete (This is considered to occur as soon as a successor has been announced) (Section A-1, 5(d).	None	None	None.	None.	None.	None.	Unspecified.	None.
What credit is allowed if a user purchases the equipment he has been renting?	The credit should take into account the physical age of the system rented, and the total rental paid by the user. (Section A-1, 19).	Free credit of 65% of total rental paid during first 12 months; 60% of rental during 2nd 12 months; maximum credit of 60% of purchase price. B2500 & B3500 – rental credits accrue for first 12 months only: 70% for 1-6 mos., 40% for 6-12 months.	Free credit of 65% of total rental paid during first 12 months; 60% of rental during 2nd 12 months; maximum credit of 60% of purchase price. B2500 & B3500 – rental credits accrue for first 12 months only: 70% for 1-6 mos., 40% for 6-12 months.	60% during first 12 months; 40% during 2nd 12 months. Option good for life of contract. Max. credit of 70% of purchase price.	Free credit of 60% of total rental paid during first 24 months; 40% during remaining months. Option lasts for life of contract. Maximum credit allowed is 70% of purchase price.	Free credit of 50% of rental paid, up to 50% of purchase price.	Free credit of 50% of rental paid, up to 50% of purchase price.	Series 200 — Free credit of 80% within 12 months; 60% within 24 months, which is maximum credit period Series 400 — 80% within 12 months; 50% within 24 months	Series 200 — Free credit of 80% within 12 months; 60% within 24 months, which is maximum credit period Series 400 — 80% within 12 months, 50% within 24 months.
What is the purchase price if a user purchases the equipment he has been renting?	The lesser of the then-current or the original purchase price. (Section A-1, 19).	Current price at exercise of option.	Current price at exercise of option.	Current price at exercise of option.	As GSA requests.	As GSA requests.	As GSA requests.	As GSA requests. (See 2nd col.).	As GSA requests. (See 2nd col.).
Does the manufacturer pass on Investment Tax Credit to user?*	Not applicable.	Yes.	Not applicable.	No.	Not applicable.	Unspecified.	Not applicable.	Yes, on 5 year lease contracts.	Not applicable.

SUBJECT MATTER	IBM STANDARD TERMS		NCR STANDARD TERMS		RCA STANDARD TERMS		SDS STANDARD TERMS		UNIVAC STANDARD TERMS	
	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)	Commercial (6/67)	Government (7/66 to 6/67)
How much computer time is provided free of charge prior to installation?	Unspecified.	Varies, depending on equipment, but does not meet GSA request verbatim.	10 hours/$1,000 of basic monthly rental	10 hours/$1,000 of basic monthly rental Minimum time is 15 to 40 hours, depending on equipment	Unspecified	Spectra 70/15-10 hrs 70/25-30 hrs 70/35-40 hrs 70/55-50 hrs 20 hours extra allowed for communications systems	Unspecified	20 hours maximum.	Unspecified	Varies from 2 to 7 hours per each $1,000 of basic monthly rental.
How much computer time is provided free of charge after installation?	Unspecified.	Varies from 30 to 90 days	Any unused minimum time remaining	Any unused minimum time remaining	Unspecified	As GSA requests. (See 2nd col.)	None *	None.	None. *	None.
What charge is made for machine time needed for program testing after free time allowance has been exhausted?	Unspecified	Basic rental rate	NCR Data Center rates.	NCR Data Center rates	Unspecified.	Basic rental rate	Unspecified	Basic rental rate	Varying rates specified in price book	Prevailing prices in current GSA Schedule
What reduction in monthly rental is allowed if full utilization is not achieved?	Unspecified	None	None	None	None	None	None	None	None	None
What discounts in the rental rate are applicable in special situations? (Multiple systems)	Unspecified	None	Unspecified	None.	None	7%	None *	None.	None *	None
(Educational use)	Unspecified.	Generally 20%	20%	20%	Unspecified	Spectra 70/35 and 45-15% Spectra 70/55-20%	None. *	None	None *	None
(Hospitals)	Unspecified	10% or 30% per item; 20% if affiliated with a medical institution.	None.	None.	Unspecified.	None.	None. *	None.	None *	None
What rental adjustments may come into force? (When the rental paid exceeds the purchase price of the equipment)	Unspecified	None	None.	None.	Unspecified	None	None. *	None.	None *	None
(Whenever the purchase price of the equipment is reduced)	Unspecified.	None	None.	None	Unspecified	None.	None *	None.	None *	None
(As soon as the equipment has become obsolete)	Unspecified	None	None.	None.	Unspecified.	None.	None *	None	None *	None.
What credit is allowed if a user purchases the equipment he has been renting?	Free credit of 45% to 70% of total rental paid Option is valid for 1 year (2 years for state and local gov'ts)	Free credit of from 10% to 75% of total rental paid. Varying credits for age. Option lasts for contract life.	Varies considerably, depending on all relevant factors.	NCR 310, 315, 390, 500, 420: 0.833% of list price for each month of rental. Maximum credit of 75% Option lasts 24 months.	Free credit of 65% of total rental paid, to a maximum of 75% of original purchase price. Option lasts for life of contract.	Free credit of 65% of total rental paid. Option lasts for life of contract.	Sigma Series – 50% Nine Series – 70% of rental during first 6 months; 50% during 2nd 6 months. Maximum credit of 70% for Nine Series and 50% for Sigma Series.	Sigma Series – 50% Nine Series — free credit of 70% of rental paid during first 6 months; 50% during 2nd 6 months, 55% during 2nd year, 60% in 3rd year, and 65% in successive years	1-6 months – 90%, 6-12 months — 75%, 12-24 months – 60% of rental paid on a non-cumulative basis, maximum credit of 70% of purchase price.	1-12 months – 90%, 6-12 months — 75%, 12-24 months – 60% of rental paid on a cumulative basis, maximum credit of 70% of purchase price.
What is the purchase price if a user purchases the equipment he has been renting?	Unspecified.	As GSA requests. (See 2nd col.)	Original price.	As GSA requests. (See 2nd col.)	Original price.	As GSA requests. (See 2nd col.)	Original purchase price.*	As GSA requests. (See 2nd col.)	As listed in contract for 1 year after rental commences, thereafter prevailing rates.	GSA prices for applicable fiscal year.
Does the manufacturer pass on Investment Tax Credit to user?*	Unspecified	Not applicable.	Yes.	Not applicable.	Unspecified.	Not applicable.	Only on four-year or longer fixed-term leases.	Not applicable.	Only for 5-year non-cancellable agreements.	Not applicable.

*Unspecified in standard contract, but stated by company to be present policy.

AUERBACH

(Contd.)

AUERBACH SPECIAL REPORT:
A SURVEY OF THE CHARACTER RECOGNITION FIELD

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AUERBACH SPECIAL REPORT: A SURVEY OF THE CHARACTER RECOGNITION FIELD

.1 INTRODUCTION

In the early days of electronic data processing, when the amounts of information being handled in most computer applications were relatively small, the need to manually keypunch the information in a machine-readable code caused no particular concern. Today, when vastly more sophisticated machines are being used to store, retrieve, and process large amounts of information, this manual operation has come to be viewed as a fundamental weak point in computer-based information systems — too slow, expensive, and unreliable to be tolerated in applications involving large volumes of input information. The one solution to this problem is the automatic character reader — a device that has been developed to the point where it has replaced manual keypunching in selected application areas, although it still lacks certain functional refinements that will be necessary to make it suitable for the full spectrum of computer input operations.

Character readers are machines for directly converting alphanumeric characters or symbols into a machine-readable form. The output of the readers may be in the form of punched cards, punched paper tape, or magnetic tape — or the readers may be operated on-line (directly connected) to a computer.

Most current readers are severely limited in the type fonts they can read, and, in some cases, in the size of the character set (alphanumeric vocabulary) they can handle. On the other hand, character readers are in effective and economically efficient use in several major industries. Banking is probably the largest current application area for character readers. The credit-card industry, led by the oil companies, and utility bill processing are other major application areas. In addition, some retail merchandising firms are now using character readers, and the United States Post Office Department (which is already using optical ZIP-code reader/sorters) has expressed interest in seeing a character reader developed to read hand-written addresses.

Character readers offer the advantages of being faster and more accurate than manual keypunching, since they permit printed data to be entered directly into data-processing systems without any additional human action. The present purchase prices of commercial magnetic character readers average around $80,000. The prices for optical character readers range from $80,000 upward, depending upon the speed and sophistication of the machine (rentals run between $3,000 and $15,000 per month).

.2 CHARACTER READER TYPES AND FUNCTIONS

There are two basic types of character readers: magnetic and optical. Magnetic character readers are used almost exclusively within the banking industry. They can handle only special type fonts printed in magnetic ink. The font most widely used in the United States, and adopted as a standard by the American Bankers Association, is Font E-13B — a highly stylized font that can be used to represent only 10 numeric digits and 4 special symbols (Figure 2). Another font, which was developed by Compagnie des Machines Bull-General Electric, is capable of representing all the characters in the alphabet as well as all the numeric symbols (Figure 3). However, the Bull font, which has been adopted as a standard by the European banking community, can at present be read only by the Bull CMC-7, GE MRS200, and Olivetti 7750 magnetic character readers.

Since magnetic readers detect only magnetic marks, non-magnetic dirt or other marks will not cause reading errors. However, considerable care must be taken with the quality of the printing on the documents. Ink densities and character image are both critical. Relatively high quality-control standards must be maintained in the printing process to prevent character deterioration and extraneous ink spots.

Optical character readers are used in nearly all major application areas, including banking. They work on the principle of recognizing the difference in contrast between the characters and the background on which they are printed. Some optical readers do not require special fonts and are theoretically capable of reading most type fonts (with suitable adjustments). So far, however, this theoretical capability is too expensive to realize for most commerical applications, although there are several optical character readers that can read more than one type font. The least expensive units are restricted to one font, which is usually specially designed for low error rates and is often restricted to numerics plus a few special symbols. Also, optical readers tend to be somewhat less reliable than magnetic readers because of their greater sensitivity to dirt, document creases, and poor paper quality. Despite these drawbacks, optical readers seem to offer the most promise for the future, and new techniques are being explored and developed to overcome the major functional problems.

.2 CHARACTER READER TYPES AND FUNCTIONS (Contd.)

All existing commercial character readers, whether magnetic or optical, consist of three basic functional units.

- Document transport,
- Scanner, and
- Recognition unit.

A functional block diagram of a typical character reader is shown in Figure 1.

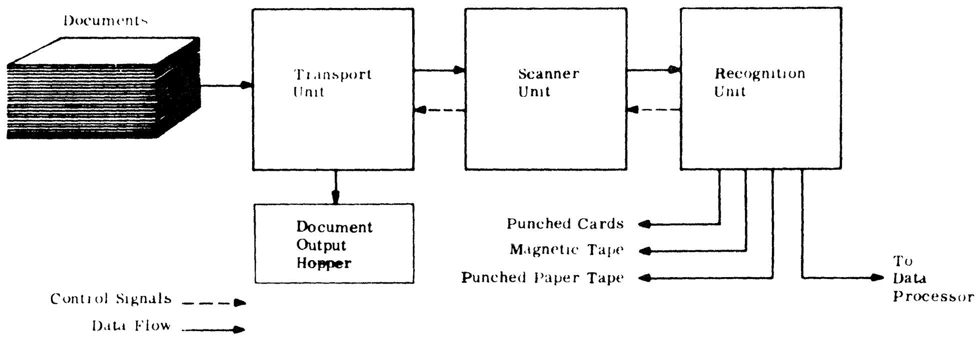

Figure 1. Functional Diagram of a Character Reader

The function of a character reader's document transport is to move each document to the reading station, position it properly, and move it into an "out" hopper. Transport mechanisms can be divided into two basic types: one for handling individual documents (paper sheets or cards) and the other for handling continuous rolls (cash register or adding machine tapes).

The function of a character reader's scanner is to convert the alphanumeric characters and symbols on a document into some analog or digital representation that can be analyzed by the recognition unit There are two basic methods for accomplishing this: magnetic and optical.

The recognition unit is the heart of the character reader. This unit matches patterns from the scanner against reference patterns stored in the machine and either identifies the patterns as specific characters or rejects them as being unidentifiable.

.3 DOCUMENT TRANSPORTS

Document transports in character readers designed to handle adding machine or cash register tapes consist of a tape well in which the paper roll is loaded, paper guides, and a paper drive control. Once the tape has been manually threaded, the paper is automatically moved past the read head in a manner similar to the movement of a film reel in a movie projector. A vacuum system is frequently used to keep the paper flat. The maximum length of the paper roll that can be handled ranges from 1200 feet for the National Cash Register Optical Journal Reader to "any reasonable length" for the Recognition Equipment Journal Tape Reader. The paper-roll mechanisms are usually designed so that the roll can be backed up any time rereading is required. A special feature of the feeder mechanism used in the Recognition Equipment Journal Tape Reader is an automatic tape advance, which speeds up tape movement when there are large spaces between print lines. In most other readers, tape speed is constant at all times.

In character readers designed to handle individual sheets or cards, the document-transport function is divided into two phases: (1) feeding the documents from the input hopper, and (2) transporting the documents past the reading station. A common device for document feeding is called a friction feeder. This consists of a belt wound around capstans and partially resting on the document stack. Constant pressure is exerted against the belt by the document stack. As the belt moves across the top of the stack, it pushes the top documents into a separator station, where a combination of rollers and another belt separates the top document from all documents below it. This technique is used in the IBM 1419 Magnetic Character Reader.

Vacuum or suction feeders are also used to lift documents off the input stack. One example of a vacuum feeder is used in the Philco-Ford 6000 Print Reader, which employs a pair of vacuum belts to lift the document from the stack and carry it forward to the transport unit.

Both the friction and vacuum devices, however, have problems in handling documents of thin paper and may occasionally feed more than one document at a time. A feeder, designed by Rabinow Electronics (a subsidiary of Control Data Corporation) uses a set of

.3 DOCUMENT TRANSPORTS (Contd.)

cone-shaped rollers to feed the documents. The rolling cones engage a corner of the top-most document and roll the corner away from the pile up into paper rollers, which carry the document to the transport unit. This unit is said to eliminate the possibility of feeding two sheets at a time.

A popular method for transporting the document to the reading station is a vacuum-drive conveyor belt. Some character readers, such as the IBM 1428, use the conveyor belt to place the document on a rotating drum, which moves the document past the read head. The paper is held to the drum by means of a vacuum.

One of the basic disadvantages of the above mechanical techniques is that they cannot move the document as fast as it can be read. One approach to this problem has been the use of a high-resolution CRT scanner, developed by Philco Corporation, which can scan the entire document without requiring any mechanical movement. Another method, used by RCA, uses a vidicon scanner which takes a picture of the entire document at once. Both of these systems will be discussed later in this report.

.4 MAGNETIC SCANNER UNITS

Scanner units, as previously mentioned, are divided into two basic categories: magnetic and optical — and these designations are used to characterize the readers themselves.

Since the banking field represents the major application area for magnetic character readers, all of the magnetic readers produced in the United States have scanning units designed to handle the E-13B font shown in Figure 2.

Figure 2. Sample of E-13B Font Characters

Most scanning units convert the magnetic characters into an analog voltage waveform for subsequent identification. The principle used is based on the electrical signals that are generated by moving the characters past the read head. Each character generates a signal that has a unique waveform, which the recognition unit matches against reference waveforms. The companies presently using this technique are Burroughs, General Electric, and National Cash Register.

IBM uses a digital scanning technique, which is exemplified by the IBM 1419 Magnetic Character Reader. In this machine, each character is scanned by 30 magnetic heads stacked vertically and interconnected to give 10 outputs. The outputs are transmitted to a 70-bit shift register in the recognition unit, where they are matched against stored reference patterns.

.5 OPTICAL SCANNER UNITS

Optical scanning methods are based on the differences in contrast between the characters and the background on which they appear. The function of the scanner is to sample either portions of a character or a complete character to determine the relationships between light and dark areas. The common types of scanners used are mechanical discs, flying-spot scanners, parallel photocells, and vidicon scanners.

.51 Mechanical-Disc Scanner

The mechanical-disc scanner consists of a lens system, a rotating disc, a fixed aperture plate, and a photomultiplier, as Shown in Figure 4. The characters to be read are flooded with light, which is reflected from the surface of the document into a rotating disc via the lens system. The disc has apertures extending from its center toward its periphery. As the disc rotates, the apertures pick up light samples. A fixed aperture plate regulates the amount of light and directs the light to a photomultiplier. The photomultiplier tube converts the light samples into signal pulses. By varying the voltage threshold, the photocell outputs can be adjusted for different background colors.

The mechanical-disc scanner senses a character of data at a time. Movement between characters and lines is accomplished either by moving the document, as in the NCR Optical Journal Reader, or by repositioning the lens system, as in the IBM 1428 Alphameric Optical Reader. Consequently, this type of scanner is relatively slow by comparison with the other scanners mentioned.

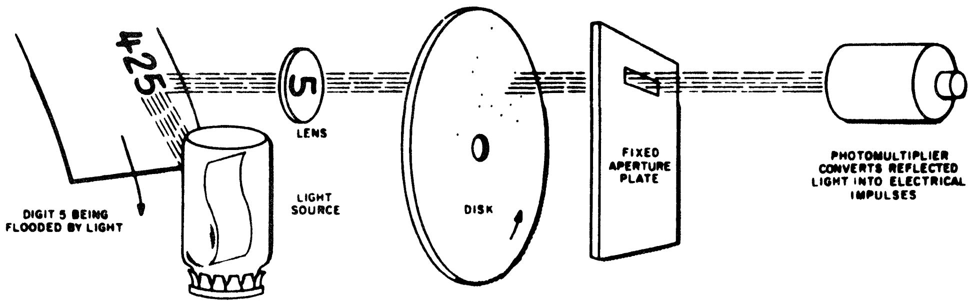

Figure 4. Mechanical-Disc Scanner

.52 Flying Spot Scanner

The flying-spot scanner consists of a cathode-ray tube, a projection lens, a phototube, and a control unit. A beam of light is generated in the cathode-ray tube and deflected across the tube in a scan pattern. The lens system projects this scanning light spot onto the document, from which it is reflected into a phototube. The phototube generates a voltage signal whose level is proportional in each instant to the amount of reflected light, thus indicating light and dark areas. The resulting signals are then either fed directly to the recognition unit in analog form or first transformed into digital form.

The flying-spot scanner offers more flexibility than the mechanical disc, since its scanning pattern can be automatically adjusted by the control unit. This permits the use of different scanning modes (i.e., scanning certain character fields, scanning specified portions of the document). Also, being completely electronic, it is faster than the mechanical disc and is generally classified as a medium-speed device.

The introduction of high-resolution cathode-ray tubes (2000 optical lines) has made manufacturers look to the development of a reader in which a complete document can be scanned without any document motion other than that required to position it under the read station. A scanner of this type is found in the Model 6000 Print Reader developed by Philco-Ford. Sylvania Corporation has worked on the development of a similar device, which was expected to achieve very high reading speeds of up to 6,000 characters per second.

.53 Parallel Photocells

The use of a vertical grouping of photocells speeds up scanning operations by simultaneously sampling a number of points which, when combined, add up to a complete vertical slice of the character. The electrical signals generated by the photocells are then quantitized into either black, white, or gray levels. This data is fed into a shift register and stored until data on the entire character has been accumulated. Due to the parallel sampling, this type of scanner can achieve higher speeds than the flying-spot scanner.

A variation of this method that eliminates the need for shift registers uses a full "retina" of photocells to sample an entire character rather than just one vertical slice. Besides eliminating the shift register, this method also increases reading speed to approximately 2,400 characters per second. Rabinow Electronics (a subsidiary of Control Data Corporation) and Recognition Equipment are two of the companies currently using a retina of photocells for sampling. This sampling technique has the present capability for achieving a higher speed than any of the previously-mentioned techniques.

.54 Vidicon Scanner

So far, we have discussed scanning methods that read characters by reflecting light from the document to one or more photocells. A totally different method being used is to project the characters onto a vidicon television camera tube and scan the active surface with an electron beam. The resulting video signals are quantitized to digitally indicate black or white.

This type of scanner is currently being used by RCA in their 70/251 Document Reader. By storing a group of characters on the tube, the need for document movement during the scanning operation is eliminated in cases where the document contains a reasonably small number of characters. The advent of high-resolution vidicon tubes could permit the character capacity to be increased to the point where document movement during scanning will be eliminated on most documents.

Another advantage of the vidicon scanner is speed. Since it takes only a few milliseconds for the beam to scan the entire tube, a full grouping of stored characters can be read in that time. At present the RCA device can scan up to 1500 characters per second.

.6 RECOGNITION UNITS

Recognition units probably represent the area of greatest technical development in the character reader field. Because of the rapidity of the progress being made, we will limit our discussion to the five most common types of recognition units now available commercially.

(Contd.)

.61 Optical Matching

Optical matching was one of the earliest recognition methods to be used. It is based on the use of two photographic masks for each character. One mask is a positive transparency of the character and the other is a negative transparency. The positive transparency shows all the significant areas that should be covered by the character, and the negative transparency shows those areas that should be left blank.

The negative and positive images of the unknown character are projected onto their opposite masks; i.e., the positive image is projected onto the negative mask, and the negative image onto the positive mask.

Phototubes behind each mask detect any light passing through. A character is identified by first measuring the total light passing through each of the reference masks and selecting the one that passes the smallest amount. Character identification or rejection is then made by comparing the amount of light passed through the selected mask with a threshold value. Ideally, no light should pass through the reference mask if it matches the character being identified. In practice, however, the match is seldom precise enough to completely blank out all light, which is the reason for establishing the threshold value as a tolerance.

The advantages of the optical-matching technique are its ability to identify a full alphanumeric character set and its relative simplicity, which makes it less expensive than some of the other techniques. Also, the masks can be manually changed to enable the reader to handle different character fonts. The major disadvantage is that errors are easily caused by characters that do not meet strict standards of shape and registration. Also, there may be problems in distinguishing between such similar letters as "Q" and "O" or between different punctuation marks.

.62 Analog Waveform Matching

Analog waveform matching is another recognition method that has been in use for some time, particularly in the magnetic character readers used by the banking industry. It is based on the principle that each of certain characters passing under a read head will produce a unique voltage waveform as a function of time; that is, the waveform of each character will differ either in shape or length with respect to time. Characters are identified by matching their waveforms against reference waveforms.

Machines using this technique have reading speeds of approximately 500 characters per second. The principal disadvantage of this system is that only a limited number of characters have unique waveforms. Consequently, this technique is found mainly in systems dealing with a limited character set.

.63 Frequency Analysis

Frequency analysis is a digital recognition method developed for fonts consisting of closely-spaced vertical lines. The outstanding example of this kind of font is the Bull magnetic-ink font shown in Figure 3. The Bull CMC-7 and Olivetti 7750 magnetic character readers use this recognition technique. The widths of the gaps between the vertical lines of each character are measured by variations in magnetic flux. An unknown character is identified by comparing the sequence and number of its narrow and wide gaps with stored codes for each of the alphanumeric characters. An analog version of this technique is currently being used in the General Electric MRS200 Document Reader.

The advantages of the frequency-analysis technique include the ability to accommodate a full character set, and increased reading speeds.

.64 Matrix Matching

This technique, one of the more widely-used, stores the scanner signals in a digital register that is connected to a series of resistor matrices. Each matrix represents a single reference character. The other end of each matrix is connected to a second digital register, whose voltage outputs are representative of what should be obtained if the reference character were present. Recognition is based upon the resultant output voltage obtained from each matrix.

The advantage of the matrix-matching technique is that the resistor matrices can be modified easily, making it easy to change character fonts. In addition, a full alphanumeric character set can be read. The technique also has the advantage of being quite fast, since the matching is done by resistor matrices. Reading speeds of up to 2,400 characters per second have been obtained. The technique is similar in theory to the optical-matching technique described earlier, but it can handle misregistered characters much more effectively. The numerous machines using this technique are listed in the comparison chart.

.65 Stroke Analysis

This technique, used by Farrington Electronics, is based on the stroke or line formation of each character. The characters are differentiated from each other by the number and position of vertical and horizontal strokes. The formation of the unknown character is matched by a special-purpose computer against a character truth table, which indicates

.65 Stroke Analysis (Contd.)

the stroke formation for each reference character. At present, this technique is limited to identifying only a special character font called the Selfchek font, which emphasizes straight lines. Work is being done to generalize the technique so that it can be applied to any character font.

Stroke analysis has the advantage of being able to handle a full alphanumeric character set, but the maximum speeds obtainable by the Farrington character readers are about 300 characters per second, which is low compared to the 2,400 characters per second obtained by machines using the matrix-matching technique. Also, the stroke-analysis method does not have the font flexibility of the matrix-matching technique because of the need to change the wire recognition program in the special-purpose computer every time it is necessary to switch to a different character font.

.7 ECONOMICS AND SELECTION CRITERIA

The question of whether it pays to replace a manual keypunching operation with an automatic character reader cannot be answered in any general way. The answer depends upon the characteristics of the specific application — particularly upon the volume of input data that must be regularly handled, the accuracy requirements of the input operation, and the speed of the computer. A rule of thumb that can be helpful in reaching a preliminary decision on whether to seriously investigate the use of a character reader is that an installation preparing 10,000 input documents per day or requiring 8 to 12 keypunch operators is about the smallest that might gain from using character-recognition equipment. As the daily input volume approaches 30,000 documents, character readers tend to cost significantly less to operate than keypunch devices. The final criterion for making the decision is, of course, the number of characters produced per dollar. A simple formula for determining this cost is to determine:

$$F = \frac{a}{b + c}$$

Where:

F = number of characters processed per dollar.

a = total characters processed per month.

b = monthly equipment rental and overhead costs.

c = monthly employee salary costs, including supervision and fringe rates.

An example follows for a 10,000-document-per-day installation, using the following parameters:

Keypunching	OCR Reading
No. of keypunch operators = 12	OCR rental = $4000/mo.
No of direct supervisors = 1	OCR machine O/H = $500/mo.
Operators' salaries (including O/H) = $400/mo.	Operators's salary = $400/mo.
Supervisor's salary (including O/H) = $750/mo.	OCR throughput = 300 char/sec.
Machine Overhead = 10%	Characters/document = 64
Machine (026) rental = $60/mo.	Reject rate = 10% (Rejected documents must be keypunched).
Keypunch throughput = 7500 char/hr.	
Effective hours/day = 7	
Days per month = 20	

The application involves the processing of strictly-controlled, field-typed documents.

CASE I — KEYPUNCHING OPERATION

a = (12)(7500)(7)(20)	=			12,800,000 char/mo.	
b = (12)(66)	=			$ 792	
c = (12)(400) + (1) (750)	=	4800 + 750	=	5550	
				$6342	Total cost per month.

$$F = \frac{12,800,000}{\$6342}$$

= 2018 characters per dollar.

.7 ECONOMICS AND SELECTION CRITERIA (Contd.)

CASE II — OCR OPERATION

a = 12,800,000 (using same volume as in Case I; OCR reader's potential throughput is actually approx. 43 million char/mo.)

b = 4000 + 500	=	\$4500
c = (1)(400) + (.2)(750) + 635 operator supervisor keypunching of rejects (10%)	=	1185
		\$5685 Total cost per month.

$$F = \frac{12,800,000}{\$5685}$$

= 2251 characters per dollar.

Figure 5 shows the same relationships calculated for volumes of 8,000 through 30,000 documents per day.

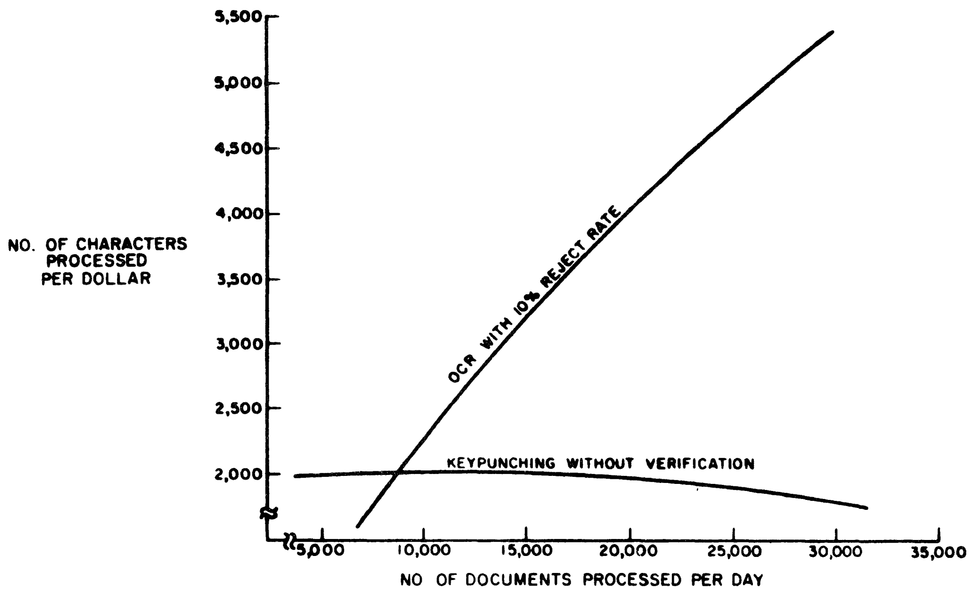

Figure 5. Comparison of keypunching versus OCR costs. (See text for basis of curves.)

There are four major criteria for evaluating optical character readers. Cost, as discussed above, is the most obvious one, but it must be carefully related to the functional capabilities of data throughput speed, flexibility, and reliability. Naturally, all three of these capabilities directly influence the cost of character-reading equipment; but, as is the case with all equipment, the initial cost is only part of the story.

Throughput speeds are a function of reading speed, document transport speed, data density on the document, and multi-line or page reading capabilities. The rated reading speeds of optical character readers currently on the market range from about 200 to 2,400 characters per second. You will find, when comparing machines of different speeds and prices, that the number of characters read per dollar tends to increase at a much faster rate than machine costs.

Better performance in terms of flexibility and reliability might also save you money over the long run despite the higher initial equipment cost incurred. Flexibility pertains to a reader's ability to read a variety of character fonts, as well as its rescan ability (i.e., ability to re-read a line of characters), paper-handling capability, and special format features. The ability to read only selected fields and to skip over crossed-out characters are two format features that are very useful in some applications.

Reader reliability is, of course, a fundamental criterion. The reliability of a character reader is measured by its reject and error rates. The reject rate is generally defined as the percentage of the total documents read which the reader rejects because it is unable to recognize one or more characters. The error rate refers to the percentage of documents

.7 ECONOMICS AND SELECTION CRITERIA (Contd.)

containing one or more characters which were incorrectly identified by the reader. The reject rates of present readers range from about 2% to 20%, while the error rates generally do not exceed 2%. The best way of judging the reliability of a character reader is to compare it with the error rate of the current keypunch operation which the machine is being considered to replace.

.8 TRENDS AND FUTURE DEVELOPMENTS

The scope of applications for character readers is currently limited primarily by their inability to read a variety of different fonts, by their poor performance on handwritten documents, and by the lack of standardization within the industry. Consequently, considerable development effort is being put into these areas, as well as into improvements in reliability and speed.

.81 Multi-Font Capabilities

The work being done on the development of multi-font character readers is taking the form of three basic approaches: manual, semi-automatic, and fully automatic.

The manual method consists of altering the recognition logic by manually replacing such machine parts as plugboards and optical masks. This method is low in cost but is clearly inadequate for reading a stack of documents in which the character fonts are mixed.

The semi-automatic approach consists of effecting changes in the recognition logic by means of operator controls. This means that either the machine must store all the different reference patterns that can occur, or the recognition parameters must be modified by means of a special-purpose control unit. The latter technique is used in the presently-available Philco-Ford 6000 Print Reader. Although it has the advantage of being flexible, it is expensive. The monthly rental for the Philco-Ford character reader is approximately $15,000, as compared with the typical rental charges of around $3,000 for first-generation character readers.

The automatic technique demands a recognition unit that can automatically sense a change in the character style and adjust itself to the change. This is really a self-adaptive or learning machine, a type of device that is still in the early experimental stages.

.82 Recognition of Handwriting

Since each individual has his own style of handwriting, it is difficult to set any recognition standards for handwritten characters that will not lead to a high reject rate. Consequently, this problem is even more preplexing than the multi-font recognition problem, because the recognition logic of the machine can never be set for a particular style.

The work being done on the recognition of handwritten characters can be divided into two classes: hand-printed characters and script. Some of the techniques currently being investigated in connection with handwritten documents are curve tracing, detection of selected features, and context recognition (which is discussed below). Although a number of companies are working on the problem, most of the work has been kept confidential. The primary customer for a reader capable of handling handwritten documents appears to be the U. S. Post Office Department.

Three companies presently offer machines capable of reading a limited hand-printed character set: Optical Scanning Corporation (OpScan 288), IBM Corporation (1287), and Recognition Equipment Corporation (ERCR).

.83 Improvements in Reliability

Naturally, reliability in the form of low error and reject rates is a prime consideration in all the development work being done on character readers. One approach that is being followed to reduce these rates is to improve the resolution of the scanning units and thereby increase the number of sample points from which the equipment can make an identification. As previously mentioned, Philco-Ford Corporation is using a cathode-ray tube that has a resolution of 2,000 optical lines. Even better resolution can be expected in the near future.

A longer-range approach to the reliability problem is the work being done on "context recognition." This is an attempt to simulate a human being's ability to read by context. When a person reads, the legibility of individual letters or even individual words is usually not critical. This is because human beings read letters within the context of the entire word and words within the context of the entire sentence. Consequently, the word "Ouic" in the phrase "Ouic and dirty" would easily be identified in context by most human readers as the word "Quick," even though the first letter of the word is an "O" and the last letter is missing.

The first thing needed to automate this process of context recognition is a group of fundamental rules that will aid the machine in identifying the characters on the basis of the context in which they are used. These context rules must be chosen to agree with the type of material being read. If a new application is added, then new rules should be instituted.

.83 Improvements in Reliability (Contd.)

Changes of these rules can be accomplished by utilizing either hardware (e.g., plugboards) or programming techniques.

Although context recognition is not yet sophisticated enough to become the major element of a recognition scheme, it can be used as a backup method for identifying illegible characters. The most obvious advantage is the ability to identify a complete word even if one or two characters present recognition difficulties. Context recognition will certainly involve an enormous increase in the storage capacity and logical capabilities of character readers, but this may be justified by the increase in efficiency that can be attained. However, the economics of context-recognition readers will remain highly speculative until considerably more development work has been undertaken.

Context recognition also promises to be useful in the problem of reading handwriting. It could be the basis of a technique for reading complete words rather than a character at a time. Again, it would radically increase the storage requirements and the cost for a reader, but the results might well be worth it. Again, the economics will remain unclear, pending additional development work.

.84 Improvement in Speed

Another, though less critical, area of development emphasis in character-reader engineering is speed. The major limitation on reading speed is the amount of time it takes to mechanically move the document past the reading station. Work now under way indicates that this limitation will be removed by overlapping the two functions of transporting and scanning documents. This is already being done in the Document Reader RCA 70/251 through the use of a vidicon scanner, which photographs an entire card-type document and performs the scanning function within the cathode-ray tube. This allows a new document to be moved into place while the previous one is being scanned. Speed can be further increased by the use of control logic that permits selective scanning; i.e., scanning only those areas of the document that contain pertinent information.

.85 Improvements in Standardization

The "jack of all trades, master of none" theory can certainly be applied to recognition logic facilities. Great sacrifices in reading reliability and increased costs result from having to recognize a multitude of font styles. The first giant step toward standardization, however, has taken place in the acceptance of the USASI standard character set for optical character recognition. Assuming that all subsequently designed OCR equipment contains facilities for reading this character set, the industry can expect greater cooperation from users of business forms and manufacturers of data processing equipment, and much progress is sure to result.

.86 Summary

Although the optical character recognition field is still relatively new, and much work remains to be done in improving equipment performance and developing more flexible readers at lower cost, the past year has seen some significant developments. Several multi-font readers are now available, and three machines capable of recognizing hand-printed characters has been introduced on the market. Reliability has improved significantly, with one manufacturer claiming reject rates of less than 1% and error rates of less than 0.1% in turnaround applications. As a result of the recently adopted USASI standard OCR font, a trend toward low-cost, single-font readers may take place concurrently with the development of larger multipurpose machines, introducing a wider cost spread than exists at present. If this happens, and a truly low-cost, reliable optical character reader results, we can expect to see OCR replacing punched cards as the primary computer input medium.

.9 THE COMPARISON CHART

The accompanying comparison charts summarize the significant characteristics of representative optical and magnetic character readers in terms of the type of document feed and transport unit, document size, document speed (documents/minute), types of scanners and recognition units, type font, character set, and reading speed. It should be noted that the indicated reading speed usually represents a maximum or potential speed; the actual speed is dependent on the size and number of documents being read.

COMPARISON CHART: OPTICAL CHARACTER READERS

IDENTITY		Control Data Corp. 915 Page Reader	Farrington Electronics Page Reader, Model 2030	Farrington Electronics Document Reader, Model 3010
DOCUMENT HANDLING	Document size, inches (width x length)	4.0 x 2.5 to 12.0 x 14.0	4.5 x 5.6 to 8.5 x 13.5	2.0 x 2.25 to 6.0 x 8.5
	No. documents/min.	180 lines/minute (approx.)	150-400 lines/minute	440
	Transport type	Conveyor belt	Drive rollers	Drive belt
	Feed mechanism	Vacuum	Vacuum	Friction
	Sorting facilities	Dual output stackers	Dual output stackers	Three output stackers
INPUT FORMAT	Max. characters/line	110	75	64
	Max. lines/inch	6	6	6
	Max. lines/pass	78	70	5
CHARACTER READING	Max. reading speed, characters/second	370	400	330
	Font styles read	USASI font	Selfcheck 12F and 12L	USASI, Selfcheck 12F, 12L, or 7B; IBM 1428
	Character set	Alpnameric	Alphameric	Alphameric
RECOGNITION	Scanning technique	Parallel photocells	Mechanical disc	Mechanical disc
	Recognition method	Matrix matching	Stroke analysis	Stroke analysis
FLEXIBILITY		Reads selective fields under control of computer program	Format control by plugboard, reads selective fields	Format control by plugboard, reads selective fields
ERROR CONTROL		Character display; marks documents; manual correction by keyboard entry, has rescan feature	Rescan feature, character display, manual correction by keyboard entry, marks documents	Rescan feature, data field check digit
OUTPUT		Data to computer; or punched cards, punched paper tape, or magnetic tape	Data to punched cards, punched paper tape, or magnetic tape	Data to computer, or punched cards, punched paper tape, or magnetic tape
OPERATING CONTROL		On-line with CDC 8090, 3000 Series, or 6000 Series computers	Off-line	Off-line, or on-line with any computer
SPECIAL FEATURES		Reads mark-sense	Underscore feature permits encoding of upper and lower case characters in output record	Batch header feature, mark-sensing head (optional); list-printer (optional)
APPROXIMATE PURCHASE PRICE		$84,000 (plus control unit and output unit)	$99,500	$99,500
AVAILABILITY		4 months	6 to 9 months	6 to 9 months
FIRST DELIVERY		November 1965	April 1967	September 1965

COMPARISON CHART: OPTICAL CHARACTER READERS (CONTD.)

IDENTITY		Farrington Electronics Optical Reader/Card Punch, Model 3020/3022	Farrington Electronics Page Reader, Model 3030	Farrington Electronics Journal Tape Reader, Model 3040
DOCUMENT HANDLING	Document Size, inches (width x length)	Standard 51 or 80 column tab cards	4.5 x 5.6 to 8.5 x 13.5	Journal tape, 1 to 350 ft x 1-5/16 to 4-9/16 inches
	No. documents/min.	550	150-400 lines/minute	400 lines/minute
	Transport type	Drive belt	Drive rollers	Drive rollers
	Feed mechanism	Friction	Vacuum	Journal spools
	Sorting facilities	Dual output stackers	Dual output stackers	—
INPUT FORMAT	Max. characters/line	65	75	32
	Max. lines/inch	6	6	6
	Max. lines/pass	1	70	—
CHARACTER READING	Max. reading speed, characters/second	600	400	1000
	Font styles read	USASI; Selfcheck 12F, 7B, IBM 1428, 1428E	USASI, Selfcheck 12F and 12L	Selfcheck 12F/12L, USASI, IBM 1428, NCR NOF
	Character set	Alphameric	Alphameric	Numeric plus alpha control symbols
RECOGNITION	Scanning technique	Mechanical disc	Mechanical disc	Flying spot
	Recognition method	Stroke analysis	Stroke analysis	Stroke analysis
FLEXIBILITY		Format control by plug-board, limited selectivity	Reads selective fields, operator programmable by software, formatting and editing facilities provided	Format control by plug-board or external computer program
ERROR CONTROL		No rescan feature; data field check digit; automatic insertion of correct character; punch check	Character display, marks documents, manual correction by keyboard entry, has rescan feature	Rescan feature, character display, keyboard insertion marks journal tapes
OUTPUT		Punches Hollerith code into input cards	Data to computer or punched cards, punched paper tape, or magnetic tape	Data to magnetic tape or computer
OPERATING CONTROL		Off-line	On-line with DMI 620 computer	Off-line, or on-line with any computer
SPECIAL FEATURES		Batch header feature; serial and sequential numbering, reads reverse image	Reads mark-sense, accumulates totals, extensive formatting and editing features	Journal tape header entry, magnetic tape label entry
APPROXIMATE PURCHASE PRICE		$100,500	$143,000	$107,000
AVAILABILITY		6 to 9 months	6 to 9 months	6 to 9 months
FIRST DELIVERY		December 1966	January 1967	March 1967

COMPARISON CHART: OPTICAL CHARACTER READERS (CONTD.)

IDENTITY		General Electric Co. Bar Font Reader, Model DRD 200	IBM 1282 Optical Reader Card Punch	IBM 1285 Optical Reader
DOCUMENT HANDLING	Document Size, inches (width x length)	2.75 x 4.0 to 3.875 x 8.0	Standard 51 or 80 column tab cards	Journal tape, 36 to 200 ft x 1-5/16 to 3-1/2 inches
	No. documents/min.	1200	200	2200 lines/minute
	Transport type	Drive belt	Clutch	Conveyor belt
	Feed mechanism	Vacuum	Friction	Vacuum
	Sorting facilities	Multistacker	Single stacker	—
INPUT FORMAT	Max. characters/line	65	32	32
	Max. lines/inch	6	10	6
	Max. lines/pass	1	1	—
CHARACTER READING	Max. reading speed, characters/second	2400	267	540
	Font styles read	GE COC-5 Bar Font	IBM 1428; Selfcheck 7B	IBM 1428, National Cash Register NOF
	Character set	Numeric	Numeric	Numeric
RECOGNITION	Scanning technique	Photocell	Mechanical disc	Flying spot
	Recognition method	Bar spacing analysis	Stroke analysis	Curve tracing
FLEXIBILITY		No format control; limited field selectivity	Reads selective fields, format control by plugboard program and program card on drum	Formatting under control of external computer program; limited field selectivity
ERROR CONTROL		No rescan feature; has error indicator	Selfcheck digits with automatic insertion of correct character, rescan feature	Rescan feature, character display with manual key-board entry, marks documents
OUTPUT		Data to computer	Punches Hollerith code into input cards	Data to computer
OPERATING CONTROL		On-line with GE-400 computer	Off-line	On-line
SPECIAL FEATURES		Mark-sensing feature; reads bar code	Reads mark-sense, reads reverse image	
APPROXIMATE PURCHASE PRICE		$56,000	$72,000	$84,000
AVAILABILITY		12 months	12 months	6 months
FIRST DELIVERY		2nd quarter, 1968	March 1965	September 1966

COMPARISON CHART: OPTICAL CHARACTER READERS (CONTD.)

IDENTITY		IBM 1287 Optical Reader	IBM 1418 Optical Character Reader	IBM 1428 Alphameric Optical Reader
DOCUMENT HANDLING	Document size, inches (width x length)	2.25 x 3.0 to 5.91 x 9.00 or journal tapes	2.75 x 5.875 to 3.67 x 8.75	3.5 x 2.25 to 8.75 x 4.25
	No. documents/min.	3200 lines/minute	420	400
	Transport type	Conveyor belt	Vacuum drum/conveyor belt	Vacuum drum/conveyor belt
	Feed mechanism	Vacuum	Friction	Friction
	Sorting facilities	Multistacker	Multistacker	Multistacker
INPUT FORMAT	Max. characters/line	85	80	80
	Max. lines/inch	6	10	10
	Max. lines/pass	—	2	2
CHARACTER READING	Max. reading speed, characters/second	2000	500	500
	Font styles read	IBM 1428, 1428E; Selfcheck 7B, 12F, 12L; USASI; NCR NOF; handprinted 3/16 Gothic	IBM 407-1, 407E-1	IBM 1428
	Character set	Numeric, plus 5 letters	Numeric	Alphameric
RECOGNITION	Scanning technique	Flying spot	Mechanical disc	Mechanical disc
	Recognition method	Curve tracing	Matrix matching	Matrix matching
FLEXIBILITY		Formatting under control of computer program; selective fields	Reads selective fields; format control by external computer program	Reads selective fields under control of computer only
ERROR CONTROL		Rescan feature, character display with manual keyboard entry, marks documents	Rescan feature, character display; keyboard insertion	Rescan feature, error checking by external computer program
OUTPUT		Data to computer	Data to computer	Data to computer
OPERATING CONTROL		On-line with IBM System/360 computer	On-line with IBM 1400 Series or System/360 computer, may be used off-line as 13-pocket sorter only	On-line with IBM 1400 Series or System/360 computers
SPECIAL FEATURES		Reads mark-sense; reads hand-printed digits 0-9 and 5 alphabetic control symbols	Reads mark-sense, reads reverse image	Reads mark-sense, reads reverse image
APPROXIMATE PURCHASE PRICE*		$144,000	$120,000 to 142,000	$150,000
AVAILABILITY		24 months	6 months	6 months
FIRST DELIVERY		2nd quarter 1968	October 1961	October 1962

COMPARISON CHART: OPTICAL CHARACTER READERS (CONTD.)

IDENTITY		National Cash Register 420-2 Optical Reader	Optical Scanning Corp. OpScan 288 Character Reader	Philco-Ford Corp. Model 6000 Print Reader
DOCUMENT HANDLING	Document size, inches (width x length)	Journal tape, 1.31 x 10 to 3.25 x 1200	3.5 x 2.5 to 8.5 x 4.5	3 x 5 to 8.5 x 14.0
	No. documents/min.	3120 lines/minute	200 to 600	180 to 360
	Transport type	Journal spools	Drive belt	Conveyor belt
	Feed mechanism	Rollers	Friction and vacuum	Vacuum
	Sorting facilities	—	Dual output stackers	Dual output stacker
INPUT FORMAT	Max. characters/line	32	80 (machine-printed), 25 (hand-printed)	90
	Max. lines/inch	4	3 (machine-printed); 2 (hand-printed)	6
	Max. lines/pass	—	3	78
CHARACTER READING	Max. reading speed, characters/second	1664	800	1250
	Font styles read	NCR (NOF)	USASI, E-13B, 1428, 407E, hand-printed (choice of one)	Multifont
	Character set	Numeric	Numeric plus C, N, S, T, X, Z, +, -	Alphameric, upper and lower case
RECOGNITION	Scanning technique	Mechanical disc	Photocells	Flying spot
	Recognition method	Matrix matching	Matrix matching	Matrix matching
FLEXIBILITY		Formatting, editing, and field-selection by plugboard program	Reads selective fields programmed by plugboard; reads intermixed fields	Selective fields; reads intermixed fonts within a document or batch; extensive formatting and editing features
ERROR CONTROL		Character display with manual keyboard entry; rescan feature, marks documents	Error character substituted for unreadable characters, no rescan feature	Character display with manual keyboard entry; marks documents
OUTPUT		Data to computer; or punched paper tape, tab cards, or magnetic tape devices	Magnetic tape, 7 or 9 track, 556/800 bpi	Magnetic tape, punched cards or paper tape, or data to computer
OPERATING CONTROL		On-line with NCR, IBM 1400 Series, or UNIVAC 9000 Series computers; or off-line	Off-line	Off-line
SPECIAL FEATURES		Header-line entry (Note: Model 420-1, which is half as fast as the 420-2, is now offered on an "as returned" basis at a price of $60,000)	Handles stock from 20 to 100 pounds; reads hand-printed characters	Reads mark-sense; reads punched holes. Header documents can be used for format specifications to program
APPROXIMATE PURCHASE PRICE		$80,000	$98,088	$450,000
AVAILABILITY		30 days	9 months	12 months
FIRST DELIVERY		February 1966 (420-2) November 1961 (420-1)	1st quarter 1968	May 1965

(Contd.)

COMPARISON CHART: OPTICAL CHARACTER READERS (CONTD.)

IDENTITY		Radio Corp. of America Videoscan III Document Reader	Recognition Equipment Electronic Retina Document Carrier	Recognition Equipment Electronic Retina Rapid Index Page Reader
DOCUMENT HANDLING	Document size, inches (width x length)	2.5 x 4.0 to 2.5 x 8.5	3.25 x 3.25 to 4.25 x 8.50	3.25 x 3.25 to 14.0 x 14.0
	No. documents/min.	1800	1200	24
	Transport type	Conveyor belt/drum	Conveyor belt	Vacuum drum
	Feed mechanism	Vacuum	Vacuum	Vacuum
	Sorting facilities	Dual output stacker	Multistacker	Multistacker
INPUT FORMAT	Max. characters/line	80	90	150
	Max. lines/inch	6	8	8
	Max. lines/pass	1	2	100
CHARACTER READING	Max. reading speed, characters/second	1500	2400	2400
	Font styles read	RCA N-2	Multifont, handprinted	Multifont, handprinted
	Character set	Numeric	Alphameric, upper and lower case	Alphameric, upper and lower case
RECOGNITION	Scanning technique	Vidicon scanner	Parallel photocells (Retina)	Parallel photocells (Retina)
	Recognition method	Stroke analysis	Matrix matching	Matrix matching
FLEXIBILITY		Limited field selectivity under control of external computer program	Selective fields; extensive editing and formatting features under control of internal program	Selective fields; extensive editing and formatting features under control of internal program
ERROR CONTROL		Error character substituted for unreadable characters, reject stacker	Programmable actions, rescan features, sorts documents into error stacker	Programmable actions, rescan features; marks documents
OUTPUT		Data to computer	Any peripheral device using magnetic tape, punched cards, or paper tape	Any peripheral device using magnetic tape, punched cards, or paper tape
OPERATING CONTROL		On-line with RCA Spectra 70 computers	Off-line; self-contained software	Off-line; self-contained software
SPECIAL FEATURES		Reads mark-sense; reads holes	Reads mark-sense, reads bar-code; accumulates totals	Reads mark-sense; reads bar-code; accumulates totals
APPROXIMATE PURCHASE PRICE		$126,900	$550,000	$550,000
AVAILABILITY		24 months	6 to 12 months	6 to 12 months
FIRST DELIVERY		4th quarter 1966	December 1964	November 1964

COMPARISON CHART: MAGNETIC CHARACTER READERS

IDENTITY		Burroughs B102/103 Sorter-Readers	General Electric Co. MRS200 Document Reader	IBM 1259 Magnetic Character Reader
DOCUMENT HANDLING	Document size, inches (width x length)	2.69 x 5.94 to 4.06 x 9.06	2.5 x 5.25 to 4.1 x 9.0	2.5 x 4.14 to 5.5 x 8.75
	No. documents/min.	1,565	1,200	600
	Transport type	Conveyor belt	Conveyor belt	Conveyor belt and roller
	Feed mechanism	Friction	Vacuum	Friction
	Sorting facilities	13 output stackers	12 output stackers	11 output stackers
INPUT FORMAT	Max. characters/line	59	64	66
	Max. lines/pass	1	1	1
CHARACTER READING	Max. reading speed, characters/second	1,300	1,800	1200
	Font styles read	E-13B	E-13B COC-5	E-13B, CMC-7
	Character set	Numerals, four control symbols	Numerals, four control symbols	Numeric + 4 symbols
RECOGNITION	Scanning technique	Magnetic	Magnetic	Analog waveform
	Recognition method	Analog waveform matching	Analog waveform matching	Matrix matching
FLEXIBILITY		Splits fields using control symbol	Early character reader turnoff; reads COC-5 intermixed with E-13B	Split fields using control symbol.
ERROR CONTROL		Validity check, signal level amplification check	Validity check	Validity check; timing check.
OUTPUT		Sorted input documents and/or data directly to computer, if used on-line	Sorted input documents and/or data directly to computer, if used on-line	Data to computer
OPERATING CONTROL		Off-line, or on-line with B100/B200/B300 and B2500/B3500 computers	Off-line, or on-line with GE-400 Series computers	On-line with System 360/20, 360/30, or 360/40; or off-line for sorting only.
SPECIAL FEATURES		Automatic code translation; handles intermixed sizes, 16-pocket version available	Automatic code translation; handles intermixed sizes; endorsing feature; reads COC-5 optically; TCD verification; missing digit detection; multiple digit selection	Automatic code translation, handles intermixed sizes.
APPROXIMATE PURCHASE PRICE		$91,200	$80,000	$49,500 (Mod. 1) $63,000 (Mod. 2)
AVAILABILITY		12 months	6 months	9 months
FIRST DELIVERY			March, 1962	July, 1968

(Contd.)

COMPARISON CHART: MAGNETIC INK CHARACTER READERS (CONTD.)

IDENTITY		IBM 1412 Magnetic Character Reader	IBM 1419 Magnetic Character Reader	NCR 402 MICR Sorter-Reader
DOCUMENT HANDLING	Document size, inches (width x length)	2.75 x 6.0 to 3.67 x 8.75	2.75 x 6.0 to 3.76 x 8.75	2.5 x 5.25 to 4.5 x 10.0
	No. documents/min.	1600	1,515	750
	Transport type	Conveyor belt	Conveyor belt	Conveyor belt
	Feed mechanism	Friction	Friction	Friction
	Sorting facilities	13 output stackers	13 output stackers	12 output stackers
INPUT FORMAT	Max. characters/line	66	40	56
	Max. lines/pass	1	1	1
CHARACTER READING	Max. reading speed, characters/second	2,112	2,112	1,200
	Font styles read	E-13B, CMC-7	E-13B	E-13B
	Character set	Numerals, four control symbols	Numerals, four control symbols	Numerals, four control symbols
RECOGNITION	Scanning technique	Magnetic	Magnetic	Magnetic
	Recognition method	Matrix matching	Matrix matching	Analog waveform matching
FLEXIBILITY		Splits fields using control symbol	Splits fields using control symbol	Splits fields using control symbol
ERROR CONTROL		Validity check; timing check.	Validity check, timing check	Validity check; timing check
OUTPUT		Data directly to computer	Sorted input documents and/or data directly to computer, if used on-line	Sorted input documents and/or data directly to computer, if used on-line
OPERATING CONTROL		On-line, with IBM 360/30, 40, 50, and 65 computers; or off-line for sorting only.	Off-line or on-line with IBM System 360/30 or 360/40 computers	Off-line, or on-line with NCR 315, 315-100, or 315 RMC computers
SPECIAL FEATURES		Automatic code translation; handles intermixed sizes	Automatic code translation; handles intermixed sizes	Automatic code translation, handles intermixed sizes
APPROXIMATE PURCHASE PRICE		$110,500	$110,500	$45,000
AVAILABILITY		9 months	14 months	Available on an as-returned basis.
FIRST DELIVERY		October, 1962	October, 1962	April, 1962

COMPARISON CHART: MAGNETIC INK CHARACTER READERS (CONTD.)

IDENTITY		NCR 404 MICR Sorter-Reader	NCR 407 MICR Sorter-Reader
DOCUMENT HANDLING	Document size, inches (width x length)	2.5 x 5.8 to 3.85 x 8.75	2.75 x 4.0 to 4.5 x 8.75
	No. documents/min.	600	1,200
	Transport type	Rollers	Conveyor Belt
	Feed mechanism	Friction	Vacuum
	Sorting facilities	11 output stackers	18 output stackers
INPUT FORMAT	Max. characters/line	65	56
	Max. lines/pass	1	1
CHARACTER READING	Max. reading speed, characters/second	1,200	2,400
	Font styles read	E-13B	E-13B
	Character set	Numerals, four control symbols	Numerals, four control symbols
RECOGNITION	Scanning technigue	Magnetic	Magnetic
	Recognition method	Matrix matching	Analog waveform matching
FLEXIBILITY		Splits fields using control symbol	Splits fields using control symbol
ERROR CONTROL		Validity check, timing check	Validity check, timing check
OUTPUT		Sorted input documents and/or data directly to computer, if used on-line	Sorted input documents and/or data directly to computer, if used on-line
OPERATING CONTROL		Off-line, or on-line with NCR 315 or 315-100 computers	Off-line, or on-line with NCR 315, 315-100, or 315 RMC computers
SPECIAL FEATURES		Automatic code translation; handles intermixed sizes	Pocket pullout; plugboard programmable off-line; batch number advance in endorser; endorser; field validation; valid amount, transaction code stop; automatic code translation
APPROXIMATE PURCHASE PRICF		$29,900	$95,000
AVAILABILITY		6 months	6 months
FIRST DELIVERY		October 1966	January 1966

SPECIAL REPORT

DECISION TABLES: A STATE-OF-THE-ART REPORT

by

the Technical Staff of
AUERBACH Info, Inc.

DECISION TABLES-THEIR GENERAL CONSTRUCTION AND ACCEPTANCE IN PROGRAMMING

In 1957, decision tables were applied to problem formulation for computer programming for the first time. Since then, much progress has been made in defining the concept for computer applications. This includes refinement of methods and procedures for constructing and checking decision tables for completeness and accuracy. Although limited, some techniques have been implemented for converting decision tables to computer programs.

Though the existing literature almost unanimously describes the advantages and significant value of decision tables, they have not received wide acceptance. Yet, during the same time period, FORTRAN, COBOL, and many other problem oriented programming languages have been developed, widely accepted, and used.

Numerous reasons seem to account for this. One is that programmers and system analysts are taught flow charting as the conventional method used in formulating a logical solution to a problem, and decision tables compete with this. A second reason is that decision tables are not well suited for scientific or mathematic applications which comprise a large portion of computer usage. Finally, it is seldom that a computer application can be formulated entirely in terms of decision tables.

Thus, the decision table technique must be supplemented with a compatible formulation technique to enable computer application, at the present time, no such technique has been developed.

Many of the advantages of decision tables coincide with current problem areas in the use of computers for business applications, such as formulation and documentation. Decision tables provide an effective means of communication between people in and out of the data processing field, in defining both problems and their logical solutions. They provide a concise and compact form of definition and description suitable for use in analysis, programming, and documentation. The extent and nature of the changes required to update or revise an applications program is provided by their unique form of problem statement.

However, the state-of-the-art has not advanced sufficiently to enable economic realization of these advantages. Though some parts of a problem may be suitable for decision tables, no technique has been developed which includes decision tables as a part of the formulation of the entire problem. Decision table languages developed for use in programming are too restrictive, thus losing many of the initial decision table advantages, or they produce object programs which are not economical in core storage requirements and running time.

Problem oriented languages, such as FORTRAN and COBOL, are more natural to the programmer than machine oriented languages, and thus make applications programming machine independent. Now, a language is needed that will assist in stating the application logically and help the programmer obtain optimum logical flow in the solution. A possible method is the use of decision tables for problem definition and formulation.

What Is A Decision Table?

Basically, a decision table is a tabular representation of data arranged in a particular form to assist in making decisions. The two categories used are "action" and "condition". The form must take into consideration the rules specifying each action, and the specific value of each condition.

Decision tables are conventionally represented by a rectangle divided into four quadrants, separated by double lines, as shown in Figure 1. These areas are known as "conditions stub", "conditions entry", "action stub", and "action entry". Each contains a listing of all appropriate information relating to the problem. The horizontal items are called rows; the vertical items are called rules. This is illustrated in Figure 2.

A row is a condition statement which may be Y (yes), N (no), don't care, or an extension of the condition, as in Figure 3. If a row contains only Y, N, and don't care, it is called a "limited-entry" row; otherwise, it is an "extended-entry" row.

A rule is a set of condition values and the associated set of actions. If all condition values are specifically stated, it is a "simple" rule; otherwise (when don't care values are included), it is a "complex" rule. Conventionally, rules are numbered across the top from left to right and are tested in that order.

When all sets of condition values satisfy two rules, and actions are identical in both, the rules are redundant; if the actions are different, the rules are contradictory.

The combinations of rules determine whether a decision is "perfect" or "imperfect". If all possible combinations of condition values are covered by the rules of the table, it is "perfect";

CONDITION STUB	CONDITION ENTRY
ACTION STUB	ACTION ENTRY

Figure 1: Quadrants of a Decision Table

Statement	Rule 1	Rule 2	Rule 3
Condition Row 1			
Condition Row 2			
Condition Row 3			
Condition Row 4			
Action Row 1			
Action Row 2			
Action Row 3			

Figure 2: Items of a Decision Table

Age	<25	25	>25
Salary range	Below $10K	$10 - $20K	Over $20K
Bell is	Alarm	Phone	Door
Code equals	A	B	C
Go to	Work	Conference	Hideout

Figure 3: Examples of extended entry rows

otherwise, it is "imperfect". In an "imperfect" decision table, the last rule must be null (all "don't care" values). This specifies the action taken when the condition values do not satisfy any other rule.

Therefore, decision tables are identified by these three characteristics:

1. rows (horizontal)
   a.) limited entry
   b.) extended entry
   c.) mixed entry
2. rules (vertical)
   a.) simple
   b.) complex
3. complement of rules
   a.) perfect
   b.) imperfect

Though many combinations of the above are possible, the characteristics usually are mixed entry, complex, imperfect; when a decision table is referred to, this is the norm. Otherwise, the deviations are specified (e.g., limited-entry decision table).

A new concept introduced in this paper is that of a generic rule, which covers the specific values in a "complex rule". As noted above, a "complex" rule is one where any "don't care" values appear. In this case, the remaining specific values form the generic rule. In Figure 9, the generic rule consists of the last two condition values of rule 1, Y, N. Figure 10 illustrates this more completely by showing rules 1a through 1d as the complete family of rules for the generic rule 1 of Figure 9.

Decision Table Construction

The most basic decision table is limited — entry, simple, perfect, such as Figure 4. Ordering of rows, rules, and actions are completely irrelevant to the proper solution of the problem. Construction of such a table is simply an orderly listing of all relevant conditions, actions and rules. Any decision table can be expanded into this type, and conversely, the smallest decision table formulating a problem can be derived from a limited-entry, simple, perfect table. However, a limited-entry, simple, perfect decision table containing N conditions must have 2^N rules. Usually, this is too many for practical workability.

Therefore, the table must be broken down; two methods of doing this are proposed. The first is to divide the table into a number of smaller, interrelated tables. In addition to being easy to do, this method retains most of the advantages of working with a limited-entry, simple, perfect decision table. However, the work load is increased slightly, and the entire problem cannot be seen at one time. A more sophisticated approach to this method is parsing the original table; the success of this depends on the skill of the analyst.

	1	2	3	4	5	6	7	8
Is phone ringing	Y	Y	Y	Y	N	N	N	N
Is alarm clock ringing	Y	Y	N	N	Y	Y	N	N
Is door bell ringing	Y	N	Y	N	Y	N	Y	N
Turn off alarm clock	X	X			X	X		
Answer Phone	X	X	X	X				
Answer Door	X		X		X		X	
Ignore								X

Figure 4: Example of a limited-entry simple perfect decision table

The second solution is to construct a higher-level type table, which makes the learning of decision table techniques almost equivalent to those of flowcharting. Factors requiring constant attention must be kept in mind when constructing such a sophisticated type table. For example, Figure 5 shows a mixed-entry, simple, imperfect decision table. The values of the second condition are not mutually exclusive, and a rule covering combinations does not exist. Therefore, it does not contain a perfect rule set.

The most effective way to reduce the number of rules is to reduce the number of stated conditions and use extended-entry rows. However, in re-wording statements, care must be taken not to introduce any meaningful change in the scope of the problem. In using extended-entry rows, condition values must be mutually exclusive, or an action for reentering the table must be included. Figures 6, 7 and 8 illustrate these points.

This can result in significant savings in the number of rules. For example, a decision table with N extended-entry conditions and three values for each condition contains 3^N rules. If each pair of limited-entry conditions can be combined into a single extended-entry condition, a table with eight conditions requiring 256 rules could be reduced to a table with four conditions and 81 rules.

In general, the number of rules contained in an extended-entry, simple, perfect decision table is the product of all M^N values, where M is the number of possible condition values, and N is the number of condition statements having exactly M condition values.

Another method of reducing rules, and consequently the size of the decision table, is to state complex rules. However, this is difficult to implement, since the order in which the rules are stated is of significant importance.

To combine rules into a complex rule, it is necessary that their action sets be identical. If two or more rules have identical action sets, they can be combined into a single complex rule by substituting a "don't care" value for all Y and N condition values.

Though the above applies to limited-entry tables, a complex rule can be created for an extended-entry table in the same manner if the rules being combined have a generic rule and do not include all possible values for the remaining conditions. Figures 9 through 12 illustrate this method.

The final way to reduce the rules contained in a decision table is to construct an imperfect decision table, by establishing the extreme right rule as a null rule, (sometimes referred to as the else rule). <u>All</u> condition values of the null rule are "don't care", and the actions specified are those to be taken when no previous rule is satisfied. This poses no problem in construction, except for ascertaining that the preceding rules cover all sets of conditions for which the action set differs from that specified in the null rule.

In summary, the construction of proper decision table requires a complete set of conditions and actions be known or developed during the construction process. The construction process is simple with the significant exception of the use and placement of complex rules. The sequence in which conditions are tested and actions taken within a rule is not a property of any type of decision table. However, the sequence in which rules are stated is important for complex decision tables. Finally, successful construction and interpretation of most decision tables hinges on the understanding of the concept of a generic rule, as related to the interpretations of "don't care" values in complex rules.

	1	2	3	4
Is Bell ringing	Y	Y	Y	
Bell is at least	Alarm	Phone	Door	—
Turn off alarm	X			
Answer phone		X		
Answer door			X	
Ignore				X
Reenter table	X	X	X	
Go back to sleep				X

Figure 5: Example of a mixed-entry simple imperfect decision table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Salary <10K	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Salary ≥10K	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	N	N	N
Yrs. of Service <5	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N
Yrs. of Service ≥5	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Record in File A		X			X	X	X	X		X				X		
Record in File B			X				X		X	X	X	X			X	
Record in Error File	X	X	X	X	X			X	X			X	X	X	X	X

Figure 6: Limited-entry decision table of hypothetical problem

	1	2	3	4	5	6	7	8	9
Salary (<10, ≥10, I)	<10	<10	<10	≥10	≥10	≥10	I	I	I
Yrs. of Service (<5, ≥5, I)	<5	≥5	I	<5	≥5	I	<5	≥5	I
Record in File A	X	X	X	X			X		
Record in File B		X		X	X	X		X	
Record in Error File			X			X	X	X	X

(I = Indeterminent)

Figure 7: Extended-entry decision table of hypothetical problem

	1	2	3	4	5	6	7	8
Salary <10K or Service <5 yrs.	Y	Y	Y	Y	N	N	N	N
Salary ≥10K or Service ≥5 yrs.	Y	Y	N	N	Y	Y	N	N
Salary or Service Indeterminate	Y	N	Y	N	Y	N	Y	N
Record in File A	X	X	X	X				
Record in File B	X	X			X	X		
Record in Error File	X		X		X		X	
Impossible								X

Figure 8: Decision table of hypothetical problem with conditions restated

(Contd.)

INCORRECT:
Rule 1 is incorrectly placed in FIG. 9.
Its expansion in FIG. 10 leads to a contradiction in the decision table.

	1	2	3	4	5	6	7	8	9
Salary < 10K	-	Y	Y	N	N	-	Y	N	-
Salary ≥ 10K	-	N	N	Y	Y	-	N	Y	-
Yrs of Service < 5	Y	Y	N	Y	N	N	-	-	-
Yrs of Service ≥ 5	N	N	Y	N	Y	Y	-	-	-
Record in File A	X	X	X	X			X		
Record in File B			X	X	X	X		X	
Record in Error File	X					X	X	X	X

FIGURE 9:

	1a	1b	1c	1d	2	3	4	5	6	7	8	9
Salary < 10K	Y	Y	N	N	Y	Y	N	N	-	Y	N	-
Salary ≥ 10K	Y	N	Y	N	N	N	Y	Y	-	N	Y	-
Yrs of Service < 5	Y	Y	Y	Y	Y	N	Y	N	N	-	-	-
Yrs of Service ≥5	N	N	N	N	N	Y	N	Y	Y	-	-	-
Record in File A	X	X	X	X	X	X	X			X		
Record in File B						X	X	X	X		X	
Record in Error File	X	X	X	X					X	X	X	X

FIGURE 10:

CORRECT:
The rules are correctly ordered in FIG. 11; consequently, the expansion of rule 5, including the remaining values of condition rows 1 and 2 with respect to the generic rule, results in FIG. 12 which illustrates a proper creation of a complex rule for an extended-entry decision table.

	1	2	3	4	5	6	7	8	9
Salary < 10K	Y	Y	N	N	-	-	Y	N	-
Salary ≥ 10K	N	N	Y	Y	-	-	N	Y	-
Yrs of Service < 5	Y	N	Y	N	Y	N	-	-	-
Yrs of Service ≥5	N	Y	N	Y	N	Y	-	-	-
Record in File A	X	X	X		X		X		
Record in File B		X	X	X		X		X	
Record in Error File					X	X	X	X	X

FIGURE 11:

	1	2	3	4	5a	5b	6	7	8	9
Salary <10K	Y	Y	N	N	Y	N	-	Y	N	-
Salary ≥10K	N	N	Y	Y	Y	N	-	N	Y	-
Yrs of Service < 5	Y	N	Y	N	Y	Y	N	-	-	-
Yrs of Service ≥ 5	N	Y	N	Y	N	N	Y	-	-	-
Record in File A	X	X	X		X	X		X		
Record in File B		X	X	X			X		X	
Record in Error File					X	X	X	X	X	X

FIGURE 12:

The Use of Decision Tables in Programming

There are three primary problems relating to the current use of decision tables in programming. The first is the problem of training analysts and programmers to construct and interpret all types of decision tables. The second is the problem of developing a formulation technique which includes decision tables, and permits formulation of that part of the problem which is inappropriate for formulation by decision tables. The third is that of converting a decision table into a computer program.

Although much work has been done on converting decision tables into computer programs, this problem is not yet solved and is still a major obstacle. Manual conversion poses the least constraints on the decision table construction, but loses all of the advantages attendant to high-order languages such as COBOL and FORTRAN. Compiler pre-processors which accept decision tables, such as the DETAB/65 pre-processor for COBOL, have been developed, as have decision table compilers, such as TABSOL. However, both of these methods of conversion tend to place such restrictions on decision tables that most of their advantages and flexibility are lost.

A further complication is the fact that while sequencing of condition testing and actions taken is immaterial to the decision table, sequencing can have a significant influence on the efficiency of the program generated. This is particularly true in terms of running time. Thus, special attention must be paid to this point, either during the decision table construction phase, during the conversion phase, or both. Otherwise, the resulting program may be significantly less efficient than a program generated by another technique, and therefore more costly in the end.

Pending a solution of the conversion problem, very little work has been done on the first two problems. This appears to be primarily due to the fact that a solution to the conversion problem is necessary for the effective use of decision tables in programming and thus it has overshadowed all other problems.

Conclusions

The construction of a decision table per se is not as difficult as some analysts and programmers claim. The significant difficulty is the concern for efficient object programs, and the requirements of existing decision table pre-processors and compilers. Also, a supplementary formulation technique must be employed in order to develop the problem at hand. Therefore, many analysts and programmers are not motivated to learn the decision table technique because of the limited number of instances in which it presents them with a significant advantage.

The communication of a problem and its solution is of significant concern within the computer industry currently. Here the advantage of decision tables over existing techniques is very significant. English narratives and program flow-charts of complex problems are difficult to prepare, and easy to misinterpret; their length often precludes easy and complete cross-referencing. Both reflect the capabilities of their creator, and neither can incorporate changes easily. Decision tables virtually eliminate these problems. But this is more of an advantage to management than to the analyst or programmer. Therefore, the use of decision tables to gain this advantage must be imposed by management; then, management must pay the currently high conversion and operating costs.

It is expected that work toward solving the problems relative to using decision tables in programming will continue. However, decision tables will not enjoy wide acceptance until a significant breakthrough occurs in the area of automatically converting decision tables into efficient object programs. That is, until analysts, programmers, or managers can obtain a consistent and general net advantage from the use of decision tables as a problem formulation technique.

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MAGNETIC TAPE RECORDING: A STATE-OF-THE-ART REPORT

by

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MAGNETIC TAPE RECORDING: A STATE-OF-THE-ART REPORT

.1 INTRODUCTION

Recently-compiled evidence indicates that reports of the death of magnetic tape were premature and greatly exaggerated.

When the swing toward removable disk packs began, there were numerous predictions that this new glamour medium would soon displace magnetic tape from its long-held position as the primary high-speed computer input-output medium. Now that the dust has settled, it is clear that peaceful coexistence between tape and disk packs is possible and, from the computer user's viewpoint, highly desirable. It is equally clear that magnetic tape will continue to be a vitally important computer I/O medium for many years to come, in a wide variety of both new and conventional applications.

This Special Report broadly surveys the current state of the art in magnetic tape recording. Starting with an objective analysis of the relative merits of magnetic tape and disk packs, it goes on to describe some important new uses for magnetic tape, the characteristics and behavior of the tape itself, the techniques used to record and verify data on tape, the characteristics of current tape handlers, and the future prospects for magnetic tape. Thorough reading of this report will update and enhance an understanding of what magnetic tape can do, how it's done, and how it can be used most effectively in a computer installation.

.2 MAGNETIC TAPE VERSUS DISK PACKS

The advent of the disk pack has unquestionably exerted a significant braking effect upon the growth rate of magnetic tape sales and usage. Introduced by IBM with the 1311 Disk Storage Drive in 1962, the removable disk pack has, during the past year, become the glamour medium of the EDP field. Control Data, GE, Honeywell, RCA, and UNIVAC all currently offer "IBM-compatible" disk storage drives for their computer systems, and more than a dozen companies are now marketing disk packs which are interchangeable with the original IBM 1316 Pack.

Disk packs offer most of the benefits of magnetic tape — large on-line data capacity, high data transfer rate, rapid interchangeability, and convenient storage and handling — plus the one highly significant additional feature that has been mainly responsible for their enthusiastic acceptance: rapid random access to all of the data stored on the disks. What can magnetic tape offer to compete against all these appealing disk pack attributes? The answer is a matter of straightforward economics.

Table I has been prepared to illustrate some of the key functional and economic aspects of both magnetic tape and disk pack storage. It compares the capacity, performance, and cost of both types of storage as used in third-generation computer systems. For consistency, all characteristics and costs are based upon current IBM equipment. Three different cases using magnetic tape and two cases using disk packs are evaluated.

The table is largely self-explanatory, and it clearly indicates that disk pack storage is a very expensive and hard-to-justify luxury in any installation where its rapid random access capability cannot be used advantageously. As the table shows, the two storage media tend to be quite similar with respect to on-line data storage capacity, data transfer rate, and sequential access time (i.e., the time required to access the block of information located immediately adjacent to the block just read). When random accessing is required, several minutes of tape passing time may be required to reach the required record, and the disk packs are faster by several orders of magnitude.

But the continued prosperity of the magnetic tape industry is virtually assured by the figures in the cost rows in Table I. These figures show that the cost per million bytes of data stored is lower for tape than for disk packs by a factor that ranges from 3.5 to 65, depending upon the specific cases chosen for comparison.

TABLE I: COMPARISON OF TAPE AND DISK PACK STORAGE CHARACTERISTICS

Storage Medium	200-bpi tape (2400-foot reel)	800-bpi tape (2400-foot reel)	1600-bpi tape (2400-foot reel)	IBM 1316 Disk Pack	IBM 2316 Disk Pack
Assumed drive unit	IBM 2415-1 Magnetic Tape Unit	IBM 2401-2 Magnetic Tape Unit	IBM 2420-7 Magnetic Tape Unit	IBM 2311-1 Disk Storage Drive	IBM 2314 Direct Access Storage
Assumed block length, bytes	3,625	3,625	3,625	3,625 (1 track)	3,625 (1/2 track)
Total data storage capacity, bytes	5,500,000	20,000,000	36,000,000	7,250,000	29,000,000
Data transfer rate, bytes/sec	3,750	60,000	320,000	156,000	312,000
Average random access time, msec	760,000	190,000	71,000	87.5	87.5
Average sequential access time, msec	40	8	2	12.5 (1/2 rev.)	12.5 (1/2 rev.)
Typical cost of storage medium	$35	$35	$37	$490	$650
Cost per million bytes stored	$6.37	$1.75	$1.03	$67.50	$22.30

.2 MAGNETIC TAPE VERSUS DISK PACKS (Contd.)

Thus, it seems clear that magnetic tape is to be preferred wherever sequential processing techniques can be used effectively and a large amount of information must be stored off-line. Conversely, disk packs combine most of the functional characteristics of magnetic tape with the rapid random access capability that is vital in many of today's applications — though at a substantially higher cost per character stored.

Each of the two media has its own unique advantages, and the applications and sales of both media are likely to continue to increase steadily during the years to come. In fact, computer systems using both disk pack drives — for random processing applications — and magnetic tape handlers — for economical handling of large sequential files — will probably become increasingly common as computer users become more familiar with the cost-effectiveness relationships between the two media.

.3 NEW USES FOR MAGNETIC TAPE

Since the earliest days of the computer industry, magnetic tape has been accepted as the principal input-output medium for applications that require fast data transfer rates and large off-line storage capacities. During the last few years, some important new classes of applications have opened up for magnetic tape. These new uses, described in the following paragraphs, should help to ensure the continued prosperity of the magnetic tape industry.

.31 Keyboard-to-Tape Encoding

For many years, an often-heard question among computer users was "Why doesn't somebody build a machine that will let us encode data directly onto magnetic tape from a keyboard?" Such a device would make it unnecessary to keypunch, verify, and transcribe punched cards as an intermediary between source documents and the magnetic tape that was ultimately required for high-speed input to a computer. But early attempts to encode data directly onto magnetic tape had proved to be impractical, and the case appeared to be closed insofar as the major manufacturers of data processing equipment were concerned.

In 1964 a newly-formed company called Mohawk Data Sciences Corporation met the problem head-on and announced the 1101 Keyed Data-Recorder. The 1101 writes keyed-in data on magnetic tape at 200 bits per inch in a format compatible with the IBM 729 Magnetic Tape Units and the tape handlers used in most other second-generation computers. Moreover, the same unit can be used to verify the accuracy of previously recorded data.

(Contd.)

.31 Keyboard-to-Tape Encoding (Contd.)

Initial deliveries of the Mohawk Data-Recorders were made in April 1965, and customer response was enthusiastic (1, 2). Since then, the Mohawk product line has been expanded to include both 7-track and 9-track Data-Recorders, as well as models equipped with auxiliary input or output units, special controls, and communications interfaces. The Mohawk Data-Recorders are also marketed by the National Cash Register Company as the NCR 735 Magnetic Tape Encoders.

Mohawk has convincingly demonstrated the practicality and economic advantages of keyboard-to-tape encoding. Users cite significant cost savings through increased operator productivity, elimination of card costs, reduced down-time, and increased computer throughput (1). As a result, it seems likely that punched cards will gradually be phased out of most computer installations that do not actually require a machine-processable unit record of each transaction.

The Honeywell Keytape units, announced in January 1968, are functionally similar to the Mohawk Data-Recorders, though Honeywell claims improved performance through features such as higher tape speed, vacuum-drive tape handler, take-up reel (vs. Mohawk's tape bin), improved displays, and simplified operation. Honeywell, like Mohawk, offers a broad range of models for both 7- and 9-track IBM-compatible tape. As an indication of the potential size of the market for keyboard-to-tape encoders, Honeywell points out that between 350,000 and 500,000 keypunches are now in use, representing a yearly rental income of up to $450 million for IBM.

Sangamo Electric Company announced a line of Data Stations at the Spring Joint Computer Conference last April. Sangamo's machines are functionally similar to the Mohawk and Honeywell units and are offered in a similar range of models. Their chief advantage is a continuous alphanumeric display of the present location and the content of the data in the machine's buffer memory.

The IBM 50 Magnetic Tape Inscriber, also introduced in April 1968, differs from the Mohawk, Honeywell, and Sangamo units in that it uses special magnetic tape cartridges that are not compatible with standard 7- or 9-track tape handlers. These cartridges can be read into a System/360 computer at the comparatively slow speed of 900 characters per second by the 2495 Tape Cartridge Reader, which was announced concurrently. The tape cartridges are identical with those used by the IBM Magnetic Tape Selectric Typewriter. Nine tracks are recorded across the tape's 16-millimeter width at a density of 20 characters per inch. The capacity of each cartridge is 23,000 characters. One significant advantage of the IBM 50 Inscriber is its capability to store eight different format programs, any one of which may be selected by the operator.

Communitype and Tally Corporation also market keyboard-to-tape encoders, though both these units were designed primarily for data communications applications and record on "non-compatible" tape. Other entries into this burgeoning new market can be expected soon.

.32 Source Data Automation

Magnetic tape is one of the very few input-output media that can come reasonably close to keeping up with the high internal processing speeds of digital computers. It permits large quantities of information to be stored in a highly compact form. Moreover, the tape itself is relatively inexpensive and can be reused many times.

For all of these reasons, magnetic tape would be a highly desirable output medium for equipment used to record data describing events or transactions at the time and place where they occur. Yet few of the source data automation devices currently on the market use magnetic tape. Computer-compatible digital recording equipment has generally been considered too complex, too bulky, and too expensive for practical use in connection with individual cash registers, typewriters, or other point-of-transaction devices.

Some recent developments point to a change in this situation and indicate that magnetic tape will soon occupy a key position in the mushrooming field of source data automation.

Magnetic tape is being used effectively as the output medium in many transmitting data collection systems, in which the data entered at multiple input stations is transmitted via cables or communications lines to a central recording unit. The data transmitted from all

.32 Source Data Automation (Contd.)

the input stations can be captured on a single reel of tape and then read into a computer system at high speeds.

Some source data automation equipment records its output on narrow, low-density tape that is not suitable for direct input to computer systems. An example is the Digitronics Data-Verter system, which records adding-machine data on 1/4-inch tape for later transmission to a remote computer system. This type of magnetic tape has many of the same advantages and disadvantages as punched paper tape, plus two significant additional features: the tape is usually supplied in conveniently interchangeable cartridges, and it can be reused indefinitely.

Peripheral equipment manufacturers are striving to perfect low-priced magnetic tape recorders that can handle computer-compatible tape. Potter Instrument Company recently announced the ME-4210, a desk-top incremental magnetic tape unit that records up to 60 characters per second asynchronously at 200 bits per inch on IBM-compatible tape. The price of this unit, complete with electronics and power supply, is said to be less than $1,400 in production quantities. Ampex Corporation offers a line of Buffered Tape Memories designed primarily for data acquisition applications. The buffers in these units make it possible to record data from real-time processes in formats that are suitable for direct input to computers.

.33 Information Interchange

Magnetic tape has long served as an effective medium for interchanging information between different computers or different locations within individual corporations. Now its role is expanding to include broader types of information interchange. In these new applications, the compactness and machine-readability of magnetic tape can lead to large savings in clerical and shipping costs.

For example, the U.S. Internal Revenue Service now accepts tax data on magnetic tape. The submission of tax data in this form relieves both the computer-using corporation and the IRS of many hours of clerical labor that would otherwise be required to prepare, mail, and transcribe hard-copy records of the data.

Magnetic tape information interchanges of this sort, as well as conversions to new computers, have often been hindered by discoveries that tape compatibility does not necessarily guarantee compatibility with respect to recording format, character code, and collation sequence. These problems, however, are gradually being overcome through steady progress on two fronts:

- The work of the USA Standards Institute in developing the USA Standard Code for Information Interchange (USASCII) and standards for implementing this code on magnetic tape, paper tape, and punched cards (3, 4).

- The gradual industry-wide swing toward the IBM way of doing things, which has led to a fairly high degree of de facto standardization of tape, recording formats, and codes.

.4 THE MAGNETIC TAPE MEDIUM

Magnetic tape is a vital factor in the performance of every computer system that uses it, yet many computer users pay surprisingly little attention to the tape until it starts giving them serious trouble. To help you get the most out of your tape — and, in turn, your computer — the following paragraphs review the characteristics of current and recently-announced magnetic tapes, the causes and remedies for tape errors, and some suggestions for purchasing, storing, and handling tape.

.41 Tape Characteristics

Nearly all magnetic tape currently used in data processing applications consists of a base, or substrate, of polyester film (oriented polyethylene terephthalate or equivalent) coated on one side with a layer of ferromagnetic oxide. The oxide coating is a dispersion of ferromagnetic material with thermosetting binders, lubricants, solvents, dispersing agents, and other additives. The formulation of the coating is a key factor in determining the durability, flexibility, and performance of the tape.

Standard half-inch-wide computer tape has a nominal thickness of 1.9 mils (0.0019 inch), with a tolerance of ± 0.3 mil. The thickness of the polyester base is a nominal 1.42 mils (about as thick as a piece of cigarette paper), while the thickness of the coating averages about 0.4 mils and may not exceed 0.6 mils (4, 5).

(Contd.)

.41 Tape Characteristics (Contd.)

The coating is applied to one side of a wide roll of polyester film which has previously been coated with a very thin primer coat to assure a strong bond between the base and coating. Then the coated film passes through a strong magnetic field that orients the magnetic particles in the proper direction. After the coated film has dried, it is slit into multiple half-inch widths. All of these manufacturing operations must be carefully and constantly controlled; otherwise, the tape will contain "built-in" defects that will prevent it from meeting the stringent demands of data processing applications.

Most current computer tape has a nominal length of 2400 feet and is wound on reels with an outside diameter of 10.5 inches. Eight-inch reels holding 1200 feet and other smaller reel sizes are used in some installations. Most tape is tested and certified by the manufacturer for operation under one or more of the following conditions:

- 7-track tape handlers at 200, 556, or 800 bits per inch.
- 9-track tape handlers ("total surface" or "full width" testing) at 800 bits per inch or 3200 flux changes per inch (i.e., 1600 bpi using the phase modulation recording technique).

.42 New Tape Formulations

Only three U.S. companies — Celanese Plastics Company, Du Pont, and 3M Company — currently produce the polyester base magnetic tape, but more than a dozen companies manufacture and apply the oxide coating and market the finished tape (6). As a result of this competitive pressure, plus the need for improved tape to keep up with advances in tape handler technology, several significant new tape developments have been announced during the past year.

Only one of these new formulations — Du Pont's Crolyn — represents a deviation from the usual combination of polyester base and ferromagnetic oxide coating. Crolyn, announced in mid-1967, uses chromium dioxide as the magnetic medium. Du Pont states that the greater magnetic strength of chromium dioxide, coupled with precise control of particle size and shape, offers two principal advantages over conventional coatings: a higher signal output at the same degree of resolution, and improved resolution at any given signal level. These improvements should permit reliable operation at higher recording densities; in fact, Crolyn tape is said to provide the same performance at 1600 bpi as conventional tape at 800 bpi.

Although Crolyn tape can be used interchangeably with conventional tape in many applications, Du Pont states that greater performance benefits can be obtained on equipment designed or adapted for use with the new tape. Honeywell became the first computer manufacturer to offer such specially-adapted equipment in November 1967, when it announced a special feature that permits Crolyn tape to be used at a density of 1200 bpi in the 204B-9 Tape Unit. The feature costs $25 per month and increases the unit's data transfer rate from 96,000 to 144,000 characters per second. Honeywell's list price for the Crolyn tape itself was quoted as $56 per 2400-foot reel, compared to $38 for conventional tape. This cost premium, though significant, could be more than offset by the increased storage capacity and performance of the Crolyn tape.

IBM, after marketing tape made largely by 3M Company for many years, finally entered the tape manufacturing business in October 1967 when it introduced Series/500 tape. This new tape, the product of a two-year joint development effort with Sony Corporation, is said to have a formulation that provides an optimum balance among all the important properties such as signal strength, signal quality, pulse width, noise, binder strength, surface toughness, durability, tear resistance, elasticity, and coating adhesion.

The 3M Company caused a major stir in the tape industry last May by adding a "guaranteed performance" tape to its product line. The new tape, called "Scotch" Brand 777GP, uses the same binder formulation and oxide coating as 3M's older Brand 777 certified tape. But the new tape, according to 3M, is so carefully controlled and tested throughout the manufacturing process that individual bit-by-bit certification of each reel is no longer necessary. As a result, a cost saving of about $3 to $4 per reel is being passed on to buyers of Brand 777GP tape. Brand 777 tape will continue to receive bit-by-bit certification and is still offered "for those who feel the added cost of certification is warranted because the information being recorded or stored is irretrievable and even the remotest chance of a write-skip cannot be risked."

.42 New Tape Formulations (Contd.)

Shortly after 3M Company announced its lower-cost uncertified tape, Ampex Corporation introduced a new 870 Series tape that will be sold at a "slight premium." Ampex claims an improved binder formula that provides longer tape life and greatly reduced head wear. Moreover, Ampex guarantees the 870 Series tape to be 100 percent free from original permanent errors.

.43 Causes of Tape Errors

Magnetic tape is probably the most efficient medium yet developed for transferring data into and out of high-speed computer systems — as long as all goes well. But when excessive tape errors are encountered, the throughput of those expensive computers can be greatly reduced, and thousands of dollars can be lost through wasted machine time, added labor, and missed deadlines. An essential first step toward overcoming these errors is a clear understanding of what causes them.

By far the most common cause of tape data errors is the "dropout," a reduction of 50 percent or more in the strength of the signal transferred between the tape and the read/write head. This loss of signal strength can cause data to be either obliterated or misinterpreted. Dropouts can occur either while reading or writing. Sometimes dropouts are caused by misalignment between the tape and the read/write heads or by bare spots on the tape. By far the most common cause of dropouts, however, is separation between the tape and the heads.

A magnetic tape handler cannot function properly unless positive contact between the tape and the heads is maintained at all times. A gap of as little as 140 millionths of an inch between tape and head can result in a dropout (5). Separation between the tape and heads is usually caused either by the presence of foreign matter (such as a speck of dust) or by distortion of the tape so that it will not lie flat against the heads.

Dropouts resulting from separation between tape and heads can be divided into three classes:

- Permanent dropouts are caused by imperfections in the tape manufacturing process. These "built-in" dropouts are normally detected and registered when the tape is certified.
- Temporary dropouts are caused by bits of dust and other foreign matter that adhere lightly to the tape surface. These can usually be dislodged when the tape handler cycles through the re-try operations that follow detected errors.
- Embedded dropouts are formed when temporary dropouts become permanent. This occurs when the foreign particles become bonded to the tape surface due to pressure and heat effects that occur when the tape passes at high speeds over the heads, tape guides, and other hardware elements.

Embedded dropouts represent by far the biggest single tape problem in most computer installations. Though foreign matter such as dust and cigarette ashes are usually blamed for embedded dropouts, an even more common cause appears to be "self dirt" from the magnetic tape itself. The two principal types of self dirt are chips of magnetic oxide that break away from the coating surface and chips and burrs left on the edges of the tape due to faulty slitting. Thus, a key quality criterion for magnetic tape is its freedom from self dirt, both initially and after long use.

Physical distortion of the tape is another common cause of errors and malfunctions. The distortion is usually caused by improper winding, which may lead to skewed tape, rippled edges, or horizontal creases. Longitudinal creases are sometimes caused by badly misaligned tape guides or rollers. Regardless of the cause, the usual effect of such tape distortion is to prevent the tape from lying flat against the read/write heads, resulting in dropouts (5, 7).

.44 Tape Handling and Storage

Many of the causes of tape errors described above can be minimized through proper care and handling of the tape. The manufacturers of magnetic tape and tape handlers all supply detailed instructions for handling their products, but a few basic guidelines seem important enough to deserve mention here (5, 8).

- Store tape reels on edge, preferably in a dustproof container that supports the reel by its hub.
- Keep the temperature and humidity of the tape storage area within the range recommended by the tape manufacturer at all times.

(Contd.)

.44 Tape Handling and Storage (Contd.)

- Bring tape stored under different conditions into the computer environment at least six hours before use to enable it to come to thermal equilibrium.
- Use solid-flange reels for even rewinding and to keep fingers from touching the tape edges.
- Always handle tape reels by their hubs, and never squeeze the flanges together.
- Never touch the tape between the load points. (If it is absolutely necessary to do so, wear rubber gloves.)
- Rewind all tapes in long-term storage at least once a year to relieve the internal stresses that build up as a result of temperature variations.
- Clean all read/write heads, capstans, and tape guides regularly in accordance with the manufacturer's instructions.
- Make sure rewind mechanisms and tape guides are checked and adjusted regularly to the manufacturer's specifications.
- Check all tapes and tape reels for contamination regularly in accordance with the tape manufacturer's instructions.
- Do not store ordinary paper notes inside a canister with a reel of tape; the paper is likely to shed and cause contamination.
- Never allow any portion of the tape to touch the operator's clothing or the floor.
- Keep the computer room as clean, dust-free, and smoke-free as possible.
- Consider the advisability of a formal program of tape testing, cleaning, and recertification, using either specialized in-house equipment of the types manufactured by Cybetronics and General Kinetics Incorporated, or the tape rehabilitation services provided by a firm such as GKI Tape Service Corporation (9).

.45 Shopping for Magnetic Tape

For a number of years, the list price of computer-grade magnetic tape held firm at or near the level of $40 per reel, and the selling price seldom dropped below $30 per reel regardless of the quantity purchased. During the past few months, however, there have been some very significant reductions in magnetic tape prices. It now appears that there are real bargains to be had, and that the economy-minded tape buyer will be well-advised to shop around for the supplier who offers the quality he needs at the minimum price.

The U.S. Government, which is by far the largest single user of data processing equipment, began making significant progress on obtaining cost reductions on large-volume procurements of computer equipment and supplies. The General Services Administration established a centralized magnetic tape purchasing system early in 1968, and promptly began obtaining drastically reduced prices. The lowest price reported to date was $11.50 per reel for an order of 30,000 reels of certified 7-track tape from Audio Devices, Inc. A price of $12.00 per reel was obtained on another order for 47,000 reels of 7- or 9-track tape from 3M Company. Prices of $13.00 per reel or less have been obtained from several other tape suppliers, and to date the Government has noticed no deterioration in the quality of the tape obtained at these low prices (11). It would, of course, be unrealistic for small-volume users of magnetic tape to expect price quotations as low as those obtained by the Government.

Buyers of magnetic tape should always remember that price is by no means the only factor in determining the best buy. Quality is even more important, because the cost of the tape itself is insignificant compared to the losses that can result from excessive tape errors. But quality, in the case of magnetic tape, has many aspects which are difficult to measure and evaluate objectively.

.45 Shopping for Magnetic Tape (Contd.)

Though the buyer should give careful consideration to the manufacturer's warranty and reputation, the only sure test of quality is the actual performance of the tape in the buyer's own installation. Therefore, whenever possible, the buyer should test several reels of a new brand of tape in his own installation before placing a large order. And, of course, continuous records should be kept of the number of errors encountered in processing each reel of tape. These records make it easy to decide:

- Which specific reels of tape are flawed and should be rehabilitated or destroyed; and
- Which brand of tape provides the best overall performance throughout its lifetime.

.5 RECORDING ON MAGNETIC TAPE

To aid computer users in understanding the functions and effective utilization of magnetic tape equipment, the following paragraphs briefly explain the techniques that are currently being used to record data on tape and to ensure its validity. Throughout this section the emphasis is on techniques used in IBM and IBM-compatible tape handlers (12, 13).

.51 Data Recording Techniques

Magnetic tape recording is based upon the interaction between a moving magnetic storage medium (the tape) and a stationary magnetic transducer (the read/write head). During recording, the head magnetizes the oxide coating of the tape in a small region immediately adjacent to the head. During readback of the recorded signals, the head provides an induced voltage that reflects the rate of change of magnetization. The path of recorded signals generated along the surface of the tape by each head is called a "track." Current IBM-compatible tapes are recorded by either 7 or 9 heads in parallel, and are therefore referred to as 7-track or 9-track tapes.

In recording digital data, the two binary digits 0 and 1 must be converted into the appropriate states of magnetic surface saturation (and/or reversals in saturation). The three most important digital recording techniques are NRZ (non-return to zero), NRZI (non-return to zero, IBM), and phase modulation (called "phase encoding" by IBM). A continuous writing current is used in all three methods, although manufacturers' documentation often refers to discrete magnetized "spots" on the tape.

NRZ (non-return to zero) was at one time the most common method of digital recording, though it is no longer widely used for the reasons discussed below. In NRZ recording, the direction of the writing current is reversed whenever a 0 is followed by a 1 or a 1 is followed by a 0 in the input data. Therefore, one direction of surface magnetization corresponds to a 1 while the opposite direction corresponds to a 0. Figure 1 shows the relationships between the input data and the writing current for a single track in NRZ recording. A major disadvantage of the NRZ technique is that if any one bit is in error, all the bits that follow will be read erroneously until the next signal pulse is encountered.

NRZI (non-return to zero, IBM) is the technique used in all current IBM magnetic tape handlers operating at recording densities of 200, 556, and 800 bits per inch. In NRZI recording, the direction of the writing current is reversed every time a 1 is to be recorded. Therefore, a 1 is represented by either a positive or negative pulse, while a 0 is represented by the absence of a pulse. These relationships are illustrated in Figure 1. NRZI offers one major advantage over NRZ recording: if any one bit is misread in NRZI, the error will have no effect on the bits that follow.

Phase modulation (or phase encoding) is the technique used in all current IBM magnetic tape handlers operating at 1600 bits per inch. In this method, a 1 is represented by a positive change in the writing current, while a 0 is represented by a negative change. As Figure 1 shows, an additional current reversal must be inserted at mid-bit time whenever a 1 is followed by another 1 or a 0 is followed by another 0. This means that a tape to be used for 1600-bpi recording in the phase modulation mode must actually be capable of storing 3200 magnetic flux reversals per inch. The phase modulation technique provides a clear distinction between 0 bits and no data; the NRZI mode lacks this distinction.

Because the phase modulation technique records a flux reversal in every track position of every properly-recorded data frame, it has two inherent advantages over the NRZI technique:

- The absence of a flux reversal indicates an error condition; this indication, in combination with a vertical parity check, permits in-flight correction of single-track read errors.
- Each track is self-clocking, so the chances of errors due to skewed recording are greatly reduced.

(Contd.)

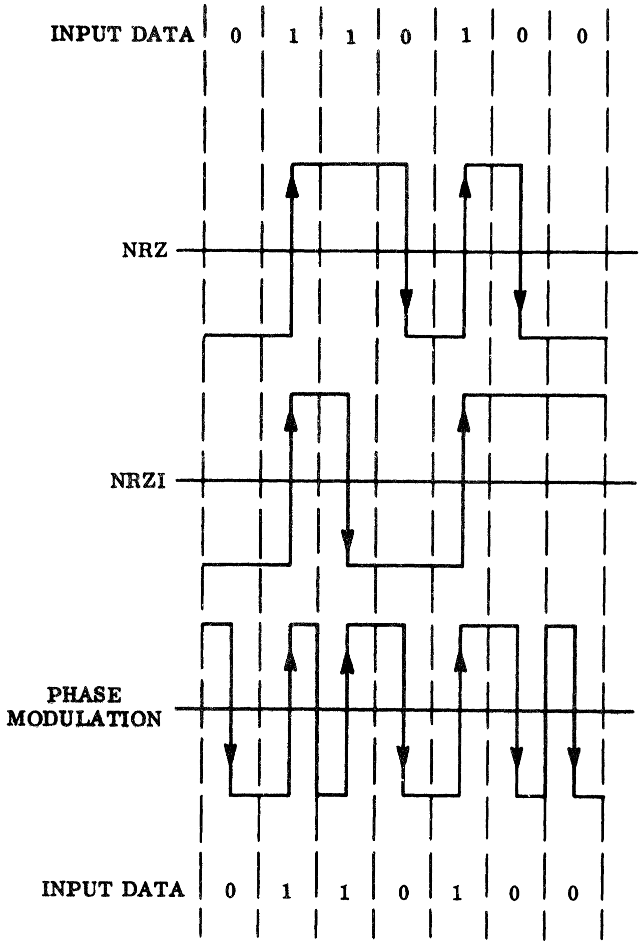

Figure 1. Comparison of write currents in three different recording modes.

.52 Validity Checking Techniques

Adequate provisions for ensuring the accuracy of the recorded information must be provided in every digital tape recording system. The detection of tape errors is usually a hardware function, while the correction of these errors may be performed by the hardware, by programmed routines, or by a combination of the two methods. The capability to detect and correct write errors at the time they occur is a particularly desirable feature; if the error is not detected until the tape is read back, its correction may involve a long, expensive reconstruction process.

The hardware error checking techniques used in current IBM magnetic tape handlers are explained in the paragraphs that follow. Table II (13) summarizes the checking schemes used in the various models and makes it clear that the schemes used in the 7-track NRZI, 9-track NRZI, and 9-track phase modulation modes all differ very significantly from one another.

Vertical redundancy checking, otten called "row parity checking", is probably the oldest and most commonly used check upon recording accuracy. A parity bit is appended to the code for each character or byte to be recorded on the tape; the value of this bit is either 0 or 1, whichever is needed to make the sum of all the 1 bits in the row either even (in even-parity checking) or odd (in odd-parity checking). Nine-track tape is always recorded in the odd-parity mode.

When the tape is read, each row is checked to make sure that it contains an even or odd number of 1 bits, depending upon the parity mode. In the NRZI system, each row is also read back and checked for proper parity immediately after it is written; this is often called "read-after-write parity checking." Vertical redundancy checking detects all single-bit errors, but it may fail to detect errors involving two or more bits in a tape row unless it is combined with other checking techniques.

TABLE II: ERROR CHECKING IN IBM TAPE HANDLERS

Recording Technique	IBM Magnetic Tape Unit	Error Checking Technique						
		Vertical Redundancy Check	Longitudinal Redundancy Check	Cyclic Redundancy Check	Single-Track Error Correction	Envelope Check	Multiple-Track Error Check	Skew Check
NRZI	2401 Models 1-3 (9-track)	R, W	R, W	R	R (Programmed)			W
	2401 Models 1-3 (7-track)	R, W	R, W					W
	2401 Models 4-6 (9-track)	R, W	R, W	R	R (Programmed)			W
	2415 Models 1-6 (9-track)	R, W	R, W	Note 1				W
	2415 Models 1-6 (7-track)	R, W	R, W					W
Phase Modulation	2401 Models 4-6 (9-track)	R			R (Automatic)	W	R, W	R
	2415 Models 4-6 (9-track)	R			R (Automatic)	W	R	R
	2420 Model 7 (9-track)	R			R (Automatic)	W	R, W	R

R — Check is performed during tape Read operations.
W — Check is performed during tape Write operations.
Note 1 — CRC byte is written for compatibility with 2401, but is not checked.

.52 Validity Checking Techniques (Contd.)

Longitudinal redundancy checking, used in all IBM-compatible, NRZI-mode tape handlers, monitors all seven or nine tracks to ensure the presence of an even number of 1 bits in each track of every block recorded on the tape. During writing, a longitudinal redundancy check (LRC) character is appended to each block; the LRC character contains either a 0 or 1 bit in each track position, as required to make the total number of 1 bits even in that track of the block being recorded. As the block is read, the LRC character is regenerated and checked for agreement with the LRC character read from the tape. Longitudinal redundancy checking detects all single-bit errors, but it may fail to detect errors involving two or more bits in one track within a block.

The combination of vertical and longitundinal redundancy checking, combined with the read-after-write checking made possible by dual-gap read/write heads, proved to be a very effective system for detecting (but not correcting) tape errors in the 7-track NRZI tape handlers used in most second-generation computer systems.

Cyclic redundancy checking is used, in addition to vertical and longitudinal redundancy checking, in the IBM 2401 Magnetic Tape Units when operating in the 9-track NRZI mode at 800 bpi. This third type of redundancy checking provides additional information that permits programmed correction of single-track read errors. As each block is written, a cyclic redundancy check (CRC) character is automatically calculated from the data bytes and appended to the block, just ahead of the LRC character. During a read operation, the CRC character is recalculated in the same manner and compared with the CRC character read from the tape. When a single-track read error occurs, the track in error can be identified and the error corrected by means of a programmed reread.

Read errors involving two or more tracks cannot be corrected in this manner, although IBM emphasizes that they can often be reduced to correctable single-track errors through repeated reading of the faulty block. In fact, the standard IBM tape error routines read each error block 100 times, backspacing the error block across the tape cleaner to dislodge any loose particles after every tenth try, before conceding that the block contains an uncorrectable permanent error.

(Contd.)

.52 Validity Checking Techniques (Contd.)

Single-track error correction is performed automatically and "in flight" by the 1600-bpi IBM tape handlers that use the phase modulation recording mode. When reading, these handlers continuously monitor the signals from all nine tracks. As soon as any one track fails to provide a flux reversal in any data frame, that track is "disabled" for the remainder of the block (i.e., its contents are disregarded). Using the vertical redundancy check bit for each row, the information bits in the disabled track are then regenerated automatically.

This scheme provides automatic correction of all errors which are confined to a single track. Errors involving weak signals from two or more tracks within a block are detected and recognized as uncorrectable, and standard error recovery procedures (backspace and reread) must be used in these cases.

Envelope checking and multiple-track error checking are two specialized checks employed in the IBM tape handlers that record in the phase modulation mode at 1600 bpi. These handlers do not perform redundancy checks during write operations, but a weak signal from any track is indicated by the envelope check on signal amplitudes. The multiple-track error check indicates an abnormal change in data rate during writing or the detection of weak signals from two or more tracks within a block during reading.

Skew checks are designed to detect (and in some cases compensate for) excessive vertical misalignment of the 7 or 9 recorded bits comprising each row. Excessive skew is usually a result of improper tape winding or handling techniques.

.6 MAGNETIC TAPE HANDLERS

Having examined the magnetic tape medium and the techniques used for recording and checking data on it, we will now survey the current status of magnetic tape handlers, the computer hardware components that transport the tape and read and record information on it.

.61 Mechanical Design

Magnetic tape handlers used to record digital data can be divided into two basic classes: incremental and constant-speed.

In an incremental tape handler, the tape is started and stopped each time a character is recorded. This permits the unit to operate asynchronously in applications where the input data is received at widely varying rates, as in telemetry or industrial data collection. But the speed and reliability of incremental data handlers are generally regarded as inadequate for effective on-line use with high-speed digital computers.

Therefore, virtually all magnetic tape handlers currently used in computer systems fall into the constant-speed class. In these units, the recording of a block of data is not permitted to begin until the tape has been accelerated to a velocity very close to its rated speed. Once the proper tape velocity has been reached, all of the characters or bytes comprising the block are transferred to the tape handler at a constant rate and recorded on the tape at a constant density. Blank spaces, called interblock gaps, must be left between the recorded blocks of data so that the tape can be stopped and then reaccelerated to its rated velocity between consecutive blocks.

To achieve high performance in computer tape handlers, it is necessary to drive the tape past the read/write heads at speeds ranging from about 20 to 200 inches per second. Moreover, the handler must be capable of accelerating the tape to these velocities — and decelerating it back to a standstill – within a few milliseconds. Providing for these ultra-fast starts and stops has severely taxed the current state of the art in electromechanical design.

The physical form of nearly all computer tape handlers can be characterized by the methods used to perform two key mechanical functions:

- Driving the tape past the read/write heads, and
- Buffering (isolating) the movement of the tape past the heads from the comparatively massive inertia of the reels on which the tape is wound.

The portion of tape to be accelerated can be isolated from the storage reels by vacuum columns, by swinging tension arms, by a combination of vacuum and arms, or by storage bins. Nearly all of the tape handlers currently in use with computer systems have buffers of the vacuum-column type, ranging from a few inches to several feet in length. Tension arms and storage bins are still used in lower-performance tape handlers for off-line use; the Mohawk Keyed Data-Recorders, for example, use a tape bin in lieu of a take-up reel.

Three basic methods, with numerous variations, are used to drive the tape past the read/write heads (14). In each of these methods, the tape is held in contact with a rotating capstan.

.61 Mechanical Design (Contd.)

Pinch rollers were among the earliest methods developed for obtaining rapid tape acceleration, and they are still in widespread use despite the advantages of the newer drive methods described below. The pinch-roller method uses two capstans rotating in opposite directions at a constant speed. The tape is driven in either direction by a roller that clamps it against the appropriate capstan. Tape movement is stopped by a brake or by another pinch roller that clamps it into contact with a stationary capstan. This method subjects the tape to very high accelerating forces. Moreover, the rubbing and hammer-like blows from the pinch rollers have been accused of causing excessive tape wear.

Dual vacuum capstans are used in a newer drive method that imposes lower accelerating forces and less wear on the tape. Two counter-rotating, slotted capstans are used. When either capstan is evacuated, the tape adheres to it and is driven in the corresponding direction. Simultaneously, the other capstan is pressurized so that the tape "floats" over it on an air film. Vacuum brakes are used to stop the tape. A variation of this method uses positive air pressure, applied externally, to "clamp" the tape to the capstan. Still other tape handlers use a combination of vacuum and pressure clamping.

Single-capstan drives are used in many of the high-performance tape handlers announced during the past four years. This method uses a single capstan, driven by a low-inertia, high-response servomotor, that accelerates and decelerates in either direction at the same speed as the tape. The tape is held in contact with the capstan by vacuum techniques. This drive method combines fast starts and stops with low tape wear; in many current handlers the oxide (recording) surface of the tape touches only the read/write heads and the tape cleaner.

The principal physical characteristics of most of the current computer tape handlers, as discussed in the preceding paragraphs, can be summarized by a simple tree diagram (Figure 2). Each of these tape drive and buffer methods is highly developed today; obtaining further improvements in mechanical performance (as distinguished from increases in recording density) may demand new approaches to the drive and buffer problems.

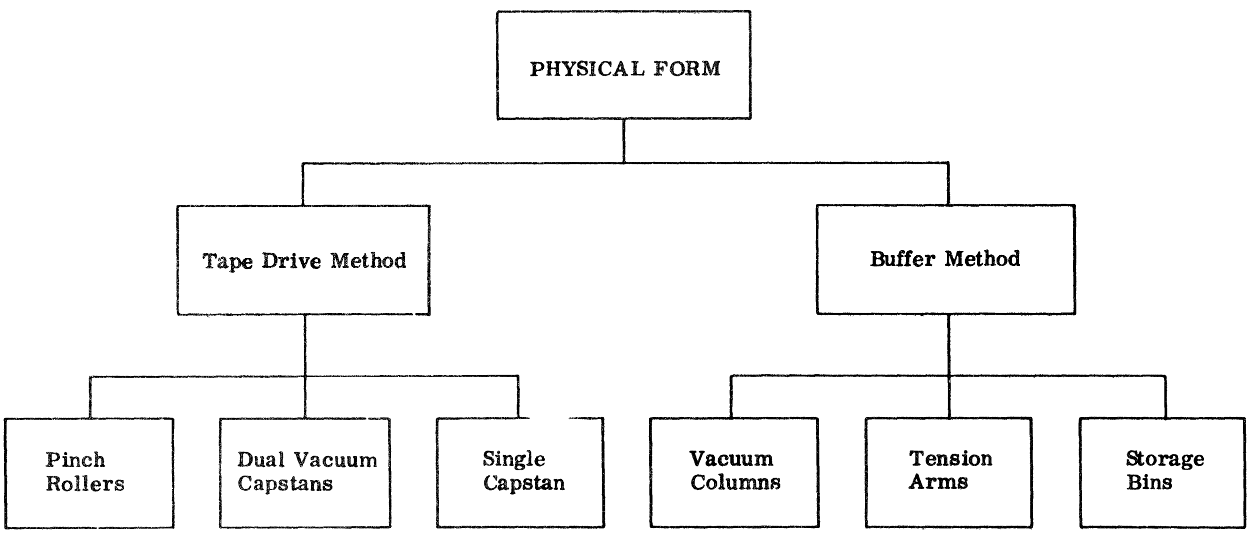

Figure 2. Principal physical characteristics of current magnetic tape handlers.

.62 Characteristics of Current Tape Handlers

More than two dozen U.S. companies now manufacture digital tape handlers, and they offer models with a wide range of performance characteristics and prices. The great majority of the tape handlers now on the market are "IBM compatible." They use standard 1/2-inch tape and record in one or more of the following modes:

- 7-track NRZI at 200, 556, and/or 800 bits per inch.

(Contd.)

TABLE III: CHARACTERISTICS OF REPRESENTATIVE TAPE HANDLERS

IDENTITY		RECORDING CHARACTERISTICS				PERFORMANCE		
Manufacturer	Model No.	Tape Width, inches	No. of Tracks	Recording Density, bits/inch	Interblock Gap Length, inches	Tape Speed, inches/sec	Data Transfer Rate, KB or KC/sec	Rewind Time, minutes
Burroughs	B 9391	0.50	7	200/556/800	0.75	90	18/50/72	1.6
Burroughs	B 9393	0.50	9	200/800/1600	0.60	90	18/72/144	1.6
Control Data	604	0.50	7	200/556/800	0.75	75	15/42/60	1.3
Control Data	609	0.50	9	800	0.60	37.5	30	3.5
Control Data	626	1.00	14	800	0.75	150	240	1.3
GE	MTH301	0.50	7	200/556/800	0.75	75	15/42/60	1.3
GE	MTH311	0.50	7	200/556/800	0.75	75	30/83/120	1.3
GE	MTH412	0.50	9	200/556/800	0.60	150	40/111/160	1.3
Honeywell	204A-2	0.75	9	400	0.67	120	64	1.3
Honeywell	204B-9	0.50	7	556/800/1200	0.70	120	24/96/144	1.3
Honeywell	204C	0.50	9	800	0.60	36	29	
IBM	2401-1	0.50	9	800	0.60	37.5	30	3.0
IBM	2401-6	0.50	9	1600	0.60	112.5	180	1.0
IBM	2420	0.50	9	1600	0.60	200	320	1.0
NCR	633-117	0.50	7	200/556/800	0.75	50	10/28/40	3.2
NCR	633-211	0.50	9	1600	0.60	90	144	2.0
RCA	70/441	0.50	7	500	0.58	50	25	3.2
RCA	70/445	0.50	9	800	0.65	150	120	1.2
UNIVAC	U VIC	0.50	9	800	0.60	42.7	34	3.0
UNIVAC	U VIIIC	0.50	7	200/556/800	0.75	120	24/67/96	1.3

.62 Characteristics of Current Tape Handlers (Contd.)

- 9-track NRZI at 800 bits per inch.
- 9-track phase modulation at 1600 bits per inch (3200 fci).

All of the major computer manufacturers are now offering IBM-compatible tape handlers for use with their computers, and it seems apparent that non-compatible tape handlers will soon be obsolete except in specialized applications.

Table III summarizes the major characteristics of 20 representative magnetic tape handlers currently being marketed by the major computer manufacturers. All except three of these units (the Control Data 626, Honeywell 204A, and RCA 70/441) fall into the IBM-compatible class. Table III is by no means a complete listing; its purpose is simply to illustrate and compare the main features of some typical third-generation tape units.

Tape speeds for the present computer tape handlers range from less than 20 to 200 inches per second. Data transfer rates (the product of tape movement speed times recording density) range from about 4,000 to 320,000 characters or bytes per second. Start and stop times of 2 to 10 milliseconds are common. Interblock gap length is generally 0.75 inch for 7-track tape and 0.60 inch for 9-track tape. Full-reel rewind times are usually in the range of 1 to 4 minutes. Most of the current tape handlers use vacuum-column buffers and vacuum tape drives, although pinch-roller drives are still in common use, especially within the IBM line.

.63 Significant Recent Developments

Four recent developments within the magnetic tape handler market seem to merit discussion:

- The entry of most of the computer manufacturers into the peripheral equipment business.
- The availability of plug-and-program-compatible tape handlers designed to replace IBM equipment.
- The announcement of IBM's high-performance 2420 Magnetic Tape Unit.
- The introduction of Burroughs' low-cost, ultra-compact Magnetic Tape Cluster.

.63 Significant Recent Developments (Contd.)

As a result of rapid progress in increasing the performance and reducing the cost of computer mainframes, it is estimated that peripheral equipment now accounts for about 65 percent of the total hardware cost of typical computer systems — and that this figure will rise to 75 percent within the next few years. As a result of this trend, nearly all of the major computer manufacturers are now building most of their own peripheral equipment, and several are now offering their magnetic tape handlers to all comers on an OEM basis.

During the past year, Ampex, MAI, Potter, and Telex have all announced new magnetic tape handlers that are plug-interchangeable and program-compatible with the IBM 729 and/or 2400 Series Magnetic Tape Units. (The MAI handlers are manufactured by Potter.) Potter claims to have orders for over 600 of its plug-compatible units to date.

The IBM 2420 Magnetic Tape Unit, announced in January 1968, reads and writes standard 9-track tape at a speed of 320,000 bytes per second while maintaining compatibility with IBM's slower 1600-bpi tape handlers. Tape speed is 200 inches per second, and access time to the next sequential block of data is less than 2 milliseconds. A single-capstan vacuum tape drive is used, and tape threading is automatic. Rewinding is performed at 500 inches per second without removing the tape from the vacuum-column buffers (15).

An optional tape cartridge can be attached to each reel of tape used with an IBM 2420 Tape Unit. Both reel and cartridge are mounted on the handler as an integral unit. The cartridge provides a sealed container for the tape and, in conjunction with the automatic threading feature, eliminates all physical handling of the tape. In view of the improvements it provides in both performance and tape handling, the IBM 2420 must be rated as the most significant advance in tape handler technology in several years. In the wake of the 2420's introduction, there were two noteworthy related developments:

- IBM stopped accepting orders for the 7340 Model 3 Hypertape Drive, which provided data transfer rates of 340,000 bytes per second but used non-compatible one-inch-wide tape in sealed twin-reel cartridges.
- Telex (formerly Midwestern Instruments) announced a new tape handler that will serve as a plug-compatible replacement for the IBM 2420 Tape Unit and provide identical performance.

Whereas the IBM 2420 is designed to provide maximum performance, the Burroughs Magnetic Tape Cluster represents a novel approach to the problem of providing moderate performance at minimum cost. Announced in 1966, the Magnetic Tape Cluster provides two, three, or four tape drives in a single compact cabinet (33 inches wide, 30 inches deep, and 42 inches high). Each tape drive has its own pinch-roller drive mechanism and vacuum-column buffers, but a single drive motor, power supply, vacuum supply, ventilation system, and electronics unit serve all the tape drives in a cluster (16). The feed reel and take-up reel for each drive are mounted on concentric shafts, with the feed reel above the take-up reel. Tape speed is 45 inches per second, and data transfer rate is 9,000 bytes per second at 200 bpi, 36,000 bytes per second at 800 bpi, or 72,000 bytes per second at 1600 bpi. This approach to tape-handler packaging raises the hope of further cost-cutting innovations yet to come.

.7 THE FUTURE OF MAGNETIC TAPE

This report has presented considerable evidence indicating the continued importance of magnetic tape, as a computer input-output medium. Sales of both tape and tape handlers for data processing use are expected to increase during the next few years at the rate of 10 to 15 percent per year. As explained in Section .2 of this report, magnetic tape and disk packs will each find their way into the types of applications for which they are best suited, and computer systems using both of these media will become increasingly common.

Further improvements in the performance of magnetic tape handlers will be achieved mainly through increases in recording density. During the past decade, practical recording densities have increased from 100 or 200 bits per inch to the present 800 or 1600 bits per inch, and the full potential of achievable tape resolution has not yet been exploited. Many experts believe that further improvements in both tape formulations and tape handler designs will make recording densities of 3000 to 4000 bits per inch practical within the next few years.

(Contd.)

.7 THE FUTURE OF MAGNETIC TAPE (Contd.)

Conversely, the advances in the mechanical elements of magnetic tape handlers have been far less dramatic. The Uniservo I tape drives used with UNIVAC I in 1951 had a tape speed of 100 inches per second, and the fastest drives available today provide only a 2-to-1 advantage over that speed. No major breakthroughs in mechanical design that are likely to change this picture can currently be foreseen.

Cartridge loading and automatic threading techniques such as those employed in the IBM 2420 Magnetic Tape Unit will probably be more widely used. In fact, such techniques will be almost mandatory to avoid contamination of the anticipated ultra-high-density tapes.

In tape handler design, there is still plenty of room for further decreases in cost, improvements in reliability, and reductions in tape wear. Progress in any of these areas will be warmly welcomed by tape users, and the intensified competition among tape handler suppliers should spur them to increased efforts.

Rapid growth in the use of magnetic tape in direct keyboard-to-tape encoding, source data automation, and information interchange, as described in Section .3 of this report, will help to ensure a bright future for magnetic tape in EDP.

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HIGH-SPEED PRINTERS: A STATE-OF-THE-ART REPORT

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HIGH-SPEED PRINTERS: A STATE-OF-THE-ART REPORT

.1 BACKGROUND

Since its inception two decades ago, the computer industry, as a result of numerous advances in electronic technology, has succeeded in developing and producing progressively faster central processors. Concurrently with, and as a consequence of, these advances, the industry has been continually faced with the problem of getting information into and out of these central processors at rates compatible with their ever-increasing internal speeds.

In the early days of the industry, when computers were utilized mostly in scientific and mathematical applications, single-action character printers were fast enough to cope with the limited amount of output data that they were required to print. These applications involved large amounts of computational time with relatively small volumes of input and output. With the advent of commercial and business applications for electronic computers, circumstances changed drastically. Large volumes of data were fed into the computer and a relatively small amount of computation was perfomed on each data record. In many cases the data output was voluminous, causing serious problems in producing usable output fast enough.

When input-output devices are connected directly to a computer system, the throughput of that system becomes limited by its slowest component, whether that component is a magnetic tape unit, the card reader, the central processor, or the output printer. In most cases, the card reading and magnetic tape data transfer rates are sufficiently fast to make the printer the slowest factor. Thus, the use of an on-line printer tends to slow down the system considerably.

A temporary solution reached in the mid-1950's was to record data at high speeds on magnetic tape, and then, at separate "off-line" stations, transcribe this data from the tape to various types of printers. The speeds of these printers ranged from 5 lines per minute up to 1,800 lines per minute. However, these stations were quite expensive and performed only a single function. Accordingly, they have all but disappeared, to be replaced, at least in larger installations, by small computing systems, thought of as "satellites" to the central computer. Thus, while the printer is "on-line" to the small computer, it is "off-line" to the central system, and does not slow down the throughput rate of a large, expensive computer.

.2 THE DEVELOPMENT OF HIGH-SPEED PRINTERS

Whatever the specific method of incorporating a printer in a computer system, speed has been a major consideration in the development of printing devices. Various mechanisms have been tried. Generally, the most successful from the standpoint of speed have been impact-type printers, which print by means of some kind of mechanically-driven typebar or type-generating device. More specifically, the trend has been to parallel ("line-at-a-time") printers, which print an entire line essentially with one stroke, or, at least, in one complete printer cycle. Since there is no moving carriage in these printers, much greater speeds are achieved than are possible with serial ("character-at-a-time") printers, which print each character essentially in a separate cycle, in correct left-to-right sequence across the print line.

These non-sequential printers generally utilize continuous pin-feed forms, and incorporate some form of high-speed skipping, in which multiple lines can be skipped at several times the normal printing speed.

.3 SOME HISTORICAL METHODS OF PRINTING

The following paragraphs describe three printing methods which have all but disappeared from the high-speed printer scene, but which are of historical interest because of their influence upon the designs of today's high-speed printers.

.31 Stick Printers (Example: IBM 370)

One technique used for serial printing at intermediate speeds employed a single print stick, which was normally an eight-sided metal element embossed with eight characters on each face to provide sixty-four print characters. The character to be printed was selected by the decoding logic, which actuated a rotation and/or an in-out movement of the stick. At the time of the "dwell" (no movement) of the stick, a single hammer struck the paper from the rear, moving the paper into contact with an inked ribbon against the printing stick to produce the printed character.

Horizontal positioning and carriage returns were accomplished by moving the entire printing assembly across the platen in a manner somewhat similar to the action of typewriters.

.31 Stick Printers (Example: IBM 370) (Contd.)

The general characteristics of stick printers were:

- Relatively low speed (30 to 60 lines per minute).
- Ribbon motion across the paper, as in a conventional typewriter.

It is to be noted that this general printing method is still widely used in console typewriters and communication devices, such as the IBM Selectric element and the newer Teletype models, where economy is more important than high speeds.

.32 Multiple Type-Bar or Wheel Printers (Examples: IBM 403, 407)

Many early line printers, including several that were adapted from punched-card tabulating machines such as the widely-used IBM 407 and 403, employed a series of type bars or wheels. Each printing position had a separate bar or wheel containing all characters of the print set. All positions were printed simultaneously, after the entire line had been decoded and each bar or wheel had been independently positioned. The actual printing occurred when hammers, driven by electronic triggers, struck the paper into contact with an inked ribbon against the type face.

The general characteristics of wheel or bar type printers were:

- Relatively low speed (50 to 150 lines per minute).
- Ribbon motion across the paper, as in a conventional typewriter.

.33 Matrix Printers (Examples: IBM 720, 730)

Since the physical positioning and recoil movement of individual hammers against the embossed characters has been one of the limiting factors in the design of faster printers, a number of high-speed printers employed matrix-type print heads. Each head consisted of a small rectangle of fine wires. Characters were formed by electromechanically actuating selected individual wires in each print head and, with these wires, striking the ribbon against the paper. Matrix printers employed either a stationary head assembly or a moving head assembly. The stationary assembly had one head for each printing position, while the moving assembly had one-half or one-fourth as many individual heads spaced farther apart. Each head of the moving assembly printed in two or four positions in turn after the entire head assembly had been shifted laterally a short distance.

In general, experience with matrix printers was characterized by frequent and troublesome mechanical maintenance and service problems.

The general characteristics of matrix printers were:

- High speed (500 to 1,000 lines per minute).
- A hidden flat metal platen.
- Ribbon motion across the paper, as in a conventional typewriter.
- A relatively poor-quality printed image.

.4 HIGH-SPEED PRINTERS TODAY

.41 On-the-Fly Printing Techniques

The printing techniques described above have given way almost completely to several variations of the "on-the-fly" approach, in which high print speeds are achieved by extremely rapid hammer action against continuously moving type elements. The principal variations involve the use of a rotating drum, a horizontally-moving chain, or an oscillating bar, as detailed below; the actual methods of printing are quite similar in all three techniques.

During each print cycle (normally the time allocated to load the print buffer; decode its contents; print one line, including hammer action and recoil; and space the paper), all characters move past the print hammers at each printing position. The character to be printed is selected by decoding, and a fast-action hammer, controlled by an actuator, presses the paper against the type slug at the exact moment the required character is in position. If the machine is printing at 600 lines per minute, each total printing cycle takes one six-hundredth of a minute. This interval is in turn divided into discrete timing units for each character which is available, plus several units for paper advance.

In the asynchronous mode of printing, such as is used in the Anelex 5000 drum printers, the firing of the hammers does not commence at any fixed point during the rotation of the character set. Rather, firing commences whenever a signal is received to indicate that line spacing has been completed and the print buffer loading is finished. Firing terminates when a counter indicates that all characters have moved past the hammers or when the buffer holding the line of characters to be printed has been sensed and found empty.

Hammer action in "on-the-fly" printers is either by: (1) free flight, or "ballistic," hammers (movement stopped by contact with the paper and the type element), or (2) "controlled flight"

(Contd.)

.41 On-the-Fly Printing Techniques (Contd.)

hammers (fixed spatial movement). The most important advantage claimed for the latter design principle is positive control over the depth of penetration of hammer action. When such a printer is operated without paper in the tractor feed, the hammers are prevented from striking the type element by "end of paper" safety switches.

Vertical format control is generally effected by an 8- or 12-channel paper tape loop. The vertical spacing of the punches controls the actual spacing on the printed sheet. In some printers it is necessary to use a loop the exact vertical size of the printed page; in others it is possible to use loops representing only the vertical area to be imprinted. It is usually possible to space the printer under program control.

The general characteristics of current "on-the-fly" printers are:

- High speeds (300 to 1,200 lines per minute).
- The absence of a platen.
- Ribbon movement parallel with paper motion; ribbon width at least equal to maximum line length.
- Hammers which strike the paper from behind.

.42 Drum Printers (Examples: Anelex 4000, Honeywell 222, GE PRT201)

A widely-used on-the-fly printing technique is to provide a complete character set (sometimes two or more complete sets) at each print position, and to distribute these character sets around the circumference of a solid, continuously rotating drum. The timing mechanism senses the passage of a particular character in front of the hammers, and then fires the hammers which correspond to the positions in which the given character is to be printed. Thus, if all the hammers were fired at the same instant, the printed line would consist of the same character printed at all positions.

Several drum printers have utilized the "shuttle" technique, which cuts in half the number of hammers needed and hence reduces the cost. In a "shuttle printer" (e.g., Anelex 4000), the odd-numbered columns are printed in one cycle, then the paper is "shuttled" one column to the left and the even-numbered columns are printed. Note that since two cycles are needed to print each line, the effective speed is halved.

.43 Chain Printers (Examples: IBM 1403, Potter HSP-3502, CDC 512)

In a chain printer the hammers must be individually timed, because each character travels horizontally across many printing positions during the print cycle. Several identical sets of characters are assembled serially on a horizontally moving chain which resembles a bicycle chain. At each print position, the paper is forced into contact with the ribbon against the chain by a solenoid-activated hammer fired as the appropriate character on the chain passes the printing position. In the IBM 1403 Model 3, the chain has been replaced by a "train" mechanism in which type slugs move in the same horizontal plane as in the chain at more than twice the speed of the original 1403 Printer. If all hammers were fired simultaneously in a chain printer, several sets of sequential characters rather than a line of identical characters would be printed.

.44 Oscillating-Bar Printers (Examples: IBM 1443, UNIVAC 3030, Datamark OBP)

An oscillating-bar printer operates much like a chain printer, except that the print slugs are inserted in a horizontal bar that moves rapidly back and forth instead of being attached to a continuously-traveling chain.

The highest printing speeds that can be achieved using this start-stop-reverse type of motion are considerably lower than those that are possible with a continuously-rotating chain or drum; the fastest available oscillating-bar printer operates at about 600 alphanumeric lines per minute. However, a bar printer is likely to cost less than a drum or chain unit of comparable speed, and it offers the added advantage of permitting rapid removal and replacement of type-bars, a valuable asset where an installation's application mix requires the use of several different character sets.

.45 Higher Speeds and Improved Registration

A number of techniques have been implemented to increase effective printing speeds, usually by making the speed a function of the character set or of the actual number of characters being printed at a given instant.

One of these techniques is useful where only numeric printing is necessary. Printers designed for all-numeric printing are equipped with drums or chains on which numeric type faces are repeated several times, often with blank print segments between the groups for spacing. Such an arrangement (generally with two sets of print characters) permits two lines to be printed for each drum revolution. Thus, at 1,000 revolutions per minute, 2,000 lines of numeric print per minute can be produced.

Another popular technique is to overlap cycles if only a limited character set is being used at a given time. With this technique the full character set is present on the drum, but if

TABLE I: CHARACTERISTICS OF CURRENT LINE PRINTERS

IDENTITY		PHYSICAL FORM				PRINTING CHARACTERISTICS			
Manufacturer	Model	Printing Technique	Vertical Format Control Tape	Character Set (No. of Printable Characters)	Number of Print Positions	Horizontal Spacing (char/inch)	Vertical Spacing (lines/inch)	Form Width (inches) Maximum	Form Width (inches) Minimum
Anelex Corp.	4000	Drum	8 ch. (12 opt.)	64 (96-128 opt.)	120 to 160	10	6 or 8	20	4
Anelex Corp.	5000	Drum	8 ch (12 opt.)	64 (96-128 opt.)	80 to 160	10	6 or 8	20	4
Burroughs Corp	B 9240/41/43	Drum	12 channels	64	120 to 132	10	6 or 8	20	5
Burroughs Corp.	B 320/321/325	Drum	12 channels	64	120/120/132	10	6 or 8	20	5
Burroughs Corp.	B 328/329	Drum	12 channels	64	120/132	10	6 or 8	20	5
Control Data Corp.	501/505	Drum	8 channels	64	136	10	6 or 8	20	5
Control Data Corp.	512	Horizontal chain	12 channels	48	136	10	6 or 8	21	3
Datamark, Inc.	300	Drum		64	80 to 160	10	6	14.88	4
Datamark, Inc	500	Drum		64	80 to 160	10	6 or 8	17.75	4.25
Datamark, Inc.	OBP	Oscillating bar		64	132 to 160	10	6 or 8	17.75	4 25
Data Products Corp	4300	Drum	8 channels	64 to 128	132	10	6	19	
Data Products Corp	4400	Drum	8 channels	64 to 128	132	10	6	19	
Data Products Corp.	4500	Drum	8 channels	64 to 128	132	10	6	19	
General Electric Co.	PRT100/110/ 120	Drum	8 channels	64/64/48 or 64	104 to 136	10	6	22	3.5
General Electric Co	PRT150	Drum	12 channels	64	136	10	6 or 8	19	3
General Electric Co.	PRT201	Drum	12 channels	64	136	10	6 or 8	19	3
Honeywell EDP	122/122-1	Drum	8 channels	63	120 or 132	10	6 or 8	20	4 5
Honeywell EDP	222-1/-2/-3	Drum	8 channels	63 (49 opt.)	96/108/ 120 or 132	10	6 or 8	20	4.5
Honeywell EDP	222-4	Drum	8 channels	63 (49 opt.)	120 or 132	10	6 or 8	20	4.5
Honeywell EDP	222-6	Drum	8 channels	63	120 or 132	10	6 or 8	20	4.5
IBM Corp.	1132	Drum	12 channels	48	120	10	6 or 8	16 5	4.75
IBM Corp.	1403-1/-2	Horizontal chain	12 channels	16 to 240	100 or 132	10	6 or 8	18.75	3.5
IBM Corp	1403-6/-7	Horizontal chain	12 channels	48	120	10	6 or 8	18.75	3.5
IBM Corp	1403-N1	Horizontal train	12 channels	48 to 240	132	10	6 or 8	18.75	3.5
IBM Corp	1443-N1	Oscillating bar	12 channels	13 to 63	120 or 144	10	6 or 8	16.75	4
IBM Corp.	2203-A1/-A2	Oscillating bar	12 channels	13 to 63	120 or 144	10	6 or 8	16.75	4
NCR	640-102/-300	Drum	8 channels	52 to 64	132	10	6	22	3.5
NCR	640-200/-210	Drum	8 channels	52 to 64	132/160	10	6 or 8	22	3.5
Potter Instrument Co.	HSP-3502	Horizontal chain	4 channels	Up to 192	132 or 160	10	6	18.5	2.5
RCA	70/242	Drum	12 channels	64	132 or 160	10	6 or 8	18.75	4
RCA	70/243-30/-40	Drum	12 channels	64	132/160	10	6 or 8	18.75	4
RCA	70/243-51-61	Drum	12 channels	96	132/160	10	6 or 8	18.75	4
Scientific Data Systems	7440/7460	Drum	8 channels	56	132	10	6	20	4
Shepard Laboratories	400	Drum	8 channels	64	Up to 200	10	6	21.5	4.5
UNIVAC	0758-00	Drum	None	63	132	10	6 or 8	22	4
UNIVAC	0768-00, -99	Drum	None	63	132	10	6 or 8	22	4
UNIVAC	3030-00/-02	Oscillating bar	None	63	96 to 132	10	6 or 8/6	22	4

.45 Higher Speeds and Improved Registration (Contd.)

only a restricted set of contiguous characters are being printed, the paper advance and buffer-load cycles can take place during the remainder of the drum-rotation cycle, with a consequent increase in effective speed.

While "on-the-fly" printers have been, from their inception, characterized by frequent mis-alignment or misregistration of the printed characters, it may be safely stated that printing quality has been greatly improved, especially on the more expensive printers. For example, any misregistration in chain-printed copy is horizontal; that is, the spacing between adjacent characters is uneven. This type of misregistration is less noticeable than the waviness of the printed line which is characteristic of drum printers. Even the latter are, in general, now capable of producing high-quality copy with little detectable waviness when properly adjusted and maintained.

.5 COMPARISON CHART

The accompanying comparison chart (Table I) summarizes the characteristics of more than 50 on-the-fly printer models that are currently being marketed by nine computer manu-facturers and five independent suppliers.

The information on the chart is divided into five major categories — Identity, Physical Form, Printing Characteristics, Performance, and Application — and the individual column headings are largely self-explanatory. Printing speeds, in lines per minute, are shown for three separate cases:

- Peak speed for single-spaced printing using the full alphanumeric character set, which usually contains from 48 to 64 characters.

(Contd.)

TABLE I: CHARACTERISTICS OF CURRENT LINE PRINTERS (CONTD.)

IDENTITY		PERFORMANCE					APPLICATION
Manufacturer	Model	Speed (lines/minute): Peak (with full character set)	Speed (lines/minute): Peak (with restricted character set)	Speed (lines/minute): 1-Inch Spacing (with full character set)	Maximum No. of Copies	Skipping Speed (inches/sec)	Representative Computer Systems Using This Printer
Anelex Corp.	4000	300	375	251	6	21.5	
Anelex Corp.	5000	1250	1500	740	6	25 (75 opt.)	
Burroughs Corp.	B9240/41/43	700/1040/1040	700/1040/1040	550/572/572	6	25 (75 opt.)	Burroughs 500 Systems
Burroughs Corp.	B320/321/325	475/700/700	475/700/700	360/550/550	6	25	Burroughs 200, 500 Systems
Burroughs Corp.	B328/329	1040	1040	572	6	25	Burroughs 200, 500 Systems
Control Data Corp.	501/505	800/500	1000/500	571/375	6	25	CDC 3000, 6000 Series
Control Data Corp.	512	1200	1500	?	6	70	CDC 3000, 6000 Series
Datamark, Inc.	300	300 min.	300	212	6	10	
Datamark, Inc.	500	1000	1200	545	6	25	
Datamark, Inc.	OBP	300 min.	300	212	6	17	
Data Products Corp.	4300	1000	1000	500	6	35	
Data Products Corp.	4400	360	360	216	6	20	
Data Products Corp.	4500	600	600	300	6	20	
General Electric Co.	PRT100/110/120	300/600/780	300/600/780	249/414/491	6	14.5 (63 opt.)	GE 115, 130
General Electric Co.	PRT150	600	600	484	5	27.5	GE 400 Series
General Electric Co.	PRT201	1200	1200	811	5	27.5	GE 400, 600 Series
Honeywell EDP	122/122-1	450/300	450/300	380/266	8	50/20	Honeywell 120/110
Honeywell EDP	222-1/-2/-3	650	1300	490	8	35	Honeywell Series 200
Honeywell EDP	222-4	950	1266	610	8	35 to 50	Honeywell Series 200
Honeywell EDP	222-6	1100	1100	750	6	35 to 50	Honeywell Series 200
IBM Corp.	1132	80	110	60	6	10	IBM 1130
IBM Corp.	1403-1/-2	600	1285	500	6	33 or 75	IBM 1400 Series, System/360
IBM Corp.	1403-6/-7	340/600	340/600	306/500	6	33	IBM 1401G, 1440, System/360
IBM Corp.	1403-N1	1100	1400	805	6	33 or 75	IBM System/360
IBM Corp.	1443-N1	240	600	214	6	15	IBM System/360
IBM Corp.	2203-A1/-A2	350/260	750/600		6	15	IBM System/360 Mod. 20
NCR	640-102/-300	450/600	900/1200	328/400	6	17	NCR Century Series
NCR	640-200/-210	1500	3000	888	10	90	NCR Century Series
Potter Instrument Co.	HSP-3502	450	850	240	6	16 5	
RCA	70/242	625	625	469	6	27 5	RCA Spectra 70
RCA	70/243-30/-40	1250	1250	750	6	27.5 (35 opt.)	RCA Spectra 70
RCA	70/243-51/-61	833	833	525	6	27.5	RCA Spectra 70
Scientific Data Systems	7440/7460	628/760	800/1000		6		SDS Sigma Series
Shepard Laboratories	400	1200	2400	545	6	13.8	
UNIVAC	0758-00	1200	1600	800	6	33	UNIVAC 418, 490, 1108
UNIVAC	0768-00/-99	900/1200	1100/1600		6	33	UNIVAC 9400
UNIVAC	3030-00/-02	250/600	500/1200	220/451	6	25	UNIVAC 9200, 9300

.5 COMPARISON CHART (Contd.)

- Peak speed for single-spaced printing using a restricted subset of the full character set.
- Effective speed when the average spacing between printed lines is one inch and the full character set is used.

Prices are not shown on the chart because of the difficulty of obtaining prices that are truly comparable with respect to the amount of associated control circuitry (controllers, buffers, etc.) included with the print mechanism.

.6 FUTURE OUTLOOK

.61 Conventional Printers

While future announcements of new impact-printer models are anticipated, it is likely that future advances will be made primarily in the areas of reliability and cost, rather than in speed.

Since the limiting factors on printing speed tend to be mechanical, associated with paper handling and hammer motion, it appears that present high-speed print mechanisms are approaching an upper bound of, perhaps, 2000 alphanumeric lines per minute. However, there is ample room for further improvements in overall performance through advances in mechanical reliability and serviceability, and in improved timing to give better accuracy of registration. Improvements in these areas have been noticeable over the past few years, and the upper limits have not yet been reached.

.61 Conventional Printers (Contd.)

High-speed printer mechanisms have tended to be quite expensive ($30,000 to more than $80,000); and, since no significant price reductions have occurred in the last four to five years, it may be assumed that there is, in effect, a lower limit to the price of a high-quality mechanical printer. The industry may experience some price decreases as a result of improved production methods, but these are not likely to be very dramatic.

.62 Non-Impact Printers

A breakthrough in printer design may come in the form of non-impact printing techniques such as photographic, xerographic, or cathode-ray-tube methods. Several non-impact printers are now on the market. One uses an interesting technique in which a character is written on a CRT and then piped through a fiber-optics cord to print on light-sensitive paper. This unit is reported to run at 6000 alphameric lines per minute, and is an example of the sort of inspired design of which the industry is capable.

The major hurdles facing non-impact printer manufacturers are: first, that most non-impact printers require specially-treated paper, which is expensive and often of an unpleasant consistency to the human touch; and second, that these printers are, at present, incapable of producing more than one copy of the printout, which is a crippling disadvantage in some commerical applications. It is interesting to speculate that perhaps non-impact printing devices will eventually be so inexpensive as to allow the purchase of multiple units, all driven in parallel by a single set of electronic logic; yet even there, the question of whether such parallel-produced documents are legal copies of one another will have to be resolved.

Thus, non-impact printing techniques offer the potential for high printing speeds at comparatively low costs, but some serious problems will have to be overcome before they will be effective across-the-board competitors for mechanical printers. The impact printer is here to stay, and, while it will be supplemented in certain applications by the newcomers, it is not likely that it will soon be supplanted by them.

.7 APPENDIX: LINE PRINTER TERMINOLOGY

Alphanumeric

Pertaining to a character set that includes both alphabetic characters (letters) and numeric characters (digits). Note: Most alphanumeric character sets also contain special characters, such as punctuation or control characters.

Carriage

That portion of a printing device which serves to hold and transport the paper being printed upon.

Chain printer

A line printer in which the type slugs are mounted on a chain that moves horizontally past the printing positions. Note: Chain printers generally provide more accurate vertical registration than the more commonly used drum printers, and interchangeable chains often permit rapid changes in the size or make-up of the character set.

Character set

A set of marks or signals used to represent data; e.g., a typical character set for a printer might include the digits 0 through 9, the letters A through Z, and the common punctuation marks.

Control character

A coded character which is part of a computer program or some common-language medium. Instead of being printed, a control character initiates some kind of mechanical activity on the part of the device being used for printing (e.g., carriage return, tab, or skip).

Drum

With reference to printing, the imprinting device in an on-the-fly printer, consisting of a constantly revolving shaft, drum, or series of interlocked wheels embossed with the characters which are to be imprinted.

Edit

To rearrange information. Editing may involve the deletion of unwanted data; the selection of pertinent data; the insertion of various symbols, such as page number and typewriter characters; and the application of standard processes such as zero suppression.

Font

A family of graphic character representations (i.e., a character set) of a particular size and style.

Frame

The total area of a single print position.

.7 APPENDIX: LINE PRINTER TERMINOLOGY (Contd.)

Hard copy

A visible record on a permanent medium.

Line printer

A printer that prints all the characters comprising one line during each cycle of its action.

On-the-fly printer

A printer in which the type remains in motion during the printing process; at the appropriate instants during its movement, the paper and type are forced together to cause the desired characters to be printed.

Pitch

The horizontal distance between corresponding points of adjacent type characters; e.g., 12-pitch (12 characters per inch) is "elite" pitch, 10-pitch is "pica" pitch, and 8-pitch is "billing" pitch.

Platen

An element of the carriage in a typing or printing device which is usally (but not necessarily) a hard rubber cylinder. The function of the platen is to support the paper as it is struck by the type face, and to guide the paper as it is spaced.

Print position

A position in which any one of the members of the printer's character set can be printed in each line. Note: Most of the current line printers have between 80 and 160 print positions, i.e., they can print between 80 and 160 characters per line.

Registration

The physical positioning of a print line or character (vertical or horizontal registration) with relation to a form set or the machine itself.

Skip or Slew

To move paper in a printer, without printing, through a distance greater than the normal line spacing, usually at a higher speed than in a single-line advance.

Solenoid

An electro-mechanical actuator used to convert electrical energy into physical movement. In printers, solenoids are used to fire the print hammers.

Special character

A character that is neither a letter nor a digit; it may be a punctuation mark (e.g., comma) or a control character that causes a particular operation to be performed (e.g., carriage return).

Tractor

A device used on printers to control the vertical movement of paper through the carriage, normally by means of pinion wheels which engage pinfeed or punched-hole margins.

Vernier

A printer control, normally rotational in nature, used for fine vertical or horizontal carriage adjustments to align the form being printed while the printer is operating.

Vertical format control tape

A punched paper or plastic tape, usually 8- or 12-channel, formed into a loop and used to control the spacing and skipping of a line-printer carriage.

RANDOM ACCESS STORAGE
A STATE-OF-THE-ART REPORT

Prepared by

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(Contd.)

RANDOM ACCESS STORAGE: A STATE-OF-THE-ART REPORT

.1 RANDOM ACCESS DEFINED

Random access storage is a vital component of most automated systems designed to provide faster response and improved control in an ever-widening scope of applications: management information systems, production control, order processing, inventory management, reservations, message switching, process control, and many more. The computer systems that perform these advanced data processing functions generally must employ equipment of the on-line type, in which the storage files are directly accessible to the computer so that data storage and retrieval can be both immediate and automatic. The on-line file concept calls for a storage medium that permits data to be retrieved rapidly and selectively, on a random basis.

Random access storage devices are also desirable for effective utilization of multiprogrammed computer systems (in which utilization of the equipment is maximized by processing several independent programs concurrently) and high-performance software (compilers, operating systems, sorting routines, etc.). The importance of this type of equipment in the current computer market is illustrated by the fact that IBM's System/360 line includes eight different types of random access storage devices with a wide range of data capacities, access times, and data transfer rates.

The functional meaning of the term "random access" is best understood by comparing random access storage with magnetic tape storage. Data is stored on magnetic tape in serial form, and the time required to retrieve a certain piece of data is dependent upon its location on the tape. Retrieval time, therefore, can vary widely according to the location of the data within the storage medium. In contrast, the time to retrieve data from random access storage is not related to its location in the medium. The retrieval time for any one particular item of data is — in the ideal case — the same as for any other item of data.

This idealized definition of random access storage does not strictly apply to most of the existing mass random access storage devices. In these devices the access times to retrieve two different items of data may differ slightly according to the locations of the data.

Time is required to move the section of the storage medium containing the desired data into position under the read/write head. This is called "latency" or "rotational delay". Latency is directly dependent upon the relationship between the locations of the desired data and the data currently under the read/write head; to bring the new data into position under the read-write head may require a quarter, half, or full turn of the storage medium.

An additional period of time, called "head positioning time", may be required to position the read/write head over the proper track of the storage medium. In any case, the variance in access times is measured in milliseconds — whereas several minutes would be required to search through all the data on a reel of magnetic tape.

One storage medium that does meet the strict definition of random access is the computer's internal core or thin-film memory. All data contained in it can literally be accessed in equal time, regardless of its physical location. Although functionally ideal, core or thin-film memory is economically impractical for most mass storage purposes because of the high cost per character stored.

A highly significant recent development in this area is Control Data's Extended Core Storage Units, which make up to 20 million characters of core storage available to users of the ultra-large-scale Control Data 6600 system. Data transfers between the Central Memory and the Extended Core Storage Unit start within three microseconds after the instruction is issued and proceed at the unprecedented rate of 100 million characters per second.

Large-capacity, nonmechanical storage of this type will greatly facilitate efficient utilization of large-scale computer systems in multiprogramming, time-sharing environments, but as yet its cost is still too high to justify its use for master-file storage in most applications. However, current development work in this area indicates that within a few years it may be possible to store hundreds of millions of characters in this kind of medium and access them within a few microseconds — and at a reasonable cost.

.2 HARDWARE TYPES

The most commonly-used mass random access storage devices at the present time are magnetic drums, magnetic disc files, and cartridge-loaded units. These three basic types of devices differ functionally in a number of ways that can be important from an applications viewpoint.

.21 Drums

Magnetic drum devices consist of a revolving drum with a magnetizable surface on which information is arranged in tracks. Read/write heads pick up and record data as the desired items pass beneath them. This means that there may be a rotational delay of up to one drum revolution when accessing a given record. In practice, the delay averages out to one-half revolution. Most magnetic drum devices employ an individual, fixed read/write head for each track, so that this rotational delay is the only time factor that must be considered in the accessing operation.

High data transfer rates are frequently achieved by recording data simultaneously (in parallel) in two or more adjacent tracks. IBM's 2301 Drum Storage unit reads and records four bits in parallel and transfers 1,200,000 characters per second. Control Data's 863 Drum reads and records 13 bits (2 characters plus a parity bit) in parallel and can transfer up to 2,000,000 characters per second.

When compared to the other types of random access storage devices, drums have relatively fast access times and transfer rates, relatively low storage capacities, and a relatively high cost per character stored. The type of drum memory with a fixed read/write head serving each data track is particularly well suited to the storage of systems programs, address directories for larger-capacity random access units, and for on-line applications where short response time is more important than large storage capacity.

Though most magnetic drum units use multiple fixed read/write heads, there are some exceptions. UNIVAC's Fastrand units use movable access mechanisms to decrease the number of read/write heads necessary to serve large data stores. In these drum units, as in most disc files, the access time is significantly increased whenever it is necessary to move the heads from one data track to another. (Optionally, a small extra storage area is available which is served by special fixed read/write heads and can always be accessed without head-positioning delays.)

The Fastrand II Mass Storage Unit, used with UNIVAC 418, 494, and 1108 computer systems, contains two large drums with a total storage capacity of 132 million characters — more than most disc files. The average time required to position the read/write heads over the selected tracks is 58 milliseconds, followed by a rotational delay that averages 35 milliseconds. All heads move in unison, and 688,128 characters of data are always under the heads at any given position of the access mechanism.

.22 Disc Files

Magnetic disc devices are a variation on the drum concept. They consist of multiple discs mounted on a single shaft to provide larger and usually less expensive storage capacity than fixed-head drums. Data is recorded on concentric circular tracks, usually on both faces of the discs, and usually in bit-serial form.

In the first generation of disc-file equipment, exemplified by the IBM 1405 Disc Storage Unit and the IBM 305 RAMAC, a single access arm serves all the discs. In these units, the arm moves vertically to the selected disc, then horizontally across the disc to the appropriate data track. This extensive mechanical movement of the head, plus the time it takes for the desired record to rotate past the head, makes these pioneer disc-file units significantly slower than drum devices. The average access time of these early units is more than one-half a second.

Access time has been significantly improved in later equipment models. Most of the second-generation disc file units, as exemplified by the the IBM 1301, have a separate access arm for each disc. The multiple access arms form a comb that moves as a single unit. The elimination of the need for vertical positioning reduces the average head positioning time by a factor of four to six as compared with the early IBM 1405 unit.

The IBM 1301 uses a single read/write head on each access arm to service all 250 data tracks on each disc. Other disc files, such as the Control Data 6638 and the Honeywell 262, have multiple read/write heads for each disc surface; this reduces the head repositioning times and, more important, increases the quantity of data that can be read without repositioning the heads (i.e., the "cylinder" size). *

A later IBM unit, originally named the 1302 and later redesignated the 2302, uses the same principle as the 1301 but offers more characters per track and more tracks per disc through an increase in the recording density. This approximately quadruples the capacity, doubles the peak data transfer rate, and significantly lowers the cost per character stored.

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* In designing file layouts and programs for many current random access storage devices, a key concept is the "cylinder", a collective term for the group of data storage locations that can be accessed without physical movement of the read/write heads. In a storage device in which all of the heads move in unison, there will normally be one cylinder corresponding to each discrete position of the access mechanism.

.22 Disc Files (Contd.)

A subtle but significant variation on the comb-like access mechanism is used in some disc files that have individual positioning mechanisms for each arm instead of a single mechanism that positions all arms in unison. The General Electric DSU204 Disc Storage Unit, for example, can have from 4 to 16 discs, each served by an independently positionable access arm. This arrangement provides considerable flexibility: 368,640 characters are available at any time without head repositioning, and there is no need to restrict the data layout to "cylinders" in which all the tracks to be accessed at one time are in corresponding positions on the various discs.

Burroughs, in its extensive line of Disc Files, eliminates all movement of the read/write heads by providing an individual head for each data track. Consequently, the total access time is limited, as in fixed-head drum devices, to the rotational delay time, which averages from 17 to 60 milliseconds in the various models. This is substantially less than the time required by most of the disc files in which a comb of access arms has to be moved horizontally across the disc surfaces. The head-per-track design used in the Burroughs units makes their performance characteristics more nearly comparable with those of large drums than with movable-head disc units, yet their costs are low enough to make them suitable for many large-volume applications.

Disc file development has been hampered by two major mechanical problems: positioning movable read/write heads with the desired speed and precision, and maintaining proper spacing between the heads and the disc surfaces. A number of complex electro-mechanical techniques have been developed to position the heads quickly and accurately, but their uncertain reliability still causes occasional headaches for both manufacturers and users.

The read/write heads must be kept within a few ten-thousandths of an inch of the magnetic recording surface in order to achieve the high recording densities required for high data transfer rates and large storage capacities. To avoid damaging physical contact between the heads and the rapidly revolving disc surface, many units use the principle of "floating" the read/write heads on a layer of air generated by the rotational friction of the discs. Some units also employ solenoids as a fail-safe device that retracts the heads in case of power failure. Although these solutions are obviously workable, they are mechanically complex and expensive. Several manufacturers are now developing disc files and/or drums in which continuous physical contact is maintained between the read/write heads and the recording surfaces; in these units the major design problem is the minimization of wear to ensure reliable long-term performance.

.23 Cartridge-Loaded Units

The third basic type of random access storage device is the cartridge-loaded units, which utilize a variety of different types of magnetic media. NCR's CRAM, RCA's Model 3488 and 70/568-11, and IBM's 2321 Data Cell Drive all use magnetic cards or strips, which are extracted from a replaceable cartridge and wrapped around a revolving drum that carries them past the read/write heads. The IBM 1311 and 2311, the Control Data 850 Series, and numerous other units use removable stacks of discs. Potter's RAM unit uses continuous loops of magnetic tape.

Each of these units represents an attempt to combine the rapid-access capabilities of random access devices with the practically unlimited total storage capacity (on-line plus offline) of magnetic tape. From an applications point of view, the total storage capacity and flexibility of operation gained by having interchangeable cartridge units must be measured against the relatively long delays that occur whenever cartridges must be manually interchanged to make new information available on-line.

.231 Magnetic cards

The trail-blazing NCR CRAM (Card Random Access Memory) unit uses flexible magnetic cards. A cartridge contains 128, 256, or 384 cards. For a read/write operation, the selected card is dropped from the cartridge and held by vacuum against the revolving drum, which carries it under the read/write heads. After the card has been read and/or recorded upon, it is stripped from the drum, and its momentum carries it up through a return chute and back into the cartridge. There is no need for the cards to be replaced in any particular sequence; the selector rods can cause the selected card to drop, regardless of its position in the cartridge, through the use of binary-coded notches in the top of each card.

In the original NCR Model 353-1 CRAM, each cartridge can store over 5.5 million alphanumeric characters. Each card in the cartridge has seven 3,100-character data tracks, all of which can be read or recorded upon when the card is wrapped around the revolving drum. The recording mode is similar to that of many magnetic tape systems; there are eight bit channels per track, and a "read-after-write" check is performed upon recording.

The newer Model 353-2 and 353-3 CRAM units use bit-serial recording, one bit channel per 1,120-character data track. This change in the recording mode reduces the equipment cost and increases cartridge capacity to 8 million characters in Model 353-2 and 16 million characters in Model 353-3, but it also results in a lower data transfer rate than that of the Model 353-1.

.231 Magnetic cards (Contd.)

As part of its third-generation Century Series computer line, NCR announced a new, large-capacity CRAM unit, Model 653-101. Each 653-101 unit stores up to 124,416,000 bytes (or 248,832,000 packed decimal digits) in a single 384-card cartridge. The Mylar cards are 3.65 inches wide and 14 inches long. Each card contains 144 tracks, and each track can store 2,250 bytes. Data is recorded serially by bit at a density of 1,500 bits per inch. The time required to drop a selected card from the cartridge and wrap it around the revolving drum, ready for reading or writing, has been reduced to 125 milliseconds (versus 235 milliseconds in earlier CRAM models). A movable head assembly contains 36 read/write heads which move in unison to one of four positions in order to service all of the 144 tracks on the card.

RCA's Model 3488 Random Access Computer Equipment uses the same basic principles as CRAM, but each Model 3488 unit can hold 8 or 16 interchangeable card magazines at a time. Each magazine holds 256 cards and up to 42 million characters of data. Each card contains 64 bands of two tracks each, and each band holds four 650-character blocks of data. Four pairs of read/write heads are moved, in unison, to one of 16 possible positions so that they can serve all of the 64 bands. Access time to data on a particular card is normally between 290 and 465 milliseconds, depending upon the position of the addressed magazine. Model 3488 storage is intended for applications where a large volume of relatively inexpensive random access storage is needed, rather than where fast access is important.

The newer Model 70/568-11 Mass Storage Unit, used with RCA's third-generation Spectra 70 computers, is functionally similar to Model 3488, but each of the eight on-line magazines in the 70/568-11 can store up to 67.1 million bytes. Recording is bit-serial, each card contains 128 data tracks, and each track holds 2,048 bytes. Eight read/write heads move in unison to one of 16 positions to service all of the tracks.

IBM's 2321 Data Cell Drive, like RCA's Model 3488, provides economical storage for extremely large volumes of data in applications where relatively slow access times can be tolerated. Each 2321 drive stores up to 400 million characters (or 800 million packed decimal digits) in 10 removable, interchangeable "data cells" with a capacity of 40 million characters each.

Data in the 2321 is recorded on magnetic strips, 13 inches long and 2.25 inches wide, which are arranged in data cells mounted vertically around the circumference of a cylinder or "tub file" that can be rotated. Each of the 10 data cells is divided into 20 subcells, and each subcell contains 10 magnetic strips. There are 100 recording tracks on each strip, and each track can hold a maximum of 2,000 characters. A bidirectional rotary positioning system positions the selected subcell beneath an access station. The selected strip is withdrawn from the cell, placed on a separate rotating drum, and moved past the read/write heads, where reading and/or recording take place. Then the strip is returned to its original location in the cell. When a previously addressed strip is on the drum, time to access data on a different strip varies from 375 to 600 milliseconds.

On the basis of direct equipment costs per character stored, the magnetic-card devices clearly provide the most economical random access storage now available. But the prospective buyer should not overlook: (1) the relatively slow access times of most magnetic-card devices, which may lead to intolerably low system throughputs; and (2) the spotty reliability record of these devices to date — excessive downtime and rapid card wear have been serious problems in a number of installations.

.232 Disc packs

During the past few years, much of the action in the random access storage field has involved "disc pack" drives. Pioneered by IBM with its 1311 Disc Storage Drive in 1962, the disc pack concept represents a combination of the virtues of discs and magnetic tape that is finding ever-increasing acceptance among computer installations of all sizes and types. Moreover, the production of the interchangeable disc pack cartridges is a rapidly growing industry; companies now marketing disc packs include IBM, Business Supplies Corporation of America, Caelus Memories, Consolidated Electrodynamics, Control Data, Honeywell, Kee Lox Manufacturing, Mac Panel, Management Assistance Inc., Memorex, Tab Products, and Wright Line.

The IBM 1311 and 2311 Disc Storage Drives are patterned after the larger IBM 1301 and 2302 Disc Storage Units. They use the comb-type access mechanism with interchangeable disc pack cartridges consisting of a stack of six discs. The 10 inside disc surfaces are used for data recording. A cartridge has a total storage capacity of 2,980,000 characters in the 1311 and 7;250,000 characters in the 2311, and it can be replaced in about one minute. Compared with the IBM 1301 and 2302, the 1311 and 2311 have much lower on-line storage capacities but offer the advantages of cartridge loading and lower price tags.

Control Data Corporation also offers interchangeable-cartridge disc storage drives, with three models announced to date. Model 852 introduced the concept of "compatibility" into the random access field for the first time, being functionally identical with the IBM 1311.

(Contd.)

.232 Disc packs (Contd.)

Compatibility in this case refers to the disc pack cartridges, which can be interchanged between IBM 1311 and Control Data 852 drive units. The Control Data version differs from the 1311 in having a faster head positioning time. The other two Control Data models, the 853 and 854, use the same six-disc cartridges and have the same head-positioning times as the 852, but have higher data capacities.

A number of other computer manufacturers (including General Electric, Honeywell, RCA, and UNIVAC) and independent peripheral equipment manufacturers are now marketing disc storage units that use the same disc packs — though not necessarily the same data recording formats — as the IBM 2311 Disc Storage Drive. Thus, the disc pack can potentially serve as a useful medium for inter-computer communication, in the same manner as magnetic tape has long been used.

In the IBM 2314 Direct Access Storage Facility, IBM provides nine disc storage drives (eight for on-line use and one spare), each capable of handling a removable 2316 Disk Pack and storing up to 29.18 million bytes with an average positioning time of 75 milliseconds. Although the 2316 Disc Packs used with the 2314 and the 1316 Disc Packs used with the IBM 1311 and 2311 are conceptually similar, they are not interchangeable. Each 2316 Disc Pack is divided into 200 "cylinders" holding 129,384 bytes each. The access mechanisms on the individual drives can move independently and simultaneously, although all of the access arms on any specific drive always move in unison.

A dual-spindle disc drive is the key peripheral device in the third-generation NCR Century Series computer line; every Century system will contain at least one disc unit, and all software is disc-oriented. Each NCR disc unit has two vertical spindles, and each spindle drives an interchangeable disc pack that holds 4.2 million bytes. The NCR disc pack, however, is not IBM-compatible. It consists of three discs with six plated metallic recording surfaces, all of which are used for data storage. Each spindle has a comb-type access mechanism, and each disc surface is served by 12 read/write heads, arranged in such a way that the maximum arm movement is only 3/16 inch. As a result, arm movement time never exceeds 60 milliseconds and averages only 42 milliseconds.

.233 Tape loops

Potter's RAM unit offers a number of interesting features. Data is recorded on 30-inch-long loops of standard computer-grade magnetic tape held in interchangeable cartridges. Each tape loop is two inches wide and contains 112 recording tracks. Bit-serial recording is used, at a density of 1,000 bits per inch. A single cartridge contains 16 tape loops and can store up to 7.2 million characters. (A newer dual-cartridge RAM unit stores up to 3.6 million characters in each of two 8-loop cartridges.)

Vacuum capstans and "air bearings" are used to reduce wear and contamination of the tape. Any tape loop not engaged in a data transfer process remains stationary and is drawn away from both the drive capstan and the read/write heads. Seven reading heads and seven writing heads serve each of the RAM tape loops. All of the heads move in unison to any one of 16 discrete positions. Average head positioning time is 62.5 milliseconds, and average rotational delay is 25 milliseconds. Data transfer rate is 86,000 characters per second.

.3 THE ECONOMICS

The economics of using random access devices involves considerably more than simply comparing their cost with that of magnetic tape transports. To achieve any sort of valid economic measurement, it is necessary to make a comparison between the two fundamentally different methods of processing: on-line and batch. On-line processing implies that all transactions are processed in essentially the order in which they are presented to the data processing system, so random access to the stored files is a prerequisite. In the more conventional batch processing approach, the transaction data must be arranged in the same sequence as the master file before processing. The major economic differences between the two methods can be determined by comparing their access times, storage costs, and overall throughput costs.

.31 Access Times

Comparing the access times of on-line and batch processing really necessitates a comparison between the access time of the random access device and the times for the transaction-file sorting required for batch processing. Once the transaction record is matched or merged with the master-file record in batch processing, the remaining processing time required will be about the same as that required for the on-line processing operation. In making such a comparison, keep in mind that in a well designed on-line system, most of the access time can probably be overlapped with computer processing; only the non-overlapped access time needs to be measured against the sorting time for the batch processing case.

These timing factors will vary with the file size, record size, computer system configuration, and type of random access device used. Each case will therefore need to be considered separately, and no generalized conclusion can be drawn.

.32 Storage Costs

Here we must consider the costs of: (1) the storage units themselves, (2) all control units necessary to connect the storage units to the central processor, and (3) the storage media (cartridges, tape reels, etc.) required to hold all of the necessary information, both on-line and off-line. Using currently available equipment, disc files (and large-capacity drum files) tend to compare favorably in cost with cartridge and tape units for storage requirements of up to around 100 million characters. For storing files of over one billion characters, they tend to become unwieldy because of the large number of physical units required and their space and maintenance requirements.

When properly used, the best cartridge units can offer significant advantages in storage cost over both magnetic tape and disc units for storage requirements up to several billion characters. When total storage requirements exceed this level, tape systems are unmistakably the cheapest, due to the very low cost of the tape itself.

On the basis of relative cost, it would seem that a combination of both serial and random access storage is likely to become standard practice in many of the EDP installations of the future. Discs, drums, or future nonmechanical random access stores would be used for smaller files of up to about 100 million characters, and magnetic tape would be used for the very large-volume files. Normally, the more active records would be held in random access storage for faster accessibility, while the rest would be stored on magnetic tape for economy.

.33 Throughput Costs

In determining the effect that random access storage will have on the number of transactions your EDP system can process per dollar, you are getting to the crux of whether or not random access storage is practical for your own particular installation. In attempting to make this decision, you must begin considering some of the broader systems implications of using random access storage.

It is obvious that a well-designed on-line system is greatly superior to a batch type system with respect to the total response time required to process a given transaction and update the necessary files. The advantage might be as much as seconds versus hours or even days. However, in order to handle high peak loads without excessive delays, an on-line system may require significantly more throughput capacity (computer power) than a batch-type system designed to handle the same total workload.

With currently available computer hardware, a system configuration designed for efficient batch processing generally will be able to process more records per day at a lower cost than a corresponding random access configuration of the same computer system. This is due not only to the cost of the random access units themselves, but also to the added core storage and communications equipment that is usually required for on-line processing.

On the basis of the number of transactions processed per dollar, therefore, batch processing usually shows a significant advantage over on-line processing with currently available equipment. This advantage may be more than offset, however, by a number of system performance considerations centered around a significant expansion of the data processing system's utility to the organization.

.4 SYSTEMS CONSIDERATIONS

The use of random access storage can rarely be justified solely on the basis of the economic comparisons described above. The user must ultimately decide whether an on-line system will provide enough added advantages over a batch-type system to justify the added expense. These advantages take the form of faster response, more timely management information, and the economies of integrated operations.

.41 Faster Response

On-line random access files can, of course, provide immediate responses to requests for information. Because data can be entered into the system on a random basis and filed immediately, as contrasted with the batch processing techniques used in magnetic tape systems, answers to queries are not only rapid but based on completely up-to-the-minute information. In cases where different types of data must be supplied to a system user, data retrieval can usually be accomplished in one pass, whereas a batch processing system might require a number of separate passes through the different files. The more diverse the data requirements of an organization and the greater the need for up-to-date information, the more practical an on-line system becomes.

.42 Timely Management Information

The on-line system's ability to respond quickly to diverse queries with up-to-date information is extremely attractive to management. Not only can the system provide the type of information needed to tighten the administration and control of operations, but it can provide more pertinent inputs to the management decision-making process.

.42 Timely Management Information (Contd.)

The ability of an on-line system to process transactions as they occur also simplifies the scheduling problems within the computer facility. Tradeoffs no longer need to be made between regular daily tasks and the occasional tasks such as end-of-month closings and weekly reports. This tends to reduce peak-load buildups and even out the data processing workload so that more consistent and efficient use is made of the computing equipment.

.43 Integrated Operations

Mass random access storage devices are a vital element in the development of modern information systems. By permitting rapid access to all of the pertinent information in the organization's files, random access devices open the door to a total systems concept in which each individual transaction can immediately trigger the appropriate entries in all of the affected files. For example, a single sales order might cause changes in inventory, production scheduling, material control, dispatching, billing, accounts receivable, credit, commission, and other records. Integrated systems will make it possible for large modern corporations to enjoy the same degree of centralized control and flexibility of operation as small single-proprietor businesses.

.5 THE COMPARISON CHART

The accompanying comparison chart summarizes the significant characteristics of 26 random access storage devices. These devices are representative of the equipment currently offered by the major manufacturers of general-purpose computer systems. Though there are numerous independent suppliers of random access storage units, the devices marketed by the main-frame manufacturers are believed to be of greater interest to most users of this reference service. More information about these and other random access storage units can, of course, be found in Volumes 2 through 8 of AUERBACH Standard EDP Reports.

The chart entries have been selected to pinpoint specific advantages or disadvantages of each device from a user's point of view. An explanation of the meaning and significance of each comparison chart entry follows.

- Category — The storage devices included in this chart can be grouped into three major categories: Magnetic Drums, Magnetic Disc Files, and Cartridge-Loaded Units (in which the storage medium is conveniently replaceable).
- Device — Identifies each device by manufacturer, model number, and the name by which it is commonly known.
- Representative Computer System — It is difficult (if not meaningless) to evaluate a random access storage device independently of the computer system to which it is connected. A single, representative computer system has been selected to serve as a basis for all the comparison chart entries for each storage device. The capacity and performance characteristics of some storage devices can be significantly different when they are associated with other computer systems.
- Report Reference — Indicates the section where you can find a detailed description of each device in the full, 8- or 10-volume edition of AUERBACH Standard EDP Reports.
- Storage Medium — The physical medium upon which data is recorded.
- Storage Capacity — The five entries in this general category define data storage capacity in terms of:

  (1) The number of data discs or drums per physical unit of random access storage (often a variable quantity, in which case the range is indicated).

  (2) The number of logical tracks on each disc surface or drum upon which data can be recorded. Where a "band", or logical track, is composed of two or more parallel tracks which are always read and recorded at the same time, the fact is clearly indicated.

  (3) The maximum number of alphanumeric characters that can be recorded on a single logical track.

  (4) The maximum number of alphanumeric characters that can be read or recorded without any repositioning of the read/write heads (i.e., the "cylinder" capacity).

  (5) The maximum number of alphanumeric characters (usually six or eight bits per character) that can be stored in each physical unit of random access storage. The characters are assumed to be in the code and format most commonly used to represent alphanumeric information in the particular system. It should be noted that in many random access devices, the number of decimal digits of all-numeric information that can be stored is substantially higher than the number of alphanumeric characters. For example, in most systems that use the 8-bit byte representation, two decimal digits can be "packed" into each byte.

.5 THE COMPARISON CHART (Contd.)

- **Head Positioning Time — For storage devices with movable read/write heads, the time required to reposition these heads is reported in terms of:**

  (1) The minimum time required to move the heads to the next adjacent track position.

  (2) The average time required to position the heads to read a randomly-placed record.

  (3) The maximum (worst-case) positioning time.

  For the cartridge units that use magnetic cards, the indicated "head positioning times" actually represent the times required to withdraw a card from the cartridge and position it on the read/write drum.

- Average Rotational Delay — The average time (in milliseconds) required for the first character of the selected data record to reach the read/write heads after the heads have been properly positioned (usually one-half revolution in the case of magnetic disc and drum storage devices). The total average access time for a randomly-placed record is, of course, the sum of "Average Head Positioning Time" and "Average Rotational Delay".

- Peak Data Transfer Rate — The maximum rate at which data is read from or recorded upon the random access storage medium after the desired record has been located, expressed in characters per second. When large blocks of data must be read from or recorded in consecutive storage locations, the overall effective data transfer rate, in some cases, will be significantly lower than the peak rate, due to rotational delays between records and/or the need for repositioning.

- Update Cycle Rate — The maximum number of records per second that can be accessed from random storage locations, read into the computer's main storage, updated, rewritten into the same storage locations, and checked for correct recording. The records must be at least 100 characters in length. All records are in random locations scattered evenly throughout the storage unit, and no batching of transactions or overlapping of seek times on multiple storage units is permitted. This is a useful, standardized measure of a random access storage device's performance in a straightforward on-line file maintenance application.

- Read-Only Reference Cycle Rate — The maximum number of records per second that can be accessed from random storage locations and read into the computer's main storage. In this case, no updating or rewriting is required. All other conditions are the same as for the "Update Cycle Rate" above. This figure measures a random access storage device's performance in simple inquiry/response applications where no file updating is required.

- Transfer Load Size — The number of alphanumeric characters that can be transferred to or from the random access storage device in a single read or write operation. The load size is fixed in some cases and variable in others.

- Read/Write Checking — The type of checking performed upon the accuracy of data recording and/or reading. The most commonly employed method is to generate and record a parity bit for each character, word, or record, and to check the recorded data for correct parity when it is reread. "Check characters" usually implies a similar but somewhat more powerful system for detecting errors (and, in some cases, correcting them). "Read after write" parity checking or separate (and time-consuming) "write check" operations permit detection of most recording errors at the time of occurrence — a highly desirable feature.

- Representative Cost — To complete the picture, a purchase cost figure, expressed in dollars per character, is listed for each type of random access storage. This cost is based upon the price of a single physical storage unit of the largest available capacity, together with any control units that are required to connect it to the specific computer system shown in the chart. (The costs of general-purpose computer data channels and multiplexors are not included.) It is important to note that the cost per character may vary significantly when the device is associated with a different computer system, or when more or less storage capacity is required.

COMPARISON CHART
CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		MAGNETIC DRUMS		
Device		Control Data 863 Drum Storage Unit	IBM 2301 Drum Storage	IBM 2303 Drum Storage
Representative Computer System		CDC 3300	IBM System/360	IBM System/360
Report Reference		250:042	420:043	420:045
Storage Medium		Drum	Drum	Drum
Storage Capacity	Data Discs or Drums per Physical Unit	1	1	1
	Data Tracks per Disc Surface or Drum	64 bands; 13 tracks/band	200 bands; 4 tracks/band	800
	Maximum Characters per Track	65,536/band	20,483/band	4,892
	Maximum Characters Accessible Without Head Repositioning	Total capacity	Total capacity	Total capacity
	Maximum Characters per Physical Unit	4,194,304	4,096,600	3,910,000
Head Positioning Time, Milliseconds	Minimum	0	0	0
	Average (Random)	0	0	0
	Maximum	0	0	0
Average Rotational Delay, Msec		16.7	8.6	8.6
Peak Data Transfer Rate, Characters per Second		2,000,000	1,200,000	312,500
Transfer Load Size, Characters		2 to 4,194,304	1 to 20,483	1 to 4,892
Update Cycle Rate, References per Second		11.8	22.7	16.5
Read-Only Reference Cycle Rate, References per Second		57.2	116	100
Read/Write Checking		Parity	Cyclic check characters	Cyclic check characters
Representative Cost, Dollars per Character Stored		0.045	0.050	0.039
Features and Comments		Fixed heads; interlacing permits slower data rates where desirable	Fixed heads; variable record lengths	Fixed heads; variable record lengths

(Contd.)

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		MAGNETIC DRUMS		
Device		UNIVAC FH-432 Magnetic Drum	UNIVAC FH-1782 Magnetic Drum	UNIVAC Fastrand II Mass Storage
Representative Computer System		UNIVAC 1108	UNIVAC 1108	UNIVAC 1108
Report Reference		785:042	785:043	785:044
Storage Medium		Drum	Drum	Drums
Storage Capacity	Data Discs or Drums per Physical Unit	1	1	2
	Data Tracks per Disc Surface or Drum	128 bands; 3 tracks/band	256 bands; 6 tracks/band	6,144
	Maximum Characters per Track	12,288/band	49,152/band	10,752
	Maximum Characters Accessible Without Head Repositioning	Total capacity	Total capacity	688,128 or 946,176*
	Maximum Characters per Physical Unit	1,572,864	12,582,912	132,120,576 or 132,358,624*
Head Positioning Time, Milliseconds	Minimum	0	0	30
	Average (Random)	0	0	58
	Maximum	0	0	86
Average Rotational Delay, Msec		4.25	17.0	35
Peak Data Transfer Rate, Characters per Second		1,440,000	1,440,000	153,750
Transfer Load Size, Characters		6 to 393,216	6 to 393,216	6 to 393,216
Update Cycle Rate, References per Second		46.3	11.8	4.1
Read-Only Reference Cycle Rate, References per Second		217	58.1	10.6
Read/Write Checking		Parity, char. count	Parity, char. count	Check characters
Representative Cost, Dollars per Character Stored		0.079	0.016	0.0016
Features and Comments		Fixed heads; drum search capability	Fixed heads; drum search capability	Movable access mechanism has 64 read/write heads. * With Fastband optional feature.

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		DISC FILES (NONREMOVABLE DISCS)			
Device		Burroughs B 9370-2 System Memory	Burroughs B 9372 Modular Random Storage	Control Data 6638 Disc System	Control Data 814 Disc File
Representative Computer System		B 2500/3500	B 2500/3500	CDC 6600	CDC 3300
Report Reference		210:042	210:043	260:045	250:043
Storage Medium		Disc	Discs	Discs	Discs
Storage Capacity	Data Discs or Drums per Physical Unit	1	4/module, 20/bank	72	72
	Data Tracks per Disc Surface or Drum	100	150	192	192
	Maximum Characters per Track	10,000	9,600	81,920 per band of 12 tracks	8,192
	Maximum Characters Accessible Without Head Repositioning	Total capacity	Total capacity	5,250,000	4,194,000
	Maximum Characters per Physical Unit	2,000,000	50,000,000 per bank	168,000,000	201,326,592
Head Positioning Time, Milliseconds	Minimum	0	0	34	34
	Average (Random)	0	0	70	75
	Maximum	0	0	100	110
Average Rotational Delay, Msec		17	20	26	25
Peak Data Transfer Rate, Characters per Second		291,000	240,000	1,680,000	196,700
Transfer Load Size, Characters		100 to 10,000	100 to 10,000	5,120	up to 2.1 million
Update Cycle Rate, References per Second		11.8	10.0	5.0	5.2
Read-Only Reference Cycle Rate, References per Second		57.6	49.0	10.4	10.9
Read/Write Checking		Check chars., write check	Check chars., write check	Parity	Parity
Representative Cost, Dollars per Character Stored		0.014	0.0048	0.0019	0.0013
Features and Comments		Fixed heads, 1 per track	Fixed heads, 1 per track	horizontally-opposed access "combs"; records 12 tracks, on 12 disc surfaces, in parallel	horizontally-opposed access "combs"; records in bit-serial mode

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		DISC FILES (NONREMOVABLE DISCS)			
Device		GE DSU204 Disc Storage Unit	Honeywell 262 Disc File	IBM 2302 Disc Storage	IBM 1405 Disc Storage
Representative Computer System		GE 400 Series	Honeywell 200	IBM System/360	IBM 1401
Report Reference		330:042	510:044	420:044	401:042
Storage Medium		Discs	Discs	Discs	Discs
Storage Capacity	Data Discs or Drums per Physical Unit	4 to 16	64	25 or 50	25 or 50
	Data Tracks per Disc Surface or Drum	256	256	500	200
	Maximum Characters per Track	3,840	9,216	4,984	1,000
	Maximum Characters Accessible Without Head Repositioning	368,640	4,700,000	897,120	2,000 (4,000 with optional 2nd access arm
	Maximum Characters per Physical Unit	23,592,000	300,000,000	224,280,000	20,000,000
Head Positioning Time, Milliseconds	Minimum	70	15	50	90
	Average (Random)	199	78	165	600
	Maximum	305	120	180	800
Average Rotational Delay, Msec		26	26	17	25
Peak Data Transfer Rate, Characters per Second		75,200	189,000	156,000	22,500
Transfer Load Size, Characters		240 to 7,680	1 to 1,179,648	1 to 224,280	200 or 1,000
Update Cycle Rate, References per Second		3.0	4.8	4.0	1.4
Read-Only Reference Cycle Rate, References per Second		4.4	9.6	5.4	1.6
Read/Write Checking		Check chars.	Cyclic check characters	Cyclic check characters	Parity, write check
Representative Cost, Dollars per Character Stored		0.0061	0.0010	0.0017	0.0030
Features and Comments		Individually positionable access arm serves each disc	Two independent access "combs"; 4 read/write heads serve each disc face	Two access "combs" serve 250 track positions each; no longer in production	Single access arm serves all discs; no longer in production

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		CARTRIDGE-LOADED UNITS			
Device		Control Data 852 Disc Storage Drive	Control Data 854 Disc Storage Drive	GE DSU160 Removable Disc Storage Unit	Honeywell 259 Disc Pack Drive
Representative Computer System		CDC 3300	CDC 3300	GE 400 Series	Honeywell 200
Report Reference		250:044	250:044	330:043	510:042
Storage Medium		Magnetic discs	Magnetic discs	Magnetic discs	Magnetic discs
Storage Capacity	Data Discs or Drums per Physical Unit	6 (10 sides)	6 (10 sides)	6 (10 sides)	6 (10 sides)
	Data Tracks per Disc Surface or Drum	100	200	200	200
	Maximum Characters per Track	2,000 or 2,980	4,096	3,840	4,602
	Maximum Characters Accessible Without Head Repositioning	20,000 or 29,800	40,960	38,400	46,020
	Maximum Characters per Physical Unit	2,000,000 or 2,980,000	8,192,000	7,680,000	9,204,000
Head Positioning Time, Milliseconds	Minimum	30	30	30	30
	Average (Random)	85	85	85	80
	Maximum	145	145	165	150
Average Rotational Delay, Msec		20	12.5	12.5	12.5
Peak Data Transfer Rate, Characters per Second		77,730	208,000	208,000	208,000
Transfer Load Size, Characters		4 to 29,800	4 to 40,960	384 to 38,400	1 to 46,020
Update Cycle Rate, References per Second		6.3	8.3	7.0	7.0
Read-Only Reference Cycle Rate, References per Second		12.7	14.1	11.0	10.8
Read/Write Checking		Parity, write check	Cyclic check characters	Check chars.	Cyclic check characters
Representative Cost, Dollars per Character Stored		0.013	0.0053	0.0065	0.0053
Features and Comments		Changeable Disc Pack cartridges; format is compatible with IBM 1311	Changeable Disc Pack cartridges; format is not IBM-compatible	Changeable Disc Pack cartridges; format is not IBM-compatible	Changeable Disc Pack cartridges; format is not IBM-compatible; variable record lengths

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		CARTRIDGE-LOADED UNITS			
Device		IBM 1311 Disc Storage Drive	IBM 2311 Disc Storage Drive, Model 1	IBM 2314 Direct Access Storage Facility	IBM 2321 Data Cell Drive
Representative Computer System		IBM 1401	IBM System/360	IBM System/360	IBM System/360
Report Reference		401:043	420:046	420:048	420:049
Storage Medium		Magnetic discs	Magnetic discs	Magnetic discs	Magnetic strips
Storage Capacity	Data Discs or Drums per Physical Unit	6 (10 sides)	6 (10 sides)	Eight 11-disc packs on-line	Ten 200-strip cartridges
	Data Tracks per Disc Surface or Drum	100	200	200	100 per strip
	Maximum Characters per Track	2,000 or 2,980*	3,625	7,294	2,000
	Maximum Characters Accessible Without Head Repositioning	20,000 or 29,800*	36,250	1,167,040 (145,880 per pack)	40,000
	Maximum Characters per Physical Unit	2,000,000 or 2,980,000*	7,250,000	233,408,000	400,000,000
Head Positioning Time, Milliseconds	Minimum	75 or 54*	30	25	375
	Average (Random)	250 or 154*	75	75	550
	Maximum	392 or 248*	135	135	600
Average Rotational Delay, Msec		20	12.5	12.5	25
Peak Data Transfer Rate, Characters per Second		77,000	156,000	312,000	54,800
Transfer Load Size, Characters		100 to 20,000	1 to 36,250	1 to 145,880	1 to 40,000
Update Cycle Rate, References per Second		2.8 or 3.9*	7.0	7.0	1.5
Read-Only Reference Cycle Rate, References per Second		3.7 or 5.6*	11.1	11.1	1.8
Read/Write Checking		Parity, write check	Cyclic check characters	Cyclic check characters	Cyclic check characters
Representative Cost, Dollars per Character Stored		0.023 or 0.016*	0.0072	0.0010	0.00041
Features and Comments		Changeable Disc Pack cartridges; no longer in production. * With optional feature	Changeable Disc Pack cartridges; variable record lengths	Changeable Disc Packs; each 2314 has 9 disc drives (8 on-line and 1 spare)	Changeable Data Cells hold 200 strips each; 10 cells on-line; 20 movable read/write heads

CHARACTERISTICS OF RANDOM ACCESS STORAGE DEVICES

Category		CARTRIDGE-LOADED UNITS			
Device		NCR 655-201 Disc Unit	NCR 653-101 CRAM Unit	RCA 70/568-11 Mass Storage Unit	UNIVAC 8410 Disc Storage System
Representative Computer System		NCR Century 200	NCR Century 200	RCA Spectra 70	UNIVAC 9300
Report Reference		620:011	620:011	710:043	810:042
Storage Medium		Magnetic discs	Magnetic cards	Magnetic cards	Magnetic disc
Storage Capacity	Data Discs or Drums per Physical Unit	Two 3-disc packs on-line	One 384-card cartridge	Eight 256-card cartridges	Two 1-disc cartridges
	Data Tracks per Disc Surface or Drum	192	144 per card	128 per card	100 bands; 2 tracks/band
	Maximum Characters per Track	4,096	2,250	2,048	16,000/band
	Maximum Characters Accessible Without Head Repositioning	524,288 (262,144 per pack)	81,000	16,384	32,000 (16,000 per cartridge)
	Maximum Characters per Physical Unit	8,388,608	124,416,000	536,870,912	3,200,000
Head Positioning Time, Milliseconds	Minimum	20	100	439	?
	Average (Random)	42	125	488	110
	Maximum	60	150	538	245
Average Rotational Delay, Msec		20.8	24	30	25
Peak Data Transfer Rate, Characters per Second		108,000	71,250	70,000	136,000
Transfer Load Size, Characters		1 to 4,096	1 to 2,250	1 to 2,048	160
Update Cycle Rate, References per Second		6.6	5.0	1.6	3.8
Read-Only Reference Cycle Rate, References per Second		14.7	5.0	1.8	7.2
Read/Write Checking		Parity, write check	Check chars., read after write	Checks chars., read after write	Parity, write check
Representative Cost, Dollars per Character Stored		0.0048	0.00060	0.00029	0.0067
Features and Comments		Changeable 3-disc packs are not IBM-compatible; each unit has 2 disc drives	Changeable CRAM decks hold 384 cards each; 36 movable read/write heads	Changeable cartridges hold 256 cards each; 8 cartridges on-line; 8 movable heads	Each disc face holds 1,600,000 bytes; only 1 face is accessible at a time; each unit has 2 disc drives

SPECIAL REPORT

DIGITAL PLOTTERS: A STATE-OF-THE-ART REPORT

by

the Technical Staff of
AUERBACH Info, Inc.

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DIGITAL PLOTTERS: A STATE-OF-THE-ART REPORT

.1 INTRODUCTION

Graphic recorders have been a principal output device in analog computing systems for a number of years. The rapid increase in the use of these devices in digital systems, however, is relatively recent, and present trends indicate a widening range of applications for plotting equipment in both the scientific and nonscientific fields. The chief value of a plotter is that large amounts of data can be reduced and converted to graphical form for easier study and interpretation. This type of output has proved valuable in such applications as the plotting of missile trajectories and orbits, the checking and comparing of engineering design calculations, the speeding up of the final analysis of scientific evaluation studies, and the automatic plotting of weather maps.

In the nonscientific areas, plotters are being used to generate sales, inventory, and production charts that give management a graphic tool to help forecast future trends. Other uses include the checking and charting of automatic machine-tool performance, the production of traffic density pattern data for computer-controlled highway studies, and the plotting of earth-moving and fill problems which are more easily dealt with in graphical form.

The term electromechanical plotters covers virtually all graphic recording devices from continuous strip recorders to digital X/Y plotters. Continuous strip recorders are used basically for monitoring purposes, such as room temperature and humidity, and for patient monitoring in biomedical applications. Basically, these devices consist of a paper carriage that transports paper at a constant rate of speed under the recording stylus. The recording stylus is in contact with the paper at all times and records information by back and forth movement. A continuous strip recorder may contain a number of styli, thus, simultaneously recording multiple inputs.

A variation of strip recorders combined with electrostatic printing techniques exists in the Varian STATOS V Printer/Plotter. This device contains 1024 electrostatic styli across a 12.8-inch recording line. Recording is performed by energizing the styli as a dielectricly coated paper passes underneath; thus, after developing, electrostatic printing of fine dots at a density of 80 per inch is provided. The paper can be moved synchronously or asynchronously and the styli can be used as a single set or as a number of continuous channels. This provides multichannel strip recording capability and with proper data structuring, graphic and printer type output can be achieved.

A similar system, called the LGP-2000, using a laser beam and light sensitive film for recording has been developed by Dresser Systems, Inc., SIE Division. In this system, a laser beam is swept across the light sensitive film; the beam is turned on at each spot position to be intensified. Advance to the next line is accomplished by moving the film forward over a roller. Dresser provides an extensive software package for use on IBM System/360 computers that allows the user to describe a graphic image in normal graphic coordinate terms. This software package then builds the ordered list of plotter commands that will produce the desired graphic output.

The first types of plotters developed were analog plotters, which accepted analog input signals to control pen movement and were generally associated with analog devices. Most continuous strip recorders are of this type. If an analog plotter is to be connected to a digital computer, a special digital-to-analog interface is required to convert the digital outputs of the computer to the analog signals required by the plotter.

Digital plotters were developed for direct connection with digital computers. This not only eliminated the need for special digital-to-analog converters, but allowed use of the more precise controls inherent in digital operations. Digital plotters can be used in more general applications than their analog counterparts, just as digital computers are more flexible than analog systems. Digital plotters eliminate the problems of drift, dynamic response, and changing gain settings which are inherent in analog operations.

.1 INTRODUCTION (Contd.)

The devices covered in this special report have been restricted to digital plotters, since this is the type primarily used in association with digital computers. Presented in the discussion are the general types of digital plotters currently available and a brief description of representative systems. Illustrations of plotter devices and plotter outputs follow. Finally, a set of comparison charts including most currently available digital plotters is provided.

.2 TYPES OF DIGITAL PLOTTERS

Many different digital plotters are available and can be classified by the type of plotting surface provided, the recording technique used, the method of line drawing, and the method of specifying the desired plot. The plotting surfaces currently available are table and drum. Recording techniques include pen and ink or electrical pulses; the latter recording on sensitized paper. Line drawing methods are: increment, that is, small generally one unit line segments; or stroke, long line segments. Line specification methods are: absolute, stating the specific coordinate to which a line is to be drawn; or relative, indicating simply the length and direction of a line.

Table-type plotters utilize a flat plotting surface ranging in size from 30 inches by 30 inches to 5 feet by 24 feet. The paper remains stationary throughout the plotting of a single graphic image; the writing mechanism performs all necessary movements. The writing mechanism consists of a carriage and pen assembly that moves along one axis of the plotting surface; the pen unit is also free to move along the other axis. Motion in the X or Y direction, or in both directions simultaneously, is thus obtained; and the pen can reach any coordinate value contained within the plotting area. The pen also moves up and down to allow both drawing and positioning.

Generally, table-type plotters are pen and ink type utilizing a fixed coordinate system, which allows absolute coordinate addressing and drawing straight line vectors of any length. The table plotters are generally more versatile in that they can be built to meet requirements for high precision or large size, and can incorporate many supplemental features such as interchangeable recording heads for inking, punching, or scribing, and the ability to plot more than one curve at a time. All of these advantages are accompanied by proportionately higher costs. Comparative prices of digital plotters alone (no peripheral units included) range from $4,500 to $22,000 for the drum type, and from about $15,000 to $80,000 for the table type.

A table-type plotter utilizing an electrostatic recording method has been developed by Ford Instrument Company of Long Island City, New York. This all-electronic plotting board is capable of high speeds because all the limiting physical aspects of mechanical plotting systems are eliminated. A sheet of sensitized paper is sandwiched between two X/Y conductive grids made of fine wires. When the appropriate X and Y coordinates are chosen and the wires energized, a voltage potential exists at the crossing point of the two wires. The sensitized paper reacts to this voltage potential to produce a mark at that one point. To produce the next point, a new pair of grid lines is chosen and energized. At present the Ford Instrument system is capable of handling about 50 points per second.

The second basic type of plotter, the drum plotter, uses a movable plotting surface in conjunction with a writing carriage to provide the required 2-dimensional motion. In these units the writing element moves along one axis while rotation of the drum supplies movement along the other coordinate. At the present time, California Computer Products (Calcomp), Computer Industries (formerly Benson Lehner Corporation), and Houston Instrument, Division of Baush and Lomb, are the major manufacturers that build drum plotters. All of their units employ an incremental plotting technique that produces a graph by a series of fixed incremental steps of the drum and/or carriage. Bi-directional motors are used to control motion along both the X and Y axes so that each input digital signal causes a small incremental step (1/100 inch or less) of the carriage, the drum, or both. A third (Z-axis) input signal is used to control the raising and lowering of the pen from the surface of the paper.

Drum-type plotters are less expensive than table-type but have some disadvantages. In drum-type plotters each increment must be programmed so that many program steps are required to produce a long line that can be drawn by one command in a table-type plotter. This not only causes longer programs for drum-type plotters, but plotting is slower than for table-type. Furthermore, drum-type plotters do not include an absolute coordinate reference system.

Digital plotters that record their output on film represent a new concept in digital plotting. This new concept employs the same basic techniques as electromechanical plotters in that commands from the computer are used to produce discrete incremental steps on the X and Y axes. The new electronic recording technique uses the incremental plot commands to deflect a cathode-ray tube (CRT) electron beam in discrete steps. The beam is blanked and unblanked in place of raising and lowering the pen in an electromechanical plotter. The controlled electron beam from the CRT is used to expose a 35-millimeter film strip, which is advanced at

.2 TYPES OF DIGITAL PLOTTERS (Contd.)

the end of each plot. The exposed film can be automatically processed to produce either positive or negative transparencies for direct viewing or photographic printing.

.3 USE CONFIGURATIONS

The digital plotters on the market today are generally available for off-line use. Magnetic tape, punched cards, punched paper tape, or manual keyboard provide the input medium. In most cases, the input can be a computer output specifically prepared for the plotter. This allows the computer to operate at a higher speed than would be the case if the plotter were on-line and also eliminates the problem of directly interfacing the plotter with the computer.

Most digital plotters marketed today are adaptable to on-line operation, and interface controllers are available for them for such widely used computer systems as the IBM System/360, Control Data 3000 and 6000 Series, GE 400 and 600 Series, RCA Spectra 70, Univac 490 and 1108, and Burroughs 5500, to mention a few. Most plotter manufacturers offer on-line operation as an optional input mode and supply the required interface units for widely-used computers such as the IBM System/360 or Univac 1108. In contrast to the on-line mode, all digital plotters on the market today can operate off-line, using either punched cards, punched tape, or magnetic tape as the chief source of input data. Off-line plotters using input from magnetic tape are particularly suitable for use with large, high-speed computers, because they make it unnecessary to slow the computer down to the relatively low speed of the plotter. In general, most magnetic-tape handlers available with off-line plotters are IBM 729 compatible with densities of 200, 556, or 800 bits per inch.

Some plotter manufacturers offer software support for use with their plotters. For example, Computer Industries, Inc. provides Fortran IV, IBM System/360, and Univac 1108 software for its Magnetic Tape Delta Incremental Plotter.

Remote graphic output is a new application for digital plotters. A typical example of this is the California Computer Products Model 210 Remote Plotter Controller. This device permits any Calcomp 500 or 600 Series Plotter and a separate teleprinter to be connected to a communications line. With this configuration, a computer system can service a large number of plotter terminals at transmission speeds of up to 300 bits per second, and remote terminals can interrogate the computer system for graphic information.

.4 REPRESENTATIVE SYSTEMS

Some examples of specific computer-controlled digital plotting systems are presented here to illustrate the overall relationship between the computer output and the plotting operation. In the first case, a drum-type incremental plotter manufactured by California Computer Products is connected on-line to an IBM 1130 system. An IBM 1627 Plotter Attachment is used to interface the plotter with the 1130 Processing Unit. The cost of the Plotter Attachment is $675. Total cost of the Plotter and Plotter Attachment can range from about $5,000 for 11-inch plotters to $9,000 for 30-inch plotters.

As described earlier in this report, the principles of operation are the same for each of the models of incremental plotters. The IBM 1130 BCD characters 0 through 9 are the only ones required to control plot operation. Each of the ten characters will cause a distinct plotter movement, as depicted in Figure 1.

A single output instruction can shift the IBM 1130 to an output plotting operation. The instruction will initiate the plotting of one or more points, as controlled by the data stored in the first locations of the output area. The plotting action is terminated upon receipt of a special character from the core storage of the 1130 Processor.

.41 Calcomp Model 750 Magnetic Tape Plotting System

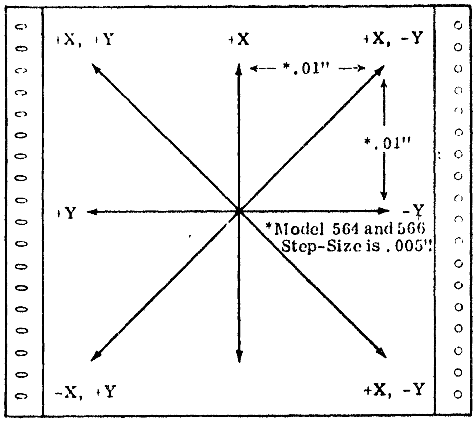
A good example of off-line operation is that of the Calcomp Magnetic Tape Plotting System (Model 750) using tapes prepared by any computer system that employs standard IBM 7- or 9-track tape written at densities of 200, 556, or 800 bits per inch. Here automatic plotting is achieved by including all necessary plotter commands on binary-coded tapes that have been prepared by appropriate computer subroutines.

Each plotter command consists of three bytes. The first byte specifies an incremental step in the X direction, the second specifies a step in the Y direction, and the third specifies a pen-up or pen-down command. Up to 93 plot commands can be recorded per inch of tape on the Model 750.

The block address of the data to be plotted can be manually preset and the tape automatically searched for the required block. Tape is searched at 60 inches per second.

The cost of this Calcomp off-line system is $21,200, excluding the plotter. Any Calcomp 500 series plotter can be used with the 750 System.

Plotter Movement



Instruction Characters

1130 Character:	0	1	2	3	4	5	6	7	8	9
Plotter Operation:	Pen Down	+Y	+Y, +X	+X	-Y, +X	-Y	-Y, -X	-X	+Y, -X	Pen Up

Figure 1. Control Characters for Plot Operation

.42 Computer Industries Inc. Magnetic Tape Delta Incremental Plotter

Another example of off-line plotting is the Computer Industries Inc. Magnetic Tape Delta Incremental Plotter. This unit also uses tape prepared by any computer system that can write in standard IBM 7-track or 9-track written at densities of 556 or 800 bits per second. With this system, up to 127 steps in both the X and Y directions can be effected from a single plotter command recorded at 800 bits per inch. The cost of this system is $27,000.

.43 Concord Control, Inc. Coordinatograph

A highly specialized type of off-line plotter is the Concord Coordinatograph produced by Concord Control Inc. The Coordinatograph System is designed to prepare final graphics quality copy for cartographic purposes from data stored on magnetic or paper tape. The system consists of a Director — a small, special-purpose digital computer — a paper-tape reader, a magnetic-tape handler (optional), and a typewriter with paper-tape punch (optional). The Director accepts data from the magnetic tape unit, paper tape reader, or keyboard; processes the accepted data; and uses the processed data to control the Coordinatograph, which is a table plotter with a five square-foot plotting surface. An accuracy of 0.005 percent can be maintained over the plotting surface. A wide variety of instrument heads for scribing, printing, projecting, scanning, and other uses can be installed in the Coordinatograph carriage.

.5 ILLUSTRATIONS

To conclude this Special Report on Digital Plotters, a sample of the commerically available digital plotters and associated equipment provided by some of the larger manufacturers is presented. In addition, representative copies of digital-plotter graphic output are included to illustrate the range of capabilities and job applications that this equipment can meet.

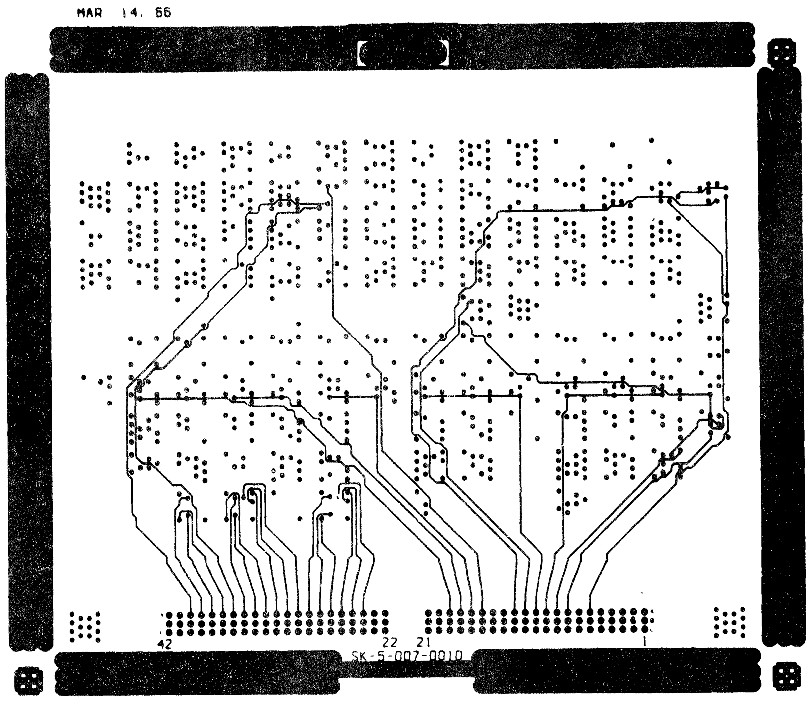


Figure 6. Example of a Backboard Circuit Layout Produced By a Gerber Scientific Plotter

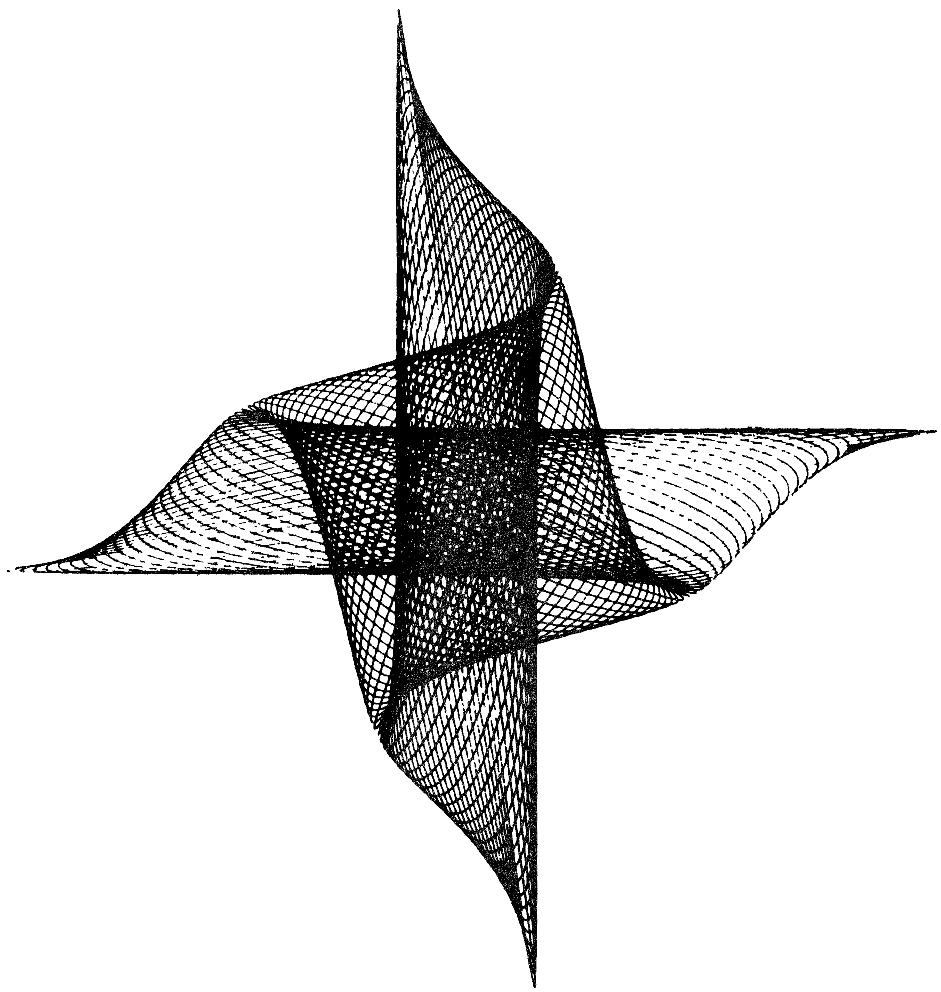


Figure 7. Geometric Pattern Produced By an EIA Dataplotter (Time of Plot: 10 Minutes)

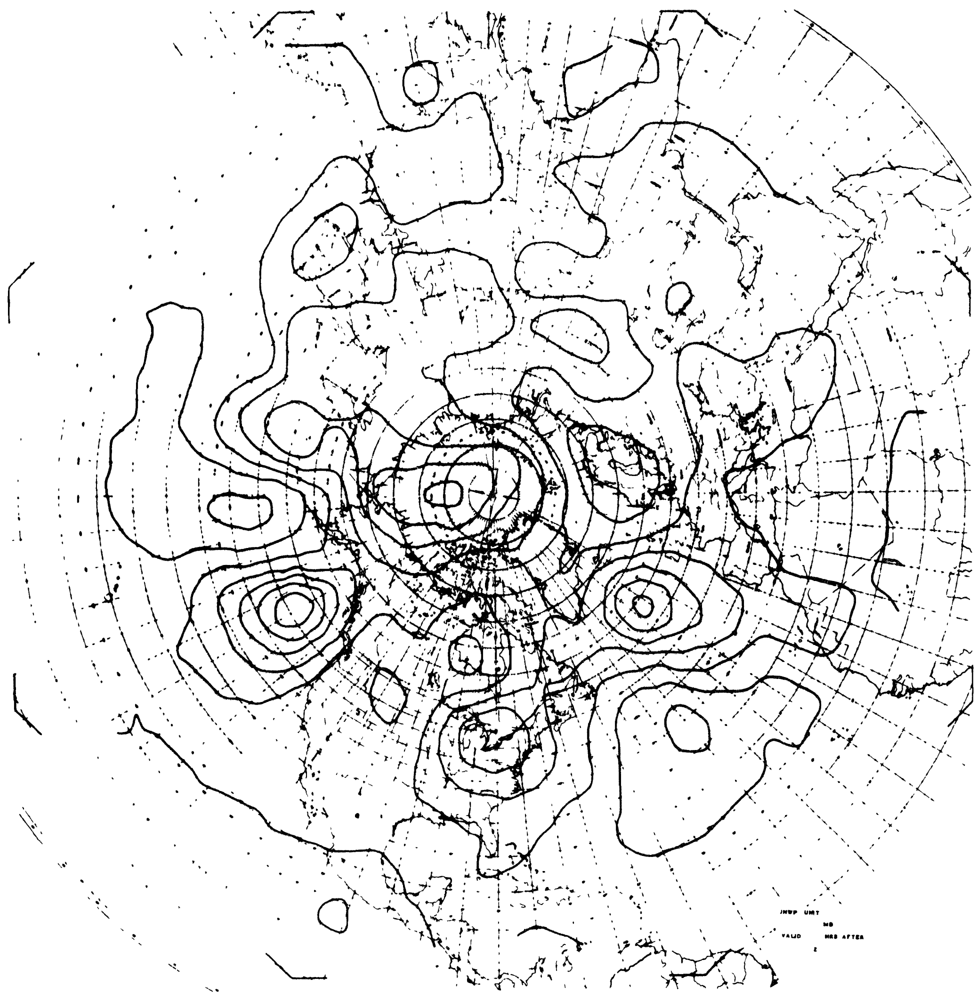


Figure 8. Example of Weather Contours Produced on an EIA Dataplotter (Time of Plot: Three Minutes)

.6 THE COMPARISON CHARTS

The accompanying comparison charts summarize the significant characteristics of representative digital plotting devices. The entries have been selected to describe specific operational criteria for each device from the user's point of view.

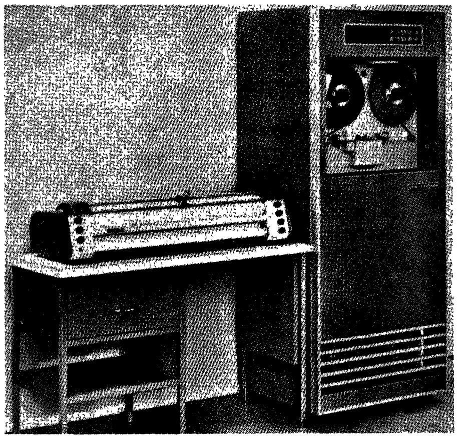
- Type: almost all of the plotters included in this chart are of either the table or drum type as described in the preceding paragraphs. Horizontal positioning of the plotting table or drum is implied unless otherwise noted.

- On-line Operation: this entry specifies whether or not a plotter can be connected to a digital computer data channel for direct, on-line output. At the present time, only a few computer manufacturers offer digital plotters as part of their standard line of peripheral equipment, but most plotter manufacturers are prepared to supply interfaces that will adapt their equipment for on-line use with most digital computers.

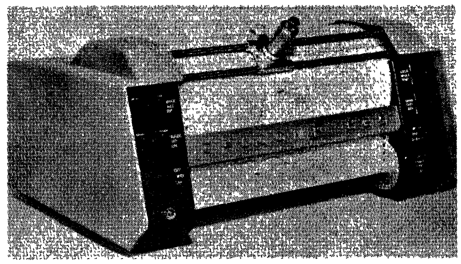
- Input Devices Supplied: several plotters are marketed as integrated systems that include a magnetic-tape transport, a card reader or a paper-tape reader as a standard part of the equipment. Some also have rather elaborate operating panels and provisions for manually entering data through a keyboard.

- Input Medium: the physical medium on which the data to be plotted can be stored is listed here. This is generally magnetic tape, paper tape, or punched cards. Facilities for manual input are also indicated here when they are provided.

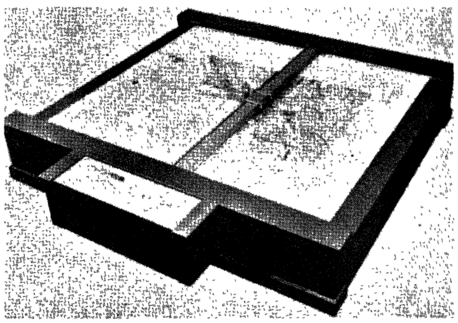
Model 563 Incremental
Plotter With Model 760 Tape Drive



Model 565 Incremental Plotter



Model 502 Incremental Plotter



Model 718 Incremental Plotter

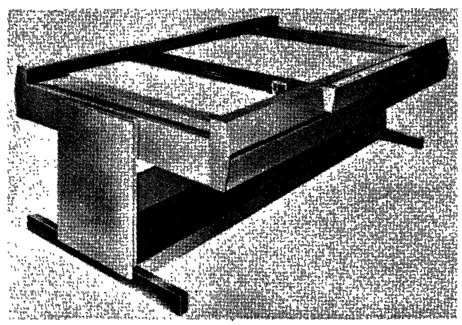


Figure 2. California Computer Products, Inc. Digital Plotters

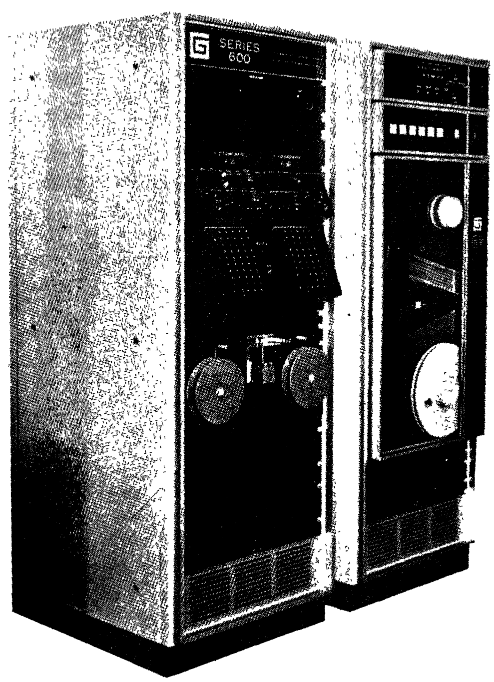


Figure 3. Gerber Scientific Instrument Companies Model 75 Graphic Display Table Shown with the Series 600 Controller

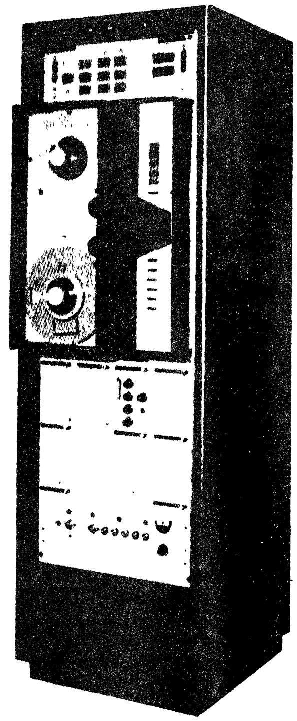


Figure 4. Milgo Electronic Corporation's DPS-6 Digital Plotting System Shown with the Milgo Model 4066 GL Tape Drive (Ampex TM-707)

Figure 5. A Calcomp Plotter Reproduction of an 18th Century Japanese Woodblock Print

.6 THE COMPARISON CHARTS (Contd.)

- Input Code: the majority of plotters receive input data in pure binary or in some binary-coded decimal (BCD) form, depending upon the type of input medium employed. For example, most table-type plotting boards require four decimal digits to specify each coordinate value, since the matrix range usually extends from -9999 to +9999. Some drum-type incremental units utilize three successive 2-bit characters to specify three of the six possible operating movements (+X or -X, +Y or -Y, pen up or pen down) for each point. In the case of magnetic tape units, all manufacturers state provisions for accepting data from IBM-compatible tapes recorded at a density of 200 bits per inch. A few models also have the ability to handle tape recorded at 556 or 800 bits per inch.

- Chart Size: the actual plotting area available is stated in inches. Only the width dimension is listed for drum-type units, since rolls of 120 feet are standard with these plotters.

- Plotting Mode: all plotters are capable of operating in a "point" mode in which a single point is plotted for each pair of input coordinates. This is a relatively simple operation for the table-type plotters, but a series of commands (including the pen-up, pen-down control) usually must be given for each point to be plotted by the drum type. An extension of the point mode is the "continuous" mode, which yields significantly higher curve-plotting speeds. However, the input data must be supplied to the plotter as a continuous train of closely spaced points. The incremental stepping of the drum units makes them particularly well suited to this type of operation.

- "Line" or "Line-Drawing" Mode: as defined for table plotters, use of this mode results in the construction of a straight line between two consecutive pairs of input data coordinate values. The drum-type plotters cannot operate in this way, but they can produce lines of any desired length by plotting the required number of incremental steps with the pen held in the down position (continuous mode).

- Accuracy: percentage figures are quoted for full-scale accuracy. For example, if a plotter with a 30-inch by 30-inch plotting surface has an accuracy figure of 0.05 percent, the plotter is capable of moving the pen to within 0.015 inch (0.05 percent of 30 inches) of the true value of any specified coordinate. Where the accuracy figures vary according to the plotting mode, both figures are listed.

- Speed: for the drum plotters, the speed is fixed for each model according to the incremental step size. For table units, however, the speed can vary greatly according to the plotting mode and the maximum distance traveled along either axis to move from one coordinate to the next. To keep the chart as orderly as possible, all figures given in this column refer to maximum speeds only, as rated by the manufacturers.

- Symbol Printing: most plotters offer symbol printing devices as optional equipment, which enable special symbols to be plotted instead of points. Alphanumeric character sets are also available with many plotters so that fully annotated graphs can be produced to further identify and define the output data.

- Purchase Price: this column supplies the approximate cost of the plotter but does not include the cost of the off-line controller or optional input devices.

- Comments: this column is used to mention any additional facts about a particular unit that are unusual or of general interest.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Auto-trol Corporation 6221 W. 56th Avenue Arvada, Colorado		
IDENTITY	Model 6000 Digital Plotter	Model 6030 Digital Plotter	Model 6300 Digital Plotter
TYPE	Table	Table	Table
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Magnetic tape transport, (7-track), card reader, paper tape reader, or manual keyboard optional	Magnetic tape transport, (7-track), card reader, paper tape reader, or manual keyboard optional	Magnetic tape transport, (7-track), card reader, paper tape reader, or manual keyboard optional
INPUT MEDIUM	Magnetic tape; punched tape; punched cards; keyboard	Magnetic tape; punched tape; punched cards; keyboard	Magnetic tape; punched tape; punched cards; keyboard
INPUT CODE TO PLOTTER	BCD or binary	BCD or binary	BCD or binary
CHART SIZE	50 x 72 to 96 x 144 inches	40 x 60 inches	48 x 60 inches
PLOTTING MODE	Point; line	Point; line	Point; line
ACCURACY (%)	0.025	0.03	0.01
SPEED (MAX)	30 inches per second	10 inches per second	10 inches per second
SYMBOL PRINTING	384 characters; alphanumeric and symbols	Numeric only	64 characters; alphanumeric and symbols
PURCHASE PRICE, $	35,000 to 50,000	12,000	75,000
COMMENTS			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	California Computer Products, Inc. 305 N. Muller Street Anaheim, California		
IDENTITY	Incremental Plotter Model 502	Incremental Plotter Model 563	Incremental Plotter Model 565
TYPE	Table	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	500 series on-line options include a wide range of interface equipment; 500 series off-line options include 3 different magnetic tape units.		
INPUT MEDIUM	Magnetic tape; any digital source	Magnetic tape; any digital source	Magnetic tape; any digital source
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	31 x 34 inches	29.5 x 120 inches	11 x 120 inches
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.02	0.1	0.1
SPEED (MAX)	4.2 inches per second	2.8 inches per second	4.2 inches per second
SYMBOL PRINTING	No	No	No
PURCHASE PRICE, $	17,000	8,000	4,550
COMMENTS	Incremental step size for Model 502 is 0.010 in., 0.005 in., 0.002 in., 0.1 mm, and 0.5 mm; incremental step sizes for Models 563 and 565 are 0.010 in., 0.005 in, and 0.1 mm. Model 565, when equipped with a communications interface, is marketed as the Model 575 Remote Plotter; the Model 575 can be connected to the public telephone network or a leased voice-band line via a Bell System Data Set 201A or 201B and sells for $5,863.		

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	California Computer Products, Inc. 305 N. Muller Street Anaheim, California			
IDENTITY	Incremental Plotter Model 602	Incremental Plotter Model 618	Incremental Plotter Model 663	Incremental Plotter Model 665
TYPE	Table	Table	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Optional controllers for on-line operation; optional magnetic tape units for off-line operations.			
INPUT MEDIUM	Magnetic tape; any digital source	Magnetic tape; any digital source	Magnetic tape; any digital source	Magnetic tape; any digital source
INPUT CODE TO PLOTTER	Option of 6 pulsed lines or 5-bit binary	Option of 6 pulsed lines or 5-bit binary	Option of 6 pulsed lines or 5-bit binary	Option of 6 pulsed lines or 5-bit binary
CHART SIZE	31 x 34 inches	54 x 72 inches	29.5 x 120 inches	11 x 120 inches
PLOTTING MODE	Point; continuous; line	Point; continuous; line	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1	0.1
SPEED (MAX)	3.1 inches per second	1.4 inches per second	4.9 inches per second	6.3 inches per second
SYMBOL PRINTING	No	No	No	No
PURCHASE PRICE, $	24,000	40,000	15,000	11,275
COMMENTS	Full-step/half-step operation; incremental step sizes are 0.005/0.0025 in., 0.002/0.001 in., 0.1/0.05 mm or 0.05/0.025 mm (Models 602 and 618) and 0.010 in/0.005 in, 0.005 in/0.0025 in, 0.0025 in/0.00125 in, (Models 663 and 665); can use 500 or 700 Series input format.			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	California Computer Products, Inc. 305 N. Muller Street Anaheim, California			
IDENTITY	Incremental Plotter Model 702	Incremental Plotter Model 718	Incremental Plotter Model 763	Incremental Plotter Model 765
TYPE	Table	Table	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Optional controllers for on-line operation; optional magnetic tape units for off-line operation			
INPUT MEDIUM	Magnetic tape; any digital source	Magnetic tape; any digital source	Magnetic tape; any digital source	Magnetic tape; any digital source
INPUT CODE TO PLOTTER	5-bit binary	5-bit binary	5-bit binary	5-bit binary
CHART SIZE	31 x 34 inches	54 x 72 inches	29.5 x 120 inches	11 x 120 inches
PLOTTING MODE	Point; continuous; line	Point; continuous; line	Point; continuous	Point; continuous
ACCURACY (%)	0.02	0.01	0.1	0.1
SPEED (MAX)	11.9 inches per second	4.6 inches per second	18.2 inches per second	23.8 inches per second
SYMBOL PRINTING	No	No	No	No
PURCHASE PRICE, $	31,000	50,000	22,000	18,000
COMMENTS	Full-step/half-step operation; incremental step sizes are 0.005 in/0.0025 in, 0.002 in/0.001 in, 0.1 mm/0.04 mm, and 0.05 mm/0.025 mm (Models 702 and 718) and 0.010 in/0.005 in, 0.005 in/0.0025 in, and 0.0025 in/0.00125 in (Models 763 and 765).			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401		
IDENTITY	LTE System	STE System	DDS Drafting System
TYPE	Table	Table	Table
ON-LINE OPERATION	Yes*	Yes*	No
INPUT DEVICE SUPPLIED	Magnetic tape transport	Magnetic tape transport	Magnetic tape transport; paper tape reader
INPUT MEDIUM	Magnetic tape or punched cards	Magnetic tape or punched cards	Magnetic tape; paper tape
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	42 x 58 inches	30 x 30 inches	5 x 5 feet; 5 x 8 feet; 5 x 12 feet; 5 x 16 feet; 5 x 24 feet
PLOTTING MODE	Point; line	Point; line	Point; line
ACCURACY (%)	0.05	0.05	See Comments
SPEED (MAX)	300 lines per min @ 1/4 inch per line	300 lines per min @ 1/4 inch per line	12 inches per second
SYMBOL PRINTING	48 characters	48 characters	None
PURCHASE PRICE, $	29,000	22,800	110,000 to 144,000
COMMENTS	Has three modes: point, line, and free-run; point mode operates at 300 points per inch. Free-run mode can be used for construction of contour maps.		Plotting error not greater than ± 0.002 inch

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401		
IDENTITY	Digital On-Line Incremental Plotter		
	Model 131	Model 135	Model 145
TYPE	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	None	None	None
INPUT MEDIUM	Any digital input source	Any digital input source	Any digital input source
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	12 inches x 120 feet	12 inches x 120 feet	12 inches x 120 feet
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1
SPEED (MAX)	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No
PURCHASE PRICE, $	4,550	4,550	5,000
COMMENTS	Incremental step size is 0.010 inch per step (Model 131) and 0.005 inch per step (Models 135 and 145); pen movement time is 20 msec. (up) and 50 msec. (down).		

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401			
IDENTITY	Digital On-Line Incremental Plotter			
	Model 321	Model 331	Model 335	Model 345
TYPE	Drum	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	None	None	None	None
INPUT MEDIUM	Any digital input source	Any digital input source	Any digital input source	Any digital input source
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	30.5 inches x 100 feet	30.5 inches x 100 feet	30.5 inches x 100 feet	30.5 inches x 100 feet
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1	0.1
SPEED (MAX)	2 inches per second	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No	No
PURCHASE PRICE, $	7,500	7,750	7,500	7,750
COMMENTS	Incremental step size is 0.010 inch per step (Models 321 and 331) and 0.005 inch per step (Models 335 and 345); pen movement time is 20 msec. (up) and 50 msec. (down).			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401		
IDENTITY	Card Input Delta Incremental Plotter		
	Model CID-131	Model CID-135	Model CID-145
TYPE	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Card reader and Delta Control Unit	Card reader and Delta Control Unit	Card reader and Delta Control Unit
INPUT MEDIUM	Punched cards	Punched cards	Punched cards
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	11 inches wide by 120 feet long	11 inches wide by 120 feet long	11 inches wide by 120 feet long
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1
SPEED (MAX)	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No
PURCHASE PRICE, $	14,550	14,550	15,000
COMMENTS	Incremental step size is 0.010 inch per step (CID-131) and 0.005 inch per step (CID-135 and CID-145); pen movement time is 20 ms (up) and 50 ms (down); up to 99 steps in x and/or y from a single plotter command; up to 20 plotter commands per 80-column card.		

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401			
IDENTITY	Card Input Delta Incremental Plotter			
	Model CID-321	Model CID-331	Model CID-335	Model CID-345
TYPE	Drum	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Card reader and Delta Control Unit	Card reader and Delta Control Unit	Card reader and Delta Control Unit	Card reader and Delta Control Unit
INPUT MEDIUM	Punched cards	Punched cards	Punched cards	Punched cards
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	30 inches wide by 100 feet long	30 inches wide by 100 feet long	30 inches wide by 100 feet long	30 inches wide by 100 feet long
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1	0.1
SPEED (MAX)	2 inches per second	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No	No
PURCHASE PRICE, $	17,500	17,750	17,500	17,750
COMMENTS	Incremental step size is 0.010 inch per step (CID-321 and CID-331) and 0.005 inch per step (CID-335 and CID-345); pen movement time is 20 msec. (up) and 50 msec. (down); up to 99 steps in x and/or y from a single plotter command; up to 20 plotter commands per 80-column card; 11-inch paper adapter is standard for 30-inch plotter.			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401		
IDENTITY	Magnetic Tape Delta Incremental Plotter		
	Model MTD-131-7 and MTD-131-9	Model MTD-135-7 and MTD-135-9	Model MTD-145-7 and MTD-145-9
TYPE	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	7- or 9-track magnetic tape transport and Delta Control Unit	7- or 9-track magnetic tape transport and Delta Control Unit	7- or 9-track magnetic tape transport and Delta Control Unit
INPUT MEDIUM	Magnetic tape	Magnetic tape	Magnetic tape
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	12 inches x 120 feet	12 inches x 120 feet	12 inches x 120 feet
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1
SPEED (MAX)	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No
PURCHASE PRICE, $	27,000 (-7); 29,000 (-9)	27,000 (-7); 29,000 (-9)	27,250 (-7); 29,250 (-9)
COMMENTS	Incremental step size is 0.010 inch per step (MTD-131) and 0.005 inch per step (MTD-135 and MTD-145); pen movement time is 20 msec. (up) and 50 msec. (down); 7-track tape recorded at 556 or 800 bpi; 9-track tape recorded at 800 bpi; unique tape format allows up to 127 steps in x and/or y from a single command.		

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Computer Industries Inc. (Formerly Benson-Lehner Corporation) Graphic Systems Division 14761 Califa Street Van Nuys, California 91401			
IDENTITY	Magnetic Tape Delta Incremental Plotter			
	Model MTD-321-7 and MTD-321-9	Model MTD-331-7 and MTD-331-9	Model MTD-335-7 and MTD-335-9	Model MTD-345-7 and MTD-345-9
TYPE	Drum	Drum	Drum	Drum
ON-LINE OPERATION	Yes*	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	7-or 9-track magnetic tape transport and Delta Control Unit	7- or 9-track magnetic tape transport and Delta Control Unit	7- or 9-track magnetic tape transport and Delta Control Unit	7- or 9-track magnetic tape transport and Delta Control Unit
INPUT MEDIUM	Magnetic tape	Magnetic tape	Magnetic tape	Magnetic tape
INPUT CODE TO PLOTTER	6 pulsed lines	6 pulsed lines	6 pulsed lines	6 pulsed lines
CHART SIZE	30.5 inches x 100 feet	30.5 inches x 100 feet	30.5 inches x 100 feet	30.5 inches x 100 feet
PLOTTING MODE	Point; continuous	Point; continuous	Point; continuous	Point; continuous
ACCURACY (%)	0.1	0.1	0.1	0.1
SPEED (MAX)	2 inches per second	3 inches per second	1.5 inches per second	2 inches per second
SYMBOL PRINTING	No	No	No	No
PURCHASE PRICE, $	29,000(-7);31,000(-9)	29,000(-7);31,000(-9)	29,000(-7);31,000(-9)	29 250(-7);31,250(-9)
COMMENTS	Incremental step size is 0.010 inch per step (MTD-321 and MTD-331) and 0.005 inch per step (MTD-335 and MTD-345); pen movement time is 20 msec. (up) and 50 msec. (down); 7-track tape recorded at 556 or 800 bpi; 9-track tape recorded at 800 bpi; unique tape format allows up to 127 steps in x and/or y from a single command; 11-inch paper adapter is standard for 30-inch plotters.			

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Concord Control Inc. 1282 Soldiers Field Road Boston, Massachusetts	Electronic Associates, Inc. Long Branch, New Jersey	
IDENTITY	Concord Coordinatograph	Model 3500 Dataplotter	Series 430
TYPE	Table	Table	Table
ON-LINE OPERATION	Yes	Yes*	?
INPUT DEVICE SUPPLIED	Small computer; teletype ASR 33; magnetic tape; card reader	Special interface unit required for on-line operation	?
INPUT MEDIUM	Magnetic tape; punched cards; paper tape	Magnetic tape; punched cards; paper tape manual keyboard; computer*	?
INPUT CODE TO PLOTTER	?	BCD or Binary*	?
CHART SIZE	60 x 60 inches	30 x 30 inches; 45 x 60 inches*	30 x 30 inches
PLOTTING MODE	Point; line	Point; line; continuous	Point; line
ACCURACY (%)	0.001	0.05 (point); 0.1 (line)	0.02
SPEED (MAX)	6 inches per second (point); 2 inches per second (line);	5.8 point per second (point); 2.3 inches per second (line); 15 inches per second (continuous)	20 inches per second
SYMBOL PRINTING	Yes	48 character alphanumeric and symbols	48 characters alphanumeric and symbols
PURCHASE PRICE, $	140,000 includes computer and table	19,800 (small table) 26,950 (large table)	17,500
COMMENTS	Interchangeable heads for line scribing, photoscribing and photoprojection; head rotation is optional; High precision machine.	Dataplotters accept 4-digit (-9999 to +9999) inputs; all units have manual input key-board for selecting one or more sets of scale factor and origin values which can then be changed automatically by program; optional program controlled, 8-pen turret.	

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Gerber Scientific Instrument Company P. O. Box 305 Hartford, Conn.		
IDENTITY	Model 22 Graphic Display Table	Model 32 Graphic Display Table	Model 75 Graphic Display Table
TYPE	Table	Table	Table
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	Paper tape; manual slew controls; optional keyboard, magnetic tape reader, and card reader; Teletype ASR with Series 1500 and 2000 controls		
INPUT MEDIUM	Paper tape; magnetic tape punched cards	Paper tape; magnetic tape; punched cards	Paper tape; magnetic tape; punched cards
INPUT CODE TO PLOTTER	EIA (8-level) and USASCII	EIA (8-level) and USASCII	EIA (8-level) and USASCII
CHART SIZE	50 x 60 inches	48 x 60 inches	5 x 8, 5 x 12, 5 x 16, 5 x 20, or 5 x 24 feet
PLOTTING MODE	Point; line; continuous	Point; line; continuous	Point; line; continuous
ACCURACY (%)	±0.007 to +0.009	±0.0009 to +0.0025	±0.005 to +0.009
SPEED (MAX)	3.3, 6.6, or 13.3 inches per second depending on control used	1.25, 2.50, or 3.75 inches per second depending on control used	6.6, 8.3, or 12.5 inches per second depending on control used
SYMBOL PRINTING	72 characters	72 characters	72 characters
PURCHASE PRICE, $	Price on request	Price on request	Price on request
COMMENTS	Incremental step size for Model 22 and 75 Tables is 0.0005 inches. Step size for Model 32 Table is 0.0001 inches; five individual control units including the Series 500, 600, 1500, and 2000 Controls are available at extra cost to be used with any one of the three Tables; control units provide input medium specified above and can also, at extra cost, interface a customer specified computer.		

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Ford Instrument Company 31-10 Thomson Avenue Long Island City, N.Y.	Milgo Electronic Corporation 7620 N.W. 36th Avenue Miami, Florida	
IDENTITY	Electronic Plotter	Model 4020D	DPS-6 Digital plotting system
TYPE	Special chart	Table (vertical or horizontal)	Table (vertical or horizontal)
ON-LINE OPERATION	Yes*	Yes*	Yes*
INPUT DEVICE SUPPLIED	None	Special Interface	Magnetic tape unit; card reader; keyboard
INPUT MEDIUM	Magnetic tape; punched cards	Magnetic tape; punched cards; paper tape; keyboard; computer	Magnetic tape; punched cards; paper tape; keyboard; computer
INPUT CODE TO PLOTTER	?	Binary	BCD
CHART SIZE	15 x 15 inches	30 x 30; 30 x 60; 45 x 60 inches	30 x 30; 30 x 60; 45 x 60 inches
PLOTTING MODE	Point	Point; line; continuous	Point; line; continuous
ACCURACY (%)	?	0.05	0.05
SPEED (MAX)	50 points per second	30 inches per second	25 inches per second (lines)
SYMBOL PRINTING	No	No	50 character alphanumeric and symbols*
PURCHASE PRICE, $	Price upon request	26,000	25,000
COMMENTS	This is a developmental model that features all electronic operation.	Has two carriages and can plot two curves concurrently.	

* Optional at additional cost.

COMPARISON CHART: DIGITAL PLOTTERS

MANUFACTURER	Houston Instrument Division of Bausch & Lomb 4950 Terminal Ave. Bellaire, Texas 77401		
IDENTITY	COMPLOT DP-1	COMPLOT DP-3	COMPLOT DP-5
TYPE	Drum	Drum	Drum
ON-LINE OPERATION	Yes	Yes	Yes
INPUT DEVICE SUPPLIED	Magnetic tape transport*	Magnetic tape transport*	Magnetic tape transport*
INPUT MEDIUM	Magnetic tape; Digital Computer	Magnetic tape; Digital Computer	Magnetic tape; Digital Computer
INPUT CODE TO PLOTTER	?	?	?
CHART SIZE	11 inches x 144 feet	22 inches x 144 feet	11 inches x 144 feet
PLOTTING MODE	Incremental	Incremental	Incremental
ACCURACY (%)	?	?	?
SPEED (MAX)	300 increments per second	300 increments per second	1200 steps per second
SYMBOL PRINTING	Yes	Yes	Yes
PURCHASE PRICE ($)	3550	6400	11000
COMMENTS			

*Optional at additional cost.

AUERBACH SPECIAL REPORT:
DATA COLLECTION SYSTEMS

PREPARED BY

THE TECHNICAL STAFF OF
AUERBACH CORPORATION

AUERBACH SPECIAL REPORT: DATA COLLECTION SYSTEMS

.1 INTRODUCTION

Automatic data collection (ADC) implies the recording, in machine-readable form, of the pertinent data about a transaction at the time the transaction occurs. Some data collection systems collect and record the transaction data in machine-readable form for later batch processing; others feed data directly into real-time computer systems to provide up-to-the-minute information for operational decisions.

This Special Report summarizes the results of a comprehensive AUERBACH survey of the characteristics and applications of the transmitting automatic data collection equipment that is commercially available in the U.S. today. The paragraphs that follow provide background information to aid you in justifying and planning an ADC installation. A comparison chart, arranged in a format designed to facilitate objective comparisons, presents the key hardware, performance, and cost characteristics of each of seven different transmitting data collection systems. *

.2 WHY AUTOMATIC DATA COLLECTION?

The need for improving the accuracy and reducing the cost of providing the necessary input to automatic data processing systems has long been recognized. Furthermore, modern manufacturing control systems require up-to-the-minute information about what is happening in the plant, so that operating decisions can be based upon current conditions rather than upon statistics covering last week's operations.

Transmitting data collection equipment that can meet both these needs is now available from several manufacturers. Through the use of such equipment, it is now feasible to design systems that can:

- Provide the complete, timely data needed for accurate cost control;
- Reduce the number of times and places at which data must be transcribed, thereby cutting clerical costs and error rates;
- Make and implement operating decisions of a routine nature; and
- Provide information about current plant conditions upon request.

Actual real-time control of manufacturing operations is still not common, but the other potential advantages of automatic data collection — reduced clerical costs, increased accuracy, more effective cost control, and sounder operating decisions — have immediate significance for nearly every business.

.3 TYPES OF TRANSACTION RECORDING UNITS

Transaction recording units are devices that can record pertinent data about a transaction in machine-readable form at the time the transaction occurs. The objective of such devices is to collect data accurately and quickly in a form suitable for processing on a computer or tabulating equipment, thus eliminating the need for manual key-punching.

A wide variety of techniques and equipment is currently being employed for transaction recording. While this report is concerned primarily with transmitting data collection systems designed for industrial use, a review of some of the other techniques and representative equipment used in transaction recording will help to establish the proper perspective.

.31 Prepunched Tags

One of the simplest transaction recording techniques has been widely used by retail outlets: prepunched tags, such as the Dennison and Kimball tags. When an item is sold, the sales clerk is instructed to tear off one section of the tag (which contains the item identification and price) and deposit it in a box near the cash register. These tags are collected periodically, carried to the data processing center, and converted to standard punched cards for use in sales analysis and inventory control applications. Although the method is simple and inexpensive, it generally involves a high error rate because clerks frequently neglect to tear off and deposit the required sections. Furthermore, the prepunched tags are difficult to modify for exceptions. The prepunched tag method is very useful for sales analysis to indicate the fast-moving and slow-moving items, but it has generally been found inadequate for accurate inventory control.

*A detailed technical report on each of these systems can be found in AUERBACH Data Handling Reports, another analytical reference service published by AUERBACH Info, Inc.

.32 Manual Recorders

Many organizations employ simple manual devices which record, in machine-readable form, information coded on embossed cards (e.g., credit cards). Imprinters for this purpose are produced by Addressograph-Multigraph, Dashew Business Machines, Farrington Electronics, and others. Usually the coded information is read by an optical character reader to produce input to a computer system. Like the prepunched tags, this system is simple, relatively inexpensive, provides for capturing a record at the source of certain relevant information about each transaction, and requires manual transportation of the recorded data to the processing center. The system is generally suitable only for billing and sales analysis by territory since only the customer's name, identification number, and amount of transaction are currently imprinted. The reject rate can be relatively high because of difficulty in maintaining the required quality of imprinting.

Other variations of this general type of transaction recorder are represented by IBM Porta-Punches, in which variable data is encoded by pushing partially punched holes out of a card; the Wagner Micro-Punch, in which variable data is set up by lever movements and punched into a card by pulling a handle forward; and the Wright Punch, a simple single-card punch.

.33 Mark Sensing

Mark sensing is a widely-used technique that permits data to be recorded at its source on standard punched cards, using no special equipment except a pencil that produces electrically conductive marks. After the cards have been carried to the central processing site, the marked data can be sensed and converted to standard punched-hole form by such machines as the IBM 514 Reproducing Punch or 519 Document Originating Machine. Newer equipment, such as the IBM 1232 Optical Mark Page Reader, can read and transcribe marks made by ordinary pencils.

.34 Byproduct Punched Tape or Cards

Another important transaction recording technique is the connection of paper tape punches (or, less frequently, card punches) to cash registers, typewriters, savings bank window machines, and other manually-operated business machines to capture a machine-readable record of each transaction. As an example of this widely-used technique, let us examine the use of a cash register with an integrated tape punch. As each sale is rung up, the clerk records the department number as well as the amount via the register keyboard. Both are punched into the paper tape, which is collected and carried to the data processing center at the end of each day to provide input data for sales analysis. Incorporation of the customer's account number into the paper tape record of each transaction enables billing to be accomplished from the same input. The obvious advantage of this system is that source data is captured in machine-readable form as a byproduct of the normal cash register operation. Serious drawbacks to the use of such systems, however, are the cost of the paper tape punch in each register, the frequency of clerical errors in entering department numbers, and the number of tape rolls that must be collected and spliced for efficient computer processing.

A variation of this basic technique is the use of optical journal tape readers, such as the NCR 420-2 and the IBM 1285, to read the printed transaction records produced by many standard cash registers, adding machines, and accounting machines.

.35 Non-Transmitting Data Collection Systems

Industrial data collection systems of the non-transmitting type, such as the Standard Register Source Record Punch, are similar to the cash registers described above in that they produce a record on punched tape or cards of the pertinent data about each transaction, which must be manually transported to a central location for subsequent processing. The system response time of such equipment is necessarily long, and it is obviously unsuitable for real-time control applications, yet its relatively low cost may make it more suitable than transmitting equipment for many small-scale installations.

.4 TRANSMITTING DATA COLLECTION SYSTEMS

The highest level of transaction recorders in the field today, and the one that will be of maximum value to most large manufacturing companies, is represented by the transmitting data collection systems that are now being used extensively for employee attendance recording, production control, labor distribution, inventory control, and a variety of other applications. The object of this report is to survey and evaluate the commercially available data collection systems of this type.

A data collection system of the transmitting type consists of:

- Input units which accept and transmit fixed data from prepunched cards and/or badges and variable data from dial, lever, or slide settings;
- Output units which record the transmitted data on punched tape, cards, or magnetic tape, or control its direct entry into a computer system; and
- Cables or communications facilities to transmit the data from the input units to the output units, which may be located in the same plant or many miles apart.

(Contd.)

.4 TRANSMITTING DATA COLLECTION SYSTEMS (Contd.)

Transmitting data collection systems can be classified as "on-line" systems, which feed data directly into a computer, or "off-line" systems, which produce machine-readable transaction records that will generally be processed later by a computer. Several of the systems surveyed in this report can be used in either on-line or off-line configurations.

A typical transaction message in a production control and labor distribution application might consist of: employee number (read from the employee's badge); job number (read from a prepunched card traveling with the job); machine operation number, transaction code, and quantity completed (entered by the employee via manually-operated dials or levers); input station number (transmitted automatically); and time, date, and an error indicator (added automatically at the central recording unit).

.5 FACTORS TO CONSIDER IN PLANNING FOR ADC

Enough successful and unsuccessful installations of transmitting data collection systems have now occurred so that we can list a number of desirable things to do — and to avoid — when planning such an installation.

.51 Detailed Systems Study

The first question is: Do you really need automatic data collection? Instead of installing an expensive mechanized system to record actual job hours, for example, it might be better to install a good hourly job standard system and not bother to record actual hours. The reduced time lags between occurence and reporting of events that automatic data collection makes possible are of no value unless mangement knows what actions are dicated by the reports it receives and initiates those actions promptly.

The decision to use automatic data collection equipment in connection with conventional batch-type processing should be made only after a detailed systems study. (It is assumed that all real-time information systems will require some form of transaction recording equipment.) The systems study must determine what information management needs and the minimum amount of data that must be collected to satisfy those needs. Then a suitable system must be designed. It is unlikely that straightforward mechanization of existing manual reporting systems will lead to the most efficient use of automatic equipment. Existing systems should be streamlined wherever possible, and the full support of top management is essential.

All potential applications should be carefully considered. For example, an integrated data collection system in a production plant can be used for attendance reporting, inventory control, parts and material requisitioning, shipping, purchasing, billing, inspection, and numerous other functions — all in addition to the primary functions of production control and labor distribution.

Complications will arise from material substitutions, returns, damaged items, obsolete parts, inaccurate counts, unplanned requisitions, reworks, etc. Provisions should be made to handle all such complications without deviating from the cardinal design principle: send all messages relating to a particular application through the mechanized system. Don't plan to mechanize only the high-volume transactions and handle the exceptions manually. Dual systems will create continual problems and additional expense.

.52 Configuration

One of the biggest problems in specifying a data collection system is determining system capacity — how many input stations and central recording units will be needed. The peak loads that will be imposed on the system must be determined; these will most commonly occur at clocking-out time in systems used for attendance reporting. Message lengths should be minimized to reduce data entry and data transmission times. Message length and transmission speed will determine the service time per transaction. The service time, in turn, determines the maximum number of input stations that can be adequately serviced by each central recorder. In determining the capacity of individual input stations, the time required to enter the necessary cards, badges, and/or variable data must be added to the data transmission time.

Closely related to system capacity is the question of where to locate the input stations. You will need to consider the maximum distance an employee should have to walk to get to an input station, the maximum waiting times that can be tolerated, and the costs of walking to the station and waiting to use it as compared to the costs of additional input stations and transmission lines.

.53 Cables Versus Two-Wire Transmission

One of the major disadvantages of transmitting data collection systems can be their relatively high cost of installation. The cable cost for systems interconnected by multi-wire cables can represent a significant portion of the total system cost. A reasonable estimate is about $1.00 per foot of cable, with the cost of the cable itself amounting to about one-third of the total and the labor involved in junction box connections accounting for much of the remainder. Input stations in most installations will be moved frequently, and each move will usually require relocation and extension of the existing cables.

.53 Cables Versus Two-Wire Transmission (Contd.)

Since many commercially available data collection systems can utilize two-wire transmission facilities as an alternative to multi-wire cables, the relative merits of the two transmission modes should be examined. Buildings separated by city streets or plants at locations remote from the central recording point can be handled more easily with two-wire hookups. A two-wire system can utilize existing telephone lines and thereby greatly reduce installation and maintenance costs. But two-wire systems generally require special adapters (usually Bell System Data Sets or equivalent modems) to provide for serial transmission of the bits that make up each character.

.54 Custom Modifications

Where the published specifications for a particular data collection system do not exactly coincide with your requirements, remember that most manufacturers will be glad to discuss potential modifications of their equipment when a sizable installation seems to require such modifications. It is probable, for example, that most "off-line" systems can be adapted for on-line use with most digital computer systems, though the user will probably have to bear the engineering costs of the necessary modifications.

.55 Training

Another important point to consider is the training and indoctrination that must be given to each employee who will be using a transaction recorder. With at least 30 minutes of well-planned instruction, it should be possible to reduce the rate of human errors to about 1 per cent of the total transactions. To ensure acceptance of the mechanized system by the employees, they must be thoroughly briefed in advance. The briefing should explain why the system is needed, how it will operate, and how it will affect each employee. Several data collection installations have failed because the need for pre-installation training and indoctrination was ignored, leading to a strongly rebellious attitude among the workers.

.56 Reliability

The need for high reliability in a data collection system can hardly be over-emphasized. Therefore, in evaluating specific equipment, it is wise to ask the manufacturer's representative such questions as:

- What happens if a single cable breaks? (Is the entire system incapacitated?)
- What happens if a central recorder fails? (Are all connected input stations incapacitated, or can another recorder pick up the load?)
- Where are the nearest service technicians, and how soon can one be summoned?

.6 THE COMPARISON CHART

The accompanying comparison chart summarizes the key characteristics of seven commercially available transmitting data collection systems, in a concise format designed to facilitate objective comparisons and pinpoint the specific advantages and disadvantages of each system. The comparison chart entries are explained below.

.61 Input

Probably the most important factor in determining the success of a data collection installation is the speed, convenience, and flexibility of data entry. Input data can be broadly classified as either "fixed" or "variable." Fixed data is defined as data read from previously prepared punched cards, plastic badges, or other semi-permanent, machine-readable data storage media. Variable data is data entered manually at transaction time by means of dial, slide, or lever settings.

.611 Punched Card Input

All the systems described in this report can accept fixed input data from standard, Hollerith-coded, 80-column punched cards. The method of entry is usually by manual insertion and removal of one card at a time. The number of columns that can be read from each card and the number of cards that can be read in a single transaction are indicated.

.612 Badge Input

Most systems can accept fixed input data from badges or tokens which are manually inserted into the input device. This capability is particularly valuable for employee attendance recording. The number of columns that can be read from each badge and the number of badges per transaction are indicated.

.613 Variable Input

The type of facilities that permit the user to enter variable data at transaction time, and the number of digits that can be entered in a single transaction, are indicated. The variable data will usually be entered by means of a set of dials, switches, slides, or levers.

(Contd.)

.614 Restricted Input

In many applications there will be certain semi-permanent data that is part of all or most messages from a given input station. If the input device includes means for entering variable data and then preventing it from being altered by unauthorized personnel or reset to zero after each transaction, this is called "restricted input." The method of restriction is noted; most commonly this consists of a hinged, lockable cover over some of the dials, levers, or slides used for variable input.

.615 Transaction Codes

Multi-purpose data collection systems usually utilize a transaction code to specify the nature and, in many cases, the message format of each transaction. The number of available codes is specified here. In some systems the transaction code is entered by the same method as the other variable data; in other systems there are special provisions. Certain types of transactions may be restricted, requiring insertion of a supervisor's key or special badge to initiate their transmission.

.616 Automatic Reset

Automatic resetting of the variable dials, levers, or slides to zero after a message has been transmitted is a feature that will increase input speeds and reduce errors in most data collection applications.

.617 Visible Settings

After the variable data for a transaction has been entered, it is important to note whether the settings are visible to the user so that he can verify that the data has been entered correctly before the message is transmitted. In systems that employ dials, levers, or slides for variable input, the settings will generally be visible, though it may not be easy to read them quickly and reliably. Some input units incorporate a direct, digital display of the data about to be transmitted.

.618 Entry Instruction Display

Entry instructions can be displayed in some systems to help the operator enter the correct data. In several input units, a knob or thumbwheel is used to rotate a cylinder so that instructions for a particular transaction can be seen through a slot that is normally located beneath the variable entry dials, switches, or slides.

.62 Output

.621 Medium

Data collection systems of the transmitting type can be broadly classified as "on-line" systems, which feed data directly into a computer, and the more common "off-line" systems, which produce a machine-readable record of each transaction for later processing. Output from an off-line system will generally be on punched tape, punched cards, or magnetic tape. The basic output media for each system are listed here.

.622 Code

The standard output code (e.g., the number of levels for punched tape output) is briefly described here.

.623 Maximum Input: Output Unit Ratio

Data collection systems of the transmitting type can assume a wide variety of equipment configurations, ranging from a single input unit with cable-connected recorder to a far-flung network with multiple input units transmitting data to multiple recorders or computers by means of both common carrier facilities and direct cable connections. Probably the most important parameter in planning the equipment configuration of a system is the maximum number of input stations that can be connected to a single central recording unit, as indicated in this entry.

.624 Error Checks

Once a data collection system has been installed and accepted, the operations of an industrial firm will tend to become heavily dependent upon it. Therefore, it is extremely important that the data collection hardware be designed to:

(1) Minimize the occurrence of errors; and

(2) Ensure that virtually all errors that do occur will be detected and corrected.

Minimization of the occurrence of errors involves a great many relatively intangible factors such as component reliability, mean time between failures, conservatism in circuit design, transmission line quality, preventive maintenance, proper training of all system users, and availability and quality of service. The prospective user of any data collection system must satisfy himself that the incidence of errors and system down-time can be kept low enough to meet his needs.

COMPARISON CHART: TRANSMITTING DATA COLLECTION SYSTEMS

MANUFACTURER SYSTEM	CONTROL DATA TRANSACTER	CONTROL DATA 8010	FRIDEN COLLECTADATA 30
Report Number*	1130*	1131*	1272*
INPUT			
Punched Card Input:			
Columns/card	15, 22, or 80	28 to 80	up to 76
Cards/transaction	1, 2, or 3	up to 4	1 or 2
Badge Input:			
Columns/badge	15- or 22-column cards	short cards used	10
Badges/transaction	used as badges	as badges	1
Variable Input:			
Type	10-position dials	10-position dials	12-position dials
Digits/transaction	6 or 9	9	10
Restricted Input:			
Type	plugboard	programmed	covered dials
Digits/transaction	10	no limit	8
Transaction Codes (number)	10	9	7
Automatic Reset	yes	yes	yes
Visible Settings	yes	yes	yes
Entry Instruction Display	no	yes	yes
OUTPUT			
Medium	magnetic tape, punched tape, or CDC computer	magnetic tape or CDC computer	punched tape or computer
Code	7-track, or 5- to 8-level punched tape	7-track	8-level
Maximum Ratio of Input to Output Units	36:1 (2)	128:1	20:1
Error Checks	input interlocks, message length, parity, special circuit checks	parity, message length, and special checks	input interlocks, message length, parity
Time Recording	yes	yes	yes
Date Recording	yes	yes	yes
TRANSMISSION			
Speed (char/sec)	60 (3)	54 (4)	30
Minimum Polling Delay	34 msec	none	none
Line Requirements	16- to 60-wire or 2-wire	24-wire or 2-wire	15-wire or 2-wire (6)
Range	14,000 ft (7)	2,500 ft (7)	2 miles (7)
COSTS (PER MONTH)			
Input Station	$34-89	$50	$40-80
Central Recorder	$390	$780	$55
Control Unit	$70	$200 (per 16 inputs) $1,060 (per 128 inputs)	$105
Typical 10-Station System	$1,040	N/A	N/A
AVAILABILITY			
First Delivery	October 1959	November 1965	1961
Delivery Period	5 to 6 months	4 to 5 months	3 to 6 months

*These references are to AUERBACH Data Handling Reports, another analytical reference service published by AUERBACH Info, Inc., where a detailed report on each of these data collection systems can be found.

See facing page for notes (1) through (8).

(Contd.)

COMPARISON CHART: TRANSMITTING DATA COLLECTION SYSTEMS (Contd.)

IBM 357	IBM 1030	RCA EDGE	TEXAS INSTRUMENTS TACTICOM
1440*	1441*	1690*	1810*
up to 80 unlimited	up to 80 1 or 2	up to 80 1 or 2	up to 79 unlimited
10 unlimited	10 1	1 to 12 1	10 1
11-position slides 6, 9, or 12	11-position slides 12	slides 10	10-position slides 12 (1)
slides can be locked	slides can be locked	coded plug 3	emitted from control unit 13
10 yes yes no	10 yes yes yes	10 yes yes no	none yes yes no
punched cards or IBM 1440 or 1460 computer Hollerith or 6-bit BCD 20:1	punched cards or IBM 1440, 1460, or 360 computer Hollerith or 6-bit BCD 24:1	punched tape or RCA 301, 3301 or Spectra 70 computer 8-level 25:1	magnetic tape or computer 7-track 40:1
input interlocks message length	input interlocks, parity, message length, punch comparison check	input interlocks, parity, start-end sequence, message length	input interlocks, parity, message length, echo recording check
optional yes	optional yes	yes yes	yes yes
20 250 msec 41- to 66-wire or 2-wire (6) 5,500 ft (7)	60 100 2-wire 8 miles (7)	27.7 (5) none 2-wire (7)	125 270 msec 2-wire 10,000 ft (7)
$29-62 $67 or 87 $79 $816	$25-140 $370 none $1,620	$69-135 $400 $215 $1,305	$60-107 $485 — —
June 1959 6 months	July 1964 6 months	1961 when available (8)	February 1967 3 to 4 months

(1) Variable input data may be alphanumeric.
(2) No theoretical limit on the number of input stations.
(3) From one or two input stations at once.
(4) From up to 15 input stations at once.
(5) From one to four input stations at once.
(6) A data set is required at each transmitting and receiving station for 2-wire operation.
(7) Range is essentially unlimited when telephone lines are used.
(8) No longer in production.

.624 Error Checks (Contd.)

Errors will occur, even in the best-engineered and costliest systems. Therefore it is important to detect and correct as many of these errors as possible. The main types of error checking performed by each system are listed here. The most common checks are:

- Input interlocks — checks which verify that the correct types and amounts of data have been inserted, in the correct sequence, for each transaction. Such checks can detect many procedural errors committed by persons entering input data into the system.
- Parity — addition of either a "zero" or "one" bit to each character code so that the total number of "one" bits in every transmitted character code will be either odd or even. Character parity checking can detect most single-bit transmission errors, but it will not detect the loss of two bits or of an entire character.
- Message length — checks which involve a comparison of the number of characters received at the output unit with the correct number of characters as specified for that particular type of transaction. Message length checks can detect many errors arising from both improper data entry and equipment or line malfunctions.

.625 Time and Date Recording

The time of day and/or the day of the week or month form an important part of the record of each transaction in most data collection applications, so special provisions are frequently made to supply this information automatically.

.63 Transmission

These entries describe the available means for connecting and transmitting data between the input stations and the central recording units, along with the resulting speeds and maximum ranges.

.631 Speed

This is the normal peak rate of data transmission, in characters per second.

.632 Minimum Polling Delay

Some control units poll constantly for input station activity, some initiate polling when an input station requests transmission, and some eliminate polling delays by determining the station to transmit during the previous transmission or through the use of direct electrical impluses.

.633 Line Requirements

Where input and output units can be linked by direct cable connections, the number of conductors required is listed here. In cable-conected systems, data will usually be transmitted in a "parallel by character" mode; i.e., all the bits comprising a single character are transmitted simultaneously via multiple conductors, and successive characters are transmitted sequentially. Where 2-wire communication lines are employed, data transmission will necessarily be "serial by bit;" i.e., each bit of each character is transmitted sequentially over the same pair of conductors. A data set is commonly used at each sending and receiving terminal to perform the necessary conversions between the parallel and serial transmission modes. Several systems can utilize either multi-conductor cables or 2-wire communication lines.

.634 Range

The maximum allowable distances between input stations and central recorders in cable-connected systems are listed here. Where common-carrier telephone lines are used, the range is essentially unlimited.

.64 Costs

The approximate single-shift monthly rental prices for each input station, central recorder, and control unit (when required) are listed here. Where there is a choice of two or more models with different capabilities, the price range is shown.

The "Typical 10-Station System" is defined as a small, off-line system providing ten input stations capable of accepting card, badge, and variable input data (where available); one central recorder; and any required central control units. Costs of cables, transmission lines, data sets, and installation are not included in the indicated monthly rentals.

.65 Availability

The first delivery date and the current time from order to delivery are shown, to give you a good idea of the length of time each system has been in operation and its current production status.

SPECIAL REPORT

THE SELECTION AND USE OF A DATA PROCESSING SERVICE CENTER

by

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THE SELECTION AND USE OF A DATA PROCESSING SERVICE CENTER

.1 INTRODUCTION

.11 Definition

A data processing service center or service bureau is an organization that provides data processing services to outside clients on a fee basis. These services may be provided continuously, under contract, or as needed. This definition encompasses centers which use only unit record equipment as well as centers which have computers. There is considerable diversity in the data processing service center industry, but a central tendency of established firms is the providing of a complete data processing service rather than merely renting equipment time. This means that a typical, established data processing service organization has qualified personnel to analyze customer requirements and write programs, as well as having control over appropriate equipment..

.12 Importance and Need

Depending on the definition used, there are some 1200 to 1800 data processing service centers in the United States which did a business in 1966 of approximately $700 million. These figures exclude universities, some of which do data processing on a fee basis. In tallies of service centers, there are differences in the treatment afforded operators of part-time service centers (often termed "moonlighters") who buy off-shift time on a computer and operate a service center with this equipment.

A data processing service center can be used either to supplant internal manual processing or to supplement an existing internal machine data processing installation. Those circumstances which justify supplanting internal manual processing are a volume of records, computations, or tabulations which can be performed at less cost or on a more timely basis by an organization equipped with data processing machines. Jobs which fit this category are quantitative or statistical analysis (such as linear programming, critical path scheduling, etc.) or record processing (including such applications as billing, accounts receivable, sales analysis, payroll, budgets, inventory analysis, etc.).

The reasons why an organization which has its own data processing equipment may need to use a service center include:

(1) Special or periodic overloads.

(2) Projects requiring specialized handling, specialized knowledge, or special equipment.

(3) Obtaining experience and assistance in connection with a conversion to new equipment.

.13 Purpose of This Report

This report is designed to assist a potential user of a data processing service center to:

(1) Locate a suitable service center.

(2) Prepare a request form to use in obtaining proposals for service.

(3) Evaluate the proposals for service.

(4) Negotiate a contract.

(5) Implement a decision to use a service center.

The report is directed primarily toward the use of a service center for commercial data processing, although there is some discussion of its use for scientific computation. The use of a time-sharing service center is considered sufficiently unique that a separate section is devoted to a summary of considerations in selecting such a service. A subsequent Special Report will cover time-sharing in more detail.

.2 DESCRIPTION OF DATA PROCESSING SERVICE ORGANIZATIONS

The diversity of service center organizations makes it somewhat difficult to categorize them. Therefore, a classification framework is presented first, followed by a short discussion of salient points connected with each classification. Next, there is a description of the way in which a typical commercial data processing center will operate for a business-type problem in which the processing is to be repeated at regular intervals such as weekly, monthly, etc.

.21 Classification

Table I summarizes the different ways in which data processing service centers may be classified. These are by ownership, control of equipment, type of equipment and type of service.

TABLE I: CLASSIFICATION OF DATA PROCESSING SERVICE CENTERS

Ownership	Control of Equipment
Manufacturer	Owner or prime lessor
Independent	Block time lessee
Organization affiliated	
University	
CPA	

Type of Equipment	Type of Service
Unit record equipment	Commercial
Computer	Scientific
Time-sharing computer	Industry specialist
	Full-line

The ownership of a data processing center provides a useful background for understanding the data processing service industry. Most of the major computer manufacturers have their own data processing centers. In fact, the largest data processing service organization in terms of number of offices and volume of work is Service Bureau Corporation, a wholly-owned subsidiary of IBM. The independent service organizations vary widely in size, with the larger ones having offices in many of the major cities.

A significant portion of the costs of a computer installation are fixed costs. Therefore, many organizations which have justified a computer for their own use, but which have not fully utilized the available time, have found it advantageous to enter into a part-time service bureau arrangement. In some cases, this arrangement involves only the sale of blocks of time to outside users, with the outside organizations providing their own programming, staffs, operators, etc. In other cases, however, organizations with large computer installations, such as banks, have organized rather complete data processing services and sell this in competition with the manufacturer-owned and independent data processing organizations.

There are other service center arrangements which are frequently found. Universities typically will sell time on their computers although they do not engage in full-service activities. Some certified public accountants and groups of CPAs have installed equipment for providing data processing service. The current Code of Ethics of the American Institute of Certified Public Accountants does not permit its members to advertise, so that a member CPA having computer facilities will not advertise his data processing service, except by notifying his own clients and other CPAs.

The control of equipment classification is based upon the fact that the availability of off-shift time on computers has made it possible for a person to set up a service center without owning or leasing his own equipment. He leases a block of time from one or more computer installations, operating these computers with his own personnel. These businesses are termed "moonlighters" by the regular data processing centers which own or are prime lessors of their equipment.

The type of equipment found in a service center may be limited to unit record equipment or it may include a computer. This report is directed primarily toward the centers using computers. The computer equipment may range from small to large. Several service centers have been organized which specialize in time-sharing, and these centers have computers especially suited for time-sharing applications.

Data processing centers tend to specialize in the type of service they offer. Some computer centers, especially smaller ones, have tended to specialize in commercial processing of accounting-type applications. Others tend to specialize in scientific processing. These centers usually provide personnel with mathematical and analytical ability in the computer solution of scientific problems. Within these commercial and scientific processing

(Contd.)

.21 Classification (Contd.)

specialties, industry specialists have developed. For example, one service bureau concentrates primarily in the retail business, while another one handles only data processing for automobile dealerships. Even where there is no announced specialty, the experience and expertise a service bureau obtains allows it to compete most effectively in the industries where it has already developed programs and solved problems.

.22 How They Generally Operate

The functions in a data processing service organization are illustrated in Figure 1. Although the organizational structure for centers may vary, there tend to be three major functions: sales, consulting/programming, and production.

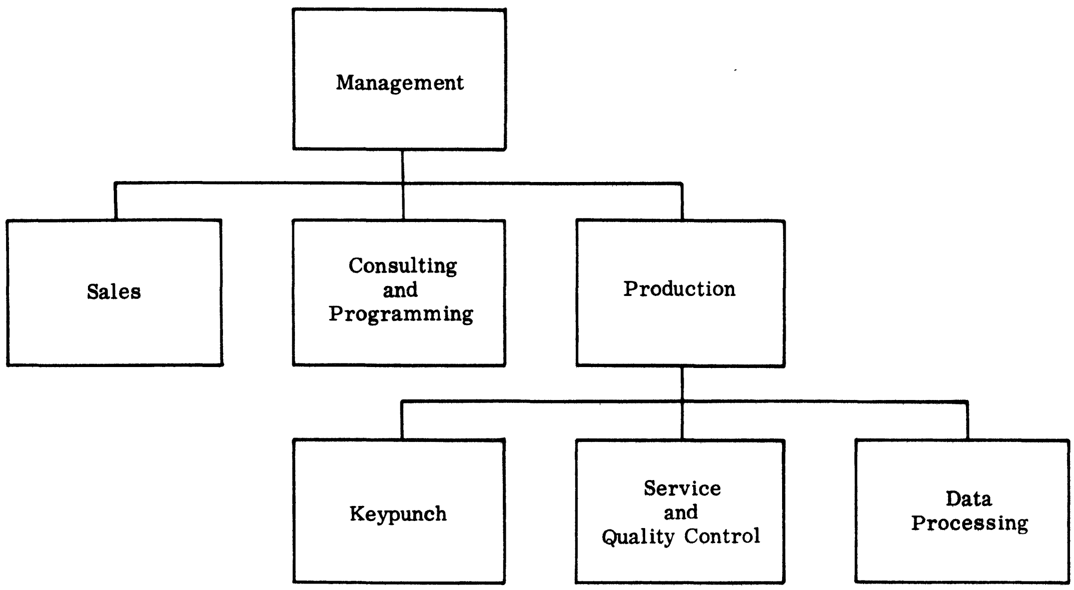

Figure 1. Functions in a data processing service organization.

The sales function is carried on by sales representatives who call upon customers to explain the services offered by the organization, analyze customer requirements, and present proposals for performing services.

The purpose of the consulting and programming function is to perform system analysis and prepare system designs for customers having unique requirements which require specialized systems. If the system is accepted by the client, this department also prepares the necessary programs.

The production department performs the data processing activity for the firm. This is typically divided into three separate areas: keypunch, quality control, and data processing. The quality control activity is concerned with controlling customer records and ensuring that the work is done correctly and on time. An account representative or account supervisor in the quality control group is assigned the responsibility for customer contact regarding the data processing.

Another way of describing how a service center operates is to trace the handling of a continuing commercial data processing contract such as preparation of a payroll, preparation of accounts receivable, or a similar application. The salesman who first calls on the customer may work out the solution and make an estimate, especially if the system is relatively uncomplicated and fits standard procedures already developed by the center. If the system is complicated or unique, the salesman will call upon the systems analysts, who will prepare layouts, system flowcharts, programs, etc.

Once the system has been agreed upon and programs have been prepared, the client's files are converted to machine-readable form in order to get the system started. Thereafter, documents received from the client are logged in by the data processing center, checked for appropriateness by the quality control unit, then keypunched and key-verified. The data processing group obtains the master records from the quality control group, runs the program, and turns the results back to quality control. The account representative examines the master records and the processed reports for completeness and accuracy and returns the master records to the storage area.

.22 How They Generally Operate (Contd.)

The completed reports are either picked up by the client or are transmitted by messenger service or mail. An error listing accompanies the reports. The client is advised through the error listing or through a personal call from the account representative as to the action which should be taken in the next data processing cycle in order to take care of the errors.

.3 CHARACTERISTICS OF GOOD APPLICATIONS FOR SERVICE CENTERS

Obviously, a good application for service center processing is one for which the data processing service center can perform the processing at a lower cost or on a more timely basis than can be performed in-house. In general, this suggests that a good application will have one or more of the following characteristics:

(1) The volume of records is significant.

(2) Considerable computation is required.

(3) The data must be rearranged in several ways to obtain different tabulations or to perform different computations.

(4) The time available for processing is too short for the regular in-house processing staff.

(5) The user cannot obtain sufficient personnel.

(6) The data processing center has specialized knowledge not available in-house.

.4 LOCATING A DATA PROCESSING SERVICE CENTER

The emphasis in service bureaus is on service. The equipment is secondary to the quality of personnel and quality of programs available for use. Therefore, the task of locating a suitable service center is analogous to locating many other services used by an organization—legal, accounting, medical, etc. In searching out possible service centers, there are various sources of helpful information.

.41 Standard Business Sources

The telephone directory classified section lists data processing service centers under data processing service. Local business directories frequently list data processing service centers. Other business contacts, especially in the same industry, may be able to provide names of service bureaus, as may accountants and consultants. CPAs providing data processing service who are members of the AICPA do not advertise, relying instead on the recommendations of their clients or other CPAs.

.42 ADAPSO Directory

The Association of Data Processing Service Organizations (ADAPSO) issues a bi-annual directory of members. ADAPSO membership is limited to for-profit organizations which utilize their own equipment on their own premises, assume full responsibility for the finished product, and have completed one full year of successful operation. This directory therefore excludes organizations, such as banks, which are only part-time service organizations and moonlighters who do not have their own equipment. Members must subscribe to a code prescribing standards of conduct. ADAPSO membership is therefore one indication of a stable, bona fide organization. The directory costs $1 and is available from ADAPSO, 947 Old York Road, Abington, Pennsylvania.

.43 Reference Listings

The most comprehensive directory of data processing service centers is published annually in the July issue of Systems magazine. There are much less complete directories in the June issue of Computers and Automation magazine, and in the Computer Yearbook and Directory published by American Data Processing, Detroit, Michigan. The September reference issue of Business Automation for the years 1964 and 1965 contained listings, but this feature was omitted in 1966.

.44 Computer Manufacturers

Computer manufacturers can be a helpful source of information because in many cases they have their own service centers, and also because they have sold equipment to service centers, so that they are aware of the centers which are doing business.

.5 HOW MUCH THEY CHARGE

The economics of the service center can be considered under two categories: the cost structure of the service center and the economics of the programs.

.51 Cost Structure of the Service Center

Table II divides typical costs of the service center into fixed and variable costs. The purpose of this tabulation is to provide some understanding of the cost structure of a service center. Note that a substantial part of the costs of a service center are fixed (standby, readiness-to-serve, etc.), while the incremental costs of service are fairly

(Contd.)

TABLE II: COST FACTORS FOR A DATA PROCESSING SERVICE ORGANIZATION

Fixed Costs	Variable and Semi-Variable Costs
Start-up costs: Installation costs Preparation of package programs	Machine operators Programmers other than basic staff Keypunching labor
Building rental Salaried sales, service, and quality control personnel Basic programming staff Supervision Advertising and promotion Equipment rental or depreciation	Sales commissions Supplies Customer magnetic tapes, card trays, holders, etc. Postage and messenger service Utilities

51 Cost Structure of the Service Center (Contd.)

low. One service center manager has estimated that the percentage of cost for two important elements—equipment rental and labor (other than supervision)—should not exceed 60 percent of gross income in order for the center to achieve a profit.

.52 Economics of the Program

The customer's application may be run either on a special program written specifically for that customer or on a generalized program to which the customer's system has been adapted. The generalized or package program is used for a number of customers and is written with that objective in mind.

There are good economic reasons for the use of package programs. The generalized program spreads the cost of programming over many users; therefore, greater programming effort can go into making the package good. Having a program already available makes the system design work with the client easier because the client's system is adapted to the program rather than the reverse (although most generalized programs do allow for options with respect to such items as format to suit the individual preferences of clients). Cost estimates are more certain because of the experience gained from running similar problems using the generalized program.

Against the use of package programs is the fact that the program being written with no single client in mind fits no one exactly and therefore does not completely please anyone. Even though the recommended approach is to adapt the customer's system to the general program, it may turn out that this is not feasible, and the service center then adapts the program to the customer's needs by making changes in the program itself.

.53 Approaches to Charging

There are three basic approaches to charging for data processing center services. These are:

(1) Fixed price.

(2) Time and materials at standard rate.

(3) Cost plus fixed fee or percentage.

The fixed fee is preferred in most cases, with the understanding that changes not agreed on in advance cost extra. This approach is well suited for standard program packages or for those cases where specifications for the customer's system are firm and few changes are to be anticipated. The fixed price may take the form of a fixed charge plus a charge for each item processed. There may be, in this case, a minimum charge. A typical minimum charge for work of a recurring nature where the service center must maintain files, controls, etc., is $25 per week. This minimum usually applies to the entire set of processing jobs performed rather than to each report or other item. The minimum reflects the fact that there is an administrative cost associated with each job no matter how small.

The "time and materials at a standard rate" approach is suitable where the problem and procedures are well defined but the running time, number of runs, or number of transactions are not known. It is also a useful method of charging in cases where the client's own program is being used. The "cost plus a fixed fee or percentage" approach is applicable where the problem or procedures are not well defined.

.54 Typical Charges

It is difficult to make statements about typical charges since charges will vary depending on the portion of the country, type of equipment used, volume of records processed, the extent of output, and other factors. In order, however, to give some feel for the cost of using data processing services, the estimates in Table III were prepared. These are based upon current charges in New York City. Lowest costs are usually obtained by having large volumes and by using standard packages.

The estimates in Table III include card punching. Since this is a significant factor, some knowledge of this cost is important. Keypunch operators typically punch some 4, 000 to 10, 000 characters or strokes per hour, depending on the type of punching. A rough standard average rate for pricing purposes for a keypunch operator is 6, 000 numeric strokes or 4, 000 mixed alphabetic and numeric strokes per hour from good source documents. The actual cost for keypunching or verifying will depend on the legibility and format of the documents, the number of punches per card (since it takes less time to punch 80 characters on one card than it does to punch one character on each of 80 separate cards), and the amount of intermixing of alphabetic and numeric characters. A rough rule of thumb for a quick estimate is one dollar per card column per one thousand cards. Depending on the characteristics of the job, the rule will tend to give a high figure (by up to 20%), but is useful for rough estimates. For example, assume a business had the following information to be punched from a document into punched cards:

Item	Digits
Product code	4
Quantity	4
Dollar amount	6
Total	14

Using the rule of thumb, the original keypunching would cost approximately $14 for each 1, 000 documents because there are 14 columns to be punched. Key verification of the punching would cost an additional $14.

Keypunching is usually not considered to be a profitable operation by service centers, but they offer it as a necessary part of the total service. Large-scale, one-time punching jobs such as file conversions are sometimes sent to England where keypunching can be performed at a lower price.

One should keep in mind that the manufacturer-rated speed of equipment usually cannot be maintained as an actual rate in data processing operations, especially in the case of card handling equipment. For example, a card sorter may be rated at 1, 000 cards per minute, but for all practical purposes (due to handling time, card jams, etc.), the effective throughput rate is only about two-thirds of this figure.

TABLE III: TYPICAL PROCESSING CHARGES

	Application	Low	High	Basis
(1)	Payroll service (paycheck, payroll register, quarterly payroll tax information and W-2 forms)* — up to about 500 employees**	30¢	45¢	per employee per pay period. $25 minimum per week is common.
(2)	Sales analysis (assume 1, 000 invoices of 2½ lines each, 300 products, and 20 salesmen):			
	• Report by product, units and dollars	$20	$27	per report
	• Additional report by salesmen, units and dollars	$ 7	$ 9	per report
(3)	Accounts receivable (aged trial balance, aged customer statements, invoice register, cash receipts journal)*	7¢	13¢	per transaction

* Including keypunching and verifying of data.

** Prices as low as 18¢ have been quoted in New York City. Prices drop substantially where large volumes of work are processed.

(Contd.)

.6 DECISIONS TO BE MADE

This section describes various key decisions which need to be made when deciding upon data processing by an outside service center. These are:

(1) Preparation of machine-readable input.

(2) Method of transporting data.

(3) Handling of input errors.

(4) Storage of the files.

(5) Security of files and data.

(6) Use of a special program versus a general-purpose program.

(7) Ownership of special programs.

(8) Payment for extras.

(9) Ensuring against interruption of service.

.61 Preparation of Machine-Readable Input

One of the options open to the user of a service center is to prepare the data in machine-readable form rather than having the service center do this operation. Methods to perform this conversion to machine-readable form may be direct or they may be a by-product of some other data processing operation:

Approach	Form of Data	Equipment
Direct	Punched cards	Card punch and verifier
	Paper tape	Paper tape punch
	Magnetic tape	Magnetic tape encoder
Indirect (By-Product)	Punched card	Punched card attachment on accounting machine
	Paper tape	Paper tape attachment on machine or an add punch
	Optical characters	Optical character printing font on unit such as cash register or adding machine

In addition there is the possibility of transmitting the data directly to the computer over communications lines. The question of relative economics of the user preparing the machine-readable input media versus turning over documents to the data processing center for conversion is beyond the scope of this report. A succeeding Special Report will specifically cover an evaluation of equipment for preparing source data input.

.62 Method of Transporting Data

Although the mails or communications lines are used in some cases, the most common method of transporting data is by messenger. The question is whose messenger. Where there is a security problem or considerations of timeliness, a client may choose to use his own messengers. Otherwise, the service center's messenger or a public messenger service can be used.

63 Handling of Input Errors

The account representative at the service bureau is responsible for all communications with the client regarding errors or failures in data processing either due to problems at the data processing center or problems regarding the input furnished to the center. When an error is detected by the computer, the computer will typically print an error message and eliminate the item from the processing run. The user then must process the item manually if it must be done before the next computer processing cycle—as, for example, is the case with a payroll check. He then sends a change record with the next run in order to update the files to include the manually processed item.

If the account representative detects an error due to improper processing by the data center, he will arrange for it to be re-run before it is sent to the client. If an error is not detected until it reaches the user, he may reject the run if the errors affect so many parts of it that the results are not usable. Otherwise, the user may accept the run, make manual adjustments, and send in corrections with the next input batch to be processed. A question to be discussed with the processing center is responsibility for the cost of re-runs due to erroneous input data.

.64 Storage of the Files

Two basic approaches are available. The client may keep his files and take them to the service center at processing time. If practical, the client's representative may remain while the data is processed and take the files back with him. The second approach is for

.64 Storage of the Files (Contd.)

the service center to keep all files on its premises. The first approach is used where there is a necessity to maintain confidentiality in the data processing applications or where the data processing center has inadequate storage facilities to maintain security and protection against destruction.

.65 Security Over Files and Data

Assuming that the data processing center stores the user's files and receives documents for processing, then a question to be considered is the security over these files and over the data transmitted to the center. This consideration may be important because of confidentiality requirements or because of the consequences of loss or destruction.

In the case of confidentiality, one method is to use a code rather than names for such items as payroll processing. Typically this is not considered necessary, but it is available as a method should it be deemed desirable.

In order to guard against loss or destruction, the client may, as pointed out above, use his own messenger service and may even store his own files (although this presents many practical problems). The security arrangements at the data processing center should include fireproof storage, procedures governing access to records and files, and insurance to pay claims which may arise. In the case of data being transmitted to the center, the client should always keep a copy of this data or have some means of reconstructing it in the event of loss.

.66 Special Program Versus General-Purpose Program

This was discussed in section .52. The general-purpose program is to be preferred because the user knows exactly what he can expect and the costs are firm. A special program is usually used only when a general-purpose program is unavailable or unacceptable.

.67 Ownership of Special Programs

If a client pays for the writing of a special program, the ownership would seem to be his. However, this should be decided explicitly beforehand. In cases where ownership does reside with the client, a copy of progress documentation should be obtained as a basis for progress billings, and the final documentation, including a copy of the program in machine-sensible form, should be obtained by the client. Provision should also be made in the contract for restricting, licensing, or otherwise controlling the use of the program by other users.

.68 Payment for Extras

Payment for the following are matters for negotiation:

(1) Systems surveys, analysis, etc., to define the customer's problem and to formulate an approach to processing.

(2) Changes to adapt general-purpose programs for the customer's use.

(3) Re-runs necessitated by erroneous input data.

(4) Re-runs necessitated by conditions not anticipated when the system was designed.

There are differences in practice as to payment for systems surveys. If a survey is used by the service center as a means for obtaining business, there is typically no specific charge for this service. If the systems survey is requested by the customer in order to decide how to extend the use of the computer or to alter his processing methods, then this may be charged as an extra-cost service.

Depending on the type of general-purpose program the service center has, there may be no changes or there may be minor modifications required to adapt it to the client's problem. If such minor changes are anticipated, they may be included in the standard charge for using the program. However, if the customer wants something not envisioned within the general-purpose program, this is presumably an extra charge and negotiated accordingly.

As a general principle, re-runs due to erroneous input data or errors caused by the customer will be charged to him. Re-runs caused by the program being unable to handle conditions which were not excluded when the contract was taken are presumably the responsibility of the service center. In all cases, however, these should be discussed beforehand rather than after the fact.

.69 Ensuring Against Interruption of Service

The service center should itself have made specific arrangements for backup service in the event of equipment failure or other interruptions of service. It is up to the user to satisfy himself that these provisions are adequate.

(Contd.)

.69 Ensuring Against Interruption of Service (Contd.)

If the user has a copy of a program and the related files, he can, of course, switch at any time to another service center having similar or compatible equipment. If the user has paid for a special program, he should also have arranged for a copy of the program. However, the generalized programs provided by the data processing center are usually not available to its clients. These are considered proprietory.

The ownership of the customer's files should be clearly spelled out so that if the service center user terminates his relationship for any reason, all master files and data files maintained by the service center will be returned to him.

.7 HOW TO SELECT A DATA PROCESSING SERVICE ORGANIZATION

In a survey of CPAs regarding the use of data processing service organizations, the following difficulties were mentioned:

- Slow service.
- Lack of accuracy in reports and excessive re-runs.
- Reports in a format confusing to clients.
- Insufficient knowledge of accounting by EDP centers.
- Insufficient planning and preparation.
- Data transmission difficulties.
- Additional service costs.
- Auditing difficulties.
- Overselling by the centers.

These difficulties can be overcome through a proper approach to the selection of a data processing bureau and by control over implementation of this decision.

There are three major steps in selecting a data processing center: (1) preparing a request for proposals; (2) evaluating the proposals; and (3) completing the negotiations. Considerations in the implementation of the decision are covered in section .8, below. The discussion that follows is oriented toward the use of a data processing center for a continuing data processing service rather than for a one-time tabulation or a one-time scientific computation. For the latter case, the general approach is similar, but the amount of investigation may be substantially less because of the one-time nature of the processing.

.71 Preparing a Request for Proposals

The basic idea underlying the request for proposals is that the prospective user of the data processing service should define his own data processing requirements using his own staff or a professional advisor. The completeness and detail of the request will depend, in part, on the capabilities of these individuals. The request should be specific but should allow the proposals submitted by service centers to suggest either alternative means for processing or alternative layouts in order to achieve economies or efficiency in processing. The request document should include the following:

(1) Purpose of the processing.

(2) A layout of the final reports if the format is important; or a complete description of content if the format itself is not vital. A sample layout is shown in Figure 2, and a description of a similar output is given in Figure 3.

(3) A copy of the input documents (blanks as well as filled-in samples) with a description of the information fields; or a layout of the input data if machine-readable media will be furnished by the user (Figure 4). If the size of a data item is variable, a range should be given.

(4) Number of records to be included in the master file, and the expected growth factor. The estimate should give a range if there is a considerable difference in activity for different periods.

(5) Handling of exceptions.

(6) Specifications for frequency of processing.

(7) Specifications for timeliness.

(8) Special requirements. For example:

(a) extra copies,

(b) special reports required,

(c) conversion specifications, including time limits, problems, etc.,

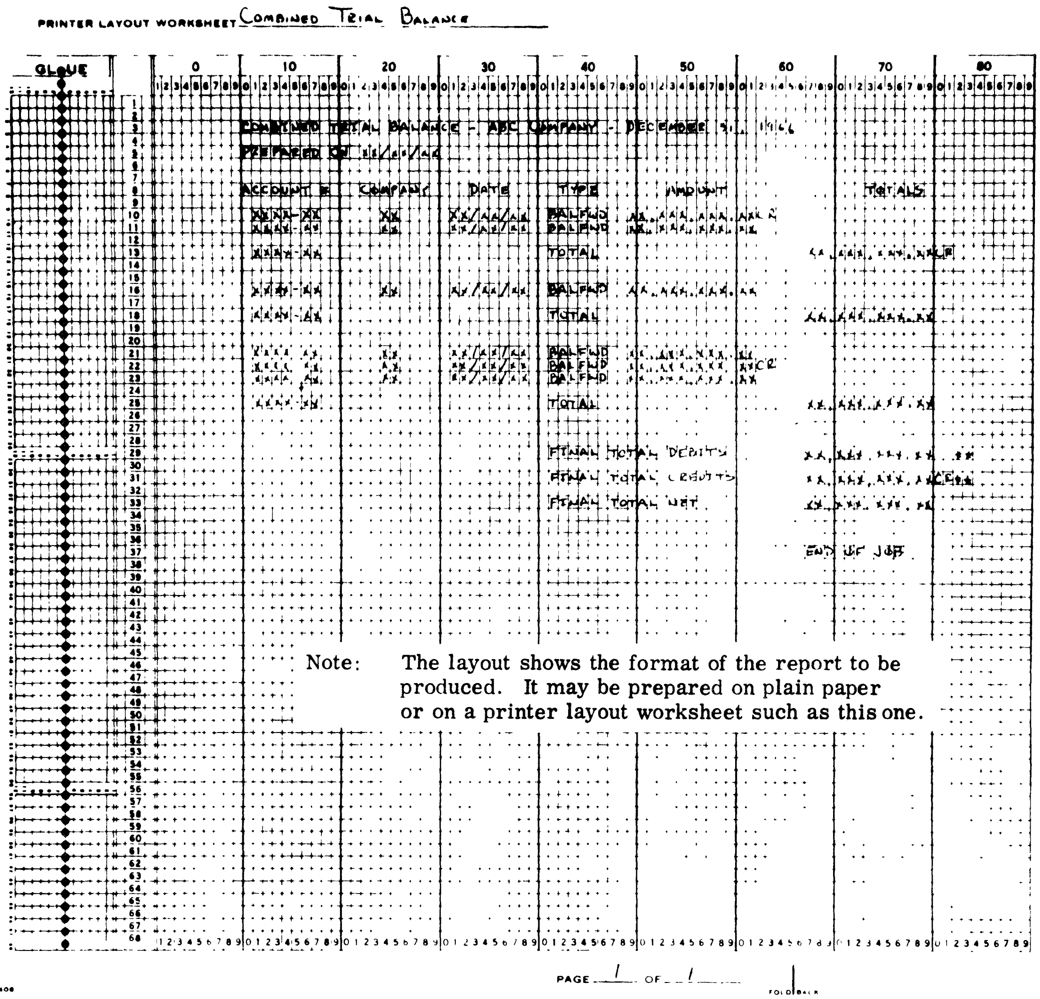

Figure 2. Layout of a proposed report.

The job is to prepare a combined trial balance from the punched card trial balance cards of subsidiary companies. The balance cards are sorted into account number order.

The output should be labeled with the date of the trial balance and the date of preparation. Each page, including the first, should be numbered. The report should list the account cards for each account number, showing the account number, company code, date, and amount. Credit balances should be labeled "CR". The total for each account number should be labeled.

Acct No	Company	Date	
XXXX	XX	XX/XX/XX	XX, XXX. XXX. XX
XXXX	XX	XX/XX/XX	XX, XXX. XXX. XX
		Total	XXX, XXX, XXX. XX

Separate totals should be kept of the debits and credits. These totals should be shown at the end of the report together with a net total.

Figure 3. Specifications for a report, in lieu of report layout.

.71 <u>Preparing a Request for Proposals</u> (Contd.)

(d) special security and control specifications,

(e) accuracy specifications,

(f) alternative methods allowed.

(9) Acceptance testing requirements such as a test run.

(Contd.)

PUNCHED CARD LAYOUT Combined Trial Balance

1. General Ledger Year-End Balance Forward Cards

ACCOUNT #	COMPANY CODE	DATE	TYPE	AMOUNT	
		(123166)	(BALFWD)		NOTE X in column 30 means credit
1–6	7–8	9–14	15–20	21–30	31–80

2.

Figure 4. Specifications for input from cards.

.71 Preparing a Request for Proposals (Contd.)

This request for proposals should be sent to those organizations which have passed an initial screening test based on their experience with similar problems, reputation, financial ability, etc. A week to ten days is usually sufficient for a data processing center to respond.

If the data processing problem is standard and well defined, the request for proposals can be used for obtaining firm proposals from service centers. If the problem is such that considerable systems work is required for the center to make a proposal, the request for proposals may be used to select a suitable organization with which to work. Where the job is a small or medium-sized one, a center can be expected to make a suitable proposal if the job is well-defined in the request, but it may not be willing to invest large amounts of design time to make a competitive proposal.

.72 Evaluating a Proposal

Figure 5 is an evaluation form listing points which are generally important in evaluating a data processing service organization. Based on the criteria which the user considers important for the particular job to be run, a computer service organization can be chosen from among those which have passed the initial screening. Note that the evaluation form requires some information which can be obtained only by visiting the data processing service center. Such a visit is strongly recommended.

A service center should certainly be competitive in its price quotations, but the integrity and professional character of the operation are equally important. In the course of a continuing relationship there will be special reports to be prepared, re-runs, changes, etc., and one should be able to have confidence in the organization.

No weights or method of rating is given in Figure 5. This is left to the user's own judgement on the basis of his particular needs. In a common approach, the user assigns an importance weight to each of the criteria and gives each organization a rating based on its position with respect to each of the items.

.73 Completing the Negotiations

After a tentative selection of a service organization, a written agreement or contract should be prepared. Many service centers use a memorandum of understanding in lieu of a formal contract. The checklist in Figure 6 indicates the types of items to be considered.

Item	Organizations Being Rated			
	____	____	____	____
Experience with similar problems				
Availability of general program packages				
Reputation and recommendations				
Financial stability				
Quality of staff		Ratings using the method preferred by the user (see text)		
Quality of sales and account representative				
Availability of control safeguards				
Backup provisions				
Proximity and convenience				
Quality of proposal				
Amount of work the center subcontracts				
Time-of-completion quotation				
Cost quotation				
Ability to meet time and price quotation				
Potential for handling requirements in future				

Figure 5. Rating form for evaluating a data processing service organization.

.8 CONTROL OVER IMPLEMENTATION

When a decision has been made to accept a data processing organization's proposal, decisions must be made regarding:

(1) Scheduling of the conversion to the new system.

(2) Conversion of the master files to machine-readable form.

(3) Procedures for acceptance testing.

(4) Period of parallel operation.

(5) Operating procedures.

.81 Scheduling

A schedule of events and dates for completion in order to achieve the conversion should be prepared and should be then used as a basis for reporting progress.

.82 Control Over File Conversion

One of the major jobs to be undertaken is the conversion of paper document files to machine-readable files. This usually involves substantial keypunching. In some cases, this may require the extracting of information from the documents in order to make it usable for the keypunch operators.

As in the normal operating procedures, irreplaceable files should not be transmitted to the data center unless there are adequate provisions for reconstructing the documents in case of loss. If these provisions do not exist, then copies should be made and sent to the data center for keypunching. Make sure the information transmitted is current. Spot checks should be made for accuracy of conversion.

As previously mentioned, very large keypunch jobs are frequently sent to England for punching because of lower labor costs. In such cases, the service center will usually supervise these contracts.

(Contd.)

(1) Processing to be performed.

(2) Content and format of input and output.

(3) Bursting and binding of reports. Pagination of reports.

(4) Break-in or parallel running period.

(5) Procedures for handling errors.

(6) Your responsibilities.

(7) Person responsible at service center for client contact and person in your organization who is authorized to deal with the service center.

(8) Charges including cost of reruns and changes if requested:

   (a) Set-up or one-time programming charge.

   (b) Single charge for control panel and wires.

   (c) Supplies, if additional cost.

   (d) Extra charge for weekend or overnight premium.

   (e) Charges for pickup and delivery.

   (f) Charges for storage, shipping, etc.

(9) If the contract is not a fixed price contract, a schedule of allowable and non-allowable costs.

(10) Form and frequency of billings.

(11) Program ownership (if a special program is being written).

(12) Delivery of documentation in connection with progress billings, in cases where a special program is written and billed for.

(13) Acceptance procedures for special programs.

(14) Conversion of master files to machine-readable form

(15) Time schedule for converting to the service center processing.

(16) Work space at service center if required by client.

(17) Liability of service center for lost data or files and errors in processing. Insurance carried by center to cover their liability.

(18) Security provisions for files and records.

(19) Backup provisions by service center

(20) Renewal and cancellation

Figure 6. Checklist for completing the negotiations.

.83 Sample Run for Acceptance Test

One of the procedures necessary before acceptance is the processing of a sample run in order to resolve any difficulties before processing begins on a regular basis. The processing of a sample run is especially important where a special-purpose program has been written.

.84 Running in Parallel

It is typically not feasible to transfer to the new system without a break-in period during which both the old and new system are operating in parallel. Except for simplest cases, a period of dual processing is necessary in order to instruct personnel in the new procedures and to become acquainted with error procedures, the new report formats, and other questions which may arise. The period of parallel operation is usually two or three processing periods.

.85 Operating Procedures

The operating procedures for user personnel will include instructions covering the following responsibilities:

(1) Form of data to be prepared; editing to ensure completeness and legibility.

(2) Schedule for preparation.

(3) Type of control figures and transmission controls.

(4) Person responsible for preparing controls.

(5) Person responsible for all contacts with the service bureau.

(6) Procedures for handling errors in input data.

(7) Person responsible and procedures for checking output received against control totals.

(8) Procedures for handling delays, errors, or failures in data processing.

.9 SELECTING A TIME-SHARING SERVICE CENTER

.91 General Description

Time-sharing makes possible the simultaneous access to a central computer by many users—each of them operating a different computer program, communicating data and requests from remote locations, and receiving on-line responses. Each user has his own input-output device, such as a teletypewriter, which is connected to the computer by a communications line. Each user can make demands at random intervals. This is in sharp contrast to the scheduled, sequential service offered by the standard service arrangement.

Time-sharing systems may be classified as either computation (scientific) or record processing (business) oriented. Most of the time-sharing systems currently operating are scientific and are designed for use with problems that can be solved by a set of computational procedures. This class of problems is characterized by very low volumes of input and output relative to the computations.

Business time-sharing is usually of the opposite character, with many records, each of which receives relatively little processing. Business data processing applications are characterized by problems of file management, forms design, report layout, procedures preparation, and somewhat specialized programming. There are currently very few time-sharing services for business data processing, and it is too soon to determine how time-sharing will work out for this type of processing. It is somewhat clearer that time-sharing will be significant for small-job scientific processing and for educational use.

Time-sharing users may have a fixed set of programs available to them, or they may be able to write their own programs from the terminals. In the case of a fixed set of programs, the processing procedures to be used are fixed, whereas with an open set of programs, the user can change the processing procedures merely by changing his program. The fixed set of programs is likely to be more common in systems oriented toward commercial data processing, whereas the scientific time-sharing systems need to allow new programs to be written each day, some of which are saved for future use while others are run and discarded.

Time-sharing is more expensive than regular service center processing, so that other factors such as the benefits of immediate response and the ability to alter programs and interact with the computer form the economic basis for using time-sharing. As examples of charges, a teletypewriter terminal costs approximately $100 per month, and monthly minimum charges for the time-shared processing may range from $350 to $800 in those cases where minimum charges apply.

Time-sharing systems have so many unique characteristics that this article will only summarize the principal considerations in selecting time-sharing service, and a detailed study of time-sharing will be the subject of a subsequent Special Report.

.92 Selection Considerations

Time-sharing computer service is available to anyone who has a telephone. The economic considerations of long-distance line charges remove from serious consideration time-sharing services that are a great distance from the user. If there is a need for on-line processing, the following are some of the selection considerations:

(1) Response time. A time-sharing system can become overloaded if too many users are connected to the system. Certain times of the day may present a serious problem. An investigation should be made into the response time and the times of day when overload is likely to occur.

(2) Terminal devices. Virtually all time-sharing services provide typewriter input-output. If the user requires higher input or output speeds, it is necessary to make sure that the particular computer system will accept this.

(Contd.)

.92 Selection Considerations (Contd.)

(3) Programming languages. If the primary purpose of the installation is to do problems that can be expressed as a set of algebraic procedures, then it is most important to have access to an algebraic compiler language such as FORTRAN, ALGOL, or BASIC. If the service center does the programming, cost estimates should be obtained. The number of standard packages available to facilitate programming is important. If the processing is primarily of a research nature, then it is important to have statistical packages so that programming will not be required for these. If the processing is primarily commercial, then the existence of prewritten commercial data processing programs is desirable. However, it frequently happens that a general-purpose program is unsatisfactory for a particular user; therefore, it is important to examine whether or not it is possible to easily modify a standard routine furnished by the service center.

(4) Assistance in systems design. The typical scientific user of a time-sharing terminal requires little assistance. A small amount of training is all that is necessary for him to be able to work out his formula-type problems at a time-sharing terminal. In the case of commercial data processing, this will not usually be true. There are forms design, handling procedures, special programs, input-output problems, error recovery procedures, and other problems which require assistance by the service center. The amount and quality of assistance furnished by the time-sharing service is therefore an important consideration.

(5) Control features. Before committing oneself to a service center and entrusting data files to it, the user should be satisfied that proper precautions have been taken against file destruction and against unauthorized use. He also should be satisfied that, in the event of system failure, there is adequate provision for file reconstruction. When beginning to use the service center, the same principle applies as in other computer installations. There should be a period of dual operation during which manual reconstruction will be possible in the event of a failure of the computer system. This dual operation should not continue for any extended period of time but should be available during a break-in period of two to four weeks.

(6) Financial integrity. As noted for conventional data processing vices, the failure of a time-sharing operation will endanger files and future processing, so there should be an assurance that the operation is properly funded and is likely to continue in operation.

SPECIAL REPORT

DATA COMMUNICATIONS - WHAT IT'S ALL ABOUT

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SPECIAL REPORT
DATA COMMUNICATIONS - WHAT IT'S ALL ABOUT

.1 INTRODUCTION

Data communications is a new and rapidly expanding field that has emerged from a wedding of the communications and data processing technologies. The need for rapid, accurate transmission of data between the widely scattered plants and offices of modern corporations has imposed strong pressures upon both the communications common carriers and the computer manufacturers to develop the necessary techniques and equipment. Impressive progress has been made during the last few years, so that now nearly every company can find transmission facilities and equipment that will effectively fulfill its data communications needs.

U.S. industry is recognizing, at an ever-increasing rate, the advantages of company-wide data communications networks and of the closely related concepts of real-time data processing and integrated management information systems. Although only about 1 percent of the computers sold in 1965 were linked to a data communications system, Western Union has predicted that 60 percent of the computers likely to be sold in 1975 will be so linked. A.T.&T. expects that the volume of information transmitted in the form of digital data will eventually equal the volume transmitted by voice.

A data communications system can be considered to consist of a group of functional units whose primary purpose is to transfer digital data between two or more terminals in a reliable manner. Each unit has a specific set of functions to perform; the exact functions and the sequence and manner in which they are enacted are determined by the overall system requirements. Because system requirements vary from business to business and from application to application, the data communications systems in use today vary widely in their functions, their structures, and their degree of complexity. Some systems transfer messages between remote terminals via one or more switching centers where communications processors are located; other systems transmit inquiries from numerous remote terminals to a central data processing facility, which generates responses and routes them back to the inquiring terminals. The design of systems such as these demands a thorough knowledge of both communications and data processing technology.

This report provides an introduction to the concepts and techniques that should be understood by every prospective user of a data communications system. The sections that follow describe the types of applications in which data communications systems are being effectively employed, the factors to be considered in designing a system, the various components of a system and their functions, and the communications facilities and services provided by the common carriers.

This Special Report, which constitutes an introduction to the concepts and equipment involved in the design of modern data communications systems, is also appearing as a feature article in the April 1966 issue of Data Processing Magazine. The report is based upon material extracted from the System Design section of AUERBACH Data Communications Reports, another analytical reference service from AUERBACH Info, Inc.

.2 APPLICATIONS

Current applications of data communications systems vary widely in their functions, their scope, and their equipment and programming requirements. New applications are being developed every day, and it would clearly be impossible to describe, or even list, all of the specific applications in which data communications equipment is being used. A more rational approach is to divide the total spectrum of data communications applications into a few fundamental "application classes," each performing a certain general function and involving a certain type of data flow pattern. Most specific applications will then fall neatly into one application class or combine the functions of two or more classes.

Although coarser or finer breakdowns could be justified, it seems reasonable to consider six fundamental application classes. The function and data flow pattern of each of these classes are described in the paragraphs that follow.

.21 Data Collection

The function of this class of applications is the collection and transmission to a central processing point of information concerning the operations of geographically separated manufacturing plants, warehouses, branch and regional sales offices, and other outlying facilities. The basic data flow pattern is unidirectional, from multiple remote (and/or local) terminals to the central processing facility. This type of system can: (1) provide the complete, timely information about a firm's overall operations that is required for accurate cost control and informed management decisions, and (2) reduce the number of times and places at which data must be manually handled and transcribed, thereby cutting clerical costs and error rates.

.22 Data Distribution

In this class of applications, the principal function is the distribution of data generated and/or processed at a central facility to one or more outlying locations. Again the basic data flow pattern is unidirectional, from the central facility to the remote (and/or local) terminals. This function, of course, is the complement of the data collection function described in the preceding paragraph, and many data communications systems combine the collection and distribution functions. To appreciate the potential value of a data distribution system, it is necessary to realize that data has no real value until it has reached the actual point of application in a useful form. Significant financial benefits can frequently be realized through cutting down the elapsed time and improving the accuracy of the data dissemination process.

.23 Inquiry Processing

To meet the competitive demands of modern business, many firms are finding it desirable (and in some cases essential) to "go on-line" by establishing central data files that can be randomly accessed to provide prompt responses to inquiries from outlying locations. In this class of applications, the basic flow pattern is bidirectional; inquiry messages are transmitted from a network of remote terminals to the central processing facility, and appropriate response messages are generated and transmitted back to the inquiring terminals.

The inquiry processing function is frequently combined with real-time file updating; the appropriate entries in the central data files are modified each time a transaction occurs so that the central files always reflect the true current status of the business. Although inquiry processing and real-time file updating systems promise great benefits for nearly every type of business organization, their advantages in terms of faster response and centralized control should be carefully weighed against their costs to ensure that the higher direct cost of a real-time system, as compared with that of a more conventional batch-type processing system, is worthwhile. Real-time inquiry systems are especially beneficial for organizations such as banks, brokerage firms, airlines, and hotels, where prompt servicing of customer inquiries is of critical importance.

.24 Computer Load-Balancing

Organizations that have two or more computers in geographically separated locations may find it advantageous to connect them by means of communications links. This permits more effective utilization of each of the interconnected computers because the slack time in one computer's schedule can be used to help smooth out the peaks in another's. Reliability is greatly enhanced because the communications links make it easy for one or more computers to take over another computer's workload when a breakdown occurs. The data flow pattern in this class of application is bidirectional; input data and results are transmitted between each pair of interconnected computers, and the volume of data flow depends upon their relative workloads at any given time.

(Contd.)

.25 Computer Time-Sharing

In an effort to make the facilities of a computer system conveniently available to multiple users, extensive development work is in progress on "time-sharing" systems. The design objective of a time-sharing system is to furnish continuous computing service to many users simultaneously, while providing each user with virtually instantaneous responses. Multiple consoles, each equipped with appropriate input and output facilities, are employed, and each console is connected to the central computer facility by a communications link. (Some or all of the consoles are likely to be close enough to the central facility so that direct cable connections can be used.)

The basic data flow pattern in a time-sharing system is bidirectional and similar to the pattern for the inquiry processing class of applications; input data and operating instructions are transmitted from the consoles to the central computer facility, and the results of computations are transmitted back to the appropriate consoles. The widely-discussed "public utility" computer concept, in which multiple subscribers would share the facilities of a giant centralized computer complex on a toll basis, is a logical extension of the computer time-sharing class of applications.

.26 Message Switching

The activities of a modern corporation tend to be spread out over a large number of widely separated locations, and an efficient system for handling communications among all these locations is vitally necessary. Where communications traffic is high, a computer-controlled message switching system is likely to be the best overall choice. In this type of application, the data flow pattern involves two-way message traffic between a number of terminals and a central switching center. The sending terminal transmits each message to the center, which stores it temporarily, performs any processing or code conversion functions that may be required, and then transmits the message to one or more designated receiving terminals. Large networks may utilize two or more switching centers which are interconnected by high-speed communications links.

.3 SYSTEM DESIGN

The installation of a data communications system should always be preceded by a thorough study and re-evaluation of the patterns of information flow throughout the organization. Money spent in simply mechanizing the existing procedures for collecting, transmitting, and disseminating information is likely to be largely wasted. The real purpose and need for every type of information that is currently being transmitted should be questioned. It is likely that most executives are regularly receiving some information that is of little or no value to them, while failing to receive other information which could aid significantly in decision-making and cost control, and which could easily be provided if the need were recognized. In some cases, the improved flow of information resulting from such a thorough study of information needs will provide far greater benefits than the data communications equipment itself — and may even preclude or postpone the need for mechanization of the information system.

.31 Information Flow Requirements

In order to determine the most suitable structure for a specific data communications system, a number of basic factors must be evaluated. These can generally be described as the "information flow requirements," and they include the following:

- The number of data sources and points of distribution, and their locations.
- The volumes of information (in terms of number of messages and lengths of messages) that must flow among these locations.
- The intervals at which messages will be transmitted. Are these intervals fixed or random? What are the peak rates, and at what times of day will they occur?
- The form of the data to be transmitted.
- The form in which the data must be when received.
- How soon the information must arrive at its destination to be useful. How much delay is permissible, and what are the penalties for delay?
- The reliability requirements. What degree of accuracy must be maintained in the transmitted data? What is the penalty for system failure?

.32 Using Existing Facilities

Usually, by the time the need for data communications develops, a company has established extensive voice and message communications facilities. The locations served by these existing facilities frequently include the locations to be served by the proposed data communications network. A serious study of the implementation of a data communications system must include an analysis of the company's present communications facilities and the ways in which they can be employed. For example, leased lines may currently carry little or no traffic at night, these lines could be used for the transfer of data during the slack hours at no increase in the present cost of communications facilities other than for switching, termination, and terminal devices. Use of present facilities requires close coordination between the company personnel responsible for general communications and the personnel responsible for data communications. The local common-carrier communications consultants should be contacted for help in determining the ways in which existing facilities can best be used or modified for data communications.

.33 Design Problems

The design of a data communications system requires a careful analysis of the foregoing factors. It also demands satisfactory solutions to a wide variety of potential problems, many of which are interrelated in complex ways. These problem areas include the following:

- Estimating the volume of data to be transmitted, now and in the future, and the associated traffic statistics.
- Providing for traffic overloads.
- Distributing the storage and computer capabilities to best fulfull the system requirements, and balancing these capabilities with the capacities and speeds of the transmission facilities to minimize the overall cost.
- Optimizing the system configuration in terms of fulfulling reliability and backup requirements and maintaining continuous, efficient operation.
- Selecting adequate yet economical error detection and correction techniques.
- Establishing the programming requirements for any communications processors, and specifying the necessary storage and processing capabilities.
- Formulating a training program for operating and maintenance personnel, and an indoctrination program to help all employees understand the purpose of the system and its effects upon their jobs.

A design problem of a slightly different character, but one that deserves considerable emphasis, is the development of a system that is "open-ended"; i.e., one that is capable of expansion to handle new plants or offices, higher volumes of traffic, new applications, and other difficult-to-foresee developments associated with the growth of the business. The design and implementation of a data communications system is a major investment; proper planning at design time to provide for future growth will safeguard this investment.

These design problems cannot be treated separately; they are interrelated through the various system parameters, so that a decision that solves one problem may lead to a variety of others. Tradeoffs become necessary among the equipment, the programming systems, the communications facilities, and the operating requirements. A clear, explicit statement of the goals to be accomplished will aid greatly in determining the appropriate tradeoffs.

.4 SYSTEM COMPONENTS

Figure 1 illustrates how data flows between two terminals in a typical data communications system of the basic point-to-point type. In most cases, several of the functional units shown in the diagram are housed in a single cabinet and marketed as a single communications terminal device. Each of these functional units is briefly discussed in the following paragraphs.

.41 Input/Output Devices

The input device at the transmitting terminal may be a keyboard, paper tape reader, card reader, magnetic tape unit, or computer. The output device at the receiving terminal may be a tape punch, card punch, printer, magnetic tape unit, display device, or computer. Devices such as magnetic tape units and

(Contd.)

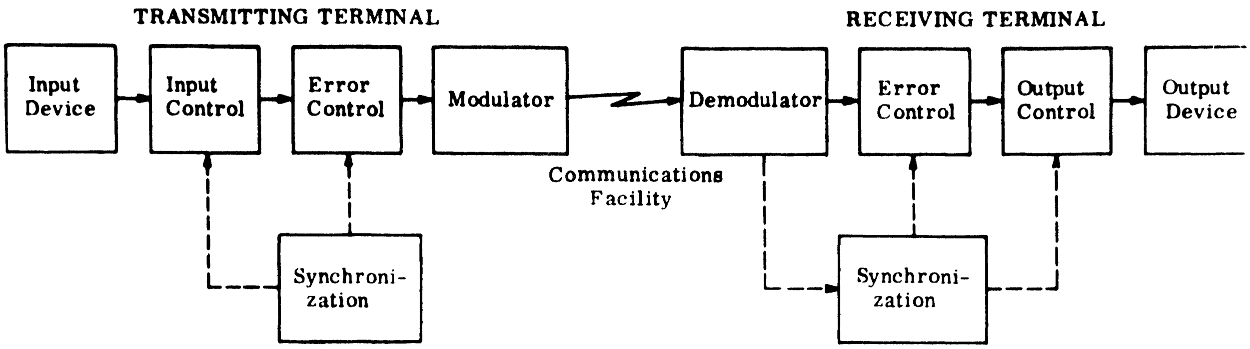

Figure 1. Data Flow in a Typical Data Communications System

.41 Input/Output Devices (Contd.)

computers frequently perform both input and output functions, either alternately or simultaneously.

The data communications terminals on the market today differ widely with respect to input/output media, speed, flexibility, operating convenience, compatibility with other equipment, and, of course, cost. The system designer's choice can range from conventional low-speed equipment (such as Teletype Corporation's low-cost and widely used line of teleprinters) to specialized high-speed devices (such as IBM's line of Synchronous Transmit-Receive Terminals, RCA's Video Data display units, and small programmable computers such as UNIVAC's 1004). Faced with such a wide variety of equipment choices, the system designer must approach the selection of terminal equipment in a systematic, objective manner.

Numerous data communications terminal devices are described in AUERBACH Standard EDP Reports. Table I lists some of these devices and the report sections where they are described.

.42 Input/Output Control Units

The input control unit at the transmitting terminal controls and accepts data from the input device at a rate that is usually dictated by the input device's speed. The control unit stores the data temporarily and transmits it at a rate compatible with that of the communications facility. At the receiving

TABLE I: REPRESENTATIVE DATA COMMUNICATIONS TERMINAL EQUIPMENT

Manufacturer	Equipment	Reference
Burroughs	B 493 Typewriter Inquiry Station	201:103, 203:101
GE	GE-115 Computer System	310:011
Honeywell	288 Data Station	510:108
IBM	1013 Card Transmission Terminal	420:106.128
	1050 Data Communication System	420:106.121
	1060 Data Communication System	420:106.122
	1070 Process Communication System	420:106.123
	2740 Communication Terminal	420:106.134
	2741 Communication Terminal	420:106.135
	7701 & 7702 Magnetic Tape Transmission Terminals	420:106.129
	7711 Data Communication Unit	420:106.131
	2260 Display Station	420:102
NCR	42-501 On-Line Window Machine	601:106
RCA	6050 Video Data Terminal	710:104
	6051 Video Data Interrogator	710:104
UNIVAC	Data Line Terminals (with UNIVAC 1004)	770:101

.42 Input/Output Control Units (Contd.)

terminal, the output control unit accepts the received data, stores it temporarily, and supplies it to the output devices at the appropriate rate. In control units which terminate more than one line, the type and capacity of the buffer storage is a primary concern because it determines the frequency at which each line must be serviced. Various types of buffers are available, such as magnetic core memories, magnetic drums, transistorized shift registers, and delay lines.

It should be noted that not all data communications terminals employ buffered input/output control units. When no buffers are used, the input, data transmission, and output functions must proceed simultaneously and at the same speed.

Complex data communications systems that terminate many lines in a central facility usually use either a multi-line communications controller in conjunction with a general-purpose computer or a specialized, stored-program communications processor These units are capable of buffering and controlling simultaneous input/output transmissions on many different lines. Again, a wide variety of equipment is now available to perform these functions. The available devices differ in the number and speed of lines they can terminate and in their potential for performing auxiliary or independent data processing. Examples include the three multi-line communications controllers available for use with the general-purpose IBM System/360 computers and the Collins Data Central system, a computer system designed especially for message switching applications.

AUERBACH Standard EDP Reports contains descriptions of most of the communications control equipment that is available for use in conjunction with general-purpose computer systems. Table II lists some of these controllers and the report sections where they are described. More detailed analyses of an even broader range of communications equipment can be found in AUERBACH Data Communications Reports, the specialized AUERBACH Info, Inc. reference service for designers and users of data communications systems.

.43 Error Control Units

The primary purpose of a data communications system is to transmit useful information from one location to another. To be useful, the received copy of the transmitted data must constitute an accurate representation of the original input data, within the accuracy limits dictated by the application requirements and the necessary economic tradeoffs. Errors will occur in every data communications system. This basic truth must be kept in mind throughout the design of every system. Important criteria for evaluating the performance of any communications system are its degree of freedom from data errors, its probability of detecting the errors that do occur, and its efficiency in overcoming the effects of these errors.

Errors in the received messages which form the output from a data communications system can result from:

- Operator errors in preparing the input or in operating the transmitting or receiving terminal.
- Malfunctioning of the transmitting or receiving terminal equipment.
- Malfunctioning of the communications lines, due either to random pulses interfering with data transmission or to a more permanent condition, such as complete failure of the line.

Techniques which merely detect and indicate errors are generally less complex and expensive than techniques which detect errors and then correct them. In most error control schemes, the digital data at the transmitting terminal is encoded to conform to some set pattern. At the receiver, the data is decoded and checked to see whether the received data pattern conforms to the prescribed rules.

There are two basic, commonly-used methods for automatic checking of data: validity and redundancy. A validity check ascertains whether each data code is one of a number of permitted bit configurations; this checking is usually performed on a character basis, and any code configuration which does not represent a legitimate member of the character set is considered an error. In redundancy checking, one or more additional bits are added to each data configuration in accordance with a specific formulation rule. Checking is accomplished by testing the additional bits to see whether they still conform to the formulation rule. The most common form of redundancy checking is parity

(Contd.)

TABLE II: REPRESENTATIVE DATA COMMUNICATIONS CONTROLLERS

Manufacturer	Equipment	Reference
Burroughs	B 100/200/300 Series Data Communications System	201:103
	B 5500 Data Communications System	203:101
Control Data	3276 Communication Terminal Controller	260:102
	6600 Series Data Set Controller	260:103
GE	Datanet-30 Data Communications Processor	330:104, 340:101
	Datanet-70 Communications Controller	330:105
Honeywell	281 Single-Channel Communication Control	510:103
	286 Multi-Channel Communication Control	510:104
IBM	1009 Data Transmission Unit	401:101
	1448 Transmission Control Unit	414:103
	2701 Data Adapter Unit	420:106
	2702 Transmission Control	420:107
	2703 Transmission Control	420:108
	7710 Data Communication Unit	401:106
	7740 Communication Control System	414:106, 420:106
	7750 Programmed Transmission Control	402:105, 420:106
	7770 Audio Response Unit	420:103
	7772 Audio Response Unit	420:104
NCR	Teletype Inquiry System	601:105
	On-Line Savings System	601:106
RCA	3378 Communications Mode Control	703:101
	3376 Communications Control	703:103
	70/652 & 70/653 Communication Controls	710:101
	70/668 Communication Controller (Multichannel)	710:102
UNIVAC	Communication Terminal Module Controller	785:102, 790:101
	Word Terminal Synchronous	785:102, 790:101
	Communication Terminal Synchronous	785:102, 790:101

.43 Error Control Units (Contd.)

checking, in which the total number of "1" bits in a data configuration of some arbitrary length is required to be either even or odd. Parity checking can be performed on a character basis, on a message basis, or both

Error correction procedures may be fully automatic, or they may require extensive manual intervention by the operators The most common method of error correction is retransmission of either the complete message or individual segments of it until the entire message has been received with no detected errors.

.44 Synchronization Units

Because the data signals are time-dependent (i.e., the bits are transmitted at precise time intervals), some means must be provided to ensure synchronization between the transmitting and receiving stations. Two commonly-employed techniques are referred to as "start/stop synchronization" and "synchronous transmission."

In the start/stop technique, extra signals are transmitted with each character of data to identify the beginning and the end of the character. The data bits within each character are transmitted in a strict time sequence, but characters are transmitted asynchronously, i.e., there is no definite time relationship between the transmission of successive characters. The advantages of this method are that it allows data transmission from sources with highly irregular data input rates (such as manual keyboards), and that the probability of cumulative errors in synchronization is minimized. The disadvantage of start/stop synchronization is that it increases the required line capacity due to the extra start and stop bits that need to be transmitted along with the data bits.

.44 Synchronization Units (Contd.)

In the synchronous transmission technique, a specific character is transmitted to the receiving terminal, which interprets the character and adjusts its synchronizing circuitry to conform with the transmitted bit rate. The synchronous method is sometimes referred to as "bit stream synchronization." The advantage of this type of synchronization is that it permits higher data transmission rates than the start/stop method; the disadvantage is that it requires highly precise and relatively expensive circuitry to maintain synchronization throughout the transmission of long messages.

.45 Modulation-Demodulation Units

The pulse signals generated by business machines usually need to be modified to obtain greater transmission efficiency and compatibility with common-carrier communications facilities. The unit used at the transmitting terminal to accomplish this modification is called a "modulator." At the receiving terminal a "demodulator" is required to convert the signals back into a form usable by business machines. Typically, both functions are incorporated into a modulation-demodulation unit for two-way data communications. This unit is commonly called a modem or data set.

Data sets are available from the common carriers for use with a wide range of standard communications facilities. Among the most widely used are the Bell System Data-Phone 200 Series Data Sets, which permit use of the public telephone network for data communications at speeds of up to 2,000 bits per second. In addition, several other companies (such as Collins Radio Co. and Lenkurt Electric Co.) manufacture data sets for use with private communications facilities or, in some cases, with leased common-carrier facilities.

.5 COMMUNICATIONS FACILITIES

A communications facility, in the broadest sense, is a means by which data can be transmitted between two or more points. Some of the common types of communications facilities are telephone and telegraph cables, high-frequency radio, and line-of-sight microwave. Although there are many types of communications facilities, the types most commonly used for data transmission at present, because of their wide availability and economy, are the standard telegraph and public telephone line facilities. Telephone line facilities, though designed specifically for voice communications, can be employed for transferring digital data at higher rates than are possible with telegraph facilities.

Communications facilities, in conjunction with appropriate terminal and/or processing equipment, can be employed for operation in one or more of the following basic modes:

- Simplex — transmission in one direction only.
- Half-duplex — transmission in both directions, but in only one direction at a time.
- Full-duplex — transmission in both directions simultaneously.

The allowable volume of data communications and the flexibility of operations are greater for full-duplex operation than for half-duplex or simplex operation, but the cost of the communications facilities and terminal equipment is also higher.

.51 The Common Carriers

A communications common carrier is a company whose services are offered for public hire for handling interstate or foreign communications by electrical means. All interstate (across state lines) traffic is regulated by the Federal Communications Commission. Intrastate (within a state) traffic is regulated by a state utility board. In some large cities, intracity traffic is regulated by a city agency.

The major common carriers providing interstate communications services are the Bell System and the Western Union Telegraph Company. The American Telephone and Telegraph Company (A.T.&T.) heads the Bell System and coordinates the operations of its wholly or partly owned operating companies. In addition, there are a number of independent telephone companies, the largest of which is the General Telephone and Electronics Company. In general, the independent telephone companies offer the same types of services as the Bell System, although rates and exact services vary to some extent. Some of the smaller companies have limited capabilities, and care must be taken when planning data communications facilities within their areas.

(Contd.)

.51 The Common Carriers (Contd.)

The communications facilities offered by each common carrier and the attendant costs are published in documents called tariffs, which are available to the public. Because of the complexity of these tariffs, the common-carrier communications consultants should be contacted early in the planning stages for a data communications system to determine the facilities and rates in the areas to be served.

.52 Classes of Common-Carrier Facilities

The facilities offered by the common carriers can logically be divided into three classes:

- Narrow-Band Facilities: These facilities provide data communications capabilities at up to 200 bits per second, and they are most commonly used with low-speed teleprinter terminals.
- Voice-Band Facilities: These facilities make use of communications channels having bandwidths of about 3,000 to 4,000 cycles per second. The public telephone network uses channels with a bandwidth of about 3,000 cycles per second. Equipment is currently available from the common carriers for data transmission at up to 2,400 bits per second over leased voice-band facilities and up to 2,000 bits per second over the public telephone network.
- Broad-Band Facilities: These facilities commonly use microwave transmission techniques to provide data communications at rates significantly higher than voice-band facilities. Telpak is a group of services of graduated capacity that can provide transmission rates of up to 500,000 bits per second. Other broad-band facilities can provide transmission rates of up to several million bits per second. In some cases, one broad-band channel can be subdivided to provide several logically independent communications channels of lower capacity.

.53 Types of Common-Carrier Service

Within a particular class of common-carrier communications facilities, different types of service can be obtained. The three general types of service are:

- Leased Service: Provides the user with the exclusive use of a communications line. Leased lines are available in all three classes.
- Public Switched Service: Provides the user with access to a communications network which is available to the general public. In general, charges are based on usage. The Bell System TWX network and the Western Union TELEX network are examples of narrow-band (low-speed) public switched services for message transmission. The public telephone network provides voice-band service on a switched (dialed) basis.
- Multistation Leased Systems: Provides the user with a private communications network accessible only by stations installed by that user. The majority of the available multistation leased systems are for narrow-band (low-speed) communications networks. In general, such a system is a packaged plan designed to provide a specific type of service, but the package is variable within certain limits to meet the needs of individual applications. Examples include the Bell System 83B series and Western Union Plans 115, 116, and 117, which are packaged systems with polling capabilities.

.6 SUMMARY

A data communications system may be of value wherever data must be transmitted between georgraphically separated locations. During the past few years a wide variety of communications equipment and facilities has become available, and the impact of data communications upon business and industry is growing rapidly. Designing a data communications system for a specific application requires a good understanding of both data processing and communications technology and of their interrelationships. A systematic, objective analysis of the information flow requirements and of the available equipment and facilities should always be performed to ensure that the resulting system will achieve its primary aim — to transmit useful information economically from one location to another.

AUERBACH SPECIAL REPORT
DESIGN AND APPLICATIONS OF AUTOMATED DISPLAY SYSTEMS

BY

THE TECHNICAL STAFF OF
AUERBACH INFO, INC.

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DESIGN AND APPLICATIONS OF AUTOMATED DISPLAY SYSTEMS

.1 INTRODUCTION

Automated display consoles are playing a key role in the everyday life of an ever-increasing segment of the world's population, in a broad spectrum of applications ranging from stock quotation systems to spacecraft control centers.

Display consoles function as links between men and automatic information processing systems. They are most effective when applied to problems whose solution requires the creativity and versatility of man in combination with the speed and storage capabilities of computers — particularly in environments where rapid response is important. In such applications, display consoles can be powerful tools for business and industry, educational and scientific institutions, the military, and other government agencies.

Continued growth in the application of automated information display systems will be limited mainly by:

- The ingenuity of display system designers and programmers;
- The ability of equipment manufacturers to design practical, economical display devices that satisfy the requirements of specific applications; and
- The ability of potential users to understand and appreciate the possibilities of computer-driven displays.

This report considers all three of these limitations, but is addressed primarily to the second: the design and selection of display devices that will meet the needs of specific classes of applications in an effective manner and at reasonable prices. After discussing the essential characteristics of display consoles in terms of their dependence on the specific tasks to be performed and on the human users, the report summarizes and interprets a recent AUERBACH study of the display characteristics that are necessary or desirable in a wide variety of applications. The results of this study are presented in an extensive table that should serve as a handy reference guide for designers and buyers of display equipment.

.11 Current Prices and Capabilities

The potential applications of computer-driven display equipment would be virtually unlimited were it not for the ever-present economic constraints. The prices of typical display consoles with their control units currently range from about $2,000 to $200,000, with specially-engineered consoles sometimes costing considerably more (2). Small alphanumeric consoles, without line-drawing capabilities, can be purchased for as little as $3,000 to $4,000 each as part of a system that includes a number of consoles. A typical self-contained, alphanumeric display console, however, is now priced at about $6,000 to $7,000 for capabilities that include:

- An 8.5-by-6.5-inch, monochromatic cathode-ray tube (CRT) screen;
- Capability to display about 500 characters at a time;
- A 500-character memory, used as an input/output buffer and to refresh the CRT display;
- A character generator with a 64-symbol displayable character set (upper-case letters only);
- A typewriter-like keyboard for data entry;
- Special editing and control keys and attendant hardware features that facilitate message composition, insertions, and deletions;
- A method of interfacing with the computer, usually via either a direct cable connection or a data communications link (3).

Some of the material in this article was derived from a project performed by AUERBACH Corporation for the National Aeronautics and Space Administration, Technology Utilization Office (Contract NASW-1646), to report on display technology work in or sponsored by NASA and the possible industry utilization of the results of this work (1).

.11 Current Prices and Capabilities (Contd.)

When the above capabilities are expanded, and augmented by the addition of features such as vector generation (line-drawing capabilities), light-pen input, hard-copy output, and special function keys, the price per console jumps to the vicinity of $100,000.

.12 Needed: Lower Costs, More Software

The challenge confronting display designers is to make display consoles economically advantageous in the many applications where they can potentially be of considerable value. This can be accomplished either by reducing the prices of general-purpose display equipment or by developing economical equipment with the specific characteristics required to meet the needs of individual classes of applications.

It is worth noting that display equipment, like digital computing equipment, tends to be quite versatile. A particular hardware configuration can often serve equally well in a number of diverse applications. The adaptability of the human viewer, who forms the display interface, adds to the versatility of automated display systems. Therefore, the desirability of developing highly specialized display equipment for specific applications could easily be overemphasized.

The computer programming associated with the use of display equipment is usually complex and time-consuming, so the availability of appropriate software is an important consideration in applying display consoles economically. An abundance of versatile display hardware is now available (3, 4, 5, 6). Applicable software is much harder to find, though programs that will allow economical use of display consoles in more applications are gradually being developed, particularly for the third-generation computers.

.13 Human Interests Versus Equipment Limitations

Every visual display device is designed for use by human beings, who are demanding in their needs and limited in their visual functions. But the display devices are subject to physical limitations and cost constraints. The resulting display systems necessarily represent compromises between the interests of the human users and the capabilities and costs of the equipment.

With regard to equipment, standards for measuring the performance of display consoles are in a confusing or nonexistent state at present. Terminology tends to be variable and imprecise. Resolution, for example, is diversely measured in terms of spot size, line width, white lines per inch, and optical lines. Many units of measurement are known by two or three different names.

With regard to the human users, the wide variations from man to man in activities and perceptions contribute to this hazy picture. For example, a man becomes more tolerant of flicker as he grows older, but his willingness to tolerate poor contrast decreases as he becomes tired. He responds to low light levels with one set of optic receptors and perceives color with another. In general, his performance is widely variable and difficult to predict.

The design characteristics of an effective display system are dictated by both the nature of the task to be performed and the capabilities of the human users. These task-dependent and human-dependent factors are discussed in the paragraphs that follow.

.2 TASK-DEPENDENT FACTORS IN DISPLAY DESIGN

The display characteristics which depend upon the nature of the task to be performed include screen size, message size, message format, response time, erasability, color, and half-tone capability. In discussing these task-dependent factors, the users' abilities to distinguish shapes, sizes, colors, etc. — as discussed in the next major section of this report — must be kept constantly in mind.

.21 Screen Size

Principal considerations in determining the size of the display screen are the size and geometric disposition of the audience, the quantity and format of information to be displayed, human visual limitations, and the availability and cost of suitable display equipment. The screen size should be consistent with the volume and detail required, the number of persons who must view it simultaneously, and the manner in which they will use the information.

.22 Message Size

The quantity of information that can be displayed at one time is usually referred to as the message size. This quantity is a function of the task to be performed, the viewer's ability to comprehend and use the information, and the type, format, and rate of data presentation. Time and money will be wasted if the display offers more or less information than the viewer can effectively understand and use. The resolving power of the equipment generally places an upper limit on message size. A large amount of information grouped into logical categories and statically displayed can be comprehended more easily than the same amount of information presented in a random, disassociated, rapidly-changing manner.

(Contd.)

.23 Message Format

Many types of information can be displayed by automated display systems. Besides the usual alphanumeric characters and symbols, some devices can display vectors, points, curves, grid lines, map outlines, and shaded areas. Other possibilities include overlays and other combinations of two or more independent image sources. Some data to be displayed is orderly, as in tabular work, while other data is random, as in maps. The data may be in digital form, as in alphanumeric display consoles, or it may be continuous, as in TV and facsimile. Display devices that operate in conjunction with a computer normally accept data in digital form.

The degree of freedom of placement and organization of the data on the screen affects the transmission requirements and equipment cost. A fixed format is one in which the various items appear in predetermined positions. Free or random placement allows the information to be positioned as a function of time or significance. Greater freedom of placement is generally accompanied by higher costs.

Coding of the displayed information is a valuable feature in many applications. The use of different colors is an effective coding technique that will probably be widely used in the future, though most current display devices are monochromatic. Special symbols are another useful form of coding. Realistic outlines of ships, planes, and guns can be recognized more quickly than the spelled-out equivalent English words. Shape recognition tests have shown that a person can, with practice, recognize between 200 and 2,000 different arbitrary shapes.

.24 Response Time

The speed of response of a display system is an important factor in three different modes of operation: tracking, updating, and replying.

The tracking response time is the time required to display the current situation. Certain display methods involve delays which are inherent in their principles of operation, while others respond almost instantaneously.

The response time for updating is the time required to present fresh data on the display.

The response time for replying is a measure of performance in inquiry-response situations; i.e., how long does it take to display a response after the operator finishes entering an inquiry? This response time is a function of the computer system and the communications link, as well as of the display device, and should total less than one second in most situations; longer response times can cause the operator to become bored, or shake his faith in the system.

.25 Erasability

Erasability is a measure of a system's ability to expunge data that has been displayed. Some display systems erase data virtually instantaneously, while others have persistence that makes rapid erasure impossible. Some systems have selective erasure capabilities, in which only specified parts of the displayed message are erased while the rest is preserved.

.26 Color

Most of the display systems in use today are monochromatic, but several manufacturers have recently introduced multi-color display equipment. The value of color for coding and classifying different types of information has already been noted. The upper limit of consistent human discrimination ranges from 10 to 12 different colors, but present color display generation methods limit the number of distinguishable colors to a practical maximum of 6 or 7.

Registration (i.e., the accuracy with which areas of different colors bound each other) can be a problem in multi-color displays. If accurate registration is critical, the number of different colors should generally be limited to four.

.27 Half-Tones

The ability of a display system to generate distinguishable shades of gray is called its half-tone capability. The term has been borrowed from the printing industry, in which the gray scale is usually approximated by modulating the size of regularly-placed dots so that the eye will perceive the integrated area of the black dots and white background as the desired shade of gray.

No formal method exists for measuring gray-scale values, although the measurement has both an objective and subjective aspect. Objectively, a factor of 2 (or 3 decibels) in luminance can be called one half-tone level. Subjectively, a half-tone level can be considered to be the smallest increment of change in brightness that can be noticed by a human. Within an overall contrast ratio of 10 to 1, there are about 10 discernible shades of gray. Typical TV displays have 5 to 10 discernible gray-scale levels. Most computer-driven display systems, however, operate in a binary manner in which a given point on the screen is either fully illuminated or dark.

.3 HUMAN-DEPENDENT FACTORS IN DISPLAY DESIGN

The basic purpose of all visual information display devices is to present intelligible data to human beings. Therefore, a logical approach to understanding and improving the man/machine relationship is to study human beings as they react to display devices. Recent studies in this area have resulted in some observations that should help in display device design.

One of the biggest problems faced by display researchers is the highly adaptable nature of man. He tends to adjust unconsciously to the particular qualities and idiosyncrasies of each display device. This adaptability often enhances the effectiveness of a display system, but it also accentuates the difficulty of accurately measuring the human parameters. In fact, the human user remains the least understood variable in the whole system.

The current state of knowledge about the human-dependent factors that must be considered in designing effective display systems is briefly summarized in the following paragraphs.

.31 Photometry

The essence of the visual display device is the creation of a light signal within the physical world and the passing of that signal into the psychological world of the human user. The physicist thinks of light as radiant energy with a particular wavelength and spectral distribution, whereas nontechnical people are more likely to think of light in terms of brightness, hue, and saturation. Photometry, the science that deals with the measurement of light intensity, attempts to mediate between these approaches by establishing average light characteristics through objective measurements. These measurements, wherever possible, are made without involving a human observer.

The physicist usually measures the total radiant energy emitted by a body, but the eye is limited to perceiving a relatively small range of wavelengths. Moreover, the eye responds differently to varying wavelengths. The psychological brightness perceived by a human viewer is called luminance or luminosity. A plot of luminosity versus wavelength produces a bell-shaped curve that peaks in the green area. The human retina, with its two kinds of receptors, actually has two luminosity curves: one for the cones (photopic receptors) in the center of the visual field and another for the rods (scotopic receptors) at the periphery. The rods are slightly more responsive to the shorter wavelengths.

.32 Brightness and Contrast

Brightness is the measure of the light intensity of a signal. Contrast is the relative brightness of a signal compared with the brightness of its background. The ease with which information can be read is directly related to contrast, but the required brightness varies with the size of the object area. If the size is decreased, the brightness must be increased for equal viewing ease.

The duration of a signal also affects the required brightness: short flashes must be brighter than longer flashes. Below durations of 0.1 second, however, isolated flashes of equal energy but unequal duration are equally visible.

Brightness is commonly measured in units called foot-lamberts. The brightness of typical displays ranges from 20 to 100 foot-lamberts. Lower light levels call for dark adaptation by the eye, but too low a light intensity causes a shift from the cone to the rod receptors, accompanied by a severe reduction of visual acuity.

There are a number of definitions of contrast in common use. Two frequently-used ones are:

- Contrast ratio. This is the ratio of the brightest to darkest portions of the display. It is employed where the gray scale is significant, as in television.
- Brightness contrast or percentage contrast. The brightness contrast is equal to image brightness minus background brightness divided by background brightness. The percentage contrast is simply the brightness contrast multiplied by 100.

Still another type of contrast is that of color. Although brightness contrast is far better for detail, color contrast can be used effectively for indicating different classes of information or for enhancing contrast in marginal situations. For example, the afterflow of long-persistence phosphors has a high orange component. The contrast can be increased by using blue ambient lighting — provided the marked contrast does not lead to undesirable psychological reactions.

.33 Resolution

As a measure of the display viewer's ability to discriminate fine detail, resolution depends partly upon the visual acuity of the eye and partly upon the resolution of the display equipment itself.

(Contd.)

.33 Resolution (Contd.)

The resolution of the display depends upon the characteristics of the image-creating elements — the bluntness of the "pen" that draws the display and the graininess of the web on which the display is presented. Other factors that affect equipment resolution include positioning accuracy, registration, repeatability, and diffusion of the image.

Several different aspects of visual acuity can be measured. Stereoscopic acuity, for example, is a measure of the minimum displacement the eye can resolve, though for most display devices there is little or no need to consider this capability.

Vernier acuity may be significant because it is the measure of how closely an operator can bring an indicating needle into alignment with a dial mark. Vernier acuity is affected by contrast, brightness, and the length of the needle or line. The eye can perform this type of operation with surprising accuracy. Typically, vernier acuity is between one second and one minute of arc.

The type of visual acuity of chief concern in the display field, however, is the minimum-detectable acuity. This capability depends upon the minimum-detecting sensor in the eye, the cone. In general, the cone can resolve an arc of about one minute, but several situations can change this limit. For example, a man will perceive a single spot of light against a dark background if only one cone is triggered; the spot may occupy considerably less than one minute of arc if it is bright enough.

.34 Flicker

Cathode-ray tube displays must be "refreshed" or regenerated periodically to produce persistent displays. The persistence of the particular phosphor used in the CRT is the principal factor that determines the required rate of refreshment. Most phosphors have exponential decay rates, with typical decay times ranging from 1 to 100 milliseconds. There are phosphors with decay times in the microsecond range, however, and there is one slow phsophor that lasts 16 seconds.

The display designer's goal should be to provide a repetition rate that ensures that the viewer will see a steady, flicker-free image. Flicker becomes more noticeable as brightness increases. Thus, brightness can be plotted against repetition rate to indicate the minimum rates for flicker-free viewing. In general, 50 to 60 repetitions per second is a safe lower limit.

Lower repetition rates, however, may be worth considering when dictated by equipment restrictions, because operators are not necessarily bothered by a small amount of flicker. Older operators tend to exhibit a greater tolerance of flicker. The flicker rates to be avoided are those in the range of 6 to 15 cycles per second, at which flicker is most objectionable. Probably there is a relationship between these flicker rates and the alpha rhythm of the brain; it is known that flicker rates in this range can induce epileptic seizures in susceptible persons.

.35 Readability

As an important characteristic of type faces, readability has long been a concern of the printing industry. Several variables are known to affect the readability of the English alphabet and Arabic numerals. Sharp corners on the symbols provide greater readability than rounded corners. The height-to-width ratio should be about 3:2 to 3:4 for optimum legibility, while the line widths should be 1/30 to 1/40 of the symbol heights. These ratios minimize blurring and fusion at a distance.

Many methods of generating characters produce non-ideal shapes. As a result, confusion often arises between symbols with similar shapes, such as 5 and S or 2 and Z. When cost constraints dictate the use of degraded character shapes, readability can be improved by increasing the size of the displayed characters.

.36 Visual Fidelity

In applications in which a display device depicts a graphical situation, the system must meet certain standards of fidelity. One type of distortion often encountered in cathode-ray tubes is the pincushion effect, well-known to early TV viewers. Another, caused by a non-linear sweep, can stretch or shrink one side of the image so that not all parts of the display appear to the same scale. If the display is geographical, its fidelity must be good enough to ensure that the relationships among all objects on the terrain will be properly depicted.

.4 CATEGORIES OF DISPLAY APPLICATIONS

One can imagine an almost endless list of potential applications for automated display consoles. On-line programming, automated design, computer-aided instruction, file management, inquiry response, text editing, message composition, and source data automation are just a few of the most promising display uses. The great majority of present and potential display applications, however, can be grouped into the four categories described in the paragraphs that follow.

.41 Category 1: Engineering and Design

In this class of applications, the user can be considered a "programmer" in the sense that a technical cross-conversation takes place between the system and the user. By means of the display console, the user engages in a flexible, interactive dialog with the computer.

Probably the most widely discussed application in this category is computer-aided design, in which the objective is to supply engineers with a set of tools that will help them:

- To perform various detailed or tedious computations;
- To see and compare the results of various design methods and parameters;
- To gain access to textbook, historical, and other types of information; and
- To store the results of various designs for future reference.

The software requirements for interactive engineering and design systems are particularly demanding. The language used for man/machine interaction must be a comprehensive one to permit flexible, efficient dialogs, yet it should be reasonably easy to learn and use. Often a "bootstrap" (self-teaching) course is programmed into the display software to aid in training the men who will work with the consoles. The hardware, like the software, must be flexible enough to permit free interchanges of information and the use of whatever graphic representations are needed for the particular application. To eliminate the need for special keyboards, the display screen itself can often be used for structured dialog; alternative choices are displayed, and the user makes his selection by means of a cursor or light pen.

Applications in Category 1 include:

- Engineering and Mathematics
  - Research
  - Design
  - Development
- Programming
  - Program development
  - Debugging
- Management Planning (Industry and Government)
  - Forecasting
  - Scheduling
  - Logistics

.42 Category 2: Information — Flexible or Structured Interaction

In these applications, the main purpose of the display console is to provide quick, convenient access to information in a large, centrally-located data base. In some cases, the information in the data base is updated by means of messages entered by the display console users. In other cases, conventional batch processing techniques are used to update the data base, and the display consoles are used only to access the information.

The applications in this category can logically be divided into two subclasses: flexible and structured. The "flexible" classification allows the same sort of flexible man/machine dialogs as in Category 1, though here the goal is mainly to provide efficient access to a fixed, though complex, data base. The "structured" classification applies to those applications where the exact form of the information to be transferred, in both directions, is known beforehand and can be structured for maximum effectiveness with respect to cost, ease of operation, reliability, etc.

There are literally hundreds of potential applications in this category. The following list, subdivided into the flexible and structured classifications, includes the ones that seem most promising at this time.

Information — Flexible Interaction

- Industrial and Government Management, Planning and Operations
  - Budgeting
  - Process control
  - Production control
  - Inventory management

.42 Category 2: Information — Flexible or Structured Interaction (Contd.)

- Military Command and Control
  - Strategy and planning
  - Damage assessment and logistics
  - Photo and map interpretation
  - Cryptography and translation
- Scientific Research
  - Laboratory experiment monitoring
  - Query and retrieval
  - Psychological studies
- Banking and Finance (in-depth customer service)
  - Credit analysis
  - Account analysis
  - Checking analysis
  - Stock portfolio analysis

Information — Structured Interaction

- Hospital Administration
  - Patient record query and retrieval
  - Nuring station aids to patient care
  - Diagnosis analysis
- Transportation
  - Airline reservations
  - Auto rentals
  - Railroad car and shipment disposition
  - Fleet vehicle location and content control
  - Hotel reservations
- Insurance
  - Policy searching
  - Claim adjustment
  - Policy file maintenance
- Banking and Finance (routine customer service)
  - Bank teller stations
  - Bank management inquires
  - Stock quotations
- Industrial Administration
  - Personnel records
  - Financial administration
  - Group insurance files
- Information Storage and Retrieval
  - Library searching
  - Text editing
  - Indexing and abstracting
- Military Administration
  - Base assets
  - Inventory control
  - Personnel records
  - Maintenance status reporting and control
  - Force status
  - Planning and war games
  - Fire control
- State and Local Government
  - Vehicle license identification
  - Driver license file searching
  - Traffic and criminal offense records
  - Deed searching
- Education
  - Computer-aided instruction
  - Programmed teaching
  - School administration

.43 Category 3: Monitor Functions

In these applications, the users are primarily spectators. They may be provided with a limited complement of manual controls, such as special pushbuttons, but not with a full keyboard. The information, usually in a completely prestructured format, is displayed for use by one or more observers. In some cases the observer has no control over the information that is displayed; in other cases he can select what he wants to see from a number of choices.

An important example of this type of application is NASA launch-vehicle checkout operations. Display consoles provide specialists with information regarding each operating element of a launch vehicle during countdown, and aid in decisions as to the health and probability of success of the ignition and flight of the vehicle.

Applications in this category include:

- System Operating Monitors
  - Data processing installations
  - Automated systems
  - Airline flight information
  - Checkout systems
  - Demonstrations
- Paging Systems
- Security Systems

.44 Category 4: Communications

In this category, the display unit serves as a means for holding and sometimes controlling information that is about to be or has been transmitted over some type of communications medium, either before it is transmitted or before it is accepted by the recipient. The transmitted information falls into two classes: alphanumeric messages and graphical/pictorial data. At the present time, these communications roles are being filled mainly by teleprinters (for alphanumeric messages) and by facsimile systems (for graphical/pictorial data), but display consoles are beginning to be used.

Among the applications in this category are:

- Alphanumeric Message Transmission
- Critical Message Validation
- Graphical/Pictorial Data Transmission
  - Newspapers and magazines
  - Criminal photographs
  - Weather information

For further discussions of display console applications, rewarding sources include the various Proceedings of the Society for Information Display (7), the Scientific American special issue on Information (8), and the Datamation special issue on Graphics (9).

.5 DESIRED CHARACTERISTICS FOR SPECIFIC APPLICATIONS

AUERBACH Corporation recently conducted a study designed to aid designers and buyers of display equipment in identifying the equipment capabilities that are necessary or desirable in a wide variety of specific display applications. For each of the applications listed in the preceding section of this report, the display characteristics desired by prospective users were ascertained and tabulated. The information was compiled through direct experience, literature surveys, and interviews with users and prospective users of automated display systems. The results are summarized in Table I.

(Contd.)

TABLE I: DESIRABLE CHARACTERISTICS FOR SPECIFIC DISPLAY APPLICATIONS

User	Number of Characters Displayed	Character Set	Special Inputs	Special Outputs	Plotting Ability	Screen Size	Color	Price Range, $
Engineering and Design								
Design Engineers and Mathematicians	High	AN	Yes	Maybe (1/N)	Yes	Large	Desir.	NC
Program Designers	Med.	AN	No	1/N	No	Med.	No	1-5K
Information, Flexible								
Industrial/Govt. Managers:								
Budgeting	Med.	AN	No	1/N	BG & T	Med.	Desir.	1-3K
Process control	Low	AN	No	1/N	BG & T	Med.	Desir.	1-5K
Production control	Low	AN	No	1/N	BG & T	Med.	Desir.	1-5K
Inventory management	Low	AN	No	Hard Copy	No	Med.	No	1-3K
Military Commanders:								
Photo and map interpretation	High	AN	Yes	1/N (low N)	Yes	Large	Yes	10-15K
Cryptography and translation	Med.	Changeable AN	No	1/N	No	Med.	Desir.	2-5K
Planning and war gaming	High	AN	Cursor, light pen	1/N	Desir.	Large	Yes	5-10K
Scientific Research Engineers	Low	AN	No	1/N	No	Med.	No	1-5K
Banking and Finance Specialists	Low	AN	No	No	No	Med.	No	1-3K
Information, Structured								
Hospital Administrators and Nurses	Low	AN	No	1/N	No	Med.	No	1-3K
Airline Reservation Clerks	Low	AN	No	1/N	No	Small	No	1-3K
Auto Rental Dispatchers	Low	AN	No	1/N	No	Small	No	1-3K
Railroad Car and Shipment Disposition Controllers	Low	AN	No	1/N	No	Med.	No	1-5K
Fleet Vehicle Location and Content Controllers	Low	AN	No	Hard Copy	No	Med.	No	1-5K
Insurance Company Managers and Clerks	Low	AN	No	1/N	No	Med.	No	1-5K
Bank Tellers	Low	AN	No	No	No	Small	No	1-3K
Bank Managers	Low	AN	No	1/N	No	Med.	No	1-5K
Stock Brokers:								
Portfolio analysis	Low	AN	No	1/N	BG & T	Med.	No	1-3K
Stock quotations	Low	AN	No	No	No	Med.	No	1-3K
Industrial Administrators (personnel records, etc.)	Low	AN	No	1/N	No	Med.	No	1-3K
Librarians:								
Library searching	Low	AN	No	1/N	No	Large	No	2-7K
Indexing and abstracting	High	AN	No	1/N	No	Med.	No	2-5K
Text Editors	Low	AN	No	No	No	Med.	No	1-3K
Military Administrators	Low	AN	No	1/N	No	Med.	No	1-5K
State and Local Government Personnel (vehicle license identification, etc.)	Low	AN	No	1/N	No	Small	No	1-5K
Educators (CAI, etc.)	Med.	AN	In some cases	No	In some cases	Med.	No	1-3K
Monitor Functions								
System Operators, Monitors, Paging Clerks, and Security Personnel	Low	AN	Video	1/N	No	Large	In some cases	1-3K
Communications								
Message Center Operators:								
Alphanumeric messages	High	AN	In some cases	1/N	No	Med.	No	About 2K
Graphical/pictorial data	High	AN	No	1/N	Yes	Large	Yes	About 5K

Number of Characters
High: 5000 or more
Med.: 1000 to 4000
Low: 1000 or less

Screen Size
Large: about 20"
Med.: about 15"
Small: about 10"

AN: Alphanumeric plus symbols
BG & T: Bar graphs and tables only
Desir.: Desirable but not essential
NC: Not critical
1/N: 1 hard-copy output device per N displays

.5 DESIRED CHARACTERISTICS FOR SPECIFIC APPLICATIONS (Contd.)

On the basis of the information in Table I, several noteworthy general observations can be made:

- The desired price ranges are generally lower than the cost of suitable display consoles which are currently on the market.
- Except for the cost problem, the small alphanumeric display consoles that are now available are generally suitable for a large number of applications.
- Hard-copy output, usually on a teleprinter, is desirable in most applications, though a single printer can often serve several display consoles.
- Special features such as light-pen input, audio output, plotting capabilities, and color are needed only in a relatively few specialized applications.

.6 COMPUTER-AIDED INSTRUCTION — AN EXAMPLE

As an illustration of the value and use of the information in Table I, consider the subject of computer-aided instruction (CAI) systems, on which a significant amount of development work is currently being done (10, 11). This work is generally directed toward the ever-growing need for individualized instruction at all grade levels. CAI can clearly have a revolutionary effect upon the efficiency of the educational process — if only the cost of suitable display consoles can be brought down to the point where every school system can afford them.

.61 Display Consoles in CAI

In most CAI systems, a terminal connected to a computer is provided for use by each student. One computer can service a large number of terminals. Each terminal is equipped with one or more output devices, such as display units and audio outputs, and one or more input units, such as keyboards and light pens.

There are three basic types of CAI systems: drill and practice systems, tutorial systems, and dialog or inquiry systems.

Drill and practice systems are largely complementary to the regular curriculum taught by the teacher. They can take a heavy burden off the teacher in subjects, such as arithmetic, where the students must be exposed to repeated drilling and extensive practice in the subject matter.

In a tutorial system, each student is guided through one or more courses of study. The system provides branching according to the reactions of the student at each step in the learning process. This branching may be either voluntary or involuntary. The student is presented with facts and examples and then asked questions about them. Wrong answers cause the system to provide diagnostic help, while correct answers allow the student to progress to more difficult subject matter.

In a system of the dialog or inquiry type, there is true conversational interaction between student and system. The system presents general problems to the student, who must request and organize various types of information from the computer to solve the problems. The student may be asked questions to gauge his thinking, but he can also ask questions of the system to round out his own knowledge.

Now, what does all this mean to the buyers and manufacturers of display equipment for use in computer-assisted instruction? What characteristics are necessary or desirable in display consoles for CAI systems? What special features do educators want, and how much are they willing to pay for them? Answers to these and other questions can be found in Table I.

.62 Desires Versus Realities for CAI

Table I shows that "Educators" would like to be able to obtain display consoles with these basic characteristics:

- Medium number of characters displayed (1000 to 4000).
- Character set consisting of alphanumerics plus symbols.
- Special inputs (e.g., light pens) in some cases.
- No special outputs.
- Plotting capability in some cases.
- Medium-size screen (about 15 inches).
- No color capability.
- Price of $1000 to $3000.

(Contd.)

.62 Desires Versus Realities for CAI (Contd.)

Clearly, there are no hard-to-satisfy technological requirements here. The critical problem — as in many promising display applications — is simply the fact that a display console with all the desired characteristics currently costs several times as much as most prospective users can afford to pay. Considerable development work, such as the University of Illinois' PLATO system, is being done in hopes of reducing the costs of CAI consoles. At present, however, $3000 will buy only a minimum alphanumeric console in a configuration in which several consoles share a single controller.

In contrast to the desired characteristics listed above, a cost-conscious CAI system designer would currently be forced to settle for a display console with characteristics more like these:

- Less than 1000 characters displayed.
- Character set consisting of 64 letters, numerals, and symbols.
- No special inputs (keyboard input only).
- No special outputs.
- No plotting capability.
- Screen size of less than 10 inches.
- No color capability.
- Price of $3000 to $4000 in quantity.

.7 CONCLUSIONS

As Table I and our CAI example clearly indicate, price considerations represent the major present deterrent to increased utilization of automated display systems. Potential users, not surprisingly, tend to want capabilities whose costs exceed the prices they are willing to pay. Yet the smallest consoles now available can satisfy the needs of numerous applications, and their costs are well within the reach of many prospective users. Where specialized equipment requirements exist, potential users will simply have to find ways to justify the higher costs — or wait for the prices to come down as a result of technological improvements and increased production.

Economic justification of automated display systems is not a simple task. Clerical help, such as keypunch operators, can sometimes be replaced with the help of display consoles, but most arguments for the use of display equipment must be based primarily upon benefits that cannot readily be evaluated in monetary terms. Among the potential benefits are increased responsiveness, better management control, elimination of routine clerical tasks, and elimination of the need for many documents and reports.

During the past few years, interest in the potential of automated display systems has greatly increased. This interest has been partly fostered by the marketing activities of the manufacturers of display equipment and computers, but increasing awareness of the potential benefits of display systems has also been an important factor. The present status and future of automated display equipment can be compared to that of the computer industry 10 to 15 years ago: two of the biggest challenges are to familiarize prospective users with the capabilities and effective utilization of the equipment, and to reduce equipment prices to a level where nearly every prospective user can justify its use.

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AUERBACH SPECIAL REPORT

KEYBOARD TO MAGNETIC TAPE ENCODERS

BY

THE TECHNICAL STAFF OF
AUERBACH INFO., INC.

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KEYBOARD-TO-MAGNETIC-TAPE ENCODERS

.1 BACKGROUND

Will Mohawk make punched cards obsolete? This question circulated throughout the industry after the announcement by Mohawk Data Sciences of its 1101 Data-Recorder in April 1965. Mohawk enjoyed almost instant success with its keyboard-to-magnetic tape innovation and has since broadened this product line to incorporate numerous models.

Mohawk was the chief producer and promoter of the new input preparation concept until January 1968, when Honeywell responded to the market potential and announced a similar entry-Keytape. Honeywell's move into the market was significant because it strengthened the keyboard-to-tape concept and implied an endorsement by a major computer manufacturer of this new technique for input preparation.

The image of punched cards as a necessary step in feeding computers received another blow at the Spring Joint Computer Conference in April 1968, when IBM, the world's largest producer of keypunch equipment, announced a keyboard-to-tape device suitable for preparation of data for input to IBM computers.

Since the introduction of the Keytape, many similar devices that utilize either standard tape reels or cassettes have also come on the market. The number of manufacturers now involved in producing keyboard-to-magnetic-tape encoders can be seen in the accompanying comparison charts. A recent development has been the emergence of multiple-station systems in which a number of data-entry consoles share a common central processor. Examples include the Logic Corporation LC-720 Data Collection System, the Sanders 6000 Display Data Recorder, the Computer Machine Corporation Key Processing System, the Realtronics R-1 Systems, and the Inforex Key Entry System. All but the last of these envisage the incorporation of many data stations to process large quantities of data; the Inforex system, with its limit of eight stations, plans to challenge smaller agregates of single-station installations for the processing of more modest quantities of data.

When the IBM encoder, the Model 50 Magnetic Data Inscriber, was announced, it represented a significant departure from the Mohawk-Honeywell class of devices by recording in a non-computer-compatible format. A Model 2495 Tape Cartridge Reader operating on line must therefore be used to input the recorded data to a computer. Its effective input rate, which is lowered by rewinding the tape and changing cartridges, corresponds to only 290 cards per minute. This figure must be compared with the capacity of many card readers to input over 1,000 cards per minute, and this capability in turn should be compared with the nominal input rate of magnetic tape into a computer of 70,000 to 80,000 characters per second, corresponding roughly to over 30,000 card images per minute.

To date Mohawk has marketed over 17,000 Data Recorders of which part has been delivered by NCR under its own label. This acceptance has amply demonstrated that a lucrative market for keyboard-to-magnetic-tape encoders exists.

The recent flurry of activity for keypunch replacements has reawakened interest in some older keyboard devices that use magnetic tape essentially as a removable buffer. The presence of units that can transcribe these reels or cartridges of tape to a standard computer tape reel make them feasible for input preparation when their particular characteristics are more suitable than "keypunches."

In this article, the salient characteristics of keyboard-to-magnetic tape devices are examined. In addition, the accompanying comparison charts present a survey of devices both available and projected, that record keyed data on magnetic tape in a form suitable for entry into a computer with or without a separate transcription operation. Other new companies can be expected to enter this market.

.1 BACKGROUND (Contd.)

While evaluating the capabilities of these devices for a specific application, keep in mind two important characteristics of punched cards that make them viable as an input medium:

- Each card is a physically discrete item that can be conveniently manipulated; this permits easy addition, deletion, or rearrangement of records and enables a clerk to make manual reference to each item.
- The cards can be interpreted, permitting easy human recognition of the data contained in each card.

.2 CHARACTERISTICS

.21 Keyboard Arrangement

There are two general keyboard arrangements for keyboard-to-tape devices: typewriter and keypunch. The primary difference between the two is the location of the number keys. The typewriter style has them arranged in a row across the top of the keyboard. The keypunch style imitates an adding machine by grouping the numbers for easy one-hand entry. (Note, however, that the keypunch layout differs from that of the conventional 10-key adding machine.)

The difference between the two basic arrangements has arisen because of the two types of applications for which the units are used. Because the typewriter style is well adapted to text messages and source document preparation, the need for an extended character set and a printed copy of the document would dictate its selection. The availability of a large work force familiar with this keyboard layout also encourages this choice. The keypunch style on the other hand, is appropriate for computer data preparation because of the high incidence of numbers in most computer data. The 10-key style is designed to promote an operating rhythm that increases production and decreases errors. To capitalize on these advantages, the keyboard-to-tape devices intended as direct successors to keypunches have retained the keyboard style. A second motive is to draw on the many keyboard operators familiar with this style.

.22 Buffering

An important function of a keypunch is the capability to duplicate previously entered data without the need to rekey the same data for each record. There are two techniques used for performing this function on a magnetic tape device: (1) entering a special code to indicate that a field is being duplicated; and (2) storing the field to be duplicated in a buffer, such as a magnetic core or delay line memory. The first method requires interpretation by the computer. The buffer technique is easier to implement than the use of a second read station as with normal keypunches.

A buffer also permits searching through many records for one containing a specific identification field by matching this field with a corresponding field stored in the buffer. Units that incorporate a buffer normally allocate a part for the controlling format program, which delimits fields and initiates automatic operations. An additional advantage to buffered operation is the capability for checking data recording errors by direct bit-for-bit comparison of the data just recorded with the data stored in the buffer.

.23 Tape Drive

A conventional, continuous-motion tape drive is normally incorporated in a buffered keyboard-to-tape device. Data is written on tape from the buffer and stored in the buffer when read from tape. Reading and writing operations are performed when the tape is moving, in an identical manner to be magnetic tape handlers in a computer system.

An incremental magnetic tape drive is required for an unbuffered keyboard-to-tape device. The operation of an incremental magnetic tape drive is significantly different from a conventional tape drive. A fixed-density recording is produced by a conventional tape drive when the tape speed is held constant. This recording technique demands a continuous stream of data during the process of recording. If buffering is not provided, data cannot be delivered at a constant rate to the recording logic and therefore, a different recording technique must be used. The incremental recorder records data on magnetic tape as the data is received. (There is no fixed-time relationship between each character of data received at the recording logic.) The incremental recorder produces a fixed-density recording from asynchronous data by stepping or incrementing the tape one character position after each character is recorded. Tape is static during the actual recording process.

.23 Tape Drive (Contd.)

Both the conventional and the incremental recording techniques can produce a recorded tape that can be read on a computer tape drive.

Current keyboard-to-tape devices employ one of two techniques for handling magnetic tape: reel or a cassette (cartridge). Some of the reel tape handlers employ standard one-half inch computer tape and record data in an IBM 729 (7-channel tape) or IBM 2400 Series (9-channel tape) compatible tape format. A reel is generally 10.5 inches in diameter and holds 2400 feet of magnetic tape; smaller reels that accommodate less tape are also available. Data recorded on these reels can be directly processed by a computer system simply by removing the tape from the recording device and mounting it on the computer tape drive. Other units use non-standard tape.

Most of the current keyboard-to-tape devices that handle reel tape provide a reel take-up mechanism. One manufacturer (Mohawk) employs a tape bin for temporary storage of magnetic tape.

The magnetic tape cartridge offers simplicity in handling and requires a fraction of the storage space required for standard computer tapes, but it holds far less data. The tape cartridge is usually a plastic container that encases both recording tape and reels as an integral unit. One manufacturer (IBM) employs a single-reel cartridge with automatic threading to a reel contained in the encoder when the cartridge is inserted. Tape cartridges are relatively easy to handle as they require no manual threading and permit rapid changeover from one tape to the next.

Most manufacturers of keyboard-to-tape devices that do not produce a computer-compatible tape format (cartridge and nonstandard reels) produce a device to transcribe the data from the noncompatible tape to a computer compatible format recorded on standard computer tape.

.24 Operating Modes

Keyboard-to-tape devices designed to replace card keypunches and verifiers normally provide three basic modes of operation: entry, verify, and search. The following discussion is oriented toward devices with a buffer. The only nonbuffered device in this category, the IBM Model 50 Data Inscriber, is discussed separately later in the article.

Data is recorded on magnetic tape in the entry mode. First, the data entered by the keyboard is stored in the buffer memory, from which it is written on magnetic tape once a complete record has been assembled. Fixed data can be retained from record to record, and duplication and skip operations can be initiated manually or under control of a stored program.

Keying errors can be corrected immediately, if detected, by backspacing and rekeying. After the record is recorded on magnetic tape, a read-after-write check is performed on the recorded data. The tape is automatically reversed to the beginning of the record, read forward and compared bit-for-bit with the record stored in the buffer memory. Recorded parity is also checked.

A magnetic tape previously recorded can be checked in the verify mode. Verification is performed by comparing the data stored on tape with that used to generate the tape; i.e., the source data. As each character is keyed, it is compared to a corresponding character stored in the buffer memory. Verification continues uninterrupted until a discrepancy is detected, whereupon the keyboard locks and an indicator lamp comes on. After attempts to rekey the character fail or if a visual check of the displayed character proves the recorded data to be incorrect, the operator must rekey the correct character.

After completing the verification and correction of a record containing errors, the operator must reverify the entire corrected record. The record is written on tape and a read-after-write check is performed as in the data entry mode.

The search mode is provided to locate a particular record that contains a unique identification code or field. The identifying data is keyed into memory in the same position it occupies in the record. Once initiated, the search mode contains until the stored identifier is matched with the corresponding field in the tape record. The tape also halts when a prescribed length of blank tape is encountered. The search mode can be used to locate a specific record for modification or correction.

.25 Programming

Keyboard-to-tape devices designed as replacements for card keypunches and verifiers typically provide two alternate programs or format specifications. Programming is required to delimit fields within a record, to define operations such as automatic duplication or verification of common information, automatic skipping or manual keying, and to indicate alphabetic or numeric shift. Mohawk, Honeywell, and Sangamo provide storage for two programs, basic and alternate, of which one is manually selected by the operator as the controlling program. IBM provides no less than eight levels of programming on its Model 50 Magnetic Data Inscriber. The multistation Logic LC-720 system stores 30 programs, each of which can be assigned to any console.

.26 Display

All keyboard-to-tape devices incorporate some technique for displaying the recorded data. The Communitype 100RO and 100SR, and the IBM MT/ST produce a printed copy of the recorded data. Other units, lacking typed output, display only the current character. In this category there are two principal representations. One usually is in the form of a binary configuration designating the character, although an interesting exception is the Honeywell KEYTAPE in which a three-digit number denoting the character is illuminated. The second type is a direct display of the character, usually distinguished from a series of darkened letters by a spot of illumination from the rear. The Sangamo Data Station the Vanguard DATASCRIBE, and the Logic LC-720 are examples of direct-display systems. The most sophisticated technique, a cathode-ray-tube display of the entire format, is employed in the Sanders System 600 and will be used in others such as the Sycor Key Cassette, and the VIATRON System 21. The VIATRON display will include an option permitting the data to be displayed in up to eight different colors.

.27 Pooling

In an environment where several keyboard-to-tape devices are employed, the records recorded at the individual tape stations are customarily combined or pooled on a single tape for entry into a computer system. Most manufacturers provide pooling capabilities that permit the selection on a particular keyboard-to-tape console or encoder as the source of the data to be recorded by the pooler. Pooling is generally performed under the control of both read and write programs.

.28 Communications

The majority of keyboard-to-tape devices provide a data communications capability. Such units can communicate with a similar device or a remote computer over the public telephone network or leased voice-band lines. Transmission speeds range from 1200 bits per second (150 or 200 characters per second) to 2400 bits per second (300 or 400 characters per second).

.29 Auxiliary Devices

Some keyboard-to-tape manufacturers provide auxiliary input or output devices to add flexibility to the data preparation operation. Auxiliary devices can include paper-tape readers, punched-card readers, serial printers, line printers, and adding machines.

.3 MULTIPLE-STATION KEYBOARD ENTRY

The multiple-station keyboard-to-magnetic-tape concept has been evolved primarily to eliminate the need for individual buffers and tape transports at each keyboard. Instead, a central processor and a single tape transport are "shared" by several keyboard stations. In these systems, there is a growing tendency to use a magnetic disc unit as an intermediate storage agency between the processor and the tape transport. Thus, completed records are written on disc first. Records can be retrieved, when desired, from the disc. This technique effectively expands the memory capacity of the processor and facilitates verification operations. This technique would also allow records from several keyboard stations to be sorted and/or merged into a longer file for transcription to magnetic tape. Retrieval of records from magnetic tape, while physically possible, is normally slow in comparison with retrieval from disc. Some of the multiple-station systems employ a removable-cartridge disc unit that accommodates disc packs compatible with disc drives used with computers; although the disc-pack prepared by such a multiple-station system could be used directly by computer systems, the data is now normally transferred to magnetic tape.

.3 MULTIPLE-STATION KEYBOARD ENTRY (Contd.)

The Logic LC-720 employs a Varian 620/i computer (central processor) with a basic 4,096-word core memory, one or two IBM 2400 Series-compatible magnetic tape units or and IBM 2311-compatible disc drive.

Up to 120 keyboards can be physically integrated within the LC-720 System, although no more than 50 or 60 are recommended by the company. Data entered from the keyboard is intermediately stored in the internal core memory of the central processor assigned to the keyboard used for entry. It follows that this data can be verified by another operator at a different console provided she is given access to that memory position in the processor.

Computer Machinery Corporation is currently marketing the Key Processing System. This system includes a small computer, an IBM 2311-compatible disk drive, and up to 32 directly connected keyboard terminals. Data entered via a keyboard terminal is processed by the computer and stored on disc in an area corresponding to the keyboard terminal used to enter data. The basic Key Processing System (six keyboard terminals) leases for $1,400 per month with additional keyboards leased at $75 per month each. Sale price of a basic system including six keyboards, processor, disc storage and system software is $70,000; it will lease for $1,400 per month. Initial deliveries are planned for April 1969.

.4 FUTURE

Although the number of keyboard-to-tape devices produced to date confirms a sizable market, the punched card field is not yet overturned; resistance from the U.S. Government and other organizations who have a large investment in EAM equipment will persist for some time. Indeed, there are some applications for which a discrete record that can be handled by both a clerk and a machine is desirable. Other techniques, such as optical character readers and magnetic-stripe documents, may do much to solve the problems of these applications. The Potter Instrument Company, for example, has announced plans to adapt its standard high-speed printer, Model HSP-3502A, to imprint magnetic characters on tab cards, with nonmagnetic data to be entered manually by means of a modified standard typewriter. A magnetic mark card reader will be introduced to read the six-line cards so produced.

Another significant development that may further prolong the life of keypunches is the combination of a buffer and a punching facility in the verifier unit. If a mismatch is encountered between a character on a punched card and an incoming character from the keyboard, the error can be corrected in the buffer so that ultimately only verified data is contained in memory. Then a new card can be automatically punched, the invalid one rejected, and the new card inserted in the deck. These features are incorporated in the UNIVAC 1700 series.

In view of the distinctly faster input speed shown by magnetic tape over punched cards, it would appear that keyboard-to-magnetic-tape devices will eventually end the reign of keypunches as the standard means of preparing input data for computers.

.5 COMPARISON CHARTS

The characteristics of all presently announced magnetic tape encoders are summarized on the following pages. Please refer to Paragraph .2 for a discussion and explanation of the comparison chart entries.

IDENTITY		COMMUNITYPE DATA RECORDING UNIT MODEL 100R0	COMPUTER MACHINERY KEY PROCESSING SYSTEM	CYBERCOM MARK I KEYENCODER SYSTEM	DARTEX DATA TERMINAL
Keyboard style		Typewriter	Keypunch	Keypunch	Typewriter
Character set		88	64	64	64
Buffering, character positions		None	256	80 or 120	None
Display		Printed copy	Direct display; current character only	Direct display; current character only	Printed copy
Programming		No provisions	300-1000 levels, manual selection	1 level	No provisions
Program entry		-	Keyboard or magnetic tape	Punched card	-
Magnetic Tape	Drive	Incremental	Continuous	Continuous	Incremental
	Type	Tape cartridge contains 200 feet of sprocketed 16 mm magnetic tape	2400-foot, 10.5-inch reel of 0.5-inch magnetic tape	200-foot reel of 0.25-inch tape in a cartridge	3-inch reel contains 0.25-inch magnetic tape
	Format	Special	IBM 729 or 2400 series compatible	Special, see comments	Special
	Code	6-level IBM Selectric plus odd parity	6-level BCD or 8-level EBCDIC	6-level BCD or 8-level EBCDIC	6-level Dartex BCD plus odd parity
	Density, char/inch	88	200, 556, or 800	200	800
	Capacity	180,000 char	Full reel	Full cartridge (600 records)	280,000 char
	Record size	Variable	Variable up to buffer size	Same as buffer size	Variable
Operating Modes		Record, Print, and Non-record; Model 100SR includes Transmit and Receive modes	Data Entry, Verify, Double Verify, and Search; Program Entry and Verify	Data Entry, Verify, and Search; Program Entry and Verify	Several operating modes depending on attached auxiliary devices
Error Control		Character and longitudinal parity are recorded and checked in print mode	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data	Character parity is recorded; character parity and validity are checked when read
Pooling		No provision	Automatic	Yes, via converter	No provision
Communications		Model 100SR transmits and receives at 150 char/sec over a voice-band line	No provision	In planning	Interface options transmits and receives at 120 char/sec over a voice-band line
Auxiliary Devices		Card reader; Program and Data-Memory provides 80,000-character fixed data storage on magnetic tape	Teleprinter	None	Typewriter, paper tape reader, paper tape punch, card reader, and IBM 729 Series and IBM 2400 Series compatible tape drives
First Delivery		June 1968	June 1969	May 1969 (7-track); third quarter 1969 (9-track)	December 1966
Pricing	Monthly rental	$180 to $355	$1950 (10 stations); $3600 (32 stations); up to $1610 for options	$145 (Encoder); $180 (7-track Converter)	$96 (basic unit); $25 to $350 per I/O unit
	Purchase	$8000 to $10,600	$92,000 (10 stations); $158,000 (32 stations); up to $81,800 for options	$7970 (Encoder); $11,500 (7-track converter)	$4800 (basic unit) $1265 to $17,500 per I/O unit
Comments		The 100SR is identical to the 100RO with the addition of a communications interface. Communitype also produces different versions of magnetic tape units (with or without a communications interface) for local or remote transcription of data to an IBM 729 or IBM 2400 Series compatible tape format	System includes stored program computer, 10 to 32 keyboard stations, and IBM 2311-compatible Disc Pack Drive for intermediate storage or output. Options include real time supervision, automatic balancing, check-digit control and operator analyses. Double Verify Mode permits simultaneous data entry and verification	Encoder output tape (cartridge) can be converted to IBM 729-compatible tape; converter can service up to 15 encoders; 9-track converter scheduled for third quarter 1969. Operator errors are displayed with instructions for corrections	Basic unit provides only tape station; multiple I/O units include magnetic tape handlers that transcribe data from Dartex tape to IBM 729 or IBM 2400 Series compatible tape format

IDENTITY		FACIT-ODHNER SYSTEM 6000	FACIT-ODHNER SYSTEM 6200	HONEYWELL KEYTAPE K-700 SERIES	HONEYWELL KEYTAPE K-900 SERIES
Keyboard style		Adding machine (10 key)	Typewriter	Keypunch	Keypunch
Character set		10	64	64	64; 256 code combinations can be recorded
Buffering, character positions		None	None	80 or 120	80, 90, 100, 110, or 120
Display		Printed copy	Printed copy	Coded numeric; current character only	Coded numeric; current character only
Programming		Single level (6005 only)	No provision	2 levels; manual selection	2 levels; manual selection
Program entry		Manual; via plug board	-	Manual keying	Manual keying
Magnetic Tape	Drive	Incremental	Incremental	Continuous	Continuous
	Type	4.5-inch reel contains 150 feet of 0.5-inch magnetic tape	4.5-inch reel contains 150-feet of 0.5-inch magnetic tape	2400-foot reel of 0.5-inch magnetic tape	2400-foot reel of 0.5-inch magnetic tape
	Format	IBM 729 or IBM 2400 compatible	IBM 729 or IBM 2400 compatible	IBM 729 compatible	IBM 2400 compatible
	Code	6- or 8-level code	6- or 8-level code	6-level BCD plus odd or even parity	8-level EBCDIC plus odd parity
	Density, char/inch	200	200	556; 200 or 800 optional	800
	Capacity	300,000 char	300,000 char	Full reel	Full reel
	Record size	Variable	Variable	Same as buffer size	Same as buffer size
Operating Modes		Record and print mode only; no capability for reading recorded tape	Record and print mode only; no capability for reading recorded tape	Entry, Verify, Search, Program Entry, and Program Verify	Enter, Verify, Search Program Entry, and Program Verify
Error Control		Character and longitudinal parity are recorded but not checked	Character and longitudinal parity are recorded and checked; see comments	Character and longitudinal parity is recorded and checked when read; reread with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read; reread with bit-for-bit check of recorded data
Pooling		No provision	No provision	Yes, some models	Yes, some models
Communications		No provision	No provision	Models K-731 thru K-735 transmit and receive at 1200 or 1800 bits/sec over a voice-band line	Models K-931 thru K-935 transmit and receive at 1200 or 1800 bits/sec over a voice-band line
Auxiliary Devices		Check digit verifier for mod 10 or 11 check digit generation	Paper tape punch	Card reader, adding machine, serial and line printers, paper tape reader	Card reader, adding machine, serial and line printers, paper tape reader
First Delivery		June 1968	August 1968	June 1968	September 1968
Pricing	Monthly rental	\$87 to \$170	\$94 to \$141	\$148 to over \$300 with options	\$165 to over \$335 with options
	Purchase	\$3975 to \$5145 plus up to \$1395 for options	\$4275 to \$4325	\$7250 to over \$13,000 with options	\$8250 to over \$14,000 with options
Comments		Three models are available: 6003 (no format capability), 6004 (programmed tab stops), and 6005 (program plugboard). All models have Code Selector. Three input units are available: two adding machine models and an accounting machine	Code Selector patch-panel programming determines recorded code for each key depression. Codes for recording are picked up photoelectrically from hole patterns in type bars; a check is made to ensure full movement of type bars	Honeywell provides a total of 36 different Keytape models equally divided between the K-700 Series and K-900 Series product lines. The different models provide a wide range of capabilities that combine multiple features and different auxiliary units	

IDENTITY		INFOREX KEY ENTRY SYSTEM	IBM MAGNETIC TAPE SELECTRIC TYPEWRITER (MT/ST)	IBM MODEL 50 MAGNETIC DATA INSCRIBER	LOGIC CORPORATION LC-720 DATA COLLECTION SYSTEM
Keyboard style		Keypunch	Typewriter	Keypunch	Keypunch
Character set		64	88	48 or 64	64
Buffering, character positions		2000	None	None	240
Display		CRT display; 128 characters	Printed copy	Coded alphanumeric; current character only	Direct display; current character only
Programming		2 or 4 levels	None	8-levels	30 levels, manual selection
Program entry		Keyboard, program library	-	Program card	Punched tape, program library
Magnetic Tape	Drive	Continuous	Incremental	Incremental	Continuous
	Type	1200-foot, 8.5-inch reel of 0.5-inch magnetic tape	Tape cartridge contains 100 feet of sprocketed 16 mm magnetic tape	Tape cartridge contains 100 feet of sprocketed 16 mm magnetic tape	1200-foot, 8.5-inch reel of 0.5-inch magnetic tape
	Format	IBM 729 or 2400, Series compatible	Special	Special	IBM 2400, Series compatible
	Code	6-level BCD or 8-level EBCDIC	6-level MT/ST plus odd parity	8-level EBCDIC plus odd parity	8-level EBCDIC
	Density, char/inch	800	20	20	800
	Capacity	Full reel	23,000 characters	23,000 characters	Full reel
	Record size	Up to 256 or 512 char.	Variable	Up to 720 characters	Same as buffer size
Operating Modes		Data Entry, Verify, Double Verify, and Search; Program Entry and Verify	Record, Print, Edit, and Search	Write, Read, Verify, and Search	Data Entry, Verify, Double Verify, and Search; Program Load
Error Control		Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data	Character parity is recorded; read-after-write check on recorded parity	Character parity is recorded; read-after-write check on recorded parity	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data
Pooling		Automatic	No provision	No provision	Automatic
Communications		No provision	MT/ST with Remote Record	No provision	No provision
Auxiliary Devices		None	None	None	Card punch and imprinter, printer
First Delivery		First quarter 1970	April 1968	January 1969	April 1969
Pricing	Monthly rental	$610 (1 station); $960 (8 stations)	$175 (single tape station without options); $233 (double tape station without options)	$180	$2200 (10 stations); $13,200 (60 stations)
	Purchase	$26,700 (1 station); $35,100 (8 stations)	$7150 (single tape station without options); (double tape station without options)	$9900	$88,028 (10 stations); $213,028 (60 stations)
Comments		System includes control unit, 1 to 8 keyboard stations, and fixed-disc storage unit; 4-level programming with 512-character records optional. Double verify mode permits simultaneous data entry and verification	The same 9-track magnetic tape cartridge is used by either device; the IBM 2495 Magnetic Cartridge Reader automatically reads up to 12 cartridges, produced by either device, at 900 characters per second. The 2495 attaches to the Multiplexor Channel of an IBM System 360 Model 25, 30, 40, or 50 computer		System includes stored program computer, up to 120 keyboard stations, and IBM 2311-compatible Disc Pack Drive for intermediate storage or output; 10.5-inch reel optional. Double Verify mode permits simultaneous data entry and verification

(Contd.)

IDENTITY		KEYMATIC DATA SYSTEMS KEYMATIC 1070 SERIES	KEYMATIC DATA SYSTEMS KEYMATIC 1090 SERIES	MAI 100 DATA TRANSCRIBER	REALTRONICS R1 SYSTEMS
Keyboard style		Typewriter	Typewriter	Keypunch	Keypunch
Character set		256	256	64	64
Buffering, character positions		None	None	99 or 199	192
Display		Binary coded; current character only	Binary coded; current character only	Direct display; current character only	Direct display; current character only
Programming		No provision	No provision	1 level	192 levels
Program entry		-	-	Keyboard or magnetic tape	Keyboard or magnetic tape
Magnetic Tape	Drive	Incremental	Incremental	Continuous	Continuous
	Type	1200-foot reel of 0.5-inch magnetic tape	1200-foot reel of 0.5-inch magnetic tape	Cartridge contains 1200-foot, 8.5-inch reel of 0.5-inch magnetic tape	1200-foot, 8.5-inch reel of 0.5-inch magnetic tape
	Format	IBM 729 compatible	IBM 2400 compatible	IBM 729 or 2400 Series compatible	IBM 729 or 2400 Series compatible
	Code	6-level BCD plus even or odd parity or 8-level code plus even or odd parity using two tape rows per char.	8-level EBCDIC plus odd parity	6-level BCD or 8-level EBCDIC	6-level BCD or 8-level EBCDIC
	Density, char/inch	556	800	556 or 800	200, 556, or 800
	Capacity	Full reel	Full reel	Full reel	Full reel
	Record size	Variable	Variable	Same as buffer	Same as buffer
Operating Modes		Record mode only; record and print mode with optional Selectric Typewriter	Record mode only; record and print mode with optional Selectric Typewriter	Data Write and Verify; Program Entry Verify, and Search	Data Entry, Verify, and Search; Program Entry and Verify; Numeric Only
Error Control		Character parity is recorded and checked using the echo-check technique	Character parity is recorded and checked using the echo-check technique	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data
Pooling		None	None	No provision	Automatic
Communications		None	None	Transmits and receives at up to 2400 bits/sec over a voice-band line	Transmits and receives at up to 4800 bits/sec over a voice-band line
Auxiliary Devices		Selectric Typewriter	Selectric Typewriter	In planning	Printer
First Delivery		April 1969	April 1969	June 1969	September 1969
Pricing	Monthly rental	$703 to $746	$858 to $1004	$145 to $160 plus up to $180 for options	$1430 (8 stations); $3469 (32 stations); plus up to $2240 for options
	Purchase	$7900 to $9500 plus up to $5,555 for options	$9640 to $11,280 plus up to $5,555 for options	$5800 to $6400 plus up to $7880 for options	$71,510 (8 stations); $173,470 (32 stations); options can add over $109,400
Comments		The Keymatic 1070 Series, at present, includes three models: 1071 (101 keyboard codes), 1072 (161 keyboard codes), and 1073 (256 keyboard codes); the 1090 series corresponds to the 1070 series; optional features include an IBM Selectric Typewriter, direct character display, adding machine format for master keyboard, and keystroke counter		Cartridge uses standard 0.5-inch computer tape; reel can be removed from cartridge and mounted directly on computer tape drive. Options include alternate program, CRT display, and multiprogram (up to 12) reader	System includes stored program computer, up to 12 disc units for intermediate storage, and up to 32 keyboard stations

IDENTITY		MOHAWK DATA SCIENCES DATA-RECORDER 1100 SERIES	MOHAWK DATA SCIENCES DATA-RECORDER 6400 SERIES	POTTER DATA RECORDER KDR-3000 SERIES	POTTER DATA RECORDER KDR-4000 SERIES
Keyboard style		Keypunch	Keypunch	Keypunch	Keypunch
Character set		64	64; 256 code combinations can be recorded	48 or 64 (optional)	64; 256 code combinations can be recorded
Buffering, character positions		80, 84, 90, 100, 120, 140, 160, or 180	80, 90, 100 or selectable from 10 to 180	160	160
Display		Binary coded; current character only	Binary coded; current character only	Binary coded; current character only	Binary coded; current character only
Programming		2 levels; manual selection	2 levels; manual selection	2 levels; manual selection	2 levels; manual selection
Program entry		Tape length or manual keying	Tape length or manual keying	Tape length or manual keying	Tape length or manual keying
Magnetic Tape	Drive	Continuous	Continuous	Continuous	Continuous
	Type	1200 foot reel of 0.5-inch magnetic tape	1200-foot reel of 0.5-inch magnetic tape	2400-foot reel of 0.5-inch magnetic tape	2400-foot reel of 0.5-inch magnetic tape
	Format	IBM 729 compatible	IBM 2400 compatible	IBM 729 compatible	IBM 2400 compatible
	Code	6-level BCD plus odd or even parity	8-level EBCDIC plus odd parity	6-level BCD plus odd or even parity	8-level EBCDIC plus odd parity
	Density, char/inch	200	800	200, 556, or 800	800
	Capacity	Full computer reel	Full computer reel	Full reel	Full reel
	Record size	Same as buffer size	Same as buffer size	Same as buffer size	Same as buffer size
Operating Modes		Entry, Verify, and Search; Program Entry and Verify	Entry, Verify and Search; Program Entry and Verify	Entry, Verify, Search, Display, Record/Read, and Program Entry	Entry, Verify, Search, Display, Record/Read, and Program Entry
Error Control		Character and longitudinal parity is recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read, re-read with bit-for-bit check of recorded data
Pooling		Yes, some models	Model 6402	Yes	Yes
Communications		Models 1103, 1109, 1112, 1115 and 1183 transmit and receive at 1200, 1600, 2000, or 2400 bits/sec over a voice-band line	Models 6403, 6409, 6412, and 6415 transmit and receive at 1200, 1600, 2000, or 2400 bits/sec over a voice-band line	In planning	In planning
Auxiliary Devices		Adding machine, paper tape reader, card reader, typewriter, line printer	Adding machine, paper tape reader, card reader, card punch, typewriter, line printer, paper tape punch	In planning	In planning
First Delivery		May 1966	April 1968	April 1969	April 1969
Pricing	Monthly rental	$125 to over $325 with options	$145 to $240; options not included	$135 to $145	$165
	Purchase	$7200 to over $13,300; options can add over $3000 to price	$8000 to $14,100; options can add over $2400 to price	$7250 to $7400 plus options	$8100 plus options
Comments		Mohawk's two product lines include a wide range of models that differ in special features, communications interface, and the attached auxiliary device. The 6400 Series product line, at present, includes 9 models, and the 1100 Series 13 models		The KDR-3000 Series product line includes four models that differ in tape density, attached auxiliary device, and special features. The KDR-4000 product line, at present, includes one model. Any record length from one to the buffer size can be recorded when the dial option is incorporated.	

(Contd.)

IDENTITY		SANDERS SYSTEM 6000	SANGAMO DATA STATION MODEL 7100	SANGAMO DATA STATION MODEL 9100	SYCOR KEY-CASSETTE SOURCE DATA ENTRY SYSTEM
Keyboard style		Typewriter	Keypunch	Keypunch	Typewriter
Character set		64	64	64; 256 code combinations can be recorded	64
Buffering, character positions		1024, 2048, or 3072 total; 256, 512, or 1024 per station	80, 100, or 240	80, 100, 120, or 240	100 or 200
Display		CRT display (2700 characters)	Direct alphanumeric display; current character only	Direct alphanumeric display; current character only	CRT display (280 characters)
Programming		30 levels; manual selection	2 levels; manual selection	2 levels; manual selection	2 levels; manual selection
Program entry		Keyboard or tape cassette	Manual keying	Manual keying	Keyboard or tape length
Magnetic Tape	Drive	Continuous	Continuous	Continuous	Continuous
	Type	1200-foot, 8.5-inch reel of 0.5-inch magnetic tape	600-foot reel of 0.5-inch magnetic tape	600-foot reel of 0.5-inch magnetic tape	Cartridge contains 280 feet of 0.25-inch magnetic tape
	Format	IBM 2400 Series compatible	IBM 729 compatible	IBM 2400 compatible	Special
	Code	8-level EBCDIC	6-level BCD plus odd or even parity	8-level EBCDIC plus odd parity	USASCII
	Density, char/inch	800	556, 200 or 800 optional	800	88.8
	Capacity	Full reel	Full reel	Full reel	Full cartridge
	Record size	1 to 1015 characters	Same as buffer size	Same as buffer size	Same as buffer size
Operating Modes		Data Entry; Program Entry	Data Entry, Data Verify, Search, Program Entry, and Program Verify	Data Entry, Data Verify, Search, Program Entry, and Program Verify	Data Entry, Verify, and Search, Program Entry and Verify
Error Control		Character and longitudinal parity are recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity is recorded and checked when read; re-read with bit-for-bit check of recorded data	Character and longitudinal parity are recorded and checked when read; re-read with bit-for-bit check of recorded data
Pooling		No provision	Yes	Yes	Yes, via converter
Communications		No provision	Model 7300 transmits and receives at 1200, 1600, 2000, or 2400 bits/sec over a voice-band line	Model 9300 transmits and receives at 1200, 1600, 2000, or 2400 bits/sec over a voice-band line	In planning
Auxiliary Devices		None	In planning	In planning	In planning
First Delivery		Fall 1969	September 1968	September 1968	February 1969
Pricing	Monthly rental	$597 (1 station); $931 (3 stations); $2458 (12 stations)	$158 plus options	$177 plus options	$180 to $205 (encoder); $350 (converter)
	Purchase	$22,618 (1 station); $33,998 (3 stations); $74,780 (12 stations)	$7640 plus options	$8200 plus options	$7000 to $7900 (encoder); $13,000 (converter)
Comments		System includes stored program computer and up to 12 keyboard stations. Very flexible cursor movement controls allow extensive editing capabilities. Format loader is portable. Prices vary widely with configurations and options	Sangamo plans to produce a wide range of models corresponding to those of Honeywell and Mohawk. Sangamo plans initial delivery of the 7300 and 9300 models by the end of the year. Models 7300 and 9300 have the same basic capabilities as the 7100 and 9100 with the addition of a communications interface. Record length can be varied via a switch, in increments of 20 positions, from 20 to 240 with options; the 7100 provides a selection of 80 or 100 standard; the 9100 provides a selection of 80, 100, or 120 standard		Also marketed by Olivetti as on-line terminal. Converter transcribes from cartridge to IBM 2400-compatible tape or the reverse

IDENTITY		TY-CORE 7500 DATA TAPE STATIONS	VANGUARD KB 600 SERIES	VANGUARD KB 800 SERIES	VIATRON SYSTEM 21
Keyboard style		Keypunch	Keypunch		Keypunch
Character set		64	64		64
Buffering, character positions		80 to 240 in increments of 20	80, 90, 100, 120, 140, 160, 180, or 200		240
Display		Direct display; current character only	Direct display; current character only		CRT display (320 characters)
Programming		2 levels; manual selection	2 levels; manual selection		2 levels; manual selection
Program entry		Keyboard or tape length	Keyboard or tape length		Keyboard or tape length
Magnetic Tape	Drive	Continuous	Continuous		Continuous
	Type	Cartridge contains 300 feet of 0.15-inch magnetic tape	10.5-inch reel contains 2400 feet of 0.5-inch magnetic tape		Cartridge contains 300 feet of 0.15-inch magnetic tape
	Format	Special	IBM 729 compatible	IBM 2400 Series compatible	Special
	Code	Modified USASCII	6-level BCD	8-level EBCDIC	USASCII
	Density, char/inch	200	200, 556, or 800	800	17.39
	Capacity	Full cartridge	Full reel	Full reel	Full cartridge
	Record size	Same as buffer	Same as buffer	Same as buffer	80 characters
Operating Modes		Data Entry, Verify, and Search; Program Entry, Verify, and Search	Data Entry, Verify, and Search; Program Entry and Verify		Data and Program Entry (1101 and 1102); Data Verify and Program Verify and Search (1102)
Error Control		Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data	Character and longitudinal parity are recorded and checked when read; reread with bit-for-bit check of recorded data		None (1101); reread with bit-for-bit check of recorded data (1102); character parity transmitted and checked when received
Pooling		Yes, via converter	Yes		Yes, via converter
Communications		In planning	In planning		Transmits and receives at 300 or 1200 bits/sec over a voice-band line
Auxiliary Devices		In planning	Card reader, punched tape reader and punch, line printer		Card punch/reader adaptor, solenoid adaptor for driving standard electric typewriter
First Delivery		Third quarter 1969	March 1969	March 1969	Late 1969
Pricing	Monthly rental	$105	$130 to $253	Not available from manufacturer	$39 to $137; options and auxiliary devices can add over $650
	Purchase	$4995 to $5100 (encoder); $10,200 to $11,000 (converter)	$7500 to $17,485	Not available from manufacturer	Not offered for purchase
Comments		Program Search capability permits finding and loading programs from library contained on tape in cartridge	Output from up to 7 systems can be pooled. Tag reader, badge reader, and magnetic disc options are in planning		1101 Microprocessor is for data entry and communications only. 1102 permits verification, searching, unattended transmit and receive, and 8-color display (optional). Converters available for IBM 729- or 2400-compatible tape or punched card output; length can be altered during conversion; reverse transcription is possible

BURROUGHS CORPORATION

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INTRODUCTION

.1 SUMMARY

The B 100/200/300 Series designates a group of three similar, small-to-medium-scale, business-oriented computer systems manufactured by Burroughs Corporation. The original entry in the Series was the B 200 line of computer systems, first delivered in October 1962. The B 200 Series provided 4,800 characters of core storage and a memory cycle time of 10 microseconds. Peripheral device flexibility was limited to punched card, line printer, MICR document, magnetic-striped ledger card, and magnetic tape input-output units. Buffered card reading, punching, and line printing were offered as standard features.

Fourteen months later the B 200 Series was significantly improved: memory cycle time was reduced to 6 microseconds; the instruction repertoire was increased from 37 to 49; 4,800 additional characters of core storage were offered; and paper tape, disk file, and data communications peripheral facilities were added. The upgraded systems were designated as "level threes", such as the B 263 and B 283 computer systems, and the original 10-microsecond systems were reduced in price and presented to the market as the economy B 100 Series. Previously-announced peripheral devices, such as the card reader, MICR sorter-reader, and line printer, were offered in new models with lower speeds and prices to meet the needs of the low-priced B 100 Series market.

The next major announcement by Burroughs occurred in May 1964, when the B 370 System for banking applications was released. The B 370 System included a 16-pocket MICR Sorter-Reader and up to 3 high-speed multiple tape listers. The first stirrings of a revamped marketing policy were perceptible when the B 370 central processor was offered with modular control and instruction features; the power and flexibility of the central processor could be tailored in price and performance to individual customer requirements.

In February 1965, more peripheral devices were announced — high-speed models such as a 1,400-card-per-minute reader and a 1,040-line-per-minute printer. Concurrently, further design improvements were incorporated into the B 200 "level three" central processor, and the B 300 Series was officially born. Emphasizing modularity, the B 300 Series was publicized to include under one title all possible system configurations, including the archetype B 370 system. The capability to add 9,600 more characters of core storage, for a Series maximum of 19,200 characters, became possible, and several new and powerful instruction options were unveiled. The memory cycle time of 6 microseconds, however, was not further improved in the new processor.

Thus, today's B 100/200/300 Series offers a wide range of peripheral devices that can be connected, with few restrictions, to two basic central processors with cycle times of 10 or 6 microseconds and with core storage capacities of 4,800, 9,600, or 19,200 characters. Monthly rental rates can vary from $2,500 for a B 100 Series card system to $20,000 for a B 300 Series system with extensive random access disk file and data communications capabilities. A wide variety of proven software is available to facilitate the programming of business applications. (The limited core storage and lack of floating-point arithmetic make the B 100/200/300 Series systems unsuitable for most scientific applications.)

In this Introduction, several significant topics are discussed, as listed below. The true scope of the B 100/200/300 Series can be best understood if each area of discussion is read. However, the topics that follow can be read separately if desired.

.1 Summary

.2 Central Processor

.3 Peripheral Units

.4 Software

.5 Compatibility with Competitive Equipment

.6 Compatibility within the B 100/200/300 Series

.2 CENTRAL PROCESSORS

The B 100/200/300 Series offers two basic central processors, with memory cycle times of 10 and 6 microseconds. All B 100 central processors have the slower cycle time, and all B 300's have the faster time. The B 200 central processor can be ordered with either cycle time. B 100 Series core storage capacity is limited to 4,800 characters, but the capacity of the 6-microsecond B 200/300 processors can be increased to 9,600 or 19,200 characters.

Each B 100/200/300 Series central processor is a character-oriented unit containing core storage facilities, an arithmetic and control unit, two input buffers, one output buffer, and an integrated console. Each instruction has a fixed length of 12 characters and is divided into an operation code, two variant characters, and three 3-character addresses. Operand lengths can vary from 1 to 12 characters and are specified in the individual instructions; no "word marks" are required in the data fields. Instructions in typical routines are executed at the rate of about 1,800 per second in the B 200/300 6-microsecond central processor.

The instruction list includes a full complement of decimal arithmetic and comparison operations as well as automatic editing facilities. Multiply and divide instructions are standard. There are no index registers and no indirect addressing facilities, but all B 200/300 central processors include an address modification instruction to increment individual operand addresses. Among the instructions recently added to the Series with the advent of the B 300 central processor are Transfer and Translate, Unit Interrogate, Transfer and Branch, Data Compress and Expand, and Binary Card Read and Punch.

All B 100/200/300 Series input-output operations are buffered except those involving magnetic tape, the ledger-card processor, and the disk file. Instruction execution by the central processor is inhibited for the duration of the latter three types of operations, with the exception of magnetic tape rewinding. Card reading and punching, paper tape reading and punching, printing, MICR sorter-reader input, and data communications operations can proceed in parallel with each other and with internal processing.

Computer system designations within the B 100 and B 200 Series are determined by the class of input-output controllers that must be added to the central processor in order to satisfy configuration requirements. For example, punched card configurations without magnetic tape or MICR facilities utilize B 160, B 260, or B 263 systems; MICR/magnetic tape operations demand B 170, B 270, or B 273 systems; and if magnetic tape is desired without MICR capabilities, then a B 180, B 280, or B 283 system is required. The MICR and ledger-card processing Visible Record Computer (VRC) is controlled by a B 250 or B 251 central processor.

The B 300 central processor is a single model designed to function with any available peripheral unit, provided that the appropriate, separately-priced input-output control module is added either at the time of manufacture or in the field.

.3 PERIPHERAL UNITS

The principal peripheral units available with the B 100/200/300 Series are listed in Table I along with their chief characteristics. A complete list of peripheral devices, indicating model numbers and performance data, is provided in the Price Data section of this report, page 201:221.101. The configuration possibilities for the B 100 Series are limited to one card reader, one card punch, one MICR sorter-reader, one line printer or multiple tape lister, and up to four magnetic tape units. The B 250/251 central processors are the only ones capable of controlling the B 401 Ledger Processor. The B 200 Series 10-microsecond central processor permits the connection of two card readers or one card reader with one sorter-reader, one card punch, two line printers or multiple tape listers, and up to six magnetic tape units. The B 200 Series 6-microsecond central processor offers the additional capability of controlling one paper tape reader and punch, up to 50 Disk File storage modules, and up to 15 data communications terminal units. The still more comprehensive B 300 Series central processor can control all these peripheral devices, plus an additional 6-tape multiple tape lister.

Burroughs card readers offer speeds between 200 and 1,400 cards per minute. The line printers can operate at peak speeds ranging from 475 to 1,040 lines per minute. Top printing speed for the multiple tape listers is 1,600 numeric lines per minute on each of up to three listing tapes.

(Contd.)

TABLE I: PRINCIPAL B 100/200/300 SERIES PERIPHERAL UNITS

Peripheral Type	Model No.	Name	Characteristics
Punched Card Equipment	B 122 B 123 B 124 B 129 B 303 B 304	Card Reader Card Reader Card Reader Card Reader Card Punch Card Punch	Reads 200 cpm. Reads 475 cpm. Reads 800 cpm. Reads 1,400 cpm. Punches 100 cpm. Punches 300 cpm; has Stacker Select option.
Punched Paper Tape Equipment	B 141 B 341	Paper Tape Reader Paper Tape Punch	Reads 5, 6, 7, or 8 level tape at 500 or 1,000 char/sec. Punches 5, 6, 7, or 8 level tape at 100 char/sec.
Printers	B 320 B 321 B 329 B 326 B 332	Line Printer Line Printer Line Printer Multiple Tape Lister Multiple Tape Lister	Prints 475 lpm. Prints 700 lpm. Prints 1,040 lpm. Prints 1,200 numeric lpm. Prints 1,600 numeric lpm.
MICR Equipment	B 107 B 116	Sorter-Reader Sorter-Reader	Reads 1,200 documents/ min, sorts to 13 pockets. Reads 1,560 documents/ min; sorts to 16 pockets.
Magnetic Tape Units	B 421 B 422 B 423 B 424 B 425	Magnetic Tape Unit Magnetic Tape Unit Magnetic Tape Unit Magnetic Tape Unit Magnetic Tape Unit	Transfers data at 18 or 50KC. Transfers data at 24 or 66KC. Transfers Data at 24KC. Transfers Data at 66KC. Transfers data at 18, 50, or 72KC.
Random Access Storage	B 450 B 475	Disk File Basic Control Disk File Storage Module	Controls 9.6 to 480 million characters. Stores 9.6 million characters; 20 msec average access time.

.3 PERIPHERAL UNITS (Contd.)

The Burroughs magnetic tape units provide a range of transfer rates from 18,000 to 72,000 characters per second and packing densities of 200, 556, and 800 rows per inch. Data is recorded on 0.5-inch, 7-track magnetic tape, providing compatibility with the tape units used in IBM 1400 and 7000 Series systems. All magnetic tape operations (except rewinding) require the use of the central processor throughout the entire operation, so there is no read/compute, write/compute, or read/write simultaneity.

The Burroughs Disk File System is a modular storage system that combines high on-line storage capacity (up to 480 million characters) with rapid random access (20 milliseconds average). The rapid accessing is made possible by the use of a fixed read-write head serving each data track, which completely eliminates head-positioning delays and provides relatively high reliability. Peak data transfer rate is 100,000 characters per second. Prices are competitive with those of other currently-available mass storage systems whose average access times are 5 to 10 times as high.

An array of data communications devices can be attached to any B 200/300 Series central processor. Up to four such processors can share the same communications network, which can consist of up to fifteen terminal units of varying capacities. The B 481 Teletype Terminal Unit provides buffered interfacing for up to 399 remote teletype stations, the B 483 Typewriter Terminal Unit can control up to 8 typewriter inquiry stations, and the B 484 Terminal Unit regulates the use of up to 8 stations of the Dial TWX network. Burroughs has recently announced another terminal unit, the B 486 Central Terminal, to channel transmissions between the central processor and up to 96 remote Teller Consoles in its On-Line Banking System. All of the terminal units are buffered and can simultaneously accept inquiries from as many remote devices as their individual buffer sizes will accommodate. Buffer sizes are specified at the time of manufacture. An operating system to control the operations of a data communications network has been announced, with delivery expected in June, 1965.

.4 SOFTWARE

A wide variety of proven software is available for the B 100/200/300 Series. Most of the existing software is designed to be used with 4,800 characters of central processor core storage. As a result of this severe storage limitation, the software is characteristically simple and straightforward, and makes extensive use of multiple passes and phases.

The most important programs provided include a basic and an advanced symbolic assembler, a Compact COBOL compiler, tape and Disk File sorts, and report generators. A translator program is also provided to convert IBM 1401 SPS source-language programs into Burroughs symbolic assembly-language programs.

Burroughs has announced a full COBOL compiler for B 200/300 Disk File systems, with delivery expected by July, 1965. A Tape/Disk Operating System is anticipated for delivery in June, 1965.

Programs currently supplied by Burroughs include:

- Compact COBOL Compiler: Provides that group of language facilities that comprise the Compact COBOL subset of COBOL-61; designed for use with 4 magnetic tape units and 4,800 characters of core storage.
- Basic Assembler: A straightforward card or tape assembly program that provides one-for-one conversions from source code to machine language. There are no provisions for use of a program library, and only two macro instructions are permitted. The coding form makes use of coding-form page and line numbers for symbolic references. All elements of every instruction must be specified in every statement.
- Advanced Assembler I: An improved assembly program designed for use on B 200/300 Series magnetic tape systems. A system library can be utilized to call utility routines, diagnostics, error routines, and other subroutines that the user inserts himself. Seven macro instructions are provided, including tape and disk instructions that call forth and set linkages to their required error routines. Symbolic names and reusable program points can reference both data and instructions. Operand sizes, once described in the Data Division, need not be specified again in individual instructions.
- Sort Generator I: Generates magnetic tape sort programs within five minutes. Sort programs can be generated that utilize from 3 to 6 tape units. The object sort program operates within 4,800 characters of core storage.
- Generalized Three-Tape Sort: A multi-phase sort program modified according to the user's parameter cards; designed for use with 9,600 characters of core storage and three magnetic tape units.
- Disk File Sort Generator III: Generates object sort programs that utilize a Disk File for intermediate storage. Tag sorting is possible, enabling most sorts to be completed significantly sooner than would be the case with record sorting. Source and result files can be contained on either magnetic tape or Disk File.
- Report Generator I: Generates specially-tailored programs that process input from punched cards, magnetic tape, or Disk File and produce reports on either punched cards or line printer.
- Utility Routines: A variety of programs designed to handle data transcription, diagnostic, and file-maintenance operations using minimal equipment configurations.
- Demand Deposit Accounting Programs: A series of standard financial programs designed for use with the Visible Record Computer (B 250 or B 251) exclusively.
- Demand Deposit/Proof and Transit Financial Application Package: A series of programs written for banks that have 4 magnetic tape units and 4,800 characters of core storage. Complete documentation is included with the package.

(Contd.)

.4 SOFTWARE (Contd.)

- Installment Loan Financial Application Package: A group of programs that process MICR loan payments. All master file information is maintained on magnetic tape. Four tape units and 4,800 characters of core storage are required.

- Bond Analysis and Accounting Package: A series of programs that provide bond portfolio management with detailed analyses and evaluations of current and proposed bonds. A B 200/300 Series central processor is required for use of this program, as well as a card reader and line printer.

- On-Line Teller System: A thoroughly documented systems approach to on-line banking operations is provided; a complete operating system is not yet available.

- Flow Chart Generator: A program that generates detailed logic charts from Basic or Advanced Assembly Language source programs. The programmers' remarks, as punched into the source card, are printed in the symbol generated for each source statement. Three magnetic tapes are required to use the generator, in addition to a B 200/300 6-microsecond central processor with 4,800 positions of core storage.

.5 COMPATIBILITY WITH COMPETITIVE EQUIPMENT

Certain hardware options available with the improved B 200 and B 300 central processors provide some degree of input-output compatibility with other commercially-oriented computer systems. Binary card reading and punching are available, as well as the reading and punching of Bull and ICT card codes. Magnetic tapes can be read and written using any 6-bit binary code. Direct compatibility is possible between the Burroughs tape units and the IBM 729 and 7330 tape units.

The B 100/200/300 Series instruction code is not directly compatible with that of any other computer system. Burroughs has developed a program translator to convert IBM 1401 SPS source code into a source code acceptable to Burroughs assemblers, but the SPS Translator is too limited in scope to serve as a really productive tool in most conversion operations. Hardware dissimilarities that could not be circumvented within the 4,800 characters used by the SPS Translator program limit the candidates for effective translation to small and relatively basic IBM 1401 card and tape programs. Even so, some manual changes will usually be required before the translated program can be assembled and run.

.6 COMPATIBILITY WITHIN THE B 100/200/300 SERIES

The standard inclusion of many additional instructions in the B 200/300 6-microsecond central processor has made downward compatibility with the slower B 200 and B 100 Series systems almost impossible unless the use of these additional features is deliberately restricted. However, upward compatibility throughout the line is completely feasible. The great majority of the available peripheral devices can be used with any central processor in the Series, although in some cases a special input-output control module is a prerequisite.

DATA STRUCTURE

.1 STORAGE LOCATIONS

Name of location	Size	Purpose or use
Character:	6 bits + parity bit	alphamerics.
Block:	group of characters	magnetic tape record.
Input buffers:	80 characters (sorter-reader, 84 char)	store input for cards, paper tape, or sorter-reader.
Output buffer:	80 characters	store output for cards or paper tape.
Print buffer:	120 characters*	store output for printer.
Lister buffer:	44 characters	store output for lister.

.2 DATA FORMATS

Type of information	Representation
Letter:	1 character.
Numeral:	1 character.
Special symbol:	1 character.
Operand:	1 to 12 characters, as specified in instruction.
Instruction:	12 characters.
Block on tape:	any number of characters greater than 6.
Arithmetic operand:	1 to 12 characters.
Data for mask:	1 to 12 characters.
Edit mask:	1 to 24 characters.
Ledger stripe:	1 to 80 characters.
Line of print for Record Processor:	160 characters.
One MICR document:	84 characters in core storage.
Internal block for transfer:	1 to 132 characters.

* 132 characters for B 325 and B 329 printers.

BURROUGHS B 100/200/300

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes 4,800 characters of core storage)			
			Model 100:			
	*B160		Card Processor	1,082	67,500	105
	*B170		MICR/Tape Processor	1,407	74,250	110
	*B180		Tape Processor	1,255	71,325	105
			Model 200:			
	*B250		MICR/Ledger Processor	1,733	56,100	110
	*B260		Card Processor	1,575	67,500	105
	*B270		MICR/Tape Processor	1,733	74,250	115
	*B280		Tape Processor	1,665	71,325	110
	*B263		Card Processor	1,680	72,000	110
	*B273		MICR/Tape/Disk File Processor	1,943	83,250	125
	*B275		MICR Processor	1,749	74,925	115
	*B283		Tape/Disk File Processor	1,875	80,325	115
			Model 300:			
	B300		Basic Processor	1,728	74,025	110
			Processor Command Modules:			
		830	Transfer and Branch Command	27	1,125	0
		831	Transfer and Translate Command	27	1,125	0
		832	Interrogate Command	69	3,325	0
		833	Data Compress and Expand Command	53	2,250	0
		834	Binary Card Read/Punch Command	105	4,500	0
		835	B 300 Lister Command	27	1,125	0
		836	16-Pocket Sorter Control	32	1,350	0
		837	Selective Stacking Control for B 304	16	675	0
			Processor Feature Modules:			
		850	Sense Switches	16	675	5
		851	Card Read Early Release	16	675	0
		852	66KC Control for B 422 and B 424	53	2,250	5
		853	72KC Control for B 425	53	2,250	5
		854	Printer-Lister Selector Switch	42	1,610	5
		855	Card Reader Busy Branch	48	1,800	0
		856	132-Print Position Capability	42	1,800	0
			B 100 I/O Adapters;			
			B 160 Adapter to Use B 124	247	0	0
			B 170 Adapter to Use B 124	158	0	0
			B 180 Adapter to Use B 124	205	0	0
			B 160 Adapter to Use B 321	247	0	0
			B 170 Adapter to Use B 321	158	0	0
			B 180 Adapter to Use B 321	205	0	0
			B 170 Adapter to Use B 102, B 103 and B 104	158	0	0
			B 170 Adapter to Use B 322	158	0	0
			I/O Control Modules:			
		810	MICR Sorter	69	2,925	10
		811	Paper Tape	126	5,400	10
		812	MICR Sorter/Paper Tape	195	8,325	10

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR (Contd.)			Processing Unit (includes 4,800 characters of core storage) (Contd.)			
		813	Supervisory Printer	16	675	0
		814	Magnetic Tape	163	6,975	10
		815	Disk File	16	675	0
		816	Data Communication	16	675	0
		817	Auxiliary Output Control for B 251	651	21,000	35
			Memory Modules:			
		800	Additional 4800 Characters (3)	289	12,375	20
		801	Additional 9600 Characters (3)	342	14,625	10
		*802	9600 Character Stack (2)	289	12,375	20
		803	19,200 Character Stack (2)	630	29,250	30
MASS STORAGE			Disk Storage			
	B9370-5		Systems Memory(3)	450	21,600	90
	B0371		Systems Memory Control(3)	150	7,200	12
	B471		Electronics Units	746	31,950	80
	B475		Storage Module, 9.6 Million Char. 20 milliseconds	1,040	44,550	115
	B478-1		19.2 Million characters Storage (40 milliseconds) (3)	1,700	81,600	205
	B478-2		Additional 19.2 Million Char. Increments (40 milliseconds)	700	45,600	85
	*B450		Basic Disk File/Disk Control Cabinet	268	11,475	40
	B452		Basic DF/DTTU Cabinet	268	11,475	40
	B247		Disk File Control	420	18,000	45
	B247-1		Disk File Control	420	18,000	45
	B451		Disk File Expanded Control	210	9,000	25
	*B248		Data Communication Control	310	13,275	45
	*B249		Data Transmission Control Unit	310	13,275	45
INPUT-OUTPUT			Magnetic Tape			
	B421		Magnetic Tape Unit (90 inches/sec; 200,556 bits/inch)	735	31,500	145
	B422		Magnetic Tape Unit (120 inches/sec; 200,556 bits/inch)	840	36,000	155
	B423		Magnetic Tape Unit (120 inches/sec; 200 bits/inch)	700	31,500	145
	B425		Magnetic Tape Unit (90 inches/sec; 200,556,800 bits/inch)	893	38,250	165
			Punched Card			
	B122		Card Reader (200 cards/min)	175	9,900	40
	B123		Card Reader (475 cards/min)	336	18,000	70
	B124		Card Reader (800 cards/min)	420	18,000	83
	B129		Card Reader (1400 cards/min)	525	27,000	126
		910	Postal Money Order Feature(5)	32	1,440	5
		911	40-Column Read Switch(5)	0	0	0
		912	Validity Check(5)	6	240	2
		913	Card Counter(5)	6	240	0
	B303		Card Punch (100 cards/min)	473	20,250	65
	B304		Card Punch (300 cards/min)	683	29,250	175
		925	Card Counter	6	240	0

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			<u>Paper Tape</u>			
	B141		Paper Tape Reader (500-100 char/sec)	420	18,000	70
		920	Input Code Translator	189	8,100	10
		921	Reader Selector Switch	16	675	0
	B341		Paper Tape Punch (100 char/sec)	200	8,550	65
		930	Output Code Translator	179	7,650	10
		931	Punch Selector Switch	16	675	0
			<u>Printers</u>			
	*B320		Printer (475 lines/min)	851	54,000	170
	B321		Printer (700 lines/min)	1,260	54,000	175
	B325		Printer (700 lines/min)	1,339	57,375	185
	B328		Printer (1040 lines/min)	1,392	59,600	195
	B329		Printer (1040 lines/min)	1,470	63,000	205
		940	"CR" Symbol for B 325, B 328, or B 329: factory installed.	-	-	0
		941	Field Installed, with Drum exchange	-	-	0
	B495		Supervisory Printer	315	13,500	35
			Listers:			
	*B322		1565 Lines/minute Numeric:	1,680	72,000	290
			First Additional	1,260	72,000	245
	*B323		1565 Lines/minute Alphanumeric:	1,785	76,500	310
			First Additional	1,365	76,500	260
	B326		1250 Lines/minute Numeric	1,355	72,000	290
	B332		1565 Lines/minute Master Alphanumeric	1,785	81,000	325
	B333		1565 Lines/minute Slave Alphanumeric	788	33,750	200
		950	Simultnaeous Skip of Tapes (B 322 only)	11	400	0
			<u>MICR Sorter-Readers</u>			
	*B101		13-Pocket Non-System (1565 documents/min)	1,985	85,050	500
	*B101 PL		13-Pocket Non-System (1565 documents/min)	-	48,000	500
	*B102		13-Pocket W/Standby (1565 documents/min)	2,100	90,000	500
	*B103		13-Pocket W/O Endorser (1565 documents/min)	2,100	90,000	500
	*B104		13-Pocket W/O Standby (1565 documents/min)	1,995	85,500	500
	*B106		13-Pocket W/O Endorser (1200 documents/min)	1,890	90,000	500
	*B107		13-Pocket W/Endorser (1200 documents/min)	2,100	99,000	550
	B116		16-Pocket W/O Endorser (1565 documents/min)	2,415	103,500	615
		900	Endorser (B 103 and B 116 only) (4)	210	9,000	50
		901	Start/Stop Bar (B 103 and B 107 only)	8	275	0
		902	Special Field Ending	11	450	0
		903	Override Code	11	450	0
		904	Validity Checking-Sort Field	11	450	0
		905	Reverse Override	11	450	0
		906-1	Counter, "Resettable"	6	240	15
		906-2	Counter, "Non-Resettable"	6	240	0
		907	Extended Sort Control (B103 only)(4)	53	2,400	15
		908	Mobile Carrier & Tray	6	240	0
		909	Document Tray	-	15	0
		915	Canadian Check Feature, B 103	-	-	0
		916	Canadian Check Feature, B 116	-	-	0
		917	Document Separators-13 pocket	21	960	0
		918	Document Separators-16 pocket	27	1,200	0
			<u>Record Processor</u>			
			Stripe Ledger Processor and Printer	1,208	63,100	540
	*B401	999	Optical Reader	88	3,475	25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Input and Display System			
	B9351-1		Control I-Single Input and Display/Location	215	9,460	27
	B9351-2		Control II-Multiple Input and Displays and/or Controls/Location	325	14,300	27
	B9351-3		Control IIA (Max. of 3 with Multiplexor and Control II)	100	4,400	20
	B9351-4		Monitor	60	2,640	10
	B9351-5		Alphanumeric Keyboard	20	880	3
	B9351-6		Input and Display Printer	45	1,980	10
	B9351-7		Remote Communications Adapter	35	1,540	3
	B9351-8		Simplexor	15	660	7
	B5351-9		Multiplexor	50	2,200	11
	B9351-10		Multiplexor Extension	50	2,200	7
	B9951-1		Input and Display Printer Adapter	30	1,320	3
	B9951-2		Insert/Delete-Character/Line	15	660	3
	B9951-3		Controlled Format	20	880	3
	B9951-4		Variable Tab Position	5	220	1
	B9951-5		Programmatic Cursor Positioning	5	220	1
	B9951-7		Display Stand, Low, without work table	-	80	-
	B9951-8		Display Stand, High without work table	-	100	-
	B9951-9		Display Stand Work Table, Right or Left	-	25	-
COMMUNICATIONS			Terminals and Line Adapaters			
	*B481		Teletype Terminal:			
			120 Character Buffer	460	20,700	55
			240 Character Buffer	480	21,600	55
	*B483		Typewriter Terminal	660	29,700	75
	*B484		Dial TWX Terminal	700	31,500	80
	B486		Central Terminal	1,150	49,275	100
	B487		Data Transmission Terminal Unit	520	22,275	95
		980	TWX/TY Adapter	40	1,800	5
		981	TTY Adapter	60	2,700	10
		983	Automatic Dial Out	30	1,350	5
		984	U 1004 Adapter	120	5,400	30
		985	IBM 1050 Adapter	85	3,825	15
		986	Burroughs (B 300 to B 300 & B 300 to B 5500) Adapter	100	4,500	30
		987	H 120 Adapter	125	5,625	30
		988	8A1 Selective Calling Service – Model 35 Adapter	85	3,825	15
		989-1	Input and Display Direct Connect Adapter	60	2,700	7
		989-2	Input and Display Data Set Adapter (300 bits/sec.)	60	2,700	7
		989-3	Input and Display Data Set Adapter (1000 to 1800 bits/sec.)	120	5,400	12
		990	Audio Dual Line Adapter	130	5,850	15
	B488		Single Line Dual Adapter Control (B 300 only)	200	9,000	25
			Remote Devices			
	*B493		Typewriter Inquiry Station	58	2,475	12
			Audio Response Devices			
	B0355-1		Voice Response Generator	795	37,200	31
	B9955-1		Audio Recording (Special)	-	2,575	-
	B9955-2		Audio Recording (Library)	-	575	-

NOTES:

* No longer in production.

(1) Maintenance charges can vary depending on location of system; rates are slightly higher outside metropolitan areas.
(2) This feature or component is for the B 263, B 273, B 275, or B 275 systems only.
(3) This feature or component is for the B 300 Basic Processor only.
(4) Factory installation only.
(5) These features apply to all card readers except B 122.

INTRODUCTION

.1 SUMMARY

The Burroughs B 5500 Information Processing System is a medium-scale computer system that is suitable for both scientific and commercial data processing. Flexibility in the choice of system configurations results in monthly rentals that range from \$16,700 to \$160,000. Typical B 5500 systems, however, fall within the \$20,000 to \$35,000 rental range.

The B 5500 system is an upgraded, improved version of the highly unconventional and imaginative B 5000 system, which was first delivered in March, 1963. Burroughs announced the B 5500 in October, 1964, as a replacement for all B 5000 systems in the field at that time, and dropped the B 5000, as such, from its product line. In most cases, field modifications permitted on-site conversion of the installed B 5000's to B 5500's.

Changes in hardware have centered principally on the central processor. The processor read access time has been reduced from 6 to 4 microseconds, the execution time of many instructions has been improved, and several new and powerful operators have been added to the repertoire. Software changes included a reworked version of the Drum Master Control Program — designed to take full advantage of the expanded instruction list — and a new Master Control Program that is oriented toward the use of Burroughs' high-performance Disk File. In addition, the COBOL and ALGOL compilers were refurbished to provide improved compilation times and greater efficiency in the generation of machine-language instructions.

It should be noted that the B 5500 is basically a more efficient and, therefore, more productive version of the B 5000; but the B 5500 system retains all the design characteristics that made the B 5000 appear so unconventional when it was announced in 1961. Primary emphasis is still placed on the exclusive use of process-oriented languages (ALGOL, COBOL, and FORTRAN) for coding all user programs. Because of this emphasis, Burroughs has developed hardware and software that is oriented toward fast and efficient compilation, with the hope that no user will feel the need for any machine-oriented languages. The B 5500 also features the capability that has come to be called multiprogramming — the ability to execute more than one independent program concurrently on the same computer system. Both the B 5500's hardware and its Master Control Program (MCP) have been designed specifically to facilitate the support of efficient multiprogramming. Benefitting from several years of experience in this area, Burroughs does not hesitate to market the B 5500 primarily on the basis of its ability to process more than one program simultaneously, leading in most cases to increased job throughput.

Some of the unusual hardware facilities that have been incorporated to help achieve the B 5500's design objectives can be summarized as follows:

- Automatic temporary storage for operands and subroutine parameters is provided by a "stack", which operates on the "last-in, first-out" principle.
- Internal operations can be performed in either the Word Mode, upon 48-bit binary operands, or in the Character Mode, upon strings of 6-bit alphameric characters.
- A common representation is used for integers and floating-point numbers.
- Recursive use of subroutines is largely automatic and unrestricted.
- All machine-language addressing is relative and/or indirect, facilitating program segmentation and relocation.
- The same two registers are used for both indexing and arithmetic operations; no index registers of the usual type are provided.

.1 SUMMARY (Contd.)

- There is effective (but not infallible) storage protection against coding errors, invalid data, and inter-program interference.
- Comprehensive interrupt facilities are provided to detect and service special conditions arising anywhere in the system.
- Each of up to 8 core storage modules can accept or transmit data independently of the other core modules and of the processor.
- Magnetic drums and/or disc files provide rapid-access auxiliary storage for the operating system, compilers, program segments, and data arrays.
- All input-output operations are controlled by independent Input/Output Channels; up to four channels can be connected, and any channel can reference any one of up to 39 peripheral devices in a system.
- A second, virtually independent central processor can be added to any B 5500 system; the two processors share all storage and input-output facilities.

.2 CENTRAL PROCESSOR

The B 5281 Processor of the B 5500 Information Processing System is the control center of a unique arrangement of memory and input-output control units, arithmetic units, and interrupt networks. All internal operations can be performed in either the Word Mode, using 48-bit binary words as operands, or in the Character Mode, using variable-length alphameric fields packed eight characters to the word. In the Word Mode, the central processor can perform fixed-point or floating-point arithmetic operations upon single or double word-length binary operands. A variety of logical and comparison operations is also provided in this mode. The Character Mode is designed mainly for data manipulation operations such as editing and scanning. Many processor functions, including addition, subtraction, branching, and table lookups, can be performed in either mode.

A program word consists of four 12-bit "syllables", and each syllable can specify an operation, a relative address, or a literal to be placed in the stack. The Program Reference Table is a relocatable table containing single data items and 48-bit "descriptors," which are used for supplementary control and indirect addressing of data arrays, input-output areas, and program segments. The "stack" consists of the two arithmetic registers (A and B) in the central processor and a relocatable area of core storage; it provides automatic temporary storage of the "last-in, first-out" type for a list of operands and control words. In a multiprogramming environment, each program has its own stack and its own Program Reference Table. Whenever an interrupt occurs during the execution of one program, the contents of the A and B registers and all necessary control information are automatically pushed down into the appropriate stack in core storage; then the Processor transfers control to the Master Control Program, which initiates the processing of the next available program.

Operands in the Word Mode are considered to be 48-bit binary words. The integer part of an operand is represented by 39 bits plus sign, and the octal exponent by 6 bits plus sign. Since the fixed-point part of a B 5500 floating-point number is represented as an integer rather than a fraction, fixed-point and floating-point operands can be intermixed without conversions.

The comprehensive interrupt system informs the Processor when any of 40 possible special conditions arises anywhere in the system. All interrupt conditions are sampled continuously and processed on a priority basis, so that a high-priority interrupt condition (such as a storage parity error) can interrupt the servicing of a lower-priority interrupt condition (such as a free Input/Output Channel).

The Processor of the B 5500 system initiates all peripheral input-output operations by sending a descriptor to a free I/O Channel. The processor is then free to perform its operations independently of the peripheral operation. Up to four "floating" Input/Output Channels can be connected to the B 5500 system, and each Channel can transfer data between core storage and any of the connected input-output devices. Up to four input-output data transfer operations can be performed simultaneously, one per installed I/O Channel, since each I/O Channel functions independently of the others.

(Contd.)

.2 CENTRAL PROCESSOR (Contd.)

The B 5500's Processor includes many improvements to the original B 5000 Processor design. Processor read access time — the total time required to transfer a word of information from core memory to the Processor or an I/O Channel — has been reduced from 6 to 4 microseconds. Syllable overlap techniques have been improved, stack manipulation operations have been accelerated, and 19 new operators have been added. The primary objective in the inclusion of these and other improvements in the B 5500's Processor has been to enable the compilers to generate more efficient object programs and to permit the Master Control Program to perform its program-segment switching and multi-programming control routines more quickly and more effectively.

.3 INTERNAL STORAGE

From three to eight B 460 or B 461 Memory Modules of core storage can be connected to a B 5500 system. Each Memory Module contains 4,096 words, providing a maximum system capacity of 32,768 words, or 262,144 6-bit characters. Each word location consists of 48 data bits and one parity bit and can hold one binary data item (in floating-point or integer form), eight alphameric characters, or one program word. The B 460 Memory Module has a memory cycle time of 6 microseconds, as compared with the newer B 461's 4-microsecond cycle time. The B 460 and B 461 are functionally identical, but they cannot be intermixed in the same B 5500 system.

Each core storage module contains its own addressing and read/write circuitry. Operating in conjunction with a switching network called the Memory Exchange, the Memory Modules can transmit data independently of the central processor. Both the Processor and the I/O Channels can communicate with the Memory Modules, but always through the Memory Exchange. Using the maximum B 5500 complement of two Processors and four I/O Channels, six different Memory Modules can be accessed simultaneously. However, only one processor or I/O Channel can access any one Memory Module during any one memory cycle.

The B 430 Magnetic Storage Drum provides an 8.3-millisecond average access time to 32,768 words of auxiliary storage. Up to 1,023 consecutive words can be transferred at the rate of 15,360 words per second. Two Storage Drums can be connected to a B 5500 system. Customers who choose to have their B 5500 system controlled by the Drum Master Control Program (see Section 203:191) must have at least one Storage Drum on-line for MCP and system program residence; two Storage Drums are required for Drum MCP-oriented installations that wish to use COBOL. Use of the Storage Drum provides the MCP with rapid access to program segments, subroutines, and blocks of data.

Burroughs' head-per-track Disk Files can also be utilized as auxiliary storage with the B 5500 system. The Disk File system is a modular on-line storage system that provides storage capacities of up to 960 million characters in modules of 9.6 million characters. Any randomly-addressed block of characters can be accessed within a maximum of 40 milliseconds, and the average access time is only 20 milliseconds. Transfer of information between the Disk File system and the Input/Output Channels proceeds at an average of 100,000 characters per second. From 1 to 1,890 48-bit words of information can be read or written by a single instruction. If two B 5470 Control Units are connected to a B 5500 system, two simultaneous Disk File accesses are possible. Disk File accessing can also proceed simultaneously with computation and up to three additional input-output operations.

In addition to providing the standard random processing capabilities, the use of Disk File storage with the B 5500 system permits the storage of on-line program libraries. The Disk File-oriented MCP (see Section 203:192) is thereby enabled to gain rapid access to all scheduled programs, a fact which adds to the efficiency of the B 5500's multi-programming capability.

.4 INPUT-OUTPUT EQUIPMENT

Most of the input-output equipment offered for use with the B 5500 computer system is conventional in design and performance. Table I lists all of the current peripheral devices (other than the auxiliary storage units described in the preceding paragraphs), together with their principal characteristics. A B 5500 system can include a maximum of two card readers, one card punch, two line printers, three paper tape units (readers or punches), 16 magnetic tape units, and 15 data communications terminal units.

Four different types of data communications terminal units are offered by Burroughs for use with the B 5500 system. The B 481 Teletype Terminal Unit provides buffered interfacing for up to 399 remote Teletype stations; the B 483 Typewriter Terminal Unit can

TABLE I: B 5500 INPUT-OUTPUT DEVICES

Type of Device	Model No.	Name	Characteristics
Punched Card Equipment	B 122 B 123 B 124 B 129 B 303 B 304	Card Reader Card Reader Card Reader Card Reader Card Punch Card Punch	Reads 200 cpm. Reads 475 cpm. Reads 800 cpm. Reads 1,400 cpm. Punches 100 cpm. Punches 300 cpm.
Punched Paper Tape Equipment	B 141 B 341	Paper Tape Reader Paper Tape Punch	Reads 5, 6, 7, or 8-level tape at 500 or 1,000 char/sec. Punches 5, 6, 7, or 8-level tape at 100 char/sec.
Printers	B 320 B 321 B 325 B 328 B 329	Line Printer Line Printer Line Printer Line Printer Line Printer	Prints 475 lpm; 120 print positions. Prints 700 lpm; 120 print positions. Prints 700 lpm; 132 print positions. Prints 1,040 lpm; 120 print positions. Prints 1,040 lpm; 132 print positions.
Magnetic Tape Units	B 422 B 423 B 424 B 425	Magnetic Tape Unit Magnetic Tape Unit Magnetic Tape Unit Magnetic Tape Unit	Transfers data at 24 or 66KC. Transfers data at 24KC. Transfers data at 66KC. Transfers data at 18, 50, or 72KC.
Data Communications Devices	B 5480 B 481 B 483 B 484 B 487	Data Communications Control Unit Teletype Terminal Unit Typewriter Terminal Unit Dial TWX Terminal Unit Data Transmission Terminal Unit	Transfers data between Processor and Terminal Units at 30KC. Controls up to 399 remote Teletype stations. Controls up to 8 typewriter inquiry stations. Controls up to 8 Dial TWX stations. Provides buffering and interfacing for wide variety of remote devices.

.4 INPUT-OUTPUT EQUIPMENT (Contd.)

control up to 8 typewriter inquiry stations; and the B 484 Dial TWX Terminal regulates the use of up to 8 stations of the Dial TWX network. The B 487 Data Transmission Terminal Unit, unlike the other Burroughs terminal units, is general in purpose, permitting a B 5500 system to communicate with a varied mix of data transmission devices without the use of additional terminal units. Most remote devices that can use the low-speed and voice-grade lines of the telephone companies can be connected to a B 487, and ultimately to a B 5500, via Burroughs line adapters. All four models of Burroughs' terminal units are buffered and can simultaneously accept inquiries from as many remote devices as their individual buffer sizes will accommodate. Buffer sizes are specified at the time of manufacture.

.5 SOFTWARE

.51 Compilers

Users of the B 5500 Information Processing System normally do all of their programming in the ALGOL, COBOL, or FORTRAN languages. Two additional languages, OSIL and ESPOL, are available for special-purpose programming. OSIL, or Operating Systems Implementation Language, is a symbolic assembly language that was developed for writing Burroughs' Drum Master Control Program. ESPOL, or Executive System Problem Oriented Language, is a modified version of the ALGOL language that was designed to facilitate the writing of the Disk File Master Control Program.

Extended ALGOL for the B 5500 includes virtually all of the facilities of ALGOL 60 and a number of useful machine-dependent extensions that enable the programmer to take advantage of the hardware capabilities of the B 5500. Some of these extensions include device-oriented input-output constructs, partial-word and double-precision arithmetic operations, B 5500 Character Mode statements, and constructs to control the operations of Burroughs data communications terminal units. The ALGOL compiler delivers translation speeds that range between 600 and 800 source-program cards per minute, or up

(Contd.)

.51 Compilers (Contd.)

to 2500 magnetic tape card images per minute. More than 100 standard mathematical functions are included in the ALGOL library of subroutines.

COBOL-61 Extended for the B 5500 is a comprehensive version of the Department of Defense's COBOL-61 Extended language. All of Required COBOL-61 has been implemented, as well as most of the Elective features of COBOL-61. Two of the three principal extensions of COBOL-61 Extended — the SORT verb and the Mass Storage language facilities — have also been implemented. (Tape or Disk File sorting on the B 5500 system, using Burroughs-supplied software, is possible only through the use of the COBOL SORT verb and the Sort Generator within the COBOL compiler.) The Mass Storage facilities provide the programmer with direct control over both sequential and random processing of records on the Disk File. COBOL language facilities are also provided to permit the effective use of Burroughs' various types of data communications terminal units. Translation speeds of up to 800 source-program cards per minute have been achieved with the COBOL compiler, and the practicality of programming and debugging exclusively in COBOL has been effectively demonstrated through more than two years of successful user experience.

FORTRAN IV for the B 5500 includes virtually all of the language features proposed by the X.3.4.3 FORTRAN group of the American Standards Association. In comparison to this standard, B 5500 FORTRAN lacks only the provisions to handle double-precision and complex variable items. Burroughs has designed its FORTRAN language to duplicate, wherever possible, the facilities of the IBM 7090/7094 FORTRAN IV language in order to facilitate conversions of scientific and engineering installations to the B 5500. Burroughs' FORTRAN translator (called FORGOL 4) converts FORTRAN IV source statements into Extended ALGOL for eventual compilation by the ALGOL compiler. No FORTRAN language facilities have been implemented to date by Burroughs to provide direct control of Disk File storage or remote terminal devices.

Almost all program debugging on the B 5500 system is done at the source language level. MONITOR and DUMP statements are provided in the ALGOL and COBOL languages to produce tracers, dumps, and snapshots as requested by the programmer.

.52 Master Control Program (MCP)

The Master Control Program, or MCP, is a comprehensive operating system that controls the scheduling, loading, and execution of every program that is run on a B 5500 system. By means of close integration with the hardware interrupt facilities of the B 5500 system, the MCP controls multiprogramming, or the simultaneous processing of two or more independent program segments.

To use multiprogramming effectively with the B 5500 system, the only prerequisites are that the programs be written in small, logical segments, and that sufficient input-output equipment be available to service the needs of the multiple program segments. The MCP continually analyzes the list of scheduled jobs and decides, on its own, when and to what degree multiprogramming is possible. The sole criterion used by the MCP in making this decision is the continuous use of as many as possible of the processing and input-output facilities of the B 5500 system.

Other functions performed by the MCP include automatic handling of most error conditions, monitoring and control of communications between the system and the operator, complete logging of processing and input-output times for each program processed, and maintenance of the system and problem program libraries.

Two versions of the Master Control Program are offered for use with the B 5500 system: the Drum MCP and the more recent Disk File MCP, both designated according to the system device on which the MCP and its control routines reside. The Drum MCP is slightly less flexible than the Disk MCP in that the Drum MCP lacks the facilities to control Disk File and data communications operations. In addition, the Drum MCP gathers its scheduled programs on a Program Collection Tape and scans this tape to access programs that are appropriate for inclusion in a multiprogramming mix at any given time. By contrast, the Disk File MCP has direct access to any object program stored in the on-line program library. This advantage can lead to significant improvements in multiprogramming performance under control of the Disk File MCP. It should be noted that the storage of frequently-accessed program segments on the magnetic drum will be advantageous even when the Disk File MCP is used, due to the drum's faster average access time of 8.3 milliseconds.

Both versions of the MCP require the permanent use of the first 1,600 words of core storage for basic control routines; other portions of the MCP are called into core storage from drum or disc storage as required. Burroughs estimates that the MCP's control functions consume between 2 and 10 per cent of the system's total processing time in typical applications; yet the improvements in throughput gained by means of MCP-controlled multiprogramming can far overshadow the small MCP overhead time.

DATA STRUCTURE

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	48 data bits plus 1 parity bit.	basic addressable unit; holds a data item, 8 characters, or 4 syllables.
Row:	6 data bits plus 1 parity bit.	magnetic tape; holds 1 character or 1/8 of a binary word.
Line:	120 or 132 characters	Line Printer reports.
Column:	12 positions	punched cards.
Block:	1 to N characters	magnetic tape, and Disk File in alphanumeric mode.
Block:	1 to 1,023 words	magnetic tape and Disk File in binary mode.

.2 DATA FORMATS

Type of Information	Representation
Instruction	four 12-bit "syllables" per word; each can be an operator, literal, operand call, or descriptor call.
Descriptor	1 word; used for indirect addressing and supplementary control.
Integer number	1 word: 39 data bits + sign.
Floating-point number	1 word: 39 bits + sign for integer part, 6 bits + sign for exponent.
Character	6 bits (internal), 1 row (tape), or 1 column (cards).
Card image	4 card columns per word; 20 consecutive words per card.

BURROUGHS B 5500

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	B5280		Basic System includes B5220 Central Control B5281 Processor, B5282 I/O Subsystem w/o I/O Channels, B5370 Power Supply, B5310 Console, B5290 Display and Distribution	7,400	307,100	265
	B5281		Processor (optional second Processor)	4,500	186,750	120
			Main Storage			
	*B460		6 μsec Memory Module (4096 Words-Max 8)	1,250	51,875	55
	B461		4 μsec Memory Module (4096 Words-Max 8)	1,450	60,175	60
ATTACH-MENTS, ADAPTERS, AND CHANNELS			I/O Control Modules			
	B5283		I/O Channel (Maximum 4)	1,250	51,875	65
		871	132 Print Position Capability, Each I/O Channel	100	4,500	20
		72	Extended Magnetic Tape Capability, Each I/O Channel	100	4,500	20
		873	Data Transmission Terminal Unit (B487) Capability, Each I/O Channel	100	4,500	20
MASS STORAGE			Disk Storage			
	*B450		Basic DF/DC Cabinet (max. 2)	268	11,475	40
	B452		Basic DF/DTTU Cabinet	268	11,475	40
	B5470		Disk File Control	590	26,550	65
	*B5480		Data Communication Control	483	20,700	55
	B249		Data Transmission Control Unit	310	13,275	45
	B451		Disk File Expanded Control	210	9,000	25
	B5470-1		Disk File Control	590	26,550	65
	B471		Electronics Unit (max. 10 for B5470)	746	31,950	80
	B475		Storage Module	1,040	44,550	115
	B477-1		96 Million Characters Storage 40 ms	3,950	224,200	495
	B477-2		Additional 19.2 Million Character Increments 40 milliseconds	700	45,600	85
	B473		Optional Additional DFEU (For B477 Ser.)	650	31,950	80
	*B430		Drum Storage			
			Storage Drum (32,768 Words-Max. 2)	1,700	70,550	65
INPUT-OUTPUT			Magnetic Tape			
	B422		Magnetic Tape Unit (24/66KC;200,556 bits/inch)	840	36,000	155
	B423		Magnetic Tape Unit (24KC; 200 bits/inch)	700	31,500	145
	*B424		Magnetic Tape Unit (66KC; 800 bits/inch)	893	38,250	165
	B425		Magnetic Tape Unit (18/50/72KC;200,556,800 bits/inch)	893	38,250	165
	B426		Magnetic Tape Unit (24/66/96KC;200,556/800 bits/inch)	977	41,850	170

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Card			
	B122		Card Reader (200 cards/min)	175	9,900	40
	B123		Card Reader (475 cards/min)	336	18,000	70
	B124		Card Reader (800 cards/min)	420	18,000	83
	B129		Card Reader (1400 cards/min)	525	27,000	126
		912	Validity Check (2)	6	240	2
		913	Card Counter (2)	6	240	0
	B303		Card Punch (100 cards/min.)	473	20,250	65
	B304		Card Punch (300 cards/min.)	683	29,250	175
		925	Card Counter	6	240	0
	H14		Card Interpreter (13 cards/min;off-line)	150	4,950	23
			Printers			
	*B320		Printer (475 lines/minute)	851	54,000	170
	*B321		Printer (700 lines/minute)	1,260	54,000	175
	B325		Printer (700 lines/minute)	1,339	57,375	185
	B328		Printer (1040 lines/minute)	1,392	59,600	195
	B329		Printer (1040 lines/minute)	1,470	63,000	205
		941	"CR" Symbol, for B325, B328 or B329:			
			Factory Installed	-	-	0
			Field installed, with Drum Exchange	-	-	0
	D5000-5		Message Printer Control Unit	2,065	85,500	115
	D5000-6		Message Printer Unit (Max. 13)	415	17,225	80
			Paper Tape			
	B141		Reader (500-1000 char/sec)	420	18,000	70
		920	Input Code Translator	189	8,100	10
	B341		Punch (100 char/sec)			
			Punch	200	8,550	65
		930	Output Code Translator	179	7,650	10
			Input and Display System			
	B9351-1		Control I-Single Input and Display/Location	215	9,460	27
	B9351-2		Control II-Multiple Input and Displays and/or Controls/Location	325	14,300	27
	B9351-3		Control IIA (max. of 3 with Multiplexor and Control II)	100	4,400	20
	B9351-4		Monitor	60	2,640	10
	B9351-5		Alphanumeric Keyboard	20	880	3
	B9351-6		Input and Display Printer	45	1,980	10
	B9351-7		Remote Communications Adapter	35	1,540	3
	B9351-8		Simplexor	15	660	7
	B9351-9		Multiplexor	50	2,200	11
	B9351-10		Multiplexor Extension	50	2,200	7
	B9951-1		Input and Display Printer Adapter	30	1,320	3
	B9951-2		Insert/Delete-Characters/Line	15	660	3
	B9951-3		Controlled Format	20	880	3
	B9951-4		Variable Tab Position	5	220	1
	B9951-5		Programmatic Cursor Positioning	5	220	1
	B9951-6		B5500 Console Modification Switch	2	88	0
	B9951-7		Display Stand, Low, without work table		80	
	B9951-8		Display Stand, High, without work table		100	
	B9951-9		Display Stand Work Table, Right or Left		25	

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS			Controllers and Line Adapters			
	*B481		Teletype Terminal:			
			120 Character Buffer	460	20,700	55
			240 Character Buffer	480	21,600	55
	*B483		Typewriter Terminal	660	29,700	75
	*B484		Dial TWX Terminal	700	31,500	80
	B487		Data Transmission Terminal Unit	520	22,275	95
		980	TWX/TY Adapter	40	1,800	5
		981	TTY Adapter	60	2,700	10
		983	Automatic Dial Out	30	1,350	5
		984	U 1004 Adapter	120	5,400	30
		985	IBM 1050 Adapter	85	3,825	15
		986	Burroughs (B300 to B5500) Adapter	100	4,500	30
		987	H 120 Adapter	125	5,625	30
		988	8A1 Selective Calling Service - Model 35 Adapter	85	3,825	15
		989-1	Input and Display Direct Connect Adapter	60	2,700	7
		989-2	Input and Display Data Set Adapter (300 bits/sec.)	60	2,700	7
		989-3	Input and Display Data Set Adapter (1000 to 1800 bits/sec.)	120	5,400	12
		990	Audio Dual Line Adapter	130	5,850	15
			Remote Devices			
	*B493		Typewriter Inquiry Station	58	2,475	10
			Audio Response Devices			
		B0355-1	Voice Response Generator	795	37,200	31
		B9955-1	Audio Recording (Special)		2,575	
*		B9955-2	Audio Recording (Library)		575	

NOTES:

*No longer in production.

(1) Maintenance charges are slightly higher outside metropolitan areas.

(2) These features apply to all card readers except B122.

SUMMARY: BURROUGHS B 6500/7500

.1 BACKGROUND

The Burroughs B 6500/7500 systems are third-generation computers designed to process medium-to-large-scale workloads in both business and scientific applications. These highly modular systems effectively bridge the gap between the medium-scale B 5500 and the ultra-large B 8500, giving buyers of large-scale computers a broad range of Burroughs equipment to choose from.

The B 6500 was originally announced in May 1966 as a third-generation version of the B 5500 with a 5-megacycle processor and a 0.6-microsecond thin-film memory. In July 1967, Burroughs announced the B 7500 series and revised the specifications for the B 6500 series. As a result, there are now five processor models available in the B 6500/7500 line. All five models are program-compatible and use the same peripheral equipment and software. The five models are distinguished by their internal clock rates and by the type and speed of their main memories, as follows:

Processor Model	Clock Rate, megacycles	Main Memory Type	Cycle Time, microseconds
B 6503	2.5	Core	1.2
B 6504	5.0	Core	1.2
B 6506	5.0	Thin-film	0.6
B 7504	10.0	Core	1.2
B 7506	10.0	Thin-film	0.6

The B 5500 processor, by comparison, has a 1-megacycle clock rate and a 4-microsecond core memory cycle time. Burroughs expects the B 6500/7500 processors' performance advantages over the B 5500 processor to be even greater than these figures indicate because of speed-ups in individual instructions, reductions in the number of memory accesses required, and other improvements.

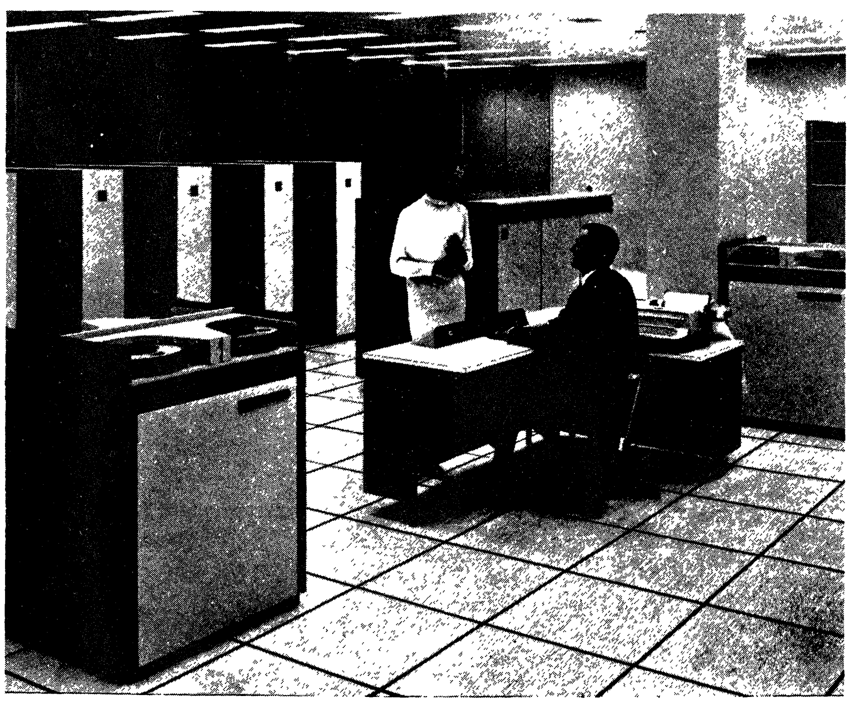

Figure 1. A Burroughs B 6500 system, showing a four-drive magnetic tape cluster in left foreground. (Burroughs states that delivered B 6500 systems will have a different console configuration.)

.1 BACKGROUND (Contd.)

Deliveries of B 6500/7500 systems are scheduled to begin during the first quarter of 1969; this represents an unusually long time lag of almost three years between announcement and initial deliveries. Rentals for B 6500/7500 systems will range from about $22,000 to $230,000 per month, with the average configuration costing $45,000 to $50,000 per month.

The B 6500/7500 systems retain many of the design concepts that made the Burroughs B 5500 a highly unorthodox computer and led eventually to an unusually high degree of user satisfaction. Among these concepts are the following:

- All user programming is done in ALGOL, COBOL, or FORTRAN rather than in a symbolic assembly language, and the hardware design is oriented toward efficient compilation and execution of programs coded in these higher-level languages.
- A comprehensive operating system called the Master Control Program schedules and directs all of the system's operations.
- Multiprogramming is regarded as the normal mode of operation and is emphasized in the design of all hardware and software.
- Two independent central processors can share all storage and input-output facilities in a system.
- Automatic temporary storage for operands and other data is provided by "stacks", which operate on the "last-in, first-out" principle.
- Internal operations can be performed upon either 48-bit binary words or strings of alphanumeric characters.
- Recursive use of subroutines is largely automatic and unrestricted.
- All machine-language addressing is relative and/or indirect, facilitating program segmentation and relocation.
- Automatic overlaying permits programs to be written and executed with no restrictions as to main memory size.
- Fixed-head magnetic disk files provide rapid-access auxiliary storage for the Master Control Program, compilers, program segments, and data arrays.
- Each main memory module can accept or transmit data independently of the other memory modules and of the processor(s).

In addition to the concepts which have been carried over from the earlier B 5500, the B 6500/7500 systems include some significant new features:

- Integrated circuits are used in the central processors.
- A system can have up to 524,288 words (3,145,728 bytes) of either core or thin-film main memory, in 16,384-word modules.
- Input-output operations are controlled by one or two I/O multiplexors, each of which can handle up to 10 simultaneous data transfer operations.
- Flexible configuration rules permit connection of up to 255 peripheral devices, including up to 19 billion bytes of disk storage.
- Data communications processors, which function independently of the central processor, enable a B 6500/7500 system to control up to 2048 communications lines.
- All programs use re-entrant coding to simplify program segmentation and reduce main memory requirements (also true of the B 5500 since July 1967).
- EBCDIC is the standard data code, though other 4-bit, 6-bit, or 8-bit codes can also be accommodated.

The B 6500/7500 central processors incorporate several other noteworthy improvements over the B 5500 processor; these are summarized in Paragraph .24, Central Processors.

B 6500/7500 systems will not be compatible at the object-program level with the other current members of the "Burroughs 500 Systems" computer family (i.e., the B 2500, B 3500, B 5500, and B 8500). The ALGOL, FORTRAN, and COBOL languages for the B 6500/7500, however, will be compatible with those for the B 5500, so B 5500 users should be able to recompile and execute their programs on B 6500/7500 systems in straightforward fashion. There is no machine-language program compatibility between the B 6500/7500 and the IBM System/360, but the new Burroughs computers will be System/360-compatible with respect to data codes and most I/O media.

(Contd.)

.2 HARDWARE

.21 Data Structure

The B 6500/7500 systems, like the earlier B 5500, are basically binary processors that use a fixed word-length of 48 data bits plus a parity bit. In addition, each word location in B 6500/7500 main memory includes 3 control bits, so the total word-length is 52 bits. The three control bits are used to identify various types of data, to provide memory protection, and to perform other control functions.

Most of the B 6500/7500 instructions use 48-bit binary words as operands. The mantissa or integer value of each single-precision operand is represented by 39 bits plus sign, and the octal exponent by 6 bits plus sign.

Each double-precision operand occupies two 48-bit words. The first word has the same format as a single-precision operand, but its 3-bit control field indicates that it is to be treated as the first half of a pair of words. In the second word, 39 bits are used to hold the second half of the mantissa, providing a total precision of 78 bits; the other 9 bits of the second word hold the high-order portion of the exponent, resulting in a total exponent size of 15 bits.

Floating-point and integer operands can be intermixed without conversions; if either or both operands in an arithmetic operation are floating-point, the result will be expressed in floating-point form. Moreover, every instruction that normally operates on single-precision operands will automatically be performed in the double-precision mode if either or both of the operands are of the double-precision type.

Edit instructions permit convenient handling of character strings and other variable-length fields composed of 4-bit, 6-bit, or 8-bit characters or bytes. Each 48-bit word can hold 6 characters in the 8-bit alphanumeric format, 8 characters in the 6-bit alphanumeric format, or 12 characters in the 4-bit "compact numeric" format.

The 8-bit Extended Binary-Coded Decimal Interchange Code (EBCDIC) is the standard data code for B 6500/7500 systems (whereas the 6-bit Burroughs Common Language code is used in the B 5500). Other 4-bit, 6-bit, and 8-bit codes can also be used because the central processors and internal storage devices are largely code-independent, and the instruction repertoire includes a Translate operator that uses a translation table to perform conversions between any two codes.

A significant difference between the B 5500 and the newer systems occurs in their instruction formats. In the B 5500, every program word consists of four 12-bit "syllables," and each syllable can specify an operation, a relative address, or a literal value. In the B 6500/7500, each program syllable is 8 bits in length, and the length of an operator (instruction) can range from 1 to 18 syllables.

.22 System Configuration

The B 6500/7500 systems are highly modular computer systems composed of the following basic elements:

- One or two central processors.
- One to 32 modules of main memory, each containing 16,384 words of core or thin-film storage. (A maximum of 8 modules can be used with the B 6503 Processor.)
- One or two I/O multiplexors. (Only one is allowed with the B 6503 processor.)
- Numerous I/O channels, peripheral controls, peripheral devices, and communications lines, connected according to the rules in the following paragraphs.

A B 6500 or B 7500 central system communicates with all peripheral devices and communications lines through one or two I/O multiplexors. Each multiplexor can house three independent functions:

- Data switching channels, which provide the linkages between main memory and all local peripheral devices (e.g., card readers, printers, magnetic tape units, and disk files). Each I/O multiplexor can include from 4 to 10 data switching channels, permitting up to 10 simultaneous I/O operations. The channels are of the "floating" type, meaning that any available channel can be used to service any connected peripheral device.

  Up to 20 peripheral controls can be connected to each I/O multiplexor, regardless of the number of data switching channels installed. These control units direct the operations of all B 6500/7500 peripheral devices. Most of the peripheral controls can accommodate only one peripheral device each, but the magnetic tape and disk file controls can accommodate multiple units. A total of up to 255 local peripheral devices can be connected to a B 6500/7500 system.

.22 System Configuration (Contd.)

There are two classes of peripheral controls: "large" and "small." The large controls have a two-character buffer and are used for high-speed devices such as magnetic tape units and disk files. The small controls have a one-character buffer and are used for low-speed peripheral devices such as card readers, punches, and printers. A maximum of 10 of the controls connected to a multiplexor can be large controls.

- Data communications processors, which handle the interfacing between B 6500/7500 systems and remote devices. Each I/O multiplexor can accommodate up to 4 data communications processors, and each DCP can control up to 256 communications lines. Thus, a B 6500/7500 system can service a maximum of 2048 communications lines. The DCP is a special-purpose computer that contains the logic and memory required to perform the basic functions associated with sending and receiving data over communications lines. (See Paragraph .26 for more information about the DCP.)
- A real-time adapter, which permits non-standard devices to be connected to a B 6500/7500 system in an on-line, real-time mode. One real-time adapter can be connected to each I/O multiplexor (except that none can be used with the B 6503 Processor). Use of the real-time adapter will generally require custom engineering to achieve the proper interface with the B 6500/7500 hardware and software.

The minimum permissible B 6500/7500 system consists of: one central processor, one I/O multiplexor, one 16,384-word memory module, one disk file unit, one magnetic tape unit, one card reader, one line printer, and one console printer and keyboard (plus appropriate control units for all peripheral devices).

The components and monthly rental prices of four representative B 6500/7500 systems are listed below. The first three are based on the specifications for AUERBACH Standard Configurations IVR, VIIA, and VIIIR, as listed in the Users' Guide. The fourth configuration, illustrated in Figure 2, is a large, dual-processor B 7500 system with 131K words of thin-film memory, 2 I/O multiplexors, 12 data switching channels, 128 data communications lines, and enough redundancy in peripheral equipment and access paths to ensure graceful degradation in the event of hardware failures.

.221 20-Million-Byte Random Access System; Configuration IVR

Equipment	Rental
1 — B 6503 Processor; 2.5 megacycles	$ 9,200
1 — B 6001-2 Core Memory; 16,384 words, 1.2-microsecond cycle	4,000
1 — B 6713 I/O Multiplexor with 4 Data Switching Channels	2,800
1 — B 9342 Console Printer and Keyboard	55
1 — B 6340 Console Printer Control	150
1 — B 9372-7 Disk File; 20 million bytes	1,200
1 — B 9371-2 Disk File Electronic Unit	650
1 — B 6373 Disk File Control	400
1 — B 9382-4 Four-Drive Magnetic Tape Cluster; 72KB	1,700
2 — B 6381-2 72KB Cluster Controls	900
1 — B 6481 Cluster Exchange; 2 x 8	200
1 — B 9243 Printer; 1040 lpm	950
1 — B 6240 Printer Control	150
1 — B 9112 Card Reader; 1400 cpm	325
1 — B 6110 Card Reader Control	100
1 — B 9213 Card Punch; 300 cpm	530
1 — B 6210 Card Punch Control	100
Total Rental:	$23,410

.222 10-Tape General-Purpose System; Configuration VIIA

Equipment	Rental
1 — B 6504 Processor; 5 megacycles	$11,600
1 — B 6001-2 Core Memory; 16,384 words, 1.2-microsecond cycle	4,000
1 — B 6714 I/O Multiplexor with 4 Data Switching Channels	3,200
1 — B 9342 Console Printer and Keyboard	55
1 — B 6340 Console Printer Control	150
1 — B 9372-1 Disk File; 10 million bytes*	850
1 — B 9371-1 Disk File Electronic Unit	650
1 — B 6373 Disk File Control	400
10 — B 9392 Magnetic Tape Units; 72KB	5,750

* One Disk File is required in every B 6500/7500 system.

.222 10-Tape General-Purpose System; Configuration VIIA (Contd.)

Equipment	Rental
2 — B 6393-1 Magnetic Tape Controls	$ 1,000
1 — B 6490 Magnetic Tape Exchange; 2 x 10	250
1 — B 9242 Printer; 815 lpm	850
1 — B 6240 Printer Control	150
1 — B 9111 Card Reader; 800 cpm	325
1 — B 6110 Card Reader Control	100
1 — B 9213 Card Punch; 300 cpm	530
1 — B 6210 Card Punch Control	100
Total Rental:	$29,960

.223 100-Million-Byte Random Access System; Configuration VIIIR

Equipment	Rental
1 — B 7506 Processor; 10 megacycles	$16,600
1 — B 7002-3 Thin-Film Memory; 32,768 words (2 modules), 0.6-microsecond cycle	11,500
1 — B 7716 I/O Multiplexor with 8 Data Switching Channels	6,100
1 — B 9342 Console Printer and Keyboard	55
1 — B 7340 Console Printer Control	150
1 — B 9375-0 Data Memory Bank; 100 million bytes; includes electronic unit	4,950
1 — B 7373 Disk File Control	400
4 — B 9393 Magnetic Tape Units; 144KB	2,600
4 — B 7393-2 Magnetic Tape Controls	2,400
1 — B 9243 Printer; 1040 lpm	950
1 — B 7240 Printer Control	150
1 — B 9112 Card Reader; 1040 cpm	325
1 — B 7110 Card Reader Control	100
1 — B 9213 Card Punch; 300 cpm	530
1 — B 7210 Card Punch Control	100
Total Rental:	$46,910

.224 Large Dual-Processor System (Figure 2)

Equipment	Rental
1 — B 7506 Processor; 10 megacycles	$16,600
1 — B 7506-1 Second Processor; 10 megacycles	16,200
1 — B 7008-3 Thin-Film Memory; 131,072 words (8 modules), 0.6-microsecond cycle	36,500
2 — B 7716 Multiplexors with 6 Data Switching Channels each	9,600
2 — B 9372-7 Disk Files; 20 million bytes each (systems memory)	2,400
2 — B 9371-2 Disk File Electronic Units	1,300
1 — B 7471-2 Disk File Exchange; 2 x 5	200
2 — B 7674 Disk File Exchange Adapters	20
1 — B 9375-3 Data Memory Bank; 100 million bytes	2,700
16 — B 9376-3 Data Memory Bank Modules; 25 million bytes each	7,200
1 — B 7471-4 Disk File Exchange; 4 x 10	350
5 — B 7675 Disk File Exchange Adapters	75
6 — B 7373 Disk File Controls	2,400
10 — B 9393 Magnetic Tape Units; 144KB	6,500
1 — B 7493 Magnetic Tape Exchange; 4 x 16	450
4 — B 7393-2 Magnetic Tape Controls	2,400
1 — B 9342 Console Printer and Keyboard	55
1 — B 7394 Console Printer Control	150
2 — B 9243 Printers; 1040 lpm	1,900
2 — B 7240 Printer Controls	300
2 — B 9112 Card Readers; 1400 cpm	650
2 — B 7110 Card Reader Controls	200
2 — B 9213 Card Punches; 300 cpm	1,060
2 — B 7210 Card Punch Controls	200
2 — B 7350 Data Communications Processors	1,800
8 — B 7350-1 Multiline Control Increments; 16 lines each	800
128 — B 7657 Teletype Model 35 Line Adapters	3,840
Total Rental:	$115,850

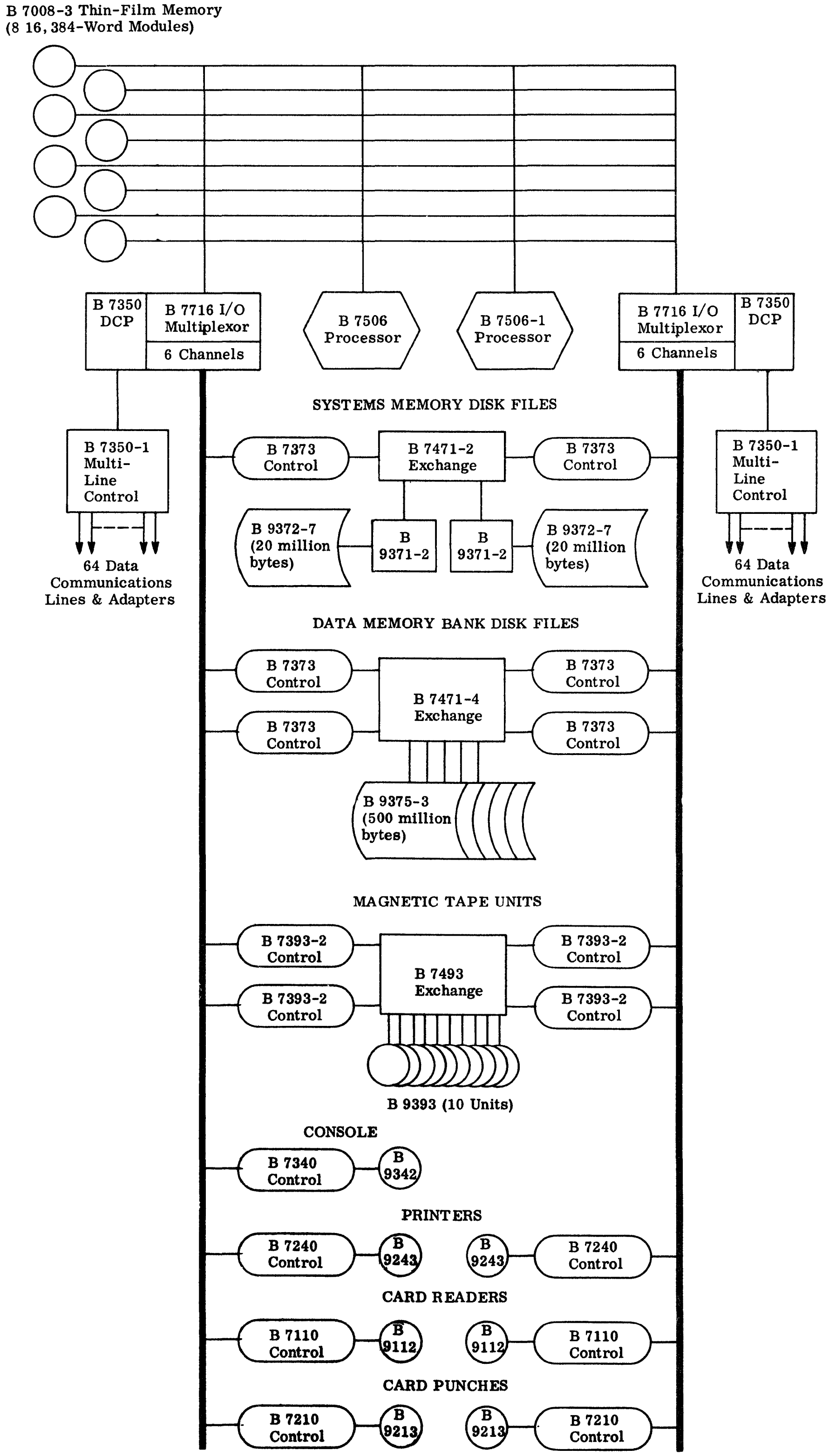

Figure 2. A large, dual-processor B 7500 system. (See Paragraph .224 for identity and rental of each component.)

(Contd.)

.23 Internal Storage

.231 Main memory

Main memory for B 6500/7500 systems can be of either the magnetic core or thin-film type. The magnetic core memory, used with the B 6503, B 6504, and B 7504 Processors, has a cycle time of 1.2 microseconds and a read access time of 600 nanoseconds. The thin-film memory, used with the B 6506 and B 7506 Processors, is twice as fast; it has a cycle time of 600 nanoseconds and a read access time of 300 nanoseconds.

Both types of main memory are supplied in functionally independent modules of 16,384 words each, and each word location consists of 48 data bits, 3 control bits, and 1 parity bit. Up to 32 memory modules can be connected to any B 6500/7500 processor except the B 6503, which can have a maximum of 8 modules. The 32 modules provide a total storage capacity of 524,288 words or 3,145,728 eight-bit bytes, which is two to three times the maximum main memory capacity of most competitive systems. Moreover, the 20-bit addressing capability of the system allows future expansion to more than one million words.

Since each memory module functions independently, up to four accesses to main memory can be made simultaneously by the central processor(s) and/or I/O multiplexor(s) in a system.

A single main memory cabinet can hold three 16,384-word memory modules, the associated control circuitry, and a memory power supply. Any two modules in a cabinet can be interlaced if the user so desires, with odd memory addresses serviced by one module and even addresses by the other. Each memory cabinet also contains a test facility that can be used for off-line checking of any one of the associated memory modules while the remainder of the system remains in operation. (The interlace facility, if used, must be disabled while one of the modules in a pair is being tested or serviced.)

.232 Disk files

Disk storage for B 6500/7500 systems is available with average access times ranging from 20 to 60 milliseconds and modular storage capacities ranging from 10 million to 19 billion 8-bit bytes per system (see Table I). All models are similar in form and function to the disk files that have been in use for several years with other Burroughs computer systems. The use of a fixed read/write head for every data track provides fast access times and high reliability.

Each data track is divided into segments of 100 bytes, and a sequential 7-digit decimal addressing scheme is used to identify the segments. Each of the four disks within a disk file module is provided with a manual lockout switch that prevents writing while still allowing the recorded data to be read.

A longitudinal check character is generated and recorded with each 100-byte segment of data. During every disk read operation, or during a programmed write check operation, this check character is automatically regenerated and compared with the character read from the disk. If the comparison is unequal, or if any other error condition is detected, an error bit is set in the result descriptor that is returned to the processor upon completion of every I/O operation.

Configuration rules for the B 6500/7500 disk files can be summarized as follows:

- A maximum of five disk file modules (or four Model B 9376-3 modules) can be connected to a disk file electronic unit, providing up to 100 million bytes of storage per electronic unit.
- All disk modules connected to an electronic unit must be of the same type.
- One electronic unit can be connected directly to a disk file control.
- Alternatively, up to 2, 5, or 10 electronic units can be connected to a disk file control through the use of a 1 x 2, 2 x 5, or 4 x 10 disk file exchange, respectively.
- A 2 x 5 or 4 x 10 disk file exchange permits a bank of disk file modules to be serviced by two or four disk file controls, respectively, providing two-way or four-way simultaneity for disk I/O operations.
- Theoretically, up to 19 disk file controls can be used in a B 6500/7500 system. Thus, a fully expanded disk file system could contain 190 electronic units and 19 billion bytes of storage.

The characteristics of the available disk file modules are summarized in Table I.

.24 Central Processors

A Burroughs B 6500/7500 system can include either one or two processors. The processors used in B 6500 systems have either a 2.5- or 5.0-megacycle clock rate, while the B 7500 processors have a 10.0-megacycle clock rate. (The B 5500, by comparison, has a 1.0-megacycle clock rate.) Both of the processors in a dual-processor system must have the same clock rate.

TABLE I: CHARACTERISTICS OF THE BURROUGHS DISK FILES

Model	Description	Average Access Time, msec	Average Data Transfer Rate, bytes/sec	Electronic Unit Model
B 9372-1	Disk File Module; 10 million bytes	20	218,000	B 9371-1
B 9372-7	Disk File Module; 20 million bytes	23	377,000	B 9371-2
B 9375-0	Data Memory Bank; 100 million bytes in 5 disk file modules	23	377,000	B 9371-3*
B 9376-0	Add'l. Data Memory Bank module; 20 million bytes	23	377,000	B 9371-3*
B 9375-2	Data Memory Bank; 100 million bytes in 5 disk file modules	40	216,000	B 9371-4*
B 9376-2	Add'l. Data Memory Bank Module; 20 million bytes	40	216,000	B 9371-4*
B 9375-3	Data Memory Bank; 100 million bytes in 4 disk file modules	60	395,000	B 9371-5*
B 9376-3	Add'l. Data Memory Bank Module; 25 million bytes	60	395,000	B 9371-5*

* Data Memory Bank prices include one electronic unit for each five disk modules; additional electronic units of the indicated models can be used for increased simultaneity.

.24 Central Processors (Contd.)

The B 6500/7500 systems, like the B 5500, employ the "stack" concept and are designed for efficient implementation of process oriented languages such as ALGOL, COBOL, and FORTRAN. Significant improvements over the B 5500 processor include:

- Operators (instructions) of varying lengths — most commonly 8 bits. (B 5500 operators have a fixed length of 12 bits. This improvement should lead to fewer accesses to main memory and higher execution speeds.)
- String manipulation capabilities that allow character-oriented data to be handled in four-bit, six-bit, or eight-bit bytes. (The B 5500 can conveniently handle six-bit characters only.)
- Capability for each processor to handle its own interrupts in two-processor systems. (B 5500 dual-processor systems use a "master-slave" arrangement in which only the master processor can service interrupt conditions. In B 6500/7500 systems, the two processors are logically identical, and each processor can perform the Master Control Program functions required by the programs running on it.)
- Hardware memory protection through use of the three control bits in each memory word. (User programs are prohibited from writing into memory locations that have the protect bit set, and attempts by any program to index beyond an assigned data area are detected automatically. The B 5500 lacks the write-lockout facility.)
- Combination of the "stack" and "program reference table," as used in the B 5500, into a single, overlayable stack for each program. (This means that all of main memory — except for required MCP segments — can be made available to any program at any time.)
- Use of re-entrant coding in all B 6500/7500 programs. (This simplifies transfers of program segments between main memory and disk storage, and reduces main memory requirements when two or more jobs are using the same compiler, MCP routines, or other software.)
- Provision of two types of hardware clocks: a real-time clock (one per system) that has a one-microsecond resolution and counts up to 24 hours; and an interval timer (one in each processor) that can provide predetermined time interrupts at intervals ranging from 500 microseconds to one second. (The B 5500 has a single timer with a resolution of 1/60th of a second.)

(Contd.)

.241 Processor states

A B 6500/7500 processor can operate in either of two states: normal or control. User programs are processed in the normal state, and entry into the control state occurs as a result of certain interrupt conditions.

In the normal state, the use of certain "privileged" instructions is prohibited, and the hardware memory protection and security provisions are enforced. An interrupt condition or a transfer to a control-state program (e.g., to initiate an I/O operation) causes the processor to switch from the normal to the control state.

In the control state, the processor can execute all instructions, including the "privileged" ones, and various classes of interrupts can be inhibited or allowed under program control. The processor switches from the control state to the normal state whenever the MCP (Master Control Program) initiates a normal-state program or transfers control back to a normal-state program following an interrupt. Although all MCP functions are intiated in the control state, many of the MCP routines are executed in the normal state and can be interrupted as necessary.

.242 Interrupts

A comprehensive interrupt system informs each B 6500/7500 processor of special conditions arising either internally (within the processor) or externally (in the connected peripheral equipment). Internal interrupt conditions are serviced by the affected processor, whereas external interrupt conditions are serviced by either processor in a dual-processor system.

Conditions that result in an internal (processor-dependent) interrupt include: invalid index, exponent overflow or underflow, integer overflow, division by zero, invalid operator, stack overflow or underflow, memory parity error, multiplexor parity error, invalid address, memory protection violation, reference to a segment not present in main memory, and interval timer runout. External interrupts can result from a wide variety of conditions, including normal completion of I/O operations. Various classes of external interrupts can be enabled or inhibited by the MCP.

A processor responds to an interrupt by recording all pertinent control information in the stack, as in the normal subroutine entry procedure, and then transferring control to an MCP subroutine that services the interrupt condition. The MCP then reactivates the interrupted program by returning control through the normal subroutine return mechanism.

.243 Descriptors

Descriptors are words used to describe and locate data and program areas in memory. The use of descriptors is one of the key concepts in the unorthodox processor architecture of the B 6500/7500 systems. Descriptors are the only types of words containing absolute addresses that can be referenced by a normal-state program. Only the MCP, however, is permitted to alter a descriptor; if a user program tries to do so, an interrupt occurs.

There are three types of descriptors: data, string, and segment.

A data descriptor defines an area of memory that is being used to store data in a word-oriented format (including input-output buffer areas). A 20-bit address field specifies the starting location of the data area in either main memory or disk storage, and a 20-bit length/index field specifies either the length of the data area or an index value. Other individual bits within the descriptor indicate: whether the data area is currently present in main memory, whether indexing is to be performed when the descriptor is referenced to obtain data, whether the data area is segmented (in 256-word segments), whether the data format is single- or double-precision, and whether the data area may be referenced for both reading and writing or for reading only. When used to initiate an I/O operation, a data descriptor specifies the I/O unit number and the memory address of the buffer area to be used.

A string descriptor describes a memory area that is being used to store data in the form of 4-bit, 6-bit, or 8-bit characters. In other respects, string descriptors are similar to data descriptors.

A segment descriptor is used to locate a program segment. It specifies the initial address of the segment in either main memory or disk storage, the segment length in words, and whether or not the segment is currently present in main memory.

.244 Stacks

One stack is associated with each program in a B 6500/7500 system. The stack is an area of memory that holds a list of operands, descriptors, and control words. The stack has three major functions:

- It provides temporary storage for data.
- It holds a dynamic record of a program's current operating status and history.
- It holds the descriptors that describe and locate the program's data areas and instruction segments.

.244 Stacks (Contd.)

The stack associated with the program that is being executed at any given moment uses the 51-bit A, B, and C registers of the processor to hold its top three words; the remainder of the active stack can be located anywhere in main memory. The processor's S register holds an address that always "points" to the last word stored in the stack area in main memory.

When used for temporary data storage, the stack operates on the "last-in, first-out" principle. An operand fetched from main memory by the program is placed in the A register; the previous contents of the A and B registers (if any) are pushed down into the B and C registers, respectively; and the previous contents of the C register are transferred automatically to the memory location addressed by the S register. Push-up operations are performed automatically when instructions call for data from the stack; the process is the reverse of the push-down procedure just described. The address in the S register is automatically incremented by one before each push-down operation and decremented by one after each push-up operation.

When a B 6500/7500 processor switches from one program to another, the information held in the A, B, and C registers is automatically pushed down and stored in the proper stack area in main memory prior to the transfer of control. The current setting of the S register is preserved to faciliate re-entry to the interrupted program.

The Master Control Program allocates stack memory space according to the number and size of programs residing in main memory. A base address register and limit register define the memory area allocated to the active program's stack, and an interrupt is initiated if either stack overflow or underflow occurs.

A "cactus stack" facility permits the segment descriptors for all program segments that are common to two or more jobs to be placed in the common trunk of a "tree" of stacks. This feature conserves memory space and aids in implementing the re-entrant coding that is used in all B 6500/7500 programs.

.245 Instructions

Although the B 6500/7500 processors are binary machines with a fixed word-length of 48 data bits, their instructions are composed of a variable number of 8-bit syllables. The instructions — called "operators" — range from 1 to 18 syllables in length, but most of the basic word-oriented operators require only one syllable. The syllables are packed six to a program word and executed sequentially from left to right. When one program word has been exhausted, the next sequential word is fetched from main memory.

All arithmetic operations are performed upon 48-bit binary words. The specified add, subtract, multiply, or divide process is performed upon the two operands at the top of the stack (i.e., in the A and B registers), and the result is placed at the top of the stack. Single- and double-precision operands in both integer and floating-point representations can be freely combined in all B 6500/7500 arithmetic operations.

Other word-mode operators perform a variety of functions, including logical operations, comparisons, stack manipulation, bit or field manipulation, and placement of literal values (up to 96 bits) into the stack.

The Edit operators are a special class of instructions used to manipulate strings of data composed of 4-bit, 6-bit, or 8-bit characters. These operators facilitate the transfer, comparison, scanning, editing, and translation of data in character form, giving the word-oriented B 6500/7500 systems character manipulation facilities that rival those of many character-oriented processors. Of particular value is the Translate operator, which causes characters to be moved from a source string to a destination area and translated into a code defined by a translation table stored in memory.

.246 Processor performance

Instruction execution times for the B 6500/7500 processors have not been released to date. A reasonable estimate of the performance of the five processor models can be derived by comparing their clock rates and main memory cycle times with the 1.0-megacycle clock rate and 4-microsecond memory cycle time of the generally similar B 5500 processor.*

Processor Model	Clock Rate, megacycles	Ratio to B 5500 Rate	Memory Cycle, microseconds	Ratio to B 5500 Cycle
B 6503	2.5	2.5	1.2	3.33
B 6504	5.0	5.0	1.2	3.33
B 6506	5.0	5.0	0.6	6.67
B 7504	10.0	10.0	1.2	3.33
B 7506	10.0	10.0	0.6	6.67

* For the B 5500 processor's performance, see Report 203 or the Comparison Charts.

(Contd.)

.246 Processor performance (Contd.)

Thus, the new processors have clock rates up to 10 times as fast and memories up to 6.67 times as fast as the B 5500. Burroughs states, however, that the performance of the B 6500/7500 processors will be even better than these figures indicate because of speed-ups in individual instructions, reductions in the number of memory accesses required, and other improvements.

.247 Console

The console serves as the operations center for a B 6500/7500 system and contains the switches, indicators, and displays required for operator control. The basic console input-output device is a version of the Burroughs Information Display System (BIDS). The operator enters information into the system via the BIDS keyboard and receives information by keyboard-selecting any one of several displays which are continually maintained by the Master Control Program. Multiple display units are an available option, as is hard copy via a character-at-a-time printer. A message log is maintained on the systems disk file and dumped, periodically or upon demand, to a high-speed line printer.

.25 Input-Output Equipment

B 6500/7500 computer systems can use most of the input-output devices offered with the Burroughs B 2500/3500 systems (Report 210). Some of the B 2500/3500 peripheral units, however, are not well suited for use with large-scale computers and are not currently offered for the B 6500/7500; in this category are the 200-cpm card reader, the 100-cpm card punch, the 700-lpm printer, and the multiple tape listers.

.251 Punched card I/O

Punched cards can be read at a peak speed of either 800 or 1400 cards per minute by the B 9111 or B 9112 Card Reader, respectively. Both models use an immediate-access clutch, a belt feed mechanism, and 13 photoelectric cells (one for timing) to read cards of 51, 60, 66 or 80 columns in column-by-column fashion. The input hopper and output stacker can each hold up to 2400 cards and can be loaded and unloaded while the reader is operating. Optional features permit 40-column Treasury checks or the round holes in Postal Money Orders to be read. Invalid characters are detected, and the read circuitry is checked for proper functioning between card cycles.

The card readers and their associated controls provide considerable code flexibility. EBCDIC, BCL, or Hollerith-coded cards can be read and translated into EBCDIC or BCL internal code. Binary cards can be read without translation.

The B 9213 Card Punch punches 80-column cards at a peak rate of 300 cards per minute. An immediate-access clutch feeds cards on demand. Punching accuracy is verified by an echo check. The input hopper holds 1000 cards, and the three-program-selectable stackers (primary, auxiliary, and error) hold 1200 cards each. Cards can be loaded and unloaded while the punch is operating. Prepunched cards can be fed, though previously-punched columns cannot be repunched.

Data to be punched can be in EBCDIC or BCL internal code. EDCDIC data is punched in the EBCDIC card code, while BCL data can be translated by the card punch control into any one of three card codes: BCL, Bull, or ICT. Binary data is punched without conversion, in column-binary form.

.252 Punched tape I/O

The B 9210 Paper Tape Reader can read punched tape with 5, 6, 7, or 8 code levels at a peak speed of either 500 or 1000 characters per second. Rated start and stop times are 5 and 20 milliseconds, respectively, and the reader can stop between consecutive characters. Automatic translation from either 5-level Baudot or 6-level BCL tape code to EBCDIC internal code is standard. Other codes can be read directly into main memory and translated by program.

The B 9220 Paper Tape Punch can punch 5-, 6-, 7-, or 8-level tape at a peak speed of 100 characters per second. The tape width can be 11/16, 7/8, or 1 inch. Automatic translation from EBCDIC internal code to either 5-level Baudot or 6-level BCL code is standard. Other codes can be handled by programmed translation.

.253 Printers

Two line printers of the conventional drum type are available for use with B 6500/7500 systems. Peak speeds are 815 lines per minute for Model B 9242 and 1040 lines per minute for Model B 9243.

Both models have 120 print positions, with 12 additional positions available through the inclusion of Feature B 9941. The normal skipping speed is 25 inches per second. When Feature B 9940 is installed, the skipping speed goes up to 75 inches per second on skips of more than 1.17 inches. Vertical format control is provided by a 12-channel paper tape loop. Forms can be from 5 to 20 inches in width and can have a maximum length of 22 inches (when printing at 6 lines per inch) or 16.5 inches (at 8 lines per inch). Data to be printed can be in either 8-bit EBCDIC or 6-bit BCL internal code.

.254 Magnetic tape clusters

The Burroughs Magnetic Tape Clusters, announced with the B 2500/3500 computers in March 1966, are novel peripheral units that provide two, three, or four tape drives in a single compact unit (33 inches wide, 30 inches deep, and 42 inches high). Each tape drive has its own drive mechanism, but the read/write electronics and power supply are shared. The feed reel and take-up reel for each drive are mounted on concentric vertical shafts, with the feed reel above the take-up reel. The tape is driven by a capstan roller and pinch rollers. Normal tape speed is 45 inches per second, and rewind speed is 90 inches per second. Tape can be read in either the forward or reverse direction.

The Magnetic Tape Clusters are offered in three basic models, whose characteristics are summarized in Table II. Two models record in the 9-track mode (8-bit EBCDIC plus parity) and one records in the 7-track mode (6-bit BCL code plus parity). All three models use 1/2-inch tape and are tape-compatible with the corresponding IBM tape units.

A maximum of eight tape drives (i.e., two 4-drive clusters) can be connected to a tape control. Reading and/or writing can be performed simultaneously on any two of the tape drives in a cluster if two tape controls and a 2 x 8 magnetic tape exchange are employed.

.255 Free-standing magnetic tape units

Burroughs also offers five different free-standing tape units for use with B 6500/7500 systems. Their characteristics are summarized in Table II. Three models record in the 9-track mode (8-bit EBCDIC plus parity) and two record in the 7-track mode (6-bit BCL code plus parity). All five models use 1/2-inch tape, can read in either the forward or reverse direction, and can rewind at an average speed of 300 inches per second.

A maximum of six free-standing tape units can be connected directly to a tape control unit. Magnetic tape exchange units can be used to achieve read/write simultaneity within a single group of tape units and/or to permit up to 16 tape units to be connected to a tape control. A 2 x 10 exchange enables one or two tape controls to serve up to 10 tape units, while a 4 x 16 exchange enables from one to four tape controls to serve up to 16 tape units. All tape units in a subsystem must record in the same mode (7-track or 9-track) and operate at the same tape speed, in inches per second, though their recording densities may differ.

TABLE II: CHARACTERISTICS OF BURROUGHS MAGNETIC TAPE UNITS

Model	Tape Speed, inches per sec	Number of Tracks	Recording Densities, bits/inch	Peak Speeds, chars/bytes per sec
Clusters				
B 9381-2, -3, -4	45	9	800 200*	36,000 9,000*
B 9382-2, -3, -4	45	9	1600	72,000
B 9383-2, -3, -4	45	7	800 556 200	36,000 25,000 9,000
Free-Standing Units				
B 9391	90	7	800 556 200	72,000 50,000 18,000
B 9392	90	9	800 200*	72,000 18,000*
B 9393	90	9	1600	144,000
B 9394-1	120	7	800 556 200	96,000 66,000 24,000
B 9394-2	120	9	800 200*	96,000 24,000*

* An optional adapter on the tape control is required for operation at 200 bits per inch.

(Contd.)

.26 Data Communications

Data transmission between B 6500/7500 systems and remote devices is controlled by Data Communications Processors (DCP's). The DCP is a small, special-purpose computer that contains enough logic and memory to perform the basic functions associated with the transmission and receipt of data over communications lines. Each DCP can control up to 256 lines, and up to four DCP's can be connected to an I/O multiplexor. Thus, a B 6500/7500 with two I/O multiplexors can service up to 2048 lines.

The interface between the DCP and each communications line consists of a Multiline Control and a Line Adapter. The Multiline Control can accommodate a maximum of 64 lines and is available in 16-line increments. Up to four Multiline Controls can be connected to each DCP. A separate Line Adapter is required for each line. Currently available Line Adapters permit communication with the following remote devices:

- Burroughs Typewriter Inquiry Station.
- Bell System TWX station.
- Burroughs B 2500 or B 3500 computer.
- Burroughs B 300 or B 5500 computer.
- UNIVAC DCT 2000 Data Communications Terminal.
- IBM 1050 Data Communications System.
- Teletype Model 35 set or Bell System 8A1 service.
- Teletype Model 28 set or Bell System 83B3 service.
- Burroughs Input and Display System (CRT display), either by direct connection or via data sets at 1200 or 2400 bps.
- Honeywell 120 computer.

Each Data Communications Processor contains a set of arithmetic registers and 512 words of read-only memory. The DCP can execute either "micro-programs" stored in its own read-only memory or "macro-programs" stored in main memory. The stored-program capability enables the DCP to perform many of the control functions that would ordinarily require wired circuitry. The DCP can also be programmed to scan all lines for activity, and to poll the remote terminals in networks that operate in the polling mode.

When a central processor initiates a data communications output operation, an I/O descriptor is sent to the appropriate DCP. The DCP reads the message control codes and the first data character from main memory. Then the DCP signals the Multiline Control to connect the proper line to its character buffer and send the message character to the proper Line Adapter. This procedure is repeated for each message character until an end-of-message code is sensed.

When an incoming message arrives, the Line Adapter signals the DCP through the Multiline Control. The DCP initiates an input request interrupt, and the data handler routine of the Master Control Program directs the incoming characters to the main memory area that has been allocated to that line.

If teletypewriters were operating simultaneously at 10 characters per second on all of the 256 lines that can be connected to a DCP, Burroughs states that the DCP could easily handle the resulting arrival rate of one character every 400 microseconds. The actual peak-load message handling capacity of the DCP has not been defined to date.

.27 Simultaneous Operations

One data transfer operation on each installed B 6500/7500 data switching channel can occur simultaneously with internal processing. A B 6500/7500 system can have one or two I/O multiplexors, and each multiplexor can contain from 4 to 10 data switching channels. Thus, a maximum of 20 data transfer operations using "conventional" peripheral equipment (card readers, printers, magnetic tape units, disk files, etc.) can occur simultaneously. In addition, data communications operations can be handled on up to 2048 lines, connected as described in Paragraph .26, Data Communications.

I/O operations can be initiated only when the central processor is operating in the control state, and their execution will normally be directed by the Master Control Program. The processor initiates an I/O operation by sending a descriptor to the appropriate I/O multiplexor. (In dual-processor systems, either processor can initiate I/O operations.) The processor is then free to proceed independently while the multiplexor and the peripheral control unit direct the I/O operation. When the operation is complete, an interrupt is signaled and a result descriptor is made available to the processor. The result descriptor indicates any errors or other abnormal conditions.

Up to 20 peripheral controls can be connected to each I/O multiplexor. A peripheral control bus is used to transfer data between the multiplexor and the control units. Data in one- or

.27 Simultaneous Operations (Contd.)

two-byte groups, depending upon the control-unit buffer size, can be transmitted along the bus at the rate of one group every 1.2 microseconds. Thus, the maximum combined data rate for the I/O operations controlled by each multiplexor is 1,667,000 bytes per second.

Since each main memory module functions independently, up to four accesses to main memory can be made simultaneously by the central processor(s) and/or I/O multiplexor(s) in a system (provided that the data to be accessed is located in four different modules). One memory cycle is required for each word of 48 data bits that is transferred to or from main memory; this takes 1.2 microseconds for the core memory used with the B 6503, B 6504, and B 7504 Processors, and 0.6 microsecond for the thin-film memory used with the B 6506 and B 7506 Processors.

.3 SOFTWARE

B 6500/7500 software provided by Burroughs Corporation includes the Master Control Program, which oversees the system's operations; compilers for the ALGOL, COBOL, and FORTRAN languages; and a number of facilities oriented toward specific problems and applications. Burroughs expects to have the software ready when the first B 6500/7500 systems are delivered, in the first quarter of 1969. All of the software — like users' programs — is written in higher-level languages.

.31 Master Control Program (MCP)

The MCP is a comprehensive operating system that controls the scheduling, loading, and execution of every program that is run on a B 6500/7500 system. It consists of a group of routines that are organized in three-level hierarchical fashion.

At the first level is the central or "hard core" portion, which occupies a small area (less than 512 words) of main memory at all times. This routine fields the hardware signals generated by interrupt conditions and transfers control to the appropriate service routines.

At the second level is the resident portion of the MCP, which contains the routines that must be available at all times to handle resource allocation. These routines allocate main memory, secondary (disk) memory, input-output devices, processors, and time. The resident and central portions together occupy less than 4000 words of main memory.

At the third level are the MCP utility routines, which reside in disk memory and are brought into main memory only when required. Among the functions performed by these routines are file control, job scheduling, diagnostics, control card interpretation, and library maintenance. These routines are modular and have precisely defined interface requirements, so that users can easily alter the routines to meet their own requirements.

The MCP is designed to take advantage of the B 6500/7500's hardware capabilities for efficient operation in a multiprogramming mode, whether the system includes one or two processors. The MCP continually analyzes the list of scheduled jobs and determines the job sequence and combinations that will maximize the use of the available processing, memory, and I/O facilities. When new or higher-priority jobs are entered, the MCP automatically adjusts its schedule. Other important MCP functions include dynamic memory allocation, loading and initiation of program segments, initiation of all I/O operations, and communication with the system operator.

Among the key elements of the B 6500/7500 Master Control Program are:

- An executive routine, which: (1) coordinates MCP operations by determining the type of control routine required and transferring control to the appropriate routine; (2) supervises I/O operations and the execution of all program segments in main memory; and (3) maintains a log of system operations.
- A scheduling routine, which evaluates the priorities and equipment requirements of a batch of jobs and maintains a schedule that ensures effective system utilization.
- An environment control routine, which dynamically allocates main memory and assigns I/O devices in accordance with each job's requirements.
- An exception condition routine, which provides standard procedures for dealing with errors.

.32 Programming Languages and Compilers

Users of B 6500/7500 systems will normally do all of their programming in the ALGOL, COBOL, and/or FORTRAN languages. The hardware has been designed for efficient compilation and execution of programs written in these process oriented languages, and Burroughs has no plans to provide a symbolic assembly system. The feasibility of coding and debugging exclusively in the higher-level languages has been illustrated by several years of successful operation of the Burroughs B 5500, which offers the same programming languages (and no symbolic assembly system).

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.32 Programming Languages and Compilers (Contd.)

The ALGOL compiler for the B 6500/7500 will include all the facilities of B 5500 Extended ALGOL, which is a nearly complete implementation of ALGOL 60 with a number of useful machine-dependent extensions. In addition, B 6500/7500 ALGOL contains new facilities that permit string manipulation and separate compilation of individual sections of large programs. Certain restrictions of B 5500 ALGOL, such as segment size and up-level addressing, are eliminated in the B 6500/7500 version. Burroughs states that ALGOL compilation speed, using magnetic tape or disk input, will be upward of 10,000 card images per minute. ALGOL programs written for a B 5500 can be compiled on a B 6500/7500 system without alteration, except for programs in which ALGOL Stream Procedures are used to manipulate B 5500 descriptors (a non-standard programming technique).

FORTRAN for the B 6500/7500 will be compatible with IBM 7094 FORTRAN IV, Version 13, with USASI FORTRAN as a compatible subset. Instead of enforcing various restrictions of 7094 FORTRAN, the B 6500/7500 version will facilitate programming by allowing more generality. Burroughs states that FORTRAN compilation speed will be comparable to that of the ALGOL compiler (i.e., upward of 10,000 card images per minute).

The COBOL language for the B 6500/7500 will be based on COBOL-65. Special provisions will be made to accommodate B 5500 COBOL, which is a comprehensive implementation of the Department of Defense's COBOL-61 Extended. Burroughs expects to achieve COBOL compilation speeds in excess of 5000 card images per minute.

B 6500/7500 ALGOL enables the programmer to control all the hardware and software facilities of the system without resorting to machine or symbolic language. For all three compiler languages, program segmentation and peripheral device assignment are performed automatically, and special diagnostic statements facilitate debugging. When a program needs to be altered, the source deck is corrected and the program is recompiled. Thus, the source deck always accurately reflects the object program that is residing in disk memory.

.33 Problem Oriented Facilities

In addition to the MCP and the three compilers, Burroughs offers a number of software facilities designed for specific application areas. They can be summarized as follows:

- Advanced Mathematical Programming System — a modular system consisting of linear programming and current extensions such as pure and mixed integer programming, non-linear programming, decomposition, matrix generation, and report writing. A flexible control language will allow the user to govern the flow of solution strategies.
- Burroughs Applied Statistical Inquiry System (BASIS) — a software package that can perform a variety of statistical analyses on user-defined data files. The system is designed to simplify the interface between the statistician and the computer. This is achieved by the BASIS language, through which the user may specify the analysis to be performed, format and names of associated data files, options to be exercised, and reports to be generated. The language includes a dialogue capability to assist the remote terminal user in this communication process. In addition, user-supplied definitions, data files, and output reports may be stored and maintained with the BASIS library for future use.
- DYNAMO — a simulation technique, developed by the Massachusetts Institute of Technology, that translates mathematical models of "servo-mechanism" systems into tabulated and graphically plotted results. The models, expressed in the form of algebraic equations, may represent mechanical, biological, or social systems.
- SIMULA (Simulation Language) — an extension of ALGOL 60 that permits precise description of "discrete event" systems. Designed by the Norwegian Computing Center, Simula is currently being used for simulation and analysis of nerve networks, communications systems, traffic flow, production systems, etc.
- Burroughs Inventory Control System (BICS) — a complete analysis and management control system for inventory operations. The BICS System includes a time series analysis model for analyzing demand characteristics, a forecast method simulator for determining the best choice of simulation technique, and an inventory system simulator which allows management to evaluate investment, operating cost, and performance characteristics in inventory operations. The BICS System is written in COBOL.
- ACTION — a generalized inventory accounting and control system for manufacturers. ACTION accepts data describing significant manufacturing transactions, maintains and continually reviews inventory records and production schedules, issues material orders and reminders, and signals all variances from management standards.

.33 Problem Oriented Facilities (Contd.)

- PERT — a network analysis technique that facilitates the control of complex projects. Both PERT/COST and PERT/TIME will be provided for the B 6500/7500.
- Advanced Project Management Information System (PROMIS) — a software package designed to provide the communications vehicle through which projects can be planned and instrumented for control. Built on the data base concept, PROMIS allows simultaneous maintenance of many networks using different calendars, date options, and computation features. Random-access storage, data communications, and list processing techniques are employed to achieve fast response.
- Production Accounting System — a system designed to maintain job or lot control from the work floor, using remote input for real-time updating. Also included are facilities for material control, tool control, product configuration control, and machine and work center efficiency reporting.
- Advanced Information Management System — a data base system designed to provide a total systems approach to information problems through the use of disk files and data communications facilities. The system is designed to provide rapid responses to inquiries and to facilitate information exchange between the home office and field locations.

.4 COMPATIBILITY

The various B 6500 and B 7500 processor models will be program-compatible with one another, but they will not be compatible at the object-program level with the other current members of the "Burroughs 500 Systems" computer family (i.e., the B 2500, B 3500, B 5500, and B 8500). This means that recompilation will be necessary before a program written for another Burroughs computer can be run on a B 6500/7500 system, and vice versa.

At the source-language level, Burroughs plans to make the ALGOL, COBOL, and FORTRAN languages for the B 6500/7500 systems compatible with those for the B 5500, so that B 5500 programs can be recompiled and executed on a B 6500/7500 in straightforward fashion. Since all B 5500 programs are written in one of these three process oriented languages, this approach should make it fairly easy for B 5500 users to move up to a B 6500/7500.

On the important matter of B 6500/7500 compatibility with the IBM System/360, Burroughs has taken the same middle-of-the-road approach as in its smaller B 2500/3500 systems. There is no machine-language program compatibility between the B 6500/7500 and the System/360, but the data codes and most input-output media used in the B 6500/7500 are System/360-compatible. Thus, B 6500/7500 and System/360 installations should be able to interchange data files but not object programs.

BURROUGHS B 6500/7500

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (Basic System includes processor, system control, and desk console)			
	B6503		Basic System	9,200	386,400	375
	B6504		Basic System	11,600	487,200	395
	B6505		Basic System	11,800	495,600	415
	B7504		Basic System	16,200	680,400	435
	B7506		Basic System	16,600	697,200	455
			Second Processors			
	B6503-1		Processor	8,000	336,000	300
	B6504-1		Processor	9,000	378,000	320
	B6506-1		Processor	11,600	487,200	340
	B7504-1		Processor	16,200	680,400	360
	B7506-1		Processor	16,200	680,400	360
			Main Storage			
			Core Memory (1.2-microsecond cycle, for use with B 6503, B 6504, or B 7504 Basic System) (1)			
	B6001-2		98,304 Bytes Core Memory	4,000	192,000	90
	B6002-2		196,608 Bytes Core Memory	7,000	336,000	115
	B6003-2		294,912 Bytes Core Memory	9,800	470,400	160
	B6004-2		393,216 Bytes Core Memory	13,300	638,400	225
	B6005-2		491,520 Bytes Core Memory	16,900	811,200	275
	B6006-2		589,824 Bytes Core Memory	20,600	988,800	325
	B6007-2		688,128 Bytes Core Memory	25,100	1,204,800	390
	B6008-2		786,432 Bytes Core Memory	28,100	1,848,800	450
	B6010-2		983,040 Bytes Core Memory	34,000	1,632,000	565
	B6012-2		1,179,648 Bytes Core Memory	40,800	1,958,400	675
	B6016-2		1,572,864 Bytes Core Memory	51,900	2,491,200	890
	B6020-2		1,966,080 Bytes Core Memory	62,700	3,009,600	1,100
	B6024-2		2,359,296 Bytes Core Memory	73,200	3,513,600	1,325
	B6032-2		3,145,728 Bytes Core Memory	96,000	4,608,000	1,765
			Thin-Film Memory (0.6-microsecond cycle, for use with B 6506 or B 7506 Basic System) (1)			
	B6001-3		98,304 Bytes Thin-Film Memory	7,000	294,000	280
	B6002-3		196,608 Bytes Thin-Film Memory	11,500	483,000	330
	B6003-3		294,912 Bytes Thin-Film Memory	14,000	601,500	380
	B6004-3		393,216 Bytes Thin-Film Memory	18,300	783,000	430
	B6005-3		491,520 Bytes Thin-Film Memory	23,200	993,000	480
	B6006-3		589,824 Bytes Thin-Film Memory	27,400	1,174,500	535
	B6007-3		688,128 Bytes Thin-Film Memory	32,300	1,384,500	580
	B6008-3		786,432 Bytes Thin-Film Memory	36,500	1,566,000	630
	B6010-3		983,040 Bytes Thin-Film Memory	45,700	1,957,500	730
	B6012-3		1,179,648 Bytes Thin-Film Memory	54,800	2,349,000	830
	B6016-3		1,572,864 Bytes Thin-Film Memory	73,100	3,132,000	1,030
	B6020-3		1,966,080 Bytes Thin-Film Memory	91,400	3,915,000	1,230
	B6024-3		2,359,296 Bytes Thin-Film Memory	109,600	4,698,000	1,430
	B6032-3		3,145,728 Bytes Thin-Film Memory	146,200	6,264,000	1,830

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS AND CHANNELS			I/O Multiplexors and Channels			
	B6713		Multiplexor with 4 Data Switching Channels, for B 6503	2,800	117,600	140
	B6713-1		Additional Data Switching Channel	500	21,000	20
	B6714		Multiplexor with 4 Data Switching Channels, for B 6504	3,200	134,400	160
	B6714-1		Additional Data Switching Channel	550	23,100	25
	B6716		Multiplexor with 4 Data Switching Channels, for B 6506	3,200	134,400	160
	B6716-1		Additional Data Switching Channel	550	23,100	25
	B7714		Multiplexor with 6 Data Switching Channels, for B 7504	4,800	201,600	240
	B7714-1		Additional Data Switching Channel	650	27,300	30
	B7716		Multiplexor with 6 Data Switching Channels, for B 7506	4,800	201,600	240
	B7716-1		Additional Data Switching Channel	650	27,300	30
MASS STORAGE			Disk Storage			
	B9372-1		10 Million Bytes, 20 msec	850	44,000	115
	B9372-7		20 Million Bytes, 23 msec	1,200	57,600	125
	B9375-0		100 Million Bytes, 23 msec	4,950	237,600	595
	B9376-0		Additional 20 Million Byte Increment, 23 msec	900	45,600	110
	B9375-2		100 Million Bytes, 40 msec	3,950	224,200	495
	B9376-2		Additional 20 Million Byte Increment, 40 msec	700	44,840	85
	B9375-3		100 Million Bytes, 60 msec	2,700	129,600	395
	B9376-3		Additional 25 Million Byte Increment, 60 msec	450	28,800	85
	B9371-1		Disk File Electronic Unit for B 9372-1	650	31,200	80
	B9371-2		Disk File Electronic Unit for B 9372-7	650	31,200	80
	B9371-3		Optional Additional DFEU for B 9375-O/B 9376-0	650	31,200	80
	B9371-4		Optional Additional DFEU for B 9375-2/B 9376-2	650	31,200	80
	B9371-5		Optional Additional DFEU for B 9375-3/B 9376-3	650	31,200	80
	B6373		Disk File Control (1)	400	16,800	20
	B6471-1		Disk File Exchange; 1 x 2 (1)	100	4,200	10
	B6471-2		Disk File Exchange; 2 x 5 (1)	200	8,400	10
	B6471-4		Disk File Exchange; 4 x 10 (1)	350	14,700	10
	B6674		Exchange Adapter for B6471-2 (1)	10	420	2
	B6675		Exchange Adapter for B6471-4 (1)	15	630	2
INPUT-OUTPUT			Magnetic Tape			
			Tape Clusters:			
	B9381-2		36KB Cluster; 2 drives	900	43,200	200
	B9381-3		36KB Cluster; 3 drives	1,100	52,800	230
	B9381-4		36KB Cluster; 4 drives	1,300	62,400	260
	B9382-2		72KB Cluster; 2 drives	1,100	52,800	225
	B9382-3		72KB Cluster; 3 drives	1,400	67,200	260
	B9382-4		72KB Cluster; 4 drives	1,700	81,600	295
	B9383-2		9/25/36KC Cluster; 2 drives	900	43,200	200
	B9383-3		9/25/36KC Cluster; 3 drives	1,100	52,800	230
	B9383-4		9/25/36KC Cluster; 4 drives	1,300	62,400	260
	B6381-1		36KB Cluster Control (1)	400	16,800	15
	B6381-2		72KB Cluster Control (1)	450	18,900	15
	B6381-3		9/25/36KC Cluster Control (1)	400	16,800	15
	B6480		Cluster Exchange; 7-track, 2 x 8 (1)	200	8,400	10
	B6481		Cluster Exchange; 9-track, 2 x 8 (1)	200	8,400	10
	B6681		200-bpi Adapter for B6381-1 Control	25	1,050	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
			Free-Standing Magnetic Tape Units:			
	B9391		18/50/72KC Magnetic Tape Unit	575	27,600	165
	B9392		72 KB Magnetic Tape Unit	575	27,600	165
	B9393		144KB Magnetic Tape Unit	650	31,200	175
	B9394-1		24/66/96KC Magnetic Tape Unit	650	31,200	170
	B9394-2		96KB Magnetic Tape Unit	650	31,200	170
	B6391-3		18/50/72KC Magnetic Tape Control(1)	500	21,000	15
	B6391-4		24/66/96KC Magnetic Tape Control(1)	550	23,100	15
	B6393-1		72KB Magnetic Tape Control(1)	500	21,000	15
	B6393-2		144 KB Magnetic Tape Control(1)	600	25,200	15
	B6393-3		96 KB Magnetic Tape Control(1)	550	23,100	15
	B6490		Tape Exchange; 2 x 10(1)	250	10,500	10
	B6492		Tape Exchange; 4 x 16(1)	450	18,900	20
	B6691		200 bpi Adapter for B 6393-1 Control(1)	25	1,050	5
	B6692		200 bpi Adapter for B 6393-3 Control(1)	25	1,050	5
			Punched Card			
	B9111		Card Reader (800 cards/min.)	325	16,250	83
	B9112		Card Reader (1400 cards/min.)	450	21,600	126
	B6110		Card Reader Control(1)	100	4,200	16
	B9916		Validity Check Switch and Indicator (for B 9111 or B 9112)	5	240	2
	B9213		Card Punch (300 cards/min.)	530	25,440	135
	B6210		Card Punch Control(1)	100	4,200	15
	B6610		BCL-BCL Code Translator for B6210(1)	15	630	5
	B9910		Card Counter	5	240	0
			Paper Tape			
	B9120		Paper Tape Reader (500-1000 char/sec)	300	16,000	70
	B6120		Paper Tape Reader Control(1)	100	4,200	16
	B9926		Input Code Translator	145	6,960	10
	B9220		Paper Tape Punch (100 char/sec)	260	15,300	65
	B6220		Paper Tape Punch Control(1)	100	4,200	16
	B9928		Output Code Translator	130	6,850	10
			Printers			
	B9242		Printer (815 lines/min., 120 positions)	850	48,000	180
	B9243		Printer (1040 lines/min., 120 positions)	950	53,500	200
	B6240		Printer Control(1)	150	6,300	16
	B9940		High Speed Slew feature	60	3,000	20
	B9941		Additional 12 Print Positions	40	2,000	10
	B9949		Powered Forms Stacker	25	1,200	5
	B9342		Console Printer and Keyboard	55	2,640	15
	B6340		Console Printer Control (1)	150	6,300	15
COMMUNI-CATIONS			Input and Display Subsystems			
	B9351-1		Control I - Single Input and Display/Location	215	9,460	27
	B9351-2		Control II - Multiple Input and Displays and/or Controls/Location	325	14,300	27
	B9351-3		Control IIA - Maximum of 3 with Multiplexor and Control II	100	4,400	20
	B9351-4		Monitor	60	2,640	10
	B9351-5		Alphanumeric Keyboard	20	880	3
	B9351-6		Input and Display Printer	45	1,980	10
	B9351-7		Remote Communications Adapter	35	1,540	3
	B9351-8		Simplexor	15	660	7
	B9351-9		Multiplexor	50	2,200	11
	B9351-10		Multiplexor Extension	50	2,200	7
	B9951-1		Input and Display Printer Adapter	30	1,320	3
	B9951-2		Insert/Delete - Character/Line	15	660	3

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Input and Display Subsystems (Contd.)			
	B9951-3		Controlled Format	20	880	3
	B9951-4		Variable Tab Position	5	220	1
	B9951-5		Programmatic Cursor Positioning	5	220	1
			Data Communications Controls			
	B6350		Data Communications Processor (1)	900	43,200	110
	B6350-1		Multiline Control; 16-line increment (1)	100	4,800	10
			Communications Line Adapters			
	B6651		Typewriter Inquiry Station (1)	30	1,440	6
	B6652		TWX/Remote Typewriter (1)	30	1,440	6
	B6653		B 2500/B 3500 (2400 bits/second) (1)	50	2,400	10
	B6654		UNIVAC DCT 2000 (1)	85	4,080	17
	B6655		IBM 1050 (1)	60	2,880	12
	B6657		Model 35 or 8A1 Selective Calling Service (1)	30	1,440	6
	B6659-1		Input and Display - Direct Connect (Multi-wire) (1)	50	2,400	10
	B6659-2		Input and Display - Data Set (1200 bits/second) (1)	50	2,400	10
	B6659-3		Input and Display - Data Set (2400 bits/second) (1)	50	2,400	10
	B6660		B 300/B 5500 (2400 bits/second) (1)	50	2,400	10
	B6661		Honeywell 120 (1)	85	4,080	17
	B6662		Model 28/83B3 (1)	40	1,920	10
	B6669-1		Automatic Dial Out (1)	20	960	5
			Remote Devices			
	B9350		Typewriter Inquiry System	55	2,640	12

NOTES:

(1) The units listed are for use in B6500 systems; the corresponding unit for use in B7500 systems has "7" as its initial digit in place of "6". For example, the B6373 Disk File Control is used in B6500 systems; the corresponding unit for B7500 systems is the B7373 Disk File Control.

REPORT UPDATE

▶ BURROUGHS ANNOUNCES NEW DATA PROCESSING SYSTEM

The B500 System, an extension of the B100/200/300 Series, has been announced by Burroughs Corporation. Bridging the gap between the B300 and the B2500, the main market of the B500 centers on the high end of the small computer field, its main competitors being the IBM 360/20 and the Honeywell H-120. First deliveries are promised for the fourth quarter of 1968.

Programs written for the B300 are compatible on an assembly-language and object level with the B500. Since the capacity to handle COBOL is offered on the B500, however, some source language compatibility is offered. The threshold user who confines his programmers to higher-level business languages may later grow into the B2500/3500 systems, or other machines of higher power, without painful reprogramming.

Built around the B300 Central Processor, the B500 offers a 6-microsecond memory cycle time, with main core memories from 9,600 to 19,200 characters. New peripherals announced for the B500 include the B9370-5 Systems Memory — a version of the head-per-track disk file storage unit used on the B2500/3500 systems. The B9370-5 has an average access time of 23 milliseconds, and a capacity of 2.4 million 6-bit characters arranged in 240-character segments. The B9245-2 and B9245-3 are low-cost low-speed line printers: 315 lines per minute, 64 character set, with 120 and 132 print positions respectively. Each printer is fully buffered. Print characters are repeated 3 times around a continuous chain, and individual type slugs may be changed.

The following 7-channel Magnetic Tape Cluster Units are also available:

- B9384-3, 3-Station, 9-25 KC (200, 556 BPI)
- B9384-4, 4-Station, 9-25 KC (200, 556 BPI)
- B9380-2, 2-Station, 9-25-36 KC (200, 556, 800 BPI)
- B9380-3, 3-Station, 9-25-36 KC (200, 556, 800 BPI)
- B9380-4, 4-Station, 9-25-36 KC (200, 556, 800 BPI)

Still another low-cost B500 peripheral is the B9131-1 MICR document Sorter-Reader, a slower version of the document handler offered with the B2500/3500 systems (1200 DPM at a rental of $1,200/month versus the original 1,565 documents at $1,900/month).

The following rental/price structure applies to a typical small magnetic tape configuration:

	Monthly Rental*	Purchase Price
Central Processor (9.6K)	$1,015	$51,450
200 CPM Reader	175	8,400
100 CPM Punch	350	18,425
315 LPM Printer (120 print positions)	500	24,000
3 Station Cluster (25KC)	950	45,600
Magnetic Tape Control	50	2,880
	$3,040	$150,755

A basic B500 using Systems Memory would rent for $4,635 per month with a purchase price of $233,910.

*176-Hour, One-year lease.

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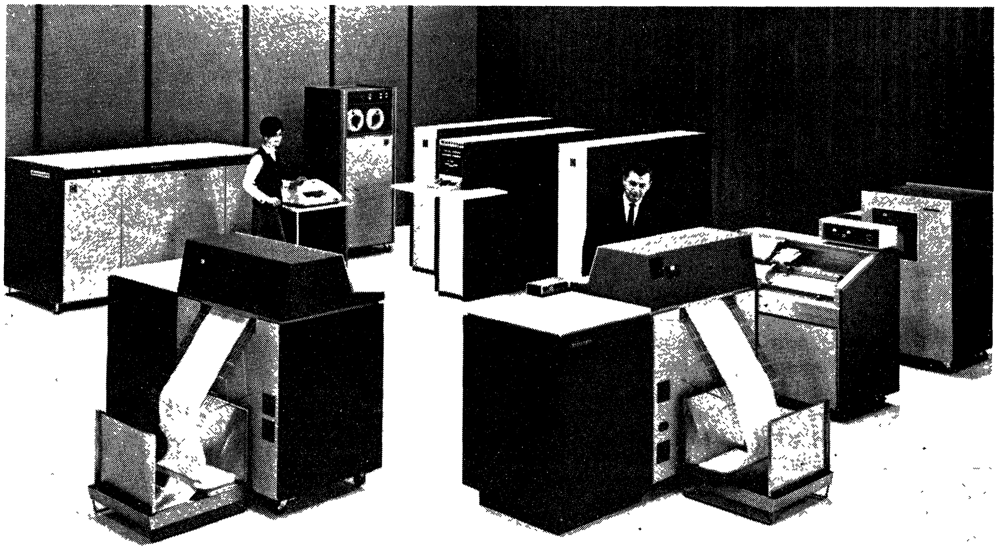
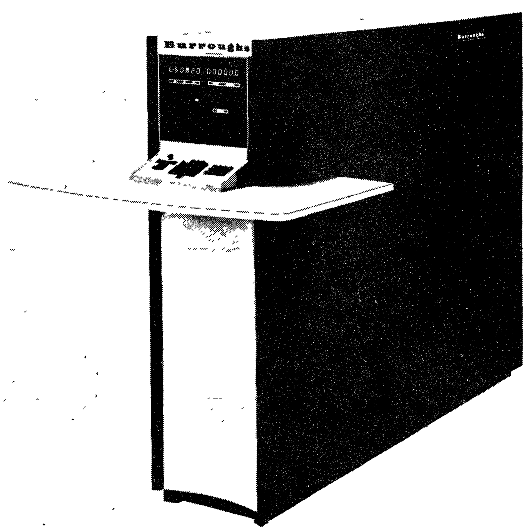
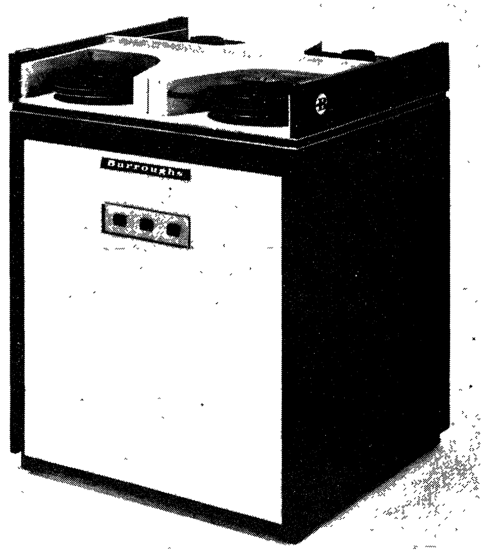


A medium-sized B 3500 random-access system with three modules of Disk File storage and two on-line printers.



The B 2500/3500 Central Processor features digital displays of register contents (Section 210:061).



This Clustered Magnetic Tape Unit contains four independent tape transports (Section 210:092).

SUMMARY

.1 SUMMARY

The B 2500 and B 3500 systems constitute Burroughs Corporation's current entry in the small-scale computer sweepstakes. The two systems are definitely "third generation" in their use of monolithic integrated circuits, and read-only memory. Their processing power in business applications is impressive in terms of both internal speed and simultaneity. Moreover, Burroughs is placing a uniuqely strong emphasis upon multiprogrammed operation — and is supplying the hardware and software required to make multiprogramming (which Burroughs calls "multiprocessing") a practical reality.

Announced in March 1966, the B 2500/3500 systems were delivered to initial customers in August 1967. Announced software was delivered concurrently with the first installations. Typical lease prices will range from about $4, 200 per month for a small B 2500 tape system to $20, 700 per month for a large B 3500 system with 100 million bytes of disc storage and 8 tape units.

The B 2500 and B 3500 are fully program-compatible with one another. The few significant differences between the two systems are in internal speed (the B 3500 is twice as fast), maximum number of I/O channels (8 for the B 2500 and 20 for the B 3500), and maximum core memory capacity 120, 000 bytes for the B 2500 and 500, 000 bytes for the B 3500.

On the important matter of compatibility with the IBM System/360, Burroughs has taken a middle-of-the-road approach. There is no machine-language program compatibility between the B 2500/3500 and the System/360, but the data formats, codes, and virtually all input/output media used in the B 2500/3500 are System/360-compatible. Thus, B 2500/3500 and System/360 installations will be able to interchange data files but not programs.

Software support for B 2500/3500 systems is divided into two levels, Basic and Advanced. Each level is designed for use with a separate operating system. An assembler, sort generator, and report generator are provided at each level. COBOL and FORTRAN compilers, however, are offered only at the Advanced level. Compilers for the ALGOL and PL/I languages have not been announced to date.

At the Basic software level — intended for small configurations — the Basic Control Program controls simple stacked-job processing and straightforward I/O operations. Systems equipped with disc storage and at least 30, 000 bytes of core memory will usually use the Advanced software. At this level the Master Control Program schedules and controls multiprogrammed operations and performs many other functions usually found only in the operating systems for much larger computers.

.11 The Burroughs 500 Systems

The B 2500 and B 3500 form the lower end of the "Burroughs 500 Systems" computer family, which currently includes three larger members: the B 5500, B 6500, and B 8500. Although all five systems utilize many of the same peripheral devices and design concepts, there is no machine-language program compatibility between the B 2500/3500 and the larger members of the family.

The Burroughs B 5500 (Report 203:) is a medium-scale computer of highly unorthodox design. In use since 1963 it has demonstrated the practicality of multi-programmed operation and of programming and debugging exclusively in higher-level languages (ALGOL, COBOL, and FORTRAN). As a result, more than twise as many B 55 systems were ordered during 1966 as during 1965.

The B 6500, announced in June 1966 and scheduled for delivery in late 1969, is a third-generation version of the B 5500. Using integrated circuits and a thin-film main memory, the B 6500 will provide about eight times the processing power of the B 5500, while maintaining program compatibility with it and using the same software.

The B 8500 is an ultra-large-scale computer with extensive capabilities for modular expansion, multiprogramming, and multiprocessing. The B 8500 was announced nearly two years ago, but only two orders have been placed to date.

Although the B 2500 and B 3500 are distinctly more conventional in design than the B 5500 and B 8500, it is apparent that their designers have borrowed certain important concepts from the larger Burroughs systems. These key concepts include operation under an integrated Master Control Program, emphasis upon multiprogrammed operation, and use of "stacks" to store subroutine parameters.

.2 DATA STRUCTURE

The B 2500 and B 3500 provide facilities for convenient handling of variable-length fields composed of either 8-bit bytes or 4-bit digits. Core memory is addressable by digit position. The basic unit of data, however, is the "word," which consists of 16 data bits plus one parity bit and is the amount of information that can be read from or written into core memory during each cycle. A word can hold either two 8-bit bytes or four 4-bit digits. Operand lengths can range from 1 to 100 digits or bytes, or up to 10,000 words, depending upon the operation being performed.

Data represented in the 4-bit format can be either signed (with a 4-bit sign digit preceding the most significant numeric digit of the field) or unsigned. Data in the 8-bit format is always unsigned, but all-numeric fields represented in the 8-bit mode can be used as operands in fixed-point arithmetic operations without the need (as in the IBM System/360) for prior conversion to the 4-bit digit mode.

Floating-point numbers have 2-digit exponents and variable-length mantissas of 1 to 100 digits. Instructions can consist of one, two, three, or four 6-digit "syllables" or a single 8-digit syllable.

As in the System/360, data can be represented internally in either of two codes, EBCDIC or ASCII, depending upon the setting of a mode flip-flop in the processor. A Translate instruction uses a table in core memory to accomplish efficient translations from any 4-bit or 8-bit code to any 8-bit code.

A hardware translator provides automatic translations between the EBCDIC internal code and the 6-bit BCL (Burroughs Common Language) code that can be used by the punched card, paper tape, and 7-track magnetic tape I/O devices. The 6-bit BCD code used by the IBM 1400 Series computers is, in turn, a subset of the BCL code. Thus, the hardware translator facilitates achieving code compatibility with earlier Burroughs and IBM equipment.

.3 HARDWARE

.31 System Configuration

The B 2500 "central system" consists of a 2501 or 2502 Central Processor and one combined input/output and memory cabinet. Core memory capacity can range from 10,000 to 120,000 bytes in 10,000-byte increments. Four I/O channels (two Type A and two Type B) are included in the basic system; a total of up to eight channels can be installed, five of which can be Type B.

The B 3500 "central system" consists of a 3501 Central Processor, one or two input/output cabinets, and from one to six memory cabinets. Core memory capacity can range from 10,000 to 500,000 bytes in 18 different sizes. Six I/O channels (three Type A and three Type B) are included in the basic system; a maximum of 14 additional channels (seven Type A and seven Type B) can be installed.

Floating-point arithmetic is available as an optional feature for both central processors. A standing and a desk-style console unit are offered, one of which is a system prerequisite.

The operations of all peripheral devices are directed by I/O control units. One I/O control can be connected to each B 2500 or B 3500 I/O channel, and each type of peripheral device requires a different I/O control. Most of the I/O controls (card reader, punch, printer, paper tape, etc.) can accommodate only one peripheral unit each, but the controls for magnetic tape and disc storage devices can accommodate multiple units, as explained in the descriptions of these devices. Further flexibility in the control of magnetic tape and disc operations is provided by a series of Exchange units, which permit a group of tape or disc units to communicate with the central processor via either of two or more I/O control units and the associated I/O channels.

The two types of I/O channels differ in their modes of communication with the processor and, therefore, in the data rates they can accommodate. Type A channels transfer only one character at a time to or from core memory and are limited to handling low-speed peripheral devices such as card readers and punches. Type B channels transfer two characters in parallel to or from core memory and can handle the faster peripheral devices such as magnetic tape and disc units.

.32 Central Processors

The central processors used in B 2500 and B 3500 systems are functionally identical and completely program-compatible; they differ only in internal speeds, as shown in Table I. The processor contains the arithmetic unit, logic controls, and hardware interrupt facilities. No facilities for multiple-processor configurations have been announced to date.

(Contd.)

TABLE I: ARITHMETIC EXECUTION TIMES

TASK (Times expressed in microseconds)	Central Processor Model	
	B 2500	B 3500
Fixed Point Binary	not avail.	not avail.
Fixed Point Decimal		
c = a + b	75	37.5
b = a + b	66	33
c = a x b	416	208
c = a/b	1,810	905
Floating Point Decimal*		
c = a + b	102	51
c = a x b	463	231.5
c = a/b	1,861	930.5
Move a to b	54	27
Compare a to b	60	30

*With optional feature.

Note: All operand lenths are considered to be five digits in length. (Therefore, floating-point mantissas are considered to have a precision of five digits.)

.321 Instruction Formats

There are two basic types of instructions: I/O instructions (called "descriptors") and processor instructions. I/O descriptors vary from one to four 6-digit "syllables" in length, and are discussed in Paragraph .35. Processor instructions may be one, two, three, or four 6-digit syllables in length and may contain — respectively — zero, one, two, or three core memory addresses. (Branch instructions are eight digits in length, and therefore constitute an exception to the normal instruction format.)

The first two 4-bit digits of a processor instruction designate the operation code and initiate execution of the appropriate string of microprograms stored in the system's Read-Only Memory, a resistive-type memory with a 100-nanosecond access time. These microprograms fetch the remainder of the instruction and perform the specified operation.

In most instructions, the third, fourth, fifth, and sixth digits of the first syllable specify the lengths of the A and B operands, which can range from 1 to 100 digits or bytes, or up to 10,000 words (depending upon the operation).

In multi-syllable instructions, the second, third, and fourth syllables (when present) specify the A-field, B-field, and C-field addresses, respectively. The first digit of each address syllable specifies: (1) which, if any, of three index registers shall be used in forming the machine address, and (2) the format of the data field. Each program has its own complement of three 8-digit index registers, which are held in reserved locations in core memory. There are four format possibilities: signed 4-bit, unsigned 4-bit, unsigned 8-bit, or indirect address (which means that the data field's address, rather than the data field itself, will be found in the memory location specified by the address syllable). The remaining five digits of each address syllable specify the data field address itself.

In many instructions, the second syllable may contain a literal operand rather than the A-field address. Literal operands are limited to a maximum length of three bytes (or six digits).

All addresses in processor instructions are "base-relative." This means that each program is written as if it started in the first location of core memory. At execution time, each address is automatically incremented by the contents of a three-digit, modulo-1000 base register to form an absolute address (which can be further modified by indexing if desired). The base-relative addressing technique facilitates program relocation and segmentation; it also permits up to 1 million digits (500,000 bytes) of core memory to be addressed although the instruction addresses are only five digits long.

.322 Processing Facilities

The instruction repertoire includes efficient facilities for arithmetic, data movement, comparison, and editing of variable-length decimal and alphanumeric data fields. No binary arithmetic facilities are available, although logical AND, inclusive OR, and

.322 Processing Facilities (Contd.)

exclusive OR instructions are provided. Fixed-point decimal arithmetic instructions include three-address addition, subtraction, multiplication, and division, as well as two-address addition and subtraction. The optional Floating-Point feature provides three-address instructions to add, subtract, multiply, and divide floating-point operands with 2-digit exponents and mantissas varying from 1 to 100 digits in length. Representative execution times are shown in Table I.

A novel feature of the new Burroughs processors is their ability to combine numeric operands in the 4-bit and 8-bit data formats in a single operation, without prior transformation. The programmer can specify the format in which the results of such mixed-format operations shall be expressed: signed 4-bit, unsigned 4-bit, or 8-bit.

A group of Scan instructions facilitates the coding of search operations by enabling the programmer, by means of a single instruction, to search a string of up to 100 characters for the presence (or absence) of a specified character or group of characters. In addition, table look up operations are facilitated by the Search instruction. A Translate instruction effects translations from any 4-bit or 8-bit code to any 8-bit code through the use of a table in core memory. The Edit instruction moves up to 100 characters or digits from a source field to a destination field under the control of a string of "micro-operators" in core memory, which can specify that any character shall be inserted, suppressed, or floated under a variety of conditions. This flexible instruction permits normal dollar-and-cent punctuation and either floating dollar sign or check protection to be accomplished in a single operation.

Two special instructions, Enter and Exit, facilitate entry to and exit from subroutines, especially when the subroutines are used in nested or recursive fashion. The Enter instruction causes return control information and subroutine parameters to be moved into the "stack," which is a core memory area that has been reserved by the programmer. If another subroutine is entered prior to exit from the first subroutine, additional return control information and parameters will be moved into the stack, causing the previously-stored parameters to be "pushed down" deeper into the stack. Thus, subroutines can be nested or used recursively to any level up to the capacity of the stack.

.323 Operational States

The central processor always operates in one of two states: the Normal State, in which user programs are executed, or the Control State, in which the functions of the MCP or BCP operating systems are performed. Several "privileged" instructions can be executed only in the Control State. These instructions permit the MCP or BCP to initiate I/O operations and to control the program mix by setting and clearing registers and flip-flops.

A powerful interrupt system causes the processor to enter the Control State and branch to the MCP or BCP whenever any of the following conditions occurs: completion of an I/O operation, memory parity error, memory address error, invalid instruction (including attempted execution of a privileged instruction in the Normal State), instruction time out (failure to complete the execution of an instruction within a preset time limit), and clock interrupt. Memory address errors can result from the formation of an address beyond the bounds established by the base and limit register settings, a non-decimal digit in an address, or a "non-synchronized" address (i.e., an address that is not modulo-2 or modulo-4 when a particular instruction or data format requires such an address). A clock interrupt occurs when the processor's six-digit timer, which is incremented once each millisecond, reaches a programmer-specified control value.

Memory protection — an essential feature for successful multiprogramming — is provided by the hardware, using the base and limit registers and the interrupt system. When the MCP initiates execution of a program, it sets the base register to the program's initial core memory location. The limit register's setting is made equal to the base register setting plus the total core memory requirement for the program. Before data is fetched, all machine addresses are checked against the base and limit register settings. An out-of-bounds address causes an interrupt and a transfer of control to the MCP, which suspends execution of the offending program.

.33 Internal Storage

.331 Core Memory

Core memory cycle times are two microseconds in the B 2500 and one microsecond in the B 3500. Read access times are 700 nanoseconds and 350 nanoseconds, respectively. Both processors access one word, consisting of 16 data bits plus one parity bit, per cycle. Because core memory is addressable by digit position and each word can hold four digits, all word addresses are modulo-4. Whenever a specific digit or byte position is addressed, the entire word in which it is located is accessed. Data can be transferred to or from core memory by either the central processor or any of the I/O control units

(Contd.)

.331 Core Memory (Contd.)

B 2500 core memory capacities can range from 10,000 to 120,000 bytes in increments of 10,000 bytes (i.e., 5,000 words). B 3500 memory capacities can range from 10,000 to 500,000 bytes in 18 different sizes; see the Price Data section (210:221) for the available capacities and the associated model numbers.

The first 1,220 digit positions of core memory are reserved for use by certain processor instructions, the interrupt system, the I/O control units, and the Master Control Program (when used). In addition, the first 64 digit positions of the core area assigned to each program are usually reserved to hold that program's index registers and other specific information.

To prevent accidental over-writing of one program by another during multiprogrammed operation, each core memory address is checked to ensure that it lies between the boundaries established by the base register and the limit register. If not, the program is interrupted and control is transferred to the Master Control Program.

.332 Address Memory

The B 2500 and B 3500 Central Processors contain an Address Memory unit with a 100-nanosecond cycle time. Address Memory is an array of from 24 to 120 word locations, expandable in increments of 12 words. Each word is six 4-bit digits in length — long enough to hold the absolute address of any core memory location. Address Memory's purposes are to reduce the number of core memory accesses required and to perform a number of functions that usually require separate processor registers. The first eight words are used by the processor, and two words are assigned to each installed I/O channel. The I/O channel words contain the initial and final core memory addresses for the I/O operation in progress on the associated channel; these words are used by the I/O control units to determine the core memory locations where output data is to be accessed or input data stored.

.34 Disk File Storage

Burroughs offers several versions of its head-per-track Disk Files for use in B 2500/3500 systems. These devices have proved to be among the fastest and most reliable mass storage units currently available. (No storage equipment of the interchangeable-cartridge type is offered at present.)

.341 Systems Memory

Burroughs' 9370 Systems Memory is a new, single-disc storage unit designed to provide, at a fairly low cost, the random-access storage required to hold the systems software and the user's program library. As in Burroughs' larger Disk Files, one read/write head serves each track, so no access-arm movement is required. Average access time is 17 milliseconds, and the peak data transfer rate is 291,000 bytes per second.

Two models of Systems Memory are offered. Model 9370-1 uses only one face of the disc and has a capacity of 1,000,000 bytes; Model 9370-2 uses both disc faces and holds 2,000,000 bytes. There are 100 data tracks per disc face. Each track is divided into 100 segments, and each segment holds 100 bytes (or 200 digits) of information. A longitudinal parity character is recorded at the end of each segment. Systems Memory is connected to a B 2500 or B 3500 Processor by means of a Systems Memory I/O Control. Two Systems Memory units can be connected to a single I/O Control by adding a Systems Memory Exchange.

.342 Modular Random Storage

The Modular Random Storage subsystem is similar to the Disk Files that have been in use for several years in second-generation Burroughs systems. The use of a fixed read/write head for every data track provides fast access times (20 milliseconds average) and high reliability. Average data transfer rate is 218,000 bytes per second. The Disk File Subsystem is compatible with the 9370 Systems Memory in segment size (100 bytes) and addressing structure, so either unit can be used to hold the systems software and program library.

The Modular Random Storage subsystem is composed of 9371 Electronics Units and 9372 Disk File Modules. Each 9372 Disk File Module contains four non-removable discs and holds 10 million bytes. From one to five 9372 Modules can be connected to a 9371 Disk File Electronics Unit, providing up to 50 million bytes of storage. Disk File Exchanges permit up to twenty 9371 Electronics Units and the associated Disk File Modules to be connected to from one to four Disk File I/O Controls. Among the available Exchanges are those designated 1 x 5, 2 x 5, and 4 x 10; the first number is the maximum number of Controls and the second is the maximum number of Electronics Units that can be interconnected. Since each I/O Control is connected to a separate channel, the 2 x 5 and 4 x 10 Exchanges, in effect, provide "floating" I/O channels and two-way or four-way simultaneity for Disk File operations.

.343 Data Memory Banks

The recently-announced Disk File Data Memory Banks will use the same head-per-track technique to provide even larger storage capacities at lower costs per byte. Models 9375-0, 9375-2, and 9375-3 will provide average access times of 23, 40, and 60 seconds, respectively. All three models have a basic storage capacity of 100 million bytes and can be expanded in modest increments to a maximum of 500 million bytes per I/O channel in B 2500 systems and 2.5 billion bytes per channel in B 3500 systems.

.35 Input-Output Equipment

Burroughs offers three card readers, two card punches, a paper tape reader and punch, four line printers, a tape lister, and three MICR Sorter/Readers for use with B 2500 and B 3500 systems. Except for certain difference in codes, all of these units are similar to previous Burroughs peripheral units used with B 100/200/300 Series and B 5500 systems. Newly-developed I/O equipment includes the Magnetic Tape Clusters (Paragraph .356) and several data communications devices (Paragraph .359).

.351 Card Readers

The 9110 Card Reader is a compact unit that reads standard 80-column cards photoelectrically, in column-by-column fashion, at a peak speed of 200 cards per minute. An immediate-access clutch permits the reading of an 80-column card to be completed within a maximum of 350 milliseconds after a "start feed" signal is received. The input hopper and output stacker have a capacity of 450 cards each.

The 9111 Card Reader uses an immediate-access clutch, a belt drive mechanism, and 13 photoelectric read cells (one for timing) to read cards of 51, 60, 66, or 80 columns at a peak rate of 800 cards per minute. The input hopper and output stacker can each hold up to 2400 cards and can be loaded and unloaded while the reader is operating. Optional features permit 40-column Treasury Checks or the round holes in Postal Money Orders to be read.

The 9112 Card Reader has a peak reading rate of 1400 cards per minute. Its appearance and physical characteristics are the same as those of the 9111 Card Reader described above.

All three card readers can read either the EBCDIC or the generally similar BCL (Burroughs Common Language) card code and translate it automatically to EBCDIC internal code. Binary card images can be read and stored in memory without conversion; the contents of each card column are stored in the six low-order bit positions of two consecutive bytes.

.352 Card Punches

The 9210 and 9211 Card Punches have been replaced by the 9212 and 9213 respectively. The 9212 Card Punch can punch standard 80-column cards at a peak rate of 100 cards per minute. Cards are punched one row at a time by a single row of 80 die punches. Punching accuracy is checked by the hole-count method.

The 9213 Card Punch punches 80-column cards, in row-by-row fashion, at a peak rate of 300 cards per minute. Punching accuracy is checked by the hole-count method.

Both Card Punches have 1000 card input hoppers and three program selectable output stackers that hold up to 1200 cards. The three stackers are: primary, auxiliary and error.

Both card punches can perform automatic translations from the EBCDIC internal code to EBCDIC card code. Alternatively, binary cards can be punched; the contents of the six low-order bit positions of two consecutive bytes of core memory are accessed and punched into each card column. A standard feature in the Card Punch Control permits automatic translation from EBCDIC internal code to the 64-character BCL (Burroughs Common Language) code, or optionally to the BULL or ICT card code.

.353 Paper Tape Units

The 9120 can read punched tape with 5, 6, 7, or 8 code levels at a peak speed of either 500 or 1,000 characters per second. Rated start and stop times are 5 and 20 milliseconds, respectively, and the reader can stop between consecutive characters. A standard plugboard permits the bit configurations read from tape to be interchanged and/or inverted. Automatic translation from either 5-level Baudot or 6-level BCL tape code to EBCDIC internal code is standard. For other punched tape codes, users can either add the optional 9926 Input Code Translator, which provides flexible code conversions under plugboard control, or read the tape codes directly and use programmed translation.

The 9220 can punch 5-, 6-, 7-, or 8-level tape at a peak speed of 100 characters per second. A standard plugboard permits the bit configurations from core memory to be interchanged and/or inverted prior to punching. Automatic translation from EBCDIC

(Contd.)

.353 Paper Tape Units (Contd.)

internal code to either 5-level Baudot or 6-level BCL tape code is standard. For other punched tape codes, either programmed translation or the optional 9928 Output Code Translator can be employed.

.354 Line Printers

Four line printers are available for use with B 2500 and B 3500 systems. Users can choose a buffered printer with a peak speed (at single spacing) of either 315 lines per minute, or an unbuffered model with a printer memory option with a peak speed of either 800 or 1100 lines per minute. Table II lists the peak printing speeds and skipping speeds of the four models.

Both B 9242-1 and B 9243-1 have 120 print positions, with 12 additional positions available through use of the 9941 option. All models use the 64-character Burroughs Common Language character set. (Other character sets are available on a special-order basis.) Forms can be from 5 to 20 inches in width and can have a maximum length of 22 inches (when printing at 6 lines per inch) or 16.5 inches (at 8 lines per inch). Vertical format control is provided by a 12-level carriage control tape loop.

B 9245-2 and B 9245-3 printers have 120 and 132 print positions respectively. Forms can be 4 to 18.5 inches in width and can have a maximum length of 22 inches. Vertical format control is provided by a four-channel punched format tape.

TABLE II: LINE PRINTER SPEEDS

Model No.	Peak Printing Speed, lines/minute	Skipping Speed, inches/second	Buffer
B 9245-2	315	16.5 (minimum)	Yes
B 9245-3	315		Yes
B 9242-1	860	25 (75 with option)	optional
B 9243-1	1100	25 (75 with option)	optional

.355 9244 Tape Lister

The Burroughs Tape Lister is designed primarily to provide high-speed printed listings of MICR documents as they are read by a MICR Sorter-Reader. From 6 to 18 listing tapes can be individually advanced and printed upon, enabling the contents of each Sorter-Reader pocket to be listed on a separate tape. The six-tape 9244-1 master unit can be used alone, or one or two six-tape 9244-2 slave units can be connected to it.

The peak printing rate of 1565 lines per minute can be maintained when printing is restricted to a 16-character set (the digits 0-9 and six special symbols). When the full, alphanumeric set of 40 characters is used, the rated speed is 600 lines per minute. Printing is performed on 2.5-inch-wide, single-ply or two-ply adding machine tapes. Print lines can extend to 22 print positions on each tape. The 9244-1 unit contains a 44-character buffer. The contents of buffer positions 1 through 22 are simultaneously printed on the master tape and on a selected detail tape. In addition, when operating in the "multiprocessing" mode, the contents of buffer positions 23 through 44 can be simultaneously printed on a third tape.

.356 Magnetic Tape Clusters

The most novel peripheral units announced for use with B 2500 and B 3500 systems are the 9381 and 9382 Magnetic Tape Clusters, which provide two, three, or four tape drives in a single compact unit (33 inches wide, 30 inches deep, and 42 inches high). Reading and/or writing can be performed simultaneously on any two of the tape drives in a cluster if two Tape Controls and a 2 x 8 Exchange are employed. Each tape drive has its own drive mechanism, but the read/write electronics and power supply are shared. The feed reel and take-up reel for each drive are mounted on concentric vertical shafts, with the feed reel above the take-up reel. Tape is driven by a capstan roller and pinch rollers. Normal tape speed is 45 inches per second, and rewind speed is 90 inches per second. Tape can be read in either the forward or reverse direction.

The standard recording medium for the Magnetic Tape Clusters is 9-track, 1/2-inch-wide tape which is compatible with the IBM System/360 9-track tape units. Each unit can read and record at any two of the following three densities: 200, 800, or 1600 rows per inch. The associated peak data transfer rates are 9,000, 36,000 or 72,000 bytes per second, respectively. A single Tape Control can handle up to 8 tape drives of either the 36KB or 72KB transfer rate, but not both.

Optionally, individual tape drives can be field-modified to use 7-track tape which is compatible with earlier Burroughs and IBM systems. Seven-track and nine-track drives can be intermixed in the same Tape Cluster, although the two types must be served by separate controls. In the 7-track mode, the available densities are 200, 556, and 800 rows per inch, and the associated data transfer rates are 9,000, 25,000 and 36,000 characters per second.

.357 Free-Standing Magnetic Tape Units

Burroughs also offers four different free-standing tape units for B 2500 and B 3500 systems. Their recording densities and speeds are summarized in Table III. Two of these units use 7-track tape and are similar to second-generation Burroughs units. The other two units use 9-track tape at recording densities of either 800 or 1600 rows per inch to achieve compatibility with the IBM System/360. All four models can read tape in either the forward or reverse direction at 90 inches per second; rewind speed averages 300 inches per second.

Up to ten free-standing tape units (all of the same type) can be connected to each Tape Control. Read/write simultaneity within a single group of tape units can be achieved (in B 3500 systems only) through use of a second Tape Control and a 2 x 10 Magnetic Tape Exchange unit.

TABLE III: FREE-STANDING MAGNETIC TAPE UNITS

Model No.	Recording Densities, rows/inch	Peak Data Transfer Rates
B 9390 (7-track)	200/556	18/50 KC/sec
B 9391 (7-track)	200/556/800	18/50/72 KC/sec
B 9392 (9-track)	200/800	18/72 KB/sec
B 9393 (9-track)	200/1600	18/144 KB/sec

.358 MICR Sorter-Reader

Burroughs, a leader in banking applications and in the design of MICR equipment, offers four MICR Sorter-Readers for use with the B 2500 and B 3500 systems. All are closely related to the MICR units used with B 100/200/300 Series systems. The maximum speed of all three units is 1565 items per minute. Model 9130 is an off-line unit that reads MICR-encoded documents and sorts them into 13 pockets. Models 9131 and 9132 are both designed for on-line use and are completely buffered; Model 9131 has 13 pockets and Model 9132 has 16 pockets. The 9134-1 is an expandable on-line unit that allows additions from a basic four pocket unit to 32 pockets in four pocket modules. It reads OCR or MICR documents at up to 1565 documents per minute. Read systems are also modular and may contain any combination of OCR or MICR with a maximum of two reading systems on any given unit.

.359 Data Communications

Data communications equipment can be connected to a B 2500 or B 3500 system through individual Line Adapters and either Single-Line Controls, Multi-Line Controls, or Terminal Unit Controls. Eleven different Line Adapters permit communications with a variety of terminal equipment and common-carrier services; see the Price Data section, 210:221, for the function of each adapter. All adapters operate in the half-duplex mode.

The Single-Line Control coordinates the transmission of data between a single communications line equipped with an appropriate Line Adapter and a single B 2500 or B 3500 I/O channel (Type B). The Single-Line Control is designed for limited data communications needs; if more than three lines must be controlled, it will be more economical to use one Multi-Line Control.

The Multi-Line Control uses two Type B I/O channels and can control simultaneous transmissions over up to 36 communications lines, each equipped with an appropriate Line Adapter. One 40-bit word of scratchpad memory holds control information and data associated with each of the 36 subchannels. Only one Multi-Line Control can be connected to a B 2500 or B 3500 system.

The Terminal Unit Control, designed for on-line banking applications, can theoretically control up to 60 communications channels and 960 remote teller consoles.

Burroughs has expanded its line of data communications equipment. The 9351 Input and Display System, is a CRT terminal that provides keyboard input and alphanumeric data displays. A 9-by-12-inch screen can display 25 lines of data with up to 80 characters per line. From one to four keyboard/display units can share a control unit with a 1020-character buffer memory. In addition, Burroughs provides support for the following communications devices:

- B 9350 Typewriter Inquiry Station
- IBM 1030
- Burroughs Audio Response System
- UNIVAC DCT 2000
- TC-500

(Contd.)

- TC-700
- Burroughs On-Line Teller Consoles

.36 Simultaneous Operations

One data transfer operation on each installed B 2500 or B 3500 I/O channel can occur simultaneously with internal processing. All I/O operations, once initiated by the central processor, are executed independently of the processor under the direction of an I/O control unit. Requests for access to core memory by the processor and the various I/O channels are granted by priority logic; the processor always has the lowest priority.

Please refer to Paragraph .31 for the minimum and maximum number of Type A and Type B channels a system can include, the peripheral devices each type of channel can service, and other system configuration parameters.

Address Memory (Paragraph .332) is used to hold the core memory addresses associated with the I/O operation taking place on each channel. Therefore, only one core memory cycle (two microseconds in the B 2500, one microsecond in the B 3500) is required for each unit of I/O data transferred to or from core memory. Type A channels transfer one character at a time to or from memory, while Type B channels transfer two characters in parallel. Thus, the Burroughs systems offer a substantially higher degree of simultaneity than most comparably-priced computers.

I/O operations can be initiated only when the central processor is operating in the control state, and their execution will usually be directed by the Master Control Program. The processor initiates an I/O operation by sending an "I/O descriptor" to the appropriate control unit. I/O descriptors vary from one to four 6-digit syllables in length, and the core addresses they contain are absolute rather than base-relative. The processor then proceeds independently while the control unit directs the I/O operation. Upon completion, the control unit initiates a processor interrupt and sends a 16-bit "result descriptor" to a reserved location in core memory. The result descriptor informs the processor of any abnormal conditions or errors that have occurred.

.4 SOFTWARE

Burroughs offers B 2500 and B 3500 users a choice of two levels of software support: a Basic package for small-scale configurations and an Advanced package for larger systems. Only the Advanced package permits use of the Master Control Program, the COBOL and FORTRAN compilers, and the multiprogrammed operational mode that Burroughs bills as principal features of the B 2500 and B 3500 systems. The facilities offered at each of the two software levels are summarized in the following paragraphs.

.41 Basic Software Package

The Basic package is designed for use with minimum-size B 2500 or B 3500 systems; it does not require a Disk File or Systems Memory unit or a Console Printer. The main component of the package is the Basic Control Program. Also included are an assembler, report generator, sort generator, and utility program generator. All of the Basic software was delivered in August 1967.

.411 Basic Control Program (BCP)

The BCP is a group of interrelated loading and I/O routines that reside permanently in core memory. Burroughs states that the BCP routines and associated tables will require about 2,000 byte positions of memory. The BCP's principal functions are:

- To load and initiate execution of user programs in sequential fashion.
- To initiate all I/O operations requested by user programs.
- To service the interrupts that result upon completion of I/O operations.
- To transfer control to error-handling routines in the user program when errors or abnormal conditions are detected. (These error-handling routines can be extracted from the I/O library when the user program is assembled.)
- To receive control when a user program completes its run, and to load and initiate the next program.
- To assist in program debugging by means of trace and dump routines.

The BCP will accept any user program generated by the facilities of the Basic software package. In fact, the BCP's presence is required for execution of any program generated by this package. The BCP can be used with any legitimate B 2500 or B 3500 system configuration.

.412 Basic Assembler

The Basic Assembler is a straightforward, tape-oriented symbolic assembly system that allows the programmer to utilize all the hardware facilities of B 2500 and B 3500 systems. Its use requires a processor with at least 10,000 bytes of core memory, two magnetic tape units, a card reader or paper tape reader for input, a line printer for the listing, and a card punch, paper tape punch, or a third magnetic tape unit for object-program output.

The assembly process is essentially a one-for-one translation in which symbolic instructions, coded in a fixed format, are converted into machine language instructions. Input-output operations — such as reading, writing, opening and closing of files, and generation and checking of labels — are coded by means of eight macro-instructions that generate linkages to the appropriate BCP I/O routines. I/O buffering, blocking, and unblocking operations, however, must be coded by the user. A group of pseudo-instructions is provided to control the assembly process. Segmentation of programs can be specified in the Basic Assembler language, but the actual overlaying of segments at object time must be coded by the user.

.413 Problem Oriented Facilities

The Basic Sort Generator accepts parametric input and produces tape sort programs in Basic Assembler language. Internal sorting is performed by the vector replacement selection technique, and a backward-read polyphase merge technique is used. From three to eight magnetic tape units can be used. Records or blocks can be up to 1000 characters long. Sort keys can be up to 100 characters long and located in up to 10 different areas of the record. Input and output records may be blocked. Multiple-reel input is allowed, and restart capabilities are provided.

The Basic Report Generator accepts problem-oriented specifications and generates programs, in Basic Assembler language, to produce the specified reports. Input to the object programs may be from punched cards or magnetic tape; output may be printed or on punched cards. Up to four levels of totals are permitted, and up to fifteen 12-position accumulators are available at each level.

The Basic Utility Program Generator accepts parametric input and generates programs to perform a variety of media conversion functions.

.42 Advanced Software Package

The Advanced package is designed for use with B 2500 or B 3500 systems that have at least 30,000 bytes of core memory, a Systems Memory unit or Disk File, and a Console Typewriter/Keyboard. Its principal component is the Master Control Program. Also included are an assembler, COBOL compiler, FORTRAN compiler, report generator, sort generator, and utility program generator. All the Advanced Software was delivered in 1967. Minimum core memory requirements for compilation are 30,000 bytes for COBOL and 40,000 bytes for FORTRAN IV.

.421 Master Control Program (MCP)

The MCP is an integrated operating system that monitors and controls all operations of a B 2500 or B 3500 system. The MCP consists of a group of interrelated routines that will permanently occupy approximately 13,000 bytes of core memory plus 235,000 bytes of disc storage. The principal functions of the MCP are:

- To schedule the execution of user programs, in a multiprogramming environment, on the basis of their priorities and memory requirements.
- To load programs into core memory from disc storage.
- To allocate core memory and relocate user programs as necessary to achieve efficient utilization of the available memory.
- To schedule and initiate all I/O operations, using tables that indicate the status of each I/O device and the priority of each I/O request awaiting processing.
- To handle all error conditions that arise, usually by first retrying the operation and then either initiating a user-supplied error routine or aborting the program.
- To handle all communications between the system and the operator.
- To maintain a detailed log of all system operations.
- To maintain libraries, on disc storage, of user programs and systems software.
- To control compilations or assemblies, and either insert the resulting object programs into a library or execute them immediately.

(Contd.)

.421 Master Control Program (MCP) (Contd.)

- To control program segmentation by loading individual segments of a program upon request.
- To perform file control operations such as blocking, unblocking, label generation, and label checking.

The MCP will accept any user program generated by the facilities of the Advanced software package. In fact, the MCP's presence is required for execution of any program generated by this package.

For B 2500 and B 3500 systems that use the MCP, Burroughs is placing a greater emphasis upon multiprogrammed operation than has the manufacturer of any previous small-to-medium-scale computer system. Multiprogramming (which Burroughs calls "multiprocessing") can increase a computer system's throughput by increasing the effective utilization of the processor, core memory, and all peripheral devices; and Burroughs has already demonstrated the practical value of multiprogramming in its B 5500 system, which uses a functionally similar Master Control Program and has been in service since 1963.

.422 Advanced Assembler

The Advanced Assembler is a disc-oriented symbolic assembly system that provides all the facilities of the Basic Assembler plus a few refinements. These refinements include:

- Facilities to operate under control of the MCP and to establish the necessary linkages with it.
- File declarations that specify, for each logical file, its label format, recording mode, buffer areas, retention period, blocking factor, etc.
- Macro-instructions to open and close files, initiate I/O operations, block and unblock logical records, seek disc records, position printer forms, etc.
- An unlimited number of symbolic labels.

The Advanced and Basic Assemblers use the same mnemonic operation codes for machine instructions and the same fixed-format coding sheet. The differences in their techniques for handling I/O operations, however, preclude direct compatibility, in either source-language or object form, between programs coded in the Advanced and Basic Assembler languages.

Burroughs states that the Advanced Assembler will use only 11,000 bytes of core memory (in addition to the 13,000 bytes required by the MCP).

.423 Compilers

COBOL and FORTRAN compilers are provided for use with any MCP-equipped B 2500 or B 3500 system that has a minimum of 30K bytes (COBOL) or 40K bytes (FORTRAN) of core storage. The COBOL language includes the facilities of the proposed minimum USA Standard COBOL language, plus useful random access, segmentation, library, and table handling facilities. Burroughs states that its FORTRAN is compatible with the USA Standard version. Burroughs states that it is practical to run COBOL or FORTRAN compilations simultaneously with each other and with a mix of production jobs.

.424 Problem Oriented Facilities

An Advanced Sort Generator, an Advanced Report Generator, and an Advanced Utility Program Generator will be provided. The input specifications and functional capabilities of these generators will be similar to those of their counterparts in the Basic software package. The essential difference is that the Advanced versions will generate programs in the Advanced Assembler language for execution under control of the MCP.

.5 COMPATIBILITY

Burroughs has changed its approach to program compatibility from emulation (as originally announced) to translation and simulation. Emulation is no longer offered; in its place is a translator that converts IBM 1400 series systems source code to B 3500 Assembly Language Programs. Languages acceptable as input to the translator are Autocoder, Basic Autocoder, and SPS, as implemented on the 1401, 1440, and 1460. In addition, Burroughs provides a translator to convert B 300 Assembly Language to B 2500/B 3500 Assembly Language.

Simulation for the B 2500/B 3500 permits execution of B 100/B 200/B 300/B 500 object programs on a B 2500/B 3500 directly.

PRICE DATA

The following pricing schedule accompanied the announcement of the Burroughs B 2500 and B 3500 computer systems in March 1966 and still applies to the rental and purchase of equipment in this series. Notable features of this pricing policy include: (1) a special conversion policy for customers who install a B 2500 or B 3500 in place of an existing computer system, (2) a purchase option supplement to the basic lease agreement, and (3) extensive use of one-time field installation charges.

According to the special conversion policy, customers who replace a Burroughs or other computer system with a B 2500 or B 3500 system are allowed a credit of 90 per cent of the replaced system's prior month's rent toward rental of the new system. The amount credited, however, cannot exceed the new system's regular monthly charge.

Customers who rent a B 2500 or B 3500 system can apply, toward the purchase of the equipment, 70 per cent of all rental charges (excluding taxes) paid during the first six months of rental and 40 per cent of all rental charges paid during the second six months of rental, if they opt to purchase the equipment within the first 18 months of rental. A discount of 10 percent of the purchase price of the equipment is available to customers who decide to purchase after the eighteenth month of rental.

One-time field installation charges, ranging from $15 to $190, are applicable to additional modules of core storage and almost all supplementary peripheral devices that are added to already-installed B 2500 and B 3500 systems.

BURROUGHS B 2500/3500

CLASS	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
PROCESSOR			Processing Unit			
	B2501		B2500: Central Processor and four I/O Channels (maximum of two channels may be Type B)	1,195	57,360	125
	B2502		Central Processor and four I/O Channels (maximum of two channels may be Type B)	1,445	69,360	130
		B2710	Type A I/O Channel	25	1,200	5
		B2711	Type B I/O Channel	50	2,400	10
		B2730	Floating Point	50	2,400	7
		B2740-1	Console (Standing Level)	15	720	0
		B2740-2	Console (Desk Level)	15	720	0
			B3500:			
	B3501		Central Processor and six I/O Channels (maximum of three channels may be Type B)	1,746	81,360	140
		B3710	Type A I/O Channel	37	1,680	5
		B3711	Type B I/O Channel	67	3,120	10
		B3730	Floating Point	103	4,800	7
		B3740-1	Console (Standing Level)	16	720	0
		B3740-2	Console (Desk Level)	16	720	0
			Main Storage			
			B2500:			
	B2001		10,000 Bytes Core Memory	450	21,600	20
	B2002		20,000 Bytes Core Memory	900	43,200	25
	B2003		30,000 Bytes Core Memory	1,325	63,600	30
	B2004		40,000 Bytes Core Memory	1,725	82,800	40
	B2005		50,000 Bytes Core Memory	2,100	100,800	45
	B2006		60,000 Bytes Core Memory	2,450	117,600	50
	B2007		70,000 Bytes Core Memory	2,775	133,200	60
	B2008		80,000 Bytes Core Memory	3,075	147,600	65
	B2009		90,000 Bytes Core Memory	3,350	160,800	70
	B2012		120,000 Bytes Core Memory	4,175	200,400	
			B3500:			
	B3001		10,000 Bytes Core Memory	515	24,000	20
	B3002		20,000 Bytes Core Memory	1,030	48,000	25
	B3003		30,000 Bytes Core Memory	1,520	70,800	30
	B3004		40,000 Bytes Core Memory	1,983	92,400	40
	B3005		50,000 Bytes Core Memory	2,395	111,600	45
	B3006		60,000 Bytes Core Memory	2,781	129,600	50
	B3007		70,000 Bytes Core Memory	3,142	146,400	60
	B3008		80,000 Bytes Core Memory	3,477	162,000	65
	B3009		90,000 Bytes Core Memory	3,786	176,400	70
	B3012		120,000 Bytes Core Memory	4,725	216,000	90
	B3015		150,000 Bytes Core Memory	5,513	252,000	110
	B3018		180,000 Bytes Core Memory	6,300	288,000	140
	B3021		210,000 Bytes Core Memory	7,088	324,000	170
	B3024		240,000 Bytes Core Memory	7,875	360,000	200
	B3030		300,000 Bytes Core Memory	9,450	432,000	260
	B3036		360,000 Bytes Core Memory	11,340	518,400	320
	B3045		450,000 Bytes Core Memory	14,175	648,000	410
	B3050		500,000 Bytes Core Memory	15,750	720,000	440

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
MASS STORAGE			Disk Storage			
			B2500 Control Units:			
	B2371		Systems Memory Control	150	7,200	12
	B2373		Disk File Control	200	9,600	12
	B2375		Combination Control	250	12,000	12
	B2473		1 x 2 Disk File Exchange	55	2,640	10
	B2474		2 x N Disk File Exchange for B 2502 System only	200	9,600	10
	B2674		Disk File Exchange Adapter for B 2474 Exchange	10	480	5
			B3500 Control Units:			
	B3371		Systems Memory Control	155	7,200	12
	B3373		Disk File Control	258	12,000	12
	B3375		Combination Control	309	14,400	14
	B3473		1 x 2 Disk File Exchange	88	4,080	10
	B3471		N_1 x N_2 Disk File Exchange (Up to 4 x 20)	200	9,600	12
	B3471-5		Control Adapter (N1 side-up to 4/exchange)	50	2,400	5
	B3471-6		EU Adapter (N2 side-up to 20/ exchange)	30	1,440	2
	B3471-7		Exchange Extension (for over 10 EU's)	150	7,200	10
	B9371-1		DFEU for B 9372-1 to -6	650	31,200	80
	B9371-2		DFEU for B 9372-7	650	31,200	80
	B9371-3		Optional Additional DFEU for B 9375-0 & B 9376-0	650	31,200	80
	B9371-4		Optional Additional DFEU for B 9375-2 & B 9376-2	650	31,200	80
	B9371-5		Optional Additional DFEU for B 9375-3 & B 9376-3	650	31,200	80
			Systems Memory Disk Files:			
	B9370-1		Systems Memory 17 ms (1 million bytes)	375	18,000	80
	B9370-2		Systems Memory 17 ms (2 million bytes)	450	21,600	90
			Modular Random Storage Disk Files:			
	B9372-1		10 million Byte Storage	850	44,000	115
	B9372-2		20 million Byte Storage	1,650	85,800	215
	B9372-3		30 million Byte Storage	2,400	124,800	315
	B9372-4		40 million Byte Storage	3,100	161,200	415
	B9372-5		50 million Byte Storage	3,775	196,300	515
	B9372-6		Additional 10 million Byte Increment	675	35,100	100
	B9372-7		20 million Byte Storage	1,200	57,600	125
			Data Memory Bank Disk Files			
	B9375-0		100 million Byte Storage	4,950	237,600	595
	B3976-0		Additional 20 million Byte Increment	900	45,600	110
	B9375-2		100 million Byte Storage	3,950	224,200	495
	B9376-2		Additional 20 million Byte Increment	700	45,600	85
	B9375-3		100 million Byte Storage	2,700	129,600	395
	B9376-3		Additional 20 million Byte Increment	450	28,800	85
INPUT-OUTPUT			Magnetic Tape			
			Tape Units:			
	B9381-2		36 KB Cluster, 2-Station (9-Channel-800 bits/inch)	900	43,200	200
	B9381-3		36 KB Cluster, 3-Station (9-Channel; 800 bits/inch)	1,100	52,800	230
	B9381-4		36 KB Cluster; 4-Station (9-Channel; 800 bits/inch)	1,300	62,400	260
	B9382-		72 KB Cluster; 2-station (9-Channel; 1600 bits/inch)	1,100	52,800	225

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CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	B9382-3		72KB Cluster - 3 station (9-channel - 1600 bits/inch)	1,400	67,200	260
	B9382-4		72KB Cluster - 4 station (9-channel - 1600 bits/inch)			
	B9390		18-50 KC M. T. Unit (7-channel; 200/556 bits/inch)	480	23,000	145
	B9391		18-50-72 KC M. T. Unit (7-channel; 200/556/800 bits/inch)	575	27,600	165
	B9392		72 KB M. T. Unit (9-channel; 800 bits/inch)	575	27,600	165
	B9393		144KB M. T. Unit (9-channel; 1600 bits/inch)	650	31,200	175
	B9394-1		24-66-96 KC M. T. Unit (7-channel; 200/556/800 bits/inch)	650	31,200	170
	B9394-2		96 KB M. T. Unit (9-channel; 800 bits/inch)	650	31,200	170
			B2500 Controls:			
	B2381-1		36 KB Cluster Control (9-channel; 800 bits/inch)	200	9,600	12
	B2381-2		72 KB Cluster Control (9-channel; 1600 bits/inch)	350	16,800	12
	B2391-1		50 KC M. T. Unit Control (7-channel; 200/556 bits/inch)	275	13,200	12
	B2391-3		72 KC M. T. Unit Control (7-channel; 200/556/800 bits/inch)	300	14,400	12
	B2391-4		96 KC M. T. Unit Control (7-channel; 200/556/800 bits/inch)	375	18,000	15
	B2393-1		72 KB M. T. Unit Control (9-channel; 800 bits/inch)	325	15,600	12
	B2393-2		144 KB Unit Control (9-channel; 1600 bits/inch)	450	21,600	12
	B2393-3		96 KB M. T. Unit Control (9-channel; 800 bits/inch)	375	18,000	15
	B2480		7-Channel Cluster Exchange (2 x 8)	175	8,400	10
	B2481		9-Channel Cluster Exchange (2 x 8)	200	9,600	10
	B2490		7- or 9-Channel Magnetic Tape Exchange (2 x 10) for B 9390 B 9391 and B9392 (B 2502 only)	250	12,000	10
	B2491		9-channel Magnetic Tape Unit Exchange (2 x 10) for B9393 (B2502)	250	12,000	10
	B2680		Adapter to convert B 2381-1 to 7-Channel Control	50	2,400	10
	B2681		200 bits/inch Adapter for B 2381-1 Control	25	1,200	5
	B2691		200 bits/inch Adapter for B 2393-1 Control	25	1,200	5
	B2692		200 bits/inch Adapter for B 2393-3 Control	25	1,200	5
	B9980		Unit Designate Switch for B 9381 Series Clusters	10	480	1
	B9989		9-25-36 KC 7-Channel Station Adapter for B 9381 Series Clusters	50	2,400	10
			B3500 Controls:			
	B3381-1		36 KB Cluster Control (9-channel; 800 bits/inch)	243	11,280	12
	B3381-2		72 KB Cluster Control (9-channel; 1600 bits/inch)	407	18,960	12
	B3391-1		50 KC M. T. Unit Control (7-channel; 200/556 bits/inch)	284	13,200	12
	B3391-3		72 KC M. T. Unit Control (7-channel; 200/556/800 bits/inch)	309	14,400	12
	B3391-4		96 KC M. T. Unit Control (7-channel; 200/556/800 bits/inch)	412	19,200	15
	B3393-1		72 KB M. T. Unit Control (9-channel; 800 bits/inch)	387	18,000	12

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
INPUT-OUTPUT (Contd.)			B3500 Controls (Contd.):			
	B3393-2		144 KB Unit Control (9-channel; 1600 bits/inch)	490	22,800	12
	B3393-3		96 KB M. T. Unit Control (9-channel; 800 bits/inch)	412	19,200	15
	B3480		7-Channel Cluster Exchange (2 x 8)	181	8,400	10
	B3481		9-Channel Cluster Exchange (2 x 8)	206	9,600	10
	B3490		7- or 9-Channel Magnetic Tape Unit Exchange (2 x 10) for B 9390, B 9391 and B 9392)	258	12,000	10
	B3491		9-Channel Magnetic Tape Unit Exchange (2 x 10) for B 9393 (B3500)	258	12,000	10
	B3680		Adapter to convert B 3381-1 to 7-Channel Control	52	2,400	10
	B3681		200 bits/inch Adapter for B 3381-1 Control	26	1,200	5
	B3691		200 bits/inch Adapter for B 3393-1 Control	26	1,200	5
	B3692		200 bits/inch Adapter for B 3393-3 Control	26	1,200	5
	B9980		Unit designate Switch for B 9381 Series Clusters	10	480	1
	B9989		9-25-36 KC 7-Channel Station Adapter for B 9381 Series Clusters	50	2,400	10
			Punched Cards			
	B9110		Card Reader 200 cards/min	175	8,400	40
	B9111		Card Reader 800 cards/min	325	16,250	83
	B9112		Card Reader 1400 cards/min	450	21,600	126
	B2110		Card Reader Control for B 2500	50	2,400	8
	B3110		Card Reader Control for B 3500	52	2,400	8
	B9916		Validity Check Switch and Indicator for B 9111 and B 9112 only	5	240	2
	B9917		Card Counter for B 9111 and B 9112 only	5	240	0
	B9918		P. M. O. Feature for B 9111 and B 9112 only	30	1,440	5
	B9919		40 Column Read Switch for B 9111 and B 9112 only	0	0	0
	B9212		Card Punch (150 card/min)	430	20,640	126
	B9213		Card Punch (300 cards/min)	530	25,440	135
	B2210		Card Punch Control for B 2500 (B9212, B9211)	50	2,400	8
	B2212		Card Punch Control for B 2500 (B 9213)	50	2,400	8
	B3212		Card Punch Control for B 3500 (B 9213)	52	2,400	8
	B2610		BCL-BCL Code Translator for B 2210 Card Punch Control	15	720	5
	B3610		BCL-BCL Code Translator for B 3210 Card Punch Control	16	720	5
			Paper Tape			
	B9120		Paper Tape Reader (500-1000 char/sec)	300	16,000	70
	B2120		Paper Tape Reader Control for B 2500	50	2,400	8
	B3120		Paper Tape Reader Control for B 3500	52	2,400	8
	B9926		Input Code Translator	145	6,960	10
	B9220		Paper Tape Punch (100 char/sec)	260	15,300	65
	B2220		Paper Tape Punch Control for B 2500	50	2,400	8
	B3220		Paper Tape Punch Control for B 3500	52	2,400	8
	B9928		Output Code Translator	130	6,850	10
			Printer			
	B9242-1		860 lines/min - 120 print positions	860	48,000	180
	B9242-2		725 lines/min — OCR "A" Numeric & Std. Alpha	860	4,800	180

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CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
INPUT-OUTPUT (Contd.)			Printer (Contd.)			
	B9242-3		725 lines/min - OCR "B" - alphanumeric	860	4,800	180
	B9243-1		1100 lines/min, 120 print pos. 44 char.	965	53,500	200
	B9243-2		900 lines/min - OCR "A" - Numeric & Std.Alpha	965	53,500	200
	B9243-3		900 lines/min - OCR "B" Alphanumeric	965	53,500	200
	B9245-2		Printer (315 lines/min; 120 print positions)	500	24,000	135
	B9245-3		Printer (315 lines/min; 132 print positions)	540	25,920	135
	B2240		Printer Control for B 2500 (B 9240, B 9241, B 9245-2, -3)	75	3,600	8
	B2242		Printer Control for B 2500 (B 9242, B 9243)	75	3,600	12
	B3240		Printer Control for B 3500 (B9240 B 9241, B 9245-2, -3)	78	3,600	8
	B3242		Printer Control for B 3500 (B9242, B 9243)	78	3,600	12
	B9940		High Speed Slew	60	2,000	10
	B9941		Additional 12 Print Positions	40	2,000	10
	B9943		Printer Memory for Series 9242/3	100	4,800	10
	B9947		Dual Printer Control (for B 9240 and B 9241 only)	200	9,600	10
	B9949		Powered Forms Stacker	25	1,200	5
	B9340		Console Printer and Keyboard	55	2,640	15
	B2340		Console Printer Control for B 2500	75	3,600	10
	B3340		Console Printer Control for B 3500	103	4,800	10
			Magnetic Ink Character Sorter/Reader			
	B9130		13-Pocket Non-System (1565 documents/min)	1,890	90,720	500
	B9131		13-Pocket w/o Endorser (1565 documents/min)	1,900	91,200	500
	B9131-1		13-Pocket w/o Endorser (1000 documents/min)	1,200	91,200	615
	B9132		16-Pocket w/o Endorser (1565 documents/min)	2,200	105,600	650
	B9134-1		Reader sorter (1565 documents/min)	1,025	49,200	390
	B2130		MICR Sorter Reader Control for B 2500	100	4,800	12
	B3130		MICR Sorter Reader Control for B 3500	103	4,800	12
	B9930-1		Mobile Carrier and Document Tray	5	240	0
	B9930-2		Document Tray, additional (for Purchase only)		15	
	B9931-1		Document Separators — 13 pocket	20	960	0
	B9931-2		Document Separators — 16 pocket	25	1,200	0
	B9932		Endorser for B 9131 and B 9132 only (3)	200	9,000	50
	B9933		Extended Sort Control (for B 9130 and B 9131 only (3))	50	2,400	15
	B9934		Start/Stop Bar (for B 9130 and B9131 only)	7	275	0
	B9935		Special Field Ending	10	450	0
	B9936		Override Code (as specified)	10	450	0
	B9937		Validity Checking	10	450	0
	B9938		Reverse Override	10	450	0
	B9939-1		Item Counter, Resettable	5	240	0
	B9939-2		Item Counter, Non-resettable	5	240	0
			Reader Sorter Controls and Features (for B9134-1)			
	B2130-1		Reader Sorter Control (MICR only)	100	4,800	12
	B2130-2		Reader Sorter Control (OCR/MICR/DUAL)	150	7,200	15
	B3130-1		Reader Sorter Control (MICR only)	100	4,800	12
	B3130-2		Reader Sorter Control (OCR/MICR/DUAL)	150	7,200	15
	B9930-3		Mobile Carrier	0	150	0
	B9932-1		Endorser — 1625 doc/min	200	9,000	50
	B9932-4		Batch Ticket Detector	10	480	1
	B9932-5		Short Document Read Feature	10	480	2
	B9932-6		Short Document Module Expander	5	240	0
	B9933-1		Basic Off-line Sort (2 fields only)	25	1,200	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
INPUT-OUTPUT (Contd.)			Reader Sorter Controls and Features (for B9134-1) (Contd.)			
	B9933-2		8-Pocket Basic Off-Line Sort (2 fields only)	30	1,440	5
	B9933-3		Expanded Off-Line Field Sort (8 fields max.)	5	240	0
	B9933-4		Extended Sort Control	50	2,400	15
	B9933-5		Zero Kill (max. of 3/reader sorter)	10	480	1
	B9933-6		No Field - No Digit (max of 3/reader sorter)	10	480	1
	B9933-7		Digit Override (max of 3/reader sorter)	10	480	1
	B9933-8		Digit Edit (max of 3/reader sorter)	10	480	1
	B9933-9		Field Override (max of 3/reader sorter)	10	480	1
	B9933-10		Field Edit (max of 3/reader sorter)	10	480	1
	B9935-1		Expansion Feature (Pockets 17-32)	100	4,800	10
	B9935-2		Four Pocket Module (Pockets 5-16)	300	14,400	35
	B9935-3		Four Pocket Module (Pockets 17-32)	300	14,400	35
	B9936-1		Stacker Overflow	10	480	1
	B9937-1		Valid Character Check	5	240	1
	B9938-1		Multi-Track E13B (1625 OPM)	375	18,000	55
	B9938-4		Numeric OCR "A" (1625 OPM)	650	31,200	98
	B9938-5		Numeric OCR "B" (1625 OPM)	650	31,200	98
	B9938-9		Dual Read Option (1625 OPM)	150	7,200	25
	B9939-3		Resettable Item Counter	5	240	1
	B9939-4		Non-Resettable Item Counter	5	240	1
	B9939-5		Running Time Meter	5	240	1
			Listers			
	B9244-1		Master A/N Lister (1565 lines/min)	1,350	67,500	325
	B9244-2		Slave A/N Lister (1565 lines/min two maximum)	650	32,500	200
	B2244		Lister Control for B 2500	75	3,600	8
	B3244		Lister Control for B 3500	78	3,600	8
			Input and Display Units			
	B9351-1		Control I — Single Input and Display/Location	215	9,400	27
	B9351-2		Control II — Multiple Input and Displays and/or Controls/Location	325	14,300	27
	B9351-3		Control IIA — Max. of 3 with Multiplexor and Control II	100	4,400	20
	B9351-4		Monitor	60	2,640	10
	B9351-5		Alphanumeric Keyboard	20	880	3
	B9351-6		Input and Display Printer	45	1,980	10
	B9351-7		Remote Communications Adapter	35	1,540	3
	B9352-1		Input and Display Terminals — Includes: 40 x 20 Monitor, Alphanu Keyboard, 960 char. Memory, Control and Variable Tab function.	195	8,775	27
	B9352-2		Input and Display Terminal — Same as B9352 except 80 x 12 monitor	195	8,775	27
	B9352-9		Modem Expander	50	2,250	11
	B9352-10		Additional 4 lines to Modem Expander	20	900	11
			Options (B9351 Series)			
	B9951-1		Input and Display Printer Adapter	30	1,320	3
	B9951-2		Insert/Delete — Character/Line	15	660	3
	B9951-3		Controlled Format	20	880	3
	B9951-4		Variable Tab Position	5	220	1
	B9951-5		Programmatic Cursor Positioning	5	220	1
	B9951-7		Display Stand, Low, without work table	—	80	—
	B9951-8		Display Stand, High without work table	—	100	—
	B9951-9		Display Stand Work Table, Right or Left	—	25	—

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
INPUT-OUTPUT (Contd.)			Options (B9352 Series)			
	B9952-1		Input & Display Printer Adapter	10	675	15
	B9952-1		Polling & Select	10	450	2
	B9952-3		Controlled Format		450	2
	B9952-4		Remote Comm. Interface — Direct Connect 1200 bits/sec	8	360	1
	B9952-5		Remote Comm. Interface — Direct Connect 2400 bits/sec	12	540	3
	B9952-6		Remote Comm. Interface — Modem-102 Type-up 300 bits/sec	5	225	1
	B9952-7		Remote Comm. Interface — Modem-202 Type-up to 1200 bits/sec	8	360	1
	B9952-9		Remote Comm. Interface — Modem-201 Type-up to 2400 bits/sec	12	540	3
			Remote Unit			
	B9350		Typewriter Inquiry Station	55	2,640	12
COMMUNI-CATIONS			Controllers			
	B2350-1		Terminal Control for B 2350-2 CTU	175	8,400	15
	B2350-2		Central Terminal Unit for B 2500	1,095	52,560	100
	B2351		Single Line Control for B 2501 and B 2502	125	6,000	14
	B2353		Basic Multi-Line Control for B 2502 only	370	17,760	30
	B2354		8-Channel Extension for B 2353	115	5,520	10
	B2355-1		Voice Response Generator	795	37,200	31
	B3350-1		Terminal Control for B 3350-2 CTU	175	8,400	15
	B3350-2		Central Terminal Unit for B 3500	1,095	52,560	100
	B3351		Single Line Control for B 3501	129	6,000	14
	B3353		Basic Multi-Line Control for B 3501	370	17,760	30
	B3354		8-Channel Extension for B 3353	115	5,520	10
	B3355-1		Voice Response Generator	795	37,200	31
	B9955-1		Audio Recording (Special)	—	2,575	—
	B9955-2		Audio Recording (Library)	—	575	—
	B9950		Audible Alarm for CTU	10	480	1
			Control and Line Adapters			
			B2500:			
	B2650		CTU Adapter for B 2350-1	35	1,680	5
	B2651		Typewriter Inquiry Station	30	1,440	5
	B2652-1		TWX/Remote Typewriter	30	1,440	5
	B2652-2		TWX/Remote Typewriter with Automatic Dial Out	45	2,160	10
	B2653-1		B 2500/B 3500	50	2,400	5
	B2653-2		B 2500/B 3500 w/ADO	65	3,120	10
	B2653-3		B 300/B 500/B 5500 Modem 201 Type — to 2400 bits/sec	50	2,400	5
	B2653-4		B 300/B500/B 5500 Modem 201 Type — to 2400 bits/sec w/ADO	65	3,120	10
	B2654-1		DCT 2000	85	4,100	5
	B2654-2		DCT 2000 w/ADO	100	4,800	10
	B2655-1		IBM 1050	60	2,880	5
	B2655-2		IBM 1050 w/ADO	75	3,600	10
	B2656-1		IBM 1030	50	2,400	5
	B2657		Model 35 on 8A1 Selective Calling Service	30	1,440	5
	B2659-1		Input and Display — Direct Connect (Multi-Wire)	50	2,400	5
	B2659-2		Input and Display — Data Set (1200 bits/second)	50	2,400	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(1)
COMMUNICATIONS (Contd.)			Control and Line Adapters (Contd.)			
	B2659-3		Input and Display — Data Set (2400 bits/second)	50	2,400	5
	B2659-4		Input & Display — 1200 bps w/ADO	65	3,120	10
	B2659-5		Input & Display — 2400 bps w/ADO	65	3,120	10
	B2659-8		B9352 Series I & D — Direct Connect	50	2,400	5
	B2659-9		B9352 Series I & D — Modem-202 Type up to 1200 bits/sec	50	2,400	5
	B2659-10		B9352 Series I & D — Modem-201 Type up to 2400 bits/sec	60	2,880	5
	B2659-11		B9352 Series I & D — Modem-202 Type up to 1200 bits/sec w/ADO	65	3,120	9
	B2659-12		B9352 Series I & D — Modem-201 Type up to 2400 bits/sec w/ADO	75	3,600	9
	B2659-13		B9352 Series I & D — Modem-103 Type up to 300 bits/sec	50	2,400	5
	B2659-14		B9352 Series I & D — Modem-103 Type up to 300 bits/sec w/ADO	65	3,120	9
	B2662		Model 28/83B3	40	1,920	5
	B2663		Audio Dual Line Adapter	105	4,800	15
	B2664-1		TC500 Direct Connect	50	2,400	5
	B2664-2		TC500 Modem 202 Type — up to 1200 bits/sec	50	2,400	5
			B 3500:			
	B3650-1		CTU Adapter for B 3350-1 (first)	37	1,680	5
	B3650-2		Additional CTU Adapter for B 3350-1 (9 maximum)	31	1,440	5
	B3651		Typewriter Inquiry Station	31	1,440	5
	B3652-1		TWX/Remote Typewriter	31	1,440	5
	B3652-2		TWX/Remote Typewriter with Automatic Dial Out	47	2,160	10
	B3653-1		B 2500/B 3500	52	2,400	5
	B3653-2		B 2500/B 3500 w/ADO	67	3,120	10
	B3653-3		B 300/ B 500/B 5500 — Modem-201 Type to 2400 bits/sec	52	2,400	5
	B3653-4		B 300/B 500/B 5500 — Modem-201 Type up to 2400 bits/sec w/ADO	67	3,120	10
	B3654-1		DCT 2000	88	4,100	5
	B3654-2		DCT 2000 w/ADO	103	4,800	10
	B3655-1		IBM 1050	62	2,880	5
	B3655-2		IBM 1050 w/ADO	78	3,600	10
	B3656-1		IBM 1030	52	2,400	5
	B3657		Model 35 on 8A1 Selective Calling Service	31	1,440	5
	B3659-1		B9351 Series, Input and Display — Direct Connect (Multi-wire)	52	2,400	5
	B3659-2		B9351 Series, Input and Display — Data Set (1200 bits/second)	52	2,400	5
	B3659-3		B9351 Series, Input and Display — Data Set (2400 bits/second)	52	2,400	5
	B3659-4		B9351 Series, Input & Display — 1200 bits/ second w/ADO	67	3,120	10
	B3659-5		B9351 Series, Input & Display — 2400 bits/ second w/ADO	67	3,120	10
	B3662		Model 28/83B3	42	1,920	5
	B3663		Audio Dual Line Adapter	109	4,800	15
	B3659-8		B9352 Series, Input & Display — Direct Connect	52	2,400	5

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $(1)	Monthly Maint. $(2)
COMMUNI-CATIONS (Contd.)			Control and Line Adapters (Contd.)			
	B3659-9		B9352 Series, Input and Display — Modem 202 Type — up to 1200 bits/sec	52	2,400	5
	B3659-10		B9352 Series, Input and Display — Modem-201 Type — up to 2400 bits/sec	62	2,880	5
	B3659-11		B9352 Series, Input and Display — Modem-202 Type — up to 1200 bits/sec with ADU	67	3,120	9
	B3659-12		B9352 Series, Input and Display — Modem-201 Type — up to 2400 BPS with ADU	78	3,600	9
	B3664-1		TC500 Direct Connect	52	2,400	5
	B3664-2		TC500 and TC700 Modem-202 Type — up to 1200 BPS			

NOTES:

*No longer in production.

(1) One-Time field installation charges, ranging from $15 to $200 are applicable to additional modules of core storage and almost all supplementary peripheral devices added to already-installed systems.
(2) Maintenance charges are about 20% higher outside metropolitan areas.
(3) Factory installation only.

INTRODUCTION

.1 GENERAL

The Series E2000, E3000, E4000, and E6000 Electronic Accounting Machines are the top models of Burroughs Corporation's extensive line of adding and calculating machines. These four systems bridge the gap between completely manual data handling and full-power electronic data processing. They are oriented primarily toward accounting and bookkeeping applications, and within this realm sales have fared well, with more than 5900 machines installed to date.

All four systems are related in their incorporation of the proven Sensimatic Accounting Machines* as primary system components. In addition, each machine in the series offers increasing relief from the necessity of performing manual operations. None, however, offers quite as much general-purpose processing power, performance, or flexibility as the best-known small-scale data processing systems such as the GE-115, Honeywell 120, IBM 360/20, RCA Spectra 70/15, or UNIVAC 9200.

Application possibilities range from simple invoicing and statement preparation to the production of incentive payrolls and summary reporting. To this end, magnetic-stripe ledger card reading and writing facilities play an important role in the systems. The E4000 and E6000 can use punched card input, and all of the systems provide punched card output. In accommodating large data files, therefore, the external storage medium can be either punched cards or magnetic ledger cards.

.2 HARDWARE AND PROGRAMMING

All of the models except the E3000 process alphabetic data internally. Each machine uses a similarly-structured 12-digit data word. All of the machines can punch paper tape, but none of them can read paper tape. Magnetic-stripe ledger cards can be written and read by all models. Printout (including continuous forms) can be printed by the accounting machine itself or, in the case of the E6000 system, by using an optional 164-lpm line printer.

Magnetic core storage that contains from 30 to 400 12-digit words is available for use with the various models. The average access time is 1.6 milliseconds. Processing and input/output characteristics of the systems are summarized in Table I.

From 36 to 65 basic operations (e.g., add, clear memory, check-digit verify) can be programmed on the various models. Burroughs supplies the programs and assembles the stop control units for all customer applications. Complete operating instructions are also provided.

.3 OPERATION

In general use, variable data is entered through the keyboard, and varying amounts of constant data, such as item prices and descriptions, can be read by the input units. Carriage movement and initiation of processing activities are controlled by stops on a control unit and a program panel under the accounting machine carriage, by a stored program, or by a combination of both.

In most updating operations, the operator need only pull the proper ledger card from a file, insert it in the carriage, key variable data in the correct columns, and refile the card. Carriage movement and arithmetic operations (e.g., total charges and credits, develop new balance, test for limits) are controlled automatically. Ledgers, posted at any desired frequency, provide individual audit trails that cannot readily be produced by tab equipment or a computer system. If the ledgers are updated frequently, they provide a visual, up-to-date activity record that is immediately available.

From one to three magnetic stripes, functionally similar to magnetic tape, can be stamped on the backs of the ledger cards. Posting line indicators are stored on one stripe, and each of the others can contain up to 10 numeric words (except for the E3000, which utilizes one stripe containing data and line indicators). The magnetic-stripe data is automatically read and the card is automatically positioned for posting when the card is placed between the front-feed forms guides. The magnetic-stripe data is rewritten as the card is ejected after

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* Detailed reports on the Burroughs adding machines and mechanical accounting machines are included in AUERBACH Data Handling Reports, another looseleaf reference service published by AUERBACH Info., Inc. AUERBACH Data Handling Reports is a comprehensive, two-volume guide to selecting and applying the wide range of support equipment and supplies used in conjunction with computer systems.

.3 OPERATION (Contd.)

posting. The magnetic-striped cards are a form of external storage that provides a basis for master file updating systems. Earnings, interest paid, sales, and other totals can be computed and stored on the stripes for later processing.

The processing speeds of the E2000, E3000, E4000, and E6000 systems are limited by the manual operations that are required, and most of the models are not well suited for applications that require a significant volume of printing (except for the E6000, which can include a medium-speed line printer).

TABLE I: CHARACTERISTICS OF THE BURROUGHS SERIES E COMPUTERS

	Computer System	E2000	E3000	E4000	E6000
DATA STRUCTURE	Numeric digit size, bits	4	4	4	4
	Alphabetic char. size, bits	8	8	8	8
	Word length, BCD digits	12	12	12	12
STORAGE	Memory capacity, words	40 or 100	30, 50, 80, or 100	100 or 200	400
	Type of storage	Magnetic core	Magnetic core	Magnetic core	Magnetic core
	Access time	—	—	1.6 msec	1.6 msec
PROCESSOR PERFORMANCE	Timing (fixed-point), msec				
	b = a + b	94	94	1.0 to 1.6	1.0 to 1.6
	b = a x b	94	94	12 to 84	12 to 84
	b = a ÷ b	94	94	16 to 84	16 to 84
PROGRAMMING FEATURES	Instruction repertoire	37	65	36	53
	No. of addresses	1	1	1	1
	Indexing	Yes	Yes	Yes	Yes
INPUT	Console	Yes	Yes	Yes	Yes
	Punched cards	—	—	Yes	Yes
	Punched paper tape	—	—	—	—
	Magnetic ledger cards	48 cards/min	50 cards/min	48 cards/min	48 cards/min
OUTPUT	Printed copy	Yes	Yes	Yes	Yes
	Line printer	—	—	—	164 lines/min
	Punched cards	18 col/sec	18 col/sec	18 col/sec	18 col/sec
	Punched paper tape	22 char/sec	22 char/sec	22 char/sec	22 char/sec
	Magnetic ledger cards	Yes	Yes	Yes	Yes
MONTHLY RENTAL	Minimum system	395	335	495	730
	Average system	675	425	835	1,120
	Expanded system	1,035	715	1,175	1,825

SUMMARY: BURROUGHS E2000 & E3000

.1 BACKGROUND

The Burroughs Series E2000 and E3000 Electronic Accounting Machines were announced in January 1964 and August 1967, respectively. They incorporate all of the features of the Burroughs Series E and F mechanical accounting machines and add an electronic computing unit. More than 4200 E2000 and E3000 systems have been installed to date.

The E2000 and E3000 feature keyboard and magnetic-striped ledger card input; output can be punched cards, magnetic-striped ledger cards, punched paper tape, and console-printed copy. A magnetic core storage unit provides 40 or 100 (E2000) or 30 to 100 (E3000) 12-digit (plus sign) word locations of data storage. Programming is performed through a rear program panel and stop control bar called the Sensimatic Control Unit, which is inserted under the carriage. Programs are "loaded" for execution by exchanging program control units. Up to four programs can be included in one control unit. A flexible command repertoire permits up to 93 discrete functional operations to be programmed, including add, subtract, multiply, divide, compare and distribute.

All computations in the E2000 and E3000 are performed by transistorized logic. There are no mechanical memory units. The only mechanical elements within the console are those required for printing and carriage control.

The first delivery dates were October 1964 and October 1967 for the E2000 and E3000, respectively, and the current delivery period is two weeks to six months for both machines.

.2 HARDWARE

.21 Data Structure

Each E2000 and E3000 data word can contain 12 four-bit digits plus a sign or six alphabetic characters. Memory access commands normally obtain full 12-digit words, but 10 digits or the upper or lower half of any word can also be accessed.

.22 Main Storage

The main storage device is a magnetic core storage unit housed in a processor cabinet immediately to the left of the console. It is used to store data such as prices and wage rates, and to accumulate totals. Previously-prepared input data is normally read into fixed positions (e.g., magnetic-stripe data into memory addresses 20 to 29).

Models of the E2000 include either 40 or 100 words of core memory. The E3000 can contain 30, 50, 80, or 100 words of core memory.

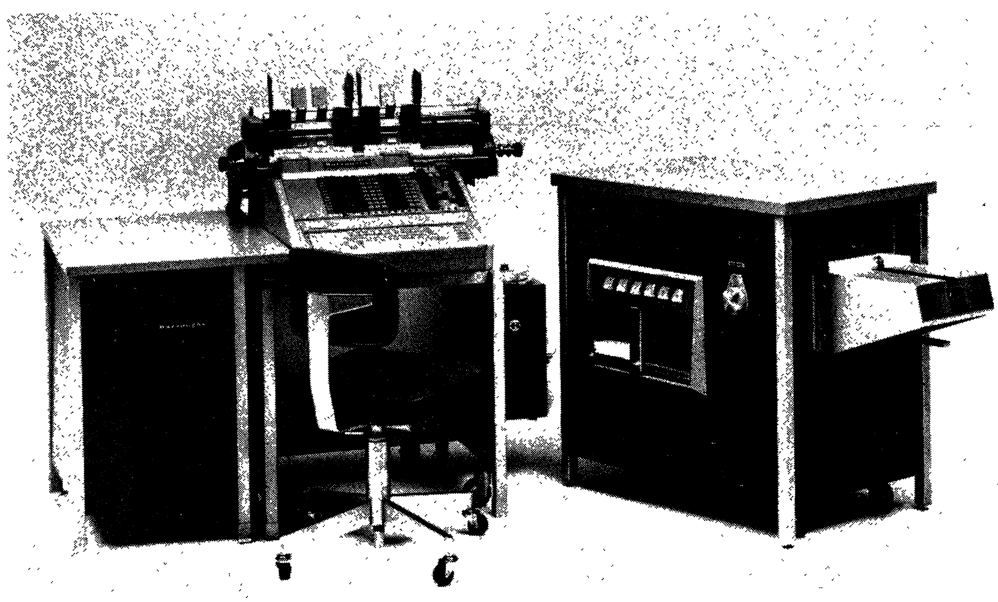


Figure 1. The Burroughs E3500 with 525 Paper Tape Perforator and 4003 Automatic Ledger Reader.

.23 Processing Unit

All of the logic for arithmetic operations (add, subtract, multiply and divide) is contained in the completely transistorized processor cabinet. Also included in the cabinet is the logic required for controlling input-output operations and for reading from and typing into memory from the keyboard. The E2000 and E3000 consoles resemble those of the smaller Series E machines and the typing Sensimatics.

The consoles feature a split-platen carriage capable of handling front- and rear-inserted forms, a 12-row (E2000) or 11-row (E3000) full adding-machine keyboard, an 84-character twin-shift typewriter keyboard, the program control panel, and control keys and indicators.

The standard 22-inch carriage includes 220 printing positions. The carriage can be stopped at any of these positions for printing and processing. Thirty styles of stops are available to control operations. The operations that can be performed at each step (many within the same 94-millisecond machine cycle) include add and subtract, multiply and divide (rounded or unrounded), testing, clearing, distribution, and printing. The program control panel directs these operations.

The following operations can take place during an E2000 arithmetic cycle, as selected by magazine pins in the panel:

(1) Shifts can be performed on data already in storage (e.g., price per hundred).

(2) Data can be read from the keyboard or a memory address (MA) into MA 00, and may be printed or non-printed.

(3) The contents of MA 00 can be added or subtracted into MA 01, MA 10, and any other MA simultaneously.

(4) The contents of MA 01 or MA 10 can then be checked for minus or non-zero, and alternate carriage movements can be selected to follow.

(5) The contents of MA 00 can be added or subtracted into any other memory address, and the contents of one, two or three other memory addresses can be added or subtracted into tens multiples of the base addresses (e.g., 12, 22, 32) for applications such as cost distributions. Also, two digits can be read, from either the keyboard or the high-order digits of the memory address, to index the addresses to be added or subtracted into.

(6) Predetermined memory addresses can be cleared.

(7) Multiplication and division can be performed. MA 00 is multiplied by MA 10 and the product is stored in MA 10, and/or MA 10 is divided by MA 00 and the quotient is stored in MA 10 and the remainder in MA 11. Alternatively, MA 02 can be used instead of MA 00 in both operations.

Memory addresses 1 and 10 are normally used for crossfooting since they can be addressed during any operation. Divide, clear and add, read six low-order digits, and enforced use of memory selection key commands are included in the E2000's repertoire of 113 commands.

The arithmetic cycle of the E3000 is similar to that of the E2000 except that data is added into MA 00 and 01 rather than MA 01 and 10. Also, the data can be selectively added or subtracted into the tens multiple addresses rather than being all added or all subtracted.

All internal processing is performed directly on values in storage; e.g., an add instruction adds the value of an amount, just entered into the system and stored in a memory address, to another value in storage where the sum is accumulated. Information is read from the console keyboard, a magnetic ledger card, or a card reader and stored in a predetermined storage location. It is then transferred to memory address 01, 00, and/or 10 for processing. All arithmetic operations are performed in 84 milliseconds.

As a standard feature, the E3000 contains the facility for generating and validating check digits. Check digits are normally used to ensure the accurate entry of amounts and other important numbers such as customer number. The check digit logic is contained in the logic console.

The standard checking system is based on the weighted Modulus 10 formula, as described below.

Keyboard column:	11	10	9	8	7	6	5	4	3	2	1	
Contents:	CD				1	2	3	4	5	6	7	
Weight:		x1	x9	x8	x7	x6	x5	x4	x3	x2	x1	
Products:					7 +	12 +	15 +	16 +	15 +	12 +	7 =	84
Total subtracted from next higher multiple of 10 = check digit												90 -84 6

(Contd.)

.23 Processing Unit (Contd.)

An Add-Double-Add and a weighted Modulus 11 system are available as options. The Modulus 11 system is the same as the Modulus 10 system except that only nine digits are weighted, and the sum of products is subtracted from the next higher multiple of 11. A two-digit check sum may result. The Add-Double-Add system is explained below.

Keyboard column:	11	10	9	8	7	6	5	4	3	2	1	
Contents:	CD				1	2	3	4	5	6	7	
Add-Double-Add:		x2	+	x2	+	x2	+	x2	+	x2	+	
Results:					+1	+4	+3	+8	+5	+1 +2	+7	= 31
Total of the digits subtracted from the next higher multiple of 10 = check digit												40 -31 9

If the check digit or the number to be checked is incorrect, or if the check digit is entered in the wrong column, the machine is locked after printing but before punching.

.24 Input-Output

The basic input device for the systems is the console keyboard shown in Figure 2. Each numeric entry can represent a variable amount to be added or subtracted (charges, credits, etc.) or descriptive information not to be included in the totals (salesman number, sales terms, etc.). An entry is recorded by depressing keys representing the data and a motor bar. Up to 12 digits of information, 4 symbols, and a 3-digit date can be printed for each entry. The large motor bar (Motor Bar 2) is used for recording normal entries (e.g., add from the charge column, multiply times price from the quantity column), and the small motor bars (1, 3, and 4) are used for exception entries.

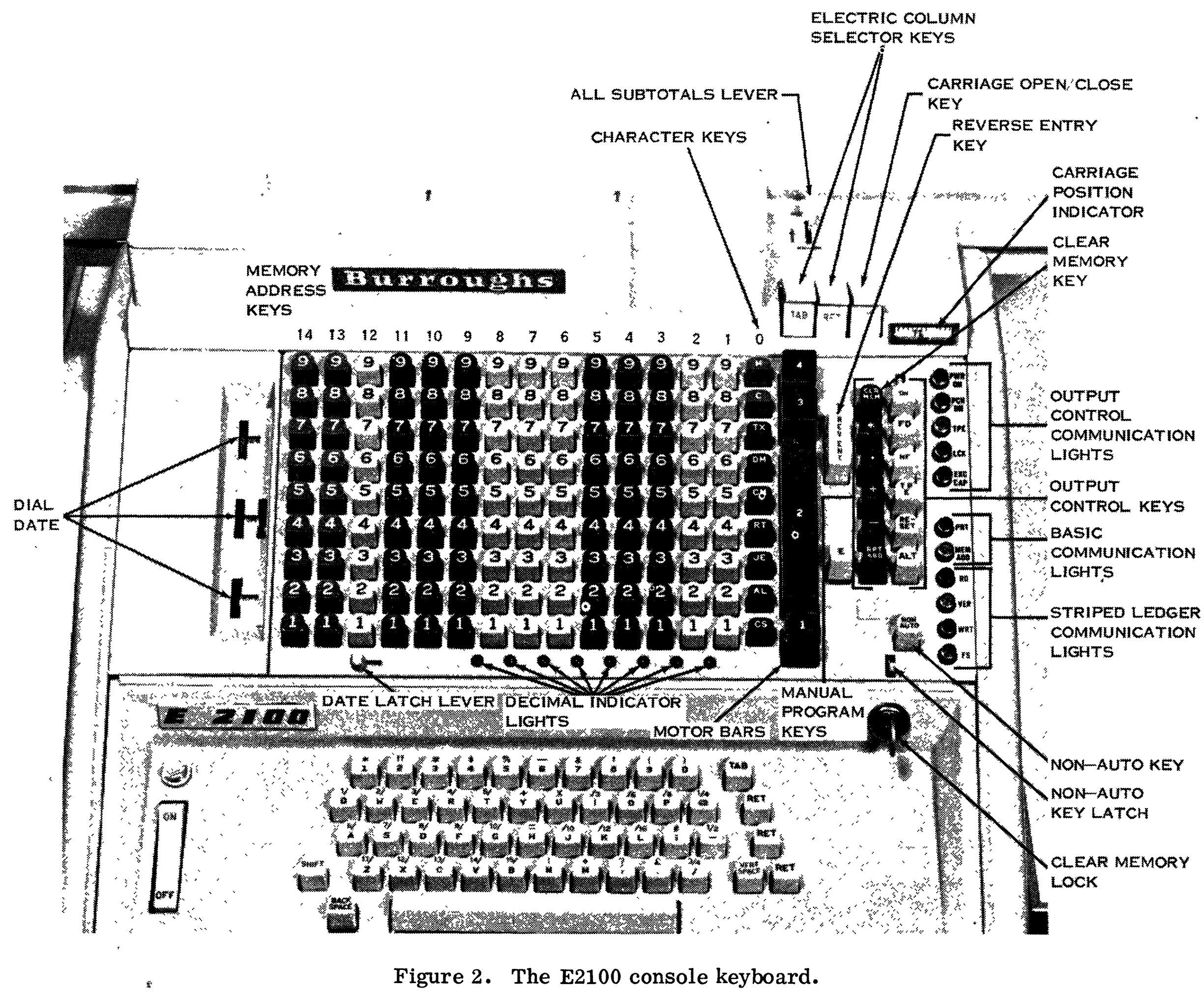


Figure 2. The E2100 console keyboard.

.24 Input-Output (Contd.)

The amount keyboard (in the style of a full-keyboard adding machine) provides 12 amount rows with 2 implied decimal points. Accuracy is provided to three decimal places. Numeric information can be keyed into the amount keyboard for use as an immediate operand or as a stored constant, depending on the program.

The typewriter-style keyboard allows upper-case alphabetic data to be typed in headings and item descriptions. The data can also be stored in memory or recorded on magnetic stripes, punched tape, or punched cards. The 42-key twin-shift keyboard has an 84-character set.

The E2000 can read 10 or 20 words of data from magnetic stripes stamped on the backs of ledger cards; the E3000 can read 4 magnetic-stripe words. Read-write heads are contained in form guides on the carriage. Dimensions of the striped ledger cards that can be processed by the E2000 are shown in Figure 3.

The stripes are located on the right rear side of the ledger. Stripes can be included on both sides of ledgers that are posted on both sides. The magnetic-stripe recording format is shown in Figure 4.

An automatic ledger reader, for compiling summary data such as sales analysis, is optionally available. It can read forms 11 inches long by 6 to 14.5 inches wide at 55 per minute. Forms can be read continuously or singly. The input hopper can hold up to a 4.5-inch stack of ledgers, or approximately 500 forms.

The optional 525 Tape Perforator provides paper tape output punched with any 5-, 6-, 7-, or 8-level code, at 22 characters per second. The optional 545 Card Punch Control allows an IBM 24 or 26 Card Punch to be connected to punch cards at 20 or 18 characters per second. Six, or optionally 12, punching formats can be plugboard-wired for each column. The punching formats can be modified by wiring through selectors actuated by a minus amount in a register, a check-digit error, or other conditions.

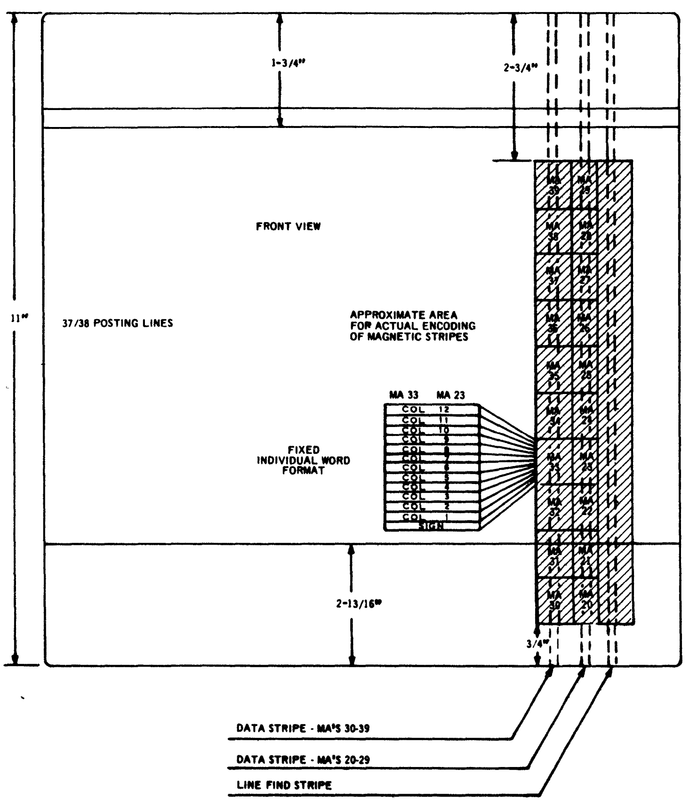


Figure 3. Magnetic-stripe ledger card read by the E2000.

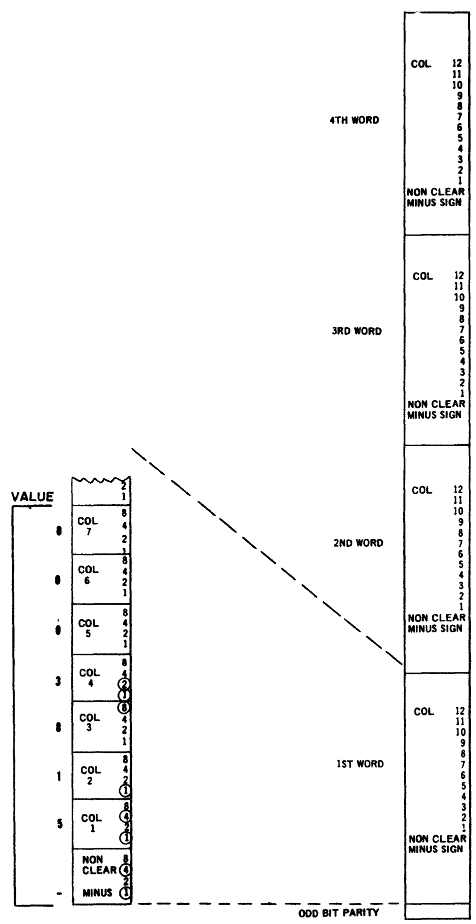


Figure 4. Magnetic-stripe recording format.

(Contd.)

.24 Input-Output (Contd.)

The paper tape may be 11/16, 3/4, 7/8, or 1 inch in width. Paper tape reels contain 1000 feet of blank tape, and the take-up reel holds 300 feet of punched tape output. Cards are punched with the standard Hollerith code. The card punch hopper and stacker hold approximately 500 cards each.

.3 PROGRAMMING

Programming is performed primarily through use of a program control panel that is inserted under the carriage. All programmed operations are performed relative to individual positions or stops along the carriage of the console printer (i.e., at each carriage stop, several programmed operations can be performed). Carriage movement to the stops is initiated by the depression of a motor bar or control key. The basic functions of the motor bars are as follows:

- Bar 1 operates the machine, spaces the forms, and returns the carriage to a predetermined position.
- Bar 2 operates the machine and tabulates the carriage to the next adjacent stop position.
- Bar 3 operates the machine, line-spaces the forms, and prevents movement of the carriage.
- Bar 4 operates the machine and causes the carriage to tabulate past normal stop positions to a predetermined position.

The basic functions of Bars 1, 2, and 4 may be altered by controls in the program control unit. Four "skip lanes" and six "return lanes" are available for carriage movement (lanes 1-5 are controlled from the numeric keyboard and lanes 26 to 30 are controlled from the typing keyboard), so that the carriage can skip to one of four positions and return to one of six positions with or without line spacing, in addition to the normal tabbing movement. Return stops and skip releases are mounted on a shaft that rotates with the stop shaft.

The minimum skip (forward) movement is 0.1 inch, and the minimum return movement is 0.2 inch.

The program control panel consists of 220 programmable stop positions that correspond to the 220 print positions along the carriage of the printer. Each programmable position consists of a row of 66 lanes into which pins of varying lengths can be inserted. The control panel is divided into six segments, as shown in Figure 5.

Lanes 1 to 5 and 26 to 30 provide ten paths for selective carriage skips and returns. Lanes 6 through 25 control basic carriage operations such as:

- Ribbon shift
- Line Space
- Carriage open
- Repeat machine operation or keyboard entry
- Alter motor-bar-initiated carriage movements
- Repeat machine operation
- Disable spacing
- Print control by position

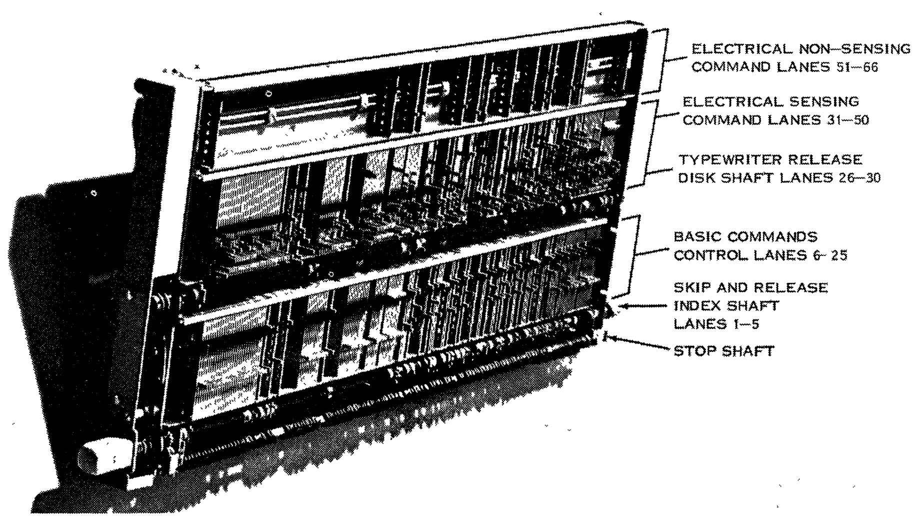


Figure 5. Program control panel used in the E2000 and E3000.

.3 PROGRAMMING (Contd.)

Lanes 31 to 50, called electrical sensing lanes because the varying lengths of the pins are sensed electrically, control operations such as:

- Add
- Subtract
- Clear
- Clear and add
- Write magnetic ledger card
- Read from memory addresses (MA's)
- Reverse entry (for error correction)
- Type to and from memory
- Card and tape punching control
- Execute arithmetic operation if tested MA is plus, or minus
- Amount protection

Lanes 51 to 56, called electrical non-sensing lanes because only one function is controlled per position, control operations such as:

- Multiply
- Divide
- Read from the keyboard
- Read and align magnetic strip card
- Add consecutive MA's (e.g., all 20-29 to 50-59)
- Enforced keyboard memory address selection
- Read and verify (e.g. compare keyboard-entered number with number read from punched card)

By comparison with smaller mechanical accounting machines, the E2000 and E3000 further reduce the complexity of the operator's job. Form alignment and ejection are automatic, keyboard entry is minimized, and some error correction procedures can be handled automatically.

These machines are well suited for low-activity master file updating applications. Ledgers can be updated, and then processed again to produce a wide variety of summary reports. Constants, such as pay rates, as well as summary data can be stored on the magnetic stripes.

The processing speed of the E2000 and E3000 is limited by the manual operations that are required, and they are not well suited for applications that require a high volume of printing. Burroughs quotes the following typical operating times:

Operation	Time in Seconds
Random ledger selection and alignment	8.0
Sequential ledger selection and alignment	3.5
Automatic form alignment	1.2
Manual insertion of form (e.g., paycheck)	3.0
Keyboard entry with memory address selection	2.0
Print cycle —	
E2000 (including tab of 0.1 to 1 inch)	0.38 to 0.6
E3000 (including tab of up to 2 inches)	0.6
Carriage travel (more than 1 or 2 inches)	11 in/sec
Arithmetic cycle	0.094

Burroughs provides housekeeping routines for handling filled ledgers, error conditions, and initial conversion to magnetic-striped ledgers, in addition to the normal processing programs. Users can attend two- to three-day programming classes held by Burroughs personnel. Typical printed output from the E2000 is shown in Figure 6.

.4 PRICE DATA

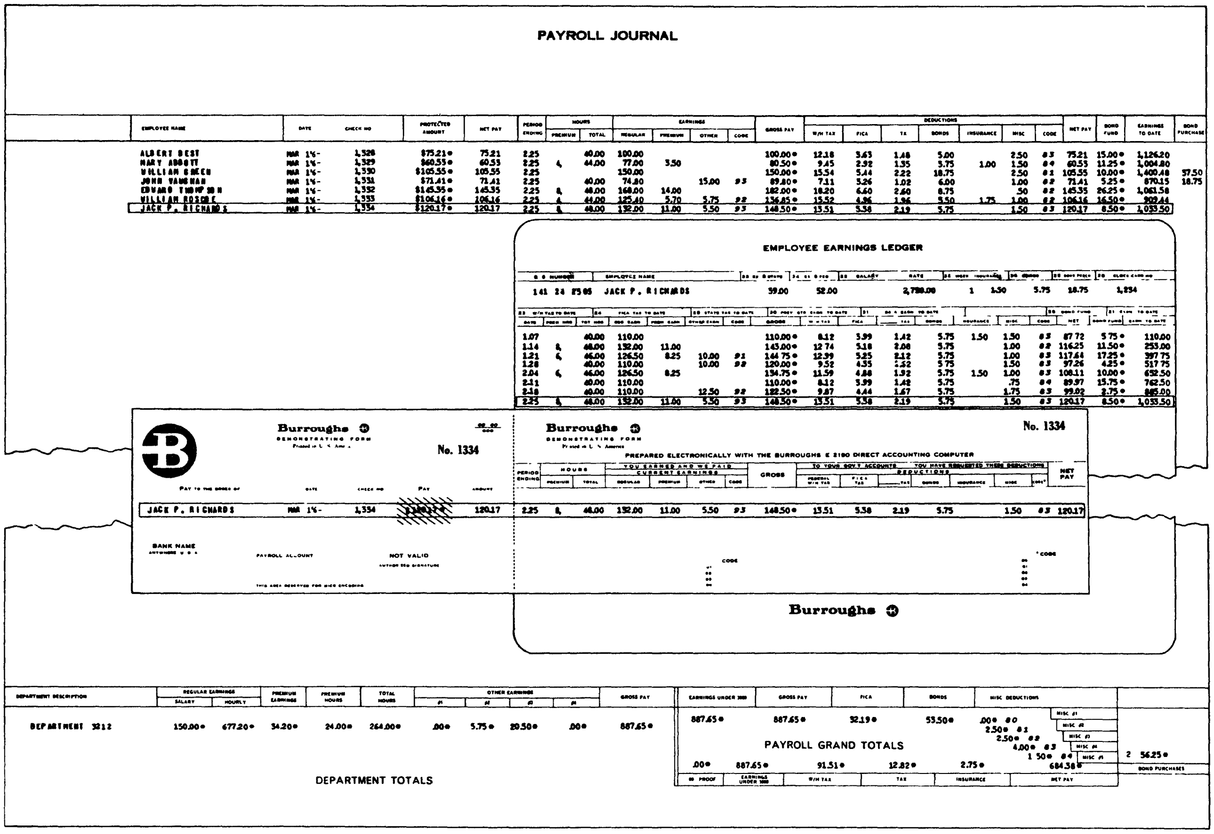
Component or Feature	Monthly Rental, $ (1)	Purchase Price, $	Monthly Maintenance, $ (2)
Series E2000 Electronic Accounting Machine	395 to 760	16,400 to 31,390	77.00 to 157.35
Series E3000 Electronic Accounting Machine	340 to 490	12,740 to 19,490	59.40 to 82.85
Options			
525 Paper Tape Perforator	42 to 68	1,690 to 2,710	14.75
Pin Tractor Carriage Attachment	50	1,590	—
4003 Automatic Ledger Reader	110	4,290	20.45
545 Card Punch Control (3)	48	1,820	14.75

(1) Purchase options are available with rented equipment.

(2) Maintenance charges are higher in rural areas.

(3) Does not include keypunch prices.

(Contd.)



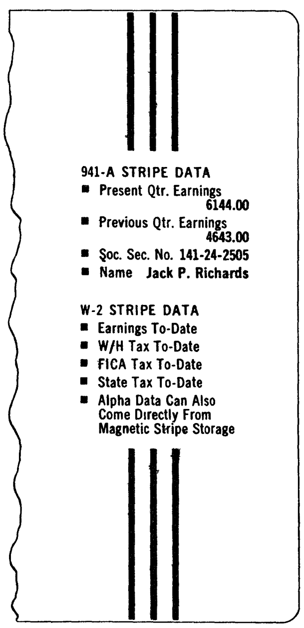


Figure 6. Pay check, ledger, and journal printed simultaneously by the E2190 (above), and data stored on the magnetic strips (below).

SUMMARY: BURROUGHS E4000

.1 BACKGROUND

Announced in May 1966, the Burroughs E4000 adds more core storage and the ability to execute internal subroutines to the capabilities of the E2000 and E3000 Electronic Accounting Machines described in Report 222. The stored programs allow greater flexibility in processing data. An optional punched card reader is also available for use with the E4000. More than 1700 E4000 systems have been installed to date.

The E4000 features keyboard and punched card input; punched card, punched tape and console printer output; and magnetic-stripe read and write heads on the console carriage. The stop control bar controls carriage movement and printing, and the program control panel and stored subroutines control processing. Up to 200 words of core storage are available. The E4000 was first delivered in May 1966, and deliveries are normally made in from one to six months.

.2 HARDWARE

All E4000 hardware is identical to that of the E2000, as described in Report 222, except for the larger internal core storage capacity (200 12-digit words), the addition of 33 internal commands, and the optional punched card reader.

.21 Punched Card Input

The 592 Card Reader reads serially by column at a rate of 180 cards per minute. The hopper and stacker can contain up to 200 cards each. Card reading is normally initiated by an internal subroutine (e.g., read cards until employee number changes). The variable data entered in the payroll operation shown in Figure 2 could be read from punched cards. Burroughs states that the check, statement, earnings record (and a payroll journal, if desired) can be produced for each employee in from 26 to 32 seconds.

Stored programs are read from punched cards and bootstrap-loaded into core memory. Three 4-digit commands are stored in each word of core memory. The internal commands allow for more flexible transfers of data within core memory and are not limited to the arithmetic-cycle sequence of operations of the pin-controlled commands. Subroutines are selected and their operation is initiated by carriage position. The E4000 can make decisions based on a minus sign, a non-zero word, or a non-zero units position of a word. A paycheck and earnings ledger printed by an E4000 are shown in Figure 2. In this application the operator enters regular hours, overtime hours, units of production (non-printed) for bonus computation, and miscellaneous deductions. The rest of the data is computed. Data in the heading was printed and encoded during the initial pass, and is updated with each posting.

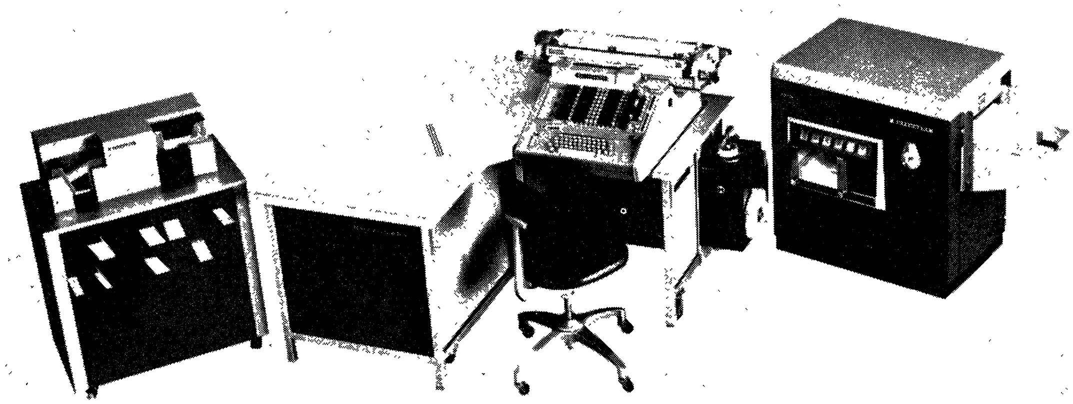


Figure 1. The E4000 Electronic Accounting Machine, with Punched Card Reader at left, and Paper Tape Perforator and Automatic Ledger Reader at right.

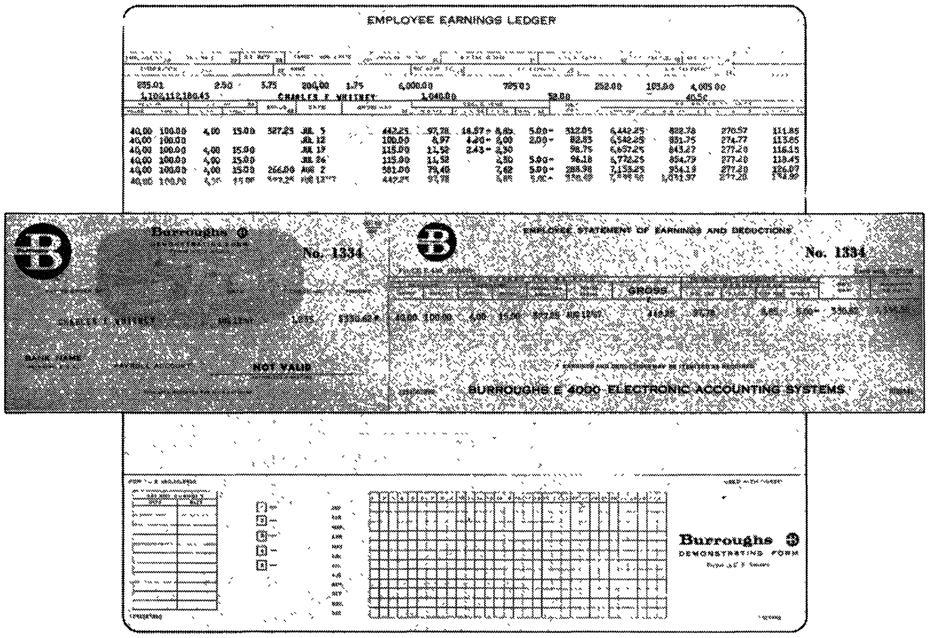


Figure 2. Earnings ledger and paycheck printed by an E4000.

.22 Processing Unit

The arithmetic cycle of the E4000 is identical to the E2000 cycle, and the operation times are the same with the following exceptions:

Operation	Time in msec
Print cycle (including tab of 0.1 to 1 inch)	500 to 600
Internal instruction times:	
Branch	0.336
Add, subtract, transfer	0.97 to 1.6
Multiply, divide	Up to 84.1

The magnetic-stripe data capacity and recording format are also the same as for the E2000. The following operations, requiring the indicated times, can be executed internally in addition to most of the pin-controlled operations that are possible with the E2000:

Operation	Time in msec
Add, subtract, or transfer (reset and add or subtract) from any Memory Address (MA) to MA 00 or MA 11	1.6
Add, subtract, or transfer from MA 00 or MA 11 to any MA	1.6
Multiply any MA by MA 00 or MA 10	17.66 to 79.92
Divide MA 00 or MA 10 by any MA (except MA 00 or MA 10)	22.64 to 85.24
Clear any MA	0.97
Branch unconditionally on any minus or non-zero MA, or on a non-zero low-order digit	0.34
Shift between MA 10 and MA 11 or between MA 11 and MA 00, rounded or unrounded	0.4 to 8.4
Read a punched card into memory	0.6

(Contd.)

.3 PRICE DATA

Component or Feature	Monthly Rental, $ (1)	Purchase Price, $	Monthly Maintenance, $ (2)
Series E4000 Electronic Accounting Machine	495 to 900	20,310 35,040	91.65 170.85
592 Punched Card Reader	58	2,480	15.65

NOTE: Base prices are shown. Burroughs prices each option separately so that customers can select only those options that are needed. Rates for other options are shown in Report 222.

(1) Purchase options are available with rented equipment.

(2) Maintenance charges are higher in rural areas.

SUMMARY: BURROUGHS E6000

.1 BACKGROUND

The Burroughs E6000 Electronic Accounting Machine was announced in November 1967. The E6000 features a line printer, greater core storage capacity, and a slightly faster card reader in addition to all of the capabilities of the E4000 as described in Report 223.

The line printer and greater memory size (400 12-digit words) widen the application range of the Series E line of electronic accounting machines. The first E6000 will be delivered in July 1968 and deliveries will normally be made in from 10 to 12 months.

.2 HARDWARE

All E6000 hardware is the same as the E4000, as described in Report 223, except for the line printer, larger memory, faster card reader, and a larger processor to accommodate the 27 commands that are executed internally rather than through program panel control.

.21 Processing Unit

Control registers in the E6000 allow the internal program to control all of the input-output operations as well as the processing. A register is loaded with instructions for a function (such as Type To Memory, Read Ledger, Activate Motor Bar, and Write Correction) to be performed during the following program halt.

Display lights on the processor cabinet show the Operation Code, Memory Address Register, Status Indicators, Internal Instruction symbol, Program Counter, and Program Flags to aid in program debugging. The Program Flags (program-testable switches) can be set by the motor bars or by internal instructions.

.22 Punched Card Input

The A594 or A592 Card Reader can be used with the E6000. The A594 reads data cards at 200 per minute, and program cards at 300 per minute. Selected data fields can be read by the A594, under program control.

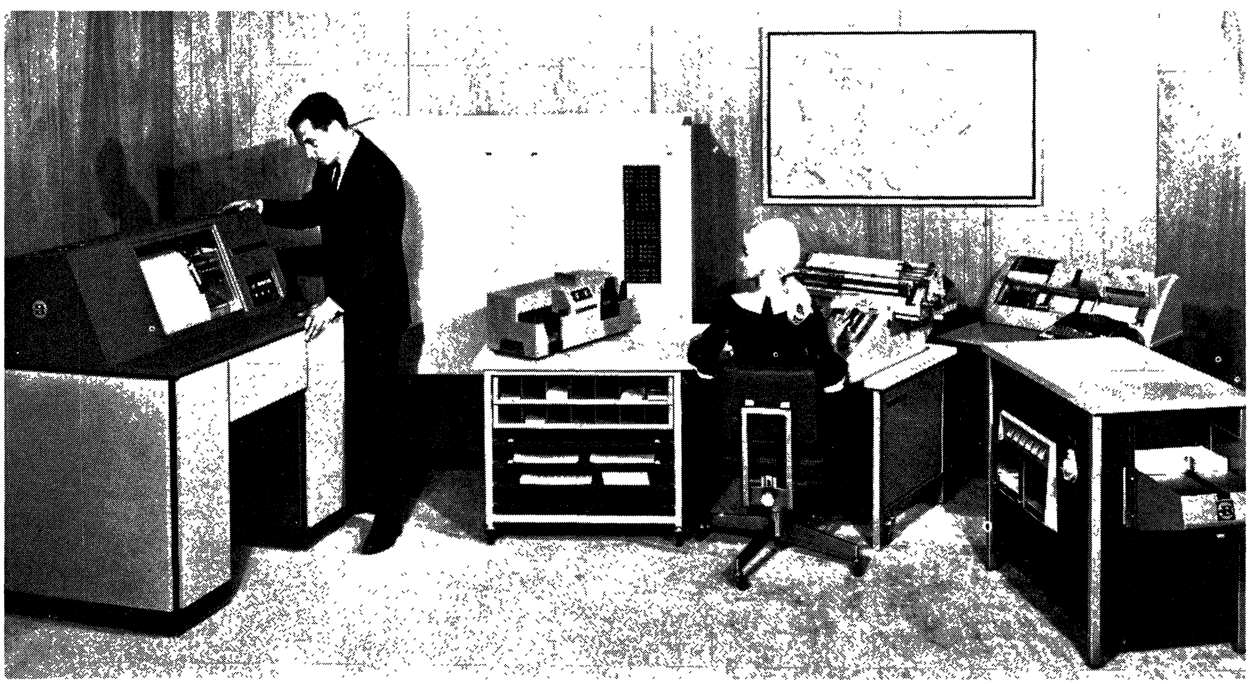


Figure 1. The Burroughs E6000 with (from left to right) an A988 Line Printer, Processor, A594 Card Reader, Control Console, Card Punch, and A4003 Magnetic Stripe Ledger Reader.

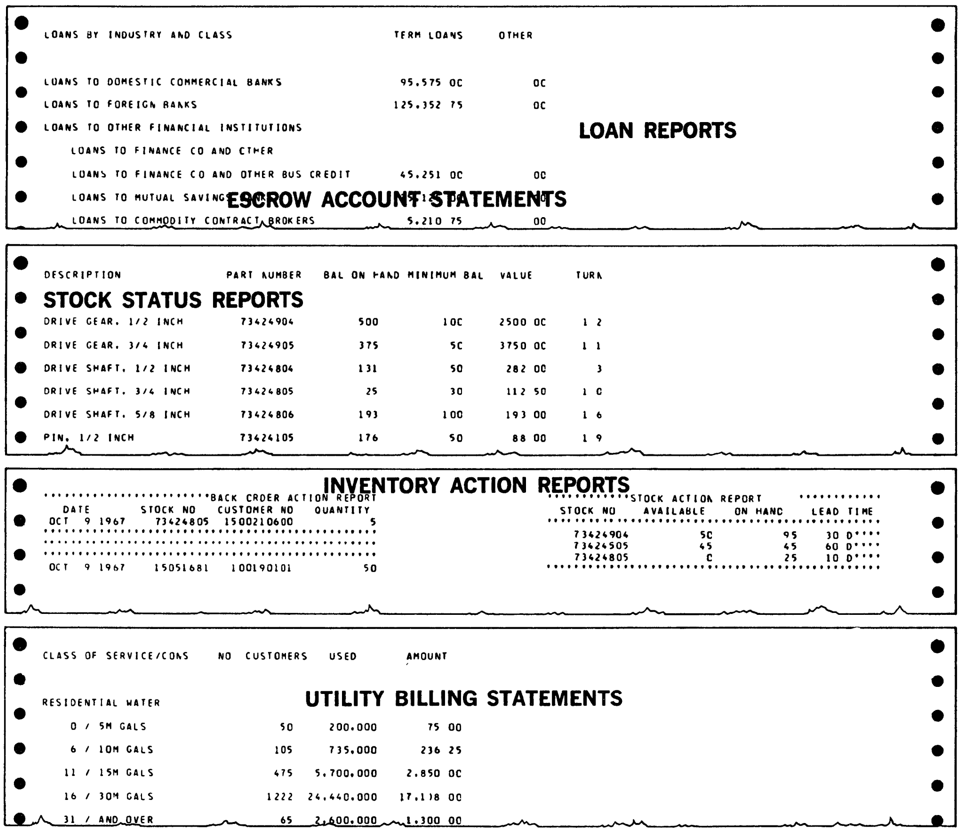


Figure 2. Printouts from the A988 Line Printer.

.23 Line Printer Output

The A988 is a buffered chain printer capable of printing 120-character lines at 164 lines per minute. The 46-character set consists of upper-case letters, numerals, and symbols. Data is printed at 10 characters per inch in a line and 6 lines per inch. Sample printouts from the A988 are shown in Figure 2. The pin-fed forms can be from 3 to 18.5 inches wide and up to 22 inches long. Burroughs states that satisfactory printing can be obtained using single- and multiple-ply forms of the following weights:

Single: . . . . 15 pound bond, or 15 to 125 pound tab card stock.

Four-ply: . . . . 51 pound total (15, 12, 12, 12) with 9 pound carbons.

Six-ply: . . . . 64 pound total (12, 10, 10, 10, 10, 12) with 9 pound carbons.

Vertical spacing is controlled by a 4-channel carriage control tape. The 120-character lines of data are printed from 20 consecutive words of memory. The next 10 words must contain printing mask codes for each character to control dollar protection, punctuation, zero printing, and debit and credit symbol printing.

A line is printed as soon as 120 characters are transferred to the printer buffer or an end-of-line indicator is detected. The following times make up a print cycle:

Load buffer: . . . . 7 msec
Print line: . . . . 340 msec
Space up to 1/2 inch: . . . . 25 msec

Subsequent lines are printed in 365 milliseconds since the buffer can be loaded during line spacing. Processing can take place during the printing and spacing time. Skips of more than 1/2 inch occur at 16.5 inches per second.

.3 PROGRAMMING

The functions of some of the control lanes in the program control unit (explained in Paragraph .3 of Report 222) are different in the E6000, and others are replaced by internal commands. The non-sensing lanes (51-66) are used for carriage-position check control, and the electrical sensing lanes (31-50) are not used. Their functions (multiply, divide, read keyboard and magnetic-stripe data, add to consecutive MA's, etc.) are controlled by internally stored commands. Thus they can be repeated one or more times in any sequence, allowing greater programming flexibility. Commands for branching to and returning from subroutines, and for loading the control register are included.

Burroughs provides all programming required for the initial customer applications, and complete operating instructions. Changes to existing programs (e.g., for new tax rates) are usually done on a fee basis. If the user wishes to do his own programming, Burroughs will provide training.

.4 PRICE DATA

Component or Feature	Monthly Rental, $ (1)	Purchase Price, $	Monthly Maintenance, $ (2)
Series E6000 Electronic Accounting Machine	730 to 930	30,120 to 38,640	148.00 to 230.00
A 988 Line Printer	465 to 515	19,270 to 21,420	88.60 to 118.75
A 594 Card Reader	105	4,260	18.75 to 22.50
A 592 Card Reader	58	2,480	19.00
A 525 Tape Perforator and Controller	68		
A 4004 Ledger Reader	110	4,290	20.00
026B Card Punch	115	5,900	28.00
A 545 Card Punch Control	48	1,850	15.00

(1) Purchase options are available with rented equipment.

(2) Maintenance charges are higher in rural areas.

CONTROL DATA CORPORATION

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SUMMARY REPORT: CONTROL DATA 1604

.1 AVAILABILITY

The Control Data 1604 is a medium-to-large-scale data processing system that is primarily oriented toward scientific and engineering applications which require extensive computation and a fairly large amount of internal storage. The 1604 was Control Data's first general-purpose digital computer system. Introduced as a solid-state contender for the phase of the computer market that was then dominated by the IBM 704, the 1604 was initially delivered in January 1960, two months after the IBM 7090.

Manufacture of the 1604 was phased out during 1962, when it was superseded by an improved model designated the 1604-A. The 1604-A features a more powerful interrupt system and the ability to handle higher input-output data rates with lower central processor delays. These refinements are described in Section 243:011 of the CDC 1604-A report.

A total of approximately sixty 1604 and 1604-A systems were manufactured before production facilities were shifted over to Control Data's newer 3000 Series systems in 1964. Used 1604 and 1604-A systems can be purchased or rented from Control Data Corporation, and Control Data assures prospective users that it will continue to provide full hardware maintenance and software support services. No inventory of used 1604 systems is maintained; they are offered on an "as available" basis, and a turnaround time of about three months is required to refurbish each returned system.

.2 HARDWARE

A Control Data 1604 system can contain 8,192, 16,384, or 32,768 word locations of core storage. Each 48-bit word can hold a fixed-point or floating-point number, a binary data pattern, or two 24-bit instructions. The core storage is divided into two banks, each with independent access facilities and a 6.4-microsecond cycle time. The resulting capability to overlap core storage accesses leads to an effective cycle time of approximately 4.8 microseconds. No parity checking is performed on data transferred to or from core storage.

The 1604 Central Processor operates in the binary mode on 48-bit operands in either fixed-point or floating-point form. Floating-point data values are represented by an 11-bit exponent and a 36-bit-plus-sign fraction. A useful repertoire of arithmetic, logical, branching, storage search, and data transfer operations is provided, but there are no direct facilities for radix conversion, format control, or multi-word data transfers. Instructions are executed at the rate of about 50,000 per second in typical scientific applications.

Each instruction consists of 24 bits: a 6-bit operation code, a 3-bit index designator, and a 15-bit address portion. The index designator can specify either indexing, using one of six index registers, or indirect addressing, which may be recursive. The address portion can specify an operand address in core storage, a literal operand, or a shift count.

The fact that each 48-bit word holds a pair of instructions causes some programming complications which necessitate careful "housekeeping" when coding in assembly language. All transfers of control (jumps) must be to the first instruction of a pair, and certain instructions behave differently depending upon which half of a word they occupy.

An interrupt system permits interruption of the program when an input-output controller becomes ready, when an arithmetic overflow occurs, or when the real-time clock overflows. The programmer can specify which controllers and channels shall be allowed to generate interrupt signals; but when an interrupt occurs, programmed testing is required to identify the specific condition that caused it. The 1604's unsophisticated interrupt system and lack of facilities for inter-program protection make it unsuitable for multiprogrammed operation.

The 1604 contains three pairs of buffered data channels for conventional input-output operations. Each pair consists of one input channel and one output channel. Logically, up to eight controllers can be connected to each pair of channels, and some of the controllers can, in turn, accommodate up to eight I/O devices. Power supply considerations, however, impose lower practical limits on certain configuration combinations. A seventh data channel, which is unbuffered and requires continuous Central Processor control, is intended primarily for high-speed data transfers.

.2 HARDWARE (Contd.)

Up to three input and three output operations can occur simultaneously provided that none of them has a peak speed of over 30,000 characters per second. Each one-word data transfer between core storage and a peripheral device requires about 14.8 microseconds of Central Processor time, and the 1604's I/O control method imposes severe restrictions upon the number of high-speed I/O operations that can take place simultaneously. For example, two 62,500-character-per-second magnetic tape units can be serviced simultaneously only if no other I/O operation is attempted on any of the other channels while the two tape units are operating.

The principal peripheral devices used with Control Data 1604 systems are as follows:

- A 350-character-per-second paper tape reader and a 110-character-per-second paper tape punch, both of which are mounted in the 1604 console desk along with a console typewriter.
- 1607 Magnetic Tape Subsystem, consisting of a Synchronizer Control Unit and up to four Ampex tape units in a single cabinet. Peak speed is 30,000 characters per second, using IBM 729-compatible tape recorded at 200 rows per inch in either BCD or binary mode.
- 1609 Card Reader/Punch, a Control Data adaptation of the IBM 521 Punching Unit, which can read and/or punch up to 100 cards per minute.
- 1617 Card Reader, which reads 80-column cards column by column at 250 cards per minute.
- 1612 Line Printer, a Control Data adaptation of an Anelex Series 4-1000 printer rated at either 1,000 or (for improved print quality) 667 lines per minute.
- 1608 Control Unit, which controls up to eight IBM 729 II or 729 IV Magnetic Tape Units at data transfer rates of 15,000 to 62,500 characters per second.
- 1610-A Control Unit for one 100-cpm IBM 532 Card Punch and/or one IBM 88 Collator used as a card reader at 650 cpm (one feed) or 1,300 cpm (both feeds).

Controllers for other IBM card readers, punches, printers, and magnetic tape units were formerly offered for the 1604, and provisions can probably be made for connecting some of the more recent Control Data peripheral devices used in CDC 1604-A systems (Report 243:).

.3 SOFTWARE

Although Control Data Corporation did not originally offer software support for its computers, it soon decided to do so, and for the past five years it has been seriously engaged in providing standard software. An impressive variety of programming systems, applications programs, and subroutines developed by both Control Data and 1604 users is now available. The software facilities that are properly documented and in general use are supplied through a well-organized, CDC-supported users' group called CO-OP.

Software facilities currently available for the 1604 and 1604-A include the CO-OP Monitor, the CODAP-1 Assembler, three FORTRAN compilers, a COBOL compiler, an ALGOL compiler, a JOVIAL compiler, a sort/merge routine, a PERT routine, a linear programming package, and many mathematical and scientific routines.

The CO-OP Monitor is an operating system that provides run-to-run supervision and conveniently integrates program translation, debugging, and execution functions. CODAP-1 is the basic symbolic assembly language for the 1604. The three versions of FORTRAN that have been implemented for the 1604 are FORTRAN-60, a compiler designed for the rapid compile-and-execute operation using a restricted version of the FORTRAN II language; FORTRAN-62, which compiles more efficient object programs and can incorporate independently-compiled subprograms; and FORTRAN-63, which offers most of the language facilities of FORTRAN IV.

CDC 1604

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*1604		Central Processor (includes 32,768 words of core storage)(1)	31,500	1,039,500	2,360
			Central Processor (includes 16,384 words)	26,500	871,500	1,970
			Central Processor (includes 8,192 words)	23,500	787,500	1,775
INPUT-OUTPUT			Magnetic Tape			
	*1607		Magnetic Tape Subsystem (includes synchronizer plus 4 tape units)	5,300	152,500	750
	*1608		Control Unit for up to 8 IBM 729 II or 729 IV Magnetic Tape Units	2,150	73,500	100
			Punched Card			
	*1609		Card Reader/Punch	1,250	49,500	190
	*1610-A		Control Unit for IBM 523 Card Punch and/or IBM 88 Collator	1,600	60,000	180
	*1617		Card Reader	610	23,500	155
			Printer			
	*1612		Line Printer	1,950	77,000	400

NOTES:

* No longer in production

(1) Price of the central processor includes console, paper tape reader and punch, typewriter, and motor/generator.

SUMMARY REPORT: CONTROL DATA 160

.1 AVAILABILITY

The Control Data 160 is a desk-size, solid-state computer designed primarily for small-scale scientific applications. Because a 160 system can include magnetic tape units, line printers, and punched card equipment, it is also suitable for use with larger computers as an off-line data transcription system or as a directly-connected satellite computer.

Initial deliveries of Control Data 160 systems were made in May 1960. Deliveries of the Control Data 160-A, a more powerful and more expensive version of the 160, began in July 1961. The 160-A features larger core storage capacities and a buffered input-output channel; it is fully described in Computer System Report 244. Programs written for a 160 system can be executed on a similarly-equipped 160-A, but modifications will be required if the user wishes to take advantage of the 160-A's increased storage capacity and simultaneity. Programs written for a 160-A system cannot, in general, be executed on a 160 without modification.

A total of more than 400 Control Data 160 and 160-A computers were manufactured. Both the 160 and 160-A are no longer in production, but used systems can be purchased or rented from Control Data Corporation on an "as available" basis. Control Data assures prospective users that it will continue to provide full hardware maintenance and software support services.

Two other computer systems whose design is closely patterned after that of the 160 are currently being produced by Control Data. The 160-G, initially delivered in March 1964, offers larger and faster core storage (from 8K to 131K words with a 1.5-microsecond cycle time) and a larger word size (14 bits), but it can be operated in a compatibility mode that enables it to execute 160-A programs without alteration. The 8090 Control Computer uses a central processor that is program-compatible with the 160-A, but the 8090 is designed primarily for communications and control applications. The 8090 is the central component of several message-switching systems installed by Control Data.

HARDWARE

The basic Control Data 160 system consists of the desk-size central processor, 4,096 twelve-bit words of core storage, and a built-in 350-character-per-second paper tape reader and 110-character-per-second paper tape punch. Core storage cycle time is 6.4 microseconds, and no expansion of the basic 4,096-word capacity is possible. (A 160-A system can have from 8,192 to 32,768 words.) No parity checking is performed on data transferred to or from core storage.

The short word length of 12 bits (11 data bits plus sign bit) provides a precision of only 3.3 decimal digits and leads to numerous programming complexities. Arithmetic of double, triple, or quadruple precision will need to be performed to obtain the precision required for many scientific applications. The single-address instructions are one or two words in length, and there are seven different addressing modes. In general, instructions that reference operands in core storage are two words long, but a single word can hold an instruction that references a location within 64 locations of the present setting of the instruction counter. Limited facilities are provided for indexing (using a single index register) and for indirect addressing (non-recursive).

The 160 has an instruction repertoire of 97 instructions, most of which are variations of a few basic instructions. The basic arithmetic mode is fixed-point binary on single-word operands. There are add-to-storage and Boolean instructions, but no standard facilities are provided for multiplication, division, direct comparisons, radix conversions, or floating-point arithmetic. In the basic 160 system, these functions are usually performed by standard subroutines. The optional 168-1 Auxiliary Arithmetic Unit provides automatic facilities for double-precision addition and subtraction and for single-precision multiplication and division, all in fixed-point mode. The 168-2 Auxiliary Arithmetic Unit speeds the execution of floating-point arithmetic operations.

Although the basic 11-bit add time is only 19.2 microseconds, double-precision addition takes 225 microseconds using subroutines and 145 microseconds using the 168-1 Arithmetic Unit. Floating-point add times are about 4,000 microseconds using subroutines and 1,000 microseconds using the 168-2 Arithmetic Unit.

.2 HARDWARE (Contd.)

Simultaneous operations cannot be performed in Control Data 160 systems; the central processor is interlocked during all input-output operations. There is no interrupt system.

The principal input-output devices used with Control Data 160 systems are the built-in tape reader and punch and the following optional units:

- An on-line typewriter, which provides the typewriter input-output facilities that are lacking in the basic 160 system.
- A card reader, rated at either 250 or 1,200 cards per minute.
- A card punch, rated at either 100 or 200 cards per minute; the slower model is an IBM 523.
- A line printer with a rated speed of either 150 or 1,000 lines per minute.
- Up to four magnetic tape units. Either the 163 Magnetic Tape Subsystem or the newer 603 Magnetic Tape Units can be connected. Both use IBM 729-compatible tape in either BCD or binary mode. The 163 subsystem consists of one to four tape handlers and a control unit; its peak speed is 30,000 characters per second at a recording density of 200 rows per inch. The 603 has peak speeds of 15,000 or 41,667 characters per second at recording densities of 200 and 556 rows per inch, respectively.

A 160 computer can be connected on-line to a larger Control Data 1604, 1604-A, or 3000 Series computer. Data can be transferred between the coupled systems by direct core-to-core transfers or by way of shared magnetic tape units.

.3 SOFTWARE

Because of the Control Data 160's short word length and machine-language programming complexity, the software available for the system is of particular importance. A useful assortment of programming systems and subroutines, developed by Control Data and by 160 users, is now available, although many significant programs that have been developed for the 160-A cannot be run on 160 systems. The software facilities that are properly documented and in general use are supplied through a well-organized, CDC-supported users' group called SWAP.

OSAS is the basic symbolic assembly system for the 160 and 160-A. It provides no facilities for macro-instructions, but library subroutines can be assembled along with the user's source programs. Only about 250 symbolic labels can be accommodated by the OSAS translator for the 160. The translator is available in different versions for systems that use paper tape, magnetic tape, or punched card input-output.

A compiler is available for 160 FORTRAN, a restricted but useful version of the FORTRAN II language. The restrictions are imposed mainly by the hardware limitations of the 160 itself. Fixed-point arithmetic is limited to single precision (11 bits), while each floating-point variable occupies three words of core storage. Mixed-mode arithmetic is permitted. Object programs compiled by 160 FORTRAN are executed interpretively.

INTERFOR is a floating-point interpretive system for the 160. Its repertoire of 22 instructions is a subset of the larger Control Data 1604's machine-language instruction repertoire; thus, INTERFOR makes it easy for 1604 programmers to write programs that can be executed interpretively on a 160. Each floating-point data value occupies four words of 160 storage. Standard INTERFOR subroutines handle input, output, and mathematical functions. INTERFOR programs can be written directly in octal format, or they can be written in a more convenient symbolic format and assembled by FLAP, a special-purpose assembler.

Among the library subroutines available for the 160 are routines to perform single-precision multiplication and division, multiple-precision fixed-point arithmetic, decimal arithmetic, floating-point arithmetic, mathematical functions, radix conversions, matrix inversion, and data transcriptions (card-to-tape and tape-to-printer).

CDC 160

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	*160		Processing Unit (includes 4,096 words of core storage, paper tape reader, and paper tape punch)	1,600	63,000	200
		*168-1	Auxiliary Arithmetic Unit (fixed point)	410	12,500	125
		*168-2	Auxiliary Arithmetic Unit (floating point)	475	14,000	130
ATTACH-MENTS, ADAPTERS, AND CHANNELS	*3681G		Data Channel Converter (permits use of CDC 3000 series peripheral equipment)	290	11,500	20
INPUT-OUTPUT			Magnetic Tape			
	*603		Magnetic Tape Unit	580	25,000	120
	*162-1		Tape Synchronizer (for 1 to 4 603 tape units)	530	21,000	105
			Magnetic Tape Subsystem:			
	*163-1		One tape handler and control	1,000	40,500	235
	*163-2		Two tape handlers and control	1,550	62,500	400
	*163-3		Three tape handlers and control	2,100	84,000	565
	*163-4		Four tape handlers and control	2,650	105,500	730
			Punched Card			
	*167-1		Card Reader (250 cards/min.)	420	16,500	140
	405		Card Reader (1200 cards/min.)	420	23,500	65
	*177G		Card Reader Controller (for 405)	105	5,000	10
	415		Card Punch(200 cards/min.)	310	19,000	60
	523		IBM Card Punch (100 cards/min.)	121	5,100	-
	*170G		Card Punch Controller (for 415 or 523)	350	14,500	55
			Printers			
	*166-2		Line Printer (150 lines/min)	720	31,500	325
	*1612		Line Printer (1000 lines/min)	1,950	77,000	400
			Typewriters			
	*161F		On-Line Input-Output Typewriter (Flexowriter)	465	16,000	110
	*161G		On-Line Input-Output Typewriter	275	11,000	95
			Plotter			
	*165-1		Incremental Plotter	220	7,400	80

NOTES:
*No longer in production.

SUMMARY REPORT: CONTROL DATA 1604-A

.1 AVAILABILITY

The Control Data 1604-A is a medium-to-large-scale data processing system that is primarily oriented toward scientific, simulation, or control applications in which extensive computations are performed.

The 1604-A was introduced in 1962 to replace the 1604, Control Data's first general-purpose digital computer system. The 1604-A features a more powerful interrupt system and the ability to handle higher input-output data rates with lower central processor delays. (A 1604-B computer was also manufactured; it provided the basic 1604 facilities plus increased input-output transfer capacities.) A total of approximately sixty 1604 and 1604-A systems were manufactured before production facilities were shifted over to Control Data's newer 3000 Series systems in 1964. Used 1604 and 1604-A systems can be purchased or rented from Control Data Corporation, and Control Data assures prospective users that it will continue to provide full hardware maintenance and software support services. No inventory of used 1604-A systems is maintained; they are offered on an "as available" basis, and a turnaround time of about three months is required to refurbish each returned system.

.2 HARDWARE

A Control Data 1604-A system can contain 8,192, 16,384, or 32,768 word locations of core storage. Each 48-bit word can hold a fixed-point or floating-point number, a binary data pattern, or two 24-bit instructions. The core storage is divided into two banks, each with independent access facilities and a 6.4-microsecond cycle time. The resulting capability to overlap core storage accesses leads to an effective cycle time of approximately 4.8 microseconds. No parity checking is performed on data transferred to or from core storage.

The 1604-A Central Processor operates in the binary mode on 48-bit operands in either fixed-point or floating-point form. Floating-point data values are represented by an 11-bit exponent and a 36-bit-plus-sign fraction. A useful repertoire of arithmetic, logical branching, storage search, and data transfer operations is provided, but there are no direct facilities for radix conversion, format control, or multi-word data transfers. Approximately 50,000 or 100,000 instructions can be executed per second in floating-point or fixed-point mode, respectively.

Each instruction consists of 24 bits: a 6-bit operation code, a 3-bit index designator, and a 15-bit address portion. The index designator can specify either indexing, using one of six index registers, or indirect addressing, which may be recursive. The address portion can specify an operand address in core storage, a literal operand, or a shift count.

The fact that each 48-bit word holds a pair of instructions causes some programming complications which necessitate careful "housekeeping" when coding in assembly language. All transfers of control (jumps) must be to the first instruction of a pair, and certain instructions behave differently depending upon which half of a word they occupy.

A major improvement of the 1604-A computer system over the 1604 is a more powerful interrupt system that enables a master routine to control input-output transfers and overlapping. When an input-output controller becomes ready, or an arithmetic overflow occurs, or the real-time clock overflows, the 1604-A can transfer control to one of nine different locations, depending on the source of the interrupt condition (compared to the one fixed location available to the 1604 interrupt system). Flexible individualized control of interruptions is provided by masks and conditions that can be indicated in the user programs. The 1604-A can also temporarily inhibit interrupt requests, whereas the 1604 must either process interrupts immediately or prevent them altogether. Despite its effective interrupt system and large core storage capacity, the 1604-A's lack of inter-program protection makes multiprogrammed operations impractical.

The 1604-A contains three pairs of buffered data channels for conventional input-output operations. Each pair consists of one input channel and one output channel. Logically, up to eight controllers can be connected to each pair of channels, and some of the controllers can, in turn, accommodate up to eight I/O devices. Power supply considerations, however, impose lower practical limits on certain configuration combinations. A seventh data channel, which is unbuffered and requires continuous central processor control, is intended primarily for high-speed data transfers.

.2 HARDWARE (Contd.)

The 1604-A has an Auxiliary Sequence Control which controls single-word transfers between core storage and the buffered input-output channels. In the 1604-A, unlike the 1604, this process is independent of the instruction sequence. Provided no unit with a transfer rate of greater than 125,000 characters per second is connected, there are no limitations upon the simultaneity of the input-output units. Therefore, the 1604-A can simultaneously compute, accept input from three channels, and send output to three channels. Each one-word data transfer between core storage and a peripheral device requires about 3.2 microseconds of central processor time, compared to the 14.8 microseconds required for a similar transaction in the 1604.

The principal peripheral devices used with Control Data 1604 systems include the following:

- A 350-character-per-second paper tape reader and a 110-character-per-second paper tape punch, both of which are mounted in the 1604 console desk along with a console typewriter.
- Up to four 818 Magnetic Disk Files, each containing 200 million bits of storage.
- 1607 Magnetic Tape Subsystem, consisting of a Synchronizer Control Unit and up to four Ampex tape units in a single cabinet. Peak speed is 30,000 characters per second, using IBM 729-compatible tape recorded at 200 rows per inch in either BCD or binary mode.
- Up to eight 606 Magnetic Tape Units, with a peak data transfer rate of 83,400 characters per second and a recording density of 200 or 556 rows per inch.
- 1609 Card Reader Punch, a Control Data adaptation of the IBM 521 Punch that can read and/or punch up to 100 cards per minute.
- 415 Card Punch, which punches up to 250 eighty-column cards per minute.
- 1617 Card Reader, which reads eighty-column cards column by column at 250 cards per minute.
- 405 Card Reader, which reads up to 1200 eighty-column cards per minute.
- 1612 Line Printer, a Control Data adaptation of an Anelex Series 4-1000 printer rated at either 1,000 or (for improved print quality) 667 lines per minute.
- 501 or 505 Line Printer, rated at 1000 and 500 lines per minute, respectively.
- 1608 Control Unit, which controls up to eight IBM 729 II or 729 IV Magnetic Tape Units at data transfer rates of 15,000 to 62,500 characters per second.
- 1610-A Control Unit for one 100-cpm IBM 532 Card Punch and/or one IBM 88 Collator used as a card reader at 650 cpm (one feed) or 1,300 cpm (both feeds).

.3 SOFTWARE

A substantial variety of programming systems, applications programs, and subroutines, developed both by Control Data and by 1604 and 1604-A users, is available for the 1604-A computer system. Software facilities that are properly documented and in general use are supplied through a well-organized, CDC-supported users' group called CO-OP.

Software facilities currently available for the 1604 and 1604-A include: the CO-OP Monitor; the Three-Phase AUTOMONITOR System; the CODAP-1 Assembler; three FORTRAN compilers; COBOL, ALGOL and JOVIAL compilers; a sort/merge routine, a PERT routine; a linear programming package; and many other mathematical and scientific routines.

The CO-OP Monitor is an operating system that provides run-to-run supervision and conveniently integrates program translation, debugging, and execution functions. Programs can be accepted directly from various input devices or requested from a library tape.

The three versions of FORTRAN that have been implemented are FORTRAN-60, a compiler designed for rapid compile-and-execute operation using a restricted version of the FORTRAN II language; FORTRAN-62, which compiles more efficient object programs and can incorporate independently-compiled subprograms; and FORTRAN-63, which offers most of the language facilities of FORTRAN IV.

The 1604-A COBOL compiler requires 32,768 words of core storage and between two and five tape units. It includes all of Required COBOL-61, the RANGE IS and USE verb elective features, and the SORT provision of COBOL-61 Extended. Since compilation takes place under the supervision of the CO-OP Monitor, COBOL language statements can be mixed with FORTRAN 62 or CODAP-1 assembly language statements within the same program.

CDC 1604-A

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*1604-A		Basic Computer (includes 32,768 words of core storage)(1)	33,000	1,081,500	2,480
	*1604-B		Basic Computer (includes 32, 768 words core storage)(1)	32,000	1,047,500	2,360
MASS STORAGE			Disk Storage			
	* 818		Magnetic Disk File (200 million bits)	2,850	124,000	405
	*1619		Magnetic Disk File Control (for 818 Magnetic Disk File)	2,050	95,500	200
INPUT-OUTPUT			Magnetic Tape			
	* 606		Magnetic Tape Unit	870	38,000	140
	*1607		Magnetic Tape System	5,300	152,500	750
	*1608		Control Unit (for IBM 729 II and 729 IV Magnetic Tape Units)	2,150	73,500	100
	*1615		Control Unit (for 606 Tape Units)	2,100	69,500	190
			Punched Card			
	405		Card Reader	420	23,500	65
	415		Card Punch	310	19,000	60
	170		Control Unit (for 415 Card Punch)	350	14,500	55
	*1609		Card Reader and Punch	1,250	49,500	190
	*1617		Card Reader	610	23,500	155
	*1614		Control Unit (for 405 Card Reader)	890	16,500	20
	*1610-A		Control Unit (for IBM 523 Card Punch, 088 Collator and 407 Printer)	1,600	60,000	180
			Printers			
	501		High Speed Line Printer	910	44,500	240
	505		Line Printer	670	27,000	210
	*1612		Line Printer	1,950	77,000	400
	*1611		Control Unit (for 501 or 505 Line Printer)	810	28,500	70

NOTES:

*No longer in production.

(1) Price of the central processor includes console, paper tape reader and punch, typewriter, and motor/generator.

SUMMARY REPORT: CONTROL DATA 160-A

.1 AVAILABILITY

The CDC 160-A system, essentially a CDC 160 with larger core storage and a single buffered input-output channel, is a solid-state desk-size computer oriented primarily toward scientific applications. Because a 160-A system can include magnetic tape units, line printers, and punched card equipment, it is also suitable for use with larger computers as an off-line data transcription system or as an on-line satellite computer.

Initial deliveries of the Control Data 160-A were made in July 1961. The 160-A is a more powerful and more expensive version of the earlier Control Data 160 system, featuring core storage capacities of up to 32,768 12-bit words, in addition to a buffered input-output channel. Programs written for a 160 system can be executed on a similarly-equipped 160-A, but modifications will be required if the user wishes to take advantage of the 160-A's increased storage capacity and simultaneity. Programs written for a 160-A system cannot, in general, be executed on a 160 without modification.

.2 HARDWARE

The basic Control Data 160-A system consists of the desk-size central processor, 8,192 12-bit words of core storage, a buffered input-output channel, a hardware interrupt system, and a built-in 350-character-per-second paper tape reader and 110-character-per-second paper tape punch.

The 160-A also provides for from one to four additional modules of core storage, for a maximum of 32,768 words. One of these modules, the Model 169 Auxiliary Memory Unit, with 24,576 words of core storage, also provides a second buffered input-output channel which permits an additional independent input or output transfer of data.

Core storage cycle time is 6.4 microseconds. Because the 12-bit address word permits direct addressing of only 4,096 locations, the 160-A requires a bank-control register to permit addressing of the entire core storage. No parity checking is performed on data transferred to or from core storage.

The short word length of 12 bits (11 data bits plus sign bit) provides a precision of only 3.3 decimal digits and leads to numerous programming complexities. Arithmetic of double, triple, or quadruple precision will need to be performed to obtain the precision required for many scientific applications. The single-address instructions are one or two words in length, and there are seven different addressing modes. In general, instructions that reference operands in core storage are two words long, but a single word can hold an instruction that references a location within 64 locations of the present setting of the instruction counter. Limited facilities are provided for indexing (using a single index register) and for indirect addressing (non-recursive). The contents of a bank-control register must be used to select one of eight available core banks, since a computer word cannot specify the complete range of possible core storage addresses.

The instruction repertoire of the 160-A, like that of the earlier 160, provides add-to-storage and Boolean instructions, but has no standard facilities for multiplication, division, direct comparisons, radix conversions, or floating-point arithmetic. In the basic 160-A system these functions are usually performed by standard subroutines. The optional 168-1 Auxiliary Arithmetic Unit provides automatic facilities for double-precision addition and subtraction and for single-precision multiplication and division, all in fixed-point mode. The 168-2 Auxiliary Arithmetic Unit speeds the execution of floating-point arithmetic operations.

The additional instructions in the 160-A which were not present in the 160 include the following: additional internal shifting; a return jump; selective stops and selective jumps; a conditional jump, depending on the status of the Buffer channel; control for the storage bank control registers and the Buffer channel control registers; clear of interrupt lockout; and several other miscellaneous functions.

Although the basic 11-bit add time is only 19.2 microseconds, double-precision addition takes 225 microseconds using subroutines and 145 microseconds using the 168-1 Arithmetic Unit. Floating-point add times are about 4,000 microseconds using subroutines and 1,000 microseconds using the 168-2 Arithmetic Unit.

Simultaneous input-output operations can be performed in the 160-A system by using the Buffer channel for data transfer and the processor for either instruction execution or data transfer on the Normal channel. Another completely independent buffered channel is optionally available for transferring blocks of data to and from the 169 Auxiliary Memory Unit. An

.2 HARDWARE (Contd.)

interrupt system is also available, providing four separate interrupt channels: one for the operator, one that occurs at the end of every buffered data transfer, and two for external equipment. Occurrence of an interrupt causes automatic program transfer to one of four fixed interrupt channel locations and locks out all further interrupts until cleared.

The principal input-output devices used with Control Data 160-A systems are the built-in paper tape reader and punch and the following optional units:

- An on-line typewriter, which provides the typewriter input-output facilities that are lacking in the basic 160-A system.
- Card readers, rated at 250 and 1,200 cards per minute.
- Card punches, rated at 100 and 250 cards per minute; the slower model is an IBM 523.
- Line printers, with rated speeds of 150 and 1,000 lines per minute.
- Up to eight magnetic tape units. A 163 or 164 Magnetic Tape Subsystem, up to four 603 Magnetic Tape Units, or up to eight 606 Magnetic Tape Units can be connected to the 160-A computer system. The 163 and 164 subsystems consist of one to four tape handlers and a control unit; the peak speed of the 163 is 30,000 characters per second and that of the 164 is 15,000 characters per second, both at a recording density of 200 bits per inch. The Model 603 and 606 Tape Units are physically identical to each other, except that the Model 603 has peak speeds of 15,000 or 41,667 characters per second at recording densities of 200 and 556 rows per inch, respectively; the 606 has a tape speed of 150 inches per second, which provides a data rate of up to 83,300 characters per second.

A 160-A computer can be connected on-line to a larger Control Data 1604, 1604-A, or 3000 Series computer. Data can be transferred between the coupled systems by direct core-to-core transfers or by way of shared magnetic tape units.

3 SOFTWARE

A useful assortment of programming systems and subroutines, developed both by Control Data and by users, is available for the 160-A computer system. The software facilities that are properly documented and in general use are published by a well-organized, CDC-supported users' group called SWAP.

OSAS-A is the basic assembly system for the 160-A. It provides no facilities for macro-instructions, but library subroutines can be assembled along with the user's source programs. The OSAS-A translator can accommodate approximately 1,000 symbolic labels (compared to 250 for the OSAS translator used with the Control Data 160 computer). The OSAS-A translator is available in different versions for systems that use paper tape, magnetic tape, or punched card input-output.

Two floating-point interpretive systems, SICOM and INTERFOR, are also available for the 160-A. Both systems use four 160-A words of core storage to hold each data item and two storage words to hold each instruction. SICOM offers a large instruction repertoire, magnetic tape operations, alphanumeric data handling capabilities, and a built-in trace mode. A disadvantage of SICOM is that it must be written in absolute numeric code. INTERFOR has a repertoire of only 22 instructions, but they comprise a subset of the machine language instructions for the large-scale CDC 1604 and 1604-A computers, making it easy for 1604 programmers to write programs that can be executed interpretively on a 160-A system. Another advantage of the INTERFOR system is the facility to write programs in symbolic language that are then assembled by FLAP, a special purpose assembler.

A compiler is available for the 160-A FORTRAN language, a restricted but useful version of the FORTRAN II language. The only significant FORTRAN II facilities not included are the FUNCTION statement and double-precision and complex variables. Fixed-point arithmetic is limited to single-precision (11 bits), and each floating-point variable occupies three words of core storage. Mixed-mode arithmetic is permitted. Object programs compiled by 160-A FORTRAN are executed interpretively, and compile-and-run operation is possible.

AUTOCOMM is a COBOL-like programming system designed for pseudo-English coding of commercial data processing applications. An AUTOCOMM source program consists of a Data Section that describes the files and items to be processed, and a Procedure Section that describes the operations to be performed, including decimal arithmetic, multi-word transfers, alphabetic and numeric comparisons, format conversions, and editing. Seven pseudo index registers can be set, incremented, and tested by procedural statements. AUTOCOMM object programs consist largely of return jumps to a library of standard macro routines that implement the source statements. The facilities of AUTOCOMM are considerably more limited than those of COBOL.

CDC 160-A

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*160-A		Central Processor (includes 8,192 words of core storage, buffer channel, paper tape reader, and paper tape punch).	2,350	94,500	225
		*168-1	Auxiliary Arithmetic Unit (fixed point)	410	12,500	125
		*168-2	Auxiliary Arithmetic Unit	475	14,000	130
			Main Storage			
			Auxiliary Core Storage:			
	*169-1		1 module of 8,192 words	1,300	52,500	100
	*169-2		1 module of 16,384 words	2,100	84,000	150
	*169-3		1 module of 24,576 words	2,900	115,500	200
			Auxiliary Core Storage:			
	*169G-1		1 module of 8,192 words	1,700	67,500	130
	*169G-2		1 module of 16,384 words	2,850	114,500	195
	*169G-3		1 module of 24,576 words	4,050	161,000	280
ATTACHMENTS, ADAPTERS, AND CHANNELS	*171G-1		2 Buffered Input-Output Channels	790	31,500	75
	*171G-2		4 Buffered Input-Output Channels	1,250	50,500	120
	*171G-3		6 Buffered Input-Output Channels	1,650	65,000	155
	*3681G		Data Channel Converter (permits use of CDC 3000 series peripheral equipment)	290	11,500	20
MASS STORAGE			Disk Storage			
	*818		Disk File	2,850	124,000	405
	*1619G		Magnetic Disk File Controller (for 818 Disk File)	2,050	95,500	200
INPUT-OUTPUT			Magnetic Tape			
	*603		Magnetic Tape Unit	580	25,000	120
	*162-1		Tape Synchronizer (for 603 Magnetic Tape Unit)	530	21,000	105
	*606		Magnetic Tape Unit	870	38,000	140
	*162-2		Tape Synchronizer (for 606 Magnetic Tape Unit)	740	29,500	115
	*163		Magnetic Tape System, including Control Unit and:			
			1 Tape Unit (163-1)	1,000	40,500	235
			2 Tape Units (163-2)	1,550	62,500	400
			3 Tape Units (163-3)	2,100	84,000	565
			4 Tape Units (163-4)	2,650	105,500	730
	604		Magnetic Tape Transport	630	27,500	130
			Punched Card			
	*167-1		Card Reader	420	16,500	140
	*167-2		Card Reader (with Hollerith-to-BCD conversion)	485	19,000	150
	405		Card Reader	420	23,500	65

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Card (Contd.)			
	*177G		Card Reader Controller (for 405 Card Reader)	105	5,000	10
	*1610A		Card Reader, Punch, Printer Control	1,600	60,000	180
			Paper Tape			
	*174G		Paper Tape Reader Punch	325	12,500	125
			Printers			
	*166-2		Buffered Line Printer	720	31,500	325
	*1612		High Speed Line Printer	1,950	77,000	400
	*1612G		High Speed Line Printer	1,950	77,000	400
	*161F		On-Line Input-Output Typewriter (Flexowriter)	465	16,000	110
	*161G		On-Line Input-Output Typewriter	275	11,000	95
			Plotter			
	*165G-2		Incremental Plotter	300	9,500	85
COMMUNI-CATIONS	8628G		Digital Communication Terminal	670	26,000	90

NOTES:

*No longer in production

SUMMARY

.1 INTRODUCTION

The CDC 3400/3600/3800 Series (Sometimes referred to as "upper 3000 series" — as contrasted with the "lower" 3100/3200/3300/3500 series) designates a group of three similar, medium-to-large scale general-purpose computer systems manufactured by the Control Data Corporation. These are 48-bit word-oriented binary processors, featuring fast execution of binary arithmetic, an extensive interrupt system, and a run-to-run operating system oriented mainly to scientific processing. Basic core storage cycle times range from 900 nanoseconds to 1.5 microseconds.

Deliveries of the CDC 3600, basically an advanced version of the earlier CDC 1604, began in June, 1963. The first deliveries of the CDC 3400 began in November, 1964. The CDC 3400 is a 3600 type system, but with a curtailed instruction set (optional-at-extra-cost floating point, lack of block transfer, list search, and byte-manipulation instructions) and greatly reduced input-output capabilities (4 channels instead of up to 32, no independent I/O processing module). The CDC 3800, a re-engineered 3600 with faster core cycle time and greater overlapped-execution capability, was first delivered in February, 1966.

A wide range of peripheral devices can be connected to the CDC 3400/3600/3800 systems. These devices include 7-track magnetic tape handlers, high-capacity drum and disc storage units, buffered line printers, card reader, card punch, on-line digital plotter, cathode-ray tube display, and flexible data communication equipment. This equipment can be very efficiently used, particularly in the 3600 and 3800 models, becuase of the high degree of simultaneity permitted by the independence of core storage banks and separate I/O processing modules.

Most of the software offered is designed to run under the control of either the tape-or drum-oriented SCOPE Operating System. This software includes a macro-assembly system (COMPASS), compilers for COBOL, FORTRAN, and ALGOL. Also included are a number of application-oriented programs, such as PERT, APT, SIMSCRIPT, Network Flow, and several linear-programming packages.

Figure 1. The Control Data 3600 Computer System"

.1 INTRODUCTION (Contd.)

Typical monthly rental rates vary from $16,600 for a 6-tape 3400 system, to over $59,000 for a 20-tape 3800 with a CDC 160A satellite.

More detailed information on the CDC 3400/3600/3800 Systems can be found in the following sections of this Summary. The true scope of the series can be best understood if all areas of discussion are read, but the topics that follow can be read separately if desired.

.1 Summary
.2 Central Processors
.3 Peripheral Units
.4 Software
.5 Compatibility within the Series
.6 Compatibility with other Systems

.2 CENTRAL PROCESSORS

The CDC 3400/3600/3800 Series uses central processors with the same basic addressing structure: they are single-address, 48-bit word-length, binary processors. Many instructions are common to all three processors; most are 24 bits in length, stored and accessed two to a 48-bit word. Floating-point arithmetic is optional on the 3400, and standard on the 3600/3800. Double-precision arithmetic is available on the 3600 and 3800 by using the standard "augment" instruction. This instruction modifies the next single-precision instruction for double-precision arithmetic. Listed in Table I are certain central processor tasks and the times required to perform these tasks.

TABLE I: ARITHMETIC EXECUTION TIMES FOR THE CDC 3400/3600/3800 PROCESSORS

TASK (Times expressed in microseconds)	CENTRAL PROCESSOR MODEL		
	CDC 3400	CDC 3600	CDC 3800
Fixed Point Binary			
c = a + b	9.0	6.0	3.0
c = a x b	23.6	10.3	7.3
c = a/b	23.6	20.0	11.9
Floating Point Binary			
c = a + b	12.0*	8.4	4.8
c = a x b	20.5*	10.3	7.0
c = a/b	20.5*	19.0	9.9

*Using optional hardware.

The three processors are upward-compatible: programs written for the smaller machines will run on the larger with minor exceptions. Because of the additional instructions on the 3600 and 3800, downward compatibility is not possible. Following are detailed descriptions of the three processors; Table II Summarizes their characteristics.

TABLE II: SUMMARY OF CDC 3400/3600/3800 PROCESSOR CHARACTERISTICS

Processor Model	Core Storage Cycle Time, μsec	Memory Capacity, 48-bit words	Input-Output Channels	Peripheral Controllers per Channel	Floating point Arithmetic	Multiprogramming and Paging Model
CDC 3404	1.5	16K to 32K		8	Optional	None
CDC 3604	1.5	32K to 256K		8	Standard	None
CDC 3804	0.9	32K to 256K		8	Standard	Optional

(Contd.)

.21 The CDC 3400 Central Processor

The 3400 central processor includes a core storage module with a capacity of 16,384 51-bit words (48 data bits and 3 parity bits) as part of the basic system. The optional 3409 Core Storage Module doubles the total core storage capacity to 32,768 words. Core storage cycle time is 1.5 microseconds.

Arithmetic operations are performed in parallel on 48-bit words. A word can contain a pair of 24-bit single-address instructions or one 48-bit input-output instruction. The operand addresses of most instructions can be indexed or indirectly addressed. Three bits are provided in the instruction for selecting one of six index registers; one of the values formed by these three bits signifies indirect addressing.

Included in the instruction repertoire are a family of Augment instructions that are used to modify the second instruction of the instruction word pairs in which they appear. This is a powerful facility which can be used, for example, to provide double indexing capabilities for most 24-bit instructions, or to one of a number of modifications to a standard instruction.

The 3400 has an interrupt system in which individual interrupt conditions can be honored or ignored, as the program warrants. An interrupt condition is executed by transferring control to a fixed location, recording a return address, and initiating an interrupt routine lockout that remains in effect until a return jump is executed. The programmer must include his own routines to identify and handle each internal and peripheral interrupt condition.

The Control Data 3400 system can be equipped with up to four input-output data channels, enabling the system to compute while simultaneously performing up to four read-write operations using any four peripheral devices in the system.

.22 The CDC 3600 Central Processor

The 3600 central processor is an improved version of the older CDC 1604 unit. The improvements are designed to retain compatibility with the 1604, yet give improved performance.

Several powerful instructions are included in the 3600 repertoire, including the Augment instructions, which modify standard instructions and permit the programmer to use extensions of the standard instruction. For instance, complementation, clearing the operational source, and changing the sign, can all be performed simultaneously with addition or subtraction.

The main improvements over the 1604 and the 3400 are the double precision operations, byte operations, the new D (or Flag) Register, the block transfer, and the table and list instructions:

- Double Precision Floating Point operations with 84-bit mantissas are possible.
- Byte-handling instructions process parts of words and considerably reduce the housekeeping involved in such things as code conversions and almost all types of character handling operations.
- Bit-directed facilities. Single bits can be tested, set, and branched upon when encountered. These facilities also can direct a 1-instruction, 49-way branch which scans a 48-bit word and jumps to a position based on the most significant 1-bit. Used in conjunction with the input-output and other control registers, this feature considerably reduces the time involved in getting through a network of subroutines. Again, the improved performance comes from the elimination of housekeeping efforts rather than the faster computation.
- Block transfer. A fast "transient" instruction is provided, which, when augmented, allows block transfers from one area of core to another at an average rate of 3.25 μsec per word.
- Table-searching and list-construction instructions. Single instructions can automatically search tables (within limits) for the following conditions within 2 microseconds: equal, greater than, less than. Search instructions can handle any character size from 1 to 48 bits. A list held in a specific prescribed form can be created and changed continuously.

Input and output are controlled by means of 1 to 4 Model 3604 Communication (I/O) Modules. These modules have peak data rates equal to that of core storage (667,000 words per second), and each can control up to eight input-output channels. The Communication Modules have direct access to each 16,384-word bank of core storage, which means that the central processor is delayed during input-output operations only if both the input-output and the central processor are attempting to access the same core storage bank. The basic system has 2 banks, and expanded versions have up to 16 banks.

.22 The CDC 3600 Central Processor (Contd.)

Each of the core storage banks initiates its word cycle independently of the others. This provides for asynchronous operation is different banks are used for instruction and data. Although the cycle time (1.5 microseconds) is fixed, the extent to which each bank is used is determined only by the program. For this and other reasons, the actual times quoted for an instruction are only approximate, and vary as much as 20 percent from the approximation.

Separate I/O modules, plus this independence of core banks, permits considerable simultaneity of operation: each I/O module can be transmitting to and from an individual core bank without interfering with the processor (except to the extent that the processor initiates I/O operations); furthermore, each I/O module can control up to eight data channels, each of which can in turn control up to eight peripheral controllers. Simultaneity is, then, in a real sense, limited only by the peak data rate of core bank.

.23 The CDC 3800 Central Processor

The CDC 3800 central processor has the same basic features of the 3600, with the following additions:

- Basic core cycle time is 900 nanoseconds; up to eight 32K core banks may be attached.
- Each 8K "group" of words in a core bank can be independently accessed by the processor or an I/O module.
- The central processor has two independent channels to core storage: one for instructions, one for operands. This allows the hardware to fetch and decode the next instruction while it is still operating on the data called for by the current instruction. If the instructions and operands are located in different core banks, the effective execution time of many instructions is decreased (30 percent in some cases). The instruction times quoted generally assume this overlapping, and are approximate or average times.
- The 3811 Relocation Unit (sometimes referred to as Multiprogramming Module) is a standard option. Under this option, program relocation can be automatically performed, at execution time, by relocation constants stored in the 3811. Main storage can be divided into page sizes ranging from 256 to 2048 words, and all addresses within a page can be modified by the same relocation constant. Thus, a program written for a specific area in memory can be loaded and successfully executed in any page, if the proper relocation constant is provided for that page. Lengthy programs can be segmented into several pages, and by using the proper relocation constants, the processor will execute a segmented program as if it occupied a contiguous region of memory.

Also, the Relocation Unit provides the capability to execute a program only partly present in main storage; the remainder being stored in auxiliary storage. An interrupt occurs when the resident portion of the program has been executed; the processor can then jump to another program elsewhere in storage (typically in a different bank) while the new portion of the first program is read into core under I/O module control. Given the appropriate software for its efficient use, this module permits sophisticated multiprogramming-oriented operation.

.3 Peripheral Units

Two seven-track magnetic tape handlers are available for CDC 3400/3600/3800 systems. The CDC 604 and CDC 607 units are both fully compatible with the IBM 729 and other equivalent units. Both offer packing densities of 200,556, and 800 char/inch; the 604 has transfer rates of 15,000, 41,667, and 60,000 char/sec, while the 607 offers rates of 30,000, 83,400, and 120,000 char/sec. Both units can read in either a forward or backward direction.

Two single-channel tape controllers are available for use with either model of tape unit: the Model 3228 Controller handles up to four tape units, while Model 3229 can control up to eight tape units. Controller Model 3423 provides dual-channel access for eight tape units The 3625 and 3624 model controllers can be used to provide three-, or four-channel facilities with up to 8 or 16 tape units connected to each controller.

The Control Data 405 Card Reader is a fast, asynchronous photoelectric reader that operates at 1,200 cards per minute when reading full 80-column cards, and at up to 1,600 cards per minute with 51-column stub cards. The input hopper can hold 4,000 cards. Two output stackers are provided: one main stacker which can hold 4,000 cards, and a reject stacker which can hold 240 cards. The cards are turned individually as they are being read so that the card deck in the output stacker is in exactly the same order as it was before being read.

(Contd.)

.3 PERIPHERAL UNITS (Contd.)

A Control Data 415 Card Punch operates at 250 cards per minute and uses a row-by-row punching technique. The punched data is then read at a post-punch read station, which counts the number of holes in the card. Subsequent to the post-punch read station, a card can be offset in the output stacker so that the operator can take any necessary action to remove mispunched cards from the card files.

The Control Data 501 and 505 Line Printers operate at up to 1,000 and 500 single-spaced alphanumeric lines per minute, respectively. Except for their operating speeds, the two units are functionally identical. Each printer contains its own 136-character line buffer.

Two types of controllers are available for card readers, punches, and line printers. One type is a single-channel controller; the other type can be connected to two data channels (though program-connected to only one at a time), so that two systems can share a card or printer unit. However, only one card reader, punch, or line printer can be attached to a controller.

The Control Data 813 and 814 Disk Files provide from 100 million to 201 million characters of random-access storage, any part of which can be accessed within 110 milliseconds. The average access time is approximately 90 milliseconds, consisting of positioning time, during which the access arms are positioned over the appropriate disc tracks and the latency time while the discs revolve under the read/write heads and the required record comes into position.

The basic structure of the 813 Disk File consists of two vertical shaft assemblies, each controlling 18 non-removable discs. The discs on both shafts are accessed by a singly hydraulic actuator assembly that contains two groups (or "combs") of 16 access arms. The access arms move in unison across the surface of the discs on each shaft. The requested positioning of one group of access arms is automatically countered by diametrically-opposed movement of the other group of arms in order to minimize mass imbalance and reduce vibrations.

Each 813 Disk File is capable of performing only one read, write, or seek operation at any one time. However, the 814 Disk File, with its two independent actuator assemblies, is capable of over-lapping read, write, and seek operations on each half of the Disk File.

Up to eight 813 or 814 Disk Files can be connected to one 3234 Disk Storage Controller which, in turn, can use one or two data channels. Multiple 3234 Controllers can be used in a single Control Data 3000 Series System.

The Control Data 863 Drum Storage Unit provides random access mass memory with very high data transmission rates — up to two million characters per second — and moderately fast access times. The 863 Drum has a data capacity of 4,194,304 6-bit characters and an average access time of 16.7 milliseconds.

The outstanding characteristic of this unit is the high data transfer rate which can be obtained. This has been achieved by recording and reading a data band of 13 tracks in parallel and using a track recording density of 1,120 bits per inch.

Under normal conditions, Control Data expects that an interlace factor of 2 will most commonly be used, which gives a peak data transmission rate of 1,000,000 characters per second.

The Model 3637 single- and dual-channel controller is available for controlling up to eight 863 Drum Storage Units. The single-channel version can handle only a single data transmission at a time, while the dual-channel controller allows two simultaneous data transmissions to take place, one on each data channel. It is not necessary that both the data channels of a dual-channel controller be connected to the same computer system; an interconnection between computers can be achieved by connecting them to different systems. Any Control Data 3000 Series computer, or a Control Data 160-A computer, can be used in conjunction with Model 863 Drum Storage Units.

Two input-output devices enhance the scientific and business capabilities of CDC 3400, 3600, and 3800 systems.

On-line digital plotting is provided by the CDC 3293 Incremental Plotter, which incorporates a plotter manufactured by California Computer Products, Inc., and records at up to 300 steps per second.

For business applications, the Control Data 915 Page Reader can optically read documents ranging in size from 4 to 12 inches in width and 2.5 to 14 inches in length. The single readable type font is the USA Standard optical font. The Page Reader can operate either on-line to the computer system or off-line, such as for transcribing data to magnetic tape. In the latter case, the Page Reader must be connected to a CDC Teleprogrammer, which contains up to 4,096 words of core storage and has a repertoire of 43 instructions.

.3 PERIPHERAL UNITS (Contd.)

Two more devices facilitate the configuration of dual- or multi-computer systems.

The Control Data 3681 Data Channel Converter simulates a CDC 3000 series data channel, allowing a Control Data 160/160-A computer to communicate with CDC 3000 series peripheral equipment. Simulation is accomplished by means of codes that are transmitted by the CDC 160 or 160-A computer to the 3681 Converter. These codes determine the input-output operation to be performed.

The 160/160-A computer can perform Connect, Function, Read, Write, and Status operations using 3000 Series peripheral equipment by means of the 3681 Data Channel Converter. The 160/160-A Computer can communicate with up to eight 3000 Series peripheral devices, and a second Converter permits connection to additional 3000 Series I/O devices.

The 3682 Satellite Coupler is used to allow a computer system to communicate directly with another physically adjacent system by permitting direct connection between any two standard 12-bit bidirectional channels or Data Channel Converters.

The 3682 Coupler acts as a data path between two 3000 Series data channels of two separate computer systems. The basic communication technique involved is that request and control signals from computer system A to computer system B are received in the same way as the equivalent status signals from any input-output unit. To transfer information between the two data channels, one channel must perform a Write operation while the other channel executes a corresponding Read operation. Thus, an input-output instruction will transfer data directly from one computer to the other at a speed limited only by the memory cycle time of the slower computer.

The major difference between the 3681 and the 3682 is that the 3681 simulates the appropriate 3000 Series data channel, while the 3682 (which is made up of two identical elements acting as buffers between the two systems) buffers and controls the actual data transmissions.

Also, both the Control Data 3274 Digital Communications Terminal and the 3275 Data Set Controller can be used for communication between two or more remotely located CDC computer systems. The 3275 Data Set Controller can interface with up to eight data sets, and can transmit 12-bit words in half-duplex mode over one line at a time at speeds up to 230,000 bits per second. The higher capacity 3274 Digital Communications Terminal provides half- and full-duplex transmission of 12-bit words over wide band communication channels or coaxial cables at speeds up to 2.5 million bits per second. Control Data also provides a data communications terminal controller that can control up to eight voice band or broad band lines, or up to 16 half- or full-duplex narrow band lines, all of which can be active simultaneously.

Multi-line data communications control is also provided by the Model 3266 Communications Terminal Controller, which can control up to 32 Model 323 Teletypewriter Terminal Units (16 send and 16 receive).

Table III Summarizes the major peripheral devices and their characteristics.

TABLE III: PRINCIPAL CDC 3400/3600/3800 SERIES PERIPHERAL UNITS

PERIPHERAL TYPE	MODEL	NAME	CHARACTERISTICS
Punched Card Equipment	405 415	Card Reader Card Punch	reads 1200 cpm punches 250 cpm
Punched Paper Tape Equipment	3691	Paper Tape Reader Punch	reads 350 char/sec and punches 120 char/sec
Printers	505 501	Line Printer Line Printer	prints 500 lpm prints 1000 lpm
Magnetic Tape Units	604	Magnetic Tape Unit	transfers data at 15, 41.7 or 60 KC
	607	Magnetic Tape Unit	transfers data at 30, 83.3 and 120 KC
Random Access Storage	863	Drum Storage Unit	stores 4.2 million characters, 17-millisecond average access time
	813	Disk File	stores 100 million characters, 25 to 110 millisecond-access time
	814	Disk File	stores 200 million characters, 25 to 110 millisecond-access time.

(Contd.)

.4 SOFTWARE

Software for the CDC 3400/3600/3800 Systems is grouped around the SCOPE operating systems. A comprehensive Assembly (COMPASS) system is provided under SCOPE, as are compilers for COBOL, FORTRAN, and ALGOL, and a variety of utility programs and application packages.

.41 SCOPE Operating Systems

Two versions of the SCOPE operating system are available: Tape SCOPE and Drum SCOPE. Tape SCOPE provides the facilities for processing single or batch jobs, and automatic handling of input-output requests and interrupts. Drum SCOPE includes the software available with Tape SCOPE, provides for run-time storage of the library file on a drum device, and permits processing of a foreground program and servicing a real-time interrupts while processing stacked jobs in the background.

Both Tape and Drum SCOPE feature a resident loader/monitor which contains provisions for continuity of job processing, automatic handling of input-output requests, and interrupt processing. Routines for job sequencing, program loading, equipment assignment, debugging, library preparation, overlay handling, and calling utility routines are also stored in the system library. The resident program occupies approximately 5,500 words of core storage for Tape SCOPE and 7,500 words of core storage for Drum SCOPE.

At the programmer's option, the SCOPE operating system can subdivide programs that exceed available core storage into main programs and any number of overlays, each of which can contain any number of segments. The main program, one overlay, and one segment can occupy storage at the same time.

Input-output operations are handled by SCOPE either in the form of macro-instructions or as "calling sequences" to the SCOPE central input-output routine which includes a subroutine for each type of peripheral device.

Library programs such as COMPASS, FORTRAN, COBOL, system macros, library subroutines, and user programs are stored in the SCOPE Systems Library. A library preparation program (PRELIB) that updates a library tape or prepares a new one is also maintained in the system library.

Basic minimum system requirements are 32K of core storage and two magnetic tape handlers or an 863 drum, plus the usual card reader and punch and line printer.

Drum SCOPE can process all programs run under Tape SCOPE and executes in a compatible manner all functions performed under Tape SCOPE. In addition Drum SCOPE allows concurrent processing of one high-priority foreground program and one stacked job in the background. Normally, the foreground program operates on an interrupt-controlled basis and is either a special purpose job requiring operator control, or an input-output oriented job, while the background program is normally a production program, such as a compilation, assembly, or library preparation. One background program, one foreground program and the control routines of Drum SCOPE can concurrently reside in core storage. Core storage is allocated first to the high-priority program and then to background jobs as it is available. Drum SCOPE provides for overlays of background programs if available core storage cannot accommodate an entire background program.

The interrupt control system of DRUM SCOPE permits switching of processor control between one program with extensive processing requirements and one with high peripheral device dependency. The background program can be run in normal mode while the foreground program is executed in the interrupt mode. The background program is executed when neither the priority foreground program nor Drum SCOPE is in control of the processor. Priority execution of jobs can be initiated either by the foreground job or by manual interrupt from the operator.

.42 COMPASS Assembly System

COMPASS is the basic assembly language of the CDC 3400/3600/3800 systems and is used with the SCOPE operating system. This language includes all the machine code instructions. COMPASS allows for source language changes to already assembled programs, and for system, installation, or programmer-provided macro instructions. Programmer-provided macros may be included in the library. Communication between different subprograms and library subroutines is provided by use of COMMON blocks and the EXTernal pseudo-operation. Communication with the operating system is by way of the system macros.

The assembly program is designed to accept as input, cards or card images containing symbolic programming instructions. It translates the symbolic instructions into machine language programs in relocatable binary, for loading into any portion of memory at run time. The assembler will produce as output any combination of:

- Output listing of the assembled program.
- Relocatable binary card output for subsequent loading and execution of the assembled program.

.42 Compass Assembly System (Contd.)

- Relocatable binary card images on an assemble and run tape for immediate loading and execution of the assembled program.
- Compressed symbolic output deck to be used as input for subsequent modification and reassembly (known as cosy deck).

.43 Process Oriented Languages

Compilers for COBOL, FORTRAN, and ALGOL are offered for operation under SCOPE. All require one or two additional tape handlers above the minimum SCOPE requirements.

COBOL meets the requirements for Required COBOL-61, plus many of the provisions of Elective COBOL-61. No significant extensions are provided.

FORTRAN meets the requirements for USASI Standard FORTRAN, plus a number of useful extensions for input-output, masking operations, and built-in functions.

ALGOL is basically the complete ALGOL-60 language, plus a full set of input-output statements.

.44 Problem-Oriented Facilities

Generalized sort/merge packages are available, as well as a good set of utility routines (card-printer, card-drum, tape-drum, etc.), and the following application packages:

- INFOL (information storage and retrieval)
- PERT (management review system)
- SIMSCRIPT (simulation programs)
- CDM4 and DPHELIF (linear programming)
- APT (automatic control of machine tools)
- Network Flow Routine
- KWIC Index production program.

.5 COMPATIBILITY

The CDC 3400/3600/3800 Series is upward-compatible: programs written for a smaller system will in general, run without problems, on a larger system. In general, since the 3600 and 3800 have greatly expanded instruction sets, 3600/3800 programs will not run on a 3400.

CDC 3400/3600/3800

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			CDC 3400 System			
	*3404		Basic 16K Computer (includes maintenance control panel, power converter and power control, six 15-bit index registers, and 16,384 words of magnetic core storage. Includes console with on-line input/output typewriter, operator control panel)	9,200	388,500	1,555
		*3409	32K Storage Option (expands basic computer memory to 32,768 words of core storage)	2,950	131,500	375
		*3410	Floating Point Option (provides single-precision floating-point instructions)	580	26,500	95
			CDC 3600 System			
	*3604		Computation Module (includes real-time clock, console, and input-output typewriter)	13,500	956,500	1,885
	*3609		16K Storage Module (16,384 words of magnetic core storage)	7,800	304,500	800
	*3603		32K Storage Module (32,768 words of magnetic core storage)	10,500	588,000	1,285
			CDC 3800 System			
	3804		Computation Module (includes console and input-output typewriter)	13,500	472,500	1,855
	3803		32K Storage Module (32,768 words of magnetic core storage)	12,500	378,000	642.50
	3811		Multiprogramming Module (Adds relocation capability; page-turning, and memory protection)	1,900	73,500	120
ATTACHMENTS, ADAPTERS, AND CHANNELS			Channels			
	*3406		Standard I/O channel for CDC 3400 (permits attachment of one to eight peripheral devices)	530	25,000	95
	*3416		Augmented I/O channel for CDC 3400 (allows 2,000,000 char/sec peak data rate)	630	29,500	105
	*3602		Communication Module for CDC 3600	2,100	132,500	275
	*3610		Dual-access Communication Module for CDC 3600 (dual-processor system)	3,450	142,000	340
	*3606		Bi-directional Data Channel for CDC 3600	950	37,000	125
	3802		Communication Module for CDC 3800	2,100	82,000	275
	3810		Dual-access Communication Module for CDC 3800 (Dual-processor system)	2,400	94,500	156
	3806		Bi-directional Data Channel for CDC 3800	970	42,000	125
	10115		Multiplexor Channel (for CDC 3800; handles up to 8 low-speed devices)	2,750	99,000	220
	3816		Priority Data Channel for CDC 3600 and 3800 (provides combined functional capabilities of 3802 and 3806)	2,000	71,000	300
	3682		Satellite Coupler (permits direct connection of satellite computer)	185	10,000	25
	3270A		Transfer Switch Controller	105	4,750	10
	3270B		Transfer Switch Controller	160	6,900	25
	8271A		Transfer Switch	53	2,200	5
	8271B		Transfer Switch	79	3,600	8

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE			Disk Storage			
	813		Disk File (100-million-character capacity)	3,450	147,000	465
	814		Disk File (200-million-character capacity)	5,500	241,500	590
	3234		Disk Storage Controller	540	25,000	65
			Drum Storage			
	863		Drum Storage (4.2 million character capacity)	2,750	140,000	400
	3637		Drum Storage Controller	1,150	48,500	135
INPUT-OUTPUT			Magnetic Tape			
	604		Magnetic Tape Transport (15, 41.7 and 60 kc)	630	27,500	130
	607		Magnetic Tape Transport (30, 83.3, and 120 kc)	920	44,000	150
	3228		Magnetic Tape Controller (for 1 to 4 Model 604 or 607 Tape Transports; one channel)	445	21,000	65
	3229		Magnetic Tape Controller (for 1 to 8 Tape Transports; one channel)	630	25,000	75
	3423		Magnetic Tape Controller (for 2 to 8 Tape Transports; two channels)	1,450	69,500	160
	3624		Magnetic Tape Controller (for 4 to 16 Model 607 Tape Transports; four channels)	4,100	194,500	380
	3625		Magnetic Tape Controller (for 3 to 8 Model 607 Tape Transports; three channels)	2,550	126,000	250
	689		Transport Channel Switch (allows Switching of a 603, 604, 606, or 607 Tape Transport between two controllers)	37	1,650	NC
			Punched Card			
	405		Card Reader (1,200 cards/min.)	420	23,500	65
	3447		Card Reader Controller (permits connection of one 405 Card Reader from one channel)	235	12,000	55
	3649		Card Reader Controller (permits connection of one 405 Card Reader from two channels)	340	17,000	40
	415		Card Punch (250 cards/min.)	310	19,000	60
	3446		Card Punch Controller (single-channel)	475	23,000	65
	3644		Card Punch Controller (dual-channel)	710	34,000	95
			Paper Tape			
	3691		Paper Tape Reader Punch (reads 350 rows/sec; punches 120 rows/sec)	325	12,500	125
			Printer			
	501		Line Printer (1,000 lines/min.)	910	40,500	240
	505		Line Printer (500 lines/min.)	670	27,000	210
	3256		Line Printer Controller (single-channel; for 501 or 505 Printer)	540	23,000	60
	3659		Line Printer Controller (dual-channel; for 501 or 505 Printer)	740	40,500	85

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Optical Reader			
	915		Page Reader	2,290	84,000	450
	3195		Page Reader Controller	490	19,500	28
			Plotter			
	3293		Incremental Plotter	300	9,500	85
COMMUNI-CATIONS	3266		Communications Terminal Control	315	13,000	55
	3275		Data Set Controller	410	25,000	60
	3274		Digital Communications	670	26,000	90
			Terminal			
	3290-Z		Entry/Display System Controller	725	24,650	80
	211		Entry/Display Station	125	4,000	10

NOTES:

*No longer in production.

SUMMARY

The Control Data 3400 is a medium to large scale data processing system that is primarily oriented toward scientific, simulation, or control applications that require extensive computations and a large amount of fast-access storage. First customer deliveries were scheduled for November, 1964. The 3400 will usually be used as a magnetic tape oriented system. Multi-computer facilities make it possible to connect other Control Data computer systems on-line to a 3400 system.

The standard arithmetic mode is fixed point binary, using 48-bit words. A single-precision floating point hardware package is optional at extra cost, and will be required for efficient performance in most scientific applications. Without the hardware package, floating point instructions are "trapped", causing jumps to subroutines which simulate the effects of the absent machine instructions.

The Control Data 3400 should not be regarded simply as a system whose capabilities fill a gap between the Control Data 3200 and 3600 systems. Although both its price and basic processing speeds are about two-thirds as high as those of the Control Data 3600, the 3400 is limited to four input-output data channels and lacks such 3600 features as the D (flag) register and the powerful block transfer, list search, and byte manipulation instructions. The absence of these advanced processing facilities will curtail the relative efficiency of the 3400 in complex real-time systems, information retrieval, and other list-processing applications. For conventional high-speed scientific processing of the FORTRAN style, however, these advanced processing facilities of the 3600 are not normally used, and their absence from the 3400's instruction repertoire will not seriously affect its productivity. In such circumstances, the Control Data 3400 can be regarded as being nearly as good as the 3600 — at a considerably lower price.

Hardware

The 3400 central processor includes a core storage module with a capacity of 16,384 51-bit words (48 data bits and 3 parity bits) as part of the basic system. The optional 3409 Core Storage Module doubles the total core storage capacity to 32,768 words. Core storage cycle time is 1.5 microseconds. Except for a few special-purpose instructions, the 3400 processor maintains upward program compatibility with the larger Control Data 3600 processor; i.e., it will be possible to run most 3400 programs on a 3600 system with little or no alteration — the converse will not be true because of the 3600's unique advanced processing facilities.

Arithmetic operations are performed in parallel on 48-bit words. A word can contain a pair of 24-bit single-address instructions or one 48-bit input-output instruction. The operand addresses of most instructions can be indexed or indirectly addressed. Three bits are provided in the instruction for selecting one of six index registers; one of the values formed by these three bits signifies indirect addressing.

Included in the instruction repertoire are a family of Augment instructions that are used to modify the second instruction of the instruction word pairs in which they appear. This is a powerful facility which can be used, for example, to provide double indexing capabilities for most 24-bit instructions, or to direct which one of a number of modifications to a standard instruction should be used.

The 3400 has an interrupt system in which individual interrupt conditions can be honored or ignored, as the program warrants. An interrupt condition is executed by transferring control to a fixed location, recording a return address, and initiating an interrupt routine lock-out that remains in effect until a return jump is executed. The programmer must include his own routines to identify and handle each internal and peripheral interrupt condition.

The Control Data 3400 system can be equipped with up to four input-output data channels, enabling the system to compute while simultaneously performing up to four read-write operations which use any four peripheral devices in the system. A wide range of both old and new peripheral equipment is available for use with the 3400 system.

Hardware (Contd.)

Two models of magnetic tape units and a variety of tape controllers are being offered The 604 and 607 Magnetic Tape Units are new additions to the Control Data line which provide a recording density of 800 characters per inch, a data transfer rate of 120,000 characters per second, and the ability to read backward. The 604 and 607 are compatible with each other, with the older Control Data 603 and 606 Tape Units, and with the IBM 729 and 7330 Tape Units.

The same Disk File subsystem that was announced recently for the Control Data 3600 system will be available for the 3400. This equipment consists of a Disk File Controller and from one to four Model 828 Disk Files, manufactured by Data Products Corporation. Each Disk File has a capacity of 33 million 6-bit characters. Each Disk File Controller includes two read-write controls which permit simultaneous access to one or two Disk Files, allowing any combination of two of the three functions of reading, writing, or positioning to occur simultaneously.

Three different printers have been announced — two "old" and one new. The improved older units operate at peak speeds of 300 and 1,000 single-spaced alphanumeric lines per minute. The new unit, built by Control Data's Peripheral Equipment Division in Minneapolis, is also rated at 1,000 lines per minute but extends the line width from 120 to 136 printing positions. New CDC-built card equipment is also available: the 405 Card Reader (1,200 cards per minute) and 415 Card Punch (250 cards per minute). Still offered, however, is an adapted version of the IBM 523 Card Punch (100 cards per minute).

Other announced peripheral units include a combination paper tape reader-punch that reads tape at 350 characters per second and punches at 110 characters per second; a program-controlled input-output typewriter which is an adaptation of the IBM 731 Selectric typewriter; and an incremental plotter that can make up to three hundred 0.01-inch steps per second.

Software

COMPASS is Control Data Corporation's symbolic assembly system for the 3400. The assembler is basically a one-to-one translator, but it includes a generous sprinkling of useful macro instructions.

The 3400 FORTRAN language allows problems of a mathematical or scientific nature to be expressed in algebraic notation. The language is a dialect of FORTRAN IV. 3400 FORTRAN is compatible with other FORTRAN languages in different degrees, and conversions will involve desk checking of varying intensities. The 3400 FORTRAN compiler and its object programs run under the control of the 3400 SCOPE operating system.

The 3400 COBOL language is the commercial and business oriented compiler counterpart of 3400 FORTRAN. The 3400 COBOL compiler and the object programs it generates run under the control of the 3400 SCOPE operating system.

SCOPE is the operating system under which programs coded in 3400 COMPASS, FORTRAN, and COBOL will generally be compiled and run. This permits the mixing of subprograms coded in different languages and provides greater flexibility. The SCOPE system controls all input-output units. It provides macros, subroutine library facilities, and job batching with elementary diagnostic facilities incorporated. SCOPE includes no announced provisions for multi-running, so unless the 3400 user elects to develop his own operating system, he will generally be able to execute only one job at a time. Two versions of the SCOPE system are available; SCOPE, which is drum resident. With the exception of the incorporation of drum input-output routines in the latter, there are no significant differences between SCOPE and Drum SCOPE for the CDC 3400.

SUMMARY

The CDC 3600 computer system can perform nearly half a million additions per second, thus making it one of the fastest commercially available internal processing systems at the time of its announcement. The core storage capacity ranges from 16,384 to 262,144 words (48 bits), and an elaborate data channel system featuring a separate communication module permits an almost indefinite number of peripheral units (or central processors) to be connected. For simultaneous operation standard systems can include up to 512 tape units. The cost of the 3600, which begins at $45,000, is lower than that of the IBM 7094 and Philco 212, and is higher than that of tne UNIVAC 1107 and the H-1800.

Although the 3600 is basically an advanced version of the CDC 1604 large scale computer system, a number of changes have been made to the CDC 1604 central processor design. Primarily, these changes include instructions which handle parts of words, or "bytes". The performance characteristics of the system are thereby greatly changed and the processing times for many of the problems used as central processor performance criteria, even without considering the faster internal core storage (1.5 compared to 3.2 microseconds), have improved by 70 percent compared to those for the same functions on the 1604.

A number of additional instructions have been included in the 3600 that do not exist in the 1604. These instructions include double precision floating point arithmetic, the ability to perform double indexing of operands, etc., and are particularly valuable in matrix calculation programs. However, they do not have the same impact on the over-all system performance as the byte-handling capabilities.

CDC 1604 programs can be run on the 3600, but the reverse is possible only under restricted circumstances. FORTRAN 63, CXA (a version of Algol 60), and COBOL-61 translators are being made available for both computer systems; thus programs written in these languages can be compiled for either system.

Across the board programming compatibility is restricted to that which is obtained by use of common languages: FORTRAN, COBOL, and ALGOL.

The magnetic tape codes and the internal BCD code for the CDC 3600 and 1604 are identical to those for the IBM 7090 and 7094 systems with IBM 729 tape units. Tapes can be exchanged between the systems; i.e., the CDC 606 tape unit can use magnetic tape reels written by IBM 729 units and vice versa.

The 3600 central processor is an improved version of its equivalent CDC 1604 unit. The improvements have been designed to retain compatibility with the 1604, yet give much-improved performance.

Several powerful instructions have been included in the 3600 repertoire, two of which act on other ordinary instructions to permit the programmer to perform many extensions of the basic instruction. For instance, complementation, clearing the operational source, and changing the sign, can all be performed simultaneously with addition or subtraction.

The main improvements incorporated into the 3600 are the double precision operations, byte operations, the new D (or Flag) Register, and the table and list instructions:

- Double Precision Floating Point operations with 84-bit mantissas are possible.

- Byte-handling instructions process parts of words and considerably reduce the housekeeping involved in such things as code conversions and almost all types of character handling operations.

- Bit-directed facilities. Single bits can be tested, set, and branched upon when encountered. These facilities also can direct a 1-instruction, 49-way branch which scans a 48-bit word and jumps to a position based on the most significant 1-bit. Used in conjunction with the input-output and other control registers, this feature considerably reduces the time involved in getting through a network of subroutines. Again, the improved performance comes from the elimination of housekeeping efforts rather than the faster computation.

Summary (Contd.)

- Table-searching and list-construction instructions. Single instructions can automatically search tables (within limits) for the following conditions within 2 microseconds: equal, not equal, greater than, less than. Search instructions can handle any character size from 1 to 48 bits. A list held in a specific prescribed form can be created and changed continuously.

Input and output are controlled by means of Communication Modules. Rates of up to 133,000 characters per second are always possible, even under worst-case conditions; however, at present no character rate greater than 83,000 characters per second is available. The Communication Modules have direct access to each 16,384-word bank of core storage, which means that the central processor is delayed during input-output operations only if both the input-output and the central processor are attempting to access the same core storage bank. The basic system has 2 banks, and expanded versions have up to 16 banks.

Each of the core storage banks initiates its word cycle independently of the others. This provides for asynchronous operation if different banks are used. Although the cycle time (1.5 microseconds) is fixed, the extent to which each bank is used is determined only by the program. For this and other reasons, the actual times quoted for an instruction are only approximate. Changes in speed of up to 20 percent are possible, depending upon the actual situation, and should be anticipated by each installation manager.

Peripherals for the 3600 system which have been announced include CDC 606 Tape Units, two card readers (one IBM, one CDC), paper tape equipment, a card punch, and a 1,000 line per minute printer. These peripherals provide for three types of interrupts within the central processor, and for automatic translation to and from internal binary coding.

The means for connecting magnetic tape units into 3600 systems are much more flexible than in the 1604. Two, three, or four tape units per controller can be used at one time, and no restriction now exists as to how many units can be reading and how many can be writing. All can be reading or all can be writing, or any mixture of the two modes of operation can be utilized.

Direct Data Communication links are available for the 3600 and two controllers are available which link the 3604 Central Processor to one or more 160 or 160-A computers. Development appears to have been concentrated on providing controllers for peripheral units.

A comprehensive body of software exists insofar as a number of routines, assemblers, supervisors, etc., have been developed for the CDC 1604, which can therefore be run with little or no modification on the 3600. Faster processing will be achieved, but no advantage will accrue to the user from the new specialized instructions.

Software for the 3600 includes:

- The SCOPE Operating System for the CDC 3600 is available in two versions — tape SCOPE and Drum SCOPE. Tape SCOPE, which is tape resident, provides facilities for the processing of single jobs on batch processing of stacked jobs and for automatic handling of input-output requests and the automatic handling of input-output requests and interrupt processing. Drum SCOPE, which is drum resident, incorporates all of the above facilities of tape SCOPE, plus input-output routines for drum devices. It also provides for run-time storage of the library file on drum and permits processing foreground program, servicing of real-time interrupts while processing stacked jobs in the background. The drum is also used to store library routines and serves as the principal input-output device.
- COMPASS is the basic assembly language of the CDC 3600 system and is used with the SCOPE operating system. COMPASS allows for source changes to already assembled programs, and for system installation on programmer-provided macro instructions. Programmer-provided macros may be included in the library. Communication between different subprograms and library subroutines is provided.
- The COBOL compiler meets the requirements for Required COBOL-61 plus many of the provisions of Elective COBOL-61. No significant extensions are provided.
- FORTRAN meets the requirements for USASI Standard FORTRAN plus a number of useful extensions for input-output, making operations and some built in functions.
- ALGOL is basically the complete ALGOL-60 language plus a full set of input-output statements.

SUMMARY

The CDC 3800 is the newest and most powerful in the Control Data 3000 series of computers. It, as was the case with the CDC 3400 and CDC 3600 is a lineal descendant of the CDC 1604. The CDC 3800 is available in core storage capacities from 32K to 256K 48- bit words, placing it in the large computer category. Taking into consideration its size, high internal speeds (900 nano-second cycle time) and high degree of simultaneity, this may be regarded as one of the more powerful computers in this category. The cost of the CDC 3800 can vary from $35,840 per month for a six-tape system to more than $59,000 for a 20 tape system with a CDC 160-A satellite.

The CDC 3800 is a re-engineered version of the CDC 3600. Its higher internal speed is greatly enhanced by the "look-ahead" feature, achieved by making each 8K "group" of words in a core bank independently accessible by the processor on an I/O module. The Central Processor has two independent channels to core storage: one for instructions, one for operands. This allows considerable overlapping an "look-ahead", in that the hardware can fetch and decode the next instruction while it is still operating on the data called for by the previous one. If the instructions and operands are located in different core banks, the effective execution time of many instructions is greatly decreased (in some cases by as much as 30 percent). The instruction times quoted generally assume this overlapping, and only approximate on average times.

Each of the core storage banks initiates its word cycle independently of the others. This provides for asynchronous operation if different banks are used. Although the cycle time .7 micro seconds is fixed, the extent to which each bank is used is determined only by the program. For this and other reasons, the actual times quoted for an instruction are only approximate.

Separate I/O modules, plus the independence of core banks, permits considerable simultaneity of operation: each I/O module can be transmitting to and from an individual core bank without interfering with the processor (except to the extent that the processor initiates I/O operations); furthermore, each I/O module can control up to eight data channels, each of which can in turn, control up to eight peripheral controllers. Simultaneity is then in a real sense, limited only by the peak data rate of a core bank.

The 3811 Relocation Unit (sometimes referred to as the Multiprogramming Module) is a standard option. Under this option program relocation can be automatically performed at execution time by using relocation constants stored in the 3811. Main Storage can be divided into page sizes ranging from 256 to 2048 words; all of the addresses within a page can be modified by the same relocation constant, which can be changed to relocate a program coded for any region in storage. Thus, a program written for a specific area in memory can be loaded unmodified and successfully executed in any page of the proper relocation constant is provided for that page. Lengthy programs can be segmented into several pages, and through the use of the proper constant for each page, the processor will execute a segmented program as if it occupied a contiguous region in storage.

Also the Relocation Unit makes possible the execution of a program that is only partly presented in main storage the remainder being stored on a drum or disc file. An interrupt occurs when the resident portion of the program has been executed; the processor can then jump to another program elsewhere in storage (typically, in a different bank) while the new portion of the first program is read into core under I/O module control. Given the appropriate software for its efficient use, this module permits a sophisticated level of multi-programming operation.

In addition to the foregoing the following features developed for the CDC 3600 have been retained.

- Double Precision Floating Point operations with 84-bit mantissas are possible.
- Byte-handling instructions process parts of words and considerably reduce the housekeeping involved in such things as code conversions and almost all types of character handling operations.
- Bit-directed facilities. Single bits can be tested, set, and branched upon when encountered. These facilities also can direct a 1-instruction, 49-way branch which scans a 48-bit word and jumps to a position based on the most significant 1-bit. Used in conjunction with the input-output and other control registers, this feature considerably reduces the time involved in getting through a network of subroutines. Again, the improved performance comes from the elimination of housekeeping efforts rather than the faster computation.

- Table-searching and list-construction instructions. Single instructions can automatically search tables (within limits) for the following conditions within 2 microseconds: equal, not equal, greater than, less than. Search instructions can handle any character size from 1 to 48 bits. A list held in a specific prescribed form can be created and changed continuously.

Arithmetic operations are performed in parallel on 48-bit words. A word can contain a pair of 24-bit single-address instructions or one 48-bit input-output instruction. The operand addresses of most instructions can be indexed or indirectly addressed. Three bits are provided in the instruction for selecting one or six index registers; one of the values formed by these three bits signifies indirect addressing.

Included in the instruction repertoire are a family of Augment instructions that are used to modify the second instruction of the instruction word pairs in which they appear. This is a powerful facility which can be used, for example, to provide double indexing capabilities for most 24-bit instructions, or to direct which one of a number of modifications to a standard instruction should be used.

The CDC 3400/3600/3800 Series is generally upward compatible: programs written for a smaller system will usually, run without problems on a larger system. Due to the expanded instruction set of the 3600/3800, the converse is not true. True compatibility can be achieved however on the source language level through the use of one of the common languages, FORTRAN, ALGOL or COBOL.

Software for the CDC 3800 is largely based on two operating systems, Tape SCOPE and Drum SCOPE. A comprehensive assembly system (compass) is provided under SCOPE as are compilers for COBOL, FORTRAN and ALGOL, and a variety of utility programs and application packages.

Two versions of the SCOPE operating system are available to users of Control Data 3800 computer system: Tape SCOPE and Drum SCOPE. Tape SCOPE provides facilities for processing of single jobs on batch processing of stacked jobs and for automatic handling of input-output requests and interrupt processing. Drum SCOPE which includes all of the software available with Tape SCOPE, provides for run time storage of the library file, on a drum device and permits processing of a foreground program and servicing of real-time interrupts while processing stacked jobs in the background.

COMPASS is the basic assembly language of the CDC 3800 system and is used with the SCOPE operating system. This language includes all the machine code instructions. COMPASS allows for source language changes to already assembled programs, and for system, installation, on programmer-provided macro instructions. Programmer-provided macros may be included in the library. Communication between different subprograms and library subroutines is provided by the use of COMMON blocks and the EXTernal pseudo-operation. Communication with the operating system is by way of the system macros.

Compilers for COBOL, FORTRAN and ALGOL are offered for operation under SCOPE. All require one or two additional tape handlers above minimum SCOPE hardware.

COBOL meets the requirements for Required COBOL-61 plus many of the provisions of Elective COBOL-61. No significant extensions are provided.

FORTRAN meets the requirements for USASI Standard FORTRAN, plus a number if useful extensions for input-output, masking operations and built-in functions. Algol is basically the complete ALGOL-60 language, plus a full set of input-output, statements.

Generalized Sort/Merge packages are available, as well as a good set of utility routines (card-printer, card-drum tape-drum etc.) and the following applications packages.

- PERT (Management review-system)
- SIMSCRIPT (Simulator Programs)
- CDM4 and OPHELIE (Linear Programming)
- APT (Automatic control of machine tools)
- Network Flow Routine
- KWIC Index production program.

SUMMARY: CDC 3100 / 3300 / 3500

.1 SUMMARY

The CDC 3100/3300/3500 Series designates a group of three similar, medium-to-large scale general-purpose computer systems manufactured by the Control Data Corporation. The original entry in this Control Data "lower 3000 Series" (as contrasted with the so-called "upper 3000 Series" systems — 3400, 3600, and 3800) was the CDC 3200, first delivered in May 1964 (just after the announcement of the IBM System/360 computer system). The 3200 provided up to 32,768 24-bit words of core storage with a cycle time of 1.25 microseconds, a 0.5-microsecond control register file, an interrupt system, and up to eight input-output data channels. Basically a scientific processing system, the CDC 3200 featured fast execution of binary arithmetic.

Deliveries of the CDC 3100, a slower and less expensive version of the 3200, began in January 1965. The large and powerful CDC 3300 followed in the Spring of 1966. By the end of 1966, the CDC 3100 and 3300 systems had effectively supplanted the 3200, which is no longer manufactured and is sold or leased only as equipment becomes available.

The CDC 3100/3300/3500 systems are based upon the design of the original 3200. The four original 3200 central processor models were replaced by one basic processor for each system. The specific hardware features which distinguished each of the four 3200 processor models — the Basic processor, the Scientific processor, the Data processor, and the General processor — are available for the 3100 and 3300 processors in the form of optional hardware processor modules that can be added to the basic fixed-point binary processor to expand its processing capabilities into both business and scientific application areas. Business processing is facilitated through the addition of logic for controlling decimal arithmetic and variable field-length instructions that use 6-bit BCD characters, generally packed four per word.

In February 1967, Control Data announced another member of the "lower 3000 Series", the specialized CDC 3150 Data Processing System. The 3150 is a standard fixed-price package that offers a mass-storage oriented computing system based on the CDC 3100 processor. This economy-class system rents for a special price of $8,300 per month. The 3150 system uses the Mass Storage Operating System and its component software packages. CDC states that 3150 is designed to serve as the initial computer system to support business and scientific programming problems or to serve as the heart of a basic management information system. Users can take advantage of the general hardware modularity of CDC 3000 Series design and the compatibility of 3000 Series peripheral devices to enlarge or modify the 3150 as the need arises.

The CDC 3500, introduced in September 1967, is upward compatible with the 3100 and 3300 systems, featuring a faster processor and core storage units. The 3500 uses "INTEBRID" circuits, which combine both monolithic integrated circuitry and hybrid circuitry. One optional feature on the 3300 that is standard on the 3500 is the Floating Point Module.

A wide range of peripheral devices can be connected to the CDC 3100/3300/3500 systems. These include IBM System/360-compatible magnetic tape units and controllers for the IBM 1311 and 2311 Disk Storage Drives. Standard peripheral units include buffered line printers, card readers and punches, an on-line digital plotter, 7-track and 9-track magnetic tape units, disc- and drum-based random access storage units, an optical page reader, cathode ray tube display devices, and flexible data communication equipment.

The Control Data 3100/3300/3500 systems currently offer a choice of medium-to-large scale computer systems with cycle times ranging from 0.9 (CDC 3500) to 1.75 microseconds (CDC 3100), and core storage capacities that range from 8,192 to 262,144 words. When appropriate optional processor features are added, these systems can be well suited for applications requiring both business and scientific capabilities. Unlike the early days of the basic CDC 3200 system, a wide variety of software is currently available to facilitate programming both business and scientific applications. Typical monthly rental rates can vary from $8,300 to $22,225.

.1 SUMMARY (Contd.)

In this Introduction, several significant topics are discussed, as listed below. The true scope of the CDC 3100/3300/3500 Series can be best understood if each area of discussion is read. However, the topics that follow can be read separately if desired.

- .1 Summary
- .2 Central Processors
- .3 Peripheral Units
- .4 Software
- .5 Compatibility within the CDC 3000 Series
- .6 Compatibility with the IBM System/360

.2 CENTRAL PROCESSORS

The Control Data 3100/3300/3500 Series uses central processors that are modular in design; additional capabilities are achieved by the addition of optional hardware features, and core storage is expanded by adding independent core storage modules in predetermined increments up to the capacity of the central processor. All three processors are single-address, fixed word-length, binary processors, which acquire decimal arithmetic and character-oriented capabilities by the addition of optional features. Listed in Table I are certain central processor binary and decimal tasks and the times required to perform these tasks for each processor.

The three central processors are machine-code compatible, can use the same software programs, and utilize the same peripheral devices, making the transition from a smaller CDC 3100 system to the larger, more powerful CDC 3300 and 3500 computer systems a relatively easy one. In addition, input-output characteristics are identical for the CDC 3100/3300/3500 systems and the larger 3400/3600/3800 systems, facilitating the use of the smaller computers as satellities to the larger.

.21 CDC 3100

Although the CDC 3100 is the smallest and most moderately priced member of the CDC 3100/3300/3500 family, it is capable of performing most functions commonly required in business and scientific problems. The 3100 can use between 8,192 and 32,768 words of core storage, and can be equipped with up to four input-output channels, enabling the system to compute while simultaneously performing up to four read-write operations on any

TABLE I: ARITHMETIC EXECUTION TIMES FOR THE CDC 3100/3300/3500 PROCESSORS

TASK (Times expressed in microseconds)	CENTRAL PROCESSOR MODEL		
	CDC 3100	CDC 3300	CDC 3500
Fixed Point Binary			
c = a + b	10.5	8.3	4.3
c = a x b	22.0	16.8	5.9
c = a/b	22.0	17.1	7.5
Fixed Point Decimal			
c = a + b	39.5*	11.4 + 1.05D*	7.27 + 1.1D*
c = a x b	**	**	**
c = a/b	**	**	**
Floating Point Binary			
c = a + b	27.2*	15.6*	5.5
c = a x b	35.6*	25.4*	8.7
c = a/b	38.4*	28.4*	12.2
Radix Conversion			
Decimal to Binary	18 per digit+	39.5 per 6 chars*	6.5 per 6 chars
Binary to Decimal	31 per digit+	106.5 per word*	7.2 per word

* Using optional hardware.
** Not available in hardware; software subroutines are provided.
\+ Performed by standard subroutine.

.21 CDC 3100 (Contd.)

four peripheral devices in the system. Use of the available buffered peripheral units, which require little data channel and central processor time, can allow the number of concurrently operating peripheral devices to increase well beyond the number of data channels in a system. See Table II for a general comparison between the CDC 3100, 3300 and 3500 central processors and core storage units.

Operating systems are available to assist the CDC 3100 in the execution of magnetic tape- and disc-oriented programs. A limited multiprogramming capability is also available: two programs can be executed concurrently, one of which can be a real-time application.

Typical Control Data 3100 configurations rent for approximately $1,000 less than similar CDC 3300 configurations. The difference in cost occurs primarily in the price of the central processor and associated optional hardware, since the same peripheral units are available for both systems. The CDC 3150 Data Processing System, a standard disc-oriented configuration that uses only the Mass Storage operating System, rents for a special price of $8,300 per month.

.22 CDC 3300

The CDC 3300 processor features expanded capabilities (compared to the CDC 3100), including a large and more powerful repertoire of business-oriented instructions, a fast-access Register File with a cycle-time of 0.5 microseconds, and a core storage cycle-time of 1.25 microseconds. As in the CDC 3100 processor, optional hardware features are required for direct execution of variable-length business-oriented instructions and for floating-point addition, subtraction, multiplication, division, and 48-bit fixed-point multiplication and division instructions.

The CDC 3300 can contain between 8,192 and 262,144 words of core storage and can be equipped with up to eight input-output channels, permitting up to eight concurrent input-output operations to be simultaneously supervised by the central processor.

An optional multiprogramming facility can be included in the Control Data 3300 processor. The dynamic storage protection and automatic program relocation facilities supplied with the "Multiprogramming Module" will assist in controlling several programs that concurrently share core storage. But these features can do little to reduce the time required to switch control from one program to another. Where this switching is at all frequent, a considerable program overhead can be incurred in interchanging and protecting the contents of the index registers and parts of the Register File.

The CDC 3300 is designed to enable multicomputer installations to be simply organized. All 16,384-word core storage modules are independent and permit access by either of two processors. Most of the peripheral units can be supplied with dual-channel controllers and switched from one processor to another under program control.

The peripheral units available with the CDC 3300 system are exactly the same as those available for CDC 3100 and 3500 systems. They are listed in Table III with their principal characteristics.

Time-sharing and multiprogramming capabilities are supported by a "paging" scheme supplied by the optional multiprogramming hardware. The 3300 memory is considered to be divided into up to 128 2,048-word pages, each of which can be further divided into four partial pages. Programs can be allocated to non-contiguous page sections, permitting efficient use of available core memory. Up to seven user-programs, including real-time applications, can be executed concurrently in a fully-expanded CDC 3300 system.

Software available for the CDC 3300 includes expanded versions of the operating systems available for the CDC 3100, but features the MASTER operating system — a large-scale file-oriented operating system which controls the multiprogramming of stacked jobs while providing on-line response to remote inquiries.

Typical CDC 3300 system configurations rent for between $13,134 and $22,225.

TABLE II: SUMMARY OF CDC 3100/3300/3500 PROCESSOR CHARACTERISTICS

Processor Model	Core Storage Cycle Time	Memory Capacity	Input-Output Channels	Peripheral Controllers per Channel	Floating point Module	Decimal Arithmetic Module	Multiprogramming and Paging Module
CDC 3114	1.75 μsec per 24-bit word	8,192 to 32,768 words	2 to 4	8	Optional	Optional*	Not available
CDC 3304	1.25 μsec per 24-bit word	8,192 to 262,144 words	0 to 8	8	Optional	Optional*	Optional
CDC 3504	.9 msec per 24-bit word	32,768 to 262,144 words	0 to 8	8	Standard	Standard	Standard

* The decimal arithmetic option for the CDC 3304 Processor provides more variable field-length capabilities than the corresponding option offered for the CDC 3114 Processor

TABLE III: PRINCIPAL CDC 3100/3300/3500 SERIES PERIPHERAL UNITS

PERIPHERAL TYPE	MODEL	NAME	CHARACTERISTICS
Punched Card Equipment	3142	Card Reader	reads 100 cpm
	405	Card Reader	reads 1200 cpm
	415	Card Punch	punches 250 cpm
Punched Paper Tape Equipment	3691	Paper Tape Reader Punch	reads 350 char/sec and punches 120 char/sec
	3694	Paper Tape Reader Punch	reads 1,000 char/sec. and punches 120 char/sec
Printers	3152	Line Printer	prints 150 lpm
	505	Line Printer	prints 500 lpm
	501	Line Printer	prints 1000 lpm
	512	Line Printer	Prints 1200 lpm
Magnetic Tape Units	601	Magnetic Tape Unit	transfers data at 7.5 or 20.8 KC
	604	Magnetic Tape Unit	transfers data at 15, 41.7 or 60 KC
	607	Magnetic Tape Unit	transfers data at 30, 83.3 and 120 KC
	608	Magnetic Tape Unit	transfers data at 30 KC
	609	Magnetic Tape Unit	transfers data at 7.5 and 30 KC
Random Access Storage	863	Drum Storage Unit	stores 4.2 million characters, 17-millisecond average access time
	865	Drum Storage Unit	stores 8.3 million characters, 17-millisecond average access time
	813	Disk File	stores 100 million characters, 25 to 110 millisecond-access time
	814	Disk File	stores 200 million characters, 25 to 110 millisecond-access time.
	821	Data File	stores 419 (Model 1) or 838 (Model 2) million characters 21 to 140 millisecond - access time
	841	Multiple Disk Drive	stores 107 to 286 million characters, 24.5 to 135 millisecond - access time
	852	Disk Drive	controls 2 million characters, 30 to 165 millisecond-access time
	853	Disk Drive	controls 4.1 million characters, 30 to 165 millisecond-access time
	854	Disk Drive	controls 8.2 million characters, 30 to 165 millisecond-access time

.23 The CDC 3500 processor features the expanded capabilities that are available with the CDC 3300. The core storage cycle time is faster - 0.9 milliseconds. Standard hardware performs a large repertoire of instructions, including floating-point arithmetic.

The CDC 3500 can contain between 32,768 and 262,144 words of core storage and can be equipped with up to eight input-output channels, permitting up to eight concurrent input-output operations to be simultaneously supervised by the central processor.

(Contd.)

.23 CDC 3500 (Contd.)

Several programs can share core storage and can be executed concurrently. The optional multiprogramming capability is facilitated by automatic program relocation and storage protection features.

The CDC 3500 processor functions in an identical manner to the CDC 3300 processor: the primary difference lies in the faster speed and the standardization of the floating point hardware.

.3 PERIPHERAL UNITS

The main peripheral units available for use in Control Data 3100/3300/3500 systems are listed in Table III. Any of the peripheral devices can be used with any of the 3100, 3300, or 3500 processors. Many of the input-output controllers supplied with CDC 3100/3300/3500 systems have two or more data channel connections. Such controllers can be used to switch peripheral units between multiple channels of a single computer system or between channels of several different computer systems.

Two different types of magnetic tape units are available for CDC 3100/3300/3500 systems. The seven-track CDC 600 Series Magnetic Tape Units are fully compatible with the IBM 729 Magnetic Tape Units and other equivalent units. They provide a range of transfer rates from 7,500 to 120,000 characters per second, with packing densities of 200, 556, and 800 rows per inch. The 9-track CDC 609 Magnetic Tape Units are fully compatible with Models 1, 2, and 3 of the IBM 2400 Series Magnetic Tape Units. The 609 units transfer data at a rate of 7,500 or 30,000 characters per second, and have packing densities of 200 or 800 rows per inch.

Performance of the Control Data 3000 Series punched card and printing equipment compares favorably with that offered by other manufacturers. Buffered and unbuffered controllers are available for card readers, card punches, and line printers. In addition, Control Data has available controllers for Models 2 and 3 of the IBM 1403 Printer and for the IBM 523 Card Punch.

Two additional input-output devices enhance the scientific and business capabilities of CDC 3100, 3300, and 3500 systems.

On-line digital plotting is provided by the CDC 3293 Incremental Plotter, which incorporates a plotter manufactured by California Computer Products, Inc., and records at up to 300 steps per second.

For business applications, the Control Data 915 Page Reader can optically read documents ranging in size from 4 to 12 inches in width and 2.5 to 14 inches in length. The single readable type font is the USA Standard optical font. The Page Reader can operate either on-line to the computer system or off-line, such as for transcribing data to magnetic tape. In the latter case, the Page Reader must be connected to a CDC Teleprogrammer, which contains up to 4,096 words of core storage and has a repertoire of 43 instructions.

Random access storage devices are available in the form of drums, disk files, and disk pack drives. The storage capacity of these devices ranges from 2 million characters to 838 million characters per unit. Average access times range from 17 to 103 milliseconds. The peak data transfer rate is two million characters per second (achieved by the 863 Drum Storage Unit). The disk-based random access units have transfer rates of 77,730, 196,000, 208,000, and 420,000 characters per second. Table III lists the various mass storage devices with their principal functional characteristics.

The use of more than one central processor in CDC 3000 Series installations is not infrequent, since both peripheral units and storage modules can be easily switched between computers under program control.

Also, both the Control Data 3274 Digital Communications Terminal and the 3275 Data Set Controller can be used for communication between two or more remotely located CDC computer systems. The 3275 Data Set Controller can interface with up to eight data sets, and can transmit 12-bit words in half-duplex mode over one line at a time at speeds up to 230,000 bits per second. The higher capacity 3274 Digital Communications Terminal provides half- and full-duplex transmission of 12-bit words over wide band communication channels or coaxial cables at speeds up to 2.5 million bits per second. For use with CDC 3300 and 3500 systems, Control Data also provides a data communications terminal controller that can control up to eight voice band or broad band lines, or up to 16 half- or full-duplex narrow band lines, all of which can be active simultaneously.

Multi-line data communications control is also provided by the Model 3266 Communications Terminal Controller, which can control up to 32 Model 323 Teletypewriter Terminal Units (16 send and 16 receive).

.4 SOFTWARE

Software for the Control Data 3100/3300/3500 systems is grouped around five integrated operating systems — Tape SCOPE, Disk SCOPE, Real-Time SCOPE, Mass Storage Operating System (MSOS), and Multiple Access Shared Time Executive Routine (MASTER). A COMPASS assembly system is provided, as well as FORTRAN, ALGOL, and COBOL compilers, and an extensive collection of utility programs and application packages.

In general, each of these software facilities (in full or subset form) can run on all 3100, 3300, and 3500 systems, provided an adequate amount of core storage is available and the appropriate peripheral devices are included in the configuration. The one major exception to this rule is MASTER, which will run only on CDC 3300 or 3500 systems.

The assembly language for the Control Data 3100/3300/3500 computer systems is called COMPASS (Comprehensive Assembly System). CDC 3100 systems use a subset of the full COMPASS language; the full version of COMPASS is available for CDC 3300 systems that use the optional 3311 Multiprogramming Module, and is also available for Control Data 3500 computer systems. The 3100 COMPASS language lacks the system control facilities of the Executive mode of MASTER, the large-scale multiprogramming operating system available for the CDC 3300 and 3500; the COMPASS subset language also lacks some business data processing instructions e.g., pack, unpack, edit, etc., that cannot be performed by the optional 10019 BCD hardware available for the CDC 3100 processors.

Control Data 3100/3300/3500 COMPASS bears only a general resemblance to the COMPASS language used for the larger Control Data 3400, 3600, and 3800 systems, and programs written in the two assembly languages are not interchangeable.

Use of the Control Data 3100/3300/3500 COMPASS program requires at least 8,192 words of core storage and four input-output devices.

In addition a BASIC assembler is still available for earlier small CDC 3100 systems that contain only 4,096 words of core storage. All CDC 3100 systems are currently produced with at least 8,192 words of core storage and, consequently, will use the COMPASS assembler.

.41 Tape/Disk/Real-Time SCOPE

The SCOPE Operating Systems can function with Control Data 3100, 3300, or 3500 systems, although they are not recommended for use with systems containing more than 32,768 words of core storage. All three versions of SCOPE have many similarities. Both Tape and Disk SCOPE feature a resident loader/monitor which contains provision for stacked job processing, automatic handling of input-output requests, and interrupt processing.

Tape-based SCOPE, which supervises the processing of single jobs or batch processing of stacked jobs, requires approximately 2,500 words of core storage for its resident program, and can operate in a system containing a minimum of 8,192 words of core storage.

The very similar Disk-based SCOPE can handle disk-oriented input-output and allows the library file to be stored on a disk device. Disk SCOPE requires approximately 3,000 words of core storage for its resident program and can operate in CDC 3100, 3300, or 3500 computer sytems with a minimum of 16,384 words of core storage.

Both Tape and Disk SCOPE operating systems provide routines that handle job sequencing, program loading, equipment assignment, debugging, library preparation, overlay handling, and calling of utility routines stored in the system library. In addition, Disk SCOPE has the capability of simulating magnetic tape input-output operations on mass storage devices.

The third version of the SCOPE operating systems, Real-Time SCOPE, is a magnetic tape oriented operating system that features control routines that supervise the concurrent processing of one foreground program, such as an input-output oriented job, and one background program such as a compilation, assembly, or library preparation. The background programs can be processed in stacked job manner. A more powerful interrupt system permits the switching of processor control between the foreground and background programs, and can service any real-time interrupts in the foreground program. Real-Time SCOPE can also perform in a compatible manner all functions performed under Tape SCOPE. The disk-oriented facilities of Disk SCOPE are not available in Real-Time SCOPE. Real-Time SCOPE requires use of systems with a minimum of 16,384 words of core storage.

A complete line of processing programs is provided under the SCOPE operating systems. These include the COMPASS assembler, plus COBOL and 3200 FORTRAN compilers. The 3100/3300/3500 COBOL currently available can operate only under control of the Real-Time SCOPE operating system and requires at least 16,384 words of core storage (FORTRAN requires 8,192 words of core storage.)

Other problem-oriented programs available for operation under SCOPE include the SAINT 1401/1460 Simulator, a Tape SORT/MERGE, a Report Generator, the Simultaneous

.41 Tape/Disk/Real-Time SCOPE (Contd.)

Peripheral Processor for concurrent data transcriptions, PERT, and REGINA — a linear programming package — all of which will operate in a minimum of 8,192 words of core storage. ADAPT, a subset of APT (Automatically Programmed Tools) will also operate under SCOPE in a minimum of 16,384 words of core storage.

.42 Mass Storage Operating System (MSOS)

The Mass Storage Operating System provides all the facilities available with Real-Time SCOPE, but is designed for use with disk-oriented random access systems. Like Real-Time SCOPE, MSOS can supervise the concurrent processing of one backgound and one foreground program, with the capability of servicing real-time interrupts in the foreground program. MSOS is also designed to accommodate remote terminals and data communications equipment for use, for example, in management information systems and in information storage and retrieval applications. MSOS requires use of systems with a minimum of 16,384 words of core storage, of which 5,000 words are occupied by the MSOS resident program.

Most of the processing programs that operate under SCOPE are also available for MSOS. A currently available COBOL compiler, similar to that used with Real-time Scope, can be used with the MSOS and MASTER operating systems, but it does not provide the capability for creating files on disk storage.

MSOS requires use of systems with a minimum of 16,384 words of core storage, of which approximately 5,000 words are occupied by the resident program.

.43 Multiple Access Shared Time Executive Routine (MASTER)

The Control Data Multiple Access Shared Time Executive Routine (MASTER) is a large-scale mass storage-oriented operating system designed exclusively for both CDC 3300 systems equipped with the optional 3311 Multiprogramming Module and for CDC 3500 systems. MASTER was announced in the spring of 1967 and later versions are currently operational. MASTER utilizes the dynamic program relocation and protection features of the optional 3311 multiprogramming module to perform concurrent processing of up to seven user programs in up to 262,144 words of core storage.

MASTER utilizes additional hardware features of the CDC 3300 Processor including the Instruction State Register and the Operand State Register, to address beyond the 32,768 words of core storage permitted by the 15-bit operand length of CDC 3100/3300/3500 word-oriented instructions. Using the two hardware registers, up to 131,072 words of core storage can be directly addressed. The addition of a Page Index File, supplied by the Multiprogramming Module, permits addressing up to 262,144 words of core storage, the current maximum for CDC 3300/3500 systems. Using the Page Index File, core storage is divided into "pages" of 2,048 words, and grouped into eight Program Address Groups of 32,768 words, each of which can contain one user program. The MASTER resident program occupies approximately 20,000 words of core memory in one Program Address Group. Systems with a minimum of 49,152 words of core storage are required for the operation of MASTER.

.5 COMPATIBILITY WITHIN THE CDC 3000 SERIES

This report concerns itself only with the CDC "lower 3000 Series" computer systems — CDC 3100, 3300, and 3500. Among these three systems (and their CDC 3200 forerunner), there is a high degree of hardware and software compatibility. All systems use compatible central processing units with upward compatible machine-language instruction sets. All systems also use core storage units organized in 24-bit words, with optional capabilities for handling 6-bit decimal data and 48-bit floating point data. Common peripheral units are used throughout the series.

Machine-level incompatibilities can arise through the addition of optional processor features. The CDC 3300's optional Business Data Processor adds capabilities (such as radix conversion, code translation, digit packing/unpacking, and editing) that are not provided in the CDC 3100's counterpart processor option, the BCD Module. Also, addition of the Multiprogramming Module to the CDC 3300 processor provides additional instructions pertaining to program relocation, interrupt handling, and memory protection that have no counterparts in the CDC 3100 processors. Programs written for CDC 3100 systems must fit within the system's maximum of 32K words of core storage, in contrast to CDC 3300/3500 programs which can be as large as 262K words.

Programs written in process oriented languages, such as FORTRAN and COBOL, can generally be compiled and run on either CDC 3100, 3300 or 3500 systems with only minor, if any, program changes required to suit the specific processing system.

Compatibility between the "lower 3000 Series" models and the "upper 3000 Series" (namely the CDC 3400, 3600, and 3800 systems) is limited to the use of common input-output units that can handle the same 6-bit external data codes, and the use of similar COBOL,

.5 COMPATIBILITY WITHIN THE CDC 3000 SERIES (Contd.)

FORTRAN, and ALGOL programming languages. There is no machine-level compatibility between the 24-bit processors of the lower 3000 Series and the 48-bit processors of the upper 3000 Series.

.6 COMPATIBILITY WITH THE IBM SYSTEM/360

There is little program or data compatibility between the CDC 3100/3300/3500 systems and the IBM System/360. The CDC machines basically use 24- and 48-bit binary words, and 6-bit BCD characters. The IBM System/360 systems, by contrast, basically use 32- and 64-bit binary words, and 8-bit EBCDIC characters (or bytes).

Control Data offers a single 9-track magnetic tape unit, Model 609, that reads and records in a manner compatible with Models 1, 2, and 3 of the IBM 2401 Magnetic Tape Units. However, the fact remains that the CDC 3000 Series and the IBM System/360 systems use different internal and external data codes, reducing the value of the CDC 609 Magnetic Tape Unit as a device for bridging the gap between two essentially different machine series. The same comments can be applied to a special CDC disk storage controller that permits use of the IBM 2311 Disk Storage Drive.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3114		Central Processor for CDC 3100 system(1)	3,850	105,500	207
			Features for CDC 3100 Processor:			
		10018	Floating Point Module	870	31,500	25
		10019	BCD Module	350	13,000	30
		10020	General Purpose Arithmetic Module: provides floating point and BCD capabilities	1,150	42,600	35
	3150		Data Processing System(2)	8,300	325,000	874
	3304		Central Processor for CDC 3300 system(3)	4,500	163,000	180
	3304-2		Central Processor for CDC 3300 system (includes Business Data Processing Module)	4,600	175,000	270
			Features for CDC 3300 Processor:			
		3310	Floating Point Module	870	31,500	35
		3311	Multiprogramming Module	1,500	52,500	125
		*3312	Business Data Processing Module	990	37,000	90
	3504-1		Central Processor for CDC 3500 system(4)	12,500	495,000	850
	3514		Central Processor for CDC 3500 (includes Floating Point Module and Real Time Interrupt Expansion capability):			
		3514-1	Basic Processor	9,500	330,000	810
		3514-2	Processor with Business Data Processing Module	10,500	400,000	875
		3514-3	Processor with Multiprogramming Module	11,500	430,000	890
		3514-4	Processor with Business Data Processing Module and Multi-programming Module	12,500	500,000	925
		3522-16	Real-Time Interrupt Processor (for 3514 Processor; basic module provides 16 interrupt lines; can be expanded to 32, 48, or 64 lines)	800	20,000	215
			Main Storage			
	3119		Storage Module (8,192 words of core storage for CDC 3100 systems; one read/write control, accessible from two computers or special devices)	1,300	44,000	114
	3113		Storage Module (16,384 words of core storage for CDC 3100 systems; one read/write control, accessible from two computers or special devices)	2,550	84,000	133
		10123	Memory Protect for CDC 3100	150	5,500	
	3309		Storage Module (8,192 words of core storage for CDC 3300 systems; one read/write control accessible from two computers or special devices)	1,450	52,500	125
	3302		System Storage (core storage for CDC 3300 systems; one read/write control per 16K words):			
		3302-16	16,384 words	2,500	90,500	165
		3302-32	32,768 words	4,500	163,000	330
		3302-49	49,152 words	6,750	244,500	495
		3302-65	65,536 words	8,000	290,000	660
		3302-81	81,920 words	10,000	362,500	825
		3302-98	98,304 words	12,000	435,000	990

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR (Contd.)			Main Storage (Contd.)			
		3302-114	114,688 words	14,000	507,500	1,155
		3302-131	113,072 words	16,000	580,000	1,320
		3302-147	147,456 words	18,000	652,500	1,485
		3302-163	163,840 words	20,000	725,000	1,650
		3302-180	180,224 words	22,000	797,500	1,815
		3302-196	196,608 words	24,000	870,000	1,980
		3302-212	212,992 words	26,000	942,500	2,145
		3302-229	229,376 words	28,000	1,015,000	2,310
		3302-245	245,760 words	30,000	1,087,500	2,475
		3302-262	262,144 words	32,000	1,160,000	2,640
		1023	Memory Protect for CDC 3300	-	1,500(5)	-
	3502		System Storage (core storage for CDC 3500 systems; one read/write control per 16K words)			
		3502-32	32,768 words	5,000	180,000	375
		3502-65	65,536 words	9,400	340,000	750
		3502-98	98,304 words	14,100	510,000	1,125
		3502-131	131,072 words	18,800	680,000	1,500
		3502-163	163,840 words	23,500	850,000	1,875
		3502-196	196,608 words	28,200	1,020,000	2,250
		3502-229	229,376 words	32,900	1,190,000	2,625
		3502-262	262,144 words	37,600	1,360,000	3,000
		10121	Storage Access (provides additional access to 3502 System storage; maximum of 3 additional access per block of 32K words)	120	4,500	20
ATTACHMENTS, ADAPTERS, AND CHANNELS			Channels(6)			
			For CDC 3100 Systems:			
	3107		Communication Channel 24-bit I/O data exchange)	210	8,900	45
	3106		Communication Channel (bidirectional, buffered, 12-bit I/O data exchange)	125	5,800	28
			For CDC 3300 Systems:			
	3306		Communication Channel (12-bit I/O data exchange)	160	5,800	35
	3307		Communication Channel (24-bit I/O data exchange)	265	8,900	50
			For CDC 3500 systems			
	3507-1		Communication Channel (12 or 24-bit I/O data exchange)	355	40	15,000
			Adapter			
	3682		Satellite Coupler (permits direct connection between any two standard 12-bit bidirectional channels, or Data Channel Converters)	185	10,000	25
MASS STORAGE			Disk Storage			
	813		Disk File (100 Million characters of storage; 25 to 110 millisecond positioning times; 196kc transfer rate)	3,450	147,000	465
	814		Disk File (200 million characters of storage; 25 to 110 millisecond positioning time; 196kc transfer rate)	5,500	241,500	590
	852		Disk Drive (2 million characters; 30 to 165 millisecond positioning time; 77.73kc transfer rate)	390	17,500	50
	853		Disk Drive (4.1 million characters; 30 to 165 millisecond positioning time; 208kc transfer rate)	350	15,500	48

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental	Purchase	Monthly Maint.
MASS STORAGE (Contd.)			Disk Storage (Contd.)			
	821-1		Data File (419 million characters; 25-145 millisecond positioning time; 420 kc transfer rate)	3,000	135,000	470
	821-2		Data File (838 million characters; 25-145 millisecond positioning time; 420 kc transfer time)	5,500	250,000	800
	841		Multiple Disk Drive (capacity varies according to number of on-line drives; each model includes an off-line standby drive; 25-135 millisecond positioning time; 420 Kc transfer time)			
	841-3		3 on-line drives, 107 million characters	2,070	87,000	280
	841-4		4 on-line drives, 143 million characters	2,660	112,000	330
	841-5		5 on-line drives, 179 million characters	3,200	135,000	380
	841-6		6 on-line drives, 214 million characters	3,690	156,000	430
	841-7		7 on-line drives, 250 million characters	4,130	175,000	480
	841-8		8 on-line drives, 286 million characters	4,520	192,000	530
	854		Disk Drive (8.2 million characters of storage; 30 to 165 millisecond positioning time; 208kc transfer rate)	520	23,000	72
	849		Disk Pack (removable cartridge for 852 Disk Drive)			
	*850		Disk Pack (removable cartridge for 852, 853, or 854 Disk Drive)	18	570	NC
	851		Disk Pack (removable cartridge for 852 or 853 Disk Drive)			
	871		Disk Pack (removable cartridge for 841 Multiple Disk Drive)	19	625	NC
	*3231		Disk Pack Controller (permits direct connection of one to five IBM 1311 Disk Storage Drives)	500	20,000	50
	3232		Disk Pack Controller (for up to five 852 Disk Drives)	500	20,000	50
	3234		Disk Storage Controller (for up to eight 813, 814, 853, or 854 Disk Drives)	540	25,000	65
	3553-2		Mass Storage Controller (for one 841 Multiple Disk Drive, or for up to eight 821 Data Files)	880	37,000	140
		10163	Dual Access Option (permits connection of two 3553 controllers to an access mechanism of the 841 Multiple Disk Drive or the 821 Data File to accomplish simultaneous reading and or writing)	125	5,000	15
			Drum Storage			
	863		Drum Storage (4,194,304 characters of storage; 17 millisecond average access time; up to 2-million-kc transfer rate)	2,750	140,000	400
	865		Drum Storage (8,388,608 characters of storage; 17 million average access time; up to 1-million-kc transfer rate)	2,850	145,000	420
	3637		Drum Storage Controller (for up to eight model 863 Drums, requires two standard channels)	1,150	48,500	135

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Magnetic Tape			
	601		Magnetic Tape Transport (37.5 inches/sec; 200 and 556 bits/inch; 7.5 and 20.8kc)	300	13,500	100
	3127		Magnetic Tape Controller (for 1 to 8 Model 601 Tape Transports; one channel)	335	14,500	55
	604		Magnetic Tape Transport (75 inches/sec; 200, 556, and 800 bits/inch; 15, 41.7 and 60kc; read forward and reverse)	630	27,500	130
	607		Magnetic Tape Transport (150 inches/sec; 200, 556, and 800 bits/inch; 30, 83.3 and 120kc; read forward and reverse)	920	44,000	150
	3228		Magnetic Tape Controller (for 1 to 4 Model 604 or 607 Tape Transports; one channel)	445	21,000	65
	3229		Magnetic Tape Controller (for 1 to 8 Model 604 to 607 Tape Transports; one channel)	630	25,000	75
	3423		Magnetic Tape Controller for 2 to 8 Model 604 or 607 Tape Transports; (two channels)	1,450	69,500	160
	*3622		Magnetic Tape Controller (for 1 to 16 Model 606 or 607 Tape Transports; two channels)	2,950	142,000	305
	*3623		Magnetic Tape Controller (for 1 to 8 Model 606 or 607 Tape Transports; four channels)	3,050	147,000	290
	3624		Magnetic Tape Controller (for 4 to 16 Model 607 Tape Transports; four channels)	4,100	194,500	380
	*3625		Magnetic Tape Controller (for 3 to 8 Model 607 Tape Transports; three channels)	2,550	126,000	250
	*3626		Magnetic Tape Controller (for 1 to 16 Model 606 or 607 Tape Transports; three channels)	3,300	160,000	340
	608		Magnetic Tape Transport (37.5 inches/sec; 200, 556, and 800 bits/inch; 7.5, 20.8, and 30kc; read forward and reverse)	380	15,500	105
	609		Magnetic Tape Transport (37.5 inches/sec; 200 and 800 bits/inch; 7.5 and 30kc)	380	15,500	105
	3121		Magnetic Tape Controller (for one or two 609 Tape Transports; one channel)	425	18,500	65
	3128		Magnetic Tape Controller (for one to eight 608 Tape Transports; one channel)	400	17,500	65
			Punched Card			
	405		Card Reader (1200 cards/min with 80 column cards or 1600 cards/min with 51 column cards)	420	23,500	65
	3142		Card Reader (100 cards/min; includes controller)	335	11,000	55
	3447		Card Reader Controller (for 405 Card Reader; one channel; full card buffer)	235	12,000	55
	*3248		Card Reader Controller (for 405 Card Reader; one channel; unbuffered)	105	5,000	35
	3649		Card Reader Controller (for 405 Card Reader; two channels; full card buffer)	340	17,000	40
	415		Card Punch (250 cards/min)	310	19,000	60
	*3245		Card Punch Controller (for 415 or IBM 523 Card Punch; one channel, unbuffered)	345	14,500	50
	3446		Card Punch Controller (for 415 or IBM 523 Card Punch; one channel; full card buffer)	475	23,000	65
	3644		Card Punch Controller (for 415 or IBM 523 Card Punch; two channels; full card buffer)	710	34,000	95

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Paper Tape			
	3691		Paper Tape Reader Punch (350-char/sec reader and 120-char/sec punch)	325	12,500	125
	3694		Paper Tape Reader Punch (1,000-char/sec, reader and 120-char/sec punch)	680	29,000	255
			Printers			
	501		High-Speed Line Printer (1,000 lines/min; 64 characters; 136 columns)	910	44,500	240
	505		High-Speed Line Printer (500 lines/min; 64 characters; 136 columns)	670	27,000	210
	3256		Line Printer Controller (for one 501 or 505 Printer; one channel)	540	23,000	60
	3659		Line Printer Controller (for 501 or 505 Printer; two channels)	740	40,500	85
	*3152		Line Printer (150 lines/min, 64 characters; 120 columns; includes controller)	660	30,500	280
	3458		Line Printer Controller (for IBM 1403 Model 3; one channel)	950	42,000	110
	*3258		Line Printer Controller (for IBM 1403 Printer, Model 2 or 3; one channel)	740	42,000	110
	3254		Line Printer with Control (300 lines/min; 64-character set same as 501; 136 column; one channel)	925	38,500	180
	3254-2		OCR Line Printer with Control (300 lines/min; prints stylized USASCSOCR font and Rabinow special characters)	1,000	39,000	230
	512-1		Line Printer (1,200 lines/min with 48-character train; interchangeable train cartridges not included; 136 columns)	975	45,000	225
		595-1	Train Cartridge (63 printing characters plus space; same as 501 character set)	100	3,000	NC
		595-2	Train Cartridge (48 printing characters plus space; same as IBM "AN" arrangement)(7)	100	3,000	NC
		595-3	Train Cartridge (48 printing characters plus space; same as IBM "HN" arrangement)(7)	100	3,000	NC
	3555-1		Line Printer Controller (for one 512-1 Printer; one channel)	625	27,000	45
			Optical Character Reader			
	915		Optical Character Page Reader	2,290	84,000	450
	3195		Page Reader Controller (for one 915 Page Reader; buffered)	540	19,500	28
			Plotter			
	3293		Incremental Plotter (300 steps per second; 0.01 inch per step; 11-inch width)	300	9,500	85

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			CRT Displays			
	3290-2		Inquiry/Retrieval Controller (contains storage and control logic for up to 12 local or remote display/entry stations; character set compatible with 501 Printer, one channel)	725	24,650	80
		10033	Format Option (provides 13-line 80-char/line format for attached displays)			
	3291		Single Station Entry/Display (includes controller and keyboard; 20-line, 50-char/line display format; one channel)	380	14,000	40
	3298		Digigraphics Controller (controls one to three 273 Consoles and one 275 Memory; one channel)	1,025	48,000	150
	273		Digigraphic Console (line-drawing, 22-inch CRT console; includes light pen and 25-button function control keyboard)	1,500	47,500	110
	275		Buffer Drum Memory (provides display buffer for Digigraphics subsystem)	2,425	42,000	100
			Microfilm Recorders			
	3898		Microfilm Recorder and Controller (includes 284 microfilm recorder cabinet, which contains camera, film magazine, 5-inch CRT and associated controls; provides control logic and symbol and vector generators; 126 symbol character set; contains buffer storage; provides interface for up to two 282 or 283 output units; one channel)	5,450	169,000	395
	3899		Microfilm Recorder Controller (same as 3898 with the addition of an interface for one 607 Tape Transport)	6,100	189,000	420
	282		Display Console (direct view CRT; 11.5 by 11.5-inch usable display area)	865	28,000	50
	283		Hardcopy Recorder (projects image from 7.5 inch CRT to 9- by 10 7/8-inch photo-sensitive paper)	1,350	49,000	40
			Analog/Digital			
	3286		Analog/Digital Conversion Controller (contains analog-to-digital converter and provisions for expansion up to 32 analog input channels and 32 12-bit digital input channels):			
		3278-A	8-bit analog-to-digital converter; 8 analog and 8 digital input channels	880	27,500	130
		3278-B	10-bit analog-to-digital converter; 8 analog and 8 digital input channels	930	29,000	140
		3278-C	12-bit analog-to-digital converter; 8 analog and 8 digital input channels	970	30,000	145

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Analog/Digital (contd.)			
	3287		Analog/Digital Conversion Controller (contains analog-to-digital converter and provisions for expansion up to 64 analog input channels and 32 12-bit digital channels):			
		3287-A	8-bit analog-to-digital converter; 16 analog and 8 digital input channels	950	29,500	140
		3287-B	10-bit analog-to-digital converter; 16 analog and 8 digital input channels	1,000	31,000	145
		3287-C	12-bit analog-to-digital converter; 16 analog and 8 digital input channels	1,050	32,000	150
		456	Multiplexed Digital Inputs (provides third set of eight 12-bit digital inputs for 3286 or 3287 controller)	63	2,350	6
		457	Multiplexed Digital Inputs (provides second set of eight 12-bit digital inputs for 3286 or 3287 controller or expands 456 by eight inputs)	32	1,150	6
	3288		Digital/Analog Conversion Controller (provides one computer controlled analog output and 24 computer controlled relay closures; can be expanded by 454, 455, 458, 459 and 460 options to 10 analog outputs and 48 relay closure outputs			
	454	3288-A	10-bit digital-to-analog converter	660	20,500	110
	455	3288-B	12-bit digital-to-analog converter	690	21,500	115
	458	454	Analog Output Channels (adds one 0.1% analog output channel to 3288 controller)	74	2,650	7
	459	455	Analog Output Channels (adds one 0.1% analog output channel to 454; max of 10 channels per 3288 Controller)	21	820	5
	460	458	24 Relay Closure Outputs (adds third set of 24 relay closure outputs to 3288 Controller)	74	2,550	7
		459	24 Relay Closure Outputs (adds second set of 24 relay closure outputs to 3288 Controller or to 458)	26	1,000	5
		460	Additional Analog Outputs (adds one 0.05% analog output channel to 3288B Controller; maximum of 4)	53	1,750	6
COMMUNICATIONS	3316-1		Multiplexer Controller (provides eight connection points for up to four 304-1 Multiplexors, eight 303-1 Expansion Units, or combinations of both; requires dedicated 3106, 3306, or 3507-1 Communications Channel; can access up to 16k of core storage)	700	27,500	85
	304-1		Communications Multiplexor (occupies two connection points on 3316-1 or 303-1; can accommodate up to 8 half-duplex voice-band lines up to 16 half- or full-duplex telegraph-grade, up to 32 simplex telegraph-grade lines, or combinations of these through optional adapters)	415	16,000	55
	303-1		Communications Expansion Unit (occupies one connection point on 3316-1; provides eight connection points for 304-1 Multiplexors)	65	2,450	12
	3275		Data Set Controller (provides connection for a Bell System 201 or 301 series Data Set; permits transmission rates of from 2,000 to 40,800 bits/sec; one channel)	410	20,500	60

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNICATIONS (Contd.)			Terminals			
	217-2		Remote Single Station Entry/Display (includes keyboard, 20-line, 50 char/line display and controller; compatible with Bell System Data Set 201A and 201B)	330	12,000	40
		10034	Format Option (provide 13-line, 80 char/line display format)	NC	150(8)	NC
		224-1	Terminal Card Reader (300 cards/min)	165	6,500	35
		222-2	Terminal Line Printer (300 lines/min; 136 column; 63-character set)	700	27,500	180
		218-1	Output Station (typewriter output 15.5 char/sec; independent buffer)	270	8,000	25
	8231		Card Reader/Line Printer Terminal (includes stored program processor with 8192 words of core storage and typewriter for control; reads 1,200 cards/min; prints 1,000 lines/min peripherals can be augmented by CDC 3000 series units; compatible with Bell System Data Set 301B)	4,250	163,000	765
	8130		Card Reader/Printer Terminal (reads 100 cards/min; prints 300 lines/min; compatible with Bell System Data Set 201A or 201B)	1,680	63,000	265

NOTES:

* No longer in production.

(1) The 3114 Central Processor includes two input-output channels, desk display console, entry keyboard, chair, on-line I/O typewriter and can accommodate up to 32K words of core storage and 2 additional 3106 I/O channels.

(2) The 3150 Data Processing System is a complete, fixed configuration system that includes a 3114 Processor, 16,384 words/of core storage, two 12-bit data channels, one 24-bit data channels, one 405 Card Reader, two 854 Disk Storage Drives, one 3254 Line Printer, and appropriate controllers.

(3) The 3304 Central Processor includes desk display console, entry keyboard, chair, on-line I/O typewriter and can accommodate up to 8 input-output channels and 32,768 words of core storage; with the 3311 Multiprogramming up to 262,144 words of core storage can be accommodated.

(4) The 3504-1 Central Processor includes Business Data Processing Module, Floating Point Module, Multiprogramming Module, desk display console, entry keyboard, chair, and on-line I/O typewriter; it can accommodate up to 8 I/O channels and 262,144 words of core storage.

(5) One time charge for factory or field installation.

(6) Each Communication channel is bidirectional and buffered; each channel can accommodate one to eight 3100, 3300, 3400, or 3600 peripheral Controllers.

(7) These 48-character trains are special applications and will not handle all character codes generated by standard software.

(8) One time charge for field or factory installation in both leased or purchased equipment.

REPORT UPDATE

▶LARGE SCALE CDC 7600 COMPUTER MAKES ITS DEBUT

The Control Data 7600 computer system, a large-sized extension of the CDC 6000 series, was announced in December 1968, with first deliveries expected to commence in early 1969.

With a memory cycle time of 275-nanoseconds, the 7600 is almost four times as fast as the CDC 6600. Enormous storage capacities are available; including two internal core memories of 650,000 and 5,000,000 characters; a new 800 million character Model 817 disc file; and a new drum unit, with 25 million characters of storage. The transfer rates are also impressive; both the disc file and the drum unit have 6 million character per second transfer rates, and inter-memory data transfer proceeds at a rate of 363 million characters per second.

The 7600 is oriented toward communications and time-sharing, and it is designed to accommodate thousands of peripheral devices broken up into groups at input-output stations, thus freeing the main-site facility for other activity and permitting concurrent background-foreground processing.

The peripheral processors control all of the I/O activity and operate independently of the central processor. The peripheral processors may be incorporated at remote stations.

The only peripheral devices directly connected to the Central Processor are a maintenance processor and card reader. System maintenance can be performed without interrupting the production.

Compatibility with the 6000 series systems is emphasized, and many of the 6000 series software packages and peripherals devices can be used with the 7600 with some modification.

Depending on the variety of devices that may be included, the 7600 system rentals are from $190,000 to $300,000 per month, with purchase prices in the $9 million to $15 million range.

SUMMARY

.1 INTRODUCTION

The Control Data 6000 Series is a group of three very fast, large-scale computer systems that have been designed to provide users with vast computational power in service of a large number of concurrently-operating programs. The marketing campaign for the 6000 Series, directed to both scientific and commercial computer users, emphasizes that the use of a large central computer system can be more economical for a company than the use of multiple smaller-scale systems scattered over a wide area.

Such operational goals have necessitated the design of specialized central computing equipment, flexible peripheral systems, extensive data communications facilities, and highly sophisticated software support. The minimum hardware configuration for the 6400 computer system — at the low end of the 6000 Series — includes one Central Processor with a 100-nanosecond clock-cycle time, a 1-microsecond Central Memory of 32,768 60-bit words, ten independently-operating Peripheral and Control Processors with private core storage units of 4,096 12-bit words each, and twelve floating input-output Data Channels that are each capable of transmitting I/O data at a rate of 2 million characters per second. Peripheral devices include an Extended Core Storage unit, display units, disc files, magnetic tape units, and all of the peripheral units designed for use with the Control Data 3000 Series systems. Control Data also makes available the controllers, multiplexors, and adapters necessary to control data communications networks that utilize a wide variety of remote terminal equipment.

Software for the 6000 Series represents a determined effort by Control Data to develop and supply full-scale, integrated software support. Effective utilization of the powerful 6000 Series hardware demands a comprehensive, integrated software control system, and Control Data supplies such an operating system (SCOPE) with each 6000 Series system. The concurrent operation of multiple processors simultaneously executing a large number of programs is the normal mode of operation for the 6000 Series systems. Standard equipment configurations that include the Extended Core Storage unit are also well suited for time-sharing operations. The SCOPE operating system coordinates and controls the many levels of concurrent operations inherent in these multiprocessing, multiprogramming, and time-sharing modes of operation.

Monthly rentals for the 6000 Series systems range from about $30,000 for a basic 6400 system to about $130,000 for a large 6600 system. The 6600 computer system appears to be rivalled only by the announced Burroughs B 8500 in competition for the title of "largest computer in the word," both in terms of magnitude of pure processing power and potential size of system hardware configuration.

The Control Data 6600 was first delivered late in 1965. The slower and less expensive Data 6400 system, announced in December 1964, had its initial delivery early in 1966. First delivery of the 6500 system with dual central processors was made in the summer of 1967.

.2 PROCESSORS

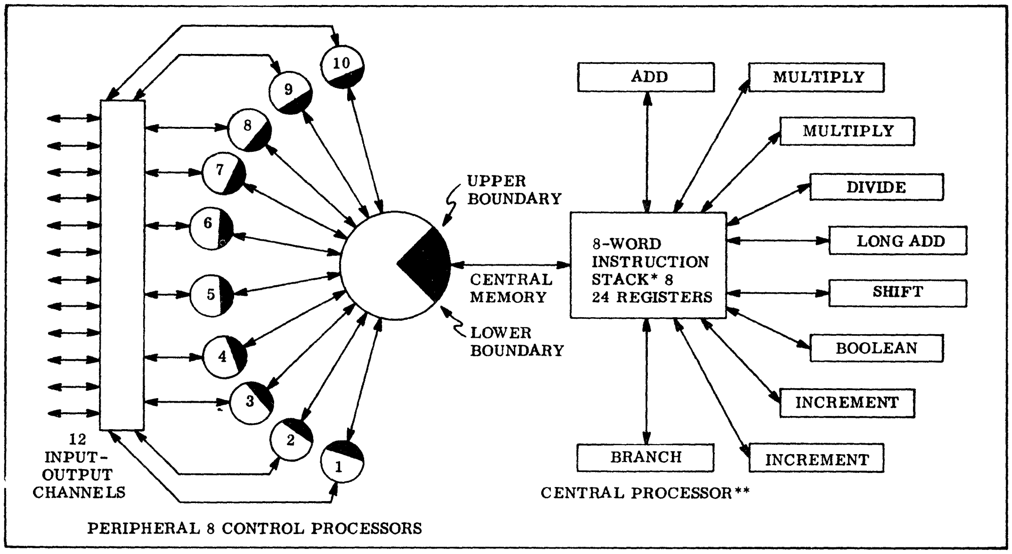
.21 Central Processors

Every Control Data 6000 Series computer system includes a Central Processor, a central core memory and ten Peripheral Processors, each with a private core memory bank. The 6600 Central Processor contains ten specialized, independently-operating functional units that theoretically enable them to execute up to ten machine instructions simultaneously. The 6400 Central Processor contains a single general-purpose instruction execution unit. Additional central processing power can be obtained in 6400 computer systems by including a second 6400 Central Processor in the configuration. This additional power is already available in a 6500 configuration.

A 6000 Series Central Processor, at any one time, can access only one continuous segment of the central core memory, as defined by a Lower Boundary and an Upper Boundary. Any reference to a location outside this area which is attempted by a Central Processor program automatically results in an interrupt and a call to the executive program. The 6600 processor does not access the central memory directly either for instructions or operands; instead, it uses an eight-word instruction stack (which holds the present instruction and the previous seven instruction words) and 24 operating registers: eight A (Address) registers, eight B (B-line or index) registers and eight X (60-bit operand) registers. Although the B-registers are used for purposes analogous to index registers, the form of the 6000 Series instruction, which never directly refers to central core memory operands, precludes the use of indexing or indirect addressing in the usual sense of these terms.

.21 Central Processors (Contd.)

The relationships among the processors, memory units, and input-output channels are shown in Figure 1. On the left, the input-output channels are all shown connected to a ten-way switch, so that input-output data can be passed through the independent memory banks of any of the ten identical Peripheral Processors (numbered 1 through 10). Each of the Peripheral Processors also has access to the central core memory of the system, and data can be transferred between the Peripheral Processor memories and the central memory without any Central Processor operations.



* Note: The 6400 and 6500 have no instruction stack nor multiple arithmetic processing units.

** Note: The 6500 has two identical central processors sharing central memory.

Figure 1. Structure of the Control Data 6000 Series Processors

The instruction stack and the 24 operating registers act as a buffer between the comparatively slow core memory and the ten fast functional units, and allow the simultaneous operation of more than one of these units. Use of this relatively small number of registers permits great reductions in the instruction sizes, so that many three-address instructions require only 15 bits, or one-fourth of an instruction word.

Parallelism of operation is one of the keys to the rapid processing speeds of the 6000 Series Central Processors. In addition to the ten concurrently-operating functional units in the 6600 Central Processor, all Central Processors in the Series have the ability to access simultaneously eight locations in Central Memory. As a result, instructions and operands can be accessed in anticipation of their actual need, and Central Processor delays caused by the need to await completion of Central Memory accesses can be greatly reduced.

The internal clock-cycle time of the 6400, 6500, and 6600 Central Processors is identical — 100 nanoseconds. Many instructions within the simplified 6000 Series instruction set consume only three or four internal Central Processor cycles. The 6600's 8-word instruction stack and 10 functional units make its performance considerably better than that of the 6400 (see comparative task timings in Table I).

Table I lists some characteristics and representative execution times of the Control Data 6400, 6500, and 6600 Central Processors.

.22 Peripheral and Control Processors

The ten Peripheral and Control Processors that form an integral part of every Control Data 6000 Series computer system are logically and functionally independent processors, each with a private core storage bank of 4,096 12-bit words. The Peripheral Processors have an instruction repertoire of 64 instructions, including fixed-point binary addition and subtraction, testing instructions, incrementing instructions, and an Exchange Jump instruction that facilitates switching between programs.

Due to the power and flexibility of the Peripheral Processors, many tasks that are performed by the central processors in more conventional systems are divided among the 6000 Series Peripheral Processors, permitting the 6000 Series Central Processor to concentrate upon performing the central computational loops of multiple programs. The principal roles

(Contd.)

.22 Peripheral and Control Processors (Contd.)

of the Peripheral and Control Processors include controlling all input-output operations, performing executive and monitor services for the entire system, performing data transcription operations, and serving the Central Processor program by performing time-consuming operations such as data conversions, file searching, and array manipulations.

The Peripheral and Control Processors that are used with the Control Data 6000 Series systems have a clock-cyle time of 1 microsecond and use core storage modules with the same cycle time.

Most Peripheral Processor instructions can be executed within one to four processor cycles. Transfer of data between each of the Peripheral Processors and any of the twelve standard input-output Data Channels can proceed at up to 2 million characters per second.

TABLE I: CHARACTERISTICS OF THE 6000 SERIES CENTRAL PROCESSORS

System Identity			CONTROL 6400/6500	CONTROL DATA 6600
Computer System Report No.			263	264
DATA STRUCTURE	Word Length	Binary Bits	60	60
		Decimal Digits	18	18
		Characters	10	10
	Floating Point Representation	Radix	Binary	Binary
		Fraction Size	48 or 96 bits	48 or 96 bits
		Exponent Size	11 bits plus sign	11 bits plus sign
CENTRAL PROCESSOR	Model Number		6413, 6414, 6415 (6400) 6513, 6514, (6500)	6613, 6614, 6615
	Arithmetic Radix		Binary	Binary
	Operand Length, Words		1	1
	Instruction Length, Words		1/4 or 1/2	1/4 or 1/2
	Addresses per Instruction		3	3
	Likely Fixed Point Execution Times, μsec (5 Digits Min. Precision)	c = a + b	0.6*	0.3*
		c = ab	7.8*	1.9*
		c = a/b	9.1*	4.5*
	Likely Floating Point Execution Times, μsec	c = a + b	1.1*	0.4*
		c = ab	5.7*	1.0*
		c = a/b	5.6*	2.9*
	Checking	Data Transfers	None	None
		Arithmetic	Interrupt	Interrupt
	Number of Index Registers		Eight	Eight
	Indirect Addressing		Not applicable	Not applicable
	Special Editing Capabilities	Mathematical	None	None
		Commercial	None	None
	Boolean Operations		AND, INC OR, EXC OR	AND, INC OR, EXC OR
	Table Look-up		None	None
	Console Typewriter	Input	Yes	Yes
		Output	No; displays are used	No; displays are used
	Features and Comments		Supported by 10 Peripheral Processors; sequential execution of one instruction at a time.	Supported by 10 Peripheral Processors; up to 10 instructions can be executed concurrently.

* **Execution times are elapsed times for Register-to-Register tasks, with no allowance for transferring data to and from main core storage; these data transfers can be overlapped and do not necessarily add to the time used.**

.3 INTERNAL STORAGE

The Control Data 6000 Series offers a wide variety of internal storage devices of diverse capacities and speeds, designed to serve specific functions within the total integrated computer system. Central Memory can be considered as the private, high-speed core storage for the Central Processor, with direct data paths to the Peripheral Processors and to the optional Extended Core Storage unit. Central Memory capacities range from 320,768 to 1,310,720 six-bit characters; transfer rates extend from 80 to 100 million characters per second, depending on the unit's size and model. Table II lists the principal characteristics of the Central Memory units.

TABLE II: CENTRAL MEMORY CHARACTERISTICS

Computer System	6400/6500 or 6600		
Core Storage Capacities, in 60-Bit Words	32,768*	65,536	131,072
Cycle Time per Word, μsec	1.0	1.0	1.0
Independent Banks of Storage	8	16	32
Interleaved Cycle Time per Word, μsec	0.13	0.10	0.10
Peak Transfer Rate, Millions of Words per Second	8	10	10

* Not available in the 6500 system.

Each of the ten Peripheral Processors has a core memory unit consisting of 4,096 12-bit words to serve the general computational needs of the Peripheral Processor, to hold in residence the system's control programs, and to provide private input-output buffer areas for data transferred to and from Central Memory. Data can be transferred between a Peripheral Processor memory unit and Central Memory at the rate of 2 million characters per second.

Control Data 6000 Series users can optionally include the newly-developed Extended Core Storage unit in their hardware configuration to provide very fast and comparatively inexpensive auxiliary core storage in capacities up to 167 million characters (see Table III). Blocks of data can be transferred between Extended Core Storage and Central Memory at the rate of 100 million characters per second. The entire 1,310,720 characters of a 131K 6800 Central Memory can be exchanged with the same number of characters stored in Extended Core Storage in 13.1 milliseconds. These data transfer rates are so impressive that Control Data has utilized the technique of swapping programs between Extended Core Storage and Central Memory as the heart of its time-sharing systems for the 6000 Series. This "roll-in/roll-out" method provides the Central Processor with almost immediate access to any program.

No internal parity checking is performed in any of the 6000 Series core storage units except extended core storage. Control Data emphasizes the high degree of reliability built into its third-generation core memories and suggests the use of software checking techniques when absolute assurance of reliability is required. The extra time required to perform some form of software checking is implied as being insignificant in view of the extremely high processing speeds of the 6000 Series systems.

TABLE III: EXTENDED CORE STORAGE CHARACTERISTICS

Computer System	6400/6500 or 6600				
Extended Core Storage Capacities, in 60-Bit Words*	125,952	251,904	503,808	1,007,616	2,015,232
Number of Memory Banks	1	2	4	8	16
Number of Characters Accessed per Cycle	80	80	80	80	80
Cycle Time, in Microseconds	3.2	3.2	3.2	3.2	3.2
Peak Transfer Rate, Millions of Characters per Second	25	50	100	100	100

Three types of random-access disc storage units are offered as part of the 6000 Series hierarchy of storage devices. The 6603 Disk File is a Bryant-made unit with 14 non-removable disks; capable of storing up to 75 million characters. Either the 6603 Disk File or the new 6638 Disk File (with a better price/performance ratio) can be included in every 6000 Series configuration as the "System Disk." The 6638 can hold up to 167 million characters. The 6638 features rapid-access actuator arms in a reactively-balanced positioning mechanism

(Contd.)

TABLE IV: DISC STORAGE CHARACTERISTICS

Device	Capacity (millions of characters per unit)	Average Access Time (milliseconds)	Data Transfer Rate (char/sec)	Report Reference
6603 Disk File	75.0	110.0	1,048,000 to 1,342,000	260:044
6638 Disk File System	167.0	67.5	1,680,000	260:045
853 Disk Storage Drive	4.1	87.5	208,333	260:046
854 Disk Storage Drive	8.2	87.5	208,333	260:046

.3 INTERNAL STORAGE (Contd.)

developed by Control Data. The 850 Series Disk Storage Drives can also be used with the 6000 Series. These units provide inexpensive "Disk Pack" storage with capacities up to 8.2 million characters per pack. Table IV lists the principal features of these random-access disc storage devices.

.4 INPUT-OUTPUT EQUIPMENT

Control Data provides a wide range of local and remote peripheral devices for the 6000 Series, emphasizing that input-output equipment considerations should not be permitted to impede the performance of the powerful 6000 Series processing and core storage units. Any of the input-output units provided for the Control Data 3000 Series computer systems (and described in Report Sections 245:041 through 245:102) can be connected to a 6000 Series system through use of 6681 Data Channel Converters. Some other devices have been developed especially for use with the 6000 Series; these units are described below.

- 6416 Augmented Input-Output Buffer and Control — a large-scale multiple-device subsystem that can virtually double the input-output capabilities of a basic 6000 Series configuration. The 6416's components include 12 high-speed bidirectional Data Channels, 10 Peripheral and Control Processors, each with a private core storage unit that consists of 4,096 12-bit words, and one Main Memory unit consisting of 16,384 60-bit words. The 6416 is, in effect, an additional 6000 Series computer system, minus the Central Processor. Up to twelve Augmented Input-Output Buffer and Control Units can be connected to a 6000 Series computer system.
- 6612 Display Console — a dual-display cathode-ray unit used as the basic local console device in every 6000 Series computer system. The 6612 uses two 10-inch cathode-ray tubes as the sole output media and uses a console keyboard for input purposes. There are no other displays, indicators, switches, or other special-purpose hardware devices on the console. The system can edit and display instructions to the operator, messages and/or graphs for the programmer, or any other relevant data, in any appropriate format. The display can be retained on the scope as long as desired (perhaps until some action such as mounting a tape has occurred) and then erased to make room for other displays. Each line in the display can be up to 64 characters wide, and a maximum of 32 lines can be displayed. Graphical data can be displayed, but there is no provision for light pen input.

  During normal operation, one of the two scopes is reserved for communication with the computer operators and the other is used for messages and displays initiated by the program itself. At least one Model 6612 Display Console is used with each Control Data 6000 Series system. Additional consoles can be used in conjunction with time-shared operations, with each scope servicing a different program or group of programs.

  The 607 7-Track Magnetic Tape Unit offers packing densities of 200, 556, or 800 characters per inch and a tape speed of 150 inches per second. The 607 unit is compatible with the IBM 729 Magnetic Tape Unit and operates at a peak data transfer rate of 120,000 characters per second.

.5 DATA COMMUNICATIONS

Due to the great power inherent in the 6000 Series processing equipment, many installations will include numerous remote devices communicating with the central computer via communications lines. Control Data offers facilities to connect any of its own remote terminal equipment and most of the industry-standard terminal devices to the 6000 Series systems.

The 3266 Communication Terminal Controller is a multiplexing control unit that enables a wide variety of standard and specialized data communications devices to be connected to the standard 6000 Series Data Channels via a 6681 Data Channel Converter. First used with the Control Data 3000 Series systems, the 3266 Controller can control up to 32 simplex telegraph-grade lines (16 sending and 16 receiving), or up to 16 half-duplex or full-duplex telegraph-grade lines, or up to 8 half-duplex or full-duplex voice-grade lines. The 3266 provides the speed and mode conversions required to communicate with the 6000 Series systems.

.5 DATA COMMUNICATIONS (Contd.)

The 6000 Series Data Set Controllers are single-speed communications control units designed specifically for the 6000 Series computer systems. Four different models permit various types of communications devices and remote computer systems to be connected directly to the 6000 Series Data Channels. The 6000 Series Controllers communicate with the remote devices over the public or private communications facilities of the telephone or telegraph companies, using standard data set modems as interfacing units at the remote and central ends of the transmission lines. Two models permit computer-to-computer communication at 40,800 bits per second over Telpak A lines. Another model permits up to 64 Teletype Model 33 or 35 terminals to communicate with a single 6000 Series Data Channel. A fourth model permits terminal to computer communications over voice grade communication lines.

.6 SOFTWARE

The software support for the 6000 Series computers offered by the earlier Chippewa and SIPROS operating systems is only of historical interest. The new 6400/6500/6600 SCOPE operating system fullfills the multiprogramming and multiprocessing requirements of current large-scale applications.

SCOPE is a disk-oriented operating system designed to maintain control over all job execution and scheduling, storage allocation, input-output operations, and operator communications. The multiprocessing environment of the dual-processor 6500 is also controlled by this operating system.

SCOPE provides debugging aids, such as dumps, memory maps, utility routines for performing sort/merge and file maintenance. Also provided are language compilers and assemblers, including COMPASS, FORTRAN, ALGOL, and COBOL. These routines may run concurrently with user programs through SCOPE's multiprogramming scheduling facility.

The system components of SCOPE are distributed among the central and peripheral memories and a disk unit. The central resident portion, consisting of system tables and pointers, communications areas, and frequently used routines, resides in central memory. One of the ten peripheral processor memories contains the monitor routine, while another one contains the system display program. The remaining eight peripheral memories have no fixed assignment but are available for SCOPE assignment as required. The remainder of SCOPE is stored on disk.

Control cards that preceed each job specify priority levels, time limits, memory requirements, as well as the specific operations to be performed. The SCOPE loader can link object programs, separately compiled or assembled programs, and will also link library routines. Program segmentation is possible because the loader can load and overlay segments. Thus, programs that exceed the available storage can be executed by segments, thereby increasing system throughput and providing efficient utilization of storage.

The COMPASS assembly system replaced the predecessor ASCENT and ASPER systems, which required different versions to program for the central and peripheral processors. COMPASS provides features such as free-field format, macro and micro definitions, and a special facility for redefining machine mnemonics.

The FORTRAN language is an expanded version of FORTRAN-66, which is a dialect of the IBM 7090/7094 FORTRAN IV implemented by Control Data for its 1700 and 3000 Series systems. The compiler permits the inclusion of statements written in the COMPASS assembly language. The ALGOL language is basically an extension of ALGOL-60, closely conforming to the ACM input-output procedures proposed in 1964 and providing a concise computation language oriented to scientific-engineering applications.

The COBOL business language contains all of the facilities of COBOL-65 with facilities for program segmentation, extensive diagnostics at programmer specified points, and a report writer package. All of the compiler and assembly languages operate under the control of SCOPE, thereby allowing execution to be concurrent with the execution of other system programs.

Extensive data transcription facilities are available to transcribe data from one data medium to another. Standard routines in the SCOPE library allow input from card, magnetic tape, or disk.

A variety of application packages permit the user of a 6000 Series computer system to handle advanced system objectives, such as linear programming systems (OPTIMA), matrix algebra problems, managerial evaluation aids (PERT), model simulation techniques (SIMSCRIPT), and programmed-tooling routines (APT). In addition, a comprehensive file management system (RESPOND II) enables remote users to create, store or modify files at the central site. The EXPORT/ IMPORT systems provide batch processing facilities for remote users.

SCOPE checks the functioning of the various system components through an on-line diagnostic routine that runs concurrent with production processing. A chronological record of all jobs run and errors encountered is maintained in a file, known as the "dayfile."

CDC 6400/6500/6600

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			CDC 6400:			
	6413		Central Computer for 6400 system (with 131,072 60-bit words of core storage, 12 data channels, and 10 peripheral processors each with 4,096 12-bit words of core storage).	58,000	2,373,000	6,100
	6414		Central Computer (same as 6413 but with 65,536 60-bit words of core storage)	37,500	1,365,000	3,525
	6415		Central Computer (same as 6413 but with 32,768 60-bit words of core storage)	24,000	861,000	2,340
			CDC 6500:			
	6513		Central Computer for 6500 system (with 131,072 60-bit words of core storage, 12 data channels, and 10 peripheral processors each with 4,096 12-bit words of core storage)	64,000	2,573,000	7,100
	6514		Central Computer (same as 6513 but with 65,536 60-bit words of core storage)	43,500	1,565,000	4,525
			CDC 6600:			
	6613		Central Computer for 6600 system (with 131,072 60-bit words of core storage, 12 data channels, and 10 peripheral processors each with 4,096 12-bit words of core storage)	89,500	3,675,000	7,210
	6614		Central Computer (same as 6613 but with 65,536 60-bit words of core storage)	62,500	2,310,000	6,400
	6615		Central Computer (same as 6613 but with 32,768 60-bit words of core storage)	46,000	1,627,500	5,700
ATTACHMENTS, ADAPTERS, AND CHANNELS	6416		Augmented Input-Output Buffer and Control (includes 16,384 60-bit words of core storage and 10 peripheral processors each with 4,096 12-bit words of core storage; includes 12 data channels and connection for Extended Core Storage; communicates with 6400 or 6600 Central Computer via standard channel or through Extended Core Storage)	13,000	483,000	530
	6641-1		Extended Core Storage/Mass Storage Adapter (creates data paths among Extended Core Storage, 6000 series peripheral devices, and peripheral processors)	1,500	60,000	185
	6681		Data Channel Converter (permits 6400, 6500, or 6600 system to use CDC 3000 series peripheral devices)	325	14,000	40
	6683		Satellite Coupler (for direct connection of two standard data channels)	185	10,000	25
MASS STORAGE			Core Storage			
	6633		Extended Core Storage for CDC 6400 or 6600 systems (includes 125K words of core storage and control permitting communication 6640 Extended Core Storage Controller and 6400/6600 Central Computer of 6416 I/O Buffer and Control)	6,800	270,000	740

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Maint. $	Purchase $	Monthly Rental $
MASS STORAGE (Contd.)			Core Storage (Contd.)			
	6634		Extended Core Storage (same as 6633 but with 250K words of core storage)	12,000	480,000	1,125
	6635		Extended Core Storage (same as 6633 but with 500K words of core storage)	22,500	900,000	1,800
	6636		Extended Core Storage (same as 6633 but with 1,000K words of core storage)	43,500	1,740,000	2,800
	6640		Extended Core Storage Controller (couples up to 2 million words of extended core storage with one to four 6400 or 6600 Central Computer or 6416 I/O Buffer and Control Units in any combination)	2,200	80,000	220
			Disk Storage			
	6638		Disk System (provides over 100,000 characters of storage; 1,680,000 char/sec transfer rate; two independent access mechanisms; two channels)	9,400	325,000	755
		10037	Read/Write Control Option (factory installation only)	720	26,500	60
	*6603		Disk System (75 million characters of storage; 1.1 to 1.25 million char/sec transfer rate)	5,900	205,000	610
		10098	6603 Disk System Speed-up (reduces position/time from 201-268 msec to 156-170 msec; reduce head switching/time from 1-67 msec to 1 msec	---	2,500(1)	---
		10124	6603 Disk Speed-Up Augment (decreases positioning/time from 156-170 msec to 60-160 msec; requires 10098)	---	5,000(1)	---
INPUT-OUTPUT			Console			
	6612		Console Display (includes two CRT displays, input keyboard, and controller)	1,200	48,000	160
COMMUNICATIONS	6671		Data Set Controller (accommodates 1 to 16 narrow-band or voice-band lines; compatible with Bell System Data Set 103 and 201 series)	1,200	42,000	145
	6673		Data Set Controller (accommodates two broad-band lines; compatible with Bell System Data Set 301B; operates at 40,800 bits/sec)	900	35,000	120
	6674		Data Set Controller (accommodates four broad-band lines; compatible with Bell System Data Set 301B; operates at 40,800 bits/sec)	1,300	52,000	180
	6676		Data Set Controller (accommodates 1 to 64 narrow-band lines; compatible with Bell System Data Set 103)	2,000	79,000	175

NOTES

* No longer in production.

(1) One time charge for factory or field installation in leased or purchased equipment.

ADVANCE REPORT: CDC 7600

.1 BACKGROUND

The large-scale Control Data 7600, introduced in December 1968, is not offered as a fourth generation computer, but rather as a natural evolution from the CDC 6600. Thus, the CDC 7600 is properly placed at the upper end of CDC's 6000 Series product line.

CDC has been interested in broadening its customer base and directing its large-scale systems to more commercial applications as well as maintaining their traditional emphasis on scientific processing. The company estimates that the improvement in throughput of the typical data processing job by the 7600 over the performance of the 6600 is as high as a factor of eight. This rate is largely attributable to the arrangement of CPU functional units, permitting the simultaneous execution of more than one instruction of the same type, and the expanded input-output structures.

The likely competition in the $8-million-plus range stems from the IBM 360/90 Series and the Burroughs 8500. CDC had announced a 6800 system earlier, but it never reached the market because of CDC's concern for quality performance. The first 7600 was delivered in January 1969.

The 7600 uses a 27.5-nanosecond machine cycle, or clock period, as opposed to the 100-nanosecond period of the 6600, making the 7600 approximately 3.6 times faster than the 6600 in basic clock time; theoretically the 7600 is capable of executing up to 36.3 million two-clock-period instructions per second because of the parallel and segmented organization of the functional units.

The major features of the CDC 7600 may be summarized as follows:

- 27.5-nanosecond clock period.
- A multi-instruction feature that allows concurrent processing of similar or dissimilar instructions.
- Two core memories of 650,000 (small core memory) and 5,000,000 (large core memory) characters capacity.
- A maintenance processor for performing most system maintenance without interrupting processing.
- The elimination of user input-output processing from the CPU by shifting the I/O control to up to 14 peripheral processors.

The 7600 is organized into a network of "work stations," each with its own operator control and peripheral equipment. The system programs can be loaded onto and executed from any one of these stations. Each station is independent and operates concurrently with the other stations, thus providing a multiprocessing environment. The user is, in effect, getting a number of computers in one package.

Peripheral processors control the flow of data to and from the CPU. Communication between the work stations and the main system is buffered by the CPU large core memory, which holds the data and files ready for processing by the program in CPU small scale memory.

Two improvements over the 6600 are worth noting:

- The 6600 branch instruction, which took 11 machine cycles, has been reduced to three machine cycles in the 7600.
- The CPU instruction stack, which accommodates complete program loops, has been increased by 50 percent (from 8 words to 12 words).

The 7600 supporting software has not been fully defined and the first user plans to write his own systems support. However, much of the software developed for use with the 6000 Series can also be used with the 7600, including Assemblers, Compilers (COBOL, FORTRAN, ALGOL), APT, Sort/Merge, PERT/TIME, etc. Control Data states that they plan to provide, at a later time, comprehensive operating support facilities for data management, information retrieval, time-sharing, etc.

.2 HARDWARE

.21 System Configuration

The basic 7600 system is offered as a primary package that includes the following components:

- One Central Processing Unit with two main memories containing 65,536 and 512,000 60-bit words respectively.
- Six Peripheral Processor Units, each containing 4,096 12-bit words.
- A Disc File System comprised of one controller and one disk file (two storage units) with a capacity about 800 million characters.
- An Operator Station consisting of a visual display console and eight million characters of buffer storage.
- A Maintenance Control Unit with card reader and visual display.
- Peripheral equipment consisting of a card reader, card punch, two printers, and two magnetic tape drives.

Additional peripheral processors, disc and drum units, and other peripheral devices may be added for an expanded system. Also, any CDC 6600 peripheral devices can be field-modified to the 7600.

.22 Processors

Central Processing Unit

The 7600 Central Processing Unit contains four component sections housed in one mainframe cabinet: a computation section, two memories, and an I/O multiplexor. Communication outside the mainframe is asynchronous: the completion of an operation signals the start of a new operation.

The internal CPU Computation Section operates in a synchronous mode based on the 27.5-nanosecond clock period. The section is composed of the following elements:

- Nine functional units,
- A twelve-word instruction stack, and
- 24 operating registers.

Data enters and leaves through the operating registers including:

- Eight 60-bit "x" data registers, which direct the data flow to and from the two memory sections.
- Eight 18-bit address registers, which hold addresses of locations in one of the CPU memories corresponding to the data in the "x" registers.
- Eight 18-bit index registers, which are used primarily for modifying addresses and controlling program loops.

The CPU instruction work stack (IWS) consists of twelve 60-bit registers holding the current program instruction words ready for execution and arranged by rank. The IWS is essentially a push-up stack continually filled with new instruction words that are at least two words ahead of the instruction word currently being executed. The register containing the last word to enter the stack is designated rank 12, and when a shift stack condition occurs, the ranks are reset; the rank one instruction word is discarded, and the remaining instruction words move down the stack from the next high order ranks.

All instructions in the IWS originate in CPU small core memory (SCM), which contains the program being executed by the CPU. Associated with the IWS is a push-down instruction address stack made up of twelve 18-bit address registers containing the small-core memory addresses of the instruction words in IWS: this permits branching within the stack and the holding of non-contiguous program loops.

The IWS is particularly efficient when processing small program loops. If a loop can be contained entirely in the stack, it can be executed without the need to fetch any instructions from memory.

Nine independent specialized arithmetic units provide the functional capabilities for instruction execution in the CPU Computation Section, as shown in Table I. The units can operate simultaneously. Table I lists the processor units, descriptions of their functions, and their segmentation and execution times as expressed in clock periods of 27.5 nanoseconds.

As specified in Table I, with the exception of the floating multiply and divide units, all of the functional units can accept a new operand every clock period cycle. The instruction information is held in a new set of registers at the end of each clock period, thus allowing a new instruction for unrelated computation to be introduced before the prior instruction has been fully processed by the functional unit. The floating multiply unit has a two-clock-

TABLE I: CDC 7600 CPU FUNCTIONAL UNITS

Unit	Function	Segment Time, Clock Periods*	Execution Time, Clock Periods*
Boolean	Basic logical operations: transfers, logical sum, product, difference, and pack/unpack floating point	1	2
Shift	Shifting, mask generation	1	2
Long Add	Integer addition or subtraction (60-bit fixed point fields)	1	2
Floating Add	Floating point addition or subtraction (single or double precision)	1	4
Floating Multiply	Floating point multiplication (single or double precision)	2	5
Floating Divide	Floating point division (single precision)	18	20
Normalize	Normalize operations	1	3
Population Count	Counts the number of 1 bits in a 60-bit word	1	2
Increment	One's complement addition and subtraction of 18-bit operands	1	2

* The clock period is 27.5 nsec. The segment time is that portion of the execution time that cannot be overlapped with another operation in the same unit.

.22 Processors (Contd.)

period delay before another multiply instruction can be introduced. Segmentation is not effective in the floating divide unit because of the iterative nature of the algorithm involved (only a two-clock-period overlap is possible). Consequently, delay can be eliminated and instruction execution maximized, if a new divide instruction follows a prior divide instruction by at least eighteen clock periods. The CPU will not progress to the next instruction until the current instruction is initiated.

Because of the independent nature of the functional units and their segmentation organization, simultaneous instruction execution occurs both among and within the units.

Communication between the CPU and each of the peripheral processors (maximum 15) is accomplished over 12-bit full-duplex channels via the CPU I/O Multiplexor. The channels have assembly and disassembly registers that convert between 12-bit PPU words and 60-bit CPU words.

Each channel path has two control lines with flags indicating the completion of the transfer of each 12-bit word and also the entire record. In addition, a verification control feature is provided by a signal that indicates the successful receipt of the data word.

Each channel has separate input and output buffers in CPU small core memory with separate "exchange packages" to process and control the transmission, which proceeds on a record basis with an interrupt signal generated at the completion of each record transmission. Interrupts can also occur during record transmission (for long records) at prescribed intervals. The frequency of this occurrence depends on the SCM buffer size and can be preset for each channel.

.22 Processor (Contd.)

Peripheral Processor Units

The 7600 basic configuration includes six peripheral processor units (PPU's), and the system can accommodate nine more for a total of 15. The primary PPU function is to perform I/O operations for the CPU, functionally acting as a communication and message switching center between the CPU and the individual peripheral device controllers. However, each PPU may function as a separate and self-contained computer system in its own right. The PPU's may be located at the main site or at a remote location; they may be independent of the CPU and each other, and each PPU can execute a separate and unrelated program at the same time.

Each PPU is composed of three major sections: a computation section, memory, and I/O control.

The PPU Computation Section (or Processor) is somewhat conventional in its organization. Seven registers facilitate instruction addressing, operand addressing, shift counts, etc.; an accumulator is provided for moving operands to and from an adder; and two additional adders are used in indirect addressing.

The PPU I/O Section functions in a similar manner to the CPU I/O Multiplexor. Each PPU has eight 12-bit full-duplex channels for communications with the peripheral device controllers and the CPU. Each channel has two symmetrical cables providing input and output paths.

.23 Internal Storage

CPU Memories

The two types of internal CPU core storage are designated small core memory (SCM) and large core memory (LCM).

SCM is arranged in 32 banks of 2,048 60-bit words; the total capacity is 65,536 words. SCM is organized in stacks, identical to those found in the peripheral processor unit's memories. The SCM banks are independent of each other, and each one contains ten stacks, which in turn are composed of 1,028 12-bit words, with a parity bit for each 12-bit word. The SCM maximum transfer rate is 27.5 nanoseconds per 60-bit word (one clock period). The total read/write cycle time is 275 nanoseconds per bank (ten clock periods).

All of the SCM banks can be accessed simultaneously. This maximum operation can be realized during block copy of data between SCM and LCM where the SCM addresses for sequentially stored words cause no bank conflicts.

Four clock periods are required to access each SCM bank and, under normal circumstances, CDC expects an average of four SCM banks to be operating at the same time. SCM is particularly effective when performing operations that require rapid random access to unrelated fields. CPU instructions and input-output channel control are executed from SCM.

The first 4,096 SCM words are reserved for I/O buffers and control areas. These words are inaccessible to the object programs. The following 1,024 words are reserved for the resident monitor, and the rest of SCM (60,416 words) is available for CPU program code or data.

Large core memory (LCM) is arranged in eight independent banks of 64,000 60-bit words each, with a total capacity of 512,000 words. Eight 60-bit words or one "LCM word" are read simultaneously during a read/write cycle of 64 clock periods duration (1.76 microseconds). There is a parity bit for each 15-bit grouping. Associated with each LCM bank is one 480-bit register that can hold 8 words. During a block copy operation, bank accesses are started at intervals of eight clock periods, thus allowing a maximum transfer rate of one word per clock period.

LCM provides the basic CPU working storage to accommodate program assembly and the data files during execution. The original input file, the data, and the final output file for small programs can be contained entirely in LCM.

The first 32,000 words of LCM storage are reserved for monitor, compiler, and other system support programs, and the remaining 480,000 words are available storage for SCM and the other operating stations.

PPU Memory

PPU memory has a total capacity of 4,096 12-bit words and a 275-nanosecond read/write cycle time. It is divided into two independent banks of 2,048 words.

In order to increase the processing speed, consecutive addresses alternate between the two banks. Each bank has its own register for holding the operand address and the data to be stored, and there is one register that holds the data read from either bank.

Table II specifies the major characteristics of the CDC 7600 Central Processor and Peripheral Processor Units.

.23 Internal Storage (Contd.)

Disk/Drum Storage

Mass data storage and retrieval is facilitated by a disk/drum subsystem consisting of one controller and one 7600 Disk File (7638-1) or up to two 7600 Drum Units. The random access subsystems rotate at 1,800 revolutions per minute and are under the control of two of the PPU's in the system.

The 7638-1 Disk File System is an integral part of the basic 7600 system package. Each of the two hydraulic positioning assemblies is regarded as one file unit, which in turn contains two half-stacks of 18 disks each (32 recording surfaces per half-stack). One read/write head is provided for each disk surface. A file system thus contains a total of 72 disks (128 recording surfaces).

The PPU interface receives and transmits 12-bit bytes at a rate of 285 nanoseconds per byte. Maximum latency is approximately 35.5 milliseconds. This translates into a data transfer rate of about six million alphanumeric characters per second. The total disk subsystem capacity is about 800 million characters, or over five billion bits.

The 7600 Drum Unit is not yet available either in the basic system package or as an add-on component. It is expected to have a capacity of over 150 million bits or 26 million characters, and a transfer rate of six million characters per second.

There are two read/write control units in the controller (disc or drum), which can be shared by two 7600 PPU's. Each PPU has two I/O channels to the controller: one for data, and one for control, which transmits output function codes and receives input status codes. Each read/write control unit operates either one disk file unit or one drum.

.24 Peripheral Equipment

The 7600 peripheral devices are modifications of the standard Control Data peripheral equipment including a card reader and punch, magnetic tape driver and line printer. In addition, all other standard Control Data peripherals, such as removable disc storage and tape transports, may also be used after undergoing field-modification.

The 7611-1 Operator Station contains eight million characters of buffer storage and a visual display console. Up to six stations can be attached to each PPU.

.25 Maintenance Control Unit

The Maintenance Control Unit (MCU) is a PPU dedicated exclusively to system maintenance. The unit's functions are that of initiation of the system from a "dead start" after an idle period or a hardware failure and scheduled preventive maintenance. In addition, memory parity and program errors are monitored and logged and a facility exists for dumping memory to analyze the error situation.

The MCU is equipped with a card reader, console and display CRT. A "dead start" operation begins with the loading of a deck of cards, activating the MCU program, which then sequentially starts the CPU and all other PPU's through a bootstrap program entered into SCM. The system programs reside on and are loaded from a library tape associated with any of the system PPU's. Designation of the library tape is established at "dead start" time through the maintenance console.

The MCU is connected to the other PPU's (up to a maximum of 14) through a scanner interface, which translates the signals to and from the MCU and affects the appropriate connections. A "dead dump" signal starts a data transmission of the entire PPU storage to the MCU for display via the console.

Maintenance checking of system operating takes place continually and is concurrent with processing. A situation requiring operator attention and/or remedial or corrective maintenance causes a temporary withdrawal from the system of just the resource affected, and the operating system will provide for the temporary reallocation of tasks and other system resources as necessary. System down time will occur only when either the CPU or the MCU requires maintenance.

.26 Processing Facilities

CPU references to either SCM or LCM are made relative to a reference address. Object programs are assigned a specific field in SCM by the Monitor for execution and another field in LCM for working storage. The object program addresses must be contiguous.

The reference address specifies the lower program limit, and the absolute address is formed by adding the program address to the reference address. The program field length is established prior to the initiation of the programs and during execution, the program storage limits are contained in four CPU hardware registers. Storage references beyond the assigned field length or below the reference address will create an error condition that will terminate the program execution.

.26 Processing Facilities (Contd.)

Program branching can involve a delay because of the instruction word stack arrangement. A branch to an SCM address of a word within the stack, as in a loop routine, involves no delay; however, if the branch is "out of the stack," the new instruction is delayed about eight clock periods until it is read from SCM into the stack.

The instruction words are divided into 15-bit fields referred to as "parcels." A CPU instruction may require one or two parcels of storage, and thus, an instruction word may contain up to four instructions (60-bits). If a two parcel instruction begins in the last parcel of an instruction word, the program may experience an unforeseen result, because the CPU will assume there is a second parcel containing all zeros. CDC states that no standard compilers or assemblers will create this condition, and that it can only occur through instruction modification or octal coding. A branch instruction destination address must reference the first parcel of an instruction word.

There are a total of 82 separate and distinct CPU instructions, including both fixed point and floating point operations.

The PPU's are also programmable and 74 12-bit or 24-bit instructions are provided. All arithmetic operations are in fixed point. Execution times for PPU instructions vary from 5 to 40 clock periods (27.5 nanoseconds per clock period), and indexed and/or indirect addressing can be specified.

.3 SOFTWARE

No comprehensive software has been released to date, however, language processors and application programs that are used with the CDC 6000 will support the CDC 7600. Control Data plans to introduce, in a logical progression, an operating system and support packages for the 7600 that will incorporate company and customers experience with the 6000 Series Chippewa and Scope operating systems.

.31 Monitor

A system Monitor is provided, which is loaded at "dead start" time and resides permanently in SCM. The rest of the Monitor remains in LCM to be called into SCM as small, task oriented overlays of the "resident" monitor.

The CPU Exchange Jump instruction is used to switch between execution of object programs and monitor programs. The Monitor controls all requests for input-output activity and error actions, in addition to its regular function of controlling the job stream.

When an exchange jump occurs, all pertinent information is stored for reinitialization upon return to the object program. The storage and retrieval of all register information is done by hardware.

.32 Testing and Debugging

The facility also exists for executing an object program in small sections during program testing and debugging. A hardware breakpoint register is loaded by the Monitor with the premature termination address. Breakpoint control can originate either from the console operator or from control cards in a job stack. Thus, it is possible to run through a program one step at a time.

.4 COMPATIBILITY

Upwards compatibility with the earlier-announced members of the CDC 6000 Series is a major feature of the CDC 7600: the instruction repertoire; data structure; and general organization of the 7600 system, especially the employment of peripheral processors, exemplify this compatibility. In addition, the use of common software support, as well as common field-modified peripheral devices further reinforce this compatibility.

(Contd.)

TABLE II: PROFILE OF THE CDC 7600 CENTRAL PROCESSOR AND PERIPHERAL PROCESSOR UNITS

	CPU	PPU
Computation Section —		
Internal word size, bits	60	12
Clock period, nanoseconds	27.5	27.5
Binary computations —		
Fixed point	Yes	Yes
Floating point	Yes	No
Features —		
Synchronous internal logic	Yes	Yes
Nine independent arithmetic units	Yes	No
Twelve word instruction stack	Yes	No
Memory Sections		
Type Memory —		
Coincident current	Yes (SCM)	Yes
Linear Selection	Yes (LCM)	—
Memory capacity, words	65,536 (SCM); 512,000 (LCM)	4,096
Independent memory banks	32 (SCM); 8 (LCM)	2
Number of words per bank	2,048 (SCM); 64,000 (LCM)	2,048
Read/write cycle time nanoseconds	275 (SCM); 1,760 (LCM)	275
Words accessed per cycle	1 (SCM); 8 (LCM)	1
Input-Output Section		
Asynchronous Independent Channels	15	8
Width of Data Path, bits	60	12

CDC 7600

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental 1-Year Lease	Monthly Rental 5-Year Lease	Purchase $	Monthly Maint. $
BASIC SYSTEM PACKAGE			Basic System includes the following(1):	172,750	155,475	8,250,000	23,225
	7601-1		Central Processing Unit				
	7602-1		6 Peripheral Processing Units (includes Maintenance Control Unit)				
	7611-1		Operator Station				
	7638-1		Disc File Station				
	407-1		Card Reader				
	417-1		Card Punch				
	517-1		2 Printers				
	617-1		2 Magnetic Tape Drives				
ADD-ON COMPONENTS	7602-1		Peripheral Processing Unit	1,250	1,125	50,000	150
	7611-1		Operator Station	5,685	5,115	236,500	1,010
	7638-1		Disc File System	12,550	11,295	400,000	1,655
	407-1		Card Reader	460	415	23,500	115
	417-1		Card Punch	345	310	19,000	105
	5517-1		Printer	1,110	1,000	45,000	405
	617-1		Magnetic Tape Drive	995	895	44,000	225

NOTES:

(1) The user must acquire the basic system package. Add-on components are optional.

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ADVANCE REPORT: GE/105

.1 BACKGROUND

The GE-105, announced in January 1969, further expands the system options available for users of GE's small-scale business-oriented systems. The marketing effort is directed to users currently employing manual or tab processing techniques as a means of "stepping-up" to the expanded data processing possibilities that a general-purpose computer system can provide.

As was true of the earlier GE-115 systems, the GE-105 will be produced by the General Electric Information System of Italy (GEISI) in collaboration with General Electric (USA). GEISI, originally Olivetti-GE, is now a wholly-owned subsidiary of GE, and GE has plans to market the new system both in the U.S. and Europe.

The GE-105 is upwards compatible within the GE-100 series, permitting growth as the user's data processing needs expand to the faster GE-115 and GE-130 systems, which have larger memory capacities and higher speed card processing equipment and printers, as well as magnetic tape drives, disc units, and communications controllers. The larger systems also offer COBOL and FORTRAN compilers, and comprehensive tape and disc operating system support.

Software support for the GE-105 is derived primarily from proven GE-115 routines, including an assembly programming system (APS); a report program generator (LOGEL); punched card processing routines (List and Summarize, Reproduce and Gangpunch); and a variety of utility routines providing such functional aids as memory dumping, card loading, reading, punching, printing, etc.

The emphasis is on "simplicity of operation" to facilitate the transition from tab processing to computer operations. The system is compact, it can be installed anywhere in a user's installation, and it is designed for quick user familiarization of programming and operational procedures.

Two models of the GE-105 are expected to be available by July 1969. The Model A, including a card reader, card punch, printer, and 4,096 core storage locations, leases for $1,250 and sells for $57,370. The Model B, with a combination card reader/punch and printer, and an 8,192 location storage capacity, carries a monthly rental of $1,450 and a purchase price of $66,410. The user will be offered the package configuration with each Model, and these peripheral components cannot be ordered separately or selectively. The projected delivery schedule target is an interval of 6 months following the receipt of an order.

.2 HARDWARE

.21 Data Structure

The basic unit of data storage is an eight-bit (plus 1 parity bit) byte, a standard GE-100 series data unit, which GE refers to as an "octet" and is equivalent to an IBM byte. Each octet is directly addressable and can store an alphanumeric character, two packed decimal characters or one 8-bit binary operand.

GE-105 arithmetic instructions perform operations on two data fields, each of which can contain from one to sixteen digits in length. The non-arithmetic instructions process fields up to 256 alphanumeric characters in length. The instruction lengths are two, four, or six characters, and zero, one, or two core storage addresses can be specified depending on the instruction function. There are a total of 39 separate instructions including decimal and binary arithmetic, data transfer, packing and unpacking, comparison, edit, translate, logical, search table, etc.

Note that there is no direct compatibility between the GE-105 and the IBM System 1360 Model 20, although both systems use 8-bit character codes.

.22 System Configuration

The GE-105 system is offered in two basic packages, both of which are dedicated to punched-card processing, and, hence, as replacements for unit record accounting operations.

Package A, as specified below, differs from Package B in that A has a faster card reader and a slower card punch and printer. The two packages are designed to accommodate the needs of users who place greater emphasis on either input or output processing. Package A also provides the option of reduced core storage capacity and reduced rental by eliminating the additional memory module (AM105).

Typical Card System: Standard Configuration I (GE-105 Package A)

Equipment	Rental
1 - GE-105 Model A04 Central Processor, with 4,096 characters of core storage	$1,250
1 - AM105 Additional Memory, provides 4,096 additional characters of core storage	180
1 - GE-105A04 Card Reader; 350 cpm	NC
1 - GE-105A04 Card Punch; 60-200 cpm	NC
1 - GE-105A04 Printer; 250 lpm	NC
Total Rental	$1,430

Typical Card System: Standard Configuration I (GE-105 Package B)

Equipment	Rental
1 - GE-105 Model B08 Central Processor, with 8,192 characters of core storage	$1,450
1 - GE-105B08 Card Reader/Punch; reader, 300 cpm, punch, 300 cpm	NC
1 - GE-105B08 Printer, 300 cpm	NC
Total Rental	$1,450

.23 Central Processor

Both the GE-105A and GE-105B Control Processors are composed of four functional units: a Store Unit, a Command and Control Unit, an Arithmetic Unit, and a Peripheral Control Unit. These units are housed in a "U"-shaped cabinet comprising three wings, one of which functions as a printer controller.

The Command and Control Unit fetches the instructions from core storage, and then decodes and controls the execution. The Arithmetic Control Unit performs the actual execution of all instructions except the I/O operations.

The Peripheral Control Unit provides two I/O channels and three peripheral connectors for the control of the transmission of data between core storage and the peripherals. An overlap feature allows the simultaneous operation of all the peripherals.

.24 Internal Storage

The Central Processor Store Units in both systems operate at a machine cycle rate of 7.5 microseconds - slightly less than the 6.5 microsecond cycle time of the GE-115.

Package B provides 8,192 core storage locations, while package A offers either 4,096 or 8,192 locations. Each location can accommodate an eight-bit alphanumeric character or "octet" plus one parity bit. Odd-parity checking is performed on all data stored in or read from core.

There are no index registers and, consequently, no address modifications are possible other than direct modification of the instruction.

.27 Peripheral Equipment

GE-105A Card Reader

This unit operates at a speed of 350 cards per minute, and can read standard 80-column cards punched in either Hollerith or column-binary (core storage, two decimal digits per column), or it can read them intermixed. The cards are read in a serial fashion, column-by-column, as they pass by twelve photoelectric cells. A 51-column option is available.

The single input hopper and the primary output stacker can each hold a maximum of 2000 cards. One auxiliary output stacker is available with a 500-card capacity, and stacker selection under program control is permitted.

Error conditions requiring operator attention include malfunctioning of the photocells, columns misread, input hopper empty, output stacker full, end-of-file mark sensed, and card jam.

An early termination feature permits program control of the number of columns read, and a computer-overlap feature allows the feed and eject portions of the read cycle to be overlapped by processor activity.

GE-105A Card Punch

This unit punches the standard 80-column cards at 100 columns per second, or 60 to 200 cards per minute depending on the number of columns punched in each card. Hollerith or column-binary cards are fed in a serial manner. A 1500-card input hopper and output stacker are provided.

Error checking includes card synchronization, parity, chad box full, and echo checking while punching, in addition to the card feed, card jam, stacker full, and hopper empty checking that takes place on the card reader.

The unit has a fully buffered controller providing overlap of punching and compute functions, as well as other peripheral operations.

GE-105A Card Printer

This is a 250 line per minute printer that prints a 120 character line (136 characters optional) at a density of 10 characters per inch. Skipping control is by a program space command or a paper tape control loop. All 64 alphanumeric characters can be printed. Error checking features include out of paper, end of page, hammer failure, and memory transfer parity error.

GE-105B Card Reader/Punch

This unit both reads and punches separately or intermixed at a speed of 300 Hollerith or column-binary cards per minute. The cards are fed in a parallel manner and the reading and punching are performed row-by-row. The same card may be read and then punched.

The reader/punch controller is fully buffered permitting simultaneous compute and card operations. A separate 80-character external buffer is also provided which is shared by both the reader and punch.

System Package B has decreased the operational speed of the reader and increased the speed of the punch over that of Package A, thus the emphasis on output as opposed to input processing capabilities.

GE-105B Printer

This unit is identical in all respects to the GE-105A Printer with the exception that the operational speed has been increased to 300 from 250 lines-per-minute. This increased printer capability further emphasizes the output orientation of Package B.

.3 SOFTWARE

There has been no comprehensive operating system developed to date for the GE-105, as contrasted with the Extended Tape and Disk Operating Systems provided with the larger GE-115 and GE-130 systems, primarily because of the punched-card orientation of the GE-105. All of the card-oriented GE-115 software may be used with the GE-105 including an Assembly Programming System, an extended report program generator called LOGEL, and an assortment of utility card processing programs for listing, summarizing, reproducing, and gangpunching.

The Assembly Programming System (APS) is a basic card-oriented language processor which translates source programs written in assembly language into object programs. Mnemonics are provided for all GE-105 instructions. In addition, supplementary mnemonics extend the range of the conditional jump instructions, and pseudo mnemonics control memory assignment and program listing formats.

Data constants may be coded in decimal, alphanumeric, or hexadecimal form. APS provides listings of both the source and object programs, a listing of all symbolic names used in the program, and programming error diagnostics.

LOGEL is a logic-generating language offering the user a simple file-management card system including report generation. LOGEL is a medium-level compiler divided into five divisions; GENERAL, which defines the input and output files; INPUT, which defines the input records; DATA, which specifies the data fields, constants, and core storage areas; CALCULATION, which contains the instructions to perform the required operations; and FORMAT, which specifies the format for the print lines and the output records.

The LOGEL program essentially generates sets of routines and the logical linking of these routines in accordance with the source program statements. Assembler instructions may be intermixed with the LOGEL statements.

The List and Summarize Program Generator creates reports from a punched-card file controlled by "parameter cards", which also define the file format. The object program produced to generate the reports is listed and punched into an object program deck.

Reproduce and Gangpunch operations are performed by a prior-developed program and a set of specification statements for each given run. A variety of card processing functions can be performed: the reproduction of a deck of cards from one to nine times for each run, the transfer or selection of selected fields, the gangpunching into detail cards of fields contained in master cards, and the calculation of a product or percentage from a field in each detail card and a field in a master card.

All of these card-oriented programs are currently available with the GE-115 system. They require only 4,096 core storage locations, so that a GE-105A04 configuration will suffice.

Several GE-115 business application packages have been developed for such applications as invoicing, inventory control, payroll, purchasing, general accounting, production control, public utility services, etc. Those application packages specifically oriented toward card processing will be available with the GE-105 including SIMTAB for the simulation of tab jobs, a 4,096 core capacity payroll program, PROCON-115 for production control, and Critical Path Method (CPM).

CPM is a management tool for planning, scheduling, and controlling business, industrial, and scientific projects. A model is constructed through specification statements showing the critical path network of all events contained in the project. Up to 350 nodes (events) can be handled in a minimum 4,096 character storage configuration. The end product are reports designed to simplify project evaluation and review.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
BASIC SYSTEMS	105A04		GE-105A System including: 4,096 octets* of core storage Card Reader (300 cards/min) Card Punch (60 to 200 cards/min) Printer (250 lines/min)	1,250	57,370	261
	105A08		GE-105A System including: 8,192 octets* of core storage Card Reader (300 cards/min) Card Punch (60 to 200 cards/min) Printer (250 lines/min)	1,430	65,890	274
	105B08		GE-105B System including: 8,192 octets* of core storage Card Reader/Punch (300 cards/min) Printer (300 lines/min)	1,450	66,410	288
		OPT105	16 additional print positions for 105A04, 105A08, or 105B08	35	1,540	8

Notes:

*Each octet consists of eight data bits plus one parity bit.

REPORT UPDATE

ADDITIONAL PERIPHERAL UNITS EXPAND GE-115 AND GE-130 SYSTEMS

General Electric has expanded the capabilities of the GE-115 and GE-130 systems by providing another magnetic Tape Subsystem. This is in addition to the two magnetic tape units (MTH106 and MTH103) added previously. A paper tape punch was also added to the product line.

Magnetic Tape Units

The new tape subsystem consists of a MTC 114 Controller used with a MTH 117 Tape Handler. This is a seven-track unit compatible with the GE-400 and the IBM 729 and 7330 units. The MTH 117 operates at a speed of 37.5 inches per second, and records at 200 or 556 rows per inch with a data transfer rate of either 7,500 or 21,000 bytes per second, respectively. The unit can read backward, and has a rewind speed of 75 inches per second. The inter-record gap is 0.75 inches, with a stop/start time of 21.1 milliseconds for continuous read/write, 31.1 milliseconds when the tape stops moving, and 16.9 milliseconds when the Central Processor is busy.

Up to six tape units can be connected to each controller. Connection can be through a multiple peripheral adapter, or directly on connector 3 on the GE-115, and connector 3 or 4 on the GE-130.

The tape used is standard 1/2 inch, 1.5 mil iron oxide coated Mylar film tape on 1200 and 2400-foot reels.

The following chart can be used to compare the new Tape Subsystem with the MTH 103 and MTH 106 Magnetic Tape Handler previously reported.

Model	No. of Tracks	Tape Speed (IPS)	Tape Density (BPI)	Transfer Rate (Kc)	Inter-Record Gap (Inches)	Stop/Start (ms)	Compatibility	Read Back-ward	Re-wind (IPS)
MTH 103	7 (option)	37.5	200 556 800	7.5 21 30	0.75	21.1(a) 31.1(b) 16.9(c)	GE-400 IBM 729 IBM 7330	Yes	75
	9	37.5	800	30	0.60	16.0(a) 26.0(b) 11.8(c)	IBM 2400		
MTH 106	7 (option)	75	200 556 800	15 42 60	0.75	10.8(a) 20.8(b) 8.8(c)	GE-400 IBM 729 IBM 7330	Yes	150
	9	75	800	60	0.60	8.3(a) 18.3(b) 6.3(c)	IBM 2400		

(a) Nominal inter-block gap time in continuous read/write.
(b) Stop/Start time when tape stops moving.
(c) Stop/Start time when Central Processor is busy.

Paper Tape Punch

The PTP 110 Paper Tape Punch for the GE-100 line has a speed of 60 characters per second. Tape used can be the standard 1-inch, 7- or 8-channel tape, or 11/16-inch, 5-channel tape, with 10 characters per inch. Each self-loading 8-inch reel holds 1,000 feet of tape, which can be Mylar. Checking is performed at the end of the reel, with a parity check on transfer between memory and the controller, and checking for broken or torn tape. Connection can be by a standard interface on connector 3 or 4 or a multiple peripheral adapter on connector 3 for the GE-115 and connector 3 or 4 for the GE-130.

REPORT UPDATE

TWO NEW HIGH-DENSITY MAGNETIC TAPE SUBSYSTEMS INTRODUCED

GE recently announced the availability of two new nine-track, 1600 bit-per-inch magnetic tape units for use on the GE-115 and GE-130. The MTS-163 and MTS-166 Magnetic tape subsystems both comprise a controller and one tape unit. Up to seven additional tape units can be connected to each subsystem.

The MTH-163 Magnetic Tape Unit is IBM 2400 Series-compatible, operates at a tape speed of 18.75 inches per second, and has a maximum transfer rate of 30 KC. The MTH-166 Magnetic Tape Unit, which is also IBM 2400 Series compatible, is twice as fast with a tape speed of 37.5 inches per second and a maximum transfer rate of 60 KC. Both subsystems rewind at 300 inches per second and can read forward or backward in continuous or start-stop mode. Seven-track, IBM 729-compatible options are available for both subsystems with lower recording densities of 200, 556, and 800 bits per inch. These same recording densities are also available for the nine-track unit.

The subsystem prices are summarized as follows:

	Monthly Rental	Purchase Price	Monthly Maintenance
MTS-163 Magnetic Tape subsystem, includes one controller and one MTH-163 Magnetic Tape Handler, 1600 bpi	$ 800	$36,600	$83
MTH-163 Magnetic Tape Handler*	300	13,520	45
OPT-183 Controller Option; 200,556,800 bpi	200	9,910	16
OPT-193 Magnetic Tape Handler: 9-track; 200,556, 800 bpi	25	1,130	4
OPT-173 Magnetic Tape Handler; 7-track; 200,556,800 bpi	25	1,130	4
MTS-166 Magnetic Tape subsystem, includes one controller and one MTH-166 Magnetic Tape Handler 1600 bpi	1,200	53,910	122
MTH-166 Magnetic Tape Handler*	450	19,290	64
OPT-186 Controller Option; 200,556,800 bpi	200	9,910	16
OPT-196 Magnetic Tape Handler; 9-track; 200,556,800 bpi	25	1,130	4
OPT-176 Magnetic Tape Handler; 7-track; 200,556,800 bpi	25	1,130	4

*Up to seven additional handlers can be added to the basic magnetic tape subsystems.

SUMMARY REPORT: GE 115

.01 INTRODUCTION

The GE-115, announced in March 1965, represents the first joint development and marketing effort by General Electric (USA), Bull-GE (France), and Olivetti-GE (Italy). Designed by Olivetti-GE, the 115 was first marketed as a free-standing system in Europe and, with limited peripheral device support, as a remote terminal system in the United States market.

In May 1966, customers in the U.S.A. were offered the GE-115 as a full-scale computer system and the peripheral device complement was correspondingly expanded. Initial emphasis was placed upon using the GE-115 as a "first step" into data processing for punched-card tabulating installations. In early 1967, GE rounded out its U.S. marketed small-scale system with the addition of magnetic tape units, random access disc storage units, and an improved line of card readers and printers, all of which had previously been offered in Europe.

With this increased capability, the GE-115 moved into direct competition with such systems as the IBM System/360 Model 20, Burroughs B 100, Honeywell 120, RCA Spectra 70/15, and the Univac 9200/9300 systems.

Within this highly competitive group, the GE-115 offers much in the way of high-speed peripheral devices, very impressive software support, and an efficient central processor with a good instruction repertoire. Although system performance using the AUERBACH benchmark problems has yet to be measured, it is evident that the combination of the above factors make the GE-115 a real contender in the small computer sweepstakes.

A GE-115 system with a card reader, printer, and communications adapter (a typical remote terminal configuration) can be rented for as little as $1,370 per month. Typical card systems will range between $1,655 and $2,615 per month; typical tape systems will range between $3,640 and $4,600; and typical disc systems will range between $3,920 and $6,410. First system deliveries were made in early 1966, and the present delivery schedule is three to six months for most components.

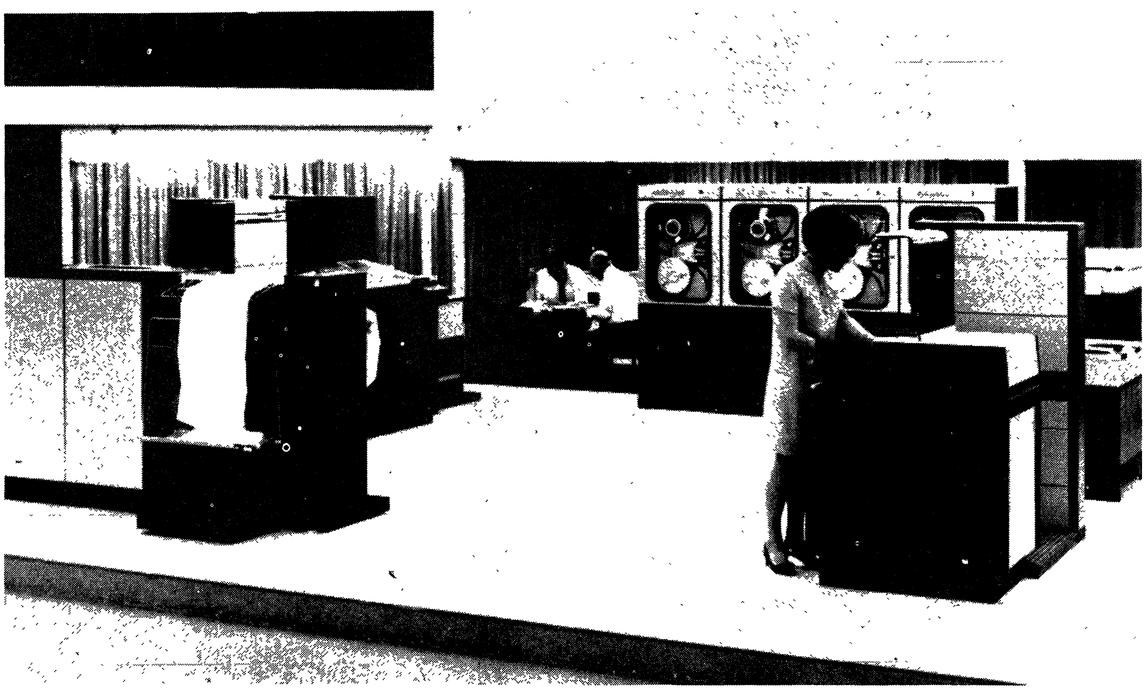

Figure 1. An expanded GE-115 configuration.

.01 INTRODUCTION (Contd.)

Significant features of the GE-115 include:

- Up to 16, 384 eight-bit character positions of 6. 5-microsecond core storage (Paragraph . 041).
- Over 59 million alphameric characters of on-line random-access storage using the DSS130 Disc Storage Unit (Paragraph . 042).
- Card readers with speeds of 300 or 600 cards per-minute (Paragraphs . 071 and . 072).
- Economical 300-card-per-minute photoelectric card reader/punch (Paragraph . 073).
- Card punching speeds of up to 300 cards per minute (Paragraphs . 074 and . 075).
- Punched paper tape reading at 500 characters per second (Paragraph . 076).
- Printing at speeds of 300, 600, or 780 lines per minute (Paragraphs . 081, . 082, and . 083).
- Magnetic tape data transfer rates of 30KC and 60KC (Paragraphs . 091 and . 092).
- Adapters that permit communication with a remote computer system (Paragraph . 101).
- Ability to perform two unbuffered I/O data transfer operations simultaneously, plus as many additional data transfers as there are buffered I/O devices connected to the processor. Available buffered I/O devices include a printer, several card punches, and a card reader/punch (Paragraph . 11).
- A wide range of software (most of it already delivered) that includes language processors, service routines, a logic generating language (more extensive than typical report program generators), input-output control systems, operating systems, utility programs, applications packages, and data communications packages. Claiming a high degree of software efficiency, GE states that an overwhelming majority of its card-oriented systems sold or leased to date are equipped with only 4K-characters of core storage. Because of this, each card system configuration in Paragraph . 03 specifies prices at both 4K- and 8K-characters of core storage. (The AUERBACH Standard System Configuration for typical card systems requires use of at least 8K characters of main memory.)

.02 DATA STRUCTURE

The basic unit of data storage is an eight-bit (plus 1 parity bit) byte, which GE prefers to call an "octet". Each octet can contain one alphameric character, two decimal digits (packed), a one-decimal-digit arithmetic operand, or an 8-bit binary operand. Decimal arithmetic is performed on unsigned 4-bit BCD digits (one digit per octet): the remaining four bits of each octet are ignored. This mode of arithmetic may sacrifice efficiency in the use of core storage, but, by avoiding repetitive packing and unpacking operations it can, in many cases, result in a savings of processor time.

GE-115 arithmetic instructions can process operands from 1 to 16 digits in length. Most others, including code translation and editing instructions, can operate on fields of up to 256 characters. GE-115 instructions are two, four, or six characters in length and specify zero, one, or two core storage addresses, respectively.

Note that there is no direct compatibility between the GE-115 and the IBM System/360 Model 20, although both systems use 8-bit character codes.

.03 SYSTEM CONFIGURATION

Every GE-115 computer system has a GE-115 Central Processor with a built-in console, and one to four core memory modules of 4, 096 characters each, availing the user of from 4, 096 characters to 16, 384 characters of 6. 5-microsecond core storage.

One printer and one card reader, each having an integrated controller, can be connected directly to a GE-115 Central Processor. Two other peripheral devices can be connected through the GE-100 Standard Interface. Alternately, one of the two I/O connectors can accommodate up to 64 peripheral devices operating in overlapped mode through Multiple Peripheral Adapters (MPA) connected to the Standard Interface.

Peripheral devices available include line printers, card readers, card punches, a paper tape reader, magnetic tape units, and a removable disc storage unit. The peripheral devices are summarized in Table I with their rated speeds.

Table I also indicates the configuration possibilities of each peripheral device, and the connector or connectors which must be used to service the device. These connectors are diagrammed in Figure 1, Configuration Selector. Table II shows the relationship between the number of peripheral units connected to the shared-channel and the corresponding requirement for Multiple Peripheral Adapter Units (MPA's).

(Contd.)

TABLE I. GE-115 PERIPHERAL DEVICES

Device	Model Number	Maximum Number in System	Uses Connector(s) No.	
Card Readers	CRZ100: 300 cpm CRZ120: 600 cpm	1	2	B
Card Punches	CPZ101: 60/200 cpm CPZ103: 300 cpm	67(6)	3, 4	C D
Card Reader/Punch	CRP100: 300 cpm	67(6)	3, 4	E
Line Printers	PRT100: 300 lpm PRT110: 600 lpm PRT120: 780 lpm	1 1 67(6)	1 1 3, 4	F G H
Magnetic Tape Units	MTC103/MTC106: Controller MTH103: 30 KC MTH106: 60 KC	4(2) 24(3) 24(3)	3 - -	I
Disc Storage Units	DSC130: Controller DSU130: (77.5KC; 2.98 million chars. per Disc Drive Unit)	4(4) 20(5)	3 -	J
Punched Paper Tape Reader	PTR100: 500 cps	67(6)	3, 4	K
Data Communication Controller	DATANET-10: 2000 or 2400 bps	4 Controllers (single buffer)	4	L

(1) Only one peripheral unit can be serviced by Connector No. 4.
(2) Up to 4 controllers can be connected, using MPA115 Multiple Peripheral Adapter units.
(3) Up to 6 Tape Handlers can be serviced by one controller.
(4) System is limited to 4 Disc Controllers using MPA channel.
(5) Each Disc Controller can handle 5 Disc Drive Units.
(6) Theoretically limited to 67; practical system configuration considerations will reduce this number considerably.

TABLE II: MULTIPLE PERIPHERAL ADAPTER (MPA) REQUIREMENTS

NUMBER OF MPA'S AS A FUNCTION OF NUMBER OF PERIPHERAL SUBSYSTEMS CONNECTED TO CONNECTOR NO. 3					
NO. OF PERIPHERAL SUBSYSTEMS	NO. OF MPA'S	NO. OF PERIPHERAL SUBSYSTEMS	NO. OF MPA'S	NO. OF PERIPHERAL SUBSYSTEMS	NO. OF MPA'S
0 — 1	—	23 — 25	8	44 — 46	15
2 — 4	1	26 — 28	9	47 — 49	16
5 — 7	2	29 — 31	10	50 — 52	17
8 — 10	3	32 — 34	11	53 — 55	18
11 — 13	4	35 — 37	12	56 — 58	19
14 — 16	5	38 — 40	13	59 — 61	20
17 — 19	6	41 — 43	14	62 — 64	21
20 — 22	7				

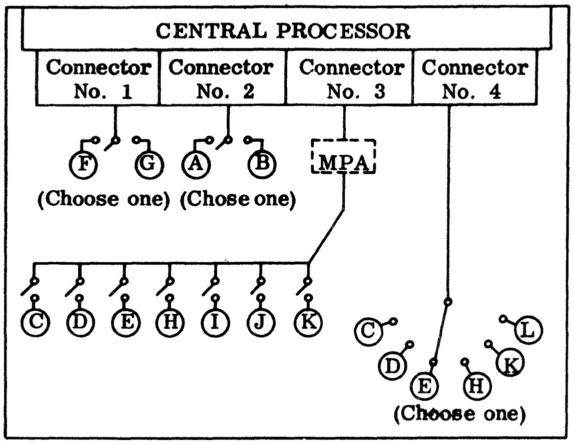

Figure 2: Configuration Selector

.03 SYSTEM CONFIGURATION (Contd.)

A typical configuration that could be used to replace a unit record accounting machine is presented in Paragraph .031 — AUERBACH Standard Configuration I. Paragraph .032 illustrates a GE-115 configuration suitable for use as a remote terminal for a GE-400 or GE-600 Series computer system. Paragraphs .033 through .036 show GE-115 systems arranged according to AUERBACH Standard Configurations II, III, IIIR, and IVR.

.031 Typical Card System: Standard Configuration I

Equipment	Rental
1 — GE-115 Model I Central Processor, with 8,192 characters of core storage	$750
1 — PRT120 Printer; 780 lpm	945
1 — CRZ120 Card Reader; 600 cpm	315
1 — CPZ103 Card Punch; 300 cpm	605
Total Rental:	$2,615

Note: the price for a GE-115 card system that is similar to Configuration I but which uses a lower-speed CRZ100 Card Reader (300 cpm), PRT100 printer (300 lpm), and CPZ101 Card Punch (65-200 cpm), rents for $1,655 per month. Use of the smallest available core storage unit of 4,096 characters reduces the system rental still further to $1,475 per month.

.032 Typical Remote Terminal System

Equipment	Rental
1 — GE-115 Central Processor with 4,096 characters of core storage	$570
1 — PRT100 Printer; 300 lpm	450
1 — CRZ100 Card Reader; 300 cpm	140
1 — Datanet-10 Communications Terminal*	210
Total Rental:	$1,370

*Does not include cost of the necessary digital subset.

Note: A DSU130 Removable Disc Storage Unit can be added to provide 2,980,000 characters of on-line random-access storage. Total rental of the above system with one DSU130 unit (one disc handler and controller) would be $1,985.

.033 4-Tape Business System: Configuration II

Equipment	Rental
1 — GE-115 Central Processor, with 8,192 characters of core storage	$750
1 — PRT110 Printer; 600 lpm	650
1 — CRZ120 Card Reader; 600 cpm	315
1 — CPZ101 Card Punch; 60-200 cpm	315
1 — MCT103 Magnetic Tape Controller	475
1 — MTH103 Magnetic Tape Handlers; 30KC	1,360
Total Rental:	$3,865

(Contd.)

.034 6-Tape Business System: Configuration III

Same as Configuration II, except that 2 more MTH103 Magnetic Tape Handlers are added.

Total Rental:	$4,545

.035 5-Million Byte Random Access System: Configuration IIIR

Equipment	Rental
1 — GE-115 Central Processor, with 16,384-characters of core storage	$1,425
1 — PRT110 Printer; 600 lpm	650
1 — CRZ120 Card Reader; 600 cpm	315
1 — CPZ101 Card Punch; 60-200 cpm	315
1 — DSC130 Disc Controller	315
3 — DSU130 Disc Drive Units	900
Total Rental:	$3,920

.036 20-Million Byte Random Access System: Configuration IVR

Equipment	Rental
1 — GE-115 Central Processor, with 16,384 characters of core storage	$1,425
1 — PRT110 Printer; 600 lpm	650
1 — CRZ120 Card Reader; 600 cpm	315
1 — CPZ101 Card Punch; 60-200 cpm	315
2 — DSC130 Disc Controller	630
10 — DSU130 Disc Drive Units	3,000
1 — MTC106 Magnetic Tape Controller	475
4 — MTH106 Magnetic Tape Handlers; 60 kc	1,980
1 — MPA115 Multiple Peripheral Adapter	75
Total Rental:	$8,865

Note: A minimum system similar to Configuration IVR above, but with 8,192 characters of core storage and no tape units, rents for $5,635 per month. According to GE, this minimum configuration would be adequate to accommodate their low-level disc-resident software.

.04 INTERNAL STORAGE

.041 Core Storage

Magnetic core storage for the GE-115 Processor is available in storage capacities of 4,096, 8,192, 12,288, and 16,384 alphameric characters. Core Storage cycle time is 6.5 microseconds per character. Each character position is individually addressable and consists of eight data bits and one parity bit. The maximum effective internal transfer rate is 46,090 characters (or 92,180 packed decimal digits) per second, and the peak data transfer rate is 154,000 characters per second.

.042 DSS130 Disc Storage Subsystem

The DSS130 Disc Storage Subsystem recently added to the GE-115 product line consists of from one to four DCS130 Disc Controllers, and from one to five DSU130 Disc Drive Units per controller for a total system capacity of 20 Disc Drive Units.

The DSU130 Disc Drive Unit currently being marketed for use with the GE-115 system is the Control Data 852 Disc Storage Drive. This random access device provides a minimum on-line data capacity of 2 million alphameric characters, and access times which vary from 30 to 145 milliseconds. The unit uses the same data recording mode as the IBM 1311 Disc Storage Drive, and their respective Disc Packs are functionally interchangeable.

The DSU130 Disc Drive Unit holds a single removable Disc Pack that contains 6 discs. Ten of the 12 available disc surfaces are used for recording data. There are 100 data tracks on each disc surface, yielding a total storage capacity of 2.0 or 2.98 million alphameric characters in the Sector and Track modes, respectively.

Each DSU130 Disc Drive Unit is serviced by a single comb-like access mechanism that moves horizontally between the disc surfaces. Each of the ten access arms that make up the access mechanism contains a single dual-gap read-write head to service all 100 tracks of one disc surface. The ten data tracks that can be accessed when the ten-armed access mechanism is in any given position are referred to as a "cylinder." The total number of characters that can be stored per cylinder and accessed by electronic switching (without access arm positioning) is from 20,000 to 29,800 alphameric characters.

.042 DSS 130 Disc Storage Subsystem (Contd.)

When access arm positioning is required to read or record on a selected track, the access time ranges from 30 to 145 milliseconds. The rotational delay, or the time required for the addressed record to pass under the read-write head once the proper track has been selected, varies from 0 to 40 milliseconds. The total update cycle time to read a randomly-addressed 100-character record, update it, and perform a write-check operation, is 159 milliseconds.

The DSU130 Disc Drive unit can store up to 2 million 6-bit (plus parity) characters when recording is performed in the Sector Mode. In this mode, each track is divided into 20 sectors, and each sector holds a 5-character address and up to 100 six-bit alphameric characters of data. When data is recorded in the Full-Track Mode (i.e., with each record occupying a full data track), each track can hold 2,980 six-bit characters, for a total drive capacity of 2.98 million characters. The DSU130 Disk Drive Unit records data in the NRZI (Non-Return to Zero) data recording mode. A parity bit is generated and recorded with each character of data.

The DSU130 can also operate with an 8-bit character format. In this case, each sector holds a five-character address and up to 75 8-bit alphameric characters, or 150 4-bit numeric digits. This feature is of particular value when handling numeric data, since it increases the disc storage capacity by 50 percent. A summary of the characteristics of the DSU130 Disc Drive is provided in Table III below.

The DSC130 Disc Controller can serve up to five DSU130 Disc Drive Units. A maximum GE-115 mass storage configuration can include four Disc Controllers and a total of 20 Disc Drive Units. Thus, in the Track and Sector modes, respectively, an on-line storage capacity of 40.0 and 59.6 million alphameric characters is provided.

.05 CENTRAL PROCESSOR

The GE-115 Central Processor is basically a character-oriented, variable-word-length, two-address, sequential processor. All addressing is in the binary mode and is direct; i.e., no indexing or other automatic address modification facilities are provided.

The basic instruction format is:

Part:	F	C	IA	IB
Size in bits:	8	8	16	16

Reduced formats of two or four 8-bit characters are used for some instructions which require no reference, or only one reference, to memory. The operation code is represented by F; the high-order two bits of this word specify the format of the instruction. The C character can represent an operand length for logical instructions (up to 256 characters), the length of two operands for arithmetic instructions (up to 16 digits each), an 8-bit literal, an I/O device specification, or the complement of the

TABLE III. CHARACTERISTICS OF GE DSU130 DISC DRIVE UNITS

MODEL NUMBER	DSU130
Storage Capacity per Pack (millions of characters)	2.0 (Sector Mode) 2.98 (Track Mode)
Discs per Pack	6
Recording Surfaces per Pack	10
Tracks per Disc Surface	100
Sectors per Track	20
Characters per Sector	100
Characters Stored per Track*	2,000 (Sector Mode) 2,980 (Track Mode)
Disc Rotation Speed (rpm)	1,500
Rotational Delay (msec)	0 to 40
Access Time with Direct Seek (msec)	30 to 145
Data Rate (char/sec)	77,730

* In 6-bit character format.

(Contd.)

.05 CENTRAL PROCESSOR (Contd.)

operation code, depending upon the particular instruction. The 16-bit fields IA and IB, when present, represent the addresses of the operands.

A total of 39 instructions provide facilities for decimal addition and subtraction, binary addition and subtraction, decimal and binary comparison, editing, branching based upon the status of indicators set by compare operations, and the Boolean operations Inclusive OR, AND, and Exclusive OR. Literal operands can be used only in a one-character store and a one-character compare operation.

Several interesting and potentially valuable instructions are included in the GE-115 repertoire. Among these are the Transcode instruction for translating between any two 8-bit codes; the Pack and Unpack instructions for converting decimal data between the two-digits-per-location packed format and the one-digit-per-location format required for arithmetic instructions; and search instructions for locating a specified character within a field. Note that all decimal arithmetic instructions operate on unsigned fields. A subroutine is required to obtain the conventional algebraic type of arithmetic operations. The only interrupt facility is the capability for recognizing a request from a DATANET-10 terminal.

Probable execution times for decimal arithmetic are as follows, where B represents the operand length in 8-bit characters and D represents the operand length in decimal digits. Note that these times are for unsigned fields; additional time must be allowed if signed, algebraic-type operations are desired.

	Time, Microseconds
For random addresses —	
$c = a + b$:	78.0 + 27.6D.
$b = a + b$:	39.0 + 14.6D.
Sum N Items:	(39.0 + 14.6D) N.
$c = ab$:	*
$c = a/b$:	*
For arrays of data —	
$c_i = a_i + b_j$:	302 + 32D.
$b_j = a_i + b_j$:	190 + 16D.
Sum N items:	(176 + 16D) N.
$c = c + a_i b_j$:	(328 + 32D) N.
Moving data:	39 + 13B.

*Subroutines are required for multiplication and division; typical subroutine times supplied by GE are as follows:

5 digit x 5 digit multiply — 4,380 microseconds.
10 digit ÷ 5 digit division — 12,500 microseconds.

.051 Compatibility

There is no direct program compatibility between the GE-115 and any of GE's other computer systems (the 200 Series, 400 Series and the 600 Series). Neither is there any direct compatibility with the IBM System/360. However, through use of the Transcode instruction, data files on punched cards and paper tape from almost any other system can be utilized. At the source language level, GE states that GE-115 COBOL will be a compatible subset of the COBOL-61 language implemented in the GE 400 Series, with many additional features specified by DOD COBOL 65.

.06 CONSOLE

A control panel built into the central processor cabinet provides the switches, keys, and lights required for manual control of the system. No provision for keyboard input or console typewriter output has been announced to date.

.07 PUNCHED CARD AND PAPER TAPE INPUT-OUTPUT

.071 CRZ100 Card Reader

Developed by GE (USA), the CRZ100 is a low-cost device that can read standard 80-column cards punched in either Hollerith code or Column Binary code (core image, two decimal digits per column); intermixed reading of the two codes is also allowed. Card reading, which takes place column-by-column in a serial fashion, occurs at a 300-cpm rate, as the cards are fed past a bank of twelve photoelectric cells.

The single input hopper and single output stacker each hold 500 cards, and can be loaded and unloaded during normal machine operation.

The reader can operate simultaneously with other peripheral devices when in the batch mode, or with data transmission when in the remote terminal mode. Demand imposed upon the processor by the CRZ100 at peak reading speed is 55 percent.

Error indications include malfunctioning of the photocells, column misread, input hopper empty, output stacker full, end-of-file mark sensed, and card jam

.072 CRZ120 Card Reader

This unit, developed by Olivetti-GE, reads standard 80-column (or, optionally, 51-column) punched cards at a peak speed of 600 cards per minute. The effective speed will normally be very close to the peak speed because the unit has an infinite clutch, so a complete cycle is not lost when the processing time exceeds the time available between cards.

A 2000-card input hopper and primary output stacker are provided, along with an auxiliary output stacker having a 500-card capacity. All can be loaded and unloaded during normal machine operation. Selection of either the primary or the auxiliary stackers is under program control. Column-binary or Hollerith code can be read, and may be intermixed within a single run. Error conditions sensed are identical to those in the CRZ100 Card Reader.

The card reader can operate concurrently with any other peripheral device connected to the other data channel. However, the only time available for internal processing is the time between card cycles. This time varies with the number of characters read from the card and is a minimum of 27 milliseconds per card when all 80 columns are being read at the peak 600-cpm speed.

.073 CRP100 Card Reader/Punch

With all reading and punching operations done in a row-by-row manner, the fully-buffered CRP100 performs card reading, punching, or intermixed reading and punching operations at the constant rate of 300 cards per minute upon standard Hollerith or column-binary coded 80-column cards.

Cards to be read and/or punched are loaded into a 300-card input hopper. Up to 800 blank cards are loaded into a secondary input hopper for punching. Three output stackers are provided — a 3000-card normal stacker, an 800-card select stacker, and a 600-card reject stacker. Routing of cards to either the normal or reject stackers is program-controlled. All hoppers and/or stackers are accessible for loading or unloading purposes during normal machine operations.

Checking features include read after punching (echo check), read brushes functioning, input hopper(s) empty, card jam, memory-to-buffer and buffer-to-memory parity errors, output stackers full, end-of-file, and off-line malfunction.

A fully-buffered controller permits complete overlapping of the reader/punch's operations with central processing and with other I/O operations.

.074 CPZ101 Card Punch

This unit, developed by Bull-GE, punches standard 80-column cards serially by column at 100 columns per second. The peak punching speed varies from 60 cards per minute when punching 80 columns per card to a maximum of 200 cards per minute when punching a restricted number of card columns. The CPZ101 is equipped with one 1500-card hopper and one 1500-card stacker. Cards can be loaded or removed at any time while the punch is operating. Cards can be punched in either Hollerith or card-image code format. A fully-buffered controller overlaps the card punch operations with internal computing and with other I/O operations.

Checks are made to ensure correct card feed and synchronization, proper parity, and accurate punching (echo check). Also sensed are card jam, stacker full, chad box full, and hopper empty conditions.

.075 CPZ103 Card Punch

This is a 300-cpm constant speed device that punches 80-column cards row-by-row in either Hollerith or 12-column binary format. The 1200-card hopper and stacker are supplemented by an auxiliary program-selectable 100-card output stacker. Cards can be loaded or removed at any time while the punch is in operation. A fully buffered controller provides overlap of the punching operations with computing and with other I/O operations.

Detectable error conditions include card feed, card synchronization, parity, card jam, stacker full, chad box full, and hopper empty. An echo check is used to insure accurate punching.

.076 PTR100 Paper Tape Reader

This unit, developed by Olivetti-GE, is capable of reading up to 500 characters-per-second. If the unit must stop after each character and await a command to proceed to the next character (asynchronous), the reading rate falls to a maximum of 200 characters-per-second.

Rewinding proceeds at 775 characters-per-second under console control, or 500 characters-per-second under program control. Thus, the 8-inch, 1000-foot reel can be reviewed in either 2.7 minutes (console control) or 4.0 minutes (program control). Reels are self-loading for convenience.

(Contd.)

.076 PTR100 Paper Tape Reader (Contd.)

Standard 1-inch, 7- or 8-channel tape, or Telex 11/16-inch, 5-channel tape can be read undirectionally or bi-directionally (with an optional feature).

Parity checking, using the parity check channel, and end-of-reel-checks are performed.

.08 PRINTERS

.081 PRT110 Line Printer

The PRT110 Printer is an asynchronous line printer developed by Olivetti-GE. Skipping is initiated immediately following the last printed character of a line. Some of the more important characteristics of this printer are:

- 104, 120, or 136 printing positions.
- 10 characters-per-inch horizontal spacing.
- 6 lines-per-inch vertical spacing.
- 64 printable characters (GE standard character set).
- 17.0 inches-per-second continuous skipping speed.

The PRT110 will accept continuous forms from 3 to 22 inches in width. An optional feature permits forms skipping at 63 inches per second.

The maximum printing rate utilizing the full 64-character set is 600 single-spaced lines per minute.

.082 PRT100 Line Printer

The PRT100 Printer is a slowed-down version of the PRT110 Printer described in the previous paragraph. The maximum printing rate of the PRT100 is 300 single-spaced lines per minute when using the full 64-character set. Other characteristics of the PRT100 Printer are similar to those of the PRT110, except that the high-speed skip option is not available for the PRT100.

.083 PRT120 Buffered Printer

The newly-announced PRT120 Printer is a fully-buffered device capable of printing up to 780 lines per minute using a maximum of 48 of the 64 available print characters. The peak speed drops to 620 lines per minute when the full character set is used. Multiple-line paper advances can take place at 63 inches per second using a fast-skip optional feature. The PRT120 Printer with 120 print positions rents for $945 per month; addition of the 136-print position feature adds $105 to the basic monthly rental.

The PRT120 will accept continuous forms from 3.5 to 22 inches in width. Up to five carbon copies can be made, and ledger and card stock can also be handled.

.09 MAGNETIC TAPE

.091 MTH103 and MTH106 Magnetic Tape Handlers

Two tape units are available for use with GE-115 systems. The two units are designated the MTH103 and MTH106 Magnetic Tape Handlers. Both are nine-track units (with seven-track options), fully compatible with the IBM 2400 Series Magnetic Tape Units used with the IBM System/360. The MTH103 unit operates at 37.5 inches per second, records at either 200, 556 or 800 rows per inch, and has a peak data transfer rate of 30,000 bytes per second. The basically similar MTH106 unit operates at 75 inches per second, developing a peak data transfer rate of 60,000 bytes per second. Both units can read in the forward and backward directions. Table IV summarizes the important characteristics of each tape unit.

TABLE IV. CHARACTERISTICS OF THE MTH103 AND MTH106 MAGNETIC TAPE HANDLERS

Model	No. of Tracks	Tape Speed, inches per sec	Tape Density, rows per sec	Transfer Rate, chars per sec	Inter-Record Gap		Compatibility	Rewind Time, inches per sec
					Inches	msec		
MTH103	7 (option)	37.5	200 556 800	7,500 21,000 30,000	0.75	20	GE-400 IBM 729 IBM 7330	75
	9	37.5	800	30,000	0.60	16	IBM 2400	75
MTH106	7 (option)	75	200 556 800	15,000 42,000 60,000	0.75	10	GE-400 IBM 729 IBM 7330	150
	9	75	800	60,000	0.60	8	IBM 2400	150

.091 MTH103 and MTH106 Magnetic Tape Handlers (Contd.)

Up to six tape units can be connected to an MTC103 or MTC106 Magnetic Tape Controller, and up to four Controllers can be connected to a GE-115 central processor, providing a maximum of 24 magnetic tape units per system.

.10 OTHER INPUT-OUTPUT EQUIPMENT

.101 SLC100 DATANET-10 Communications Controller

This device enables a GE-115 system to be connected to a remote DATANET 30, GE-400 Series, GE-600 Series, another GE-115, or any other manufacturer's computer equipment that uses USASCII data codes via a second DATANET (any model) at the remote site and a dial-up or private-line communication circuit.

The DATANET-10 allows the GE-115 to be connected to the Bell System DSS 201A on a 2, 000-baud circuit. Use of a Bell System DSS 201B data set allows communications via 2, 400-baud private-line circuits.

Typical transmission rates between a GE-400 or GE-600 Series computer system and the GE-115 are shown in Table V. These rates are based on record lengths of 80 characters per card or 120 characters per print line. Reduced record lengths can increase the transmission rates up to the peak rates of the individual peripheral devices.

TABLE V. TYPICAL GE-115 REMOTE TERMINAL PERFORMANCE

Peripheral Device	Rate
Card Reader (any model)	125 cards/min
CPZ101 Card Punch	85 cards/min
Printer (any model)	95 lines/min

The SLC100 receives and transmits 7-bit characters (plus odd parity bit) in a serial synchronous mode. Parity is checked as each character is received or transmitted, and a longitudinal parity check is performed upon each message block. Standby status and automatic disconnect features are provided which can be initiated if data is not received in the SLC100 buffer within a specified time interval. Synchronization of data transmission timing with processor timing is controlled by a buffer within the controller.

.11 SIMULTANEOUS OPERATIONS

The GE-115 Central Processor has two data channels and four outlets for connecting peripheral devices (see Figure 1 earlier in the report). Under program control, the data channels can be switched to service different outlets. Data Channel 1 can service outlets 1 and 2, Data Channel 2 can service outlets 2, 3, and 4. Only a printer can be connected to outlet 1; only a card reader can be connected to outlet 2. One peripheral device with controller can be connected to outlet 3 and one to outlet 4 through the GE-100 Standard Interface. Alternatively, a communications device can be connected directly to outlet 4, and a total of up to 64 peripheral devices with controllers can be attached to outlet 3 via Multiple Peripheral Adapters.

Data transfers on both channels can take place concurrently through time-sharing of the core storage accesses required by each peripheral device. The processor, however, is locked out during every peripheral operation from the initiation of the data transfer until all data for that operation has been transferred. Thus, the time between card columns is not available for internal processing, but the time between successive cards and successive print lines is available. In general, the processor delay is dependent upon the number of characters transferred in a peripheral operation (see Table II).

The MPA115 Multiple Peripheral Adapter (or "Channel Expander") enables four peripheral controllers to be connected to one outlet. Each outlet of the Adapter can be similarly expanded, and up to 21 levels of Adapters can be cascaded in this manner. Thus, up to 64 peripheral controllers can be connected to outlet 3. Each controller is addressed individually. Two peripheral devices connected to the same outlet via Adapters cannot transfer data simultaneously.

Table VI summarizes the delays imposed upon central processor operations by most of the GE-115 input-output devices.

.15 SOFTWARE

The GE-115 system's software consists of language processors, program generators, input-output control systems, operating systems, utility programs, application packages, and data communications software support. There are three levels of support: basic card support, tape system software, and disc-oriented software. Table VII summarizes the major software packages offered and indicates the amount of core storage required to use each system.

(Contd.)

TABLE VI. PROCESSOR DELAYS DURING I/O OPERATIONS*

Function	Device	Peak Speed	Cycle Time, msec	Maximum Processor Delay, msec
Card Reading	CRZ100 CRZ120 CRP100	300 cpm 600 cpm 300 cpm	200 100 200	108 80 3.6
Card Punching	CPZ101 CPZ103 CRP100	100 col/sec 300 cpm 300 cpm	300(min.) † 200 200	2.4 2.4 2.4
Printing	PRT100 PRT110 PRT120	300 lpm 600 lpm 780 lpm	200 100 77	160 80 1
Paper Tape Reading	PTR100	500 cps	†	?

† Varies with number of characters read, punched, or written.

* Processor delays during magnetic tape and disc storage operations have not been specified by GE to date.

TABLE VII. CORE STORAGE REQUIREMENTS FOR GE-115 SOFTWARE

Core Storage Size	MAJOR SOFTWARE PACKAGES																					
	Cards					Tapes									Discs						Cobol	
	BAPS	LOGFL	BIOS	CPM	Mathematical Routines	EAPS	LOGFL	TOS	EIOS	Sort/Merge	CPM	Mathematical Routines	Matrix Inversion	Media Conversion	APS	LOGEL	DOS	EIOS	Sort/Merge	Linear Programming	Tape	Disc
4K	░	░	░	░	░																	
8K	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░		
12K	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░
16K	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░

.151 Card-Oriented Software

The GE-115 boasts an impressive array of card system software elements. With the exception of the matrix inversion routine, all operate in a minimum 4K character core storage environment. Included in the card-level support are utility routines, such as LIST AND SUMMARIZE, REPRODUCE AND GANG PUNCH, MEMORY DUMP, etc.; a basic assembler (BAPS); powerful file-management program generators (LOGEL 1 and LOGEL 2); an input-output control system (BIOS); a card management system; application packages such as CPM; and data communications programs (GERTS/115, 115/115, DATANET 30/115, etc.). Brief descriptions of each component follow.

List and Summarize Program Generator — a very basic language processor designed to create reports from a file of punched cards. It also offers the option of punching the specific report-generating program, prepared during any run, for future use as an independent program. List and Summarize is controlled by using up to five types of "parameter cards," which direct the operations and also define the file format. The program, which can be executed in a single pass, reads and prints up to nine fields; summarizes up to six of these fields on up to three levels; maintains page overflow control; provides page numbering; prints variable numbers on report headings, page headings, control headings, and detail and control totals; algebraically accumulates

.151 Card-Oriented Software (Contd.)

input field values conditionally or unconditionally to one or more summary fields; provides page subtotals on any or all summary fields; carries page subtotals to the following page; punches summary cards; prepares a user-specified number of reports from a single input file; and lists and punches the object program.

Machine requirements at the minimum level include: 4K characters of core storage, one card reader and one printer. A card punch is required if object program or summary and punching is desired.

Reproduce and Gang Punch — a set of specification statements and a program developed for card-oriented systems. This package analyzes the specifications coded by the user and processes an input card file in order to: reproduce a deck of punched cards; provide a transfer or suppression of selected fields; reproduce detail cards with gang punching of fields contained in master cards; calculate a product or percentage from a field in each detail card and a field in a master card, and punch the result; gangpunch a serial number or a constant into some or all cards; and produce from one to nine copies of each card punched.

Required hardware includes: at least 4K characters of core memory, one card reader, one card punch, and one printer.

APS Basic Card Assembler — APS, which stands for Assembly Programming System, is a basic card-oriented language processor (sometimes referred to as BAPS) which is capable of translating source programs written in assembly language into object programs. An Assembly language equivalent is provided for all GE-115 program instructions. In addition, supplementary mnemonics are included to extend the range of conditional jump instructions, and pseudo mnemonics are provided to control core storage allocation and program listing formats.

Symbolic names can be used to represent all core storage addresses and data constants. Constants can be coded in decimal, alphameric, or hexadecimal form. BAPS accepts all Basic Input/Output subroutines (BIOS), and provides programming error diagnostics, source and object program listings, and a listing of all symbolic names used in the program.

Basic APS requires the use of at least 4K characters of core storage, one card reader, one card punch, and one printer.

LOGEL 1 and LOGEL 2 — logic-generating language processors that provide the user with a simple file-management card system that is adaptable to many data processing applications, including (but not limited to) report generation. In general, LOGEL is a medium-level language and compiler that provides the flexibility and power of an assembly with the convenience and sophistication of a higher-level language processor, like COBOL.

LOGEL 1 provides a basic program-generating capability for use with a card system. LOGEL 2 is very similar but has added features which permit faster and easier programming.

LOGEL is divided into five divisions; GENERAL, which defines the input and output files; INPUT, which defines the input records; DATA, which specifies the data fields, constants, and core storage areas; CALCULATION, which contains the instructions to perform the required operations; and FORMAT, which specifies the format for the print lines and the output records.

As an example of the convenience and ease of programming using LOGEL, consider the following multiplication of A x B = C, where A and B are signed numbers of 5 and 3 digits, respectively.

APS Assembler	LOGEL
MVQ 251 (16), A	MULN ABC
MVC 251 (1), A + 4	
MVQ 219 (16), B	
MVC 219 (1), B + 2	
SUB YMULS	
MVQ C, 234 (8)	
MVC C, 7 (1), 234	

LOGEL also permits the inclusion of assembler instructions intermixed with LOGEL statements, enabling the programmer to take advantage of the basic features of the assembler program. Another feature of LOGEL is that it can reduce the need for flowcharting the problem program.

The information on the five LOGEL coding forms is punched into source cards and translated by the LOGEL compiler into an intermediate level program in basic APS language. This deck is then translated by the basic APS assembler into an executable machine language object program.

(Contd.)

.151 Card-Oriented Software (Contd.)

The LOGEL program generates sets of routines and establishes the logical linking of these routines in accordance with the data and instructions contained in the source program. Each programming job that is to be produced by LOGEL is structured within the five LOGEL divisions, regardless of the type of application.

The logical structure of LOGEL 1 and LOGEL 2 is the same. The main differences are that LOGEL 1 can accept one input file and produce two output files, while LOGEL 2 can accept two input files and produce three output files. LOGEL 1 contains 28 instructions and LOGEL 2 has 58 instructions. LOGEL 2 provides arithmetic conversion and operations with constants, whereas LOGEL 1 does not. Programs written in LOGEL 1 can be compiled by a LOGEL 2 compiler, with only minor changes required prior to compilation.

The minimum system configurations required to compile a LOGEL 1 or LOGEL 2 program are shown in Table VIII below. Note that these are minimum compilation requirements and are not intended to indicate restrictions on system size or unit types which may be required for actual object program execution.

Basic Input/Output Subroutines (BIOS) — a set of subroutines developed to control basic input/output operations using card readers, printers, card punches, card reader/punches, and paper tape readers. All subroutines are supplied on cards. They are utilized by including appropriate calling sequences in the source program. The cards containing the called subroutines are placed at the end of the source program deck. When the source program is assembled, the subroutines are integrated into the object program by the Basic APS processor.

Card Management System (CM) — a set of utility routines and subroutines that perform functions usually associated with operating systems, such as card program loading, memory to printer dump, memory to card dump, program listing, card reproduction, and program patch tracing.

Critical Path Method Program (CPM) — a powerful management technique for the planning, scheduling, and controlling of business, industrial, and scientific projects, based on a model showing the critical path network of all events contained in the project. The CPM applications package consists of a set of specification statements and a CPM program. The program analyzes the specifications coded by the user and produces reports designed to simplify project evaluation and review. Up to 350 nodes (events) can be handled in a minimum 4K character core storage configuration. Use of 8K character core memory allows up to 1,350 nodes to be processed. One card reader, one card punch, and one printer are also required for use of the CPM program.

Matrix Inversion Program (MIP) — allows the user to invert a square matrix of Nth order, in which each operand is expressed in floating-point format, using the Gauss-Jordan method. Systems with at least 8,192 positions of core storage are required to use MIP.

Data Communications Program (GERTS) — a package that allows a GE-115 serving as a remote terminal to transmit user programs and data to the central computer for processing, and to print or punch results received from the central computer's processing runs.

A GE-115 to GE-115 communication package is also available that allows one GE-115 serving as a remote terminal to read and transmit punched card data to a second GE-115 processor, and to print or punch data received from the other GE-115 processor. A Datanet-10 Communication Controller, a card reader, and printer are required to use this system.

TABLE VIII: MINIMUM LOGEL MACHINE CONFIGURATIONS

Equipment	LOGEL 1	LOGEL 2
GE-115 Core Storage (chars)	4K	8K
Card Reader	CRZ100 or CRZ120	CRZ100 or CRZ120 or CRP100
Card Punch	CPZ101 or CPZ103	CPZ101 or CPZ103 or CRP100
Printer	PRT100 or PRT110	PRT100 or PRT110

.152 Tape/Disc-Oriented Software

Magnetic tape and disc oriented software support for the GE-115 includes a small Tape Operating System (TOS), a Disc Operating System (DOS), a COBOL compiler, an extended Automatic Programming System (APS) assembler, a Tape Sort/Merge Program, magnetic tape IOCS routines, an improved version of the card-oriented LOGEL (Logic Generating Language) compiler, and programs for performing CPM, matrix inversion, and linear programming operations.

All magnetic tape-oriented software except the COBOL compiler can function with a minimum hardware configuration that includes a GE-115 processor with 8K characters of core storage, three magnetic tape handlers, and one card reader and printer. Use of the COBOL compiler requires a minimum system of 12K characters of core storage, four magnetic tape units (or two disc storage units), and one card reader and printer. All software can utilize the full 16K characters of core storage available in the largest GE-115 processor.

Tape Operating System (TOS) — scheduled for delivery in December 1967, TOS will permit stacked-job processing using system control cards. No form of TOS multiprogramming has been announced to date. TOS can load user programs, perform the processing operations, terminate the jobs, and call in the next job.

In addition, TOS will provide memory and tape dumps, generate data samples, prepare system tapes, perform tape prints, update system library tapes, and generate debugging routines.

Disc Operating System (DOS) — also scheduled for delivery in December 1967, the Disc Operating System for the GE-115 is functionally identical to TOS. DOS requires the use of one disc subsystem with two disc drive units in place of the three tape handlers required by TOS.

COBOL Compiler — functioning under control of TOS or DOS, the GE-115 COBOL compiler language is a subset of COBOL 65, and includes arithmetic, logical, and decision functions, input-output statements, editing capabilities, report writer statements, program segmentation provisions, the ability to include APS routines within the COBOL source program, and a provision for requesting object program listings. Scheduled availability of the GE-115 TOS COBOL compiler is March 1968. DOS COBOL is scheduled to be released one month later.

Extended APS — an expanded version of Basic APS, and designed to run under supervision of the Tape Operating System (TOS). The additional features provided by Extended APS include: a complete set of signed and unsigned arithmetic macro-instructions, a larger set of input-output macros, and the ability to subdivide programs into segments and to overlay these segments.

The arithmetic and the input-output macro-instructions allow faster and more efficient coding than does Basic APS. The ability to segment a program and to overlay segments permits the programmer to use considerably less storage than he normally would require. Source programs written in Basic APS can be assembled using the Extended APS language processor.

LOGEL 3 — due for completion in February 1968, LOGEL 3 is an extension of LOGEL 1 and 2 previously described for the card-oriented systems. It is run under supervision of either the Tape Operating System or the Disc Operating System and permits the user to write file management programs that utilize up to three input files and three output files, four consultation tables, and one printed report.

Tape and Disc Sort/Merge Generator — analyzes specification statements completed by the user in order to generate a program capable of sorting and/or merging the user's data files. Input data files can be read from either punched cards, magnetic tape, or discs (under DOS). The sorted and merged output files produced by the program are on magnetic tape (TOS) or discs (DOS). The sort method used is the polyphase technique, and exits are provided within the program that allow the user to branch to routines he has written during execution of the program. All tape sort/merge operations are performed in ascending order, using from three to eight tape units.

The time required to sort 10,000 100-character records, using 8,192 characters of core storage and three 30KC tape handlers, is 37 minutes. Substituting 60KC tape units lowers the processing time to 27 minutes.

Extended Input-Output Subroutines (EIOS) — a set of macro-instructions developed for use with either the Tape or Disc Operating System. These macros are inserted in source programs written in the extended assembly language. Upon encountering such a macro-instruction in a source program, the extended assembly language processor generates the object code necessary to perform the following tape or disc input-output operations, such as: read a record from tape or disc (GET), write records (PUT), seek a disc record (SEEK), update a disc record (PUTX), delete a disc record (DEL), skip all records in the current block of records (RLS), write a checkpoint on tape (CHKP), write a checkpoint on disc (DCKP), open a tape or disc file (OPEN), close a disc or tape file (CLOSE), and change a tape or disc volume (NEXT).

GE-115

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
	115A04		GE-115 Central Processor (4K characters)	570	25,440	40
	115A08		GE-115 Central Processor (8K characters)	750	33,320	56
	115A12		GE-115 Central Processor (12K characters)	1,000	46,160	80
	115A16		GE-115 Central Processor (16K characters)	1,300	63,600	100
	MPA115		Multiple Peripheral Adapter	75	3,320	6
MASS STORAGE			Disc Storage			
	DSU130		Removable Disc Storage Unit (2 million characters)	300	11,910	52
	DSC130		Removable Disc Storage Controller	315	13,780	28
	DCT160		Removable Disc Cartridge for DSU130	20	560	-
	DSU160		Removable Disc Storage Unit	590	25,510	70
	DSC161		Removable Disc Storage Controller	450	19,872	36
		OPT005	115 Accelerator	50	2,200	5
INPUT-OUTPUT			Magnetic Tape			
	MTH103		Magnetic Tape Handler (9-track, 30kc)	320	12,390	82
	MTC103		Magnetic Tape Controller (7/9-track, 30kc)	450	20,070	57
	MTH106		Magnetic Tape Handler (9-track, 60kc)	480	18,200	116
	MTC106		Magnetic Tape Controller (single channel, 7/9-track)	450	20,070	57
		OPT007	7 Track Option for MTH103 or MTH106	55	2,500	3
			Punched Card			
	CRZ100		Card Reader (300 cards/min)	140	5,390	30
	CRZ111		Card Reader (400 cards/min)	230	9,180	45
		OPT024	51-Column Card Option	50	2,016	8
	CRZ120		Card Reader (600 cards/min, 2 stackers)	315	12,240	60
		OPT025	51-Column Card Option	40	1,540	8
		OPT026	Transcoder Bypass Option	20	680	6
	CPZ101		Card Punch (60-200 cards/min.)	315	11,670	72
	CPZ103		Card Punch (300 cards/min, 2 stackers)	605	22,420	138
	CRP100		Card Reader/Punch (300 cards/min.)	590	21,510	142
			Paper Tape			
	PTR100		Paper Tape Reader (500 char/sec)	120	4,520	26
			Printers			
	PRT100		Printer and Control (300 lines/min, 104 columns)	450	16,800	100
		OPT075	120 Column Option	40	1,540	8
		OPT076	136 Column Option	75	2,790	17
	PRT110		Printer and Control (600 lines/min, 104 columns)	650	24,240	145
		OPT077	120 Column Option	50	1,880	11
		OPT078	136 Column Option	95	3,510	22
		OPT079	Fast Skip Option	75	2,790	17
	PRT120		Printer and Control (780 lines/min, 120 columns)	945	35,000	216

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printers (Contd.)			
		OPT085	136 Column Option	105	3,890	24
		OPT086	Fast Skip Option	75	2,790	17
COMMUNI-CATIONS			<u>Channels</u>			
	SLC100 (CLI100)		DATANET-10 Communications Controller, Synchronous (2000 or 2400 bits/sec)	210	9,320	16
	SLC102		DATANET-12 Single Line Communications Controller (19,200, 40,800, or 50,000 bits/sec)	300	12,000	48

REPORT UPDATE

▶ GE ANNOUNCES NEW ADDITION TO GE-100 SERIES

General Electric recently announced the GE-120 system, the fourth member of the expanding GE-100 family of small-to-medium scale computers.

The GE-120 is designed with monolithic integrated circuitry (as is true of all members of the GE-100 family) and has a memory cycle time of four microseconds and core storage capacities of 12, 288, 16, 384, or 24, 576 bytes. This places the GE-120 between the smaller, slower GE-115 (with a memory cycle time of 6. 5 microseconds and a maximum memory capacity of 16, 384) and the larger, faster GE-130 (with a memory cycle time of two microseconds and a maximum storage of 32, 768 bytes). All of the GE-100 Series computers are upwards compatible in that the data structure, instruction repertoires, and supporting software are either common or a subset of the larger-scale system.

The GE-120 is available in both magnetic tape and disc configurations. A typical tape configuration rents for $2, 980 and sells for $128, 600: a disc system carries a monthly lease of $3, 310 and a purchase price of $143, 702. Estimated delivery time following the receipt of an order is six months.

The GE-120 has a repertoire of 63 instructions, eight index registers, the capability of overlapping processing with I/O operations, a program interrupt and communication capabilities. A full line of peripherals are available including card readers and punches, magnetic and paper tape handlers, line printers, disc storage units, and communication controllers and terminal devices.

A new Report Program Generator, GE-100 RPG, is now available with all members of the GE-100 Series, facilitating compatibility with competitive equipment. In addition to the RPG, the GE-120 system provides extensive software support including tape and disc operating systems, an assembly programming system, COBOL 65, FORTRAN IV, and sort-merge generators.

ADVANCE REPORT: GE-130

.1 INTRODUCTION

The GE-130, announced in May 1968, represents a significant enhancement of the earlier GE-115 (Report 310) and the establishment of a GE-100 line of compatible systems. A GE-115 system can be upgraded to a GE-130 by simply changing the central processor. The GE-130 offers a larger memory capacity, faster storage cycle time, index registers, a larger instruction repertoire, greater overlapping of input-output operations with internal processing, more efficient software, a wider range of peripheral units, and a one-level interrupt capability for data communications.

Developed by General Electric Information System of Italy (GEISI) in collaboration with General Electric (USA), the joint marketing effort for the GE-130 is directed toward upgrading GE-115 installations, as well as toward offering users of other systems a more sophisticated replacement for second-generation equipment. General Electric regards the new GE-130 system as in direct competition with the IBM System/360 Model 25/30, the Honeywell 120/125, the RCA Spectra 70/25, and the UNIVAC 9300 systems. The GE-115 will still be offered as a lower-priced system to satisfy the needs of users with smaller data processing requirements.

The primary objective in designing the GE-130 has been to maximize performance in typical business data processing applications while maintaining competitive price levels. The available operating systems currently do not support punched-card systems. Typical magnetic tape systems range between $4,685 and $9,070 in monthly rental, while typical disc systems range between $4,270 and $9,055. Paper tape readers and data communications controllers are also available for expanded processing requirements. Core storage capacities range from 16,384 to 32,768 eight-bit locations.

Two operating systems, oriented toward magnetic tape and disc systems, provide executive monitoring, input-output control, and debugging routines to control the system's operations and reduce the need for operator intervention. Language processors include an Assembly Programming System (APS), COBOL 65, and FORTRAN IV. In addition to the basic software, a number of application programs and mathematical and statistical subroutines are available. All of the software that is operational for the GE-115 can be used with suitably-equipped GE-130 systems.

The first customer deliveries of GE-130 systems are scheduled for April 1969; the first DSS161 Disc Storage Subsystem will be delivered in October 1969. The new CRZ111 Card Reader is currently available, as are all of the peripheral devices used with the GE-115 system. GE is currently promising deliveries 8 months following the receipt of an order.

.2 HARDWARE

.21 Data Structure

The basic unit of data storage in the GE-130 is an "octet" consisting of eight bits plus a parity bit. Thus, a GE octet is equivalent to an IBM byte. Each octet is addressable and can hold data represented in alphanumeric, packed numeric, unpacked numeric, or binary form. Maximum arithmetic operand lengths are 16 digits in the unpacked numeric mode, 31 digits in the packed numeric mode, and 16 octets in the binary mode.

Unpacked numeric digits contain the numeric value in four low-order bits of each octet with a constant binary configuration in the four high-order "zone" bits. In an unpacked numeric field, the binary value of the zone quartet of the right-most octet represents the sign.

In the packed numeric mode, each octet contains two 4-bit digits, leading to more efficient allocation of data in core storage and on magnetic tape and disc storage, as well as increased transfer rates and a reduction in computing time. The sign of a signed packed numeric field is located in the low-order 4 bits of the rightmost octet.

.22 System Configuration

Every GE-130 system includes a central processor with a built-in Operator Control Panel and 16,384, 24,576, or 32,768 octets of 2-microsecond core storage.

The central processor has three I/O channels and four peripheral connectors. The appropriate connections between the central processor and all peripheral subsystems are established under program control, within certain limitations, via the three channels and four connectors.

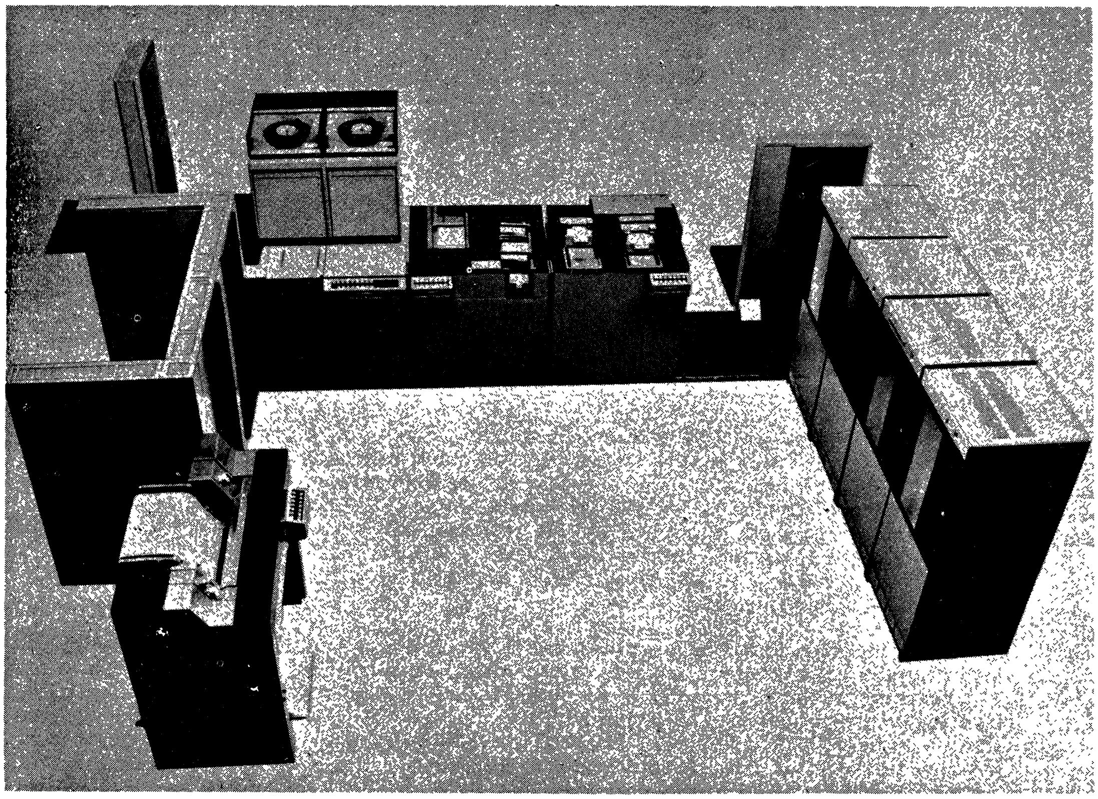

Figure 1. A typical GE-130 configuration.

.22 System Configuration (Contd.)

Integrated controllers for a 300-lpm unbuffered printer and a card reader are permanently associated with Connectors 1 and 2, respectively. Connectors 3 and 4 can be linked to either single or multiple peripheral subsystems. The maximum number of peripheral subsystems that can be used in a GE-130 system is 34.

Table I lists the peripheral subsystems available for the GE-130 and shows which of the connectors and channels each subsystem can utilize.

.221 GE-130 6-Tape Business System; Configuration III

Equipment		Rental
1 — 130A16 Processor with 16,384 octets of core storage		$2,000
1 — CRZ111 Card Reader; 400 cpm		230
1 — CPZ101 Card Punch; 60-200 cpm		315
1 — PRT110 Printer; 600 lpm		650
1 — MTC103 Magnetic Tape Controller		450
6 — MTH103 Magnetic Tape Handlers; 9-track, 60KC		1,920
1 — MPA130 Multiple Peripheral Adapter		75
	Total Rental:	$5,640

.222 GE-130 6-Tape Auxiliary Storage System; Configuration V

Equipment		Rental
1 — 130A16 Processor with 16,384 octets of core storage		$2,000
1 — CRZ111 Card Reader; 400 cpm		230
1 — CPZ101 Card Punch; 60-200 cpm		315
1 — PRT100 Printer; 300 lpm		450
1 — MTC103 Magnetic Tape Controller		450
6 — MTH103 Magnetic Tape Handlers; 9-track, 60KC		1,920
1 — DSC161 Disc Storage Controller		450
3 — DSU160 Disc Storage Units; 7.6 million char.		1,770
1 — MPA130 Multiple Peripheral Adapter		75
	Total Rental:	$7,660

(Contd.)

TABLE I: GE-130 PERIPHERAL SUBSYSTEMS

Model No.	Description	Connectors	Channels
	CARD READERS		
CRZ111	400 cards per minute	2	1-2-3
CRZ120	600 cards per minute	2	1-2-3
	CARD PUNCH		
CPZ101	100 columns per second	3-4	1-3
	CARD READER-PUNCH		
CRP100	300 cards per minute	3-4	1-3
	PRINTERS		
PRT100	300 lines per minute	1	2
PRT110	600 lines per minute	1	2
PRT120	780 lines per minute	3-4	1-3
	PAPER TAPE READER		
PRT100	500 characters per second	3-4	1-3
	MAGNETIC TAPE SUBSYSTEMS		
MTC103	Controller for up to six MTH103 7/9-track tape drives, up to 30 KC	3-4	1-3
MTC106	Controller for up to six MTH106 7/9-track tape drives, up to 60 KC	3-4	1-3
	MAGNETIC DISC SUBSYSTEMS		
DSS161	DSC161 controller for up to eight DSU160 disc drives	3-4	1-3
	LINE CONTROLLERS		
SLC100	DATANET-10: 2,000/2,400 BPS	3-4	1-3
SLC102	DATANET-12: 19,200/40,800/50,000 BPS	3-4	1-3

.23 Internal Storage

.231 Core Storage

The working storage in the GE-130 consists of 9-plane ferrite core stacks. Each grouping of nine bits (including parity bit) constitutes one octet location. Storage capacities of 16,384, 24,576, and 32,768 octets are available. An odd-parity check is performed on all data stored in or read from core. The maximum internal data transfer rate is 500,000 octets per second, reflecting the cycle time of 2 microseconds — a significant improvement over the 6.5-microsecond cycle time of the GE-115.

Each storage location is directly addressable and holds an octet consisting of eight data bits plus one parity bit. Address modification is provided by index registers. No indirect addressing facility is available. Special-purpose areas are provided in lower memory for peripheral unit referencing, a multiplication and division work area, eight index registers, and program interrupt flags.

.232 Disc Units

The DSS161 Removable Disc Storage Subsystem, consisting of a DSC161 Disc Controller and from one to eight DSU160 Disc Units, provides a flexible, removable-cartridge mass storage system that is suitable for both batch and random-access processing.

The DSU160 Disc Units allow removable disc packs to be mounted and dismounted, thereby providing external data storage with an enormously expanded storage capacity. The DCT160 Removable Disc Cartridge (disc pack) has six interchangeable discs with ten recording surfaces. The GE disc pack is IBM 1316-compatible, although the GE recording format differs from IBM's. The disc pack, with a diameter of 14 inches and a height of 4 inches,

.232 Disc Units (Contd.)

has a total of 2000 working tracks divided into 20,000 individually addressable sectors. Each track has 10 sectors capable of storing 576 numeric characters (288 octets or 384 alphanumeric characters). Table II specifies the capacities of the disc storage organizational subdivisions.

The DSU160 Disc Unit contains five positioning arms with ten "floating" read-write heads, all of which move in unison. The average positioning time to access one cylinder is 75 milliseconds, with an average latency time of 12.5 milliseconds.

Data, recorded in either 6-bit alphanumeric or 4-bit packed numeric form, is transferred at a rate of 312,000 numeric or 208,000 alphanumeric characters per second. A parity check is performed on each character transferred.

TABLE II: DSU160 DISC STORAGE CAPACITIES

Location	Numeric Characters	Alphanumeric Characters	Octets
Sector	576	384	288
10-Sector Track	5,760	3,840	2,880
10-Track Cylinder	57,600	38,400	28,800
200-Track Surface	1,152,000	768,000	576,000
2000-Track Disc Pack	11,520,000	7,680,000	5,760,000
8-Disc-Pack Subsystem	92,160,000	61,440,000	46,080,000

.24 Central Processor

The GE-130 Central Processor is functionally organized in the same manner as the GE-115, with character orientation, variable word length, and sequential processing. The component parts include: a magnetic core memory for program and data storage, a command and control unit for program execution, an arithmetic control unit for computation and initiation of input-output operations, a peripheral control unit for channel switching and direct control of the card reader and line printer, an operator control panel, and connectors for peripheral subsystems.

.241 Instruction Format

The basic GE-130 instruction format includes lengths of 2, 4 and 6 octets. Zero, one or two memory addresses may be specified. The three types are represented as follows:

Two-Address	OC	CC	← I_A →	← I_B →
One-Address	OC	CC	← I_A or I →	
No-Address	OC	CC		

Where OC = 1-octet operation code, specifying the arithmetic, logical, data movement, input-output, etc., operation to be executed.

CC = 1-octet complementary code, modifying the basic operation code to define the specific conditions of execution. Complementary codes can define effective field lengths (minus 1), program transfer conditions, constant values, peripheral unit names, or index register references.

I_A, I_B = 2-octet addresses of first and second operands.

I = 2-octet address of the next instruction to be executed.

Address fields, in binary form, always occupy two octets. The high-order bit specifies absolute or relative addressing. When relative addressing is indicated, the binary value of the index register to be used is located in the next three high-order bits. This leaves the 12 low-order bits to express the relative address, with a binary addressing capacity of 4096 octets. The effective storage address is calculated by adding the relative address contained in the instruction to the base address in the specified index register. Relative addressing facilitates the repeated use of the same instruction, without altering the instruction itself, through changing the contents of the index register.

.242 Arithmetic Control Unit

The arithmetic control unit executes the fundamental operations of the GE-130 system. The unit's functions include: arithmetic operations on signed packed numbers, unsigned unpacked numbers, and binary fields; Boolean operations; data comparisons; table searches; internal data transfers; packing and unpacking of numeric data; editing of output data, and data transfers between the central processor and peripheral devices.

(Contd.)

.242 Arithmetic Control Unit (Contd.)

The arithmetic control unit can also enter qualitative results obtained from arithmetic or logical operations into the status indicators (underflow/overflow and zero/non-zero). The values in these indicators can subsequently be tested by conditional transfer instructions.

.243 Peripheral Control Unit

The peripheral control unit determines, in response to program signals, the appropriate connections between the peripheral subsystems and the central processor. Three channels and four connectors are provided for this purpose. The peripheral control unit also contains integrated controllers for a 300-lpm or 600-lpm unbuffered printer and a card reader.

The input-output channels receive orders from the central processor, check the availability of the peripheral units, transfer signals and data between the central processor and peripheral units, and regulate accesses to the central processor from the peripheral units. Data is transferred in parallel, one octet (eight bits plus parity bit) at a time.

An interleaving technique is employed to overlap the core storage accesses of several concurrently-operating peripheral units. Core storage cycles are divided among the three channels, servicing requests for central processor time in the order in which they are received and giving priority to Channel 1, which is also used by the arithmetic control unit for internal processing.

The maximum total I/O data rate of the GE-130 system is 380,000 octets per second. Channels 1 and 3 can each accommodate data transfer rates of up to 220,000 octets per second, while Channel 2 is limited to the data rate of the printer or card reader connected to the integrated control units.

Maximum simultaneity in a GE-130 system will normally be achieved in one of two situations:

- Overlapping of three I/O operations, two of which may involve magnetic tape and/or discs, without internal processing; or
- Overlapping of two I/O operations with internal processing.

In either case, additional I/O operations on buffered peripheral units can overlap other peripheral operations and internal processing. Buffered I/O units available for the GE-130 include the card punches, the CRP100 Card Reader/Punch, and the 780-lpm PRT120 Printer.

.244 Program Status Register

The Program Status Register (PSR) in the central processor occupies 4 octets and contains a "picture" of the current program status. The PSR contains three elements: the current instruction address, an interrupt mask, and the status indicators.

The instruction address increases progressively as a program is executed and is changed in response to a program jump or a DATANET (data communications) interrupt. The interrupt mask allows the programmer to specify whether interrupts shall be accepted or rejected. The status indicators reflect the qualitiative results of certain arithmetic or logical operations: overflow/underflow and zero/non-zero conditions.

.245 Command and Control Unit

The Command and Control Unit directs program execution by performing the following functions:

- Updates the Program Status Register.
- Extracts the program instructions from memory and transfers them to the Instruction Register.
- Analyzes each instruction for the type of operation involved.
- Processes instruction operands and addresses, as well as status indicators and interrupt signals.
- Controls the actual execution of the instructions by the arithmetic control unit.
- Communicates the program status to the operator by means of console lights, and permits operator intervention.

.246 Interrupt Processing

Unless interrupt servicing is inhibited by the interrupt mask in the PSR, interrupt signals from DATANET line controllers have immediate access to the central processor and the system allows real-time control of the remote terminals.

The following elements are part of the interrupt facility:

- Detection of interrupt signals on connectors 3 & 4.
- Modification of the Program Status Register (PSR) in the command and control unit.

.246 Interrupt Processing (Contd.)

- Provision of two reserved storage areas: the Old Program Status Register (OPSR) stores the status of an interrupted program to permit future re-initiation, while the Interrupt Program Status Register (IPSR) contains the data for servicing the interrupt condition.

At installation time, connectors 3 & 4 are enabled to receive interrupt signals.

The programmer can disable this facility by changing the Program Status Register interrupt mask. The command and control unit tests for the presence of an interrupt signal. When detected, and the connectors are enabled, the current program status is saved and the interrupt program status is activated. When the interrupt request has been satisfied, the original program status is re-established.

.247 Processing Facilities

The GE-130 system has a repertoire of sixty-three instructions, as listed in Table III. Facilities are provided for: decimal and binary arithmetic operations; comparisons and data movement; editing of output data; packing and unpacking of numeric fields; translation between any two 8-bit codes; memory searches; conditional branches on internal status indicators and external sense switches; Boolean operations for bit manipulation and testing; subroutine linkage; console-light alert control; and input-output operations.

Addition and subtraction operations can be performed in the packed decimal, unpacked decimal, and binary modes. Multiplication and division operations, which are available only through software routines in the GE-115, are standard hardware instructions in the GE-130, though only in the packed decimal mode.

The input-output instructions transfer data to and from core storage and the peripheral units, perform auxiliary peripheral operations such as line spacing and tape rewinding, testing for parity errors, and testing the availability of channels, connectors, or peripheral units. Control fields specifying the type of operation and the execution procedure are established in core memory and referenced by the I/O instructions.

Table IV summarizes the performance of the GE-130 Central Processor.

.248 Operator Control Panel

Manual control of the GE-130 system is provided by an Operator Control Panel built into the Central Processor. Switches, keys, and lights allow the operator to set external program switches, execute the program one step at a time, clear the system to initial conditions, display the operation code and addresses of the next instruction to be executed, and display the contents of the interrupt mask and the status indicators.

.25 Input-Output Equipment

General Electric offers a fairly wide choice of peripheral subsystems to support the GE-130 as listed in Table I. All of the devices available for the GE-130 system can also be used with the smaller GE-115.

The new Disc Storage Subsystem is described in Paragraph .232 of this Advance Report, while the new CRZ111 Card Reader and the augmented data communications facilities are described in the following paragraphs. For details on all the other peripheral subsystems, please turn to Paragraphs .071 through .091 of the GE-115 Summary, Report 310.

.251 CRZ111 Card Reader

The CRZ111 Card Reader is a new 400-cpm photoelectric reader designed especially for the GE-100 system. It is identical to the 600-cpm CRZ120 Card Reader in all respects except for its lower speed. Standard 80-column, 12-row punched cards are read in column-by-column fashion by 12 photocells. Data in either Hollerith or column-binary (two BCD characters per column) code can be read, and the two codes can be intermixed within a single run. The input hopper holds 2000 cards. The primary 2000-card-capacity output stacker and the auxiliary 500-card output stacker can be unloaded while the reader is running. Output stackers can be selected under program control.

.252 Data Communications

The DATANET-10 and DATANET-12 Communications Controllers enable the GE-130 system to be connected to a remote DATANET-30, a GE-115, a GE-400 or GE-600 series system, another GE-130, or another manufacturer's computer system. Data in 7-bit (plus odd parity bit) character format is transmitted and received in a serial synchronous mode. A "transcoding" table in the Central Processor translates the 7-bit codes. The DATANET-10 allows the GE-130 to be connected to a Bell System data set through a half-duplex 2,000 or 2,400 bps circuit. The DATANET-12 operates over a faster TELPAK 19,200, 40,800, or 50,000 bps circuit.

(Contd.)

TABLE III: INSTRUCTION LIST FOR THE GE-130

Arithmetic Operations	Data Transfers
Add decimal	Move complete octets
Subtract decimal	Move right quartets
Add decimal packed	Move packed
Subtract decimal packed	Move immediate octet to store
Multiply decimal packed	Load register
Divide decimal packed	Store register
Add binary	Load address
Subtract binary	Load program status register
Add memory to register	
Subtract memory from register	**Reformatting Instructions**
Comparisons	Pack
	Unpack
Compare complete octets	Pack with sign
Compare right quartets	Unpack with sign
Compare packed	Translate to octets
Compare memory to immediate	Edit
Compare register to memory	
Search to the right	
Search to the left	**Input-Output General Instructions**
Logical Operations	Call peripheral
	Call peripheral indirect
AND on complete octets	Transfer peripheral
OR on complete octets	Command peripheral
Exclusive OR on complete octets	Examine peripheral
AND on immediate	Set peripheral
OR on immediate	Test peripheral
Exclusive OR on immediate	
Test under mask	**Miscellaneous Instructions**
Branch Instructions	Halt system operation
	No operation
9 conditional jumps	Turn alert light on
Jump and return	Turn alert light off
Jump if Switch 1 set	Inhibit single-step
Jump if Switch 2 set	Enable single-step

.252 Data Communications (Contd.)

Each character transmitted or received is checked for parity, and each message block undergoes a longitudinal parity check. Interrupt signals can be transmitted to the GE-130 for program interruption if the interrupt mask in the Program Status Register is enabled. A four-word buffer synchronizes data transmission timing with processor timing. The Communications Controllers are automatically disconnected if no data is received in the DATANET-10 or DATANET-12 buffer within 60 seconds.

.3 SOFTWARE

Upward software compatibility from the GE-115 to the GE-130 permits the utilization of all programs written for the lower-level computer. Two operating systems designed specifically for the GE-130 system, EXTENDED TAPE OPERATING SYSTEM (ETOS) and EXTENDED DISC OPERATING SYSTEM (EDOS), are oriented toward magnetic tape and disc systems, respectively. In addition, language processors, program generators, input-output control systems, utility programs, application packages, and data communications software are provided.

General Electric states that the aims of its operating systems include the full exploitation of the operative capacities of the electronic system and the reduction of system start-up and management costs. Programming is done on the logical input-output level, without dependence on the type of peripheral units in the system. Compiling and test execution, as well as the system production programs, are automatically linked.

The minimum configuration requirements common to both the Extended Tape Operating System (ETOS) and the Extended Disc Operating System (EDOS) are 16K octets of core storage, any GE-100 series card reader, and any GE-100 series line printer. ETOS also requires an MTC103 Magnetic Tape Controller with four MTH103 or MTH106 Magnetic Tape Handlers. A DSC161 Disc Controller with two DSU160 Disc Units completes the minimum configuration for EDOS.

TABLE IV: PERFORMANCE OF THE GE-130 CENTRAL PROCESSOR

Task	Execution Time in Microseconds
Unpacked Decimal Mode (1)	
c = a + b	78
b = a + b	44
c = a x b	#
c = a ÷ b	#
Move a to b	34
Compare a to b	44
Packed Decimal Mode (2)	
c = a + b	62
b = a + b	34
c = a x b	548
c = a ÷ b	864
Binary Mode (3)	
c = a + b	68
b = a + b	38
c = a x b	#
c = a ÷ b	#

Hardware facility not available.

(1) Based on unsigned 5-octet fields.

(2) Based on signed 5-digit (i.e., 3-octet) fields.

(3) Based on 32-bit (i.e., 4-octet) binary fields.

.31 System Operation

The System Tape (ETOS) or Disc (EDOS) is used for compiling, testing, and debugging of the user's programs. It includes the entire software system used to prepare the Library and Master Tapes or discs. The Library Tape (ETOS) or Disc (EDOS) contains all of the user's programs which are already debugged and operational. The Master Tape (ETOS) or Disc (EDOS) relates to a given work period (i.e., one day's work) and contains all of the system and user programs required to accomplish a given task.

The normal operational scheme involves off-line updating of the System Tape or Disc from the Library Tape or Disc, and then the updating of the Master Tape or Disc from both the System and Library Tape or Disc. Under a production run, it is the Master Tape or Disc that contains the linked program flow for orderly system task execution.

.32 Supervisor

The ETOS and EDOS Supervisor is a central management program that coordinates all of the software elements for the automatic control of a complex of generator, service, compiler, and debugging programs. The Supervisor initializes the system and loads all of the system programs from magnetic tape or disc.

.321 Extended Input-Output System

The Extended Input-Output System (EIOS) controls, on a logical level, the handling of input-output files. Such functions as file blocking and deblocking, I/O error analysis, end-of-file, and multi-volume processing are performed. The Supervisor, in turn, initiates and controls the input-output activity on the physical level.

.322 Service Routines

The Supervisor is supported in program control by service routines that provide for automatic linkage of programs for a production run, program segmentation, and generation and management of the program library. Other service routines handle operator-machine communication control.

.323 Debugging Routines

A package of debugging routines enables the operating systems to prepare the user's programs for execution through memory-to-print and memory-to-card dumps, program listings, and patch tracing.

(Contd.)

.324 Lanugage Processors

The principal language processors for the GE-130 are the machine-oriented Assembly Programming System (APS), a COBOL compiler, and a FORTRAN IV compiler.

The Assembly Programming System (APS) is a card-oriented language processor that translates source programs written in assembly language into object programs ready for testing or execution. APS requires a 16K GE-130 Central Processor with at least one card reader, one card punch, and one printer. Mnemonic operation codes are provided for the entire GE-130 instruction repertoire, with extended mnemonics for the conditional jump instructions and pseudo-mnemonics to control core storage allocation and program listing formats. EIOS macros and other standard routines can be called by APS for insertion into the assembled object deck.

For magnetic tape and disc-oriented systems, tape-extended APS and disc-extended APS versions are available. The extended APS versions provide the following additional features: a complete set of signed and unsigned arithmetic instructions, a larger set of input-output macros, and the ability to subdivide programs into segments and to overlay these segments.

GE-130 COBOL is a subset of COBOL-65, including arithmetic, logical, and decision functions, EIOS routines, editing capabilities, report writer statements, program segmentation provisions, the ability to include APS routines within the COBOL source program, and a provision for requesting object-program listings.

The GE-130 FORTRAN IV Compiler requires a minimum system configuration of one card reader, one printer, 16K octets of core storage, and either four magnetic tape units (ETOS) or two disc drives (EDOS).

The GE-130 Sort Program Generator (SPG) is designed to facilitate sort and merge applications on magnetic tape (ETOS) and discs (EDOS). User-coded sequences in APS can be added. All sort and merge operations are perfomed in ascending order using the polyphase technique.

GE-130

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
	130A16		GE-130 Central Processor (16,384 octets of core storage)(1)	2,000	88,000	150
	130A24		GE-130 Central Processor (24,576 octets of core storage)(1)	2,500	111,120	185
	130A32		GE-130 Central Processor (32,768 octets of core storage)(1)	3,000	133,440	220
	MPA130		Multiple Peripheral Adaptor (MPA)	75	3,312	6
MASS STORAGE			Disc Storage			
	DSC161		Disc Storage Controller	450	19,872	36
	DSU160		Disc Storage Unit	590	25,510	70
	DSC130		Disc Storage Controller	315	13,780	28
	DSU130		Removable Disc Storage Unit (2 million characters)	300	11,910	52
	DCT160		Removable Disc Cartridge (for DSU130 or DSU160)	20	560	0
INPUT-OUTPUT			Magnetic Tape			
	MTH103		Magnetic Tape Handler (9-track, 30 kc)	320	12,390	82
	MTC103		Magnetic Tape Controller (7/9-track, 30 kc)	450	20,070	57
	MTH106		Magnetic Tape Handler (9-track, 60 kc)	480	18,200	116
	MTC106		Magnetic Tape Controller (7/9-track, 60 kc)	450	20,070	57
		OPT007	7-Track Option for MTH103 or MTH106	55	2,500	3
			Punched Card			
	CRZ111		Card Reader (400 cards/min)	230	9,180	45
	CRZ120		Card Reader (600 cards/min)	315	12,420	60
		OPT025	51-Column Card Option	40	1,540	8
		OPT026	Transcoder Bypass Option	20	680	6
	CPZ101		Card Punch (60-200 cards/min)	315	11,680	72
	CPZ103		Card Punch (300 cards/min)	605	22,420	138
	CRP100		Card Reader/Punch (300 cards/min)	590	21,510	142
			Paper Tape			
	PTR100		Paper Tape Reader (500 char/sec)	120	4,520	26
			Printers			
	PRT100		Printer (300 lines/min, 104 print positions)	450	16,800	100
		OPT075	120 Column Option	35	1,540	8
		OPT076	136 Column Option	70	2,790	17
	PRT110		Printer (600 lines/min, 104 print positions)	605	24,240	145
		OPT077	120 Column Option	45	1,880	11
		OPT078	136 Column Option	90	3,510	22
		OPT079	Fast Skip Option	70	2,790	17
	PRT120		Printer (780 lines/min, 120 print positions)	900	35,000	216
		OPT085	136 Column Option	100	3,890	24
		OPT086	Fast Skip Option	70	2,790	17

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS	SLC100		DATANET-10 Communications Controller (2000 or 2400 bits/sec)	210	9,230	16
	SLC102		DATANET-12 Communications Controller (19,200, 40,800 or 50,000 bits/sec)	300	12,100	48

NOTES:

(1) Each octet consists of eight data bits and one parity bit.

SUMMARY

.1 INTRODUCTION

The GE-200 Series consists of three compatible, small-to-medium-scale, second-generation computers. Designated the GE-215, GE-225, and GE-235, the three machines differ primarily in their processor speeds. All have identical instruction repertoires, and there is a common set of input-output units, as well as a common set of software packages for all. The GE-200 computers are binary, word-oriented systems, and they offer both floating-point and decimal arithmetic options. Each word consists of 20 bits and may contain a one-address instruction, a data word, or 3 alphameric characters. Monthly system rentals can vary from approximately $2,600 to over $40,000, with typical configurations renting in the $5,000 to $18,000 range. Several hundred GE-200 Series systems have been installed.

The initial member of the GE-200 Series was the GE-225, first delivered in March 1961. The "family" was actually created in early 1963, when the GE-215 (a slowed-down GE-225) and the GE-235 (a faster, re-engineered GE-225) were introduced. The GE-215 possesses reduced input-output capability, with fewer data channels than the GE-225. The GE-235, with a basic cycle three times as fast as the GE-225, is further distinguished by its much faster floating-point module.

The essential differences among the three GE-200 Series systems are summarized in Table I.

The GE-215 is no longer being produced, but used machines can be delivered as available. The GE-225 is officially out of production, but it is still being marketed, tied to a DATANET-30 communications processor, as the GE-255 Time-Sharing System. The GE-235 is still being actively produced and marketed under its own number and as the GE-265, a time-sharing system combining a GE-235 processor with a DATANET-30.

The following sections describe the data structure, hardware characteristics, software offerings, and intra-line compatibility of the GE-200 Series.

.2 DATA STRUCTURE

The GE-200 Series is basically word-oriented. A GE-200 Series word consists of 20 bits plus a parity bit. Each 20-bit word can hold a one-address instruction, a 20-bit binary data word, or 3 alphameric characters in 6-bit BCD representation. A floating-point number is stored in two consecutive GE-200 Series words, using 30 bits plus sign for the fraction and 8 bits plus sign for the exponent.

.3 HARDWARE

.31 Central Processors

The GE-215, GE-225, and GE-235 systems all utilize essentially the same central processor. The GE-215 processor is a slowed-down GE-225 unit; the GE-235 processor, while re-engineered for additional speed, retains all the features of the earlier GE-225 model. All three models use identical instruction sets. The essential differences among them are the core storage cycle times, the number of input-output channels, and the maximum I/O channel transfer rates, as listed in Table I.

TABLE I. DISTINGUISHING CHARACTERISTICS OF THE GE-200 SERIES SYSTEMS

System	Core Storage Cycle Time, Microseconds	Max. No. of I/O Controllers (other than card and paper tape)	Maximum Gross Channel Transfer Rate, Words/Sec.	Maximum Mag. Tape Speed, Char/Sec.	Maximum Printer Speed, Lines/Min.	I-O Typewriter Facilities
GE-215	36	3	27,800	15,000	450	Output std. Input opt.
GE-225	18 (14 with option)	8	55,600	60,000	900	Output std. Input opt.
GE-235	6	7	111,000	60,000	900	Output std. Input std.

.31 Central Processors (Contd.)

The GE-200 Series central processors provide complete arithmetic facilities for single word-length binary operands. Loading, storing, addition, and subtraction of double-length binary data items can also be performed. An optional feature permits addition and subtraction (but not multiplication or division) of single- or double-length data items in BCD form. This feature can significantly reduce the number of time-consuming radix conversions required in business data processing, but will seldom eliminate the problem completely.

Three index registers and a fourth location that serves as a convenient counter register are standard. An optional feature makes 31 additional 4-word groups in core storage available as index registers or counters. Only one group, selected by a special instruction, can be active at a time. Other optional features for the central processor are a Move command (which expedites internal block transfer operations), Three-Way Compare, Automatic Priority Interrupt, and a Real-Time Clock. In typical routines, instructions are executed at the rate of about 10, 000 per second in the GE-215, about 20, 000 in the GE-225, and about 75, 000 per second in the GE-235.

An Auxiliary Arithmetic Unit can perform double-length arithmetic in either fixed or floating-point mode under control of the central processor. This optional unit greatly increases internal processing speeds on scientific problems.

.32 Internal Storage

Working storage is provided by a magnetic core store, which can contain 4,096, 8, 192, or 16, 384 word locations. Core storage cycle times are listed in Table I. A parity check is performed upon all internal transfer operations.

A Disc Storage Unit (DSU) is also available. This unit consists of 4, 8, 12, or 16 permanently-mounted discs, and provides disc storage for a maximum of 18.87 million alphameric characters in 98,304 fixed record locations of 64 words (or 192 characters) each. The average total waiting time for access to a randomly-placed record is 225 milliseconds. Up to 294,912 characters per disc unit can be transferred without repositioning any of the 16 access arms. A maximum of four disc file units can be connected to each disc controller. No more than one disc controller may be connected to a GE-215 system; the GE-225 and GE-235 systems permit eight and seven controllers, respectively.

.33 Input-Output Devices

All peripheral devices except the console typewriter and the card and paper tape readers and punches are connected to the central processor through a multiplexing device called the Controller Selector. This device provides capabilities for simultaneous operations that rival those of far more costly systems. Controllers for magnetic tape units, disc storage units, printers, magnetic document handlers, data communication equipment, and the Auxiliary Arithmetic Unit can be connected to the Controller Selector: three on the GE-215, eight on the GE-225, and seven on the GE-235. In addition, if the Auxiliary Arithmetic Unit is included, it occupies one "hub" of the Controller Selector (except in the GE-235, where it is connected directly to the Central Processor). One peripheral unit on each controller can operate simultaneously with internal processing and card or paper tape reading and punching. Accesses to core storage are allocated automatically.

Standard 80-column punched cards can be read at 400 or 1, 000 cards per minute and punched at 100 or 300 cards per minute. Paper tape can be read at 250 or 1, 000 characters per second and punched at 110 characters per second. A console typewriter provides typed output; input via the console typewriter is standard on the GE-235 and optional on the GE-215 and -225.

The high-speed printer available with the GE-215 has a rated speed of 450 alphameric lines per minute. The GE-225 and -235 systems may include a 900-line-per-minute model. Both printers have skipping speeds of 25 inches per second, and the controllers for both provide automatic editing and format control.

Three magnetic tape handler models are available. One, the only model available with the GE-215, has a peak data transfer rate of 15,000 characters per second at a recording density of 200 rows per inch. A second model offers a choice of 200 or 556 rows per inch, with corresponding peak speeds of 15,000 or 42,000 characters per second. The remaining tape handler offers a choice of 200, 556, or 800 rows per inch, with corresponding speeds of 15,000, 42,000, or 60,000 characters per second. The 60KC model is a single-unit handler, mounted one to a cabinet; the two slower models are mounted two to a cabinet, one above the other. Up to eight tape handlers can be connected to each tape controller. No more than two 42KC or 60KC tape read or write operations may occur at a time, but the number of simultaneous 15KC tape operations is limited only by the number of tape controllers in the system.

(Contd.)

.33 Input-Output Devices (Contd.)

Magnetically encoded paper documents can be read and sorted at a peak speed of 1,200 documents per minute. Two document handlers can be connected to each controller, providing a peak sorting speed of 2,400 documents per minute.

GE's MOSE (Modification of Standard Equipment) group offers a variety of special-purpose hardware for use with GE-200 systems, such as peripheral device switching controllers, printer plotting option, plotter interface units, etc.

.34 Data Communications Equipment

The DATANET-15 controls the transmission and reception of digital data over telephone and telegraph lines and two-wire cables at speeds ranging from 60 to 2,400 bits per second. Up to 15 data transmission lines and a paper tape reader and punch can be connected to a DATANET-15, but it can control only one data transfer operation at a time.

GE's line of data communications equipment available for use with the GE-200 Series also includes:

- The DATANET-30 programmed data communication system.
- The DATANET-90 magnetic-tape-to-computer terminal.
- The DATANET-91 off-line magnetic-tape-to-magnetic-tape terminal.
- A variety of special digital input-output terminal devices.

.4 SOFTWARE

.41 Process Oriented Languages

GECOM is offered as an all-purpose process oriented language. The basic language structure is similar to that of COBOL-61 but is not compatible with it. GECOM also handles algebraic expressions and mathematical functions, and includes a report writer and TABSOL, a system that permits decision logic to be expressed in a concise tabular format. At least four magnetic tape handlers and 8,192 core storage locations are required for GECOM compilations.

COBOL-61 is also offered for the 200 Series, implemented by a COBOL-to-GECOM translator. The translator converts COBOL source language to a source program in GECOM. The GECOM compiler then processes this source language to produce an object-language program.

FORTRAN is available in two versions: one for card-oriented systems, the other requiring four magnetic tape units. Both versions require at least 8,192 core storage locations, and both provide several useful extensions of USASI Basic FORTRAN.

WIZ is a one-pass algebraic compiler for use on punched card or paper tape systems with at least 8,192 core storage locations. WIZ is less powerful than the FORTRAN language, but it is easy to learn and provides high compilation speeds.

.42 Machine Oriented Languages

The General Assembly Program (GAP) is the basic symbolic assembly system for the GE-200 Series. It permits full utilization of the hardware facilities, is relatively easy to learn and use, but provides few refinements. GAP-coded programs can be assembled on GE-200 Series systems with punched card, paper tape, or magnetic tape input-output equipment.

ZOOM is a "macro assembly system" designed to facilitate machine-oriented programming by reducing the amount of detailed coding required while retaining high object program efficiencies. The ZOOM programmer uses a combination of pseudo-English statements, algebraic expressions, and GAP symbolic statements. These are translated into an all-GAP program which is then assembled in the normal manner. Magnetic tape is not required, but can be utilized to facilitate the translation process.

.43 Problem Oriented Facilities

BRIDGE II is a tape file maintenance and run sequencing program whose functions are directed by control cards. FORWARD is a generalized sort/merge generator. Simulation programs are available for simulating the operations of IBM650 and Control Data LGP-30 computers on GE-200 systems. The Card Program Generator simplifies the programming of existing punched card tabulator and calculator runs. An adequate library of generalized input-output, diagnostic, and mathematical routines is available, as are special-purpose packages for the banking and electric utility industries, numerical tool control, inventory management, assembly line balancing, critical path method (CPM), and information retrieval.

.5 COMPATIBILITY WITHIN THE SERIES

Since the GE-215, GE-225, and GE-235 all use the same instruction set and essentially the same central processor, there is, in effect, complete interchangeability of programs among the three systems. The obvious restrictions are the following:

- The systems must be equipped with comparable input-output units.
- A program cannot call on a feature not present on the system in question.
- Since the input-output and core cycle times are different for each of the systems, programmed timing loops must be modified or avoided.

GE-200 SERIES

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			GE-205 Central Processor; including console, output typewriter, single channel adapter and:			
	*CA205A		4,096 word magnetic core memory	1,200	57,600	130
	*CB205A		8,192 word magnetic core memory	1,300	64,900	150
	*CC205A		16,384 word magnetic core memory	2,500	120,000	200
			GE-215 Central Processor, including console, output typewriter, 3-channel controller selector, and:			
	*CA215A		4,096 word magnetic core memory	2,200	72,500	130
	*CB215A		8,192 word magnetic core memory	2,500	87,500	150
	*CC215A		16,384 word magnetic core memory	3,900	132,300	200
			GE-225 Central Processor, including console, output typewriter (no controller selector), and:			
	*CA225C		4,096 word magnetic core memory	1,900	72,500	130
	*CB225D		8,192 word magnetic core memory	2,500	87,500	150
	*CC225B		16,384 word magnetic core memory	3,900	132,300	200
			GE-225 Central Processor, including console, output typewriter, 8 channel controller selector, and:			
	*CA225B		4,096 word magnetic core memory	2,900	72,500	130
	*CB225C		8,192 word magnetic core memory	3,500	87,500	150
	*CC225A		16,384 word magnetic core memory	4,900	132,300	200
			GE-225 Central Processor, including console, output typewriter, printer adapter and:			
	*CA225D		4,096 word magnetic core memory	1,930	116,000	130
	*CB225E		8,192 word magnetic core memory	2,530	140,000	150
	*CC225C		16,384 word magnetic core memory	3,930	184,000	200
	*CB225L		Magnetic Core Memory (4,096 words)	600	24,000	20
			Features for GE-205/215/225			
			Auxiliary Arithmetic Units:			
	X225A		Auxiliary Arithmetic Unit (for floating point, double precision arithmetic)	650	26,000	43
	J104A		N-Register Interface	225	4,400	7
	J225A		Decimal Package consisting of three way compare, additional index words, decimal add and subtract	200	3,530	11
	J225B		Automatic Interrupt	75	3,040	5
	J225C		Move Command	75	2,640	5
	J225E		Real Time Clock	75	2,880	7
	J225F		Additional 8k Memory	1,400	44,800	50
		OPT036	225 Time Sharing Option	175	8,080	13
			Speed-up Options for GE-225			
	EPN208		Speed-up Option (14-microsecond memory) for GE-225 Processors with 8k memory	450	10,500	31
	EPN216		Speed-up Option (14-microsecond memory) for GE-225 Processors with 16k memory	550	12,500	37
	EPU216		Speed-up Kit to Upgrade from 8k to 16k processor(1)	100	2,000	6
	EPN200		Speed-up Option for X225A Auxiliary Arithmetic Unit (requires EPN208 or EPN216)	50	1,000	3

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR (Contd.)	CA235		GE-235 Central Processor and Console and I/O Typewriter	2,880	115,200	127
	CA235X		Central Processor, Console, I/O Typewriter, N-Register Interface	3,080	134,400	140
			GE-235 Main Memories:			
	MM235A		4,096 word magnetic core memory	670	25,840	62
	MM235B		8,192 word magnetic core memory	1,300	49,920	83
	MM235C		16,384 word magnetic core memory	2,420	87,120	145
			Features for GE-235			
	AAU235		Auxiliary Arithmetic Unit with I/O Channel and Console display	1,500	48,000	77
	BCD235		BCD Package	245	3,920	19
	API235		Automatic Program Interrupt	95	3,600	7
	MVC235		Move Command	95	3,200	5
	RTC235		Real Time Clock	95	3,520	7
		OPT035	Time sharing option	175	8,080	13
ATTACHMENTS, ADAPTERS, AND CHANNELS			For GE-205/215/225			
	J225H		Peripheral Switch Console	180	6,800	13
	J225J		Peripheral Switch Unit	95	3,360	6
	J225G		CPU Printer Adapter	30	1,000	2
	CB225CX		Typewriter, Input Modification	-	-	-
			For GE-235			
	AIO235		Printer Adapter	200	19,200	23
	CSS235		Single Access Controller Selector (7 Channel)	1,000	19,200	32
	CSD235		Dual Access Controller Selector (7 Channel)	2,280	43,760	73
MASS STORAGE			Disc Storage			
	DSF204		Disc Storage Unit (4 discs)	1,170	53,000	375
	DSF208		Disc Storage Unit (8 discs) (B)	1,380	61,000	375
	DSF212		Disc Storage Unit (12 discs) (B)	1,590	69,000	375
	DSF216		Disc Storage Unit (16 discs) (B)	1,795	76,000	375
	J102C		DIOC with History Repeater	NA	199,207	1,016
	DSU204		Disc Storage Unit (4 discs)	1,170	53,000	375
		OPT201	4 additional discs	210	8,000	0
		OPT202	8 additional discs	420	16,000	0
		OPT203	12 additional discs	625	23,000	0
		OPT204	Fast Access I (4 discs)	315	15,000	0
		OPT205	Fast Access II (8 discs)	420	20,000	0
		OPT206	96 Read/Write Option	130	5,770	10
	M225B		Controller for DSU 204 (controls up to 4 disc files)	940	37,000	62
	M225BX		Dual Access DSU Controller	1,590	46,080	75
		OPT207	Real Time Feature for M225B and M225BX	0	0	0
INPUT-OUTPUT			Magnetic Tape			
	MTH301		Magnetic Tape Handlers (single, 60kc)	615	26,230	88
	MTH680		Magnetic Tape Handlers (dual, 15kc)	850	23,760	108
	MTH690		Magnetic Tape Handlers (dual, 41.6kc)	1,300	34,460	292
	MTB690		Magnetic Tape Buffer	100	4,000	7
	MTC225		Magnetic Tape Controller (single channel, controls up to 8 single 60kc MTH)	1,200	48,000	80

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	MTC690		Magnetic Tape Controller (controls up to 4 dual 41.6kc Tape Handlers)	1,030	37,080	62
	MTC680		Magnetic Tape Controller (controls up to 4 dual 15kc Magnetic Tape Handlers)	800	30,000	50
	*T225A		Magnetic Tape Handlers (dual, 15kc)	850	26,400	108
	*T225B		Magnetic Tape Handlers (dual, 41.6kc)	1,300	38,280	292
	*MTH695		Magnetic Tape Handlers (single, 60kc)	750	37,000	198
	*MTC695		Magnetic Tape Controller (single channel, controls up to 8 single 60kc MTH)	1,200	60,000	62
	*MTC696		Magnetic Tape Controller (dual channel, controls up to 8 single 60kc MTH)	1,500	75,000	75
	*U225A		Magnetic Tape Controller (15kc)	800	30,000	50
	*U225B		Magnetic Tape Controller (41.6kc)	1,030	37,080	62
	*MTC200		Magnetic Tape Controller (single channel, controls up to 4 single 15/41.6kc MTH)	750	30,000	62
			Punched Card			
			Card Readers:			
	D225B		Console Card Reader and Control (400 cards/min)	375	9,175	112
	D225C		Card Reader and Control (1000 cards/min)	810	19,440	121
	*-		Read-Intermixed Feature	50	2,000	1
	D225D		Card Reader and Control (1000 cards/min with read intermixed feature)	860	20,940	121
	CRD125		Console Card Reader and Control (360 cards/min)	375	14,680	112
	CRD135		Console Card Reader and Control (360 cards/min)	375	14,680	112
	CRC235		Console Card Reader and Control with Read Intermixed (400 cards/min)	375	9,175	112
	CRD235		Card Reader and Control (1000 cards/min with read intermixed feature)	810	19,440	121
			Card Punches:			
	E225K		Card Punch and Controller (100 cards/min)	400	17,170	87
	E225K1		Card Punch and Controller (100 cards/min and 10 columns DPBCD) (2)	405	17,400	87
	E225K2		Card Punch and Controller (100 cards/min and 20 columns DPBCD) (2)	410	17,630	87
	E225K3		Card Punch and Controller (100 cards/min and 30 columns DPBCD) (2)	415	17,860	87
	E225M		Card Punch and Controller (300 cards/min with read-after-punch check)	825	32,920	154
	CPA235		Card Punch and Controller (100 cards/min)	400	17,170	87
		OPT100	10 Columns of DPBCD (2)	5	230	0
		OPT200	20 Columns of DPBCD (2)	10	460	0
		OPT300	30 Columns of DPBCD (2)	15	690	0
	CPD235		Card Punch and Controller (300 cards/min with read-after-punch check)	825	32,920	154
	*E225B		Card Punch Controller	315	16,900	0
	*E225C		Card Punch (100 cards/min)	85	4,560	87
	*CPF225		Card Punch and Controller (100 cards/min with read-after-punch check)	480	25,780	87
	*E225C300		10 Positions DPBCD (2) (maximum 30 positions)	8	370	1
	*E225G		Card Punch and Controller (250 cards/min)	825	39,150	154

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Paper Tape			
	GA651A		Paper Tape Reader (1000 char/sec) and Paper Tape Punch (110 char/sec) with spooler	490	17,600	88
	GA651B		Paper Tape Reader (1000 char/sec) and Paper Tape Punch (110 char/sec) without spooler	440	15,840	79
	GA652A		Paper Tape Reader, Punch, and Spooler (5-, 6-, 7 , and 8-level)	585	20,680	103
	GA652B		Paper Tape Reader and Punch with 7-8 (5-, 6-, 7-, and 8-level)	535	18,920	95
	GB651A		Paper Tape Reader and Spooler (1000 char/sec)	300	12,000	60
	GB651B		Paper Tape Reader (1000 char/sec; without spooler)	260	10,400	52
	GB652A		Paper Tape Reader and Spooler (5-, 6-, 7-, and 8-level)	395	15,080	75
	GB652B		Paper Tape Reader (5-, 6-, 7-, and 8-level)	355	13,480	68
	*GA651E		Paper Tape Reader (1000 char/sec) and Paper Tape Punch (110 char/sec) with spooler (5-channel)	490	17,600	88
	*GA651F		Paper Tape Reader (1000 char/sec) and Paper Tape Punch (110 char/sec) without spooler (5-channel)	440	15,840	80
	*GA651C		Paper Tape Punch (110 char/sec) 6-, 7-, or 8-channel	190	7,200	36
	*GA651D		Paper Tape Punch (110 char/sec) 5-channel	190	7,200	36
	*GA651G		Paper Tape Reader with spooler (1000 char/sec; 5-channel)	745	28,550	103
		*OPT652	Expansion to 8-channel code capability	99	3,080	3
			Printers			
	P215C		Printer (120 columns 450 lines/min. includes controller with FORTRAN character compatibility)	795	48,360	246
	P215E		Printer (120 columns; 450 lines/min)	775	48,000	246
	P225A		Printer (120 columns; 900 lines/min; includes controller)	1,275	49,200	246
	P225C		Printer, On-line (120 Column 900 lines/min.) (includes Controller with FORTRAN character compatibility)	1,295	49,560	246
		PDR225	Standard GE Print Drum with COC-5 Character Set for P225A	80	3,600	18
		PDR226	Standard GE Print Drum with COC-5 Character Set for P215E	80	3,600	18
	*P225D		Printer (120 Column; 300 lines/min; includes Controller)	550	33,000	246
	*P225B		Printer (300 lines/min)	600	36,000	246
	*PA690A		Off/On-line Printer (120 Column; 900 lines/min; Printer Reader handles magnetic tape of 200 bits/inch density)	2,950	109,800	300
	*PA690B		Off/On-line Printer (120 Column; 900 lines/min; Printer Reader handles magnetic tape of 200/555.5 bits/inch density)	3,500	126,000	392
	*MSL690		Multiple Tape Lister and Control (900 lines/min)	1,700	65,280	335
			Document Handler Subsystem for GE-225/235			
	SA225A		Single Channel Sorter Adapter	540	8,640	29
	SB225A		Dual Channel Sorter Adapter	680	10,880	36
	S12B		GE MICR Document Reader/Sorter (12 pocket, 1200 doc/min)	-	24,500	465
	S12D		GE MICR Document Reader/Sorter (12-pocket, 1200 doc/min)	1,850	29,440	465

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Document Handler Subsystem for GE-225/235 (Contd.)			
		OPT010	Mod II, TCD Check Option	100	4,500	15
		OPT011	Endorser Option	100	4,500	23
	BFR225		COC-5 Bar Font Reader Option for S12D and S12B	520	20,000	100
COMMUNICATIONS	*DTC901		DATANET - 15 (2 stations)	720	30,000	100
			Optional Features for DATANET - 15			
	*DAC901		4 additional Input/Output stations	21	400	2
	*DAC902		13 additional Input/Output stations	52	1,300	12
	*CLC901		5-Level Mode of Operation	16	200	1
	*CLC902/3/4		6-, 7-, or 8-Level Mode of Operation	11	120	1
	*DTU901/2/3/4/5		75-, 110-, 1050-, 50-, or 500-Baud Timing Unit	11	120	1
	*PTA901		Paper Tape Station Adapter	26	600	1

NOTES:

*No longer in production.

(1) Processor must also be upgraded from 8k to 16k with J225F additional 8k memory.

(2) DPBCD is Double Punch and Blank Column Detection

REPORT UPDATE

GE UNVEILS TWO NEW MEMBERS OF THE GE-400 TIME-SHARING FAMILY

GE's recently-announced GE-430 and GE-440 time-sharing systems supplement the GE-420 system announced one year ago. Improved software systems and more extensive use of the new DSU-160 removable disc units offer faster response time at a lower cost per line.

The GE-430 time-sharing system, with a 32,768 word memory capacity, can serve up to 30 time-sharing users concurrently, and leases for $15,421 per month. The larger, faster GE-440 system, with 65,536 words of memory, carries a monthly lease of $22,187 and is capable of serving up to 50 users concurrently.

Both systems provide floating point hardware and memory protection and each contains a DATANET-30 processor connected to the control processor by an interface unit for control of the communication line service.

Four DSU-160 (expandable to eight) removable disc storage units, with a total storage capacity of over 30 million characters, and a card reader and printer are standard components of each system configuration. The user may optionally add additional peripheral units.

An extended form of the BASIC (Basic All-Purpose Symbolic Instruction Code) language, developed by Dartmouth College and currently used on the GE-265 system, and a conversational ASA-compatible FORTRAN IV are offered as standard software.

Confidential files are secured by a password technique, thereby precluding unauthorized or accidental access.

Besides the time-sharing facilities, such GE-400 operating systems as the Direct Access Programming System, the Disc Programming System, or the Magnetic Tape Operating System, may be utilized for transforming the GE-430 and GE-440 into direct access or batch processing systems.

The GE-430 and GE-440 time-sharing systems are scheduled for first delivery during the first quarter of 1969.

REPORT UPDATE

GE-410 TIME-SHARING SYSTEM MAKES ITS DEBUT

General Electric has recently introduced the GE-410, a smaller version of the GE-430/440 time-sharing systems announced earlier. These systems compliment the GE-420, the first system in the 400 Series with features specifically oriented towards time-sharing.

The GE-410 can serve up to 10 users simultaneously and can accommodate up to a maximum of 40 keyboard terminals. When not involved in time-sharing, the GE-410 can be expanded to accommodate multiprogrammed batch processing.

Upgrading from a GE-410 to a GE-430 or GE-440 is a relatively simple matter because the basic system design and software is identical for the three systems.

The GE-410 basic configuration includes a central processor with a 32,768-word core memory (6.3-micro-second cycle time), two DSU 160 Removable Disc Storage Units with 15 million characters of storage, a card reader, and a Datanet 30 data communications processor. This configuration rents for $10,475 per month and sells for $495,380. The first deliveries are scheduled for August 1969.

REPORT UPDATE

ADDITIONAL CORE AND DISC STORAGE NOW AVAILABLE FOR GE-405

The GE-405 is no longer limited to a 12,288 word memory. A second additional 4,096 word work memory module can be added, thus raising the maximum memory size to 16,384 words.

In addition, the DSS 160 Removable Disc Subsystem (see Section 330:043) is now available for use on the GE-405. One DSS 160 subsystem, consisting of one DSC 160 Disc Storage Controller and up to eight DSU 160 DSU 160 Disc Storage Units, can be connected to a GE-405. The subsystem provides up to 61.4 million characters of on-line storage.

The GE-405 memory prices and the prices of the DSS 160 subsystem are summarized as follows:

	Monthly Rental	Purchase Price	Monthly Maintenance
CPU 405 Central Processor Unit with 8,192 words of memory	$1,800	$ 75,540	$158
First Additional 4,096 memory	800	34,400	52
Second Additional 4,096 memory	250	9,700	48
DSC 160 Disc Storage Controller*	540	24,000	40
DSU 160 Disc Storage Unit	590	25,510	70
ADC 160 Additional Data Channel	185	8,230	14

*Price includes one high-speed channel (HC6012)

MULTIPLE-DRIVE DISK SUBSYSTEMS INTRODUCED FOR GE-435

GE has recently introduced two new mass auxiliary storage subsystems for use with the GE-435. The DSS-167 and the DSS-170 Disk Storage Subsystems are similar in design to the IBM 2314 in that the subsystems contain multiple, removable storage disc drives. The disc packs used with both systems have eleven-high disc stacks are contracted with the six-high stacks in the DSS-160 packs used with the GE-100 and GE-400 Series.

The DSS-167 provides 90 million six-bit characters of storage, expandable to 120 million; the DSS-170 has a 220 million character storage capacity. The average access time for both systems is 75 milliseconds, and there is simultaneous seek overlap. The DSS-167 peak transfer rate is 208,000 characters per second, and that for the DSS-170 is twice that or 416,000 characters.

Deliveries of the new units are scheduled to begin by July 1970. The following prices will be charged for the two subsystems:

	Monthly Rental	Purchase Price	Monthly Maintenance
DSS-167 Removable Disc Storage Subsystems, 90 million characters	$3,185	$136,080	$375
ADC-167 Additional Data Channel (Non-Simultaneous)*	185	8,230	14
DEP-167 Data File Protect*	52	2,320	4
ADU-167 Additional Disc Unit, 30 million characters, optional	675	28,800	80
DSS-170 Removable Disc Storage Subsystem, 220 million characters	5,675	256,400	705

*Required only when using DPS or DAPS Operating Systems.

SUMMARY: GE-400 SERIES

.1 BACKGROUND

The GE-400 Series is a program-compatible family of medium-scale data processing systems. Hardware capabilities such as floating-point arithmetic, memory protection, random-access and data communication devices, as well as sophisticated software and an impressive library of immediately-available application programs, will attract users other than the medium-sized business firms which represent the GE-400's main marketing target.

Originally announced in December 1963, the GE-400 Series currently includes five systems: the GE-405, GE-415, GE-425, GE-435, and GE-420. The first four systems utilize different core storage units but share the same processor. The smallest computer of the series, the GE-405, uses a slightly restricted set of available peripheral units. The GE-420 couples the GE-415 computer with certain options, communications equipment, and software to form a time-sharing, multiprogramming system.

Monthly rentals can range from approximately $5,120 for a minimum tape-oriented GE-405 system to over $25,000 for an expanded GE-435 system. First customer delivery of a GE-415 system occurred in May 1964, and the first GE-425 and GE-435 systems were delivered in June and October 1964, respectively. The last members to be announced, the GE-405 and GE-420, were first delivered in October 1967. The interval between the placing of a firm order and actual delivery averages 4 to 5 months, depending mainly on the number and complexity of options included.

.2 COMPATIBILITY

All members of the GE-400 Series utilize the same instruction repertoire, and almost all hardware options and peripheral equipment are available for each member. (Special lower-priced and slower peripherals are offered for the GE-405.) Thus, programs can be freely interchanged among GE-400 Series systems having equivalent peripheral devices, memory capacities, and special features. There is no direct program compatibility between the GE-400 Series systems and other GE computer systems such as the older GE-200 Series, the small-scale GE-100 Series, and the large-scale GE-600 Series.

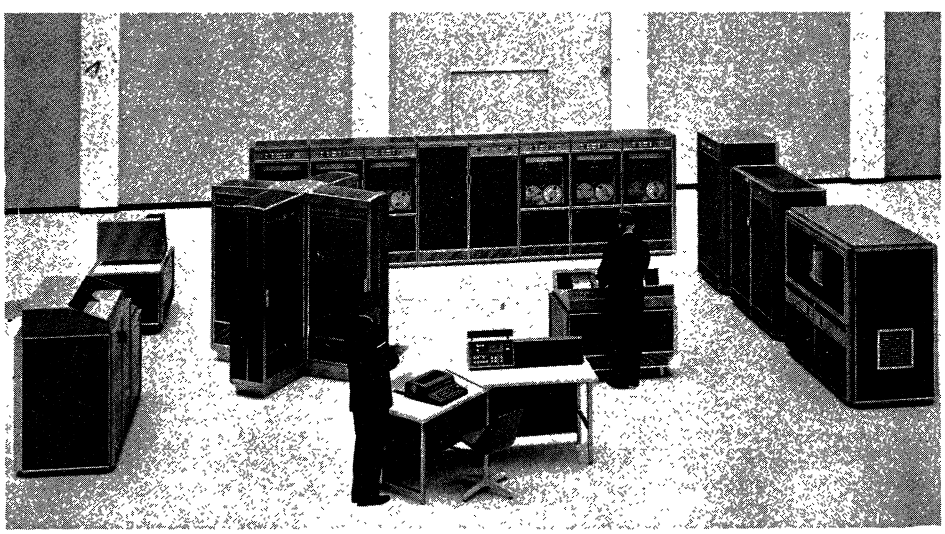

Figure 1. The most powerful of General Electric's medium-scale computers for business and scientific applications is the GE-435. This typical system includes an operating console and card reader, a high-speed line printer, a card punch, the central processor, and magnetic tape and disc storage subsystems.

.2 COMPATIBILITY (Contd.)

Because a large number of IBM 1401 installations are candidates for replacement, strong emphasis is currently being placed by computer manufacturers on hardware and software facilities designed to minimize the amount of reprogramming effort required to convert from an IBM 1401 to a different system. GE presently offers two 1401 compatibility techniques, both aimed at direct simulation.

One method, the IBM 1401 Simulator Program, is a free-standing, core-resident software simulation routine that requires only one control card and a format control loop for the printer in addition to the IBM 1401 object program. This routine handles programs written for IBM 1401 systems with a 1402 Card Read/Punch, a 1403 Printer, up to six magnetic tape handlers, and up to 16,000 positions of core storage.

The 1401 Simulator Program requires a GE-400 Series computer with at least 8,192 core storage locations (32,768 characters) and peripheral devices as needed by the 1401 programs to be simulated. In general, to run a 1401 program, a GE-400 Series system must have about eight times the core storage capacity required on the 1401; e.g., a 4,000-character 1401 program would require a GE-400 Series core storage unit of at least 8,192 word locations. IBM 1401 peripheral devices not mentioned above, and all RPQ items, cannot be simulated. In addition there are some restrictions on the size of operands in multiply and divide operations. GE estimates that execution times for typical programs are from one-half to four times as long on a GE-400 Series computer system using the 1401 Simulator Program as on the original 1401.

The second method for achieving 1401 compatibility is a hybrid hardware-software approach. The 1401 Compatibility Option enables 4,096 24-bit words of a GE-400 Series core storage unit to be addressed as 12,288 8-bit character positions. Six of the eight bits are used for data, the seventh is unused, and the eighth is used as a word mark as in the 1401. With this option, one I/O channel (assigned to a magnetic tape handler) is modified to transfer data between the 8-bit character-addressable locations of core storage and the tape handler connected to that channel. The related software routine utilizes the character-addressable segment of core storage to hold the 1401 object program and simulates the 1401 operations in a manner similar to the 1401 Simulator Program described above.

The 1401 Compatibility Option permits direct execution of 1401 programs using up to 12,000 core positions, a 1402 Card Read/Punch, a 1403 Printer, and up to six magnetic tape units on a GE-400 Series system having at least 8,192 words of core storage and peripheral devices as needed by the 1401 program. The chief advantages of the 1401 Compatibility Option over the 1401 Simulator Program are the reduced core storage requirement and increased performance. In addition, the 1401 Compatibility option allows 1401 programs to be included in the Standard input stack intermixed with programs written directly for the GE-400 system. GE estimates that typical 1401 programs that can be run on a GE-400 Series system with this option take from about one-half to twice the time required by the original 1401. Full advantage of the GE-400 systems' increased internal performance, peripheral speeds, and simultaneity can be obtained only through complete reprogramming.

.3 CENTRAL PROCESSORS

A GE-400 Series computer system has extensive data-manipulating capabilities that make it particularly suitable for many business applications. For example, there are 18 different data transfer instructions, 72 variations of the Shift command, scatter-read and gather-write facilities, two indexing methods, and multilevel indirect addressing. The scatter-gather techniques reduce the need for internal data movement operations and permit tighter packing of data on tape. When combined with indirect addressing, gather-write facilitates sorting and merging by enabling the user to sort only the addresses of data keys instead of the entire data record. The availability of floating-point hardware is the basis of the GE-400's attraction for the scientific user. For the same user, the absence of fast binary multiply and divide instructions will seem a drawback, although this facility is available with floating point hardware.

A GE-400 Series system is capable of a relatively high degree of simultaneity. Up to 12 buffered input-output data channels are available, so that multiple read-write operations can be executed while internal processing continues. In addition, a 400 Series system's random-access and data communications capabilities make it suitable for many real-time processing requirements.

The standard core storage unit is housed in one wing of the GE-400 processor cabinet. Core storage capacities of 8,192, 16,384, and 32,768 words of 24 data bits (plus one parity bit) are available for each member of the GE-400 Series. Extended memories for the 425 and 435 systems are housed in separate cabinets. Extended-memory processors can support from three to eight 16,384-word core storage modules, providing storage capacities for 49K to 131K words. Core storage cycle times per access of one 24-bit word are:

(Contd.)

.3 CENTRAL PROCESSORS (Contd.)

- GE-405: 8.0 microseconds
- GE-415/GE-420: 5.8 microseconds
- GE-425: 3.9 microseconds
- GE-435: 2.7 microseconds.

Each data word can hold four BCD characters, four decimal digits, or a 24-bit binary operand. Instructions are stored in binary form for maximum efficiency.

The central processor is essentially a single-address, fixed word-length, sequential processor. It does, however, have the ability to handle a group of two-address instructions and to manipulate operands that range from one to four words (4 to 16 characters) in length. An adequate complement of instructions is available for manipulating each kind of word format. Both decimal and binary add/subtract instructions are provided, but there are no facilities for fixed-point binary multiply/divide operations, although available with floating point hardware. Business data processing computations will generally be performed in the decimal mode. The decimal multiply and divide instructions are of the single-step variety and require programmed loops to handle multipliers or quotients greater than one digit in length.

Each binary instruction word consists of a 6-bit operation code, a 3-bit address control field, and a 15-bit storage address field. The two-address capability is implemented either by using the address control field to specify a fixed index register which contains the address of the second operand, or by using the next consecutive word in the instruction sequence to specify the second address.

A feature of the processor is the ability to change both the size (one to four words) and location (anywhere in core storage) of the accumulator. Adjusting the accumulator length to fit the data allows faster execution times on shorter fields, while still handling larger fields with one instruction. Tasks of the load-add-and-store type can be accomplished in less time by means of the relocatable accumulator feature.

The Floating Point Option provides a complete set of floating-point and fixed point operations including addition, subtraction, multiplication, division, comparison, shifting, and storing or loading of the fraction and exponent, separately or together. Each floating-point operand is 48 bits long (two core storage locations); the fraction consists of 38 data bits plus sign bit, while the exponent consists of 8 data bits plus sign bit. Thus, the range of numbers that can be represented is approximately $\pm 1 \times 10^{\pm 78}$, with a precision of 11.4 decimal digits. The fixed point operand is 24 bits long.

The floating-point hardware consists of a group of registers and logic circuits housed in an additional wing of the central processor cabinet. The execution of floating-point operations proceeds independently of other processor functions. Thus, the fetch and address modification of the next instruction can be overlapped with the execution time of some of the longer floating-point operations such as multiplication or division. The resultant effective execution times are quite fast relative other systems in this price range. However, no radix conversion instructions are provided; conversions between the BCD format and the binary floating-point format must be accomplished by subroutines. In some applications the cost of these conversions can be very significant.

Address modification can be accomplished by means of six conventional fixed index registers, or through the use of an "address modification sequence" wherein any word in storage can be used as a modifier. Indirect addressing can be specified in conjunction with an address modification sequence. The second address of a two-address instruction cannot be modified but can be determined by a second-address-sequence, which also allows multiple levels of indirect addressing. Savings in total storage space and processing time can be realized through skillful use of these flexible addressing techniques.

The capabilities of a GE-400 Series computer system for operating in a multiprogramming mode or in a remote-inquiry processing mode have been enhanced through the introduction of the Direct Access Option. The features included in this option are Memory Protection, an Interval Timer, a Second-Level Interrupt, a Symbol-Controlled Move instruction, a Non-Stop Mode, and Channel Expansion. The Memory Protection feature provides individual base address and limit registers for core storage and for each I/O channel. In addition, a special mode of operation, the master mode, is implemented. In the normal (user) mode, references by programs to addresses outside their own segments result in interrupts. In the master mode, all of memory is accessible; the base address and limit registers can be altered only in this mode. Separate index registers and control word areas are maintained for each program. Each program area is protected from the effects of an I/O operation initiated by a second program residing in core storage at the same time.

The Interval Timer is program-addressable and is decremented every millisecond; a unique interrupt occurs if the timer is decremented past zero. The Second-Level Interrupt feature allows a peripheral device on a special I/O channel to gain immediate access to memory

.3 CENTRAL PROCESSORS (Contd.)

even if another interrupt is being processed. The Symbol-Controlled Move instruction allows data transfers to be stopped upon recognition of a specified character; this feature facilitates the handling of data fields of unknown or variable lengths. The Non-Stop Mode feature prevents a program in the user mode from halting the processor and thereby inhibiting the recognition of interrupts from another program. The Channel Expansion feature permits up to four additional I/O channels (a total of 12) to be added to a GE-400 Series System. The Symbol-Controlled Move and Channel Expansion features are available separately if desired.

The basic input-output control section of the central processor has the ability to control up to eight peripheral operations concurrently with internal processing. The logic for controlling an additional four channels is provided by the optional Channel Expansion feature. Several types of data channels are available; they differ in maximum data transfer rate and buffering capabilities. All peripherals operate on a priority interrupt basis. The program interrupt facility causes a transfer of control to a fixed core storage location upon completion of an input-output operation, upon occurrence of certain processor conditions, or upon request.

.4 PERIPHERAL EQUIPMENT

Six different models of magnetic tape units are available for use with the GE-400 Series systems, and each is offered in both a 7-track and a 9-track version. Peak data transfer rates range from 7,500 to 160,000 characters per second. All six models are compatible with one another with respect to both programming and tape format. The tape format of the 7-track versions is also compatible with that of the IBM 729 and 7330 tape units in either BCD or binary mode. The tape format of the 9-track versions is compatible with that of the IBM 2400 Series tape units used in the System/360. Tape recording is checked by a read-after-write parity check. Single- and dual-channel controllers are available for handling up to 8 or 16 tape units, respectively. Intermixing of 7-track and 9-track tape handlers on a 9-track controller is permitted. The dual-channel controllers can significantly improve operating flexibility and system throughput by permitting simultaneous read-write, read-read, or write-write operations on any two of the connected tape units.

Punched card equipment includes a 900-card-per-minute reader and 100- and 300-card-per-minute punches for standard 80-column cards. The line printer operates at single-spaced speeds of 949 lines per minute for the full 64-character set or 1,200 lines per minute when a limited set of 46 contiguous alphameric characters is used. A multiple-tape lister has six independent forms-advancing mechanisms and can perform numeric listing at up to 2,000 single-spaced lines per minute. Two special peripheral units are offered for the GE-405 system only: a 600-cpm card reader and a 600-lpm line printer.

A wide selection of mass storage units is now available for GE-400 Series systems. The DSU204 Disc Storage Unit (the only disc file originally announced for the series) contains either 4, 8, 12, or 16 discs. A 16-disc file has a capacity of 23.5 million 6-bit characters, and up to four 16-disc files can be connected to one DSC200 Controller. The controller contains an addressable 1024-character buffer that permits efficient handling of searching and linking operations. Each disc has a separate positioning arm, and average random access time to a disc record is 225 milliseconds. Optionally, four or eight discs can have fixed arms to provide a 26-millisecond average access time to high-priority data.

The DSU160 Removable Disc Storage Drive features replaceable, IBM 1316-compatible disc cartridges that can store up to 7.68 million characters of data. From one to eight drives can be connected to a single controller. There is one access mechanism per drive. The average random access time to any sector is 97.5 milliseconds, and the peak data transfer rate is 208,000 characters per second; this high rate requires the use of a High Speed Data Channel for connecting the DSU160 subsystem to the processor.

The DSU270 Disc Storage Unit is a high-performance disc storage unit. One to twenty File Units comprise a subsystem that provides a maximum storage capacity of 307 million characters. The read/write mechanism of the DSU270 is of the fixed-head-per-track design. Average access time to all disc locations is 26 milliseconds, and the peak data transfer rate is 333,000 characters per second. A High Speed Data Channel is required to connect this subsystem to a GE-400 Series processor.

The MSU388 Mass Storage Unit uses the RCA "RACE" unit with a controller manufactured by GE. This subsystem provides economical on-line random-access storage for extremely large volumes of data in applications where relatively slow access times can be tolerated. The average random access time is approximately 400 milliseconds. As used in the GE-400 Series, the capacity of each MSU388 is 340 million 6-bit characters. Up to four MSU388 drives can be connected to a single controller, providing a storage capacity of 1.357 billion characters per subsystem. Peak data transfer rate is 80,000 characters per second.

(Contd.)

.4 PERIPHERAL EQUIPMENT (Contd.)

The DATANET-30 Data Communications Processor can be connected to a GE-400 Series system to provide access to a communications network and handle simultaneous input-output from many remote stations. In addition, the DATANET-20 and DATANET-21 Single Line Transmission Controllers can handle data communications on a single-line basis. In this case, an operator can dial any remote station using a digital subset, or an Automatic Calling Unit can enable the computer to initiate the call, send data, and terminate the call.

The DATANET-760 Display Terminal (see Section 6321 of AUERBACH Data Communications Reports) is also available for GE-400 Series systems. This device provides local or remote alphanumeric or graphical displays.

GE-115 computer systems (Report 310) can be connected, via communications links, to a GE-400 Series system. The GE-115 is a small-scale, 8-bit-character-oriented system manufactured by Olivetti-GE in Italy. Peripheral equipment available for the GE-115 includes card readers, card punches, printers, paper tape readers and punches, and a small-capacity, removable-cartridge disc storage unit.

.5 SOFTWARE

Four programming systems are offered for use with the GE-400 Series. A GE programming system consists of an operating system, language translators, and miscellaneous service routines suitable for a particular purpose and generally requiring a specified hardware configuration for efficient operation.

MTPS, the Magnetic Tape Programming System, includes a single-task Basic Operating System (BOS/MT), an Extended Operating System (EOS/MT) capable of handling up to six additional tasks, BAL, MAP, COBOL, and two versions of FORTRAN. (The characteristics of the GE-400 Series language processors are summarized below.) MTPS requires a minimum of 8K words of core storage. The Card Operating System for the GE-400 Series is loaded via cards rather than a system tape.

DPS, the Disc Programming System, includes a Basic Operating System (BOS/Disc), an Extended Operating System (EOS/Disc) capable of controlling three additional tasks, BAL, MAP, COBOL, RPG, and ASA FORTRAN. DPS requires a minimum of 16K words of core storage.

TSPS, the Time-Sharing Programming System, includes TSOS (Time-Sharing Operating System), BASIC, and ASA FORTRAN. COBOL is not currently available in the time-sharing system. A GE-415 with 32K words of core storage, a DATANET-30, and the DAP930 Direct Access Option is required for a time-sharing system. Extended Memory modules are at present not recognized by the operating system.

In addition, the following programs and programming systems are provided by GE. Except where otherwise noted, the software is currently available:

- The Macro Assembly Program (MAP) is the basic symbolic programming system for the GE-400 Series. It consists of the Basic Assembly Language (BAL), which is machine-oriented and supplies assembly-control pseudo-operations, and the Macro Assembly Program language, which is field-oriented and uses COBOL-like data descriptions and sequencing. The Macro Assembly Program language supplies macro-instructions for communication with the Basic and Extended Input-Output Systems, which facilitate the coding of input and output operations. Macro-instructions for arithmetic, data movement, and procedure control operations help to minimize the amount of tedious hand coding that must be done and reduce coding errors. At least 8,192 words of core storage, 4 magnetic tape units, card reader, punch, and printer are required for MAP assemblies.
- The GE-400 Series COBOL compiler can translate source programs that use all of Required COBOL-61 and selected elements of Elective COBOL. Equipment required for COBOL compilation is the same as for the Macro Assembly Program.
- A Basic FORTRAN IV Compiler, first available in June 1965, facilitates the programming of scientific applications. The principal restriction upon this version of FORTRAN IV is the lack of capabilities for handling complex, logical, and double-precision operations. Equipment requirements are the same as the Macro Assembly Program.
- An ASA FORTRAN Compiler is fast (approximately 500 average statements compiled per minute on a GE-435) and capable of handling real, integer, logical complex and double-precision operations. ASA FORTAN is coded for both tape and disc systems. The Time-Sharing ASA FORTRAN has all the capabilities of the tape and straight disc versions mentioned above except double-precision operations. Moreover, it offers free-field I/O.

.5 SOFTWARE (Contd.)

- The IBM 1401 Simulator Program and the IBM 1401 Compatibility Option routine enable a GE-400 Series computer system to run IBM 1401 object programs. See Paragraph .2, "Compatibility," for descriptions of these two simulation methods.
- The Tape Operating System is an integrated set of three routines: the Program Monitor, Loader, and I/O Supervisor. The Program Monitor can speed up run-to-run changeovers in both debugging and production operations. In the debugging function, the System Tape, which contains all language processors and debugging aids, is used as the operating tape, providing a "compile and run" capability. The Program Monitor can also use a library tape of production programs as the operating tape.
- The Card Operating System provides all the facilities of the Tape Operating System except the System Tape; language translations cannot be performed while using this version of the Operating System.
- The Report Program Generator (RPG) provides for the preparation of reports or records from files on punched cards, punched tape, or magnetic tape. Output may be assigned to magnetic tape, printer, and/or card punch.
- The GE-400 Series Sort and Merge Generators produce programs for efficient sorting and merging of magnetic tape files. User-coding options permit pre-sort and post-sort editing.
- Service routines for debugging, program library maintenance, media conversion, recovery for reruns, program loading, and other utility functions are available.

One of the important strengths of the GE-400 Series is its rich selection of packaged application programs, some of which are listed below:

IDS — Integrated Data Store
IDS/COBOL for Index Sequential Management Systems
IDS — Batch Sort
IDS — File Restructuring System
MLRD — Multiple Linear Regression
ANOV — Analysis of Variance
FACS — Flexible Accounting Control System
Transportation Package
Linear Programming Packages
Numerically-controlled Machine Tool Packages
CPM — Critical Path Method
CPM/Monitor
ASTRA — Automatic Scheduling Program
SIGMA — Status Analysis of Elastic Structural Systems
Traverse Analysis — Survey Traverses
Curved Bridge Geometry
Slope Stability Analysis System
Retaining Wall Design
Composite Beam Analysis
Horizontal Geometry
Earthwork Analysis
Transient Electrical Stability Programs
B-matrix Loss Formulas
Load Flow Programs
Electrical Fault Programs
Expandable Machine Accounting Simulator
Simcon-Scientific Inventory Management & Control
GE Parts Explosion System
Automated Costing and Estimating
Payroll Packages
Accounts Receivable
Purchasing, Receiving & Accounts Payable
Document Handler Lister
Magnetic Tape Reporting for IRS
Mortgage & Installment Loan Accounting
Bond Portfolio Analysis
Savings Account Transactions
Corrugator Scheduler Program
GE CAST — Time Series Forecasting

GE-400 SERIES

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Units and Core Storage(1)			
			GE-405:			
	*CPU405		GE405 Central Processor (4,096-word memory)	1,800	75,540	158
	*AMM405		Additional Memory (4,096 words)	800	34,400	52
			GE-415:			
	*AMM405A		Additional Memory (4,096 words; second addition)	250	9,700	48
	CPU415		Central Processor (8,192-word memory)	2,135	94,620	158
	AMM415		Additional Memory (8,192 words; first addition)	1,250	55,400	92
	AMM416		Additional Memory (16,384 words; second addition)	1,250	55,400	92
			GE-425:			
	CPU425		Central Processor (8,192-word memory)	3,120	138,500	231
	AMM425		Additional Memory (8,192 words; first addition)	1,250	55,400	92
	AMM426		Additional Memory (16,384 words; second addition)	1,460	64,600	107
	CPU427		Central Processor (for expanded-memory GE-425 configuration)(2)	2,990	132,900	222
			GE-435:			
	CPU435		Central Processor (16,384 word- memory)	5,111	230,000	420
	AMM436		Additional Memory (16,384 words)	1,875	73,440	150
	CPU437		Central Processor (for expanded-memory GE-435 configuration)(2)	5,715	254,000	424
			Main Memory for CPU427, CPU437, and CPU440:			
	MSM416		Main Storage Module (16,384 words; maximum of two per CPU427, CPU437 or CPU440)	1,870	83,120	139
	ASM416		Additional Storage Module (16,384 words; maximum of three per MSM416)			
			GE-430:			
	CPU430		GE-430 Time-Sharing Central Processor (8,192-word memory)(3)	4,200	186,700	312
			GE-440:			
	CPU440		GE-440 Time-Sharing Central Processor(4)	7,000	311,200	519
			Central Processor Features			
			GE-405:			
	*CMP405		IBM 1401 Compatibility	200	8,150	23
	*TDC405		Time of Day Clock	115	4,930	8
			Other 400 Series Processors:			
	CM6051		1401 Compatibility Module	315	13,850	23

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			IDENTITY OF UNIT	PRICES		
			Central Processor Features (Contd.)			
PROCESSOR (Contd.)	TC6012		Time of Day Clock	115	5,080	8
	DAP930		Direct Access Package (Includes memory protect, interval timer, symbol controlled move, and provision for channel expansion)	315	13,850	23
	SM6010		Symbol Controlled Move	68	3,000	5
	FP6015		Floating Point Hardware for CPU415	365	16,160	27
	FP6025		Floating Point Hardware for CPU425, CPU427 and CPU430	470	20,770	35
	FP6035		Floating Point Hardware for CPU435, CPU437 and CPU440	575	25,390	42
ATTACHMENTS, ADAPTERS, AND CHANNELS			I/O Channels			
			Character, word, and doubleword channels are available as needed without extra charge except for channel expansion feature for more than eight channels. A special channel for the MICR Reader/Sorter is available at no extra charge. The High Speed channels are priced separately.			
	*CEF405		Channel Expansion (GE-405)	80	3,410	6
	CE6010		Channel Expansion (other GE-400 series systems)	130	5,770	10
	HC6012		High Speed Channel (for all except GE-405)	260	11,540	19
MASS-STORAGE AND INPUT-OUTPUT			The GE-400 Series computer system share a common set of peripheral devices with the GE-600 Series systems; these are shown in the GE-600 Series Price Data. The GE-405 cannot accommodate the following peripherals: DSU270 File Storage Unit MDU200 Magnetic Drum Unit MSU388 Mass Storage Unit DSU160 Disc Storage Subsystem			
COMMUNICATIONS	SLC401		DATANET-20 Single Line Controller (asynchronous)	290	12,230	41
	SLC402		DATANET-21 Single Line Controller (synchronous)	315	13,340	45
	SLC403		DATANET-21 Single Line Controller (synchronous)	390	16,670	55

NOTES:

* No longer in production.

(1) Field changes from one memory size to another or from one processor model to another are normally ordered from a list of CPC options.

(2) CPU427 and CPU437 require DAP930 Direct Access Package. They use MSM416 and ASM416 memory modules. Minimum memory allowable for these two processors is 49,152 words.

(3) GE-430 requires 32,768 words of memory. Additional memory modules for the GE-430 are the same as those for the GE-425; i.e., AMM425 and AMM426.

(4) GE-440 require 65,536 words of memory. The CPU440 uses the MSM416 and ASM416 memory modules.

REPORT UPDATE

▶ GE INTRODUCES NEW ADDITION TO GE-600 SERIES FAMILY

The recently-announced GE-615 represents GE's latest entry in the medium-scale computer market, expanding the options of users of the GE-600 Series. The new system is essentially a slower and less-expensive GE-625 system.

All of the peripheral equipment available to the larger GE-600 Series systems can be used on the GE-615. Compatability is emphasized. Like the GE 625/635 systems, the GE-615 operates in three concurrent modes: multiprogrammed, local and remote batch processing, and time-sharing. Overall system control is offered by the General Comprehensive Operating System (GECOS III).

The GE-615 is available in memory sizes of 65,536 to 262,144 36-bit words in 32,768 word increments. The memory cycle time is 2 microseconds per access of one 36-bit word, as contrasted with the 2-microsecond cycle time for a two-word fetch on the GE-625 and with the 1-microsecond cycle time for a two-word fetch on the GE-635.

A system configuration consisting of a 65,536 word memory, 30 million characters of disk storage, a card reader and punch, eight magnetic tapes, a 1200-line-per-minute printer, and a console typewriter rents for approximately $30,000 per month.

The first deliveries of the GE-615 are expected in June, 1969.

REPORT UPDATE

MULTIPLE-DRIVE DISK SUBSYSTEMS INTRODUCED

GE has recently introduced two new mass auxiliary storage subsystems for use with the GE-600 Series systems. The DSS-167 and the DSS-170 Disk Storage Subsystems are similar in design to the IBM 2314 in that the subsystems contain multiple, removable storage disc drives. The disc packs used with both systems have eleven-high disc stacks as contrasted with the six-high stacks in the DSS-160 packs used with the GE-100 and GE-400 Series.

The DSS-167 provides 90 million six-bit characters of storage, expandable to 120 million; the DSS-170 has a 200 million character storage capacity. Access time for both systems is 75 milliseconds, and there is simultaneous seek overlays. The DSS-167 transfer rate is 208,000 characters per second, which is doubled with the 416,000 character per second transfer rate of the DDS-170.

Deliveries of the new units are scheduled to begin by July 1970. The following prices will be charged for the two subsystems:

	Monthly Rates	Purchase Price	Monthly Maintenance
DSS-167 Removable Disc Storage Subsystem 90 million characters	$3,185	$136,080	$375
ADC-167 Additional Data Channel (non-simultaneous)	185	8,230	14
DEP-167 Fata File Protect	52	2,320	4
STC-167 Stack Command	15	720	1
DCA-167 Disc Controller Adapter	NC	NC	-
ADU-167 Additional Disc Unit, 30 million characters	675	28,800	80
DSS-170 Removable Disc Storage Subsystem 200 million characters	5,675	256,400	705

SUMMARY: GE-600 SERIES

.1 SUMMARY

The GE-600 Series represents the General Electric Company's current entry in the large-scale computer field. Operating under the control of a sophisticated operating system, the General Comprehensive Operating Supervisor (GECOS III), the GE-625 and GE-635 systems offer formidable competition for such systems as the IBM System/360 Models 50 and 65, the Control Data 6400, and the UNIVAC 1108.

A "three-dimensional" approach, designed to facilitate concurrent local and remote batch processing with time-sharing in a multiprogramming and multiprocessing environment, underscores GE's determination to satisfy the needs of virtually any large-scale computer application and to improve its competitive position in the industry.

The GE-625 and GE-635, announced in May 1964, share all components except core storage, and their performance and prices are quite similar. The GE-625 operates at a cycle time of 2 microseconds per pair of 36-bit words, while the GE-635 has a 1-microsecond core storage cycle time. A typical configuration, operating under GECOS III and including 20 magnetic tape units and random-access drum storage carries a monthly rental of $54,275 for the GE-625 and $55,400 for the same configuration with GE-635 memory modules. Customer deliveries of the GE-600 Series systems began in April 1965.

Specialized GE-600 Series models designed for military procurement include a militarized version of the GE-625 (the M-625) and the M-605, which is similar to the M-625 but lacks floating-point and double-precision hardware.

In December 1965, GE announced the GE-645, a large-scale computer system specifically designed for multiple-console, time-shared operation. The formal announcement of the GE-645's commercial availability had been anticipated since GE's prior announcement, months earlier, of the receipt of orders for prototype time-sharing systems from Massachusetts Institute of Technology, Bell Telephone Laboratories, and Ohio State University. The GE-645 is still in the research and development stage and is not currently being marketed.

The characteristics of the GE-645 hardware and the associated MULTICS (Multiplexed Information and Computing Service) programming system have been the subject of considerable interest throughout the computer industry. The design of the GE-645 and its supporting software has been largely a joint effort among the GE Computer Division, MIT, and Bell Telephone Laboratories. The GE-645's design is based on that of the GE-635, with several improvements to facilitate time-shared operation. The most significant change is a different form of addressing logic that incorporates segments and pages to permit efficient dynamic reallocation of memory. Other improvements include changes in the interrupt logic, a redesigned input-output control unit, and 2- to 4-way interleaving of memory accesses.

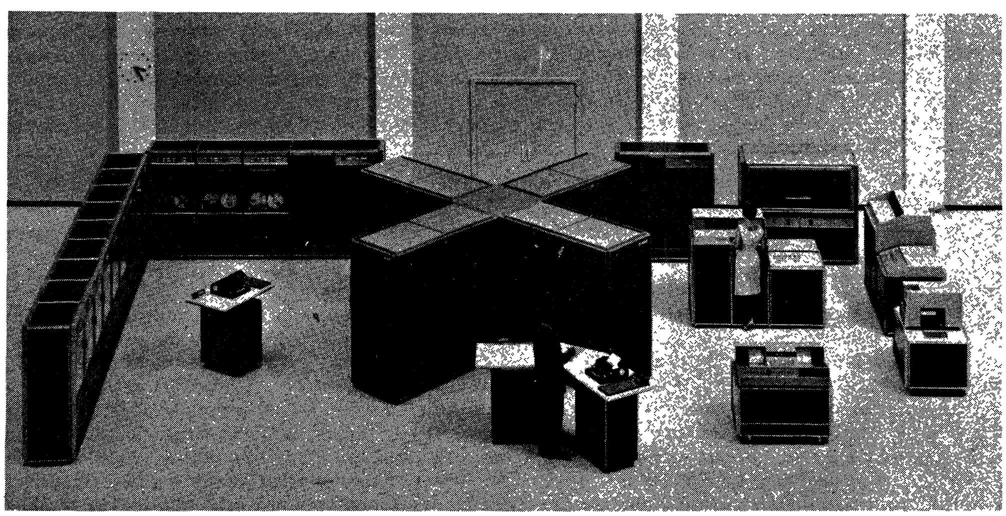

Figure 1. A typical GE-625 computer system configuration.

.1 SUMMARY (Contd.)

The GE-645 uses core storage that can range in size from 32,768 to 1,048,576 36-bit words. Core storage cycle time is 1 microsecond per pair of 36-bit words. Monthly rental prices for GE-645 systems range from about $40,000 to $250,000, with typical systems renting for about $90,000 per month.

An analysis of the GE-645 will be published in AUERBACH Standard EDP Reports as soon as possible after detailed specifications are made available by GE.

The remainder of this report is devoted exclusively to the two commercially available members of the series, the GE-625 and GE-635.

.2 HARDWARE

A GE-625 or GE-635 computer system includes four major types of components: Processor Module(s), Memory Module(s), Input/Output Controller Module(s), and peripheral devices. These components, and the configuration rules for combining them, are described in the paragraphs that follow.

.21 Processor Module

The GE-600 Series Processor Module uses a single-address instruction format and has a wide range of address modification capabilities, including various combinations of indexing and indirect addressing. There are two basic modes of processor operation: master mode and slave mode. Control programs will normally be executed in the master mode, and the user's object programs in the slave mode. Programs running in the master mode have access to the entire core memory, can initiate peripheral and internal control functions, and do not have base address relocation applied. Programs running in the slave mode have access to a limited portion of the memory (as specified by the Base Address Register), cannot initiate peripheral control instructions, and have the contents of the Base Address Register added to all relative memory addresses of the object program. The processor is automatically put into the master mode of operation when the Master Mode Indicator is set or when any interrupt is recognized. In a system having multiple Processor Modules, one is designated the control processor. Only the control processor, operating in the master mode, can respond to I/O interrupts.

Instructions are fetched in pairs — an even word and the successive odd word. Address modification, operand fetching, instruction execution, and fetching of the next pair of instructions are overlapped to increase processor performance wherever possible. Indexing does not increase the instruction execution times, but indirect addressing does.

Processor registers include a timer register, eight index registers, an indicator register, an instruction counter, a 72-bit accumulator (which can also be used as two independent accumulators or four independent index registers), an exponent register for floating point operations, and the Base Address Register mentioned above.

A total of 175 basic instructions are available, most of which will be familiar to programmers of other large-scale binary computers. The instruction repertoire includes comparisons (logical, algebraic, magnitude, masked, and between limits), loading, storing, Boolean operations, branching, and shifting instructions. Provision is made for the use of half-word, single-word, or double-word operands in many operations.

Floating-point operations include single or double precision loading, storing, comparison, addition, subtraction, multiplication, and division. Floating-point numbers are represented by a mantissa of 28 bits (single precision) or 64 bits (double precision) and a binary exponent of 8 bits. Both the exponent and mantissa are represented in two's complement notation. Single precision is equivalent to about 8 decimal digits, and double precision to 19 decimal digits.

Several special instructions can reduce programming effort and increase efficiency by facilitating the processing of lists of data and the coding of routines that require multi-word precision. There are, however, no editing instructions, no code translation instructions other than Gray to binary, and no radix conversion instructions other than a one-digit-at-a-time binary to BCD instruction.

Interrupt processing is handled by GECOS III, the standard supervisory routine. Machine or program error conditions are regarded as system "faults", and when these situations occur, a GECOS III master-mode control program can swap out the current job and call in another one in order to maintain continuous on-line operation. Remedial action is always attempted. Certain faults, such as arithmetic overflow or memory parity error, can be masked to allow processing to continue. Other faults, such as time runout, memory address violation, illegal operation code, machine lockup, etc., are non-maskable and will halt processing on the current job. The status of the location counter and indicators are stored in a fixed control supervisor area before transferring to the applicable fault routine.

(Contd.)

.22 Memory Module

The two general-purpose members of the GE-600 Series, the GE-625 and the GE-635, differ only in the speed of their core storage units. The GE-625 uses a core memory with a cycle time of 2 microseconds; the GE-635 uses a unit with a 1-microsecond cycle time. Each access, in both systems, is for a word-pair (two 36-bit-plus-parity words).

Up to 262,144 36-bit words of core storage can be incorporated in a single-processor GE-600 Series system, in modules of 32,768 words.

The Memory Module is the heart of every GE-600 Series system. Each Memory Module is composed of a System Controller and one to four 32K modules of core storage, and is an independent unit capable of being accessed simultaneously with other Memory Modules.

The System Controller performs many of the priority and control functions in a GE-600 Series system. Among these functions are:

- Control of communication between memory and the central processor and between memory and the I/O Controller.
- Control of input-output interrupts for multiprocessor systems, system programs, and peripheral devices.
- Switching of control signals, addresses, and data to and from the Memory Module.

Each System Controller has eight "memory ports" (channels) for connection to Processor Modules, I/O Controller Modules, or non-standard peripheral devices.

.23 Input/Output Controller Module

The I/O Controller is a small processor containing the necessary logic circuits for independent handling of all I/O operations once a connection to a Memory Module has been established. The I/O Controller uses information from the supervisory area of core memory to indicate the input or output area of memory. It also performs an address check to prevent an I/O operation from either reading or writing in an area outside the proper program area. An I/O Controller can have up to 16 input-output channels: 10 standard-speed (up to 25,000 characters per second) and 6 high-speed (up to 400,000 characters per second). Each I/O Controller can access up to four Memory Modules, and each Memory Module can be connected to up to four I/O Controllers, providing the capability for connecting a large number of peripherals on-line to a GE-600 Series computer system.

TABLE I: GE-600 SERIES PERIPHERAL SUBSYSTEMS

Required I/O Channels		Subsystem
No.	Minimum Channel Rate	
1	25KC	CRZ201 Card Reader — 900 cpm
1	25KC	CPZ100 Card Punch — 100 cpm
1	25KC	CPZ200/201 Card Punch — 300 cpm
1	25KC	PRT201 Printer — 1200 lpm
1	25KC	PTP200 Perforated Tape Punch — 100 char./sec.
1	25KC	PTR200 Perforated Tape Reader — 500 char./sec.
1	25KC	PTS200 Perforated Tape Reader/Punch
1	200KC	Single-channel Magnetic Tape Subsystem (1 to 8 magnetic tape units) — 7,500 to 160,000 char./sec.
2	200KC	Dual-channel Magnetic Tape Subsystem (1 to 16 magnetic tape units) — 7,500 to 160,000 char./sec.
1 or 2	400KC	DSU270 Disc Storage Unit (15.3 million chars.) — 26 msec average access time
1	200KC	DSU200 Disc Storage Unit (23.6 million chars.) — 225 msec average access time
1	400KC	MDU200 Magnetic Drum Unit (4.66 or 9.32 million chars.) — 17 msec average access time
1	200KC	MSS388 Mass Storage Subsystem (680.0 million chars.) — 430 msec average access time
1	25KC	DATANET-30 Data Communication Processor
1	25KC	Console with Typewriter

.24 Peripheral Equipment

The peripheral devices currently available for the GE-600 Series computers are listed in Table I, along with the number of high-speed or standard-speed input-output channels required for each subsystem.

.25 System Configuration

Configuration rules for the GE-600 Series Components can be summarized as follows:

- Each Processor Module can be connected to 1 to 4 Memory Modules.
- Each Memory Module can be connected to a total of up to 4 Processor Modules and 4 I/O Controller Modules. Up to 262,144 words of core storage can be incorporated in a single-processor system.
- Each I/O Controller Module can be connected to 1 to 4 Memory Modules and can have from 3 to 6 high-speed and from 5 to 10 low-speed input-output channels.

.3 Software

General Electric is providing a well-integrated line of software for the 600 Series that includes:

- General Comprehensive Operating Supervisor (GECOS III) — This is a master control routine, and all activities of a GE-600 Series computer system are normally carried out under its control. GECOS III has provisions for receiving job programs from a card reader or from a program library, scheduling, allocation of peripherals and memory, and communication with the operator. It can control the execution of up to 63 programs concurrently in a multiprogramming mode. Scheduling is based on priority and peripheral availability. Communication with GECOS III is handled through control cards or the console typewriter.

  Introduced in November 1967, GECOS III includes all the facilities of its predecessors, GECOS I and II, plus numerous improvements. An on-line, tree-structured, hierarchial file system is provided, with file protection and access control. Serial magnetic tape processing can be simulated on disc or drum. An elaborate accounting system accounts for all of the time spent by each processor and peripheral device. All input-output requests, as well as activities and jobs, are queued according to a priority scheme. An on-line peripheral test system runs concurrently with other system programs. Core storage is allocated dynamically with memory protection control.

  Jobs may be entered from remote terminals, with concurrent local and remote batch processing. The Time-Sharing Executive (a specialized control routine of GECOS III) supervises and controls from one to three DATANET-30 Data Communications Processors.

- General File/Record Control (GEFRC) — This is the control routine that will usually be used by programmers specifying input-output operations. It permits all input-output data to be regarded by the programmer in terms of files, and frees the programmer from tedious coding of input-output operations. File Specifications in the user's programs specify record sizes, blocking, and other information. (They are produced automatically by the COBOL and FORTRAN compilers.) The device assigned to each file at execution time depends upon the content of the File Control Card submitted at load time, providing a degree of freedom from the need for specific types of peripheral devices.

- General Loader — The functions of the General Loader include: (1) loading programs from the magnetic drum (or disc) into core storage when they have been scheduled to run; (2) relocating subprograms into a contiguous area of memory and setting the required linkages; and (3) loading overlay segments and setting up the required linkages. The General Loader can also cause debugging facilities to be incorporated at load time.

- General Remote Terminal Supervisor (GERTS) — GERTS is the control program for handling jobs from remote terminals. It accepts jobs, stores them on the magnetic drum (or disc), and submits them to GECOS for execution based on a priority transmitted with the job.

(Contd.)

.3 Software (Contd.)

- MACRO Assembler (GMAP) — GMAP is the symbolic assembly language for the GE-600 Series. The prime feature of GMAP is its extensive macro capabilities.
- COBOL — GE-600 Series COBOL incorporates all of Required COBOL-61, most of optional COBOL-61, and the SORT and Report Writer facilities of Extended COBOL-61. The implemented features of Elective COBOL-61 include the CORRESPONDING option of the MOVE verb and the COMPUTE, ENTER, and USE verbs.
- FORTRAN — This is a standard implementation of the IBM 7090/94 FORTRAN IV language, with a few extensions. Capabilities for debugging and variable-field input and output are featured.
- SORT/MERGE — The GE-600 Series Sort/Merge routine accepts input from magnetic drum, disc, or tape and will produce output to any of the same devices. Sorts can be performed on numeric or alphanumeric keys, with the individual fields of a key in either ascending or descending order.
- Bulk Media Conversion — The Bulk Media Conversion routine is contained in the system library and can be called by control cards. Conversion capabilities include punched card to magnetic tape or disc; perforated tape to disc; magnetic tape to printer or punched card; and disc to punched card or magnetic tape.
- Mathematical Routines — An extensive library of mathematical routines includes trigonometric, exponential, and logarithmic function evaluation, matrix manipulation, curve fitting, and polynomial root determination.
- Service Routines — An integrated set of service routines is provided for file maintenance, software maintenance (updating of system or user's compilers or programs), and diagnostics.
- Integrated Data Store (I-D-S) — This routine provides the capability for organizing files on a disc storage unit in a non-sequential manner. Individual detail records are linked together to form chains. A record can belong to more than one chain, effectively eliminating the need to store duplicate information. Macro operations are provided for obtaining a record to be processed, for storing and linking a processed record, and for deleting a record. I-D-S can be used to provide mass storage facilities for COBOL or assembly-language programs for any GE-600 Series computer system that includes a disc storage unit.
- GE-225 Simulator — This routine simulates the operations of GE-225 systems on a GE-625 or GE-635.
- IBM 1401 Simulator — This routine simulates the operations of IBM 1401 systems on a GE-625/635. Provision for IBM 1401 simulation was desirable because of the number of IBM 7090/7094 installations that use IBM 1401 systems as satellites for performing data transcription and edit/print operations. IBM 7090/7094 installations are likely prospects for GE-625/635 equipment because of the hardware/software simulation offering described in the following Compatibility section.

.4 COMPATIBILITY

General Electric has a hardware/software simulation system that enables IBM 7090/7094 object programs to be run with little, if any, alteration on a GE-625 or GE-635 computer system. The "7094 Simulator Aid" (or 9SA) is a hardware device that serves as an auxiliary central processor unit, containing the same number and types of accumulators and registers as the simulated IBM 7090 Series processor. The 9SA feature can directly execute many 7090 instructions. GE provides a series of subroutines that will perform all requests for multiply, divide, floating-point, and input-output operations. The software subroutines that handle I/O operations act as an interface mechanism with the General File Record Control (GEFRC) I/O system that operates under control of GECOS III. GE states that the IBM 7090 Series object programs run on a GE-600 Series computer system will produce results identical to those obtained on the simulated computer.

The IBM 7044 can also be simulated on a GE-625/635 computer system with the aid of the same hardware facility — 9SA. IBM 7044 instructions that cannot be directly executed by 9SA are performed by software subroutines.

There is no direct machine-language program compatibility between the GE-600 Series and the smaller GE-100, 200, or 400 Series computer systems, all of which have different word lengths and instruction repertoires.

GE-600 SERIES

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSORS			Central Processing Unit (GE-625/635)			
	CP8030		Central Processor Unit (includes 1 CPU Port)	10,400	480,000	680
	CP8030		Central Processor Unit, Dual (includes 1 CPU Port for each processor)	18,720	864,000	1,224
		OPT809	CPU Port (maximum of 3 additional per processor)	73	3,360	5
		SA8030	7090/7094 Simulator Aid	4,160	192,000	272
			Main Storage (GE-625/635)			
	MM8038		GE-625: 32,768 Words with Controller (2-microsecond cycle time; includes 2 Memory Ports)	6,085	280,800	398
	AMM601		GE-625: Additional 32,768 Word Memory (2-microsecond cycle time)	4,025	185,800	264
	MM8030		GE-635: 32,768 Words with Controller (1-microsecond cycle time; includes 2 Memory Ports)	6,760	312,000	442
	*MM8032		GE-625: 40K Memory with Controller (2-microsecond cycle time)	7,020	324,000	460
	AMM600		GE-635: Additional Memory Module, 32,768 words (1-microsecond cycle time)	4,475	206,400	292
	AM8030		Auxiliary Memory, 32,768 words (1-microsecond cycle time)	4,475	206,400	292
		OPT802	Memory Port (up to six additional)	84	3,840	5
		OPT815	Execute Interrupt	105	4,800	7
	*MM8033		GE-635: 49K Memory with Controller (1-microsecond cycle time)	7,800	360,000	510
		*OPT800	Additional 24K Memory (1-microsecond cycle time)	5,620	259,200	368
			Central Processing Unit (GE-645)			
	CP8031		645 Central Processor with one Memory Port Pair	14,560	672,000	952
		CPP600	Processor Port Pairs for CP8031	260	12,000	17
			Main Storage (GE-645)			
	MM8040		32,768 Words with GE-645 System Controller (1-microsecond cycle time)	6,760	312,000	442
		REC600	Reconfiguration Option for MM8040	85	3,840	6
		CAB601	Auxiliary Cabinet for 32/64K Memory extension and clock/switch options	260	12,000	17
		AUM600	32,768 Words (1-microsecond cycle time; first memory module installed in CAB601)	4,475	206,400	292
		AMM600	Additional Memory Module (32,768 words 1-microsecond cycle time; second memory; module installed in CAB601)	4,475	206,400	292
		OPT802	Memory Port (up to 6 additional)	84	3,840	6
		OPT815	Additional Interrupt Cells	105	4,800	7
		CLK600	Optional GE-645 System Clock with time of day and alarm interrupt features	760	35,000	50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSORS (Contd.)			Main Storage (GE-645) (Contd.)			
		MSW600	Memory Switch	50	2,250	3
	EMU302		Extended Memory Unit (24 million characters)	12,430	531,200	1,328
	EMC302		Controller for EMU302 (includes 2 memory ports)	NC	NC	NC
	MCU302		Cooling Unit for EMU302	NC	NC	NC
	APP302		Additional Port pairs for EMC302	260	12,000	30
			Processing Unit Options (GE-625/635)			
	CO8030		Master Console	420	19,200	28
	CO8031		Auxiliary Console	390	18,000	28
	ST8030		Console Storage	31	1,440	2
			Processing Unit Options (GE-645)			
	SCC600		System Control Console (permits semiautomatic system reconfiguration)	600	27,700	139
ATTACHMENTS, ADAPTERS, AND CHANNELS			Input-Output Channels (GE-625/635)			
	DC8032		Input-Output Controller (IOC) (includes one Memory Interface Port)	5,620	259,200	368
	CH0500		Additional Peripheral Channel Package (five 25kc channels)	260	12,000	17
	CH0030		Additional Peripheral Channel Package (three 400kc channels)	315	14,400	20
	CH0530		Additional Peripheral Channel Package (five 25kc and three 400kc channels)(1)	575	26,400	37
	MIP601		Additional Memory Interface Port	84	3,840	5
		OPT806	Additional Peripheral Channel, 25kc (maximum of 5 extra)	52	2,400	3
		OPT811	Additional Peripheral Channel, 200kc (maximum of 3 extra)	105	4,800	7
			Input-Output Channels (GE-645)			
	DC8031		645 Generalized I/O Controller (GIOC) includes one memory Port pair, four status channels, two priority level groups, one HPC600, one IPA with six IPC, and one CAB600.	5,620	259,200	368
	MIP600		GIOC Port Pairs	260	12,000	17
	PLP600		Priority level modules, 12 level	65	2,880	3
	CAB600		Adapter Cabinet	990	45,600	65
	AMA600		GIOC Adapter Maintenance Aid	NC	NC	NC
	IPA600		Indirect Peripheral Adapter	600	27,600	39
	IPC600		Indirect Common Peripheral Channel for IPA600 (maximum of 6 per IPA600)	35	1,440	2
	HPC600		Direct Common Peripheral for GIOC	680	31,200	46
	CAA600		Character Asynchronous Adapter for GIOC	195	8,800	10
	CAC600		Character Asynchronous Channel for CAA600	85	3,840	5
	CSA600		Character Synchronous Adapter for GIOC	195	8,800	10
	CSC600		Character Synchronous Channel for CSA600	85	3,840	5
	DGA600		Dialing Adapter for GIOC	130	6,000	9
	DGC600		Dialing Channel for DGA600	35	1,440	2
	TTA600		Teletypewriter Adapter (includes Teletype speed options of 45.5, 50, 56.9, 74.2, 110, 133.2, 150, and 165 bits/sec)	420	19,200	29
	TTC600		Teletypewriter Channel Group for TTA600	125	5,760	9
	TTL600		Teletypewriter Channel Extensions	65	2,880	2
	DDA600		Direct Disc Adapter (for DSC11F)	680	31,200	52
	CDA600		Custom Direct Adapter	2,325	55,000	92

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Contd.)			Motor Generators			
	MG8030		M. G. Set, 31.3 KVA, 60 Cycle, 220/440 V.	265	12,190	30
	MG8031		M. G. Set, 62.6 KVA, 60 Cycle, 440 V.	320	14,590	36
	MG8032		M. G. Set, 62.6 KVA, 60 Cycle, 480 V.	320	14,590	36
	MG8033		M. G. Set, 62.6 KVA, 50 Cycle, 380 V.	340	15,600	39
	MG8034		M. G. Set, 62.6 KVA, 60 Cycle, 208 v.a.c. input	320	14,590	36
		OPT825	Power Sequencer, 60 Cycle	17	770	1
		OPT826	Power Sequencer, 50 Cycle	21	960	1
			Peripheral Switches			
	PSC200		Manual Peripheral Switch Console (includes one OPT510)	175	7,620	13
	OPT510		Manual Peripheral Switch Unit	42	1,850	8
	PS6010		Programmable Peripheral Switch (not available for GE-600 Series)	520	23,080	38
MASS STORAGE			Disc Storage			
	DSC160		Disc Storage Controller, Single Channel (2)	540	24,000	40
		ADC160	Additional Data Channel (Non-simultaneous)	185	8,230	14
		DFP160	Data File Protect	52	2,320	4
	DSU160		Removable Disc Storage Unit	590	25,510	70
	DCT160		Disc Cartridge	20	560	(3)
	DSC200		Disc Storage Controller, Single Channel	1,535	68,080	113
	DSU204		Disc Storage Unit, 4 Discs	1,170	53,000	350
		OPT201	4 additional discs(4)	210	8,000	NC
		OPT202	8 additional discs(4)	420	16,000	NC
		OPT203	12 additional discs(4)	625	23,000	NC
		OPT204	Fast Access I (4 discs)(4)(5)	315	15,000	NC
		OPT205	Fast Access II (8 discs)(4)	420	20,000	NC
	DSC270		Single Channel Controller	1,200	53,340	89
	ADC270		Additional Channel	400	17,780	30
	DFE270		File Electronics Unit	650	31,200	52
	DSU270		File Storage Unit	850	44,000	121
			Drum Storage(6)			
	MDC201		Magnetic Drum Controller for MDU200 and ADS201 Includes MDU200 Magnetic Drum Unit with 4.7 million-character storage capacity	3,435	146,700	367
	ADS201		Additional Drum Storage Unit (4.7 million characters)	2,090	89,580	224
		ADC201	Additional (non-simultaneous) Data Channel for MDC201(7)	270	11,560	29
	MGS200		Motor Generator Set, 2 KVA, for MDC201 (208 volt, 60 cycle, 3 phase to 120/208 volt, 60 cycle, 3 phase)	95	4,080	10
			Magnetic Strip Storage			
	MSC388		Mass Storage Controller	835	36,930	62
	MSU388		Mass Storage Unit	3,020	136,000	650
	*MDS200		Magnetic Drum Storage Unit and Controller (4.66 million characters)	3,435	146,700	367
INPUT-OUTPUT			Magnetic Tape			
			Controllers, Single Channel:(8)			
	MTC330		All Speeds, Address Select	940	41,540	69
	MTC331		All Speeds, No Address Select	940	41,540	69

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	MTC400		9-Channel, All Speeds Address Select	1,010	44,770	75
	MTC401		9-Channel, All Speeds, No Address Select	1,010	44,770	75
			Controllers, Dual Channel:(9)			
	MTC334		All Speeds, Address Select	1,435	63,700	106
	MTC336		All Speeds, No Address Select	1,435	63,700	106
	MTC404		9 Channel, All Speeds, Address Select	1,545	68,540	114
	MTC406		9 Channel, All Speeds, No Address Select	1,545	68,540	114
			Magnetic Tape Handlers:			
	MTH200		7.5/21kc, Single, 7-Channel	305	12,890	43
	MTH201		15/42kc, Single, 7-Channel	505	21,560	72
	MTH300		7.5/21/30kc, Single, 7 Channel	420	17,780	59
	MTH301		15/42/60kc, Single, 7 Channel	615	26,230	88
	MTH402		10/28kc, Single 9 Channel ASA	305	12,890	43
	MTH403		10/28/40kc, Single, 9 Channel ASA	420	17,780	59
	MTH404		20/60kc, Single, 9 Channel ASA	505	21,560	72
	MTH405		20/60/60kc, Single, 9 Channel ASA	615	26,230	88
	MTH492		40/11kc, 200/556 bits/inch	780	34,620	113
	MTH493		40/111/160kc, 200/556/800 bits/inch	895	39,500	130
	MTH372		30/83kc, 200/556 bits/inch	780	34,620	113
	MTH373		30/83/120kc, 200/556/800 bits/inch	895	39,500	130
			Punched Card			
	CRZ201		Card Reader and Control (900 cards/min)	680	26,000	121
	CPZ100		Card Punch and Control (100 cards/min)	520	20,000	93
	CPZ201		Card Punch and Control (300 cards/min)	860	33,000	154
			Paper Tape			
	PTR200		Perforated Tape Reader (500 char/sec)	520	20,000	100
	PTP200		Perforated Tape Punch (150 char/sec)	585	22,400	112
	PTS200		Perforated Tape Subsystem (Includes both PTR200 and PTP200)	990	38,000	190
			Printers			
	PRT201		Printer and Control (136 column; 1200 lines/min). (Choice of PDR201, PDR202 or PDR203. Drum at no extra charge.)(10)	1,460	56,000	280
		PDR200	Standard ASCII Print Drum and ASCII Code Wheel Standard FORTRAN Print	-	-	-
		PDR201	Drum and ADCII Code Wheel (0.103" characters)	-	-	-
		PDR202	Standard FORTRAN Print Drum and ASCII Code Wheel (0.091" characters)	-	-	-
	DRD200		COC-5 Document Reader (2 stackers, 1200 doc/min)	1,200	46,460	233
	MSM200		Mark Sense Module for DRD200	100	3,880	20
	PDR210		Standard Print Drum with COC-5 characters for PRT200, PRT201	84	3,600	18
		PDR203	Standard OCR Farrington (12F Self-Check) Print Drum with ASCII Code Wheel	-	-	-
		PCW200	Standard FORTRAN Code Wheel (not required for PDR201 and 202) to print in FORTRAN sequence	-	-	-
			MICR Reader/Sorter			
	MRS200		MICR Document Reader/Sorter (12-pocket; 1200 doc/min)	2,080	80,000	400
		OPT311	MOD II Check Option	105	4,500	15

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			MICR Reader/Sorter (Contd.)			
		OPT312	Endorser Stamp Option	105	4,500	23
		BFR200	COC-5 Bar Font Reader Option	520	20,000	100
			Optical Reader			
	DRD200		COC-5 Document Reader (2 Stackers, 1200 doc/min)	1,200	46,460	233
	MSM200		Mark-Sense Module Option for DRD200	100	3,880	20
COMMUNICATIONS			DATANET-30 Processors			
	DCP930		Processor (4,096 word memory)	1,250	70,000	292
	DCP931		Processor (8,192 word memory)	1,560	95,000	292
	DCP932		Processor (16,384 word memory)	2,080	130,000	292
	AMC930		Additional Module Cabinet	235	10,390	17
	CSU931		Controller Selector Unit	315	13,500	35
	CPC930		Common Peripheral Channel	260	11,200	35
	CPC931		Common Peripheral Channel, High Speed	360	17,340	58
	PIU930		Processor Interrupt Unit	210	9,000	20
			Remote Terminals			
			Datanet 760:			
	DTU760		Display Terminal Unit	55	2,020	10
	DCU760		Display Controller Unit	350	14,000	24
	TMU760		Terminal Memory Unit	110	4,600	8
	DLC760		Data Line Controller (1200 bits/sec)	105	4,200	14
	DLC765		Data Line Controller (2400 bits/sec)	125	5,000	16
	PPC760		Page Print Controller	50	2,100	4
	EMC760		Entry Marker Control	10	375	2
	FKG760		Function Key Group (8 Key Group)	15	550	3
	FKG765		Function Key Group (16 Key Group)	20	735	4
	DMU765		Display Monitor Unit (23-Inch Read-Only Monitor)	25	900	5
	DLC761		Data Line Controller (1,200 bits/sec full duplex, asynchronous)	170	6,250	20
	DLC766		Data Line Controller (2,400 bits/sec full duplex, synchronous)	190	7,950	26
	LRU760		Line Repeater Unit	15	550	3
	KVA760		Keyboard Video Amplifier	5	185	1
	PLJ760		Party Line Junction	5	185	1
	PLM760		Party Line Monitor	5	185	1
	DMU761		Display Monitor Unit (14 inch Read Only-or for use with EKB761)	30	1,250	5
	EKB761		Electronic Keyboard	25	1,000	5
	EMC761		Entry Marker Control for EKB761	10	375	2
	FKG761		Function Key Group for EKB761	15	550	3
	FKG766		Function Key Group for EKB761	20	735	4
	SEXXXX		Closed Circuit TV Compatibility	(11)	(11)	(11)
	SEXXXY		Video Switching and Monitoring	(11)	(11)	(11)
	*TIM224		248kc Digital Data Modem	150	7,000	23
			DATANET-91 Magnetic Tape Terminal:			
	*-		with 256 character Buffer	1,100	48,200	160
	*-		with 512 Character Buffer	1,120	49,100	164
	*-		with 1,024 Character Buffer	1,160	50,900	170
	*-		with 2,048 Character Buffer	1,230	54,090	180
	*-		with 4,096 Character Buffer	1,350	59,450	197
	*PTT600		DATANET-600 Paper Tape Terminal	290	8.250	35

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $

NOTES:

* No longer in production.

(1) CH0530 should not be used when CH0500 and/or CH0030 are ordered.

(2) Price includes one high-speed channel (HC6012) when the DSC160 is ordered with the GE-400 Series System.

(3) Time and materials.

(4) No charge for factory installation. One time charge of $625 for field installation.

(5) Not available with OPT203.

(6) Not available for GE-405 or GE-415 System.

(7) ADC201 is available only on GE-400 line (not GE-405 or GE-415); it allows two GE-400 line systems to share one Magnetic Drum Subsystem.

(8) Controls up to 8 single Magnetic Tape Handlers.

(9) Controls up to 16 single Magnetic Tape Handlers.

(10) Special code wheels can be ordered using special (SEXXXX) number; prices will be quoted upon approval of special.

(11) Negotiated separately.

INTERNATIONAL BUSINESS MACHINES CORPORATION

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SUMMARY: IBM 1401

.1 BACKGROUND

The IBM 1401 is a small-scale data processing system, oriented toward business applications, that features a wide range of peripheral devices and supporting software. Monthly rentals for typical card configurations range from $1,300 to $4,300. In expanded configurations, including magnetic tape and disk storage, a 1401 system can rent for upwards of $12,000 per month.

The IBM 1401 was originally announced in 1959 as a system specifically designed to facilitate the transition from punched card unit-record equipment to faster, larger-scale data processing. The first 1401 system was installed in September 1960, and during the ensuing years it has been regarded as the workhorse of the data processing industry. This reputation has evolved as a result of the wide acceptance that the 1401 has received, not only as a small-scale business data processing system, but as an off-line input-output processor for larger tape-oriented systems such as the IBM 7070 and 7090 Series. At this writing, approximately 9300 1401 systems are still in use.

The use of transistorized circuits in the 1401 components resulted in a relatively low-cost system with increased reliability and decreased maintenance and space requirements as compared to earlier vacuum-tube computers. Those components requiring operator attention are easily accessible. The controls and arithmetic components are consolidated into a single set of modular cabinets.

The 1401 system is well suited to the processing of large volumes of card documents. The magnetic tape configurations provide more compact record handling and storage for higher-speed data processing. The disk storage configurations permit rapid access to large volumes of data without the necessity of processing large card volumes or sorting tape records.

The 1401 Model G was introduced in 1964 for those installations not large enough to justify the purchase or rental of higher-performance 1401 models. The 1401-G, with approximately 1600 installations to date, provides an economical punched-card system without tape or random-access processing capabilities. The most important selling point of the 1401-G is price. The average monthly rental of the minimum 1401 card system (1,400 core storage positions, card reader-punch, and printer) has been reduced from $2,565 for a 1401 Model A to $2,260 for the Model G.

Although the 1401 Model G has the same instruction set and processing speed as the earlier 1401 models, there is a significant reduction in system throughput as a result of the use of slower models of the card reader-punch and printer.

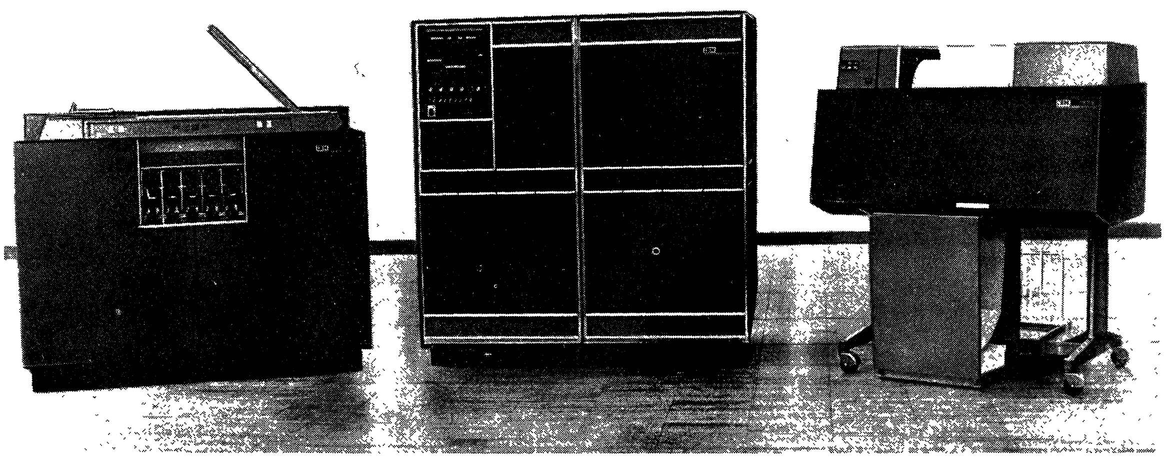

Figure 1. A basic IBM 1401 card system, consisting of a 1401 Processing Unit (center), 1402 Card Read-Punch (left), and 1403 Printer.

.1 BACKGROUND (Contd.)

The 1401 Model H, introduced in May 1967, represents a further reduction of the average monthly rental to $1,300. Like its predecessor, the 1401-G, it was designed to replace punched-card equipment. However, the 1401-H has a slower core storage cycle time than that of the other 1401 models, which, when combined with its slower input-output devices, further reduces the throughput rate.

The basic characteristics of the various models of the 1401 system are summarized in Table I.

The 1401 was the first member of the IBM 1400 series of data processing systems, and it is now the second smallest in price and throughput. The IBM 1440 (Report 414), the smallest member of the series, is program-compatibile with (and slightly faster than) the 1401 with respect to internal processing, but the 1440 uses slower input-output units and different instructions to control them. The IBM 1460 (Report 415) uses the same set of stored-program instructions as the 1401, so programs coded for a 1401 can, in general, be run without alteration on a 1460 with the same (or expanded) complement of input-output units and optional features. The 1460 is nearly twice as fast internally as the 1401 and uses most of the same peripheral devices. The faster, more expensive IBM 1410 (Report 402) uses a different addressing method and instruction set, but can execute many 1401 programs without alteration through the use of built-in 1401 compatibility circuits.

The 1401 constitutes the principal "second generation" computer system from the leading computer manufacturer. It was regarded, for a number of years, as the primary standard of comparison for users with small to medium-size data processing requirements.

The 1964 introduction of the "third-generation" IBM System/360 series, with its 1401 emulation facility and improved performance/cost ratio, made it apparent that the 1401 would gradually be replaced. However, the proven reliability of the 1401 hardware and supporting software, the relatively low cost, the widespread availability of programmers and analysts trained in 1401 processing, and the numerous available application programs and special-purpose peripheral devices ensure that the 1401 will continue to have considerable practical utility for many computer users. As a result, the 1401 is virtually assured a substantial position in the industry for some years to come.

.2 HARDWARE

.21 Processing Unit

The 1401 Processing Unit contains the logic, arithmetic, and control circuitry for the entire system, together with a magnetic core memory with a capacity of 1,400, 2,000, or 4,000 alphanumeric character positions. Additional core storage is available in 4,000-position modules, providing system memory capacities of 8,000, 12,000, or 16,000 positions.

Each position is individually addressable and contains an 8-bit character consisting of six data bits, a parity check bit, and a word mark bit for field definition. The character set includes 10 numeric, 26 alphabetic, and 12 special characters.

Data and instructions are stored in variable word-length form. A word is a single character or group of characters that represents a complete unit of information, defined by a word mark bit in the high-order position. Instructions range from one to eight characters in length; the basic two-address instruction format consists of a one-character operation code and two three-character operand addresses. Instructions are normally stored in sequential locations and executed in that order except when a branch instruction is executed.

TABLE I: CHARACTERISTICS OF THE IBM 1401 MODELS

1401 Processing Unit Model	Model A	Model B	Model C	Model D	Model E	Model F	Model G	Model H
Core storage capacity:								
Maximum positions	16,000	16,000	16,000	16,000	16,000	16,000	4,000	4,000
Minimum positions	1,400	1,400	1,400	1,400	1,400	4,000	1,400	4,000
Core storage cycle, µsec	11.5	11.5	11.5	11.5	11.5	11.5	11.5	19.3
Card reader speed, cpm	800	800	800	None	800	800	450	450
Card punch speed, cpm	250	250	250	None	250	250	250	250
Printer speed, lpm	600	600	600	600	600	600	465 or 340	340
729 Magnetic Tape Units	None	None	Up to 6	Up to 6	None	Up to 6	None	None
7330 Magnetic Tape Units	None	None	Up to 6	Up to 6	Up to 6	Up to 6	None	None
1311 Disk Storage Drives	None	Up to 5	Up to 5	None	Up to 5	None	None	None
1405 Disk Storage Units	None	None	None	None	None	1 unit	None	None

(Contd.)

.21 Processing Unit (Contd.)

Core storage cycle time is 11.5 microseconds (19.3 microseconds in Model H), compared to 11.1 microseconds in the IBM 1440, 6.0 in the 1460, and 4.5 in the 1410. Instructions are executed at the rate of about 4,000 per second in typical 1401 routines.

All data transfers are automatically checked by an odd-bit parity check code.

Every character read into core storage from the card reader is checked for validity. Address validity checking is performed to insure that all addresses used in a program are within the core-storage capacity of the system.

An instruction is addressed in its high-order position and scanned from left to right until the word mark associated with the next sequential instruction is sensed. The final instruction must have a word mark set at the right of its low-order position. A data field is read from right to left until a word mark is sensed.

Any of the possible positions in core storage is addressable by a three-character address. The addresses are basically decimal, but zone bits over the hundreds and units positions are used for all addresses larger than 0999. Table II outlines the 1401 addressing scheme. The Advanced Programming feature provides an indexing facility for address modification; zone bit over the tens position of the address indicates which of three 3-character index registers shall be used to modify it.

There are four address registers in the 1401: one controls the program sequence, two control data transfers from one storage location to another, and one specifies the storage location that is active during a particular storage cycle. An operation code register and two character registers store data during the execution of an instruction.

A "chaining" capability permits a series of basic operations, such as arithmetic functions and data movements, to be performed efficiently on fields arranged in consecutive storage locations, thereby saving storage space and execution time. A powerful editing operation provides zero suppression, insertion of identifying symbols, and punctuation of print output. Four areas of storage are reserved for input-output buffering of card readers, punches, and line printers.

The flexible editing capability is standard, but multiplication, division, indexing, three-way comparisons, sense switches, and multi-word internal transfers are all extra-cost options. Without these optional features, the processing capabilities of the 1401 are severely limited. In fact, the Advanced Programming Feature (which provides three index registers, instructions to store the address register contents, and the "move record" instruction) is nearly indispensable if the user hopes to take advantage of the much-heralded variable field-length capabilities of the 1401.

TABLE II: IBM 1401 ADDRESSING SCHEME

Actual Addresses	Zone Bits Over Hundreds Position	Zone Bits Over Units Position	3-Character Addresses
0000 to 0999	No zone bits	No zone bits	000 to 999
1000 to 1999	A-bit (Zero-Zone)	No zone bits	≠00 to Z99
2000 to 2999	B-bit (11-Zone)	No zone bits	100 to R99
3000 to 3999	AB-bits (12-Zone)	No zone bits	?00 to I99
4000 to 4999	No zone bits	A-bit (Zero-Zone)	00≠ to 99Z
5000 to 5999	Z-bit (Zero-Zone)	A-bit (Zero-Zone)	≠0≠ to Z9Z
6000 to 6999	B-bit (11-Zone)	A-bit (Zero-Zone)	10≠ to R9Z
7000 to 7999	ZB-bits (12-Zone)	A-bit (Zero-Zone)	?0≠ to I9Z
8000 to 8999	No zone bits	B-bit (11-Zone)	00! to 99R
9000 to 9999	A-bit (Zero-Zone)	B-bit (11-Zone)	≠0! to Z9R
10000 to 10999	B-bit (11-Zone)	B-bit (11-Zone)	!0! to R9R
11000 to 11999	AB-bits (12-Zone)	B-bit (11-Zone)	?0! to I9R
12000 to 12999	No zone bits	AB-bits (12-Zone)	00? to 99I
13000 to 13999	A-bit (Zero-Zone)	AB-bits (12-Zone)	≠0? to Z9I
14000 to 14999	B-bit (11-Zone)	AB-bits (12-Zone)	!0? to R9I
15000 to 15999	AB-bits (12-Zone)	AB-bits (12-Zone)	?0? to I9I

.21 Processing Unit (Contd.)

The use of dynamically variable field lengths (i.e., fields whose lengths vary from record to record within the same file) deserves very serious consideration. The main advantage of variable field lengths is that the required input-output time is reduced, and this is a valid consideration when the input-output time is the limiting factor on overall processing time. The additional data manipulation required to utilize these fields of varying length and varying location within a record, however, can significantly increase the central processor time (sometimes to the point where it exceeds tape input-output time) and the programming complexity.

An alternative method of reducing total time requirements for a problem is the use of a variable record-length technique employing combinations of variable and fixed-length fields. All fields (usually numeric) that require considerable manipulation are assigned fixed lengths and fixed locations in the record, while any fields (usually alphabetic) that require very little manipulation form the variable portion (usually the end) of the record. This method effectively reduces total time requirements for most applications without unduly complicating the programming.

System operation is basically serial in nature (i.e., one operation at a time). Little overlapping of input-output operations with one another or with internal processing is possible unless optional features such as Print Storage, Processing Overlap, and Read Punch Release are added. Use of these features increases the system's capability for simultaneous operations, but also increases programming complexity and input-output area storage requirements.

.22 Peripheral Equipment

The 1401 Card Read-Punch reads standard 80-column cards at a peak speed of 800 cards per minute (450 cpm for Models 4, 5, and 6) and punches them at 250 cards per minute in all models. The 1403 Printer prints up to 600 alphameric lines per minute (465 lpm on Models 4 and 5, 340 lpm on Model 6). It features a horizontal-chain printing mechanism that produces high-quality printing and permits interchangeable character sets. The 1404 Printer is a combination unit capable of processing either card forms at up to 800 lines per minute or continuous paper forms at up to 600 lines per minute.

Up to six 729 and/or 7330 Magnetic Tape Units can be connected to a 1401 system. Peak data transfer rates range from 7,200 to 62,500 characters per second. Only one tape read or write operation at a time is possible. The central processor is interlocked during tape read and write operations unless the Processing Overlap feature is added. With Processing Overlap, internal processing can be overlapped with tape start-stop times and (at transfer rates of 20,016 characters per second or below) with character transfers to or from a tape unit.

Up to four 7340 Model 2 Hypertape Drives can be connected to a 1401 through the Serial Input/Output Adapter. These magnetic tape units are cartridge-loaded, have peak data transfer rates of 34,000 characters or 68,000 decimal digits per second, and are compatible with the faster Hypertape Drives used on IBM 7074, 7080, 7090, and 7094 systems (but not with the 729 or 7330 tape units).

Up to five 1311 Disk Storage Drives can be used in a 1401 system. Each drive holds one replaceable Disk Pack at a time, providing random-access storage for 2,000,000 alphameric characters in addressable sectors of 100 characters each. With the optional Track Record feature, a single 2,980-character record can be recorded on each track, increasing the capacity of a single Disk Pack to 2,980,000 characters. Up to 20,000 characters can be read or recorded without movement of the comb-like access mechanism, so the system is suitable for sequential as well as random processing. Total waiting time for access to a randomly-placed record averages 270 milliseconds; with the optional Direct Seek feature, the figure is reduced to 170 milliseconds.

The older 1405 RAMAC Disk Storage Unit provides 10,000,000 or 20,000,000 character positions of non-replaceable storage, in 200-character blocks. Average random access time is about 600 milliseconds.

The capabilities of the 1401 can be expanded through the attachment of numerous other units, including:

- IBM 1009 Data Transmission Unit
- IBM 1026 Transmission Control Unit
- IBM 7710 Data Communication Unit
- IBM 7740 Communication Control System
- IBM 7770 Audio Response Unit
- IBM 1011 Paper Tape Reader

(Contd.)

.22 Peripheral Equipment (Contd.)

- IBM 1012 Paper Tape Punch
- IBM 1445 Printer
- IBM 1412 and 1419 Magnetic Character Readers
- IBM 1231 Optical Mark Page Reader
- IBM 1285 Optical Reader
- IBM 1418 Optical Character Readers
- IBM 1428 Alphameric Optical Reader

The Serial Input/Output Adapter permits connection of any one of the following devices at a time: a paper tape reader or punch, a magnetic or optical character reader, a data transmission terminal, or a direct system-to-system link with an IBM 1440, 1460, or another 1401.

.3 SOFTWARE

.31 Assemblers

The Symbolic Programming System (SPS) is basically a one-for-one assembly system in which one symbolic statement is written for each instruction in the object program. SPS-1 requires a minimum core storage capacity of 1,400 positions, while SPS-2 requires 4,000 positions. The language of SPS-2 is essentially the same as that of SPS-1; a fixed-form coding sheet is used, and there are no facilities for literals or macro-instructions. The output deck contains a self-loading routine that loads the object program.

Basic Autocoder 2K is a symbolic assembler designed specifically for card systems with 2,000 core storage positions. A processor program assembles the source program into machine-language form ready for execution.

Autocoder (on Tape) is more flexible because the processor program resides on and operates from magnetic tape. This version offers a more powerful language that includes macro-instruction facilities, free-form coding, and literals. The macro routines, provided in the Autocoder Library, can relieve programmers of much repetitive work. Autocoder (on Tape) requires a 4K Processing Unit and four magnetic tape units for assembly.

Autocoder (on Disk) requires no magnetic tape units for assembly. The assembly process is made automatic through the use of 1311 Disk Storage. The Autocoder Library in this version has expanded capabilities and can be relocated to any area in disk storage. Multiple Autocoder libraries can be built. Jobs can be stacked on the disk unit for consecutive or selective execution. Alternatively, the object programs can be loaded from punched cards.

.32 Compilers

FORTRAN is a symbolic language that closely resembles algebra. Three FORTRAN compilers are available for the 1401. One operates on an 8K card system and uses a restricted language that is essentially FORTRAN I. The other two compilers accept the FORTRAN IV language and require a 12K Processing Unit; one uses at least four magnetic tape units, while the other uses a 1311 Disk Storage Drive for system residence.

COBOL is a common business-oriented language, similar to English, that was designed to facilitate commercial data processing. The 1401 COBOL compiler (tape version) translates COBOL source statements from punched cards into Autocoder-language statements which are then assembled into machine language. The compiler resides on magnetic tape; it requires a 4K Processing Unit and at least four tape units.

COBOL (on Disk) is similar in design to the tape version. The major difference is that the disk-oriented compiler resides on a file-protected area of 1311 Disk Storage and operates under a system control program. The control program or monitor permits stacking of tasks and user assignment of input-output devices for defined record files. A 4K Processing Unit and one 1311 Disk Storage Drive are required for compilation.

.33 Report Program Generators

The 2K Report Program Generator (RPG) produces programs that write reports based upon data from card input files. The RPG user writes a set of report specifications instead of a detailed program for each report to be produced. The generator is designed for use on a card system with 2,000 core storage positions. The output may be punched cards and/or a printed report.

Larger versions of the 1401 Report Program Generator are available for card, tape, or disk-oriented systems with at least 4,000 core storage positions. They provide more flexibility in input-output media, an edit listing of the source program, and an error analysis of the specification cards.

.33 Report Program Generators (Contd.)

FARGO, a "load-and-go" system, produces IBM 407-type reports in a 4K, card-oriented 1401 system. Report definition statements are read into the 1401 together with the data cards. The FARGO program, which uses these specifications to modify itself, is ready for immediate execution without any assembly procedure.

.34 Input-Output Control Systems

IOCS (on Tape) is designed to eliminate much of the detailed programming of input-output operations. It consists of a set of library routines that supplement the Autocoder program on tape. There are routines for blocking and deblocking of records, I/O error correction, file labeling, and standardized macro-instructions for reading and writing such as GET, PUT, OPEN, and CLOSE.

IOCS (on Disk) differs from the tape version in that it makes available macro-instructions that process disk I/O operations.

Communications IOCS (1026/DDC and 1448-7740/DDC) provides routines that free programmers using a data communications system from most of the detailed coding required to transfer data to and from remote terminals connected to an IBM 1026 Transmission Control Unit, or between a 1401 system and a 7740 Communication Control System.

.35 Testing Aids

Autotest is an effective aid in the testing of Autocoder, SPS, and FARGO programs. The programs may be stacked, and documentation is produced to evaluate the tested programs. Standard features include an automatic printout of core storage and magnetic tapes, and the generation of operating instructions.

The Autotest program can use any of the following features in any combination for more efficient testing: the ability to patch the object program without reassembling or manually calculating patching addresses, to trace and print the flow of data during program execution, to snapshot core storage during program execution, and to produce an 80/80 listing of any punched card output. The program can accept input only from cards.

.36 Utility Routines

IBM has developed a total of 11 generalized routines to handle sorting and merging operations on 1401 systems, using magnetic tape, disk storage, or both. The Multiple Utility Program, designed primarily for 1401 systems serving as input-output processors for larger IBM computers, can control card-to-tape, tape-to-card, and tape-to-printer data transcription operations simultaneously. Other utility routines perform functions such as:

- System initialization.
- Core storage dumps on cards or printer.
- Multiplication and division (in systems that lack the hardware feature).
- Control of paper tape punching.
- Data transcriptions between cards, magnetic tape, disk storage, and printer.
- Creation and maintenance of disk storage files.
- Control of data transmission via a 1009 or 7710 controller.

.37 Application Programs

Packaged programs have been developed for a wide variety of 1401 applications by IBM, by users, and by independent software firms. Among the application programs currently available from IBM are: Demand Deposit, Auto Rating for Fire and Casualty Companies, Wholesale IMPACT (inventory control), Autoprops II (numerical control), Bank Management Simulation, Management Decision-Making Laboratory, Data Analysis and Reduction, KWIC (Key Word In Context) Indexing, Financial Analysis (common stocks), Bond Trade Analysis, Decision Logic Translator (decision tables to FORTRAN), Selective Dissemination of Information, Autoplotter, Portfolio Selection, Engineering Scheduling, Homeowners Rating (insurance), Linear Programming, and Allocation of Resources for Savings and Loan Associations.

IBM 1401

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	1401		Processing Unit			
			Processing Unit (includes 4,000 positions of core storage):			
			Card System - Model A3	1,430	87,700	55.00
			Card System - Model G3	1,180	59,750	58.00
			Card System - Model G13	1,070	59,350	54.00
			Card System - Model H3	500	35,000	50.00
			Expanded Card System - Model B3	1,580	97,600	60.00
			729 Tape/Card System - Model C3	2,680	131,000	91.50
			7330 Tape System - Model D13	2,175	130,000	79.00
			729 Tape System - Model D3	2,655	130,000	81.50
			7330 Tape/Card System - Model E3	2,080	126,400	80.00
			RAMAC/Card System - Model F3	1,610	98,950	62.00
			RAMAC/Card/7330 Tape - Model F23	2,110	127,750	82.00
			RAMAC/Card/729 Tape - Model F13	2,590	127,750	84.50
			Corrections to above prices for other storage sizes:			
			1,400 characters (includes core storage)	-230	-4,000	-1.50
			2,000 characters (includes core storage)	-130	-3,200	-1.50
			4,000 characters (includes core storage)	0	0	0
			8,000 characters(1)	+50	+2,150	+2.00
			12,000 characters(1)	+75	+2,550	+3.50
			16,000 characters(1)	+75	+2,550	+3.50
	1406		Main Storage			
			Core Storage Module:			
			Model 1 - 4,000 characters	575	24,500	15.00
			Model 2 - 8,000 characters	1,075	45,800	17.50
			Model 3 - 12,000 characters	1,575	67,100	23.50
			Optional Features:			
		1060	Advanced Programming	105	3,935	1.00
		4575	High-Low-Equal Compare	75	2,800	1.75
		5730	Processing Overlap	250	15,000	15.25
		1470	Bit Test	20	800	0.50
		1990	Column Binary	100	3,600	2.50
		5275	Multiply-Divide	325	11,700	9.00
		7600	Sense Switches	15	550	0.50
		2210	Compressed Tape (1060 required)	35	1,300	3.25
		3580	800 char/inch Tape Adapter	35	1,575	0
		5591	Read-Compare (for 5590 feature on 1404 Printer)	75	4,250	1.25
ATTACHMENTS, ADAPTERS AND CHANNELS	1414		Attachments			
			Input/Output Synchronizer			
			Model 1 (controls up to 10 729 Magnetic Tape units)	975	43,500	26.75
			Model 2 (controls up to 10 7330 Magnetic Tape units)	500	24,900	28.00
			Model 3 (controls punched card devices)	675	30,375	29.50

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			IDENTITY OF UNIT / PRICES			
ATTACHMENTS, ADAPTERS, AND CHANNELS (Contd.)			Attachments (Contd.)			
			Model 4 (controls punched card and communications units)	700	39,900	32.75
			Model 5 (controls communications devices)	1,125	35,700	23.75
			Model 7 (controls up to 10 729 Magnetic Tape units)	600	49,500	27.50
			Model 8 (for 1403 only)		30,500	20.75
		6025	Read, Punch Column Binary (on Model 4 only)	175	8,750	2.00
		7864	Telegraph I/O Feature (for 1414 Models 4 and 5)	500	30,500	10.25
		7871	Telegraph Input Feature (requires 7864)	110	6,750	3.25
		7875	Telegraph Output Feature (requires 7864)	125	7,750	3.25
	7080		Serial I/O Adapter (required for 1009; 1011, 1012, 1231, 1285, 1445, 1412, 1418, 1419, or 7641; only one of these can be connected to a system)	100	3,750	1.50
	7155		Switch Control Console:			
			Model 1 - For up to 2 tape units	30	1,050	6.50
			Model 2 - For up to 4 tape units	50	1,550	12.25
			Model 3 - For up to 6 tape units	65	2,050	18.50
			Model 4 - For up to 8 tape units	80	2,600	24.50
	7814		Tape intermix (on 1414 Model 1 only; to intermix 729 II's, 729 IV's and 7330's in any combination).	45		NC
			Tape intermix Units:			
	7804		729 IVs with 729 II/Vs	0	0	0
	7805		729 II/Vs with 729 IVs	0	0	0
	7806		7330s with 729 II/Vs	45	2,250	0
	7807		7330s with 729 IVs	45	2,250	0
	7808		7330s with 729 IIs/IVs/Vs (require 7804 or 7805)	45	2,250	0
MASS STORAGE	1311		Disk Storage			
			Disk Storage Drive Model 2 (additional on system)	360	16,510	45.50
			Model 4 (first on system, includes 3339 adapter)	385	17,610	46.50
		3281	Direct Seek (Model 4 only)	50	2,400	3.25
		6396	Scan Disk (Model 4 only; 4575 feature required on 1401)	35	1,680	.50
		6400	Seek Overlap	40	1,950	1.75
		8011	Track Record (Model 4 only)	40	1,920	.50
	1405		Disk Storage Unit:			
			Model 1 (10,000,000 characters)	965	36,000	157.00
			Model 2 (20,000,000 characters)	1,515	48,500	170.00
			Additional Access Arm:			
		1008	For 1405 Model 1	400	14,750	56.75
		1009	For 1405 Model 2	425	15,500	56.75
		3327	Disk Storage Control	355	10,850	42.50
		5620	Priority Feature	40	1,725	1.25
	3326		Disk Storage Control (on first 1405 on each channel)	400	13,950	41.25
	7576		Successive Disk Storage (required for each 1405 Disk unit after the first one each channel)	15	600	1.00
	3470		Dual Synchronizer Adapter	325	13,000	8.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model II (15/41.7 kc)	700	36,000	103.00
			Model IV (22.5/62.5 kc)	900	41,250	114.00
			Model V (15/41.7/60 kc)	750	37,200	108.00
			Model VI (22.5/62.5/90 kc)	950	42,450	119.00
	7330		Magnetic Tape Unit	450	22,000	58.50
	7340		Model 2 Hypertape Drive	1,050	55,000	98.00
	7641		Hypertape Control Unit	2,500	125,000	65.50
			Punched Card			
	1402		Card Read/Punch:			
			Model 1 (Read 800 cards/min; punch 250 cards/min)	550	30,000	120.00
			Model 4, 6 (Read 450 cards/min; punch 250 cards/min)	400	28,000	109.00
			Model 5 (Read 450 cards/min; punch 250 cards/min)	380	27,000	107.00
		3550	Early Card Read	10	215	0
		4150, 1013	51-Column Feed	60	3,810	31.75
		5890, 5895	Punch Feed Read	80	2,985	5.75
		6040	Read Punch Release	25	950	0.50
			Paper Tape			
	1011		Paper Tape Reader (7080 adapter required)	500	20,200	56.00
	1012		Tape Punch	465	17,950	60.00
			Printers			
	1403		Printer:			
			Model 1 (600 lines/min, 100 positions)	725	32,900	166.00
			Model 2 (600 lines/min, 132 positions)	775	34,000	177.00
			Model 4 (465 lines/min, 100 positions)	550	31,400	134.00
			Model 5 (465 lines/min, 132 positions)	600	32,500	142.00
			Model 6 (340 lines/min, 120 positions; includes 5540 control)	400	29,000	131.00
	1404		Printer (includes 5539 and 5563 controls)(2)	1,550	75,000	372.00
		3740	Interchangeable Chain	75	3,125	0
		3835	Expanded Print Edit	20	750	0.50
		5585	Print Storage	375	12,600	24.25
		5990	Read-Compare	175	9,750	23.00
		7246	Space Suppression	75	60	0
			Optical and Magnetic Character Readers			
	1412		Magnetic Character Reader	2,000	91,400	171.00
		2385	Document Counter	15	600	2.25
		3610	Electronic Accumulation (5215 required)	250	9,750	17.75
		5215	Multiple Column Select	50	2,250	2.00
			Self-Checking Numbers:			
		7061	Modulus 10	40	1,950	1.75
		7062	Modulus 11	65	3,000	2.75
	1419		Magnetic Character Reader			
		3610	Electronic Accumulation (requires 5201)	2,275	110,500	229.00
		5201	Multiply Column Control	250	9,750	17.75
		7440	Split Field	50	2,250	2.00
			Self-Checking Numbers:			
		7061	Modulus 10	20	1,225	0.75
		7062	Modulus 11	40	1,950	1.75

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)		3791	Endorser:	65	3,000	2.75
			for 1412	350	17,150	29.50
			for 1419	375	18,350	30.00
	1418		Optical Character Reader:			
			Model 1 (3 stackers)	2,600	120,300	197.00
			Model 2 (13 stackers)	2,900	133,800	230.00
		4950	Mark Reading Station	125	5,950	6.00
			Additional Read Station			
		6045	0.093-inch characters	125	5,450	15.00
		6046	0.130-inch characters	125	5,450	15.00
	1428		Alphameric Optical Reader:			
			Model 1 (3 stackers)	3,000	138,600	230.00
			Model 2 (13 stackers)	3,300	152,100	264.00
		4950	Mark Reading Station (not with 6044)	125	5,950	6.00
		6044	Read Station (not with 4950)	125	5,450	15.00
COMMUNI-CATIONS			Transmission Units			
	1009		Data Transmission Unit	500	26,400	13.00
	1014		Remote Inquiry Unit	200	8,000	21.00

NOTES:

(1) Requires appropriate 1406 core storage modules

(2) Cannot be connected to A-, D-, G-, or H-series Processing Units.

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The IBM 1410 is a small to medium scale, solid-state computer system oriented toward solving business data processing problems. System rentals range from approximately $7,000 to $40,000 per month, and most installations will probably fall within the $12,000 to $20,000 range.

The 1410 is compatible with the IBM 1401 to the extent that built-in 1401 compatibility circuits enable many 1401 machine language programs to be run directly on a 1410. The increased speed and power of the 1410 cannot be fully utilized in this mode of operation, however, and 1401 programs that use the Processing Overlap, Column Binary, Compressed Tape, Punch Feed Read, or Serial Input-Output features cannot be run on the 1410. The buffers for card read and card punch operations for the 1410 are significantly different from those for the 1401.

Programs written for the 1410 can be operated unaltered on the more powerful 7010 with an identical configuration of input-output devices. Programs for the 1410 which use IBM 1405 Disk Storage, 1412/1419 Magnetic Ink Character Readers, or the Program Addressable Clock will not operate on the 7010 because these 1410 input-output devices are not available for connection to the 7010.

The core storage of the 1410 can consist of 10,000, 20,000, 40,000, 60,000, or 80,000 character positions, with each position containing 6 data bits, a parity bit, and word mark bit. The core storage cycle time is 4.5 microseconds and can be reduced to 4.0 microseconds by using the optional Accelerator feature. In addition, up to 5 disc storage units with a total capacity of up to 280,000,000 characters can be connected. The 1301 Disk Storage Unit and the 1311 Disk Storage Drive each utilize a comb-like access mechanism which makes it possible to access corresponding bands on all discs simultaneously. The 1405 is the familiar RAMAC unit which utilizes one read-write mechanism to search all disc surfaces (i.e., its operation is similar to that of a juke box).

The central processor is a variable word-length, alphameric processor with add-to-store logic, which utilizes a five-character address structure. Instructions contain from 1 to 12 characters. Input-output, arithmetic, and data transfer instructions are usually 10, 11, and 12 characters in length, respectively. Although 15 index registers are provided, their usefulness is limited because no special instructions are available for incrementing or testing them. Floating point arithmetic is available on an RPQ (Request for Price Quotation) basis only.

The application of variable length field definitions to a data processing problem should be given very serious consideration. The main advantage of variable length fields is that the required input-output time is reduced. This advantage is a very valid consideration if the input-output time is the limiting factor for the total time required. However, in reducing the input-output time by using variable length fields, the additional data manipulation required to utilize these fields increases the required central processor time.

An alternative method to reduce to a minimum the total time requirements for a problem is to use a variable length record technique employing combinations of variable and fixed fields. That is, any fields (usually numeric) that require a great deal of manipulation are assigned fixed field length in fixed locations in the record, and any fields (usually alphabetic) that require very little manipulation form the variable portion of the record. Using this method effectively reduces the total time requirements for the majority of applications.

The 1410 instruction repertoire is characterized by: 64 data move instructions; versatile editing capabilities; table look-up capability; basic arithmetic instructions, including multiply and divide; comparison instructions; and logical branching. The variable

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length operand fields are defined by word marks, enabling the program to be designed for the data rather than the machine.

The 1410 can operate with a variety of peripheral units, including magnetic ink character readers, telegraphic equipment, and remote inquiry units, in addition to magnetic tape, paper tape, and unit record equipment.

Punched card input-output and printer output are buffered; thus internal processing can be overlapped with card reading, punching, and printing. Unless the Processing Overlap feature is installed, however, magnetic tape reading and writing cannot occur simultaneously, either with each other or with internal processing. Additional facilities for expanding the degree of simultaneity available in a 1410 system include priority interrupt and a second input-output channel. With two channels and Processing Overlap, simultaneous read, compute, and write operations are possible.

The 1402 combination Card Read-Punch unit provides the 1410 system with a peak reading capability of 800 cards per minute and a peak punching capability of 250 cards per minute. A 1442 card reader, which can read 400 cards per minute, can also be connected to the 1410 system (see 414:071). The 1011 Paper Tape Reader has a peak speed of 500 characters per second.

The 1403 Model 1 and 2 Printers have 100 and 132 print positions, respectively. Each uses a 48-character print set and operates at a peak speed of 600 alphameric, single-spaced lines per minute. The 1403 Model 3 Printer has 132 print positions with a 48-character print set and operates at a peak speed of 1,100 alphameric lines per minute.

The IBM 729 series and 7330 Magnetic Tape Units can be used in the 1410 system. Peak transfer rates can range from 7,200 to 90,000 characters per second. The effective transfer rates can range from 6,100 to 50,000 characters per second using 1,000-character blocks. Since the effective transfer rate of core storage is 111,000 characters per second, very little data manipulation during tape read or write time is possible when using the higher speed tape units. Up to 20 tape units (10 per channel) can be connected, and no more than 2 tape read or write operations can occur simultaneously with internal processing.

The IBM 1412 or IBM 1419 Magnetic Ink Character Readers can be connected to a 1410 system to provide input from paper or card documents inscribed with magnetic ink.

A wide range of telegraphic equipment is available for connection to the 1410, including the powerful 7750 Program Transmission Control, the 7864 Telegraph Input-Output, the 1009 Data Transmission Unit, and the 1014 Remote Inquiry Unit.

Autocoder, the basic machine oriented coding system for the 1410, is available in two versions: Basic Autocoder and Autocoder. Autocoder is more powerful than Basic Autocoder in that it provides macro-instructions, longer literals, and the means to call on library routines. However, a minimum of 4 magnetic tape units and 20,000 positions of core storage are required for the assembly of Autocoder programs. The Autocoder library includes the Input-Output Control System (IOCS), which provides control and macro-instructions that handle reading and writing, tape blocking and unblocking, file labeling, and magnetic tape error detection.

The Autocoder library also includes the following programs:

- Simulation of the IBM 650; Enables the 1410 to assume the characteristics of the 650.
- 1410 Sort 10: Generalized program for ordering records of an unordered file on either magnetic tape or a RAMAC disk file.
- 1410 Sort/Merge 11: Generalized program for ordering and merging tape records; does not use Processing Overlap or the Priority Feature.

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- 1410 Sort/Merge 12: Generalized program for ordering and merging tape records; uses Processing Overlap and Priority Features.
- 1410 Card Report Program Generator: Facilitates the preparation of report programs.
- 1410 Tape Report Program Generator: Facilitates the preparation of report programs for tape files.
- Seven 1405 and six 1301 Disk Storage utility programs which provide the basic facilities for program testing, and service functions for production runs.

The library also contains a Procedure for Automatic Testing (PAT) which can include any or all of the following:

- Tracing routine: Traces each instruction within a specified area.
- Snapshot routine: Prints out the contents of selected areas of core storage following the execution of any instruction in the program being tested.
- Post Mortem: Prints out the entire contents of 1410 core storage.
- Clear Storage: Sets all of core storage to blank.
- Tape Duplicate: Duplicates data on one tape upon another.

Both COBOL-61 and FORTRAN II have been implemented for the 1410. Both the COBOL and FORTRAN compilers are on the Processor Operating System Tape, both produce Autocoder programs which must be translated to 1410 machine language by the Autocoder translator, and both require at least 20,000 positions of core storage and 4 magnetic tape units in the translating 1410 system. IBM 1410 COBOL includes a number of useful electives, such as the COMPUTE and ENTER verbs; but several significant features of Required COBOL-61, including the EXAMINE verb and the COBOL library, have not been implemented for the 1410. FORTRAN II for the 1410 is distinguished by the fact that the programmer can specify any desired degree of precision for the internal representation of both fixed and floating point data items.

The 1410 FORTRAN language includes complete facilities for defining and using subroutines and functions, but does not allow Boolean operations, complex arithmetic, or symbolic coding.

IBM 1410

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	1411		Processing Unit (includes core storage)			
			Model 1 (10,000 characters)	3,800	189,400	124.00
			Model 2 (20,000 characters)	4,550	223,000	129.00
			Model 3 (40,000 characters)	5,400	262,000	133.00
			Model 4 (60,000 characters)	7,250	380,000	180.00
			Model 5 (80,000 characters)	8,100	419,000	186.00
			Model A1 (10,000 characters)	3,960	197,400	124.00
			Model A2 (20,000 characters)	4,710	231,000	129.00
			Model A3 (40,000 characters)	5,560	270,000	133.00
			Model A4 (60,000 characters)	7,410	388,000	180.00
			Model A5 (80,000 characters)	8,260	427,000	186.00
		5737	Program Addressable Clock	40	1,650	2.75
	1415		Console	250	10,880	16.00
ATTACHMENTS, ADAPTERS, AND CHANNELS			Adapter			
	4660		I/O Adapter	160	5,600	4.00
		1007	Accelerator	350	17,500	6.00
		5730	Processing Overlap	200	8,200	5.25
		5620	Priority Feature	125	5,375	2.75
		5621	Priority Feature - Extension (5620 required)	20	675	1.75
MASS STORAGE			Disk Storage			
	1301		Disk Storage Unit			
			Model 1 (28,000,000 characters)	2,100	115,500	230.00
			Model 2 (56,000,000 characters)	3,500	185,500	343.00
			Optional-Cylinder Mode	25	3,000	2.00
	1311		Disk Storage Unit			
			Model 5 (First on channel)	985	46,010	81.50
			Model 2 (Additional on channel)	360	16,510	45.50
		3341	Disk Storage Drive Adapter for Channel 1	120	3,000	2.00
		3342	Disk Storage Drive Adapter for Channel 2	120	3,000	2.00
	6396		Scan Disk (model 5 only-#6397 or 6398 required)	35	1,680	.50
		6397	Scan Feature for channel 1	30	600	NC
		6398	Scan Feature for channel 2	30	600	NC
		6400	Seek Overlap (model 5 and each model 2)	40	1,950	1.75
		8011	Track Record (model 5 only)	40	1,920	.50
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model 2	700	36,000	103.00
			Model 4	900	41,250	114.00
			Model 5	750	37,200	108.00
			Model 6	950	42,250	119.00
		7830	Tape Switching Feature	85	4,400	6.50
		3585	800 char./inch Feature (channel 1)	35	1,575	NC
		3586	800 char./inch Feature (channel 2)	35	1,575	NC
	7330		Magnetic Tape Unit	450	22,000	58.50

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			IDENTITY OF UNIT	PRICES		
INPUT - OUTPUT (Contd.)			Punched Card			
	1402		Model 2 Card Read Punch	615	32,700	138.00
		3550	Early Card Read	10	215	NC
		4150	Feed, 51-column Interch Read	50	3,175	31.75
		5890	Punch Feed Read	25	935	4.00
	1442		Model 3 Card Reader	250	13,850	37.00
		4661	I/O Adapter (for 1414 Controller Model 5-8)	50	2,750	.75
	1403		Printer			
			Printer			
			Model 1 (600 lines/min.)	725	32,900	166.00
			Model 2 (600 lines/min.)	775	34,000	177.00
			Model 3 (1,100 lines/min.)	900	41,200	183.00
		1376	Auxiliary Ribbon Feeding	75	3,075	17.75
		4740	Interchangeable Chain Cartr. Adapter	75	3,125	NC
		5110	Multiple Character Set Feature	10	450	1.75
		5381	Numerical Print	225	9,050	9.00
		1416	Interchangeable Train Cartridge	100	3,000	NC
			Optical and Magnetic Character Readers			
	1412		Magnetic Character Reader	2,000	91,400	171.00
	1419		Magnetic Character Reader	2,275	110,500	224.00
			Magnetic Character Reader Adapter:			
		4900	channel 1 (not with 4902)	215	8,875	17.25
		4902	channel 2 (not with 4900)	215	8,875	17.25
		4903	second adapter (4900 or 4902 required)	115	4,750	9.25
		2385	Document Counter (DC)	15	600	2.25
		3610	Electronic Accumulation (EA) (5215 required)	250	9,750	17.25
		5215	Multiple Column Select (MCS)	50	2,250	2.00
			Self Checking Numbers			
		7061	Modulus 10 (M-10)	40	1,950	1.75
		7062	Modulus 11 (M-11)	65	3,000	2.75
COMMUNICATIONS			Controller			
	7750		Model 2 Programmed Transmission Control	7,950	490,000	410.00
		1067	Control Adapter (for Channel 1)	325	9,000	4.00
		1068	Control Adapter (for Channel 2)	325	9,000	4.00

INTRODUCTION

The solid-state IBM 7070 is most effective as a tape oriented data processing system for high volume business applications.

Core storage may consist of 5,000 or 9,990 word locations, and each location can hold one single-address instruction, five alphameric characters, or a data word of ten decimal digits plus sign. The core storage cycle time is six microseconds.

The instruction repertoire is versatile and effective; the only significant omission is the lack of automatic editing facilities. Three accumulators are provided, and many of the instructions can refer to any one of the three. Ninety-nine core storage locations can be used as index registers. Floating point arithmetic is optional. While the 7070 is basically a fixed word-length system, operand sizes for most internal operations can vary from one to ten digits, and several short fields of like sign can readily be packed into a single core storage location.

A major feature of the 7070 is its ability to transfer several blocks of data to or from different core storage areas in a single operation. This scatter-read and gather-write capability facilitates internal data transfers as well as transfers between core storage and magnetic tape, disc storage, or unit record devices.

Automatic interruption facilitates effective use of the system's capabilities for simultaneous operations. Execution of a priority routine can be initiated automatically whenever an operation is completed by a selected peripheral unit or a manual inquiry request is made.

Overall internal speeds of the 7070 are significantly lower than those of other systems in the same price range. Full-word internal transfers are parallel by word, but transfers of fields less than ten digits in length and all arithmetic operations are performed serially by digit. A 7070 system can, at a rental increase of at least $5,000 per month, be converted to an IBM 7074. The 7074 offers greatly increased internal speeds, up to 30,000 words of core storage, and faster magnetic tape drives, while maintaining program compatibility with the 7070.

The IBM 729 series of magnetic tape units is used in 7070 systems. Peak transfer rates can range from 15,000 to 90,000 characters per second. Up to ten tape units can be connected to each of a maximum of four channels, and up to four tape read/write operations can occur simultaneously with internal processing.

Two different types of magnetic disc storage may be used; the maximum total capacity is 278 million characters. When the faster and more flexible 1301 Disk Storage Units are used, the maximum number of magnetic tape channels is reduced to two.

A line of unit record devices, including a 500 card-per-minute reader, a 250 card-per-minute punch, and a 150 line-per-minute printer, is offered for the 7070 on an "as available" basis. A maximum of three readers and three output devices (printers and/or punches) can be connected. The 7070 has been found to be most effective in tape oriented configurations, and most installations utilize IBM 1401 systems for off-line card-to-tape, tape-to-card, and tape-to-printer operations. As a result, the on-line reader, punch, and printer are no longer in production. A console card reader, rated at 60 cards per minute, is useful in tape systems for direct card input on an exception basis.

Paper tape readers, remote inquiry stations, data transmission terminals, and telegraph transmitters and receivers can be connected to the system through the 1414 Input/Output Synchronizer and the 7907 Data Channel.

INTRODUCTION – Contd.

Autocoder is the basic machine oriented coding system for the 7070. It is offered in three versions for different translating computer configurations. The full, six-tape version includes powerful macro generation and input-output control facilities.

A FORTRAN II processor is available, and a COBOL 61 processor was delivered in March, 1962. A "compiler systems tape" combines the Autocoder, COBOL, and FORTRAN processors and a Report Program Generator. The manufacturer also offers generalized sort and merge routines, program testing aids, and various utility routines. A wide variety of user-developed routines is available through GUIDE, the 7070 users' organization.

IBM 7070

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7601		Arithmetic and Program Control	3,000	145,500	137.00
		4419	Floating Decimal Arithmetic	750	33,350	19.25
		4760	Interval Timer	70	3,375	1.75
			Main Storage			
	7301		Core Storage:			
			Model 1 (5,000 words)	3,500	195,000	70.00
			Model 2 (9,990 words)	6,800	343,000	77.00
	7150		Console Control Unit	300	13,050	26.50
	7802		Power Converter (required in every system)	400	20,000	12.50
ATTACHMENTS, ADAPTERS, AND CHANNELS			Attachments			
	7602		Core Storage Control			
			Model 1 (for card-only system)	1,400	65,200	23.75
			Model 2 (two channels-tape/disk system)	1,600	73,950	35.00
			Model 3 (one channel-tape/disk system)	1,500	69,800	32.75
			Model 4 (three channels-tape/disk system)	1,800	83,800	40.75
			Model 5 (four channels-tape/disk system)	1,900	88,500	43.00
		3315	Disk Storage Attachment	300	14,250	NC
		7830	Tape Switching Feature (for 729 II, IV, V, VI)			
		7835/6/7/8	Additional 729 Tape Attachment	100	4,500	.50
	7600		Input/Output Control:			
			Model 1 (for any card system)	1,400	63,000	41.00
			Model 2 (for tape/disc systems)	800	33,000	19.75
	4671		Inquiry Control-Synchronizer (first)	400	18,250	6.50
	4672		Inquiry Control-Synchronizer (second)	350	15,250	5.00
	7604		Tape Control:			
			Model 1 (two channels)	2,700	125,500	97.25
			Model 2 (one channel)	1,850	96,300	54.00
			Model 3 (two channels, 800 char./inch)	3,300	155,300	99.50
	7155		Switch Control Console			
			Model 1 (for up to 2 tape units)	30	1,050	6.50
			Model 2 (for up to 4 tape units)	50	1,550	12.25
			Model 3 (for up to 6 tape units)	65	2,050	18.50
			Model 4 (for up to 8 tape units)	80	2,600	24.50
	1414		Model 6 Input/Output Synchronizer	850	43,350	24.75
		7871	Telegraph Input (requires 7864)	110	6,750	3.25
		7875	Telegraph Output (requires 7864)	125	7,750	3.25
		7864	Telegraph Input/Output	500	30,500	10.25
			Channels			
	7907		Data Channel			
			Model 1 (one channel)	2,000	80,000	57.00
			Model 2 (two channels)	3,000	120,000	91.75
		3221	Data Channel Attachment (on 7601 and 7602)	450	18,000	5.00
		3224	Data Channel Switch	25	650	1.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Contd.)			Adapters			
	6136		Remote Inquiry Unit Adapter	200	11,500	5.75
	5514		Paper Tape Reader Adapter	100	3,750	1.50
	3238		Data Transmission Unit Adapter	200	11,000	3.50
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,100	115,500	230.00
			Model 2 (56 million characters)	3,500	185,500	343.00
	7300		Disk Storage Unit			
			Model 1 (6,000,000 digits)	975	62,200	217.00
	7605		Disk Storage Control (for 7300)	3,900	141,800	41.00
			File Control			
	7631		File Control (for up to five 1301 units)			
			Model 2	835	42,000	28.00
			Model 4 (for sharing disk units between two 7000 series systems except 7010's)	1,035	52,000	32.75
		3213	Cylinder Mode	25	1,250	1.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit:			
			Model II	700	36,000	103.00
			Model IV	900	41,250	108.00
			Model V	750	37,200	119.00
			Model VI	950	42,450	206.00
			Punched Card			
	7500		Card Reader	400	13,100	79.00
	7550		Card Punch	550	19,500	49.25
	7501		Console Card Reader (Price includes #2265 Card Reader Attachment on 7600	100	4,300	9.50
			Paper Tape			
	1011		Paper Tape Reader (requires 5514)	500	20,200	56.00
		5514	Paper Tape Reader Adapter	100	3,750	1.50
			Printer			
	7400		Printer	950	37,000	76.00
			Inquiry Unit			
	7900		Inquiry Station	250	10,300	25.00
	1014		Remote Inquiry Unit (requires 6136)	200	8,000	21.00
		6136	Remote Inquiry Unit Adapter	200	11,500	5.75
COMMUNI-CATIONS			Transmission Unit			
	1009		Data Transmission Unit (requires 3238)	500	26,400	13.00
		3238	Data Transmission Unit Adapter	200	11,000	3.50

INTRODUCTION

The 7072 is a solid-state tape oriented system intended for scientific applications. It offers relatively high processing speeds, large core storage capacity, decimal logic, and floating point arithmetic hardware as standard equipment. On typical scientific problems the 7072's internal speeds will be roughly twice as fast as the IBM 704, up to ten times as fast as the IBM 7070, and about 70% as fast as the more expensive IBM 7074.

Core storage may consist of from 5,000 to 30,000 word locations. Each location can hold one single-address instruction, one 5-character alphameric word, or one numeric word of ten decimal digits and sign. Core storage cycle time is six microseconds, as in the IBM 7070. The secret of the 7072's higher performance is its improved internal circuitry; all arithmetic is performed in parallel, and the number of cycles required for virtually every operation has been greatly reduced. The instruction repertoire is versatile and effective; the only significant omission is the lack of automatic editing facilities. Three accumulators are provided, and many of the instructions can refer to any one of the three. Ninety-nine core storage locations can be used as index registers. While the 7072 is basically a fixed word-length system, operand sizes for most internal operations can vary from one to ten digits, and several short fields of like sign can readily be packed into a single core storage location.

A major feature of the 7072 is its ability to transfer several blocks of data to or from different core storage areas in a single operation. This scatter-read and gather-write capability facilitates internal data transfers as well as transfers between core storage and the peripheral units.

Automatic interruption facilitates effective use of the system's capabilities for simultaneous operations. Execution of a priority routine can be initiated automatically whenever an operation is completed by a selected peripheral unit.

The only magnetic tape unit available with the 7072 is the relatively slow IBM 7330. Peak transfer rate is 7,200 or 20,016 characters per second, and the 7330 is fully compatible with the 729 series tape units used in the 7070 and 7074 systems (but not with Hypertape). Up to ten tape units can be connected to each of a maximum of two channels.

A console card reader, rated at 60 cards per minute, is useful for direct card input on an exception basis. No line printer, punched tape, or high-speed card input-output devices are offered for the 7072. It is intended strictly as a tape oriented system, and an IBM 1401 will usually be used for the required off-line data transcription operations.

Nearly all IBM 7070 software is usable without change on the 7072. Autocoder is the basic machine oriented coding system and is offered in three versions for different translating computer configurations. The full, six-tape version includes powerful macro generation and input-output control facilities.

A FORTRAN II processor is available, and a COBOL 61 processor was delivered in March, 1962. A Compiler Systems Tape combines the Autocoder, COBOL, and FORTRAN processors and a Report Program Generator. The manufacturer also offers generalized sort and merge routines, program testing aids, and various utility routines. A wide variety of user-developed routines is available through GUIDE, the 7070 series users' organization.

NOTE: In order to emphasize the close family relationship of the IBM 7072 system to the IBM 7070, report sections covering those items of equipment and software whose form and use are the same in both systems have not been duplicated in this report. In these cases, the Contents section (404:001) refers the reader to the applicable sections of Computer System Report 403 on the IBM 7070.

IBM 7072

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*7105		High-Speed Scientific Processor:			
			Model 1 (one magnetic tape channel)	7,675	310,000	260.00
			Model 2 (two magnetic tape channels)	7,775	314,000	263.00
			Main Storage			
	7301		Core Storage			
			Models 1 and 11 (5,000 words)	3,500	195,000	70.00
			Model 2 (9,990 words)	6,800	343,000	77.00
			Models 21, 22, and 23 (10,000 words)	6,800	343,000	77.00
			Additional Core Storage Attachments (required when more than 10,000 words are used)			
		1017	On 7105 Processor	450	18,450	9.25
		1018	On 7624 Power and Tape Control	25	900	2.00
		1018	On 7625 Tape Control	25	900	2.00
	7150		Console Control Unit	300	13,050	26.50
INPUT-OUTPUT			Magnetic Tape			
	7330		Magnetic Tape Unit	450	22,000	58.50
		5980	Read Binary Tape (channel 1 only)	350	14,000	1.50
		7851	Additional Tape Attachment for Channel 1	100	4,500	.50
		7852	Additional Tape Attachment for Channel 2	100	4,500	.50
	7624		Power and Tape Control (Channel 1)	2,050	84,000	73.00
	7625		Tape Control (Channel 2)	1,850	75,000	48.00
			Punched Card			
	7501		Console Card Reader	75	3,100	9.00

NOTES:

*No longer in production.

INTRODUCTION

The solid-state 7074 system is the most powerful member of IBM's 7070 series. It is most effective as a tape oriented system for high volume business applications, and the IBM 1401 is commonly used with it to perform the off-line data transcription operations. Because it offers relatively high internal speeds, large core storage capacity, and optional floating point hardware, the 7074 can also be effective as a scientific processor.

An IBM 7070 system can be converted to a 7074 in the field by replacing the central processor and power converter and altering the internal circuitry in the core storage units and console. The 7074's internal speed is, on the average, about six times as fast as the 7070 and about 1.4 times as fast as the 7072. Overall system throughput for a 7074 on typical commercial applications will average twice that of a similarly equipped 7070, according to the manufacturer. Program compatibility among all members of the 7070 series is virtually complete.

Core storage may consist of from 5,000 to 30,000 word locations. Each location can hold one single-address instruction, one 5-character alphameric word, or one numeric word of ten decimal digits and sign. The 7074's core storage cycle time is four microseconds, compared to six microseconds in the 7070 and 7072 systems.

The instruction repertoire is versatile and effective; the only significant omission is the lack of automatic editing facilities. Three accumulators are provided, and many of the instructions can refer to any one of the three. Ninety-nine core storage locations can be used as index registers. While the 7074 is basically a fixed word-length system, operand sizes for most internal operations can vary from one to ten digits, and several short fields of like sign can readily be packed into a single core storage location.

A major feature of the 7074 is its ability to transfer several blocks of data to or from different core storage areas in a single operation. This scatter-read and gather-write capability facilitates internal data transfers as well as transfers between core storage and magnetic tape, disc storage, or unit record devices.

Automatic interruption facilitates effective use of the system's capabilities for simultaneous operations. Execution of a priority routine can be initiated automatically whenever an operation is completed by a selected peripheral unit or a manual inquiry request is made.

The IBM 729 series of magnetic tape units offers peak transfer rates from 15,000 to 90,000 characters per second. Up to ten 729 tape units can be connected to each of a maximum of four channels, and up to four tape read/write operations can occur simultaneously with internal processing.

Up to ten of IBM's Hypertape Drives can be connected to each of two tape channels in place of the 729s. Hypertape offers transfer rates of up to 170,000 alphameric characters or 340,000 decimal digits per second plus backward reading, fast stops and starts, and efficient cartridge loading. Hypertape, however, is not compatible with the other IBM tape units.

Two different types of auxiliary magnetic disc storage can be used; the maximum system capacity is 278 million characters.

A line of unit record devices, including a 500 card-per-minute reader, a 250 card-per-minute punch, and a 150 line-per-minute printer, is offered for the 7070 on an "as availabe" basis. A maximum of three readers and three output devices (printers and/or punches) can be connected. A console card reader, rated at 60 cards per minute, is useful in tape systems for direct card input on an exception basis.

INTRODUCTION–Contd.

Paper tape readers, remote inquiry stations, data transmission terminals, and telegraph transmitters and receivers can be connected to the system through the 1414 Input/Output Synchronizer and the 7907 Data Channel.

Nearly all IBM 7070 software is usable without alteration on the 7074. Autocoder is the basic machine oriented coding system and is offered in three versions for different translating computer configurations. The full, six-tape version includes powerful macro generation and input-output control facilities.

A FORTRAN II processor is available, and a COBOL 61 processor was delivered in March, 1962. A Compiler Systems Tape combines the Autocoder, COBOL, and FORTRAN processors and a Report Program Generator. The manufacturer also offers generalized sort and merge routines, program testing aids, and various utility routines. A wide variety of user-developed routines is available through GUIDE, the 7070 series users' organization.

NOTE: In order to emphasize the close family relationship of the IBM 7074 system to the IBM 7070, report sections covering those items of equipment and software whose form and use are the same in both systems have not been duplicated in this report. In these cases, the Contents section (405:001) refers the reader to the applicable sections of Computer System Report 403 on the IBM 7070.

IBM 7074

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7104		High-Speed Processor:			
			Model 1 (Card-only system)	7,300	313,000	241.00
			Model 2 (One tape channel)	7,400	317,000	244.00
			Model 3 (Two tape channels)	7,500	321,000	247.00
			Model 4 (Three tape channels)	7,700	329,000	252.00
			Model 5 (Four tape channels)	7,800	333,000	254.00
		4420	Floating Decimal Arithmetic	1,000	45,000	20.50
		3315	Disk Storage Attachment	300	14,250	--
		4760	Interval Timer	70	3,375	1.75
	7802		Power Converter	400	20,000	12.50
			Main Storage			
	7301		Core Storage:			
			Model 3 and 31 (5,000 words)	4,700	225,000	89.50
			Model 4 (9,900 words)	8,000	373,000	96.75
			Model 41, 42, and 43 (10,000 words)	8,000	373,000	96.75
	7602		Core Storage Control, Model 6	1,200	49,400	28.00
			Additional Core Storage Attachments (required with more than 10,000 words):			
	1017		On High-Speed Processor	400	16,350	9.25
	1018		On I/O Synchronizer	50	2,100	1.00
	1019		On 7604 Tape Control, Model 1	50	1,800	4.00
	1020		On 7604 Tape Control, Model 2	25	900	2.00
ATTACHMENTS, ADAPTERS AND CHANNELS	7155		Switch Control Console[1]			
			Model 1 (For up to 2 tape units)	30	1,050	6.50
			Model 2 (For up to 4 tape units)	50	1,550	12.25
			Model 3 (For up to 6 tape units)	65	2,050	18.50
			Model 4 (For up to 8 tape units)	80	2,600	24.00
	7603		I/O Synchronizer (Unit record)			
			Model 1 (one input and one output)	1,000	35,900	25.50
			Model 2 (two inputs and one output)	1,300	46,000	34.25
			Model 3 (one input and two outputs)	1,350	48,300	35.00
			Model 4 (two inputs and two outputs)	1,650	59,300	43.75
			Model 5 (two inputs and three outputs)	2,000	72,700	53.50
			Model 6 (one input and three outputs)	1,700	61,600	44.75
			Model 7 (three inputs and one output)	1,600	57,100	43.00
			Model 8 (three inputs and two outputs)	1,950	70,400	52.50
			Model 9 (three inputs and three outputs)	2,300	83,700	62.00
	7604		Tape Control (for 729's)			
			Model 1 (Two channels)	2,700	125,500	97.25
			Model 2 (One channel)	1,850	96,300	54.00
			Model 3 (Two channels - 800 char./inch)	3,300	155,300	99.50
	7150		Console Control Unit	300	13,050	26.50
	7501		Console Card Reader	75	3,100	9.00
	7600		I/O Control			
			Model 1 (For any card svstem)	1,400	63,000	56.00
			Model 2 (For any tape/disk system)	800	33,000	32.25
	4671		Inquiry Control - Synchronizer 1	400	18,250	6.50
	4672		Inquiry Control - Synchronizer 2 (on 7600)	350	15,250	5.00
	1414		I/O Synchronizer, Model 6	850	43,350	24.75

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			IDENTITY OF UNIT	PRICES		
ATTACHMENTS, ADAPTERS AND CHANNELS (Contd.)			Adapters			
		3238	Data Transmission Unit Adapter	200	11,000	3.50
		5514	Paper Tape Reader Adapter	100	3,750	1.50
		6136	Remote Inquiry Unit Adapter	200	11,500	5.75
			Channels			
	7907		Data Channel (for 1301 DSU, 1414 I/O Synchronizer, and/or Hypertape)			
			Model 1 (one Channel)	2,000	80,000	57.50
			Model 2 (two Channels)	3,000	120,000	91.00
			Model 3 (three Channels)	4,500	192,000	126.00
			Model 4 (four Channels)	5,500	234,000	161.00
		3221	Data Channel Attachment (on High-Speed Processor)	350	14,000	4.00
		3224	Data Channel Switch	25	650	1.25
			Disk Storage			
	1301		Disk Storage:			
			Model (55.6 million characters)	2,100	115,500	138.00
			Model 2 (111.2 million characters)	3,500	185,500	238.00
	2302		Disk Storage:			
			Model 1 (117 million characters)	2,250	96,000	435.00
			Model 2 (234 million characters)	5,770	244,440	290.00
	7300		Disk Storage Model 1 (6 million digits)	975	62,200	217.00
	7631		File Control (for 1301 and 2302 Disk Storage Units)(2)			
			Model 2 (for 7074)	835	42,000	28.00
			Model 4 (for 7074 and a second 7000 series system except 7010)	1,035	52,000	32.75
		3213	Cylinder Mode	25	1,250	1.00
		7950	2302 Attachment	350	14,000	3.00
	7605		Disk Storage Control (for 7300 Disk Storage Unit)	3,900	141,800	41.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model II	700	36,000	103.00
			Model IV	900	41,250	114.00
			Model V	750	37,200	108.00
			Model VI	950	42,450	119.00
		7835, 7836, 7837, or 7838	Additional 729 attachment (on 7602; required when more than six 7290 are used on a channel)	100	4,500	.50
		7830	Tape Switching Feature (on 729II/IV/V/VI)	85	4,400	6.50
		5980	Read Binary Tape (Channel 1 only)	350	14,000	1.50
	7340		Hypertape Drive	1,300	64,500	113.00
		1284	Automatic Cartridge Loader	125	7,500	16.00
	7640		Hypertape Control	3,400	168,000	95.25
			Punched Card			
	7500		Card Reader	400	13,000	79.00
	7550		Card Punch	550	19,500	49.25
			Paper Tape			
	1011		Paper Tape Reader (requires 5514)	500	20,200	56.00
		5514	Paper Tapes Reader Adapter	100	3,750	1.50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printer			
	7400		Printer	950	37,000	76.00
			Inquiry Unit			
	7900		Inquiry Station	75	3,100	9.00
	1014		Remote Inquiry Unit (requires 6136)	200	8,000	21.00
		6136	Remote Inquiry Unit Adapter	200	11,500	5.75
			Telegraph Feature			
		7871	Telegraph Input (requires 7864)	500	30,500	10.25
		7875	Telegraph Output (requires 7864)	110	6,750	3.25
		7864	Telegraph I/O Feature for 7871 and 7875	125	7,750	3.25
COMMUNICATIONS			Transmission Unit			
	1009		Data Transmission Unit (requires 3238)	500	26,400	13.00
		3238	Data Transmission Unit Adapter	200	11,000	3.50

NOTES:

(1) A 7830 is required on each tape unit to be switched.

(2) The 7631 File Control can accommodate up to five 1301 Disk Storage Units and 2302 Disk Storage Units.

§ 011. INTRODUCTION

The IBM 7090 is a large-scale data processing system with the same general characteristics as the 704 and 709 general purpose computers. Comparative throughput capacities indicate that the 7090 has a six to seven times advantage over the 704. Because only low-speed printers, card readers, and punches can be connected to the system, 7090 systems are magnetic tape oriented and usually supported by off-line IBM 1401 data processing systems. The 1401 systems perform card-to-tape and tape-to-printer or tape-to-card operations, in addition to some editing for the 7090. Magnetic tape units can be switched between the 7090 and 1401 systems. Monthly rentals for two-channel, eight-tape 7090 systems start at approximately $60,000 (see System Configuration 408:031).

The 7090 transmits and receives data via a unit called the 7606 Multiplexor, which time shares the data flow between the 32,768-word core storage unit and either the processor or data channels. These data transfers are executed through 36-bit word parallel circuits. The multiplexor determines which unit requires access to storage most urgently and grants that unit access. In general, a processor request is less urgent than a data channel request because the channel controls mechanical equipment, such as magnetic tape units, which have a fixed demand cycle.

The basic cycle time of the 7090 central processor, i.e., the time for accessing the store and performing a part of an instruction, is 2.18 microseconds. Most instructions are executed in two cycles, permitting speeds of nearly 227,000 instruction executions per second in data processing applications. Multiplication and division instructions require more cycles, and are executed at 41,700 and 35,400 executions per second respectively. Therefore, applications demanding heavy use of multiply and divide operations use a larger share of central processor time than those involving primarily data movement and simple arithmetic operations. In applications that involve throughput of large volumes of data, the system tends to be speed-limited by the input-output facilities.

The processor uses binary arithmetic for both fixed and floating point operations. Fixed point arithmetic is performed on 35 bits, plus sign and two overflow bits. Floating point operands have eight-decimal-digit precision, and can assume positive or negative values between 10^{+38} and 10^{-38}, including zero. Three "table look-at" instructions in the repertoire are very useful for code conversions, radix conversions, six-bit BCD addition and subtraction, and simple editing. Address modification is facilitated by three decrementing index registers. These registers use two's complement arithmetic rather than the absolute value and sign arithmetic of the processor. However, a set of index register modification instructions compensate for this incompatibility of two types of arithmetic. In programs which use many indices for varied loop control, more indexing is required than three index registers can provide. As a result, the storing and reloading of the index registers may be required comparatively often. These operations require both data and program storage, and add a non-productive burden which, although small, is unusual in a large system of this type.

The instruction repertoire of the 7090 is comprehensive and varied, and includes five types of logical operators, single- and partial-word data transfers, input-output instructions (used to start data channels and select input-output units), and an extensive set of test and conditional transfer instructions. Interrupts (called traps by IBM) can occur when encountering: a transfer instruction a 7040 or 7044 instruction, floating point underflow or overflow, a 704 input-output instruction, or an external signal; and for certain data channel conditions.

A 7090 system can include any of three different types of data channels: the 7607 Data Channels, which can control 729 Magnetic Tapes and peripheral unit-record equipment; the 7909 Data Channel, which can be connected to 7340 Hypertapes, 1301 Disk Units, and 7320 Drums; or the 7281 II Data Communications Channel, which can control up to 32 "real-time" communication units. The 7281 II is different from the others in that it: is restricted

§ 011. **INTRODUCTION (Contd.)**

to one area of storage; can only be turned on or off; requires the Direct Data option and instructions; and has higher priority interrupts than the 7607 and 7909.

The 7607 and 7909 Data Channels are actually small processors which have program and address counters, indirect addressing, and command registers. The function of these units is to transmit data from the core store to an input-output unit, and vice versa. Data transfers to and from the store are performed through parallel 36-bit word circuits. In all of the input-output units, data transfers are serial by character to or from a six-character word. Both units can control scatter-read and gather-write operations, and skip entire data blocks or parts of data blocks being read from an input-output unit.

The 7607 Data Channel can also have a Direct Data Connection added to it to permit on-line storage-to-storage data transfers between 7040, 7044, and 7094 systems. The 7607 can act as a controller for connecting up to ten 729 Magnetic Tape units, a printer, a card reader, and a card punch.

The 7909 Data Channel has a more extensive command set than the 7607. These commands give the 7909 the ability to handle many of the input-output unit conditions that would require processor intervention with the 7607 Data Channel. The 7909 can be used for input-output editing, but the processor can perform editing tasks more economically. The 7909 has a transmit command which transfers blocks of up to 32, 768 words simultaneously with other processing.

The software for the 7090 system that is supplied by IBM is rather extensive. Included in this software are the process oriented languages FORTRAN II and IV, COBOL, and COMTRAN. Source statements in these languages are translated into machine code and into FAP or IBMAP, which are the machine oriented languages for the system.

Problem oriented languages include: 9PAC for file maintenance and report generation, IOCS for automatic input-output editing for formatting, various sort programs, and Disk and Hypertape utility routines. Each program has its own monitor routine to permit processing with a minimum of operator intervention. All of the software can be used as a part of the IBSYS Processor Operating System, which permits input-output unit assignment and can call the programs in the system, in addition to its normal monitor and maintenance functions.

The 7090 can accept nearly all 704, 709, 7040 and 7094 programs directly, as compiled on those systems. A special program, Compatibility II, is provided for 704 programs. Because of the compatibility features built into the 7090, very little interpretive running is required. Thus, programs generated for the other systems run proportionately faster on the 7090 than on the system they are generated for. With the exception of the double-precision arithmetic instruction, 7094 programs can also be run on the 7090.

A wide range of programs for handling mathematical function routines and service and utility routines, as well as many complete program systems, have been compiled and are maintained by the SHARE users organization since it was formed by 704 users. The 7090 can accept nearly all of these programs directly.

IBM 7090

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7108		Instruction Processing Unit	10,600	449,500	493.00
	7109		Arithmetic Sequence Unit	8,675	368,000	403.00
	7608		Power Converter	700	25,000	5.25
	7618		Power Control	900	35,000	15.00
			Main Storage			
			Model 1 Core Storage (32,768 words) 7151	17,500	715,000	515.00
ATTACH-MENTS, ADAPTERS, AND CHANNELS			Attachments			
			Model 1 Console Control Unit	1,225	61,700	29.50
	1414		I/O Synchronizer (communication)			
		7864	Telegraph I/O Feature for 7871 and 7875	500	30,500	11.00
		7871	Telegraph Input Feature	110	6,750	3.25
		7875	Telegraph Output Feature	125	7,750	3.25
	3238		Data Transmission Unit Adapter for 1009	200	11,000	3.50
	6136		Remote Inquiry Unit Adapter for 1014	200	11,000	5.75
	7155		Switch Control Feature (7830 required on each tape unit to be switched)			
			Model 1 (for up to 2 tapes)	30	1,050	6.50
			Model 2 (for up to 4 tapes)	50	1,550	12.25
			Model 3 (for up to 6 tapes)	65	2,050	18.50
			Model 4 (for up to 8 tapes)	80	2,600	24.50
			Channels			
	7607		Data Channels (8 max.) (1)	4,275	197,500	162.00
			Model 1 (channel for up to 10 729 II/IV's, one 711, one 716, and one 721)			
			Model 2 (channel for up to 10 729 II (IV's)	3,275	159,000	124.00
			Model 3 (channel for up to 10 729 II/IV/V/VI's one 711, one 716 and one 721)	4,360	200,900	162.00
			Model 4 (channel for up to 10 729 II/IV/ V/VI's)	3,360	162,400	124.00
	7909		Data Channel (max 4)(1)			
			Model 1 (for 1301's, 7340's, 1410's, or 7750)	2,800	112,000	100.00
		1471	BCD Translation	100	4,200	1.00
	3224		Data Channel Switch	125	5,000	1.00
	7617		Data Channel Console (one extra 7617 required for each additional 7607)	225	10,900	14.25
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,100	115,500	230.00
			Model 2 (56 million characters)	3,500	185,500	343.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)	2302		Disk Storage:			
			Model 1 (117 million characters)	5,770	244,440	230.00
			Model 2 (234 million characters)	8,135	344,830	420.00
			Drum Storage			
	7320		Drum Storage (11 million characters)	2,300	124,000	103.00
			File Control			
	7631		File Control (for up to five units)(2)			
			Model 2	835	42,000	28.00
			Model 4 (for sharing disk or drum units between two 7000 series systems except 7072's)	1,035	52,000	32.75
	3213		Cylinder Mode	25	1,250	1.00
	3451		Drum Storage Adapter (for connecting 7320 Drum units)	100	3,500	3.00
	7950		2302 Attachment	350	14,000	3.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model II	700	36,000	116.00
			Model IV	900	41,250	128.00
			Model V	750	37,200	122.00
			Model VI	950	42,450	134.00
		7830	Tape Switching Feature	85	4,400	6.50
	7340		Hypertape Drive (max. 20)	1,300	64,500	113.00
	7640		Hypertape Control (max. 1)	3,400	168,000	95.25
		5975	Read Backward Character Assembly and Storage	200	8,400	34.00
			Punched Card			
	711		Card Reader, Model 2	800	32,000	63.25
	721		Card Punch	600	25,000	65.25
		2250	Consecutive Number Punching	35	2,275	8.25
			Paper Tape			
	1011		Paper Tape Reader	500	20,200	56.00
		5514	Paper Tape Reader Adapter for 1011	100	3,750	1.50
			Printer			
	716		Printer	1,200	54,200	116.00
			Inquiry Unit			
	1014		Remote Inquiry Unit (10 max.)	200	8,000	21.00
		6136	Remote Inquiry Unit Adapter for 1014	200	11,000	5.75
COMMUNI-CATIONS			Transmission Unit			
	1009		Data Transmission Unit	500	26,400	13.00
		3238	Data Transmission Unit Adapter for 1009	200	11,000	3.50
			Multiplexor			
	7606		Model 1 Multiplexor	3,900	156,300	130.00

NOTES:

(1) Addition of 7909's reduces number of 7607's possible.

(2) With special features 3451 and 7950, a 7631 File Control can accommodate up to five 1301, 2302, and 7320 units in any combination. These special features can be connected to any 7631 File Control with a serial number of 12000 or higher.

INTRODUCTION

§ 011.

The IBM 7094 is a large-scale data processing system with the same general characteristics as the 709 and 7090 general purpose computers. Comparative throughput capacities indicate that the 7094 is about twice as fast as its equivalent 7090 system. Because only low-speed printers, card readers, and punches can be connected to the system, 7094 systems are magnetic-tape-oriented and usually supported by off-line IBM 1401 data processing systems. The 1401 systems perform card-to-tape and tape-to-printer or tape-to-card operations in addition to some editing for the 7094. Magnetic tape units can be switched between the 7094 and 1401 systems. Monthly rentals for two-channel, eight-tape 7090 systems start at approximately $66,000 (see System Configuration, 409:031).

The 7094 transmits and receives data via a modified 7606 Multiplexor, which time-shares the data flow between the 32,768-word core storage unit and either the processor or data channels. These data are transferred in parallel in units of 36-bit words. The multiplexor determines which unit requires access to storage most urgently and grants that unit access. In general, a processor request is less urgent than a data channel request, because the channel controls mechanical equipment, such as magnetic tape units, which have a fixed demand cycle.

The 7094 central processor has a basic cycle time of 2 microseconds, which is an increase of almost 10 per cent over that of the 7090. When accessing instructions from even-numbered locations that do not involve double-precision floating point instructions, the processor can accept two instructions during one instruction cycle. The first instruction is executed immediately while the next is held in the register which is normally used for one half of a double precision floating point operand. In most cases, storage access is thus saved for the subsequent instruction, which is actually used to execute the current instruction.

Since most of the commands require 2 cycles, speeds of nearly 300,000 instructions per second are possible. Multiplication and division speeds of the 7094 are almost 3 times those of the 7090, or approximately 120,000 and 65,000 operations per second, respectively. Therefore, applications demanding heavy use of multiply and divide operations use a larger share of central processor time than those involving primarily data movement and simple arithmetic operations. In applications that involve throughput of large volumes of data, the system tends to be speed-limited by the input-output facilities.

The processor uses binary arithmetic for both fixed and floating point operations. Fixed point arithmetic is performed on 35 bits, plus sign and 2 overflow bits. Floating point operands have either 8- or 16-decimal-digit precision, and can assume positive or negative values between 10^{+38} and 10^{-38}, including zero. This instruction repertoire includes double precision load and store instructions, which transfer data between an even-numbered storage address and that address plus one and the accumulator and multiplier-quotient registers, respectively. Failure to observe this addressing convention results in an interrupt (see 409:051.33).

Three "table look-at" instructions in the repertoire are very useful for code conversions, radix conversions, six-bit BCD addition and subtraction, and simple editing. Address modification is facilitated by three decrementing index registers. These registers use two's complement arithmetic rather than the absolute value and sign arithmetic of the processor. However, a set of index register modification instructions compensate for this incompatibility of two types of arithmetic. In programs which use many indices for varied loop control, more indexing is required than three index registers can provide. As a result, the storing and reloading of the index registers may be required comparatively often. These operations require both data and program storage, and add a non-productive burden which, although small, is unusual in a large system of this type.

INTRODUCTION (Contd.)

The instruction repertoire of the 7094 is comprehensive and varied, and includes five types of logical operators, single- and partial-word data transfers, input-output instructions (used to start data channels and select input-output units), and an extensive set of test and conditional transfer instructions. Interrupts (called traps by IBM) can occur when encountering: a transfer instruction, a 7040 or 7044 instruction, floating point underflow or overflow, a 704 input-output instruction, or an external signal; and for certain data channel conditions.

A 7094 system can include any of 3 different types of data channels: the 7607 Data Channels, which can control 729 Magnetic Tapes and peripheral unit-record equipment; the 7909 Data Channel, which can be connected to 7340 Hypertapes, 1301 Disk Units, and 7320 Drums; or the 7281 II Data Communications Channel, which can control up to 32 "real-time" communication units. The 7281 II is different from the others in that it: is restricted to one area of storage; can only be turned on or off; requires the Direct Data option and instructions; and has higher priority interrupts than the 7607 and 7909.

The 7607 and 7909 Data Channels are actually small processors which have program and address counters, indirect addressing, and command registers. The function of these units is to transmit data from the core store to an input-output unit, and vice versa. Data transfers to and from the store are performed through parallel 36-bit word circuits. In all of the input-output units, data transfers are serial by character to or from a six-character word. Both units can control scatter-read and gather-write operations, and skip entire data blocks or parts of data blocks being read from an input-output unit.

The 7607 Data Channel can also have a Direct Data Connection added to it to permit on-line storage-to-storage data transfers between 7040, 7044, and 7090 systems. The 7607 can act as a controller for connecting up to ten 729 Magnetic Tape units, a printer, a card reader, and a card punch.

The 7909 Data Channel has a more extensive command set than the 7607. These commands give the 7909 the ability to handle many of the input-output unit conditions that would require processor intervention with the 7607 Data Channel. The 7909 can be used for input-output editing, but the processor can perform editing tasks more economically. The 7909 has a transmit command which transfers blocks of up to 32,768 words simultaneously with other processing.

The software for the 7094 system that is supplied by IBM is rather extensive. Included in this software are the process oriented languages FORTRAN II and IV, COBOL, and COMTRAN. Source statements in these languages are translated into machine code and into FAP or IBMAP, which are the machine oriented languages for the system.

Problem oriented languages include: 9PAC for file maintenance and report generation, IOCS for automatic input-output editing for formatting, various sort programs, and Disk and Hypertape utility routines. Each program has its own monitor routine to permit processing with a minimum of operator intervention. All of the software can be used as a part of the IBSYS Processor Operating System, which permits input-output unit assignment and can call the programs in the system, in addition to its normal monitor and maintenance functions.

The 7094 can accept nearly all 704, 709, 7040 and 7090 programs directly as compiled on those systems. A special program, Compatibility II, is provided for 704 programs. Because of the compatibility feature built into the 7094, very little interpretive running is required. Thus, programs generated for the other systems run proportionately faster on the 7094 than on the system they are generated for. Double-precision arithmetic, which give the 7094 a large performance increase over the interpretive subroutines in the 7090 are inserted by the FORTRAN program.

A wide range of routines for handling mathematical function routines and service and utility routines, as well as many complete program systems, have been compiled and are maintained by the SHARE users organization since it was formed by 704 users. The 7094 can accept nearly all of these programs directly.

IBM 7094

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7109		Model I:			
			Arithmetic Sequence Unit	8,675	368,000	403.00
		7146	7094 Feature	100	4,000	NC
	7110		Instruction Processing Unit	16,350	590,000	541.00
	7151		Console Control Unit	1,325	66,700	29.50
			Model II:			
	7109		Arithmetic Sequence Unit	8,675	368,000	403.00
		7146	7094 Feature	100	4,000	NC
		7147	7094 II Feature	NC	NC	NC
	7111		Instruction Processing Unit	20,200	635,000	622.00
	7151		Console Control Unit	1,325	66,700	29.50
	7608		Power Converter	700	25,000	5.25
	7618		Power Control	900	35,000	15.00
			Main Storage			
			Model I:			
	7606		Multiplexor Model 1	3,900	156,300	130.00
		7146	7094 Feature	50	4,000	NC
	7302		Core Storage, Model 1 (32,768 words)	17,500	715,000	515.00
			Model II:			
	7606		Multiplexor, Model 2	4,600	184,300	133.00
	7302		Core Storage, Model 2 (two 16,384-word modules, 32,768 words total)	19,000	750,000	542.00
ATTACHMENTS, ADAPTERS AND CHANNELS			Attachments			
	7155		Switch Control Feature (7830 required on each tape unit to be switched)			
			Model 1 (for up to 2 MTU's)	30	1,050	6.50
			Model 2 (For up to 4 MTU's)	50	1,550	12.25
			Model 3 (For up to 6 MTU's)	65	2,050	18.50
			Model 4 (For up to 8 MTU's)	80	2,600	24.50
	3238		Data Transmission Unit Adapter for 1009	200	11,000	3.50
	5514		Paper Tape Reader Adapter for 1011	100	3,750	1.50
	6136		Remote Inquiry Unit Adapter for 1014	200	11,500	5.75
	1414		Input/Output Synchronizer, Model 6 (Communications)			
		7871	Telegraph Input Feature	110	6,750	3.25
		7875	Telegraph Output Feature	125	7,750	3.25
		7864	Telegraph I/O Feature for 7871 and 7875	500	30,500	11.00
			Channels			
	7607		Data Channel (max 8)(1)			
			Model 1 (for up to 10 729) II/IVs one 711, one 716, and one 721)	4,275	197,500	162.00
			Model 2 (for up to 10 729 II/IVs	3,275	159.000	124.00
			Model 3 (for up to 10 729 II/IV/V/VI one 711, one 716, and one 721)	4,360	200.900	162.00
			Model 4 (for up to 10 729 II/IV/V/VIs	3,360	162,400	124.00
	7617		Data Channel Console (one extra 7617 required for each additional 7607)	225	10,900	14.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACHMENTS, ADAPTERS AND CHANNELS (Contd.)			Channels (Contd.)			
	7909-I		Data Channel (max 4; for 1301, 7340, 1410 or 7750 units)(1)	2,800	112,000	100.00
		1471	BCD Translation	100	4,200	1.00
	3224		Data channel switch	125	5,000	1.00
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,100	115,500	230.00
			Model 2 (56 million characters)	3,500	185,500	343.00
	2302		Disk Storage:			
			Model 1 (117 million characters)	5,770	244,440	290.00
			Model 2 (234 million characters)	8,135	344,830	420.00
			Drum Storage			
	7320		Drum Storage (11 million characters)	2,300	124,000	103.00
			File Control			
	7631		File Control (for up to five units)(2)			
			Model 2	835	42,000	28.00
			Model 4 (for sharing disk or drum units between two 7000 series systems except 7010's)	1,035	52,000	32.75
		3213	Cylinder Mode	25	1,250	1.00
		3451	Drum Storage Adapter (for connecting 7320 Drum units)	100	3,500	3.00
		7950	2302 Attachment	350	14,000	3.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit:			
			Model II	700	2,275	103.00
			Model IV	900	36,000	114.00
			Model V	750	41,250	108.00
			Model VI	950	37,200	119.00
		7830	Tape Switching Feature	85	4,400	6.50
	7340		Hypertape Drive (Max. 20)	1,300	64,500	113.00
	7640		Hypertape Control (Max. 1)	3,400	168,000	96.25
		5975	Read Backward Character Assembly and Store	200	8,400	1.50
	711					
			Punched Card			
	711-2		Card Reader	800	32,000	74.00
	721		Card Punch	600	25,000	62.25
		2250	Consecutive Number Punching (Optional feature for 721)	35	2,275	7.25
			Paper Tape			
	1001		Paper Tape Reader	500	20,200	56.00
		5514	Paper Tape Reader Adapter for 1011	100	3,750	1.50
			Printer			
	716		Printer	1,200	54,200	135.00
			Inquiry Unit			
	1014		Remote Inquiry Unit (Max. 10)	200	8,000	21.00
		6136	Remote Inquiry Unit Adapter for 1014	200	11,000	5.75

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS			Transmission Unit			
	1009		Data Transmission Unit	500	26,400	13.00
		3238	Data Transmission Unit Adapter for 1009	200	11,000	3.50

NOTES:

(1) Additional of 7909's reduces number of 7607's possible.

(2) With special features 3451 and 7950, a 7631 File Control can accommodate up to five 1301, 2302, and 7320 units in any combination. These special features can be connected to any 7631 File Control with a serial number of 12000 or higher.

SUMMARY: IBM 7040/7044

.1 BACKGROUND

IBM 7040/7044 computer systems are medium-scale data processing systems capable of efficient performance in both scientific and commercial applications. Hardware and software of these second-generation machines are simple and straightforward, yet sophisticated enough to supply almost every need in the medium power range. The systems are no longer in production, nor can they be ordered. However, IBM still supports these systems.

The 7040 and 7044 systems differ only in their internal processing speeds — the 7040's 8-microsecond cycle as contrasted with the 7044's 2.5 microsecond time. These figures refer only to storage reference cycle time and do not adequately reflect the true ratio of power, which depends upon the application involved. Monthly rentals for the 7040 range from $21,000 to $39,000, while the faster 7044 processor requires a substantial rise in rental configurations ranging between $35,000 and $48,000.

The 7040/7044 computers are members of the "7000" series of computers manufactured by IBM. This series includes the 7040, 7044 and the larger, faster 7090, 7094, and the 7094 Model II, all of which are 36-bit-word binary machines, as well as others (7070, 7072, 7074, 7080) incompatible because of choice of radix or word-length. The 7040/7044 system is a descendant of the 704 and 709 machines, but it also uses the 1401 interchange code and much of the 1401 peripheral hardware. While the 1401 may not be program compatible, the compatibility of tape codes is used to advantage in many installations by incorporating card-to-tape, tape-to-print, and tape-to-punch routines on the 1401 for peripheral input/output.

.2 HARDWARE

.21 System Configuration

In comparison to other systems in its class, the 7040 appears to operate two to three times faster than the 709 system and at approximately half the speed of a 7090, while the 7044 will operate twice as fast as the 7040, and somewhat slower than a 7094. Ignoring Hypertape units on input-output-limited programs, the 7040/7044 speed should closely approximate that of the 7090, since the same disc storage and magnetic tape units are used with all systems.

The 7040/7044 data processing system consists of one 7106 (7040) or 7107 (7044) Central Processor with an output-only typewriter and core memory with data channels, controllers (synchronizers), and peripheral units. Core memory is available in sizes of 4,096 (7040 only), 8,192, 16,384, and 32,768 words. The central processor acts as a data channel (designated "A"); hence the central processor is frozen during input-output operations using data channel A.

Up to four additional channels may be added. These are the 7904 overlapped-transfer data channels, which may be transmitting data while the central processor is executing instructions. The channels are in turn connected to 1414 (Models I through VII) synchronizers, which act as control devices for peripheral units. Disk Storage (two models), and a drum storage, as well as up to 50 tape units may be used for data storage; card readers, card punches, printers, paper tape punches, and many other telecommunications devices may be attached.

.22 Core Memory

Core memory is available as 4,096, 8,192, 16,384, and 32,768-word modules, the first of which is available only on the 7040. Each word consists of 36 bits plus a parity bit and may be viewed as one instruction, one single-precision floating point data item, one fixed-point data item, or as six characters. Double-precision floating-point data items are formed from two adjacent words. All data transfers, into, within, and out of core memory are checked for parity bits (odd parity).

The basic cycle times of the 7040 and 7044 are 8 and 2.5 microseconds, respectively. These times are not reflected in the effective speeds of the central processors, however, since the microstructure of the instruction set may require extra storage cycles from the 7107. For example, an execution of a certain instruction might take two 7106 cycles (16 microseconds) or three 7106 cycles (7.5 microseconds).

.23 Central Processor

The standard 7106 Central Processor has a set of fixed-point arithmetic instructions and instructions for data manipulating, control, and input-output but has no index registers. The Extended Performance option includes three index registers with a set of 20 instructions for using these registers, three single-character handling instructions, a data block transfer instruction, and several sequence control instructions. Acquiring this option is almost mandatory because the software being written for the 7040/7044 relies on the option for optimum object programs; also, the option can double the system throughput with an increase of five per cent or less in rental or price.

Other options are: Single Precision Floating Point (required for FORTRAN), Double Precision Floating Point (for which the Single Precision Floating Point option is a prerequisite), a Clock and Interval Timer, and a Memory Protect option.

Instructions are commonly one address, involving one or two nonaddressable arithmetic registers. Indirect addressing of one level only, with optional pre- and post-indexing (performed by subtraction, thereby requiring at least an acquaintance with two's complement arithmetic) is available. Addressing is direct, with the operand address usually appearing within the instruction, thus it is possible for each instruction to address all of core storage directly, but reentrant coding becomes involved. No facilities are provided in the hardware for multiprocessing (with the exception of the Present Sense Lines and Store Sense Lines commands) or multirunning or time sharing.

The 7040/7044 has an extensive interrupt system that provides definitive indications of the reasons for the interrupts, in addition to links back to the main program and to an interrupt processing routine. The interrupt system grows with the size of the system; with few exceptions, adding any option or piece of equipment adds another source or kind of interrupt. All interrupts can be enabled or disabled individually or in groups.

Any instruction except storage protection set and disable may be executed by any program without an interruption; consequently, privileged mode is keyed to memory protection. Input-output may proceed to and from any core address, regardless of memory protection.

.24 Peripheral Equipment

Large direct-access storage devices are available for the 7040/7044 systems in the forms of the 1301 and 2302 disk units and the 7320 drum storage unit. Up to five of these units may be attached to a 7040/7044, allowing storage of up to 1.17 billion characters on-line to the central processor.

The 1301 comes in two models; mode 2 is actually two separate model 1 units, referred to as modules. Each module has the capacity of 27,900,000 characters and a potential transfer rate of 83,000 characters per second. Up to five model 2 units may be attached, allowing a maximum 1301 storage of about a quarter of a billion characters of information.

There are also two models of the 2302 disc storage unit; again, model 2 is simply two model 1 units. Each 2302 module can store up to 117 million characters of information, accessed by two independent access arms. This independent access arm motion more than doubles the potential transfer rate of the 1301, namely, 179,000 characters per second. When the maximum of five 2302 model 2 units are attached, a 7040/7044 system will be able to access the 1.17 billion character figure cited previously.

The 7320 drum storage may store up to 1,118,400 characters of information on 400 tracks. Each character may be retrieved or written in 8.6 milliseconds; data transfer rate is a potential 203,000 characters per second.

Magnetic tapes are available in the form of two units, the 7330 and the 729. The 7330 is a slower unit moving tape at 36 inches per second, while the 729, which is fully compatible with the 7330 and the 1401 data processing system, is capable of running at 75 and 112.5 inches per second.

The 729 comes in many models offering a variety of tape speed and recording densities (200, 556, and 800). Seven-track tape with 1401 Binary Coded Decimal Interchange Code (BCDIC, or BCD for short) is used.

1401-compatible unit record equipment is standard on all models in the 7040/7044 line and includes the 800-card-per-minute 1402 card reader (model 2), the 1402 model 2 card punch (housed in the same physical unit as the reader and operating at 250 cards per minute), the 600-line-per-minute models 1 and 2 of the 1403 printer, and the 1100-line-per-minute 1403 model 3 printer.

A wide variety of remote and teleprocessing facilities is available for use with the 7040/7044. The 1009 data transmission unit is used via the 1414 synchronizer for high-speed, two-way communications with other systems through additional 1009's, 7701 and 7702 magnetic tape transmission terminals, or the 1013 card transmission unit. Operating at 75, 150, 187.5, 250, and 300 characters per second, the 1009 provides a highly useful communications capability over leased or hardwired lines.

The 1014 remote inquiry unit may be used for low-speed data entry from a keyboard, resembling a typewriter keyboard, at speeds under 15.5 characters per second, and distances up to eight miles. Finally, the 7040/7044 may be used to transmit data directly to or from the 7106 or 7107 central processor through a 7904 data channel from such diverse devices as microwave links, telemeters, telegraph lines, radar, analog-to-digital converters, and other computer systems.

.25 Simultaneous Operations

Data channel A is part of the 7106/7107 central processor. This renders the processor incapable of operation during channel activity. However, the 7904 data channels (a maximum of four per system) will operate concurrently, one device at a time, with any central processor activity or with channel A. The installation of an optional 7288 communications channel allows multiplexing to take place within the channel itself; the 7288 replaces a 7904. Up to 48 subchannels may multiplex the 7288, a maximum of 32 simultaneously.

.3 SOFTWARE

.31 Support for a 4096-Word 7040

Supporting a 4,096-word 7040, IBM supplies only a basic assembler, primarily card oriented, which is a subset of the 7040/7044 16/32K MAP assembler. The extended performance set of instructions is required for operation of this support.

.32 Support for an 8,192-Word 7040/7044 (8K Support)

On the 8,192-word 7040/7044, IBM provides an Input/Output Control System for channel A devices, which can remove much of the programming burden for use of the 729, 7330, 1402, 1403, and the console typewriter. A subset of FORTRAN IV is available, requiring the use of the extended performance set. Also provided are an assembler (which is necessary for execution of FORTRAN-compiled programs), a Report Program Generator (RPG) and a relocatable loader. Both FORTRAN and RPG produce assembler language statements as output; this must be further processed by the assembler in order to furnish relocatable object decks for processing by the loader.

.33 Support for a 16,384 or 32,768-Word 7040/7044 (16/32 K Support)

The operating system for a machine containing 16,384 or more words consists of a system monitor, an input-output control system, and job-processing subsystems to perform a multitude of tasks. This system is in the form of a tree structure, with the system monitor being the root, activating one of several subsystems, which in turn activate individual processors.

The monitor has the primary responsibility for maintaining a continuous operation of the 7040/7044 across a stream of jobs of different characteristics, and of bringing into action one or more of a number of subsystems. In addition the monitor controls allocation of devices and error recovery and provides for intersubsystem communications.

Operating under the control of the monitor are: the Sort Monitor for producing and running sort-merge programs, the Update program for maintaining symbolic (i.e. card-image) files, the System Editor for altering the operating system itself, or for creating new copies from an older version; and the Processor Monitor. These subsystems can run independent of each other.

The Processor Monitor functions as a clearinghouse for requests, by way of a predetermined control language, for any processor under its control. Standard components of the Processor Monitor include the Macro Assembly Program (MAP), the FORTRAN compiler, the COBOL compiler, the relocatable Loader, the Debugging package, a subroutine library, and a reloading feature that makes it possible to create new processors. These processors are stored in absolute (i.e. nonrelocatable) form in the System Library, which is manipulated by the System Editor, and retrieved by the System Loader (not the Relocatable Loader) upon request from the Processor Monitor. Typical Processor Monitor activity would be a sequence of compilations and assemblies followed by loading and execution of a user program, with subsequent saving of the program in absolute format on a tape for later execution.

General software support for the 16/32K configuration is limited in the number of processors available, but highly flexible within the confines outlined. However, there is no facility for multirunning or multiprocessing in the 16/32K support.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7106		Central Processor (includes Data Channel A and Core Storage):			
			Model I (4,096 words)	7,275	470,450	175.00
			Model II (8,192 words)	7,760	494,700	185.00
			Model III (16,384 words)	8,730	543,200	200.00
			Model IV (32,768 words)	10,670	640,200	245.00
	7107		Central Processor (includes Data Channel A and Core Storage):			
			Model I (8,192 words)	16,975	1,115,500	225.00
			Model II (16,384 words)	17,945	1,164,000	235.00
			Model III (32,768 words)	19,885	1,261,000	255.00
		3880	Extended Performance	485	14,550	10.00
		4428	Floating Point Arithmetic Single Precision	340	9,700	6.25
		4429	Floating Point Arithmetic Double Precision	535	17,460	16.00
		5080	Memory Protection	73	2,910	2.25
		7498	Storage Block Internal Time	58	2,330	2.25
ATTACHMENTS, ADAPTERS, AND CHANNELS			Attachments			
	1414		Input-Output Synchronizer:			
			Model 1 (729 II, IV, V tape units)	945	42,195	26.75
			Model 2 (7330 tape units)	485	24,155	28.00
			Model 3 (punched card units)	655	29,465	29.50
			Model 4 (punched card units and communications)	750	38,705	32.75
			Model 5 (communications)	680	34,630	23.75
			Model 6 (communications)	825	42,050	24.75
			Model 7 (729 II, IV, V, VI tape units)	1,090	48,015	27.50
	7155		Switch Control Console:			
			Model I (2 tapes)	29	1,020	6.50
			Model II (4 tapes)	49	1,505	12.25
			Model III (6 tapes)	63	1,990	18.50
			Model IV (8 tapes)	78	2,520	24.50
		7814	Tape Intermix for 7330's	44	2,180	NC
	7680		Printer, 1403 Model 3 Attachment	535	22,070	15.00
	7681		Printer, 1403 Model 2 Additional Synchronizer Storage	58	2,375	1.00
			Adapters			
	1038		Adapter Card 1414 (1 max, none with 1046)	78	3,490	3.25
	1046		Adapter, 1622 (1 max, none with 1038)	92	4,560	2.25
	1040		Adapter, Tape 1414 (1 max)	116	5,335	4.25
	1034		Adapter, 1401 (1 max, requires 1080)	97	3,685	2.25
	7080		Serial Input-Output Adapter	97	3,640	1.50
			Channels			
	7904		Data Channel			
			Model 1 (Data Channel B or D)	1,455	73,235	60.50
			Model 2 (Data Channel C or E)	1,940	95,545	82.50
		1040	Adapter, Tape 1414 (1 max/channel)	87	4,075	2.25
		1074	Adapter Control (1 max/channel to attach a 7631, 1414 Model 2, or 7750)	218	7,760	3.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACHMENTS, ADAPTERS, AND CHANNELS (Contd.)			Channels (Contd.)			
		1080	Adapter, Direct Data or Non-IBM device (1 max/channel)	290	11,640	4.25
		1845	Data Channel and Adapter	242	11,000	6.75
		1846	Adapter for Data Channels C, D, and E (1 each)	49	1,800	1.00
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,035	112,035	230.00
			Model 2 (56 million characters)	3,395	179,935	343.00
	2302		Disk Storage:			
			Model 1 (117 million characters)	5,595	237,105	290.00
			Model 2 (234 million characters)	7,890	334,485	420.00
			Drum Storage			
	7320		Drum Storage (11 million characters)	2,230	120,280	103.00
			File Control			
	7631		File Control (for up to five units) (1)			
			Model 2	810	40,740	28.00
			Model 4 (for sharing disk or drum units between two 7000 series systems except 7010's)	1,005	50,440	32.75
		3213	Cylinder Mode	25	1,210	1.00
		3451	Drum Storage Adapter (for connecting 7320 Drum units)	97	3,395	3.00
		7950	2302 Attachment	340	13,580	3.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model II	680	34,920	103.00
			Model IV	875	40,010	114.00
			Model V	725	36,085	108.00
			Model VI	920	41,175	119.00
	7330		Magnetic Tape Unit	435	21,340	58.50
		3585	800 char/inch for 729V	34	1,530	NC
		7830	Tape Switching Feature for 729's attached to 7155	82	4,270	6.50
			Punched Card			
	1402 II		Card Read Punch	595	31,720	138.00
	1622		Card Read Punch	595	29,100	81.50
			Read/Punch, 1402 Read/Punch Column Binary	170	8,490	2.00
			Paper Tape			
	1011		Punched Tape Reader (1 max per 1414 Model 4, 5, or 6)	485	19,595	56.00

Notes: (1) With special features 3451 and 7950, a 7631 File Control can accommodate up to five 1301, 2302, and 7320, units in any combination. These special features can be connected to any 7631 File Control with a serial number of 12000 or higher.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)	1403		Printers Printer Model 1 (requires 7680) Model 2 (requires 7680 and 7681) Printer, Model 2	 705 750 1,505	 31,915 32,980 72,750	 166.00 177.00 372.00
	1014		Inquiry Unit Remote Inquiry Unit	194	7,760	21.00
COMMUNICATIONS	1009		Transmission Unit Data Transmission Unit (1 max per 1414 Model 4, 5, or 6)	485	25,610	13.00

SUMMARY: IBM 1620 MODEL 1

.1 BACKGROUND

The IBM 1620 Model 1 is a desk-size computer oriented toward engineering and scientific applications. The 1620 is distinctively different from most small-scale scientific computers in its use of decimal arithmetic and variable-length fields rather than the usual binary arithmetic and fixed word-length.

Announced in 1959, the 1620 filled a significant gap in the IBM product line and outperformed most of the other small scientific computers then available. As a result, the 1620 was enthusiastically received and quickly became the best-selling computer in its class. Educational institutions, in particular, found the 1620 well suited to their needs. A total of more than 2000 of the 1620 Model 1 and 2 systems were installed, beginning in October 1960, and more than 1500 are still in use at this writing.

The basic 1620 Model 1 system, at a list rental of $1,375 per month, consists of a solid-state central processor, 20,000 decimal digits of core storage with a 20-microsecond cycle time, and a 10-cps console I/O typewriter. The system's computing capabilities can be expanded with 20,000 or 40,000 additional digits of core storage, an automatic divide instruction, floating-point arithmetic hardware, indirect addressing, and other optional features. The very limited input-output facilities of the basic 1620 system can be extended through connection of a 150-cps paper tape reader, a 15-cps paper tape punch, a card read-punch unit that reads 250 or 500 cpm and punches 125 or 250 cpm, a 150- or 240-lpm line printer, a plotter, and up to four of IBM's 1311 Disk Storage Drives, which use interchangeable Disk Packs capable of storing 2 million digits each. List rental prices for these expanded configurations range from $1,600 to over $5,000 per month.

In 1962 IBM introduced the 1620 Model 2, which offers — at a significant price increase — doubled core memory speed and roughly quadrupled instruction execution speeds. Most programs written for a 1620 Model 1 can be run on a Model 2 without reprogramming. The 1620 Model 2 is fully described in Report 413.

The 1620 has been superseded in IBM's product line by the faster and less expensive IBM 1130, described in Report 418. Introduced in 1965, the 1130 marks a return to the more conventional binary, fixed word-length approach to scientific computer design. The 1620 is no longer in production, and the supply of all system components from IBM is subject to their availability. No new RPQs will be accepted, and the production of previously existing RPQ features has been discontinued.

.2 HARDWARE

.21 Data Structure

The basic unit of data representation within the 1620 Central Processing Unit is the "digit position," which consists of six bits: four information bits, a flag bit (used as a minus sign or field delimiter), and an odd parity bit. Each digit position in core storage has a unique five-decimal-digit address.

In the numeric mode, which is used for all arithmetic computation, each digit position holds one binary-coded decimal digit. In the alphameric mode, which is used when alphabetic data must be handled, two adjacent digit positions are used to represent each letter, special character, or decimal digit.

Lengths of both data fields and records are fully variable and limited only by the capacity of core storage. Numeric fields are delimited by a flag bit in the most significant digit position. Records, which may consist of any number of fields, are delimited by a record-mark code that occupies one digit position. A numeric field is addressed by specifying the address of its least significant digit position; a record, conversely, is addressed at its high-order end. A negative field is denoted by a flag bit in its least significant digit position.

Floating-point arithmetic operands have a 2-digit exponent (-99 to +99) and a variable-length mantissa of from 2 to 100 digits.

All instructions have a fixed length of 12 digits. Each instruction consists of a two-digit operation code and two five-digit operand addresses.

.22 System Configuration

Every IBM 1620 Model 1 system includes a Central Processsing Unit with 20,000, 40,000, or 60,000 digits of core storage and a console I/O typewriter. Various optional features are

.22 System Configuration (Contd.)

available for the CPU, as described in Paragraph .24. In addition, any or all of the following peripheral devices can be connected:

- One 1621 Paper Tape Unit, Model 1 (reader only) or Model 2 (reader and punch).
- One 1622 Card Read Punch, Model 1 (reads 250 cpm, punches 125 cpm) or Model 2 (reads 500 cpm, punches 250 cpm).
- One 1443 Printer, Model 1 (150 lpm) or Model 2 (240 lpm).
- One 1627 Plotter, Model 1 (12-inch-wide chart) or Model 2 (30-inch chart).
- One to four 1311 Disk Storage Drives, Model 3 (first drive on system) or Model 2 (all additional drives).

All of these devices are described in Paragraph .25 of this Summary. Most of the I/O devices require the installation of special adapters on the 1620 CPU, as noted in the Price List (Section 412:221). Magnetic tape units are not offered as part of the standard product line for the 1620, but they were added to some systems on an RPQ basis.

.23 Core Storage

The basic core storage unit is housed in the 1620 Central Processing Unit and provides 20,000 digit positions of storage. The storage capacity can be increased to 40,000 or 60,000 digits through the addition of a separate cabinet, the 1623 Core Storage unit. The 1623 Model 1 and Model 2 provide 20,000 and 40,000 additional digit positions of storage, respectively.

Core storage cycle time is 20 microseconds. Each access to storage retrieves two digits, but only the addressed one is used. Parity checks are performed upon all data transferred to or from core storage. Wrap-around addressing is used; when addresses are incremented, address 00000 follows the highest-numbered address (19999, 39999, or 59999).

Core storage is used for all instructions, working storage, and input-output areas. A 300-digit area is reserved for arithmetic tables. No lock is provided to protect this reserved area; it is used to store the loader routines when a program is being loaded.

.24 Central Processing Unit

The 1620 Model 1 CPU is a two-address, sequential processor that performs serial-by-digit operations upon variable-length fields of decimal digits or alphameric characters. The CPU cabinet includes a console control panel, a desk work area with console I/O typewriter, 20,000 digits of core storage, and space for the adapters used with various I/O devices.

Because internal operations are performed in serial-by-digit fashion, the lengths of both data fields and records are limited only by the amount of core storage that the programmer allocates to hold them. The techniques used to store, address, and delimit fields and records containing numeric and alphameric information are described in Paragraph .21, Data Structure.

The 1620, like the IBM 1400 Series computers, uses two-address instructions of the add-to-storage type; it has no accumulator. Every instruction is 12 digits in length and consists of 3 parts: a 2-digit operation code, a 5-digit "P address," and a 5-digit "Q address." The P address may specify an operand location, a jump destination, or the initial address of an input-output area in core storage. The Q address may specify an operand location, an "immediate" (literal) operand, an input-output device, a testable indicator, or a typewritter control function.

The basic 1620 Model 1 instruction set contains 32 instructions. Included are fixed-point addition, subtraction, and multiplication, plus an ample complement of comparison and branching operations. Fixed-point division, and all floating-point arithmetic operations, can be performed either by subroutines or by optional, extra-cost instructions. The optional instructions are from 3 to 10 times as fast as the corresponding subroutines and will prove well worth their price in many scientific installations.

Each of the fixed-point arithmetic instructions has an "immediate" counterpart that can simplify coding and conserve memory space by permitting the use of literal operands. For example, the Add instruction adds the operand specified by the Q address to the operand specified by the P address, while the Add Immediate instruction treats the Q-address field of the instruction itself as a 5-digit literal value which is added to the operand specified by the P address. The Add Immediate and Subtract Immediate instructions are especially useful in address modification.

The 1620 Model 1 lacks two important facilities that are found in most scientific computers: index registers and binary bit manipulation capabilities. Both of these facilities are available as optional features for the 1620 Model 2, but not for Model 1. Indirect addressing is an optional feature for Model 1 (standard on Model 2) that helps to compensate for the lack of index registers by permitting the Q-address part of most instructions to specify the location of an operand address rather than the location of the operand itself. Thus, indirect addressing can save instructions and execution time when the same address appears in multiple instructions.

(Contd.)

.24 Central Processing Unit (Contd.)

Another useful optional feature, called Additional Instructions, provides three special instructions. Two of them are used for automatic conversion of numeric fields between the alphameric mode (in which two digit positions are used to hold each character) and the numeric mode (one position per character). The third instruction moves the presence or absence of a flag bit from one storage location to another.

The 1620 Model 1 has no adder — a characteristic that makes it virtually unique among digital computers. It performs all arithmetic operations by reference to tables stored in a 300-digit reserved area of core storage. Because of this arithmetic method and the serial-by-digit mode of operation, the 1620 Model 1 is considerably slower than its 20-microsecond core cycle time might lead one to expect. A 5-digit add, subtract, or comparison operation, for example, takes 560 microseconds, while 5-digit fixed-point multiplication takes 4960 microseconds. Floating-point arithmetic execution times for 8-digit mantissas, using the optional Automatic Floating Point feature, are 1200 microseconds for addition and 12,500 microseconds for multiplication.

.25 Peripheral Equipment

The configuration rules for the IBM 1620 Model 1 are listed in Paragraph 22, System Configuration.

In a punched-tape 1620 system, all operations are performed sequentially; internal processing is suspended whenever the console typewriter, paper tape reader, or paper tape punch is operating. Addition of a 1622 Card Read Punch or a 1443 Printer significantly increases the system's capabilities for simultaneous operations; card reading, card punching, and printing are buffered and can be overlapped with one another and with succeeding operations. Data transfers to and from 1311 Disk Storage are not buffered, but disk seek operations can proceed independently of other system operations.

The basic 1620 input-output unit is the Console I/O Typewriter. Located on the right side of the console desk-top, the typewriter has a 12-inch carriage, a pin-feed platen, and an output typing rate of 10 characters per second. Its input rate is, of course, limited to the operator's typing speed. The typewriter cannot be used off-line, and its keyboard is locked except when data is being entered into core storage.

The 1621 Paper Tape Unit is an input-output device for 8-track, 1-inch paper tape. The 1621 Model 1 consists of a 150-cps photoelectric reader only, while the 1621 Model 2 includes both the 150-cps reader and a 15-cps punch. Both the reader and punch can be programmed to operate in either the numeric mode, in which each paper tape code is stored in one digit position of the 1620's core storage, or the alphameric mode, in which each tape code is converted into the corresponding internal alphameric code and stored in two successive digit positions. Odd parity checking is performed during both punching (an echo check) and reading.

The 1622 Card Read Punch is a combination input-output unit for standard 80-column punched cards, available in two models. Model 1 can read 250 cards per minute and punch 125 cards per minute, while Model 2 can read 500 cpm and punch 250 cpm. In both models, the reader and punch units, though housed in the same cabinet, are functionally independent. Input-output operations are buffered; all of the data for a card is transferred to or from core storage in 3.4 milliseconds (1.7 milliseconds in the 1620 Model 2), allowing the remainder of the read or punch cycle to be overlapped by processing or other I/O operations. Both units have a 1200-card feed hopper and two 1000-card stackers. Punched cards, like paper tape, can be read and punched in either the numeric or alphameric mode. Cards are read and punched in row-by-row fashion. Both reading and punching are checked by rereading the card and comparing its contents with the data in the reader or punch buffer.

The 1443 Printer, originally developed for use with the IBM 1440 system, can be added to a 1620 system to provide printed output at a speed of either 150 lines per minute (Model 1) or 240 lines per minute (Model 2) with the standard 52-character print set. The 1443 prints by means of a horizontally oscillating typebar, which permits rapid interchangeability of character sets. The standard 52-character typebar can be replaced by typebars with 13, 39, or 63 characters, with accompanying changes in the rated speeds. Skipping speed is 15 inches per second. The standard 120 print positions can be increased to 144 by adding an optional feature.

The 1627 Plotter is a drum-type digital plotter, manufactured by California Computer Products Corporation, that can provide graphic output from a 1620 system. The 1627 is offered in two models, whose characteristics are as follows:

	1627 Model 1	1627 Model 2
Chart width:	12 inches	30 inches
Width of plotting area:	11 inches	29.5 inches
Length of plotting area:	120 feet max.	120 feet max.
Plotting speed:	300 increments/sec	200 increments/sec
Increment size:	0.01 inch	0.01 inch

.25 Peripheral Equipment (Contd.)

The 1311 Disk Storage Drive, announced in 1962, significantly increased the power and range of practical applications for the IBM 1620. The 1311 features the use of interchangeable 1316 Disk Pack storage cartridges. As used in the 1620, each Disk Pack can store up to 2 million digits (or 1 million alphameric characters) in fixed-length sectors of 100 digits each. Average seek time is 250 milliseconds, average rotational delay is 20 milliseconds, and peak data transfer rate is 50,000 digits per second. Up to 20,000 digits can be read or recorded in a single "cylinder," without movement of the access mechanism.

A maximum of four 1311 Disk Storage Drives can be connected to an IBM 1620, providing up to 8 million digits of on-line random-access storage. The first drive on a system must be a 1311 Model 3, and the remainder must be 1311 Model 2 Drives. Disk seek operations (but not read or write operations) can be overlapped with other system functions.

.3 SOFTWARE

IBM-supplied software for the 1620 can be divided into four main categories: SPS assemblers, FORTRAN compilers, stacked-job monitors, and application programs. The assemblers and compilers are offered in several different versions to permit their use on 1620 systems equipped with various I/O devices: paper tape, punched cards, line printers, 1311 Disk Storage Drives, etc. IBM software development work for the 1620 essentially came to a halt in 1966.

.31 SPS Assemblers

SPS (Symbolic Programming System) is the basic machine-oriented language for the 1620. It permits the use of either mnemonic or machine-language operation codes, and of alphanumeric operand labels up to six characters in length. SPS also provides macro-instructions which call subroutines for floating-point arithmetic and mathematical functions and for fixed-point division. Additional macro-instructions can be defined by individual 1620 installations. Pseudo-operations are provided to control the assembly process and to define symbols, areas, and tables.

Ten different versions of SPS are currently available, permitting assembly on — and effective utilization of — 1620 configurations that include virtually any reasonable combination of input-output equipment, optional features, and core storage capacities. SPS II-D, for example, uses one 1311 Disk Storage Drive to store the assembly program, the intermediate output data, and the object program, as well as to supplement the core storage allocated to hold the symbol table. Other versions require only the basic 20K central processor with either paper tape or punched card input-output devices.

.32 FORTRAN Compilers

FORTRAN, like SPS, is available in numerous versions for operation on various 1620 equipment configurations.

The "1620 FORTRAN with FORMAT" compiler can be used on a minimum 1620 configuration: 20K processor with either paper tape or punched card I/O. This compiler, however, uses a restricted language which is basically FORTRAN I; arrays are limited to two dimensions, and numerous FORTRAN II statements are not permitted, including SUBROUTINE, FUNCTION, COMMON, EQUIVALENCE, and ASSIGN. A FORTRAN Pre-Compiler program aids in the checking and editing of source programs prior to compilation.

FORTRAN II for the 1620 requires a system with at least 40,000 positions of core storage, a 1622 Card Read Punch, and the Automatic Divide and Indirect Addressing features. Alternative versions of the FORTRAN II compiler permit effective utilization of the Automatic Floating Point feature, the 1443 Printer, and the 1627 Plotter. The 1620 FORTRAN II language permits the use of three-dimensional arrays, subroutines, functions, and flexible output formats, though complex and logical operations are not permitted. An unusual and valuable feature of 1620 FORTRAN II is the capability to preset internal item sizes to any length from 4 to 10 digits for integers and from 4 to 30 digits (including a 2-digit exponent) for floating-point items.

GOTRAN is a "load-and-go" algebraic programming system that uses a severely restricted subset of FORTRAN I as its source language. The GOTRAN system translates the source statements into an interpretive language and then executes the resulting program in an interpretive mode. The system can be used on a basic 20K 1620 with either paper tape or punched card I/O. Designed to be easy to learn and use, GOTRAN is also very limited in scope and flexibility; for example, each arithmetic statement may contain only one operator, arrays are limited to one dimension, and input-output formats are fixed.

.33 Monitors

The introduction of the 1311 Disk Storage Drive in 1962 paved the way for the development of stacked-job monitors to increase the efficiency of IBM 1620 system operations. The 1311 provides rapid access to assemblers, compilers, and program libraries. To use the monitor, the user prepares control cards (or paper tape or typewriter entries) that define the

(Contd.)

.33 Monitors (Contd.)

jobs to be executed. These are read and interpreted by the monitor, which then initiates and runs a sequence of jobs without operator intervention. Available operating modes include: compile, assemble, load and go, compile and go, and execute programs stored on a 1311 Disk.

Monitor I runs on a 20K card or paper tape 1620 system with one 1311 Drive and the Indirect Addressing feature. It includes the disk-oriented SPS II-D assembler and FORTRAN II-D compiler, plus a Disk Utility Program that provides facilities for loading, unloading, replacing, relocating, or deleting the contents of disk storage. A modified version uses the 1443 Printer in place of the console typewriter to provide fast hard-copy output.

Monitor II is designed specifically to take advantage of the index registers and binary capabilities of the 1620 Model 2; it cannot be used on Model 1 systems.

.34 Application Programs

In selecting a computer, the availability of suitable programs is a factor that can sometimes outweigh the apparent performance advantages of a newer, faster computer. As a result of the 1620's widespread acceptance among engineering and scientific computer users, a broad range of application programs has become available.

Among the programs offered by IBM are routines to perform the following functions: sorting and merging (using 1311 Disk Drives), linear programming, curve fitting, numerical tool control (AD-APT, Autospot, and Automap), civil engineering geometry (COGO), electric load flow analysis, capital investment calculations, inventory management simulation, contour map plotting, electronic circuit analysis, automated drafting (using the 1627 Plotter), optical design, and type composition.

IBM 1620 I

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	1620 Model 1		Central Processing Unit includes 20,000 digit positions of core storage and console typewriter	1,375	64,000	120.00
			Optional Features:			
		1021	Additional Instructions	30	670	1.00
		1285	Automatic Divide	55	2,400	2.75
		1288	Automatic Floating Point Operations (Automatic Divide is a prerequisite)	225	12,400	9.50
		4650	Indirect Addressing	25	1,150	1.50
			Main Storage			
	1623		Core Storage (requires 2301 and/or 2302 Adapter on 1620):			
			Model 1; 20,000 digit positions	750	37,100	30.50
			Model 2; 40,000 digit positions	1,200	58,700	37.50
ATTACH-MENTS, ADAPTERS, AND CHANNELS			Peripheral Adapters			
	1632		Card Read Punch Adapter (for 1622)	10	500	1.00
	2301		Core Storage Adapter (for 1623 Mod 1 & 2)	50	2,400	1.75
	2302		Core Storage Adapter (for 1623 Mod 2)	25	1,300	0.50
	3339		Disk Storage Drive Adapter (for 1311)	135	6,400	6.50
	5520		Paper Tape Unit Adapter (for 1621)	10	450	0.75
	5565		Printer Adapter (for 1443)	30	1,350	0.75
MASS STORAGE			Disk Storage			
	1311		Disk Storage Drive (requires 3339 Adapter on 1620):			
			Model 3 (first drive on system)	650	28,760	62.50
			Model 2 (additional drives)	360	16,510	45.50
	1316		Disk Pack	15	490	(2)
INPUT-OUTPUT			Punched Card			
	1622		Card Read Punch (requires 1632 Adapter on 1620):			
			Model 1; reads 250 cards/min, punches 125 cards/min	615	30,000	81.50
			Model 2; reads 500 cards/min, punches 250 cards/min	765	33,000	106.00
			Paper Tape			
	1621		Paper Tape Unit (requires 5520 Adapter on 1620):			
			Model 1; reads 150 char./sec.	190	8,650	15.25
			Model 2; reads 150 char./sec. punches 15 cps	215	10,050	21.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printer			
	1443		Printer (requires 5565 and 1632 Adapters on 1620):			
			Model 1; 150 lines/min	325	19,750	52.50
			Model 2; 240 lines/min	450	19,900	77.00
			Plotter			
	1627		Plotter (requires 5520 Adapter on 1620 and 1626 Plotter Control):			
			Model 1; 12-inch-wide chart	(1)	4,700	36.00
			Model 2; 30-inch-wide chart	(1)	8,150	38.50
	1626		Plotter Control	140	5,000	7.50

NOTES:

(1) The 1627 Plotter is available for purchase only.

(2) Maintenance for 1316 Disk Packs is on a time and material basis.

SUMMARY: IBM 1620 MODEL 2

.1 BACKGROUND

The IBM 1620 Model 2 was introduced in 1962 as a speeded-up version of the 1620 Model 1, which is described in detail in Report 412. The 1620 Model 2 offers improved computational facilities, twice the core memory speed, and roughly four times the instruction execution speed of the Model 1 at a list rental that is higher by about $600 to $800 per month. In most other respects, the two models are identical; they use the same peripheral equipment and, in general, the same software.

The 1620 is a desk-size computer oriented toward engineering and scientific applications. It is distinctively different from most small-scale scientific computers in its use of decimal arithmetic and variable-length fields rather than the usual binary arithmetic and fixed word-length. Originally announced in 1959, the 1620 Model 1 quickly became the best-selling computer in its class. A total of more than 2000 of the 1620 Model 1 and 2 systems were installed, beginning in October 1960, and more than 1500 are still in use at this writing.

The 1620 has been superseded in IBM's product line by the faster and less expensive IBM 1130, described in Report 418. Introduced in 1965, the 1130 marks a return to the more conventional binary, fixed word-length approach to scientific computer design. The 1620 is no longer in production, and the supply of all system components from IBM is subject to their availability. No new RPQs will be accepted, and the production of previously existing RPQ features has been discontinued.

.2 HARDWARE

The 1620 Model 2 uses the same data structure as Model 1, as described in Paragraph .21 of Report 412.

Every 1620 Model 2 system includes a Central Processing Unit, a console I/O typewriter, and a 1625 Core Storage unit with 20,000, 40,000 or 60,000 digit positions of 10-microsecond core storage. Any or all of the following peripheral devices can be connected:

- One 1621 Paper Tape Unit, Model 1 (150-cps reader only) or Model 2 (150-cps reader and 15-cps punch).
- One 1622 Card Read Punch, Model 1 (reads 250 cpm, punches 125 cpm) or Model 2 (reads 500 cpm, punches 250 cpm).
- One 1443 Printer, Model 1 (150 lpm) or Model 2 (240 lpm).
- One 1627 Plotter, Model 1 (12-inch-wide chart) or Model 2 (30-inch chart).
- One to four 1311 Disk Storage Drives, Model 3 (first drive on system) or Model 2 (all additional drives).

All of these devices are described in Paragraph .25 of Report 412. Most of the I/O devices require the installation of special adapters on the 1620 CPU, as noted in the Price List (Section 413:221). Magnetic tape units are not offered as part of the standard product line for the 1620, but they were added to some systems on an RPQ basis.

The differences between the 1620 Model 2 and the earlier 1620 Model 1 can be summarized as follows:

- Model 2 has a core storage cycle time of 10 microseconds, compared with 20 microseconds in Model 1.
- Model 2 has a decimal adder in place of the add table used in Model 1.
- As a result of its faster memory and more efficient internal logic, Model 2 has instruction execution times which are, on the average, about four times as fast as those of Model 1. A 5-digit add, subtract, or comparison operation, for example, takes 140 microseconds, while 5-digit fixed-point multiplication takes 1210 microseconds. The corresponding times for Model 1 are 560 and 4960 microseconds, respectively.
- Model 2 has a basic instruction repertoire of 43 instructions, including all of the 32 instructions which are standard in Model 1.
- The following features, which are optional in Model 1, are standard in Model 2: Indirect Addressing, Automatic Divide, and Additional Instructions.

.2 HARDWARE (Contd.)

- The Binary Capabilities feature is optional for Model 2 but not available for Model 1; it provides 10 additional instructions to handle octal-decimal conversions, input-output of binary data, testing for individual bits or bit patterns, and the logical operations AND, OR, Exclusive OR, and Complement.
- Fourteen Index Registers are optional for Model 2 but not available for Model 1; the feature includes eight additional instructions for loading, storing, modifying, and testing the index registers.
- Model 2 has an improved console typewriter: a modified IBM Selectric with a rated speed of 15.5 characters per second.

In all other respects, the 1620 Model 2 hardware is similar to the Model 1 hardware as described in Report 412.

Most programs written for a 1620 Model 1 can be run without alteration on a 1620 Model 2. The only significant exceptions are Model 1 programs that use non-standard add tables; since Model 2 uses a hardware adder instead of add tables, such programs will generally need to be recoded.

.3 SOFTWARE

All of the IBM software developed for the 1620 Model 1 is usable on Model 2 as well; please refer to Paragraph .3 of Report 412 for descriptions of the available assemblers, compilers, monitors, and application programs.

The only major software component developed especially for 1620 Model 2 systems is Monitor II, a stacked-job monitor designed to take advantage of the 14 index registers which are optionally available for Model 2. Monitor II requires a 20K Model 2 system with paper tape or punched card input-output, a 1311 Disk Storage Drive, Index Registers, and (for FORTRAN object programs) the Automatic Floating Point feature.

Monitor II includes special versions of the SPS assembler and the FORTRAN II compiler. The assembler contains additional language facilities for the Index Registers and Binary Capabilities, while the FORTRAN compiler includes an optimizing phase that uses the index registers to eliminate redundant subscript address calculations.

IBM 1620 II

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	1620		Model 2 Central Processing Unit (includes console typewriter)	1,200	52,600	94.00
			Optional Features:			
	1289		Automatic Floating Point Operations	250	13,750	10.25
	1466		Binary Capabilities	70	3,500	0.50
	4627		Index Registers	165	8,250	1.50
			Main Storage			
	1625		Core Storage:			
			Model 1; 20,000 digit positions	1,000	46,500	28.00
			Model 2; 40,000 digit positions	1,650	79,000	36.00
			Model 3; 60,000 digit positions	2,200	106,500	43.00
ATTACHMENTS, ADAPTERS, AND CHANNELS			Peripheral Adapters			
	1633		Card Read Punch Adapter (for 1622)	10	500	1.25
	3340		Disk Storage Drive Adapter (for 1311)	135	6,400	6.50
	5521		Paper Tape Unit Adapter (for 1621)	25	1,250	1.50
	5566		Printer Adapter (for 1443)	30	1,350	0.75
MASS STORAGE			Disk Storage			
	1311		Disk Storage Drive (requires 3340 Adapter on 1620):			
			Model 3 (first drive on system)	650	28,760	62.50
			Model 2 (additional drives)	360	16,510	45.50
	1316		Disk Pack	15	490	(2)
INPUT-OUTPUT			Punched Card			
	1622		Card Read Punch (requires 1633 Adapter on 1620):			
			Model 1; reads 250 cards/min, punches 125 cpm	615	30,000	81.50
			Model 2; reads 500 cards/min, punches 250 cpm	765	33,000	106.00
			Paper Tape			
	1621		Paper Tape Unit (requires 5521 Adapter on 1620):			
			Model 1; reads 150 char./sec.	190	8,650	15.25
			Model 2; reads 150 char./sec. punches 15 cps	215	10,050	21.00
			Printer			
	1443		Printer (requires 5566 and 1633 Adapters on 1620):			
			Model 1; 150 lines/min.	325	19,750	52.50
			Model 2; 240 lines/min.	450	19,900	77.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Plotter			
	1627		Plotter (requires 5521 Adapter on 1620 and 1626 Plotter Control):			
			Model 1; 12-inch-wide chart	(1)	4,700	36.00
			Model 2; 30-inch-wide chart	(1)	8,150	38.50
	1626		Plotter Control	140	5,000	7.50

NOTES:

(1) The 1627 Plotter is available for purchase only.

(2) Maintenance for 1316 Disk Packs is on a time and material basis.

REPORT UPDATE

IBM MODIFIES 1440 FOR SMALL BANKING APPLICATIONS

IBM recently announced its 1450 Bank Data Processing System. This new version of the second-generation IBM 1440 system has been specifically tailored to meet the needs of small banking applications. The 1450 system can handle applications ranging from demand deposit accounting to on-line teller terminal networks. A complete software package will accompany the system, including mortgage loan and savings accounting programs.

Data is entered via the IBM 1259 Magnetic Character Reader, being manufactured for IBM by Lundy Electronics & Systems, Inc. The 1259, which was introduced last September, has 11 pockets and can read and sort up to 600 magnetically-encoded 6-inch checks per minute.

The basic components of the 1450 system are as follows:

Unit	Model	Monthly Rental	Description
1441 Processing Unit	C4	$ 830	8K core storage
	C5	1,155	12K core storage
	C6	1,480	16K core storage
1442 Card Read Punch	1	280	Reads 300 cpm, punches 90 col/sec
	2	395	Reads 400 cpm, punches 160 col/sec
1443 Printer	3	430	140 lpm, 52-character set
	4	680	230 lpm, 52-character set
1447 Console	1	80	Console
	2	170	Inquiry Printer & Keyboard
1311 Disk Storage	6	310	
	7	285	
1259 Magnetic Character Reader	1	1,100	Reads 600 documents per minute

A typical IBM 1450 system, including the 1259, rents for $3,350 per month and sells for $160,200. The first customer deliveries are scheduled for the fourth quarter of 1968.

INTRODUCTION

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The IBM 1440 is a small-scale, stored-program data processing system that is adaptable to a wide range of business applications. It features the 1311 Disk Storage Drive with interchangeable Disk Packs. The 1440 was announced in October, 1962, and the first customer deliveries were made in April, 1963. Monthly system rentals range from about $1,800 to $10,000, with most installations falling within the $2,000 to $5,000 range.

Compatibility

The 1440 is the lowest-priced member of the IBM 1400 series of business-oriented data processing systems. It is program-compatible with (and 3.5% faster than) the widely-used IBM 1401 with respect to internal processing, but the 1440 uses slower card readers, card punches, and printers than the 1401 and different instructions to control them. Whereas the 1401 has fixed input-output areas in core storage that must be used for all printer and card input-out, the 1440 can initiate direct transfers of data between any area of core storage and any peripheral device. Through the use of the new 7335 Magnetic Tape Unit, the 1440 can be made tape-compatible with other IBM and competitive computers that use one-half inch tape at a recording density of 556 characters per inch.

Hardware

An IBM 1440 system can have from 2,000 to 16,000 alphameric character positions of core storage. Each core position contains six data bits, a parity bit, and a word mark bit that is used to denote the end of a variable-length field. Core storage cycle time is 11.1 microseconds (compared to 11.5 microseconds in the IBM 1401, 6.0 in the 1460, and 4.5 in the basic 1410).

The 1441 Processing Unit uses add-to-storage logic and has no accumulator. All operations are performed serially by character, and both data fields and instructions can be of variable length. The basic instruction format consists of a 1-character operation code and two 3-character addresses. Operand length is not specified in 1440 instructions; instead, most operations are terminated when a word mark bit is sensed in the operand itself. Facilities for editing, high-low-equal comparisons, and full-record internal transfers are standard, but multiplication, division, indexing, and sense switches are extra-cost options. Instructions are executed at the rate of about 4,000 per second in typical 1440 routines.

Operation of the 1440 system is basically serial in nature (i.e., one operation at a time). Little overlapping of input-output operations with one another or with internal processing is possible, except that printing is buffered if the optional Print Storage feature is installed. Available computing time per card read on the 1442 Card Read Punch is increased if less than the full 80 columns are read. Disk Storage seek operations (but not read-write operations) can be overlapped with one another and with other system functions.

Each 1311 Disk Storage Drive holds one Disk Pack at a time, providing on-line storage for 2,000,000 alphameric characters in addressable sectors of 100 characters each. A maximum of five drives can be connected. Up to 20,000 characters per drive can be read or recorded without movement of the access mechanism, so the system is suitable for sequential as well as random processing. Total waiting time for access to a randomly-placed record averages 270 milliseconds; with the optional Direct Seek feature, the figure is reduced to 170 milliseconds. With the optional Track Record feature, a single 2,980-character record can be recorded on each track, increasing the capacity of a Disk Pack to 2,980,000 characters.

Each Disk Pack consists of a stack of six discs with ten magnetic recording surfaces and a cover that forms a sealed container when the Disk Pack is not mounted on a drive. Diameter is 14 inches, height is 4 inches, weight is less than 10 pounds, and time to interchange two Disk Packs is about one minute.

§ 011. **INTRODUCTION (Contd.)**

In addition to the 1311 Disk Storage Drives, up to five arrays of 1301 Disk Storage can now be attached to a 1440. The 1301 discs are not interchangeable, but they use the same record formats as the 1311: each track can hold twenty addressable 100-character sectors or (with the optional Track Record Feature) a single 2, 543-character record. There are four models of 1301 Disk Storage: Model 11 or 21 has one disc array and one access mechanism, and stores up to 25.43 million characters. Model 12 or 22 has two disc arrays, each with an independent access mechanism, and stores up to 50.86 million characters. Total waiting time for access to a randomly placed record averages 177 milliseconds; up to 80,000 characters per disc array can be read or recorded without movement of the comb-like access mechanism, with an average waiting time of only 17 milliseconds. A 1440 system with the maximum complement of five 1311 drives and five 1301 arrays would have a total of 142 million character positions of random access storage.

The basic card input-output unit is the 1442 Card Read Punch, which has a photo-electric read station followed by a punch station on a single card feed path. Models 1 and 2 have rated speeds of 300 or 400 cards per minute for reading and 80 or 160 columns per second for punching, respectively. Results can be punched into the same cards from which the input data was read, but a single 1442 cannot handle separate input and output card files at the same time. The 1442 Model 4 Card Reader provides read-only ability at 400 cards per minute, while the 1444 Card Punch has an output speed of 250 full 80-column cards per minute.

The 1443 Printer uses a horizontal typebar that permits rapid interchangeability of character sets. Two models are available, which differ only in speed. Peak speeds are 150 or 240 lines per minute with the standard 52-character set and 430 or 600 lines per minute with an optional 13-character set. The optional Print Storage feature provides virtually complete overlapping of printing with other system functions.

The 7335 Magnetic Tape Unit is a recent addition to the IBM line that expands the range of applications for the 1440 by giving it a limited capability for magnetic tape operations. Only one 7335, consisting of a tape control and either one or two tape transports, can be used in a 1440 system. The 7335 is similar to the 7330 Magnetic Tape Units used in other IBM systems but has only one recording density (556 characters per inch) and one speed (20,016 characters per second).

The 1447 Console houses the operating controls and displays and, optionally, a console typewriter rated at 14.8 characters per second. Any one of the following peripheral devices can be connected to a 1440 through the Serial Input/Output Adapter: a 500 character-per-second paper tape reader, a 150 character-per-second tape punch, a 950 document-per-minute magnetic character reader, a 75 to 300 character-per-second data transmission unit, an optical mark page reader, or a 7740 Communication Control System. A 1448 Transmission Control Unit can be attached to the 1447 Console, and the 1448 can control a large network of remote data communication or data collection units. The new 7770 Audio Response Unit, which provides human-voice replies to telephoned inquiries, can be connected through the 1311 Disk Storage Drive, Model 2.

Software

The programs and programming systems supplied by IBM for the 1440 include:

- 1440 Basic Autocoder: the basic symbolic assembly system, usable on card-only 1440 systems with 4,000 core storage positions, 1442 Card Read Punch, and 1443 Printer. Two special versions of the Basic Autocoder system are available; one uses the 1444 Card Punch for object program output and the other uses a restricted form of the language and requires only 2,000 core positions for assembly.
- 1440 Autocoder: a more advanced symbolic assembly system that provides macro instruction facilities and is similar to (but not program-compatible with) the Autocoder languages available for the other IBM 1400 series systems. A 1440 with at least 4,000 core positions, one 1311 or 1301 Disk Storage Unit, a card read punch, and a printer is required. (Programs written in 1440 Autocoder can alternatively be assembled on a 6-tape IBM 1401 system by means of a special version of the 1440 Autocoder translator.)
- 1440 Input-Output Control System (IOCS): macro instructions and corresponding generalized routines which can be used in Autocoder programs to factilitate the coding of input-output operations. Individual versions of 1440 IOCS are available for systems using 1311 Disk Storage, the 1448 Transmission Control, and the Direct Data Channel, and for 1440 systems connected on-line to an IBM 1410 or 7010.

§ 011. **INTRODUCTION (Contd.)**

- 1440 COBOL: translates programs coded in a restricted version of COBOL-61 into symbolic form for Autocoder assembly. IBM 1311 Disk Storage is utilized as the primary file storage medium instead of magnetic tape, requiring several additions to the COBOL-61 language. Required are 4,000 core positions, one 1311 drive, a 1442 Card Read Punch, a 1443 Printer, and the Indexing and Store Address Register feature.

- 1440 FORTRAN IV: compiles engineering and scientific programs written in FORTRAN IV. The only important FORTRAN IV language facilities not implemented in the 1440 version are complex and double precision operations and the Assigned GO TO statement. Precision is variable; operand lengths can be preset at up to 20 digits. Machine requirements are 8,000 core positions, one 1311 Disk Storage Drive, a 1442 Card Read Punch, a 1443 Printer, and several optional features. Magnetic tape units can be used by the object program but are not required.

- 1440 Basic Report Program Generator: a "load-and-go" generator for card-only 1440 systems that facilitates the preparation of printed reports from data in punched cards.

- 1440 Report Program Generator: uses 1311 Disk Storage to generate programs to produce reports from input files in punched cards or Disk Storage.

- 1440 Sort 5: generates routines that utilize 1311 Disk Storage to sort blocked, fixed-length records.

- Auto-Test: an integrated set of utility programs designed to expedite the testing and debugging of programs coded in 1440 Autocoder. At least one 1311 Disk Storage Drive and 8,000 core storage positions are required.

- 1440 Disk File Organization Programs: thirteen programs designed to assist in establishing and maintaining data files in 1311 Disk Storage, in either random or sequential arrangements.

- Disk and Tape Utility Programs: a variety of routines to perform frequently-needed functions such as data transcription and label handling.

- Application Programs: documented programs to perform specific industry applications, which can be modified to fit individual users' requirements. Included are programs for Demand Deposit Accounting, Mortgage Loan Accounting, File and Casualty Insurance, Weekly Premium Insurance, Secondary School Systems, Hospitals, Motor Freight Accounting, On-Line Savings Accounting, Retail Accounts Receivable, Retail Fashion Inventory Control, and Chain and Wholesale Grocery Billing.

IBM 1440

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	1441		Processing Unit (includes core storage):			
			Model A2 (2,000 characters)	770	42,350	55.00
			Model A3 (4,000 characters)	970	45,600	56.00
			Model A4 (8,000 characters)	1,295	63,100	57.50
			Model A5 (12,000 characters)	1,620	80,600	58.50
			Model A6 (16,000 characters)	1,945	98,100	59.50
			Optional Features:			
		1470	Bit Test	20	800	0.50
		4631	Indexing and Store Address Registers	90	4,950	1.00
		5275	Multiply-Divide	325	11,700	9.00
		7600	Sense Switches	15	550	0.50
		3835	Expanded Print Edit	20	750	0.50
		8023	Translate Feature	60	3,000	2.50
ATTACH-MENTS, ADAPTERS, AND CHANNELS			Adapters			
	7080		Serial I/O Adapter (required for 1009, 1011, 1012, 1231, or 1412)	100	3,750	1.50
	3845		Expanded Serial I/O Adapter	325	12,200	2.00
MASS STORAGE			Disk Storage			
	1301		Disk Storage Unit			
			First units on system (3321 Disk Storage Control and 3832 Expanded Disk Storage Control required):			
			Model 11 (25.43 million characters maximum)	2,000	105,500	230.00
			Model 12 (50.86 million characters maximum)	3,475	175,500	343.00
			Additional units on system:			
			Model 21 (25.43 million characters maximum)	2,000	105,500	230.00
			Model 22 (50.86 million characters maximum)	3,475	175,500	343.00
	1311		Disk Storage Drive:			
			Model 1 (First drive on system, 3321 Disk Storage Control required)	385	17,610	46.50
			Model 2 (Additional drives, 4 maximum)	360	16,510	45.50
		3321	Disk Storage Control	250	12,000	8.00
		3283	Direct Seek for Model 1	NC	NC	NC
		3282	Direct Seek for Model 2	NC	NC	NC
		6396	Scan Disk (on 1441; one required for both 1301's and 1311's)	35	1,680	.50
		6400	Seek Overlap, on each 1311 (Seek Overlap Adapter 6399 required on 1441 — no charge)	40	1,950	1.75
		8011	Track Record (on 1441, for both 1301's and 1311's)	40	1,920	.50
	1316		Disk Pack (removable, interchangeable disk storage for 1311)	15	490	TM

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Magnetic Tape			
	7335		Magnetic Tape Unit (requires 7802 Tape Adapter)			
			Model 1 (one tape drive)	700	37,100	45.00
			Model 2 (two tape drives)	1,100	57,100	78.50
		7802	Tape Adapter	400	20,000	12.50
			Punched Card			
	1442		Card Read Punch (2 maximum):			
			Model 1 (Reads 300 cards/min, punches 80 col./sec.)	280	18,700	34.00
			Model 2 (Reads 400 cards/min; punches 160 col./sec.) (1632 adapter required on first 1442)	395	19,850	41.00
		1632	Card Read Punch Adapter	20	1,100	.50
	1442		Card Reader:			
			Model 4 (Reads 400 cards/min., 1632 adapter required on first 1442)	200	11,500	38.50
			Optional features for 1442 units:			
		1531	Card Image	30	1,650	.50
		6406	Selective Stocker (standard on Models 2 and 4)	20	1,100	.50
		5880	Punch column (Models 1 and 2, requires 5881 Punch Column skip control)	20	1,000	.50
	1444		Card Punch			
			Model 1 (Punches 80 column cards at 250 cards/min. - requires printer attachment 5561)	375	21,600	43.50
		5881	Punch Column Skip Control	10	500	.50
	1011		Paper Tape Reader	500	20,200	56.00
	1012		Tape Punch	465	17,950	60.00
			Printers			
	1443		Printer (requires 5567 and 5561 printer control attachment)			
			Model 1 (150 lines/min.)	325	19,750	52.50
			Model 2 (240 lines/min.)	450	19,900	77.00
		5559	Additional Print Positions (24)	45	2,475	2.25
		5585	Print Storage	165	9,800	4.00
		6401	Selective Character Set	25	1,375	2.00
			Character Sets:			
		1890	13 characters		400	
		1891	39 characters		450	
		1892	52 characters		475	
		1893	63 characters		500	
		5561	Printer Attachment	25	1,375	.50
		5567	Printer Control	235	13,200	5.50
			Optical and Magnetic Character Readers			
	1231		Optical Mark Page Reader(1)	430	23,100	36.25
	1412		Magnetic Character Reader(1)	2,000	91,400	171.00
	1447		Console:			
			Model 1: control section with power and operator controls (required with every system)	80	4,400	2.00
			Model 2: with inquiry printer and keyboard used with Model 1	170	7,600	21.50
			Model 4: with inquiry printer and keyboard plus controls for 1448 Transmission Control Unit; used with Model 1	230	10,450	22.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Optical and Magnetic Character Readers (Contd.)			
		2260	Console Attachment	31	970	8.25
		1390	Attachment, 1051 Model 1 (for Models 2 and 4)	25	1,250	1.00
		1490	Buffer Feature	120	6,000	3.25
		6149	Remote Terminal Attachment (for Models 2 and 4; requires 1390)	25	1,250	1.00
		7600	Sense Switches, group of six (for Model 1 only)	15	550	.50
COMMUNI-CATIONS			Transmission Units			
	1009		Data Transmission Unit(1)	500	26,400	13.00
		1491	Buffer for 1009	150	8,650	12.00
	770		Audio Response Unit (requires 7770 Adapter 7150 on 1311 Model 1)	1,200	57,600	38.50
		7150	Audio Response Adapter	300	13,050	26.50
		4667	I/O Line Expander	175	8,400	12.50
		4668	I/O Line Frame	200	9,600	2.50
		4669	I/O Line Panel	75	3,600	2.00
		8720	Vocabulary Line Expansion	100	4,800	2.00
		8721	Vocabulary Words, Additional	100	4,800	2.50

NOTES:

(1)Requires 7080 Serial I/O Adapter.

INTRODUCTION

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The IBM 1460, announced in February 1963, is a new member of IBM's 1400 series of small to medium scale business-oriented data processing systems. System rentals range from approximately $4,000 to $20,000 per month, and most installations will probably fall within the $5,000 to $12,000 range. First customer deliveries are scheduled for the fourth quarter of 1963.

Throughput and Compatibility

The 1460 ranks between the IBM 1401 and 1410 systems in price and throughput, and is directly program-compatible with the 1401. Many 1401/1460 programs can also be run without alteration on a 1410 by means of the 1410's built-in 1401 compatibility circuits. The IBM 1440, the smallest member of the 1400 series, is program-compatible with the 1401 and 1460 with respect to internal processing, but uses different input-output units and different instructions to control them.

The 1460 uses the same set of stored-program instructions as the 1401, so programs coded for a 1401 can, in general, be run without alteration on a 1460 with the same (or expanded) complement of input-output units and optional features. The 1405 (RAMAC) Disk Storage Unit, 1404 Printer, and 1407 Console Inquiry Station are not currently available for use in 1460 systems, so 1401 programs that utilize these devices must be reprogrammed. To take full advantage of the 1460's increased internal speeds, it will be desirable to re-evaluate the input-output timing considerations in existing 1401 programs and make changes in timing loops and placement of input-output instructions. (Timing loops for 1412 or 1419 Magnetic Character Reader input must be changed.)

The principal advantages of the IBM 1460 over the IBM 1401 (described in Computer System Report 401) can be summarized as follows:

- Core storage cycle time is 6 microseconds per character, compared to 11.5 microseconds in the 1401, so internal processing speeds are nearly twice as fast.

- The new 1403 Model 3 Printer can be used for alphameric output at a peak speed of 1,100 single-spaced lines per minute. (Models 1 and 2 of the 1403, used in 1401 systems, have peak speeds of 600 lines per minute.)

- The 729 VI Magnetic Tape Unit, with a peak speed of 90,000 characters per second at a recording density of 800 characters per inch, can be used in 1460 systems but not in 1401 systems.

- The free-standing, desk-style 1447 Console, with optional console input-output typewriter, makes operation of the system more convenient.

- The Move Record and High-Low-Equal Compare processor facilities, which are optional features in the 1401, are standard in the 1460.

The overall reduction in program run time that can be gained by replacing an IBM 1401 with a 1460 ranges from zero (for a run limited by the speed of a particular peripheral unit or combination of units) to 48 per cent (for pure internal processing with no input-output). Test runs by the manufacturer of specific 1401 programs on a 1460 system have shown the following reductions in over-all program run times:

- Sorting of 15,000 records: . . . . 30% reduction.

- Merging of 27,000 records: . . . . 38% reduction.

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- Production control run: . . . . 38% reduction.
- FORTRAN compilation: . . . . 26% reduction.
- FORTRAN object program execution: . . . . 40% reduction.

Hardware

A 1460 system can have 8,000, 12,000 or 16,000 character positions of core storage. IBM 1401 systems can have as few as 1,400 positions of core storage, but because of the severe programming limitations imposed by such a small store, the manufacturer has wisely decided to require the inclusion of at least 8,000 positions in every 1460 system. Each core position contains six data bits, a parity bit, and a word mark bit used to denote the end of a variable-length field. Core storage cycle time is 6.0 microseconds.

Up to five 1311 Disk Storage Drives can be used in a 1460 system. Each drive holds one replaceable Disk Pack at a time, providing random access storage for 2,000,000 alphameric characters in addressable sectors of 100 characters each. With the optional Track Record feature, a single 2,980-character record can be recorded on each track, increasing the capacity of a single Disk Pack to 2,980,000 characters. Up to 20,000 characters can be read or recorded without movement of the comb-like access mechanism, so the system is suitable for sequential as well as random processing. Total waiting time for access to a randomly-placed record averages 270 milliseconds; with the optional Direct Seek feature, the figure is reduced to 170 milliseconds.

The 1441B Processing Unit is a solid-state, alphameric processor with add-to-store logic. All operations are performed serially by character, and both data fields and instructions are variable in length. The basic instruction format consists of a one-character operation code, two 3-character operand addresses, and a one-character modifier; instruction length can vary from one to eight characters and averages about six characters. There is no accumulator. Facilities for editing, three-way comparisons, and full-record internal transfers are standard, but multiplication, division, indexing, bit testing, and sense switches are extra-cost options. Built-in floating point arithmetic is not available. Instructions are executed at the rate of about 7,000 to 8,000 per second in typical routines.

Input-output control circuits for 1460 systems are housed in a separate unit, the 1461 Input/Output Control, whereas they are contained in the Processing Unit cabinet in 1401 systems. As in the 1401, system operation is basically serial in nature (i.e., one operation at a time). Little overlapping of input-output operations with one another or with internal processing is possible unless optional features such as Print Storage, Processing Overlap, and Read Punch Release are added. Use of these features (described in Section 415:111) increases the system's capability for simultaneous operations, but also increases programming complexity and input-output area storage requirements.

The 1402 Card Read-Punch provides a peak reading capability of 800 cards per minute. The 1403 Printers have 132 print positions and a 48-character print set. Peak speeds are 600 and 1,100 single-spaced lines per minute for 1403 Models 2 and 3, respectively. The 1403 Model 3 printer can nearly double the system throughput in printer-limited applications such as tape-to-printer data transcriptions. Only one Card Read-Punch and one Printer can be used in a 1460 system.

Up to six 729 and/or 7330 Magnetic Tape Units can be connected. Peak data transfer rates range from 7,200 to 90,000 characters per second. Only one tape read or write operation at a time is possible. The central processor is interlocked during tape read and write operations unless the Processing Overlap feature is added. With Processing Overlap, internal processing can be overlapped with tape start-stop times and (at transfer rates of 41,667 characters per second or below) with character transfers to or from a tape unit.

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The Serial Input/Output Adapter permits connection of any one of the following devices: a paper tape reader or punch, a magnetic or optical character reader, a data transmission terminal, or a direct system-to-system link with an IBM 1401, 1440, or another 1460. The 1448 Transmission Control Unit permits connection of 1062 Teller Terminals for on-line processing of banking or savings and loan transactions.

Software

Software availability for the IBM 1460 can be summarized by noting that all programs and programming systems for the IBM 1401 except those that require 1405 Disk Storage will be directly usable on a similarly equipped 1460. The extensive repertoire of 1401 programs supplied by the manufacturer includes:

- SPS-1 and SPS-2: basic symbolic assembly systems, usable on a card-only 1460.
- 1401 Autocoder: more advanced assembly system, providing macro facilities; requires four magnetic tape units on the translating 1460.
- 1401-1311 Autocoder: utilizes 1311 Disk Storage instead of magnetic tape; otherwise similar to 1401 Autocoder.
- Input-Output Control Systems: provide macro instructions and corresponding generalized routines to facilitate coding of input-output operations; four versions are available for different system configurations.
- Report Program Generator: facilitates preparation of programs to produce printed reports from punched cards, magnetic tape, or 1311 Disk Storage.
- FARGO: a "load-and-go" report generator that produces IBM 407-type printed reports.
- Sorting and Merging: four generalized routines to handle sort/merge operations using either magnetic tape units or 1311 Disk Storage.
- Auto-Test: expedites testing and debugging of programs coded in Autocoder, SPS, and FARGO.
- Disk File Organization Programs: nine programs to assist in establishing and maintaining data files in 1311 Disk Storage, in either random or sequential arrangements.
- Utility Programs: a variety of routines to perform frequently needed functions such as data transcription, multiplication, and program loading in card, tape, and Disk Storage systems.
- COBOL: compiles programs coded in COBOL; 2 versions are available, for 1460 systems with 8,000 and 12,000 or more core storage positions; both versions require 4 magnetic tape units.
- FORTRAN: compiles programs coded in a severly restricted subset of the full FORTRAN language; magnetic tape is not required, and "load-and-go" operation is possible.

For detailed descriptions of these programs and programming systems, refer to the IBM 1401 report, Sections 401:151 through 401:191.

IBM 1420 Bank Transit System

The 1420 Bank Transit System is a variation of the 1460 that is specially engineered for bank transit applications. The 1421 Bank Transit Processing Unit combines most of the

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functions of the 1441B Processing Unit and the 1419 Magnetic Character Reader in a single physical unit. Magnetically inscribed card or paper documents can be processed at speeds of up to 1,600 documents per minute. From 4,000 to 16,000 character positions of core storage can be used, and cycle time is 6 microseconds per character as in the 1460 system. The only input-output devices that can be connected to a 1421 are the 1442 Card Read-Punch (which reads up to 400 cards per minute or punches up to 160 columns per second) and the 1403 Model 1 or 2 Printer (which prints up to 600 alphameric lines per minute). Programming of the 1420 system differs from programming of a 1401/1419 combination only in that timing relationships are altered and the 1442 replaces the 1402 for punched card input-output. See Section 415:052 for a more complete description of the 1420.

IBM 1460

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	1441		Processing Unit (includes core storage)			
			Model B4 (8,000 characters)	2,130	108,800	57.50
			Model B5 (12,000 characters)	2,680	137,900	58.50
			Model B6 (16,000 characters)	3,230	166,900	59.50
			Optional Features:			
		1470	Bit Test	20	800	.50
		4631	Indexing & Store Address Registers	90	4,950	1.00
		5275	Multiply-Divide	325	11,700	9.00
		1468	Binary Transfer for 1461	80	2,800	2.00
		5730	Processing Overlap	250	15,000	12.75
		7600	Sense Switches (On 1447)	15	550	.50
ATTACHMENTS, ADAPTER, AND CHANNELS			Attachments			
	1461		Input/Output Control (one required in every system)			
			Model 1 (For card system)	880	43,950	40.00
			Model 2 (For card/729 tape system)	1,980	90,200	52.50
			Model 3 (For card/7330 tape system)	1,430	71,500	52.50
			Adapter			
	7080		Serial I/O Adapter	100	3,750	1.50
MASS STORAGE			Disk Storage			
	1311		Disk Storage Drive			
			Model 1 (First on system, requires 3321 Disk Storage Control)	385	17,610	46.50
			Model 2 (Additional drives, 4 maximum)	360	16,510	45.50
		3321	Disk Storage Control	250	12,000	8.00
		6400	Seek Overlap (on each 1311)	40	1,950	1.75
		3281	Direct Seek (on 1441)	50	2,400	3.25
		6396	Scan Disk (on 1441)	35	1,680	0.50
		8011	Track Record (on 1441)	40	1,920	0.50
	1316		Disk Pack (each)	15	490	NC
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit:			
			Model II	700	36,000	103.00
			Model IV	900	41,250	114.00
			Model V	750	37,200	108.00
			Model VI	950	42,450	119.00
	7330		Magnetic Tape Unit	450	22,000	58.50
		2210	Compressed Tape (on 1461; requires 4631 on 1441)	35	1,300	3.25
		7845	Tape Intermix (permits connection of 7330's to 1461 Model 2)	45	2,250	NC
			Punched Card			
	1402		Card Read Punch (Model 3)	560	30,215	45.00
		4150, 1013	51- Column Feed	60	3,810	31.75
		5890, 5895	Punch Feed Read and Control	80	2,985	5.75
		6040	Read Punch Release	25	950	.50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Paper Tape			
	1011		Paper Tape Reader (1)	500	20,200	56.00
	1012		Tape Punch (1)	465	17,950	60.00
			Printer			
	1403		Model 2 (600 lines/min.)	775	34,000	177.00
		3835	Expanded Print Edit (on 1441)	20	750	.50
		1376	Auxiliary Ribbon Feed	75	3,075	17.75
		4740	Interchangeable Chain	75	3,125	NC
		5380, 5381	Numerical Print (requires 4740)	275	11,050	18.00
		6411, 6412	Selective Tape Listing	275	12,400	12.00
		5585	Print Storage (on 1461)	375	12,600	24.25
	1403		Model 3 (1100 lines/min.)	900	41,200	183.00
		5564	Printer Adapter	25	875	.50
		5585	Print Storage	375	12,600	24.25
		3835	Expanded Print Edit (on 1441)	20	750	.50
			Optical and Magnetic Character Reader			
	1412		Magnetic Character Reader (1)	2,000	91,400	171.00
	1419		Magnetic Character Reader (1)	2,275	110,500	224.00
	1418		Optical Character Reader (1)			
			Model 1 (3 pockets)	2,600	120,300	197.00
			Model 2 (13 pockets)	2,900	133,800	230.00
	1428		Alphameric Optical Reader (1)			
			Model 1 (3 pockets)	3,000	138,600	230.00
			Model 2 (13 pockets)	3,300	152,100	264.00
			Console			
	1447		Console (One required in every system; price includes 2260 Console Attachment when required)			
			Model 1 (No Console Printer)	80	4,400	2.00
			Model 2 (With Console Printer)	170	7,600	21.50
			Model 4 (With Console Printer and controls for a 1448)	230	10,450	22.00
		2260	Console Attachment	40	2,200	.50
COMMUNICATIONS			Transmission Units			
	1009		Data Transmission Unit (1)	500	26,400	13.00
	1448		Transmission Control Unit	1,150	56,700	70.00
		8025	Attachment	150	6,730	2.00
	3271		Direct Data Channel (1)	NC	NC	NC

NOTES:

(1) Can be connected via 7080 Serial I/O Adapter

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The IBM 7010, announced in November of 1962, is a medium to large scale solid-state computer system which is completely program-compatible with the IBM 1410 system. System rentals range from approximately $15,000 to $56,000 per month, and most installations will probably fall within the $18,000 to $30,000 range.

Capability and Highlights

The 7010 combines the faster speed of medium scale computers with the character-addressable data handling capabilities of the IBM 1400 series computers to provide a compatible, higher lever system for expanding 1410 installations.

The 7010 uses the same set of stored-program instructions as the 1410; thus, programs written for a 1410 can be operated unaltered on a 7010 with an identical (or expanded) complement of input-output units and optional features. The 1405 Disk Storage Unit, 1412 and 1419 Magnetic Character Readers, and the Program Addressable Clock are not currently available for use in 7010 systems; 1410 programs that utilize these devices must be reprogrammed. (To take full advantage of the 7010's increased internal speeds, it will be desirable to re-evaluate the input-output timing considerations in existing 1410 programs and make changes in program loops relative to the placement of input-output instructions.)

A 7010 system with the optional 1401 Compatibility Feature enables many 1401 machine language programs to be run unaltered on a 7010. However, the increased speed and power of the 7010 cannot be fully utilized in this mode of operation because the 7010 system functions as a 1401 system with 16,000 positions of core storage and the Advanced Programming, Multiply-Divide, High-Low-Equal Compare, Expanded Print Edit, Sense Switches, and Processing Overlap feature. In this 1401 mode, the second input-output channel cannot be used. Any 1401 programs which require the Selective Tape Listing, Space Suppress, Compressed Tape Operations, Punch Feed Read, and Serial I-O Adapter special features, or input-output devices which are not currently available for the 7010 system, cannot be run on the 7010 using the 1401 mode.

The principal advantages of the IBM 7010 over the IBM 1410 (see Section 402) can be summarized as follows:

- Internal processing speeds are 3.5 and 2.75 times faster than the respective times for either a basic 1410 or a 1410 with the Accelerator feature.
- Processing Overlap, an optional feature in the 1410, is standard in the 7010.
- Priority Interrupt, an optional feature in the 1410, is standard in the 7010.
- The 1410 instruction repertoire has been expanded.

Hardware

A 7010 system can have 40,000, 60,000, 80,000, or 100,000 character positions of core storage. Each core position contains six data bits, a parity bit, and a word mark bit which is used to denote the end of a variable length field. Core Storage cycle time is 2.4 microseconds per two-characters (accessed in parallel). Since this cycle time is approximately 3.5 or 2.75 times faster than the cycle time of the 1410 (basically 4.5 microseconds per single character; 4.0 microseconds with the Accelerator feature), a complete re-evaluation of all runs should be made to determine the maximum throughput capabilities. If a run was previously processor limited (i.e., processing time exceeded input-output time), it is now possible for the same run to become input-output bound. However, because

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of the faster execution times of the same instructions in the 7010, those runs that were previously input-output limited will remain that way. Since the peripheral equipment speeds have not changed (except with the use of the 1403 Model 3 Printer), an effective way to utilize the increased processing speed would be to perform more internal processing in any given run and use the increased core storage capacity. This practice would reduce the total number of runs required.

Up to five 1301 and/or up to five 1311 Disk Storage Drives can be included in a 7010 system. If both types are used in the same system, they must be connected to different channels.

The 1301 Model 1 Disk Storage Drive provides random access storage for up to 28,000,000 alphameric characters. The 1301 is connected to a 7010 system by means of a 7631 File Control. This File Control permits the 7010 system to share the 1301 with other systems and thereby set up a communication link between the systems.

Each 1311 Disk Storage Drive holds one replaceable Disk Pack at a time, providing random access storage for 2,000,000 alphameric characters in addressable sectors of 100 characters each. With the optional Track Record Feature, a single 2,980-character record can be recorded on each track, increasing the capacity of a single Disk Pack to 2,980,000 characters. This mode of operation requires more core storage because the individual records are 2,980 characters long. The ability to replace Disk Packs is very useful when dealing with large volumes of data or several different applications requiring disc storage.

The 7114 Processing Unit is a solid-state, alphameric processor with add-to-store logic. All operations are performed serially on pairs of characters; that is, two characters are accessed and transferred at a time, with built-in automatic adjustment when only one character is required. The 7114 Processor has as standard equipment the Processing Overlap and Priority features, which are optional, extra-cost features on the 1411 Processor. The Processing Overlap feature permits processing to continue during storage cycles not required for data transfer by input-output operations. The Priority feature permits automatic interruption of the stored program upon completion of selected input-output or seek operations or upon console request. The Input-Output Control System (IOCS) program package includes routines to handle priority processing. These routines service and control requests for input-output according to a preset priority.

In other respects the 7114 Processing Unit is identical to the 1411. It has a 5-character address structure and instructions are from 1 to 12 characters long. Fifteen index registers are available, but no special instructions exist for incrementing or testing them. Two instructions have been added to the 1410 instruction repertoire to provide facilities to store or restore the setting of six indicators. These indicators show the result of: High-, Low-, Equal-comparisons; zero balance for total; arithmetic overflow; and divide overflow. Their settings are represented by bit or no-bit conditions in core storage and are very useful in programming multiple branching and multiple interrupt routines.

A smaller variety of peripheral equipment is available for the 7010 system than for the 1410 system. The 7010 can control telegraphic equipment, remote inquiry units, and Tele-processing equipment, as well as magnetic tape, paper tape, and unit record equipment, but cannot be used with character recognition equipment, low speed tapes, and disc units.

The IBM 1402 Card Read-Punch unit provides the system with a peak card reading capacity of 800 cards per minute and a peak card punching capacity of 250 cards per minute. A 1442 Card Reader which can read 400 cards per minute can also be connected to the system (see 414:071). The 1403 Printer has a 48-character print set. The Model 1 has 100 print positions, while the Models 2 and 3 each have 132 print positions. Peak speeds are 600 single-spaced lines per minute for the 1403 Models 1 and 2, and 1,100 for the 1403 Model 3. The 1403 Model 3 can nearly double the system throughput in printer-limited applications, but this tends to make the card reader the limiting factor. The 1011 Paper Tape Reader, which has a peak speed of 500 characters per second, is also available.

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The IBM 729 series and 7330 Magnetic Tape Units can be used in the 7010 system. Peak transfer rates can range from 7,200 to 90,000 characters per second. Up to 10 tape units can be connected to each of a maximum of 2 channels, and up to 2 tape read or write operations can occur simultaneously with internal processing.

A wide range of Tele-processing equipment is available for the 7010, including the 7750 Programmed Transmission Control, the 7864 Telegraph Input-Output, the 1009 Data Transmission Unit, and the 1014 Remote Inquiry Unit. A 1067 or 1068 Control Adapter can connect a 1414 system (with a 1448) to the 7010 system.

Software

Software availability for the IBM 7010 can be summarized by stating that all programs and programming systems for the IBM 1410 except those that require 1405 Disk Storage, 1412/1419 Magnetic Character Readers, and the Program Addressable Clock are directly usable on an equivalent 7010 system. The extensive repertoire of 1410 programs supplied by the manufacturer includes:

- The Processor Operating System: A set of routines designed to produce object programs from source programs written in the Autocoder, RPG (Report Program Generator), COBOL, and FORTRAN symbolic languages. In addition to controlling the assembly of source programs, this system provides the facilities for updating and duplicating the system tape. Two versions of the operating system will be available for the 7010: one designed to use magnetic tape for the system storage and for intermediate processing; the other, 1301 Disk Storage.

- Autocoder: A machine-oriented symbolic assembly system that can utilize macro facilities and subroutines provided in the Processor Operating System Library.

- Report Program Generator: A programming system designed to create object programs that can write reports.

- COBOL (Common Business Oriented Language): Compiles programs written in COBOL, using macro-instructions and the Processor Operating System Library. The compiled program is then translated and assembled into a machine language program by the Autocoder Processor.

- FORTRAN (FORmula TRANSlating System): Like COBOL, produces a symbolic program that is translated and assembled into a machine language program by the Autocoder Processor.

- Input-Output Control System: Provides a library of subroutines to handle input-output operations; error detection and correction; end-of-file; tape labeling; and record blocking and unblocking for unit-record equipment, magnetic tape units, 1301 Disk Storage, and telecommunication devices connected to the 7114 Central Processor through the 1414 Synchronizer.

- Utility Programs: A variety of routines to perform frequently needed functions such as data transcription, clearing of storage, program loading, program tracing, and memory printouts.

- Disk File Organization Programs: Six programs to assist in establishing and maintaining data files in 1301 Disk Storage.

- Sorting and Merging: Three generalized routines to handle sort/merge operations using either magnetic tape or 1301 Disk Storage.

- Simulation Program: Permits the 7010 to execute programs originally written for the IBM 650.

For detailed descriptions of these programs and programming systems, refer to the IBM 1410 report, Sections 402:151 through 402:191.

IBM 7010

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage):			
	7114		Processing Unit:			
			Model 1 (40,000 characters)	10,800	540,000	157.00
			Model 2 (60,000 characters)	11,800	591,000	163.00
			Model 3 (80,000 characters)	12,800	642,000	168.00
			Model 4 (100,000 characters)	13,800	693,000	174.00
	1415		Model 2 Console (channel 1 only)	300	12,790	16.60
ATTACHMENTS, ADAPTERS, AND CHANNELS			Attachments			
	1414		Input/Output Synchronizer:			
			Model 1 (controls 729 Magnetic Tape Unit)	975	43,500	26.75
			Model 2 (controls 7330 Magnetic Tape Unit)	500	24,900	28.00
			Model 3 (controls card I/O only)	675	30,375	29.50
			Model 4 (controls card and communications I/O)	775	39,900	32.75
			Model 5 (controls communications I/O only)	700	35,700	23.75
			Model 7 (controls up to 10 729's)	1,125	49,500	27.50
			Model 8 (for 1403 only)	1,150	30,500	20.75
		7814	Tape Intermix (on 1414 Model 1 or 7 only to intermix 729 II's, 729 IV's, and 7330's in any combination)	45	2,250	NC
		6025	Read, Punch Column Binary (on Model 4 only)	175	8,750	2.00
		7864	Telegraph Feature (Model 5 only)	500	30,500	10.75
		7871	Telegraph Input Feature (Model 5 only; requires 7864)	110	6,750	3.25
		7875	Telegraph Output Feature (Model 5 only; requires 7864)	125	7,750	3.25
	7155		Switch Control Console:			
			Model 1 (For up to 2 tape units)	30	1,050	6.50
			Model 2 (For up to 4 tape units)	50	1,550	12.25
			Model 3 (For up to 6 tape units)	65	2,050	18.50
			Model 4 (For up to 8 tape units)	80	2,600	24.50
			Adapters			
			For 1414 Models 1, 2, or 7:			
	7823		I/O Adapter (for channel 7)	100	3,900	3.00
	7823		I/O Adapter (for channel 2)	100	3,900	3.00
			For 1414 Models 3, 4, 5, or 8:			
	4659		I/O Adapter (for channel 1)	125	4,300	3.50
	4660		I/O Adapter (for channel 2)	125	4,300	3.50
	3223		Data Channel Second (required for 2-channel operation)	550	22,500	12.50
		2190	Compatibility feature — 1401	300	12,000	8.50
	4661		Model 3 I/O Adapter (for 1414 Model 5 or 8)	50	2,750	.75
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,100	115,500	230.00
			Model 2 (56 million characters)	3,500	185,500	343.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Disk Storage (Contd.)			
	2302		Disk Storage:			
			Model 1 (117 million characters)	5,770	244,440	290.00
			Model 2 (234 million characters)	8,135	344,830	420.00
			File Control			
	7631		File Control (for up to five units)(1)			
			Model 1	835	42,000	28.00
			Model 3 (for sharing disk or drum units between two 1410's, two 7010's, or between a 1410 and a 7010)	1,035	52,000	32.75
		3213	Cylinder Mode	25	1,250	1.00
		7950	2302 Attachment	350	14,000	3.00
	1311		Disk Storage:			
			Model 5 (first on channel)	985	46,010	81.50
			Model 2 (additional)	360	17,610	46.50
		6396	Scan Disk (Model 5 only; 6397 or 6398 required)	35	1,680	.50
		6397	Scan Feature for Channel 1	100	2,500	1.00
		6398	Scan Feature for Channel 2	100	2,500	1.00
		6400	Seek Overlap (each disk unit)	40	1,920	1.75
		8011	Track Record (Model 5 only)	40	1,920	.50
INPUT-OUTPUT			Magnetic Tape			
	729		Model II Magnetic Tape Unit	700	36,000	103.00
			Model III Magnetic Tape Unit	900	41,250	114.00
			Model V Magnetic Tape Unit	750	37,200	108.00
			Model VI Magnetic Tape Unit	950	42,450	119.00
		7830	Tape Switching Feature	85	4,400	6.50
		3585 or 3586	800 char/inch Feature (to operate 729 V's or VI's at 800 char/inch density)	35	1,575	NC
			Magnetic Tape Unit	450	22,000	58.50
			Punched Card			
	1402		Model 2 Card Read Punch (1414 Model 3 or 4 required)	615	8,750	2.00
		6050	Read-Punch Column Binary (Model 4 only)	50	3,175	31.75
		4150,1013	51-Column Read	15	950	NC
	1442		Card Reader, Model 3	250	13,850	37.00
			Paper Tape			
	1011		Paper Tape Reader	500	20,200	56.00
		5514	Paper Tape Reader Adapter	100	3,750	1.50
			Printers			
	1403		Model 1 (100 print positions, includes Synchronizer Storage 7680)	725	32,900	166.00
			Model 2 (132 print positions, includes Synchronizer Storage 7680 and 7681)	775	34,000	177.00
			Model 3 (132 print positions, includes Synchronizer Storage 7680 and 7681)	900	41,200	183.00
		7680	Synch Storage-Printer	550	22,750	15.00
		7681	Synch Storage-Printer Addn.	60	2,450	1.00
		4740	Interchangeable Chain	75	3,125	NC
		5380	Numerical Print	50	2,000	.75
		5381	Numerical Print	225	9,050	9.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Inquiry Unit			
	1014		Remote Inquiry Unit	200	8,000	21.00
		6136	Remote Inquiry Unit Adapter	200	11,500	1.50
COMMUNI-CATIONS			Controller			
	7750		Programmed Transmission Control	7,950	490,000	410.00
		1067	Control Adapter for Channel 1	150	4,500	3.00
		1068	Control Adapter for Channel 2	150	4,500	3.00
			Transmission Unit			
	1009		Data Transmission Unit	500	26,400	13.00
		3238	Data Transmission Adapter for 1009	200	11,000	3.50

NOTES:

(1) With special feature 3451, a 7631 File Control can accommodate up to five 1301 or 2302 units in any combination. This special feature can be connected to any 7631 File Control with a serial number of 12000 or higher.

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The IBM 7080 is a large-scale business data processing system with the same general characteristics as the earlier IBM 705 systems. Internal processing speed of the 7080 is approximately six times as fast as the 705 III and ten times as fast as the 705 I or II. Instruction compatibility with existing 705 systems enables any 705 program to be processed on the 7080 unaltered. However, because the only printers, card readers, and punches that can be connected to the system are quite slow, it is much more common for the 7080 system to be tape oriented and supported by an off-line IBM 1401 data processing system. A hardware feature in combination with an interpretive routine permits the substitution of high-speed magnetic tape units for on-line unit record input-output devices without reprogramming. The 1401 system can then perform card-to-tape, tape-to-card, and tape-to-printer operations. Monthly rental for a 10-tape paired (7080 and 1401) system starts at approximately $50,000 (see System Configuration, Section 417:031). Initial customer deliveries of IBM 7080 systems were made in September, 1961.

HARDWARE

Core storage may consist of 80,000 or 160,000 character positions. One, five, or ten characters can be read from or written into storage during a single 2-microsecond cycle time, depending upon the specific function being performed.

The character-oriented Central Processor is divided both physically and logically into two parts called the 7102 Arithmetic and Logical Unit and the 7305 Central Storage and I-O Control Unit. The serial character-by-character processing of the former unit enables variable field length arithmetic and comparison operations, while the latter unit provides 1280 additional storage positions which serve as accumulator, auxiliary storage, and input-output buffer and control storage. The basic cycle time of the Processor is one microsecond, which is determined by the access time of the Central Storage. Instruction execution time ranges from a minimum of three microseconds to several hundred microseconds depending on operation and operand length. Although the 7080 uses a one-address instruction format, a limited two-address capability is provided by the fact that many instructions can specify the use of any one of 15 auxiliary storage units in the Central Storage.

The instruction repertoire includes a full complement of decimal arithmetic, comparison, and shifting operations as well as automatic editing facilities. Indirect addressing is available on a limited basis (non-recursive) in the 705 III mode and in the 7080 mode. One notable omission it the lack of automatic address modification facilities, such as index registers, which is unusual in a large system of this type. Automatic floating point arithmetic operations are also absent, so that the 7080 is clearly more efficient for commercial than for scientific processing applications.

Automatic interruption facilities permit effective use of the system's capabilities for simultaneous operations when operating in the 7080 mode. Execution of a priority routine can be initiated automatically whenever an operation is completed by a peripheral unit or a manual console request is made.

The 7080 system can include any of three types of input-output data channels. A single non-buffered channel transfers data serially by character to provide for the connection of on-line unit record devices. This channel implements the 705 compatibility feature and requires the use of a signal conversion unit which is now offered only on an "as available" basis. A 7621 Tape Control operating through a portion of the 7305 Central Storage and I-O Control provides for a maximum of four tape channels utilizing the 729 series of magnetic tape units. Peak transfer rates range from 15,000 to 90,000 characters per second, and up to four tape read-write operations can occur simultaneously with internal processing. The third input-output facility is provided by the 7908 Data Channel. This equipment is attached to both parts of the Central Processor (7102 Arithmetic Unit and 7305 I-O Control) to enable both "high-speed" and "low-speed" channels to be used. (The high-speed channels bypass the 7305 I-O Control and thus require fewer Central Storage cycles in their operation than do the low speed channels.) A maximum of four low-speed and two high-speed channels may be used to control the following types of input-output equipment:

- Up to ten IBM 7340 Model 1 Hypertape Drives connected to each of two low- or high-speed channels. Hypertape offers peak transfer rates of up to 170,000 alphameric characters or 340,000 decimal digits per second.

§ 011. INTRODUCTION (Contd.)

- Up to five 1301 or 1302 Disk Storage Units connected through one or two low- or high-speed channels. These units provide random access auxiliary storage for up to 1.17 billion characters.

- Remote communications devices connected through the remaining two channels using an IBM 7750 Programmed Transmission Control and/or an IBM 1414 I-O Synchronizer. Paper tape readers, remote inquiry stations, data transmission terminals, and telegraph transmitters and receivers can be handled by either the 7750 or 1414.

SOFTWARE

IBM 7080 Autocoder is the basic symbolic machine oriented language for the 7080. It includes powerful macro generation facilities. The 7080 Input/Output Control System is a supplement to Autocoder that facilitates the coding of input-output operations through the use of macro instructions. The Input/Output Control System can either be assembled along with the user's programs or assembled independently and entered by means of linkages generated in the user's object program.

The IBM 7080 COBOL language is a version of COBOL-61 that includes a number of useful electives and extensions, but does not permit such Required COBOL-61 facilities as OPTIONAL files, automatic assignment of tapes, the JUSTIFIED clause, certain PICTURE clause options, and the COBOL library.

IBM 7080 FORTRAN is a restricted version of the FORTRAN II language. It offers no facilities for user-defined subroutines or functions, or for Boolean, complex, or double precision arithmetic. Each fixed or floating point data item occupies 10 positions of core storage.

Report/File Language is a problem oriented language used to produce machine coding which will prepare printed reports and/or create files. Nineteen statement types describe the format and contents of print lines or tape records.

The 7080 DATGEN Languages are used to generate routines by selecting library macro instructions and linking them together in efficient sequences. The three DATGEN Languages are: Decision Language, which expresses logical decisions; Arithmetic Language, which expresses arithmetic computations in a manner similar to FORTRAN; and Table Creating Language, which sets up tables for data searching.

The 7080 Compiling System incorporates a number of compiling functions within a single expandable framework consisting of related processing and library modules. Its principal component is the 7080 Processor, which translates source programs written in 7080 Autocoder, FORTRAN, Report/File, Decision, Arithmetic, and Table Creating Languages (or any reasonable combination of these) into 7080 machine language object programs. The 7080 COBOL Processor, another Compiling System module, transforms COBOL source programs into Autocoder statements which are then automatically assembled by the 7080 Processor. Operation of the 7080 Compiling System requires at least 80,000 core storage positions and 10 magnetic tape units.

The 7080 Supervisory Control System (SCS80) consists of a Librarian Routine and an Object Time Routine designed to facilitate changeovers from one object program to the next. The Librarian creates and maintains a tape library of the user's object programs, and creates a current program tape containing those programs which are scheduled for execution. The Object Time Routine locates the program to be run, loads it, and transfers control to it. SCS80 contains no provisions for multiprogramming, so only one program can be run at a time.

Sort 80 and Merge 80 are generalized sorting and merging routines for IBM 7080 systems that utilize 729 Magnetic Tape Units. A Hypertape sort/merge routine takes advantage of the higher speed and special features (e.g., backward reading) of the 7340 Model 1 Hypertape Drive to achieve sorting speeds roughly four times as fast as Sort 80.

Other 7080 utility routines developed by IBM include an interpretive routine that permits execution of IBM 705 I or II programs on a 7080 with 729 tape units; a Testing and Operating System (TOPS) that provides automatic transitions from one utility program to another; a Memory Restore System that initiates restarts from checkpoint records written on magnetic tape; and packages of routines to perform data transcription, program loading, diagnostic, and file maintenance functions in 7080 systems utilizing 729 Magnetic Tape Units, 7340 Hypertape Drives, and 1301 Disk Storage.

IBM 7080

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	7102		Arithmetic and Logic Unit	14,500	685,000	644.00
	7305		Central Storage and I/O Control			
			Model 1 (two channels)	7,300	345,000	209.00
			Model 2 (four channels)	8,400	395,000	244.00
	7153		Console Control Unit	1,500	75,000	65.00
		6091	Real-Time Clock	175	8,000	2.75
	7804		Power Unit	1,600	60,000	30.75
			Main Storage			
	7302		Core Storage:			
			Model 1 (160,000 characters)	17,500	715,000	515.00
			Model 2 (80,000 characters)	10,000	410,000	355.00
ATTACHMENTS, ADAPTERS, AND CHANNELS			Attachments			
		2265	Console Card Readers	275	13,500	24.75
			Attachment	25	1,200	.50
	7622		Signal Control	1,500	26,000	24.50
	1414		Input-Output Synchronizer, Model 6	850	43,350	24.75
	7864		Telegraph I/O Feature	500	30,500	11.00
	7871		Telegraph Input Feature	110	6,750	3.25
	7875		Telegraph Output Feature	125	7,750	3.25
			Channels			
	7908		Data Channel:			
			Model 1 (one low-speed channel)	1,825	73,000	35.50
			Model 2 (two low-speed channels)	2,075	83,000	45.00
			Model 3 (three low-speed channels)	2,450	115,900	54.25
			Model 4 (four low-speed channels)	2,700	125,000	64.50
			Model 5 (two high-speed channels)	2,850	130,800	73.75
			Model 6 (two high-speed and one low-speed channels)	3,100	137,600	84.25
			Model 7 (two high-speed and two low-speed channels)	3,350	144,400	94.50
			Model 8 (two high-speed and three low-speed channels)	3,600	157,200	105.00
			Model 9 (two high-speed and four low-speed channels)	3,850	158,000	115.00
		3221	Data Channel Attachment for 7305 (all models)	25	1,000	NC
		3221	Data Channel Attachment for 7102 (Models 5-9)	250	11,800	2.00
MASS STORAGE			Disk Storage			
	1301		Disk Storage:			
			Model 1 (28 million characters)	2,100	115,500	230.00
			Model 2 (56 million characters)	3,500	185,500	343.00
	2302		Disk Storage:			
			Model 1 (117 million characters)	5,770	244,440	290.00
			Model 2 (234 million characters)	8,135	344,830	420.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			File Control			
	7631		File Control (for up to five units)(1)			
			Model 2	835	42,000	28.00
			Model 4 (for sharing disk or drum units between two 7000 series systems except 7010's)	1,035	52,000	32.75
			Optional features for 7631:			
		3213	Cylinder Mode	25	1,250	1.00
		7950	2302 Attachment	350	14,000	3.00
INPUT-OUTPUT			Magnetic Tape			
	729		Magnetic Tape Unit			
			Model II	700	36,000	103.00
			Model IV	900	41,250	114.00
			Model V	750	37,200	108.00
			Model VI	950	42,450	119.00
	7621		Tape Control			
			Model 2 (for 729II, IV)	3,300	147,000	207.00
			Model 4 (for 729II, IV, V, VI)	3,470	153,800	207.00
		7830	Tape Switch	85	4,400	6.50
	7340		Hypertape Drive, Model 1	1,300	64,500	113.00
	7640		Hypertape Control	3,400	168,000	95.25
		1284	Automatic Cartridge Loader	125	6,100	15.00
			Punched Card			
	7502		Console Card Reader			
			Paper Tape			
	1011		Paper Tape Reader and 5514 Adapter	600	23,980	57.50
			Inquiry Unit			
	1014		Remote Inquiry Unit and 6136 Adapter	400	19,500	26.75
COMMUNI-CATIONS			Transmission Unit			
	1009		Data Transmission Unit	500	26,400	13.00
		3238	Data Transmission Unit Adapter for 1009	200	11,000	3.50

NOTES:

(1) With special feature 3451, a 7631 File Control can accommodate up to five 1301 or 2302 units in any combination. This special feature can be connected to any 7631 File Control with a serial number of 12000 or higher.

REPORT UPDATE

NEW ANNOUNCEMENTS EXTEND CAPABILITIES OF IBM 1130

A number of software and hardware announcements have greatly increased the flexibility and power of the small-scale, low-cost IBM 1130 computer system. The climax of these announcements came in April 1967 at the Spring Joint Computer Conference with the introduction and display of a number of additional hardware features including faster and larger core storage units, expanded disk storage capabilities, and faster input-output devices. IBM states that delivery of systems with the new hardware features is planned for January 1968.

More and Faster Core Storage

Five additional models of the 1131 Central Processor Unit were announced, which provide up to 32,768 16-bit words of core storage. Three models have a cycle time of 2.2 microseconds, compared to a cycle time of 3.6 microseconds for the original units. The new models of the 1131 Central Processing Unit include:

- 1131 Model 2C — 16,384 words with a 3.6-μsec cycle time;
- 1131 Model 2D — 32,768 words with a 3.6-μsec cycle time;
- 1131 Model 3B — 8,192 words with a 2.2-μsec cycle time;
- 1131 Model 3C — 16,384 words with a 2.2-μsec cycle time; and
- 1131 Model 3D — 32,768 words with a 2.2-μsec cycle time.

Each of the new models includes the built-in Disk File that can store up to 512,000 words. The original models of the 1131 (Models 1A, 1B, 2A, and 2B) have been continued in the line. To accommodate the larger core storage units, the desk cabinet containing the processor, core memory, Disk File unit, and I/O typewriter has been extended. In the larger models, the I/O typewriter is located in the center of the desk cabinet.

More Disk Storage

The IBM 2310 Disk Storage unit, previously announced for the IBM 1800 Data Acquisition and Control System, has been adapted for use with the closely-related IBM 1130. Two new models of the 2310 are available specifically for the IBM 1130. The 2310 Model B1 provides one disk drive; the Model B2 provides two disk drives. Both disk drives of the Model B2 are housed in a single cabinet. Each disk drive is functionally identical with the built-in Disk File contained in some models of the 1131 Processor Unit and can store up to 512,000 16-bit words. The average access time to randomly-located data is 520 milliseconds in the 2310 Disk Storage units, compared to 790 milliseconds in the integrated Disk File. The peak data transfer rate of the 2310 Disk units is approximately 35,000 words per second, the same as that of the integrated Disk File.

One or two disk storage units of either model can be connected to an 1131 Central Processing Unit through the newly-announced Channel Multiplexor. All five disk drives can be active concurrently. The 2310 Disk Storage units feature removable disk cartridges. The maximum of five disk drives (including the integrated drive) permit a total of 2,560,000 words (5,120,000 characters) of data to be stored on-line. Unlimited off-line storage is provided by the removable cartridges.

The inclusion of additional disk drive units greatly enhances the capability of the 1130 for file processing tasks common to business-oriented problems. The provision of faster punched card units, faster printers, and decimal arithmetic subroutines complements the additional disk storage capacity for business applications.

High-Speed Printers

The 1403 Model 6 and 7 Printers, previously used with IBM 1401, 1440, and System/360 computers, are now available for the IBM 1130 system. The 1403 Models 6 and 7 have peak printing rates of 340 and 600 single-spaced lines per minute, respectively. Both models are fully buffered and are capable of printing 48 different symbols including alphabetics, numerics, and 12 special characters. Like the 2310 Disk units, the 1403 Printer is connected to the 1131 Processor through the Channel Multiplexor.

Faster Card Reading with Separated Card Paths

The IBM 2501 Card Reader and the 1442 Model 5 Card Punch have been made available for the 1130 system. These units are also used with IBM System/360 Model 20 computers. The 2501

Model A1 reads cards at a rated speed of 600 cards per minute, while the rated speed of the 2501 Model A2 is 1,000 cards per minute. The 1442 Model 5 Card Punch punches cards at 160 columns per second. The peak punching speed varies from 91 cards per minute when punching all 80 columns to 360 cards per minute when punching only one column per card.

Provision of independent devices for card reading and punching allows separation of card paths. The 1442 Models 6 and 7 Card Read Punches previously offered for use with the 1130 system provide only one card path for card reading and punching. Separation of the card paths eases the programming of such tasks as summary punching since blank cards do not have to be interspersed with the data cards.

Optical Reading of Pencil-Marked Documents

The IBM 1231 Optical Mark Page Reader has been adapted for connection to an IBM 1130 system. The 1231 reads ordinary pencil marks (not printed characters) from 8½ -by-11-inch data sheets directly into an 1130 computer system. The 1231 can also read data sheets marked by an IBM 1403 or 1443 Printer. Each data sheet can contain up to 1,000 marks on each side of the sheet (2,000 marks total) in predetermined locations. The 1231 Optical Reader and the 2501 Card Reader cannot both be connected to an 1130 system. The 1231 will be useful to organizations that use standardized forms for such functions as surveys, orders, applications, medical records, inventory listings, and sales analyses. The 1231's chief advantage is the elimination of much of the keypunching and verifying normally associated with the preparation of input for automatic data processing.

Data Communications

IBM had previously announced a Communications Adapter that allows the 1130 to communicate with the IBM Synchronous Transmit Receive (STR) Terminals or with another IBM computer equipped to communicate with these terminals. These communications devices, which include the 7702 Magnetic Tape Terminal, the 1978 Card Read Punch Terminal, and the 1013 Card Transmission Terminal, communicate at speeds up to 2400 bits per second over a voice-band line, and employ a 4-of-8 transmission code. Following the introduction in February 1967 of the IBM 2780 Data Transmission Terminal and the Binary Synchronous Communications (BSC) technique for the IBM System/360 computers, IBM has announced BSC capabilities for the 1130 Communications Adapter. The operator manually selects either the STR or BSC communications mode via a switch on the control panel.

IBM currently provides a set of subroutines for operating the Communications Adapter in the STR mode. These subroutines include provisions for automatic answering of incoming calls; sounding an audible alarm in case of errors; transmitting; receiving; and converting between the IBM 4-of-8 transmission code and Hollerith card code, and between the 4-of-8 code and EBCDIC. These subroutines are available to programs coded in Assembler Language only. The Communications Adapter is supported for punched card-, punched tape-, and disk-oriented systems. Software support for the Communications Adapter operating in the BSC mode has not been specified as yet, but it probably will be similar to that for the STR mode.

Configuration Possibilities

An IBM 1130 computer system can now consist of the following components:

- 1131 Central Processing Unit (any model);
- One to four 2310 disk drives;
- One 1403 Model 6 or Model 7 Printer;
- One 1132 Printer;
- One 1134 Paper Tape Reader;
- One 1055 Paper Tape Punch;
- One 2501 Model A1 or Model A2 Card Reader <u>or</u> one 1231 Optical Mark Page Reader;
- One 1442 Model 6 or Model 7 Card Read Punch <u>or</u> one 1442 Model 5 Card Punch; and
- One 1627 Model 1 or Model 2 Plotter.

A separate attachment feature is required for each peripheral device.

New Version of the 1130 Disk Monitor

Along with the new hardware features, IBM announced Version 2 of the 1130 Disk Monitor, the supervisory program for controlling the activities of an 1130 computer. The new version will include facilities to support all of the newly-announced peripheral devices and will provide for overlapping of I/O operations, including multiple disk drives. The Disk Monitor Version 2 will be available in January 1968 along with expected delivery of the new hardware features. Software support for the new hardware features will not be provided for non-disk systems.

Commercial Subroutine Package

The IBM 1130 Commercial Subroutine Package, Version 1, is currently available and provides a limited facility for performing business-oriented processing tasks. Version 1 contains a total of eight subroutines for performing variable-length alphanumeric move, compare, and edit operations, variable-length conversion between floating-point and EBCDIC, zone manipulation, character fill, and stacker select. Version 2 of the Commercial Subroutine Package will become available in June 1967 and will contain a total of 21 subroutines. All of the functions of Version 1 will be included; in addition, variable-length decimal arithmetic and overlapping of input-output operations will be provided. Support of the newly-announced peripheral devices has not been announced to date for this package. These subroutines are written in FORTRAN for inclusion in FORTRAN-coded programs. A card- or disk-oriented system is required for compilation and assembly. All previous input-output devices are supported in this package for entering or outputting data.

1130 Plotter Subroutine Package

A set of subroutines is currently available for controlling the IBM 1627 Plotter. The functions provided by these subroutines include drawing a line with scaled grid marks, positioning the pen with the pen up or down, drawing a point character at the present location of the pen, and positioning the pen and drawing annotation characters. The point characters are fixed in size and include +, x, ▽, ◁, △, and ▷. The annotation characters are variable in size and orientation; the characters available are 0-9, A-Z, and - + . , * / = ( ) $ '. The subroutines are written in Assembler Language and can be called from either an Assembler-coded or FORTRAN-coded program.

1130 Scientific Subroutine Package (SSP/1130)

The set of scientific subroutines called Mathpack has been replaced with a more comprehensive set called the 1130 Scientific Subroutines Package (SSP/1130). The SSP/1130 contains all of the computational subroutines of SSP/360, a total of 121. All subroutines are free of input-output statements and are coded in FORTRAN. These subroutines require an 1130 system with a minimum of 8,192 words of core storage. Some of the subroutines require the overlay facilities of the 1130 Disk Monitor. All of the others can be used on either a card- or disk-oriented system.

INTRODUCTION

.1 SUMMARY

The IBM 1130 is a desk-size, word-oriented computer intended primarily for small-scale scientific applications. It can also serve as a low-cost processor for certain business applications that do not require high input-output speeds. The 1130 system is designed to be easy for scientists and engineers to program (in FORTRAN) and operate, so that it will be suitable for use instead of, or as an adjunct to, a larger centralized scientific computing facility. System rentals vary from approximately $680 per month with minimum storage and input-output equipment to over $1,800 per month with disc storage and a full complement of input-output equipment. IBM announced the 1130 system in February 1965, and initial customer deliveries were made in November 1965.

.2 HARDWARE

The IBM 1130 system offers a choice of four processor models. The models differ only in respect to core and disc storage capacities, as described below:

- 1131 Model 1A Central Processor — 4,096 core memory locations.
- 1131 Model 1B Central Processor — 8,192 core memory locations.
- 1131 Model 2A Central Processor — 4,096 core memory locations and 512,000 disc storage locations.
- 1131 Model 2B Central Processor — 8,192 core memory locations and 512,000 disc storage locations.

Core storage and the Disk File drive (in Models 2A and 2B) are housed in the desk console which is an integral part of the 1131 Central Processing Unit. Core memory access time is 3.6 microseconds for each access of one 16-bit word.

The basic word length is 16 bits. The high-order bit position of the word is considered a sign bit during arithmetic operations. All processor models are essentially single-address, fixed word-length, binary processors. The instruction repertoire consists of 29 instructions, most of which permit indirect addressing and indexing. Fixed-point binary addition and subtraction in both single-word and double-word precision are provided. Single-precision, fixed-point multiply and divide are also standard instructions. No hardware facilities are provided for decimal or floating-point arithmetic, but extensive floating-point operations are possible through standard subroutines.

Excluding shift operations, all instructions can be written in either a "short" (one-word) or "long" (two-word) instruction format. The short instruction format allows indexing but not indirect addressing, and has an 8-bit address field which is added to one of three index registers or the instruction counter to produce a final memory address. The long format has a 16-bit address field, which permits direct addressing of the full range of core storage.

The Central Processor provides six interrupt levels. Interrupts are generated only by peripheral devices, and an interrupt is generally initiated for each character transferred between the device and the processor. The Disk File, however, generates an interrupt only upon completion of an entire operation.

The removable-cartridge Disk File included in the Model 2A and 2B Central Processing Units stores up to 512,000 words on a single disc, in sectors of 320 words each. Up to one full sector can be transferred in one read or write operation. The sectors are numbered sequentially, and up to 8 sectors (2,560 words, or one "cylinder") can be accessed without repositioning the access arm. The average total access time to randomly-placed data is 790 milliseconds. Only one Disk File drive can be included in an 1130 system, but unlimited off-line storage is possible with the use of additional disc cartridges.

The input-output devices that can be connected to an 1131 Central Processing Unit are limited in range and number. Only one of each of the following devices can be connected to a central processor (any model):

- 1134 Paper Tape Reader — reads at 60 characters per second.
- 1055 Paper Tape Punch — punches at 14.5 characters per second.

.2 HARDWARE (Contd.)

- 1442 Card Read Punch —
  Model 6: reads a maximum of 300 cards per minute; punches a maximum of 80 columns per second.
  Model 7: reads a maximum of 400 cards per minute; punches a maximum of 160 columns per second.
- 1132 Printer — prints at up to 82 lines per minute for alphanumeric output and up to 110 lines per minute for numeric output.
- 1627 Plotter —
  Model 1: plots at a maximum rate of 18,000 steps per minute.
  Model 2: plots at a maximum rate of 12,000 steps per minute; accepts paper of greater width than Model 1.

The various peripheral devices use several different data codes, and no automatic translation is performed during either input or output operations. IBM provides an extensive array of subroutines to perform conversions between the various data codes and between decimal and binary radices.

The interrupt structure and I/O logic of the 1130 permit overlapping of internal processing with one or more I/O data transfers. The standard I/O control subroutines provided for the 1130 Assembler allow the user to take advantage of this capability for simultaneous operations. The FORTRAN I/O subroutines, however, permit no overlapping of non-I/O processing with I/O operations, nor do they permit simultaneous operation of two peripheral devices. Since most programming for the 1130 will probably be done in FORTRAN, the 1130 will appear to most users as a sequential system capable of only one operation at a time.

One potentially interesting use of an IBM 1130 is as a remote terminal connected by a communications link to a larger central computer facility. IBM states that an adapter which allows an 1130 to be connected to a communications line is available on an RPQ basis, but complete details have not been released as yet.

.3 SOFTWARE

Three software packages are provided by IBM for use with the IBM 1130 system. Two are quite similar and are intended for use in systems with punched card or punched tape input-output but without the Disk File. The other software package is the 1130 Monitor System for use with disc-oriented systems. The Monitor System reduces the need for operator intervention by providing automatic handling of run-to-run supervision. The punched card and tape program packages became available in March 1966; the Monitor System, in April 1966.

The punched card and tape program packages include the following facilities: an 1130 Assembler; a FORTRAN compiler; a set of utility routines which provide facilities for data transcriptions, memory dumps, and loading programs; and an 1130 Subroutine Library, including subroutines for extensive floating-point arithmetic procedures, code conversions, and input-output control. The 1130 Monitor System includes a supervisor routine and a disc utility program in addition to the facilities offered by the punched card and tape packages.

The IBM 1130 Assembler is a straightforward one-to-one assembler that provides for symbolic representation of the central processor instructions. The assembler includes pseudo-instructions for calling IBM or user-coded input-output subroutines and for reserving core memory areas. Source programs can be assembled in either absolute (core image) or relocatable format.

The 1130 FORTRAN language is a subset of the IBM System/360 Basic Programming Support FORTRAN IV language. No facilities are provided for COMPLEX, DOUBLE PRECISION, or LOGICAL operations, but the available language facilities will be adequate for most small-scale scientific applications.

In addition, IBM provides applications packages to aid in solving petroleum exploration and engineering problems, civil engineering problems (COGO), and to aid in type composition. More general routines include statistical and numerical surface routines and additional FORTRAN subroutines (Mathpak). In general, these programs require a disc-oriented system.

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
CENTRAL PROCESSOR AND INTERNAL STORAGE	1131	Central Processing Unit, including Console Typewriter/Printer, core storage, and Disk Storage (if any):			
	1A	4,096 words of core storage; no Disk Storage	580	50.50	26,680
	1B	8,192 words of core storage; no Disk Storage	780	52.00	35,080
	2A	4,096 words of core storage; 512,000 words of Disk Storage (removable cartridge)	780	68.50	35,680
	2B	8,192 words of core storage; 512,000 words of Disk Storage (removable cartridge)	980	70.00	44,080
	2315	Disk Cartridge	—	—	90
		Peripheral Unit Attachments			
	7490	Storage Access Channel	25	0.50	1,125
	3616	1132 Printer Attachment	10	2.00	450
	3854	Printer Expansion Adapter	5	NC	225
	4454	1442 Attachment	35	3.00	1,575
	7187	1627 Plotter Attachment	15	0.50	675
	3623	1134 Paper Tape Reader Attachment	10	1.75	450
	3624	1134 Loader	10	NC	450
	7923	1055 Paper Tape Punch Attachment	20	1.50	900
INPUT-OUTPUT	1132	Printer (requires 3616 and 3854)	260	25.00	11,700
	1442	Card Read Punch (requires 4454):			
		Model 6	265	40.00	14,575
		Model 7	380	50.00	15,725
	1134	Paper Tape Reader (requires 3623):			
		Model 1	35	10.00	1,310
		Model 2 (includes supply and take-up reels)	60	10.00	2,260
	1055	Paper Tape Punch, Model 1 (requires 7923)	40	6.50	2,025
	3571	1055 Edge-Punching Feature	5	0.25	245
	6121	Take-Up Reel	3	0.25	120
	1627	Plotter (requires 7187):			
		Model 1	—	36.00	4,700
		Model 2	—	38.50	8,150

NC - No Charge

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
CENTRAL PROCESSOR AND INTERNAL STORAGE (Contd.)		Peripheral Unit Attachments (Contd.)			
	7490	Storage Access Channel	25	0.50	1,125
	1133	Multiplexor Channel Enclosure (not with Processor Model 1A or 1B; requires 7490)	40	—	1,800
	1865	Channel Multiplexor	165	10.00	7,425
	3201	Disk Control 1	45	2.00	2,025
	3202	Disk Control 2	40	3.00	1,800
	3203	Disk Control 3	45	2.00	2,025
	3204	Disk Control 4	40	3.00	1,800
	4424	1403 Model 6 Attachment	450	30.00	20,250
	4425	1403 Model 7 Attachment	500	35.00	22,500
	7492	Storage Access Channel II	25	0.50	1,125
	7690	Synchronous Communications Adapter	232	11.25	9,825
INPUT-OUTPUT	1442	Card Read/Punch —			
		Model 5 (requires 4449 and 3630): punches 160 col/sec	255	49.00	12,750
		Model 6 (requires 4454): reads 300 cards/min; punches 80 col/sec	265	51.00	14,575
		Model 7 (requires 4454): reads 400 cards/min; punches 160 col/sec	380	61.00	15,725
	3630	1130/1442 Model 5 Coupling	5	—	225
	2501	Card Reader (requires 8042, 3854, and 3630) —			
		Model A1: reads 600 cards/min	201	33.25	11,350
		Model A2: reads 1,000 cards/min	263	45.75	11,590
	3630	1130/2501 Coupling	5	—	150
	1231	Optical Mark Page Reader (requires 8034, 3854, and 1264)	430	36.25	23,100
	1264	Asynchronous Mode	40	4.00	1,800
	5045	Master Mark	50	1.50	2,500
	1134	Paper Tape Reader (requires 3623) —			
		Model 1: reads 60 char/sec	36	10.00	1,270
		Model 2 (includes supply and take-up reels): reads 60 char/sec	62	10.50	2,190
	1055	Paper Tape Punch (requires 7923): punches 14.8 char/sec	40	6.50	2,025
	3571	Edge-Punching	5	0.25	245
	6121	Take-up Reel	3	0.25	120
	1132	Printer (requires 3616 and 3854): prints 80 to 110 lines/min	268	25.00	11,350
	1627	Plotter —			
		Model 1 (requires 7187): plots up to 300 increments/sec	—	36.00	4,700
		Model 2 (requires 7189): plots up to 200 increments/sec	—	38.50	8,150
	1403	Printer —			
		Model 6 (requires 1133 and 4424): prints 340 lines/min	400	131.00	29,000
		Model 7 (requires 1133 and 4425): prints 600 lines/min	650	153.00	32,700
	2250	Display Unit Model 4 (requires 7490 or 7492)	2,400	110.00	115,200
	1248	Alphameric Keyboard	75	2.00	3,600
	5858	Program Function Keyboard	150	2.50	7,200

REPORT UPDATE

IBM ANNOUNCES SUPER-SCALE MODEL 195

IBM introduced a new addition to the top end of its System/360 family line on August 20. The super, large-scale Model 195, designed to compete directly with the recently-announced CDC 7600 computer system, replaces the discontinued Model 91 and 95 and offers the following features:

- High speed instruction execution — 18-nanosecond floating point multiply-divide cycle.
- High speed 54-nanosecond buffer — 32, 768 bytes of storage.
- Eight to sixteen way interleaving in main storage.
- One to four million bytes of 756-nanosecond main storage.
- 104-microsecond timer
- Universal instruction set, direct control, extended-precision, floating-point arithmetic.
- Graphic display console

The Model 195 is essentially a faster Model 85 and it can utilize all of the peripheral devices available in a Model 85 configuration with three exceptions; the 2520 Model B1 Card Read/Punch, and the 7770 Model 3 and 7772 Model 3 Audio Response Units.

The Model 195 has five functionally separate CPU units: processor storage; storage bus control; instruction processor; fixed point processor, and floating point processor. This processor organization permits up to seven different operations to proceed simultaneously.

Operating support is provided by OS MVT, available without charge. In a multiprogrammed environment, up to fifteen programs can be run concurrently. A maximum of six selector channels and one multiplexor channel can be used with the Model 195.

The following Model 195 prices are available at this time:

	Monthly Rental	Purchase Price	Monthly Maintenance
2191 Processing Unit			
Model J (1, 048, 576 bytes of main memory)	$ 96, 800	$ 4, 266, 000	$ 12, 735
Model K (2, 097, 152 bytes of main memory)	127, 800	5, 766, 000	13, 485
Model L (4, 194, 304 bytes of main memory)	167, 800	7, 766, 000	14, 985
2160 Systems Console (graphic display and light pen included)	7, 200	308, 000	450
2180 Power Unit	850	37, 400	15
2185 Power Distribution Unit	700	30, 800	10
2186 Coolant Distribution Unit	750	33, 000	10

Monthly system rentals for the Model 195 range between $165, 000 and $300, 000 with purchase prices from $7 million to $12 million, depending on the configuration. Initial delivery of the Model 195 is scheduled for the first quarter of 1971.

REPORT UPDATE

IBM UNVEILS KEYBOARD-TO-TAPE INSCRIBER AND TAPE CARTRIDGE READER

Companion units that enable information to be keyed directly onto magnetic tape and then read into a System/360 computer were announced by IBM on April 25. The new units are the IBM 50 Magnetic Data Inscriber and the 2495 Tape Cartridge Reader.

IBM states that the new data entry system is "designed primarily for users who must continually update records already stored in a computer in random order. In many other data processing applications, the preparation of a punched card — a physical unit record of information — will continue to be advantageous." Thus, IBM is responding to the Mohawk and Honeywell keyboard-to-tape inscribers.

Magnetic Tape Cartridges

The recording medium used in the two new units is 16-millimeter (0.64-inch-wide) magnetic tape, housed in cartridges that can hold a maximum of 23,000 characters of information. The cartridges are identical with the ones that have been used for several years in the IBM Magnetic Tape Selectric Typewriter (MT/ST). Information is recorded in nine tracks across the width of the tape, using System/360-compatible code.

It is important to note that the tape cartridges recorded by an IBM 50 Magnetic Data Inscriber can, at present, be read only into a System/360 computer and only by an IBM 2495 Tape Cartridge Reader. This is the most significant difference between the IBM inscriber and the competitive units manufactured by Mohawk, Honeywell, and Sangamo, which record data on standard 0.5-inch, 7- or 9-track tape that can be read by any computer equipped with "IBM-compatible" magnetic tape units.

IBM 50 Magnetic Data Inscriber

The IBM inscriber features a variable-record-length capability that eliminates the 80-character limitation that punched cards impose on unit record lengths. The operator can preset the arrangement of data to be keyed in and indicate where repetitive data shall be entered automatically. Up to eight different formats can be established, and subsequently selected, via the keyboard. Automatic data entries are recorded at the rate of 100 characters per second.

The 50 Magnetic Data Inscriber has a keypunch-style keyboard and can handle both numeric and alphabetic information. An automatic "left-zero insertion" feature allows the operator to enter only significant digits; preceding zeros are inserted automatically. The console provides a character display, and there are special provisions to facilitate the correction of keying errors.

IBM 2495 Tape Cartridge Reader

The 2495 reader feeds information recorded on tape cartridges into a System/360 computer at the rate of 900 characters per second. An entire cartridge, holding 23,000 characters, can be read in less than 30 seconds. A dozen tape cartridges can be loaded into the reader at the same time, whereupon they are read, rewound, and stacked automatically.

The 2495 Tape Cartridge Reader can be connected to the Multiplexor Channel of a System/360 Model 25, 30, 40, or 50 computer system. It can read tape cartridges recorded by an IBM Magnetic Tape Selectric Typewriter, as well as those recorded by IBM 50 Magnetic Data Inscribers. The MTST is especially well-suited for entry of unformatted text data into a computer. A single 2495 reader can, of course, serve multiple data inscribers and MTST's.

Prices and Availability

The IBM 50 Magnetic Data Inscriber rents for $180 per month and can be purchased for $9,900. The 2495 Tape Cartridge Reader has a basic monthly rental of $350 and a purchase price of $19,250. Customer deliveries of both units are scheduled to begin in the first quarter of 1969. Each tape cartridge costs from $12 to $20, depending upon the quantity purchased.

REPORT UPDATE

IBM ADDS NEW OPTICAL RECOGNITION DEVICE TO ITS PRODUCT LINE

The 1288 Optical Page Reader, announced by IBM on July 15, reads data from either formatted or unformatted documents. Typed or machine-printed data can be read and stored at a maximum speed of 2,750,000 characters per hour, or the equivalent of 860 fully-typed pages. The 1288 is an on-line device that can be attached to System/360 Models 25, 30, 40, or 50 and is supported by both the 360 Disk Operating System and the 360 Tape Operating System.

The input documents may range in size from 3" x 6.5" to 9" x 14". An input stacker accomodates up to ten inches of documents and two output stackers each have a 4.5 inch capacity.

Data can be read both vertically and horizontally in the formatted mode. Format control allows reading variable length fields in any sequence. The stored program directs the electronic flying spot optical scanner beam, a field at a time, to the data to be read. For unformatted data, the 1288 locates the first line, reads and transfers it, and then searches for each subsequent line.

Features

Handprinted numeric digits 0-9 and alphabetic characters C, S, T, X, and Z may be read with the Numeric Handwriting special feature. Character shapes and spacing must conform to the basic rules of handwriting as specified by IBM, such as the requirements for large simple block printing and connecting lines and closing loops, and the restriction against linking characters.

A special feature allows marks, that are either handmarked or machine printed, to be read vertically or with a slanted orientation at an angle of 45°.

Price and Availability

The 1288 Optical Page Reader rents for $4,900 per month and can be purchased for $230,300. Special features # 5370 Numeric Handwriting and # 5479 Optical Mark Reading carry monthly rentals of $1,000 and $100 and purchase prices of $54,000 and $5,300 respectively. The first customer deliveries are scheduled for January 1970.

REPORT UPDATE

IBM MAKES AVAILABLE ADDITIONAL CORE STORAGE CHOICES

Two new core sizes for the IBM System/360 Models 40 and 50 were announced on November 4. The Model 40 processor storage capacities range from 16,384 to 524,288 bytes and the Model 50 spans a 65,536 to 1,048,576 range.

The prices and core storage positions of the two new processor models are as follows:

Processor Model Numbers	Monthly Rental	Monthly Maintenance Charges	Purchase Price
40 GF (196,608 bytes)	$ 8,750	$ 250	$381,610
50 HG (393,216 bytes)	17,680	550	756,980

REPORT UPDATE

IBM ADDS ADDITIONAL FEATURES TO THE SYSTEM/360 MODEL 25

In November 1968, IBM made available four new features that expand the capabilities of the Model 25. The Model 25 price and performance falls between the System/360 Models 20 and 30. Unlike the Model 20, the Model 25 is program-compatible with the larger general-purpose System/360 processors, and when equipped with the appropriate compatibility features, it can execute programs written for the IBM 1401, 1440, and 1460 systems. The introduction of the following features enabled IBM to increase the compatibility attributes and add other peripheral devices to the Model 25:

- The 1401/1440/1460 DOS Compatibility (# 4470) — requires the prior attachment of the 1400 Series Compatibility Feature (# 4440) which allows the Model 25 to execute 1401/1440/1460 instructions in 16K of control storage on the processor Model 2025. The #4470 feature specifically permits 1401 and System/360 programs to be run in a single intermixed jobstream in a multiprogramming environment. There is no additional charge for the # 4470 feature.

- The 2540 Emulation Control (# 7800) — requires the prior attachment of the Integrated 2560 Attachment (# 4596) which, in conjunction with the # 9725 Model 25 Adapter, permits the attachment of the 2560 Multi-function Card Machine to the System/360 Model 25 system. Through the # 7800 feature attachment, the Model 25 user can emulate a 2540 Card Read/Punch via the 2560 Card Machine. The # 7800 feature carries a monthly rental of $60 and a purchase price of $3,048.

- The 1100 LPM Printer Adapter (# 3615) — permits the attachment of the 1403 Printer Model N1 to the 2025 processor via the Integrated 1403 Attachment (# 4590). The # 3615 feature rents for $60 a month and sells for $3,048.

- The Multiple Character Set (# 5111) — is used on the 1403 Printer N1 attached to the 2025 processor via the Integrated 1403 Attachment (# 4590) and the # 3615 Adapter. This feature rents for $10 per month and sells for $450. The # 5111 feature cannot be installed with the Universal Character Set Feature (# 8641).

In addition to the above features, IBM has announced that the maximum data transfer rate for the Selector Channel (# 6960), which previously did not permit the attachment of devices that exceed a 30KB rate, has been increased to 60KB. Thus, it is now possible to attach the 2401 Tape Drive Models 2 and 4.

REPORT UPDATE

▶ IBM ADDS NEW MAGNETIC TAPE UNIT TO ITS SYSTEM/360 PRODUCT LINE

IBM has extended the available peripheral equipment options for users of the System/360 Modes 50, 65, 75 or 85, with the introduction of the 2420 Magnetic Tape Unit, Model 7.

The 9-track 2420-7 is now the fastest tape unit in IBM's product line, operating at a peak speed of 320,000 bytes per second . . . twice the speed of the 2401-6 tape unit.

The 2420-7 features a 1,600 bytes per second recording density, a rewind speed of 500 inches per second, and the ability to accelerate from a dead start to 200 inches per second in 1.4 milliseconds and stop within a 1 millisecond time frame.

The unit is currently available at a $1,050 per month lease rate and a $54,600 purchase price. The user can expect a 4 to 5 month delivery following the placing of an order.

REPORT UPDATE

▶ IBM Provides New Disc Storage Models

Two new models of the IBM 2314 Direct Access Storage Facility, the 2314-A1 and the 2314-A2, were announced in January 1969 to replace the original Model 2314-1, a changeable - cartridge disc storage unit containing eight active disc drives, one spare drive, and internal control circuitry. Conversion and operations are facilitated by the fact that all of the supporting software is compatible.

The two new models differ from the model 2314-1 primarily in the faster average access time --- a decrease from 75 milliseconds to 60 milliseconds. Model A1 has eight independent drives on-line and one spare drive for use in case one of the other eight becomes inoperable. Total on-line capacity is 233.4 million bytes. Model A2 contains five independent drives with an on-line capacity of 145.9 million bytes. As was true with the old model, the new models require no external control unit.

The 2314 Model A1 leases for $5,675 and sells for $256,400: the Model A2 carries a monthly rental of $3,875 and a purchase price of $175,075.

The first customer shipments for new orders are expected to commence in September 1969, however the present orders for the 2314-1 will be filled with the 2314-A1, starting in June 1969.

SUMMARY

The Model 20 is the smallest currently-announced member of the IBM System/360 computer family. It was introduced in November 1964 as a card-oriented computer system designed primarily to serve as a first step upward from punched-card tabulating equipment. Later, IBM's addition of magnetic tape capability to the Model 20 expanded the range of its practical applications. In August 1966, two new models of the IBM 2311 Disk Storage Drive were announced for use with the Model 20, adding still another dimension to its processing capability.

In March 1968, IBM announced slower, lower-cost versions of the Model 20 system that make its use practical in smaller businesses and lower-volume applications. The new "Submodels 3 and 4" of the Model 20 Processor are fully program-compatible with, and somewhat slower than, the earlier "Submodels 1 and 2." Configuration possibilities for Submodels 3 and 4, however, are quite restricted; the only allowable peripheral devices are the new, slower models of the 2560 Multi-Function Card Machine and 2203 Printer, plus the 2311 Model 12 Disk Storage Drive, 2152 Printer-Keyboard, and 2074 Binary Synchronous Communications Adapter. Both prices and throughput of Submodel 3 or 4 systems average about 70 per cent of those of equivalent Submodel 1 or 2 configurations.

In June 1968, IBM further expanded the Model 20 line by introducing five new "Submodel 5" Processors that provide substantially improved performance at rental increases of only $100 per month over the corresponding Submodel 2 Processors. The Submodel 5 systems offer:

- Internal processing speeds approximately three times as fast as Submodels 1 and 2 on typical instruction mixes.
- Core storage capacities of 8K, 12K, 16K, 24K, or 32K bytes (compared with a maximum capacity of 16K bytes in the earlier models).
- Provision for connecting up to four 2311 Disk Storage Drives (compared with a maximum of two drives in the earlier models).
- Capability to overlap magnetic tape and/or disk reading or writing with other I/O operations and with internal processing.

Figure 1. The card-oriented Model 20 system in the foreground, with 2560 Multi-Function Card Machine at right, is designed to perform all the functions of the conventional tabulating machines in the background.

SUMMARY (Contd.)

- Improved serviceability through a new diagnostic aid called "System Log-Out," which operates at the micro-code level and provides for automatic storage of count and status data regarding intermittent errors.
- Full upward compatibility with the slower Model 20 Processors.

A Model 20 system that includes a Multi-Function Card Machine and printer can be rented for as little as $1,359 per month, though monthly rentals for most Model 20 systems will range from about $1,500 to $4,000. Deliveries of Model 20 systems began in the first quarter of 1966. Initial deliveries of Submodel 3 and 4 systems are scheduled for November 1968, while customer shipments of Submodel 5 systems will start in May 1969.

HARDWARE

The Model 20 uses the same basic data and instruction formats as the larger System/360 models. The instruction repertoire is a compatible subset of the full System/360 repertoire, except that the input-output instructions and some control instructions are unique to the Model 20. Decimal arithmetic (including multiply and divide), editing, and code translation instructions are standard. Floating-point arithmetic is not available. The scatter-read, gather-write, and extensive interrupt facilities of larger System/360 models are not implemented in the Model 20: interrupts occur only upon completion of peripheral data transfer operations.

A Model 20 Processor can contain from 4,096 to 32,768 bytes of core storage. Table I summarizes the model designations, core storage capacities, and representative speeds of the 21 different Model 20 Processors that are now offered. The core cycle time is 3.6 microseconds per one-byte access in Submodels 1 through 4 and 2.0 microseconds per two-byte access in Submodel 5. Every Model 20 Processor has eight 16-bit general registers (compared with sixteen 32-bit registers in the larger System/360 models), which are usable as fixed-point accumulators or as index registers.

The use of decimal arithmetic is being emphasized in the Model 20. It is performed upon 4-bit BCD digits packed two to a byte, with a sign in the rightmost four bits of the low-order byte of each data field. Decimal operands can be up to 16 bytes (31 digits and sign) in length; the length of each field is specified in the instructions that reference it, rather than by a word-mark in the field itself.

Because of the instructions which are unique to the Model 20 and certain other programming differences, programs written for a Model 20 system cannot be directly executed on a larger System/360 model. A System/360 Model 25 Processor, however, can be equipped with a Model 20 Compatibility Feature (announced in June 1968) that enables the Model 25 to execute Model 20 programs at approximately four times the internal speed of the original Model 20

TABLE I: SYSTEM/360 MODEL 20 PROCESSOR CHARACTERISTICS

Core Storage Capacity, Bytes	Processing Unit Designation				
	Submodel 1	Submodel 2	Submodel 3	Submodel 4	Submodel 5
4,096	B1	B2	B3	B4	—
8,192	C1	C2	C3	C4	C5
12,288	BC1	BC2	BC3	BC4	BC5
16,384	D1	D2	D3	D4	D5
24,576	—	—	—	—	DC5
32,768	—	—	—	—	E5
Cycle Time, Microseconds	3.6	3.6	3.6	3.6	2.0
Bytes Accessed per Cycle	1	1	1	1	2
Cycle Time per Byte, Microseconds	3.6	3.6	3.6	3.6	1.0
Processor Speeds, Microseconds*					
c = a + b	675	675	1,207	1,207	212
c = a x b	7,000	7,000	7,530	7,530	1,730
c = a ÷ b	10,810	10,810	11,340	11,340	2,130
Move a to b	185	185	451	451	68
Compare a to b	489	489	755	755	206

*Basis: Signed, packed, 5-digit decimal operands.

(Contd.)

HARDWARE (Contd.)

systems (or about 30 per cent faster than the Submodel 5 Processors). This feature also permits the 2560 Multi-Function Card Machine to be used with the Model 25 System.

A control panel, built into the top of the Model 20 Processor cabinet, provides the switches, keys, and lights required for manual control of the system. The optional 2152 Printer-Keyboard, announced in January 1968, provides keyboard input and typewriter output facilities.

Peripheral devices are connected to a Model 20 system by means of special attachments. In most cases a separate attachment is required for each peripheral device. Thus, a Model 20 processor model can be differentiated from other System/360 processors not only by its core storage size and limited instruction set, but also by its method of connecting I/O devices.

A System/360 Model 20 system can include up to three punched-card input-output units, one printer, one magnetic character reader, one printer-keyboard, one communications adapter, one 2415 Magnetic Tape Unit and Control (containing two, four, or six tape drives), and four 2311 Disk Storage Drives. Table II summarizes the principal characteristics of the peripheral devices available for use in Model 20 systems and shows the processor submodels to which each device can be connected. The following additional configuration restrictions apply:

- A system can have a maximum of three card read stations, two card punch stations, and one card print station.
- A 2560 Multi-Function Card Machine and a 2520 Card Punch or Card Read Punch cannot be used in the same system.
- A 2073 Communications Adapter can be connected only to a Submodel 2 Processor.
- A 2074 Binary Synchronous Communications Adapter can be used only with a Submodel 2, 4, or 5 Processor having at least 8K bytes of core storage.
- Disk storage drives can be connected as follows:

  Submodel 2 Processor — up to two 2311 Drives, Model 11 or 12.

  Submodel 4 Processor — up to two 2311 Drives, Model 12 only.

  Submodel 5 Processor — up to four 2311 Drives, Models 11 and 12 (may be intermixed).

Through interleaving of the core storage accesses required by I/O devices and by the central processor, one of each of the following functions can occur simultaneously in a Model 20 system: card reading, punching, printing, typing and computing. Magnetic tape or disk read or write operations, however, occur in the "burst" mode in Submodels 1 through 4, precluding simultaneous execution of any other function except printing on the buffered 1403 Printer, magnetic tape rewinding, or disk seek operations. In Submodel 5 systems, one tape and one disk read or write operation can be overlapped with other I/O operations and with computing.

The 2560 Multi-Function Card Machine (MFCM) is a unique punched-card input-output unit developed especially for the System/360 Model 20. Equipped with two 1,200-card input hoppers, a reading station, a punching station, an optional printing station, and five 1,300-card radial stackers, the 2560 MFCM combines many of the facilities of a card reader, card punch, collator, interpreter, and card document printer in a single unit under stored-program control.

Cards can be fed independently from either the primary or secondary hopper of the 2560 MFCM; they follow separate paths through pre-read, read, and pre-punch stations. The cards are read serially (column by column) by means of solar cells, at a maximum speed of 500 cpm in Model A1 and 310 cpm in Model A2. Upon leaving the separate primary and secondary pre-punch stations, the cards merge into a single feed path through the punch, pre-print, and print stations. Then the cards pass on into any of the five stackers, as selected by the program. The rated punching speed is 160 columns per second in Model A1 and 120 columns per second in Model A2. The effective speed depends upon the position of the last column punched in each card (as in the IBM 1442); when all 80 columns are punched, the punching rate is 91 cpm in Model A1 and 65 cpm in Model A2. The optional Card Print feature (for Model A1 only) provides a printing unit that can print two, four, or six lines of information on any or all cards passing through the MFCM at a rated printing speed of 140 character positions per second.

The IBM 2311 Disk Storage Drive has been adapted for use with the System/360 Model 20. The new units, called the 2311 Models 11 and 12, are similar to each other in every respect except storage capacity and access time. Model 11 provides 5.4 million bytes of auxiliary "Disk Pack" storage with 75-millisecond average positioning time; Model 12 provides 2.7 million bytes of storage with 60-millisecond average positioning time. Both models have an average rotational delay of 12.5 milliseconds, a data transfer rate of 156,000 bytes per second, and a fixed sector length of 270 bytes, with 10 sectors in each track.

The 2073 Communications Adapter provides the Model 20 (Submodel 2 only) with limited data communications facilities. With this adapter, a Model 20 can function as a single-line, point-to-point processor terminal that can communicate with another Model 20, a larger System/

TABLE II: SYSTEM/360 MODEL 20 PERIPHERAL EQUIPMENT

Device	Characteristics	Usable with Processor Submodels
2560 Multi-Function Card Machine:		
Model A1	Reads 500 cards/minute; Punches 160 columns/second; Prints 140 char/second on cards (optional)	1, 2, 5
Model A2	Reads 310 cards/minute; Punches 120 columns/second	3, 4
2501 Card Reader:		
Model A1	Reads 600 cards/minute	1, 2, 5
Model A2	Reads 1000 cards/minute	1, 2, 5
2520 Model A1 Card Read Punch	Reads 500 cards/minute; Punches 500 cards minute	1, 2, 5
2520 Card Punch:		
Model A2	Punches 500 cards/minute	1, 2, 5
Model A3	Punches 300 cards/minute	1, 2, 5
1442 Model 5 Card Punch	Punches 160 columns/second	1, 2, 5
1403 Printer:		
Model 2	Prints 600 lines/minute; 132 positions	1, 2, 5
Model 7	Prints 600 lines/minute; 120 positions	1, 2, 5
Model N1	Prints 1100 lines/minute; 132 positions	1, 2, 5
2203 Printer:		
Model A1	Prints 750 lpm with 13-character set; Prints 425 lpm with 39-character set; Prints 350 lpm with 52-character set; Prints 300 lpm with 63-character set	1, 2, 5
Model A2	Prints 600 lpm with 13-character set; Prints 300 lpm with 39-character set; Prints 260 lpm with 52-character set; Prints 230 lpm with 63-character set	3, 4
1259 Magnetic Character Reader	Reads 600 6-inch documents/minute; 11 sorting pockets	2, 5
1419 Magnetic Character Reader	Reads 1600 6-inch documents/minute; 13 sorting pockets	2, 5
2311 Disk Storage Drive:		
Model 11	Stores 5.4 million bytes on-line; 87.5 msec average random access time	2, 5
Model 12	Stores 2.7 million bytes on-line; 72.5 msec average random access time	2, 4, 5
2415 Magnetic Tape Unit:		
Model 1 (two tape drives)	15,000 char/sec; 800 bpi	2, 5
Model 2 (four tape drives)	15,000 char/sec; 800 bpi	2, 5
Model 3 (six tape drives)	15,000 char/sec; 800 bpi	2, 5
Model 4 (two tape drives)	30,000 char/sec; 1600 bpi	2, 5
Model 5 (four tape drives)	30,000 char/sec; 1600 bpi	2, 5
Model 6 (six tape drives)	30,000 char/sec; 1600 bpi	2, 5
2152 Printer-Keyboard	Selectric Typewriter; prints 15.5 char/sec	2, 4, 5

HARDWARE (Contd.)

360 processor, an IBM 1009 Data Transmission Unit, a 1013 Card Transmission Terminal, a 7701 or 7702 Magnetic Tape Transmission Terminal, or a 7710 or 7711 Data Communications Unit. Data is transmitted and received in half-duplex synchronous mode over appropriate communications facilities at speeds ranging from 75 to 600 characters per second. Multiple remote terminals can be addressed via common-carrier switched telephone networks. Automatic connections and disconnections can be made without operator intervention. Data is transmitted or received under control of the stored program. One message at a time can be transmitted or received. The Communications Adapter shares central processor time with data processing and input-output operations.

As an alternative to the 2073 Adapter, IBM offers the 2074 Binary Synchronous Communications Adapter (BSCA) as an optional feature for the Submodel 2, 4, or 5 Processor. This unit permits a Model 20 system to function as a processor terminal on either a switched or leased communications network, communicating with another appropriately-equipped System/360

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HARDWARE (Contd.)

processor in IBM's Binary Synchronous Communications (BSC) mode. With the 2074 Adapter, transmission speeds ranging from 75 to 6250 characters per second are possible, depending upon the communications facilities. Data can be transmitted in EBCDIC, USASCII, or binary form. Transmission is in half-duplex mode over privately-owned, leased, or switched telephone lines.

SOFTWARE

Because of the Model 20's restricted instruction repertoire, different I/O control methods, and limited core storage capacity, Model 20 systems cannot use the extensive array of software that IBM is providing for the larger System/360 models. Software support for Model 20 systems is provided at three different levels, for card-, tape-, and disk-oriented systems.

The card-oriented software requires a 4K Model 20 Processor with punched-card I/O equipment and a printer. The software components at this level include a basic assembler, report program generator, input-output control system (IOCS), and a group of utility routines. Among the latter are four programs that use the 2560 MFCM to simulate many of the functions of conventional tabulating equipment: Collate, Gangpunch-Reproduce, List-Summary Punch, and Merge-Sort. (A card reader and punch can be substituted for the 2560 MFCM in the Gangpunch-Reproduce and List-Summary Punch programs.) No operating system is available at the card-oriented level; operator intervention is required between programs.

The tape-oriented software provides expanded versions of the assembler, report program generator, IOCS, and utility routines, plus a Sort/Merge program. Moreover, a group of three System Control programs (Initial Program Loader, Basic Monitor, and Job Control) provide increased operational efficiency through automatic job-to-job transition, overlay control, and use of a tape library. A Model 20 Processor with 8K bytes of core storage, four tape drives, card I/O equipment, and a printer is required to take full advantage of these software facilities.

The disk-oriented software includes components and capabilities which are similar to those of the tape-oriented software. Minimum equipment requirements include a Model 20 Processor with 12K bytes of core storage, one 2311 Disk Storage Drive, card I/O equipment, and a printer.

IBM is emphasizing the use of the Report Program Generator (RPG) as the primary programming system for most Model 20 installations. The Model 20 RPG is a generalized program designed to generate coding to perform most of the routine business data processing functions. Input to the RPG consists of specifications written by the user in a format that is considerably easier to learn and use than assembly-language coding. Separate preprinted specification sheets are used to describe the input to be provided, the calculations to be performed, and the output to be produced. Most programs written in the Model 20 RPG language can be generated and run on the larger System/360 models, provided that an equivalent configuration of I/O equipment is available (but note that no unit equivalent to the 2560 MFCM is currently available for the larger System/360 models). No COBOL, FORTRAN, or PL/I compiler has been developed for the Model 20 to date.

Other software available for Model 20 systems includes specialized input-output control systems for the communications adapters and magnetic character readers, and a group of IBM-developed programs for specific applications such as hospital billing, telephone revenue accounting, wholesale inventory management, and bill-of-material processing.

IBM SYSTEM/360 MODEL 20

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			Processing Unit:			
	2020		Model B1 — 4,096 bytes	515	23,570	37.00
			Model C1 — 8,192 bytes	720	32,590	42.00
			Model BC1 — 12,288 bytes	980	44,230	48.00
			Model D1 — 16,384 bytes	1,235	55,100	52.00
			Model B2 — 4,096 bytes	595	27,060	40.00
			Model C2 — 8,192 bytes	800	36,080	45.00
			Model BC2 — 12,288 bytes	1,060	47,720	51.00
			Model D2 — 16,384 bytes	1,315	58,590	55.00
			Model B3 — 4,096 bytes	365	16,600	37.00
			Model C3 — 8,192 bytes	465	20,900	42.00
			Model BC3 — 12,288 bytes	625	28,100	48.00
			Model D3 — 16,384 bytes	785	34,900	52.00
			Model B4 — 4,096 bytes	405	18,500	40.00
			Model C4 — 8,192 bytes	505	22,700	45.00
			Model BC4 — 12,288 bytes	665	29,800	51.00
			Model D4 — 16,384 bytes	825	36,700	55.00
			Model C5 — 8,192 bytes	900	45,600	90.00
			Model BC5 — 12,288 bytes	1,160	58,000	100.00
			Model D5 — 16,384 bytes	1,415	72,800	105.00
			Model DC5 — 24,576 bytes	1,765	91,700	115.00
			Model E5 — 32,768 bytes	2,115	107,800	130.00
ATTACHMENTS, ADAPTERS, AND CHANNELS			Peripheral Adapters (on 2020)			
			1403 Model 2 Attachment	232	10,910	22.50
			1403 Model 7 Attachment	206	10,670	22.50
			1403 Model N1 Attachment	283	11,400	22.50
			1442 Model 5 Attachment	31	1,450	2.50
			2152 Attachment	90	4,500	4.50
			2203 Attachment	57	2,670	5.00
			2501 Attachment	20	960	2.00
			2520 Model A1 Attachment	51	2,420	6.00
			2520 Model A2 or A3 Attachment	25	1,250	3.00
			2560 Attachment	77	3,640	4.75
		1580	Card Print Control	25	1,200	2.25
		3480	Dual Feed Carriage Control	10	500	1.50
		5575	Printer Features Control	57	2,560	2.00
		8637	Universal Character Set Adapter	15	720	3.50
		7081	Serial I/O Channel	103	5,140	6.50
		4658	Input/Output Channel	155	7,270	4.75
		2073	Communications Adapter	155	5,820	11.00
		2074	Binary Synchronous Communications Adapter	425	17,000	16.50
			Disk Storage Controls:			
		7495	For Submodel 2 CPU	232	10,910	5.00
		7496	For Submodel 4 CPU	177	8,160	
		7497	For Submodel 5 CPU	232	10,910	

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (2)			Disk			
	2311		Disk Storage Drive (Disk Storage Control req'd.) —			
			Model 11 (5.4 million byte capacity)	590	25,510	55.00
			Model 12 (2.7 million byte capacity)	360	22,310	35.00
	1316		Disk Pack for 2311	15	490	—
INPUT-OUTPUT(2)			Punched Card			
	1442		Card Punch(1)	255	12,750	49.00
	2051		Card Reader(1)			
			Model A1 — 600 cards/min.	201	11,350	33.25
			Model A2 — 1,000 cards/min.	263	11,590	45.75
	2520		Card Read Punch, Model A1(1)	720	32,490	91.00
	2520		Card Punch(1)			
			Model A2 — 500 cards/min.	645	29,100	87.00
			Model A3 — 300 cards/min.	465	28,810	67.00
	2560		Multi-Function Card Machine(1)			
			Model A1 (reads 500 cards/min., punches 160 col/sec)	590	27,890	90.00
			Model A2 (reads 310 cards/min., punches 120 col/sec)	460	20,500	90.00
			Card Print Feature (Mdl A1 only):			
		1575	First 2 Lines (#1580 req'd.)	129	6,060	13.00
		1576	Second 2 Lines (#1575 req'd.)	129	6,060	13.00
		1577	Third 2 Lines (#1576 req'd.)	129	6,060	13.00
			Printers			
	1403		Printer (600 lines/min.)(1)			
			Model 2	775	34,000	177.00
			Model 7	650	32,700	153.00
	1403		Printer, Model N1 (1100 lines/min.)(1)	900	41,200	183.00
			On 1403 Model 2 or 7 —			
		1376	Auxiliary Ribbon Feeding Feature	75	3,075	17.75
		4740	Interchangeable Chain Cartridge Adapter	75	3,125	—
			On 1403 Model 2 only (#5575 req'd.) —			
		5381	Numerical Print Feature	225	9,050	9.00
			On 1403 Model 2 or N1 —			
		6411	Selective Tape Listing Feature	190	8,100	12.00
			Universal Character Set Feature (#8637 req'd.) —			
		8640	For Model N1	10	450	1.75
		8641	For Model 2	10	450	1.75
			On 1403 Model N1 only —			
		1416	Interchangeable Chain Cartridge	100	3,000	—
	2203		Printer			
			Model A1 (300-750 lines/min.)	525	22,310	71.50
			Model A2 (230-600 lines/min.)	400	17,000	71.50
			On 2203 Printer —			
		5558	24 Additional Print Positions	46	2,405	4.00
		3475	Dual Feed Carriage (#3480 req'd.)	103	4,850	8.50
		7815	6 Additional Tape Channels (#3475 req'd.)	10	400	1.00
			Magnetic Tape			
	2415		Magnetic Tape Unit 15,000 char/sec (Input/Output Channel req'd.) -			
			Model 1 (two tape drives and single-channel controller, 800 BPI)	775	35,650	100.00
			Model 2 (four tape drives and single-channel controller, 800 BPI)	1,240	57,040	180.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT(2) (Contd.)			Model 3 (six tape drives and single-channel controller, 800 BPI)	1,705	78,430	260.00
			30,000 char/sec (Input/Output Channel req'd.)–			
			Model 4 (two tape drives and single-channel controller, 1600 BPI)	935	43,160	115.00
			Model 5 (four tape drives and single-channel controller, 1600 BPI)	1,500	69,350	205.00
			Model 6 (six tape drives and single-channel controller, 1600 BPI)	2,065	95,540	295.00
		3228	Data Conversion (#7125, 7127, or 7135 req'd.)	46	2,100	1.00
		7125	Seven-Track Compatibility — Models 1-3	51	2,330	1.25
		7127	Seven-Track Compatibility — Models 4-6	98	4,420	3.50
		7135	Seven- or Nine-Track Compatibility — Models 4-6	160	7,220	13.00
		5320	Nine-Track Compatibility — Models 4-6	139	6,290	10.00
			Magnetic Character Reader			
	1419		Magnetic Character Reader (Serial I/O Channel req'd.)	2,275	110,500	224.00
	1259		Magnetic Character Reader, Model 1 (Serial I/O Channel req'd.)	1,100	49,500	250.00
	2152		Printer-Keyboard(1)	135	5,600	61.00

NOTES:

(1) Requires appropriate Peripheral Adapter on the 2020 Processing Unit.

(2) Most of the Model 20 peripheral devices can be connected only to certain submodels of the 2020 Processing Unit.

(3) The indicated monthly maintenance charges are those in effect for the first 36 months after installation.

SUMMARY

Model 67 is a large-scale member of the IBM System/360 family that is specifically oriented toward time-sharing operation in scientific and educational applications. Its principal design objective is to furnish continuous computing service to many users simultaneously, while providing rapid responses to each of the users. The goal is to give each user the impression that all the facilities of a large computing system are at his disposal and keep him unaware of the fact that he is actually competing with numerous other users for the use of these facilities.

Model 67 was announced in April 1965 as a replacement for the slower time-sharing Models 64 and 66, which had been announced only six weeks earlier. Model 67 was originally offered as a non-standard model available only through special proposals and individual negotiations. In August 1965, Model 67 became a member of the standard IBM product line. In January 1967, however, technical difficulties encountered in the development of the specialized software support for Model 67 caused IBM to revert to a "controlled marketing" basis, under which all Model 67 selling efforts and proposals must be approved by IBM's regional management.

Initial customer deliveries of the Model 67 hardware were made in the fourth quarter of 1966, but Release 1 of the Time-Sharing System (TSS) software was not officially delivered to Model 67 users until October 1967. Performance of early Model 67 systems has been far below expectations, though steady progress is being made in solving the problems. Typical monthly rentals range from $45,000 to $60,000 for a single-processor Model 67 system and from $100,000 to $200,000 for a two-processor system.

This subreport concentrates upon the specialized characteristics, performance, and pricing of Model 67 systems and the supporting software. All general characteristics of the System/360 hardware are described in Computer System Report 420: IBM System/360 — General.

The processors and core storage units used in Model 67 systems are essentially Model 65 units modified to provide effective performance in time-sharing, multiprocessor environments. The Model 67 hardware is characterized by:

- The use of virtual addresses rather than physical addresses in all programs to facilitate dynamic reallocation of storage.
- An eight-register associative memory that speeds translations between virtual and physical addresses.
- A main core storage cycle time of 0.75 microsecond, with eight bytes being accessed per cycle; storage accessing is two-way interleaved.

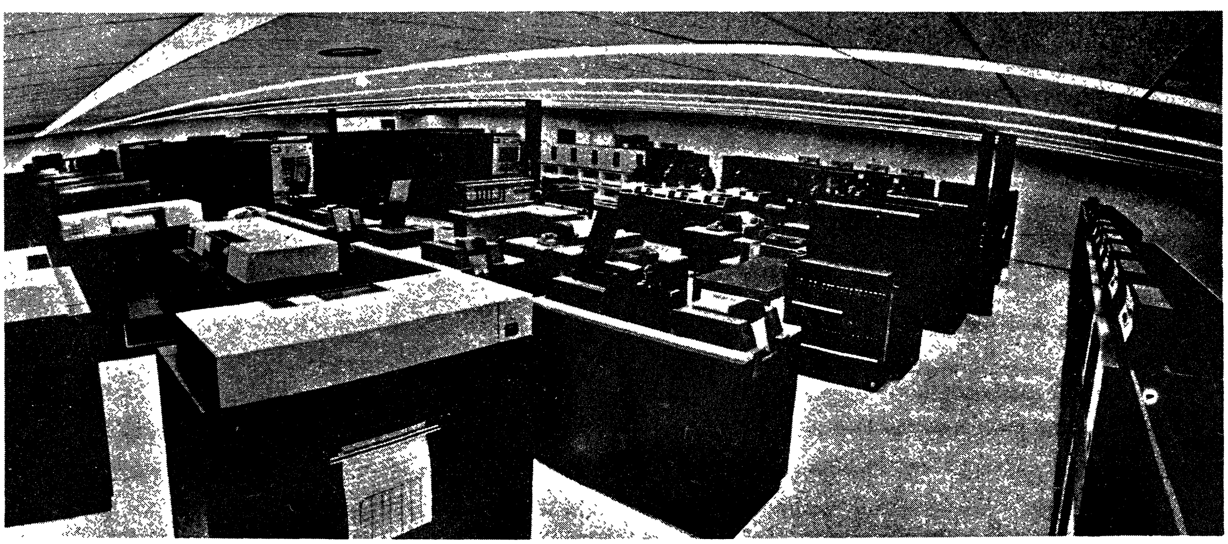

Figure 1. Panoramic view of a large Model 67 time-sharing system, with dual Processing Units in left background.

- Main core storage capacities ranging from 262,144 to 2,097,152 bytes, in independent modules of 262,144 bytes.
- One or two 2067 Processing Units and up to two 2846 Channel Controllers per system.
- Up to seven I/O channels (six Selector and one Multiplexor) per Channel Controller. (In systems that do not use a 2846 Channel Controller, up to six Selector Channels and one Multiplexor Channel can be connected directly to the 2067 Processing Unit.)
- Ability to connect most (but not all) standard System/360 peripheral devices.
- Ability to "partition" the system, by setting manual switches on the 2167 Configuration Unit, to make certain components "unavailable" for use by certain other components.
- Availability of a Compatibility Feature that permits emulation of IBM 709, 7040, 7044, 7090, and 7094 systems.

The standard complement of System/360 software is not usable for time-sharing operations in Model 67 systems, so IBM is providing a specialized software system called the Time-Sharing System (TSS). Release 1 of TSS includes: a time-sharing Supervisor with time-slicing capabilities, a Command Language for communication between the system and its users, a FORTRAN IV compiler, an Assembler, and a number of related service routines. No additional TSS facilities are currently scheduled; IBM withdrew a conversational PL/I compiler, a non-conversational COBOL compiler, a Sort/Merge routine, and other previously-announced TSS facilities in January 1967.

The TSS Supervisor and its associated service routines control the execution of all jobs entering a Model 67 system and the environment in which they operate. Operating in time-slicing fashion, the Supervisor handles the simultaneous execution of conversational-mode programs for multiple users at remote terminals. Meanwhile, programs that do not require user intervention can be executed as non-conversational background tasks.

The TSS Assembler and FORTRAN compiler use source languages which are similar to the Operating System/360 versions of these languages, though there are some differences because of the specialized hardware features and operating environment of the Model 67. Both the Assembler and the FORTRAN compiler can be used in either the conventional batch mode or in a conversational mode. In the conversational mode, the syntax of each source-language statement entered by the user is analyzed and, if necessary, corrected in a conversational interchange between system and user before the assembly or compilation is performed.

The performance of Model 67 systems is difficult to predict accurately. Central processor execution times are somewhat slower (about 12 percent overall) than the Model 65's processor execution times because of the extra time required to transform each virtual operand address into the appropriate physical address before execution in Model 67. Other factors that will tend to degrade the performance of a Model 67 system include the Time-Sharing Monitor's overhead, memory access conflicts, and cable-length delays. It can be assumed that in most cases the maximum potential throughput of multi-processor Model 67 systems will be substantially lower than that of an equal number of Model 65 processors in single-processor configurations. However, where multiple users must be served simultaneously, the overall quality of the computing service provided to these users may well be more important than the maximization of total throughput.

IBM SYSTEM/360 MODEL 67

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	2067-1		Processing Unit (max. of 1)	17,585	711,490	525.00
	2067-2		Processing Unit (max. of 2)	17,795	719,840	545.00
			Processing Unit Options			
		3274	Direct Control (2067-1 only)	258	9,020	3.00
		3800	Extended Direct Control (required on each 2067-2 in a two-processor system)	361	13,680	4.00
		3862	Extended Dynamic Address Translation	3,350	135,410	100.00
		4434	Floating Storage Addressing (2067-1 only)	25	1,100	NC
		5495	Partition Sensing (required on each 2067-2 in a two-processor system)	88	3,515	2.00
		7119	709/7040/7044/7090/7094/7094 II Compatibility	620	24,250	19.00
		7920	1052 Adapter	232	10,545	9.00
		1102	Additional 2846 Attachment (required on 2067-2 in a system with two 2846s)	144	5,840	4.00
			Main Storage			
	2365-2		Processor Storage for 2067-1 Processing Unit (262,144 bytes; max. of 4)	9,530	397,700	575.00
	2365-12		Processor Storage for 2067-2 Processing Unit (262,144 bytes; max. of 8)	9,710	405,965	584.00
			Options for 2365-12			
	8036		2067 Switching Feature (required on each 2365-12 in a two-processor system)	103	4,700	18.00
	8088		2846 Switching Feature (required on each 2365-12)	103	4,700	18.00
	8091		2846 Switching Feature (required, in addition to #8088, on each 2365-12 in a system with two 2846s)	103	4,700	18.00
ATTACH-MENTS, ADAPTERS, AND CHANNELS			Attachments			
	2167		Configuration Unit:			
			Model 1, for systems with up to: 2067-2s, two 2365-12s, two 2846s, and 16 I/O control units	1,340	55,550	92.00
			Model 2, for systems with up to: two 2067-2s, three 2365-12s, two 2846s, and 16 I/O control units	1,340	55,550	92.00
			Model 3, for systems with up to: two 2067-2s, four 2365-12s, two 2846s, and 16 I/O control units	1,340	55,550	92.00
			Model 4, for systems with up to: two 2067-2s, eight 2365-12s, two 2846s, and 32 I/O control units	1,520	63,020	102.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Contd.)			Attachments (Contd.)			
	2846		Channel Controller (max. of 2)	2,010	77,600	117.00
	1086		Additional Addressing I (required on each 2846 in systems with five or more 2365-12s)	93	3,840	2.00
	1087		Additional Addressing II (required on each 2846, in addition to #1086, in systems with seven or eight 2365-12s)	93	3,840	2.00
			Channels			
	2860		Selector Channel —			
			Model 1: one channel	2,165	100,880	55.00
			Model 2: two channels	3,090	143,750	90.00
			Model 3: three channels	4,015	186,720	125.00
	1095		Address Prefixing Feature (required on each Selector Channel in a two-processor system)	41	1,750	2.00
	2870		Multiplexor Channel	2,265	106,700	97.00
			Selector Subchannels for 2870 —			
	6990		First	410	17,940	15.00
	6991		Second	258	10,910	10.00
	6992		Third	258	10,910	10.00
	6993		Fourth	258	10,910	10.00
	1095		Address Prefixing Feature (required on each 2870 in a two-processor system)	118	5,015	3.00
			Two-Channel Switch for:			
		8100	2821 Control Unit	206	10,180	8.00
		8100	2803 Tape Control Unit	103	4,070	4.00
		8100	2403 Tape Control Unit	103	4,070	4.00
		8100	2841 Storage Control	103	4,070	4.00
		8170	2314 Direct Access Storage Facility	144	5,770	2.50
		8170	2820 Storage Control	103	4,710	2.00
		8110	Two-Processor Switch for:			
			2702 Transmission Control	77	3,490	3.50
INPUT-OUTPUT(1)			Console			
	1052-7		Printer-Keyboard (connects to 2067 Processing Unit via either a 7920 Adapter or a 2150 Console)	65	2,725	17.00
	2150		Console	530	24,440	15.00
			Operator Control Panel, First —			
	5475		For 2067-1	36	1,500	NC
	5485		For 2067-2	51	2,140	NC
			Operator Control Panel, Second —			
	5476		For 2067-1	36	1,500	NC
	5486		For 2067-2	51	2,140	NC

NOTES:

(1) For peripheral devices see IBM System/360 Price Data Sheet.

SUMMARY

The System/360 Model 85, announced in January 1968, is the most powerful computer now offered by IBM. Though slower than the "limited-edition" Model 91 (which is no longer being marketed), Model 85 can process data up to three times as fast as Model 75 while maintaining program compatibility with the smaller general-purpose System/360 processors. Rental prices for Model 85 systems will range from about $85,000 to $220,000 per month, and deliveries are scheduled to begin in the third quarter of 1969.

Key elements that contribute to the Model 85's high performance include:

- Up to 4 million bytes of main core storage with a cycle time of 960 or 1040 nanoseconds per 16-byte access.
- An 80-nanosecond buffer memory, ranging from 16,384 to 32,768 bytes in size, that provides fast-access intermediate storage between the processing unit and main storage.
- Overlapped internal operations that enable the Model 85 Processing Unit to fetch, decode, calculate memory addresses, and obtain the operands for several instructions at the same time it is executing an earlier instruction.
- Use of monolithic integrated circuits in conjunction with the hybrid SLT circuits used in earlier System/360 models. Monolithics are used in the 80-nanosecond buffer storage and in arithmetic and logic circuits.

HARDWARE

Model 85 systems are available with four different core storage capacities, as summarized in Table I. Error-checking facilities provide for automatic correction of all single-bit storage errors and detection of all double-bit errors.

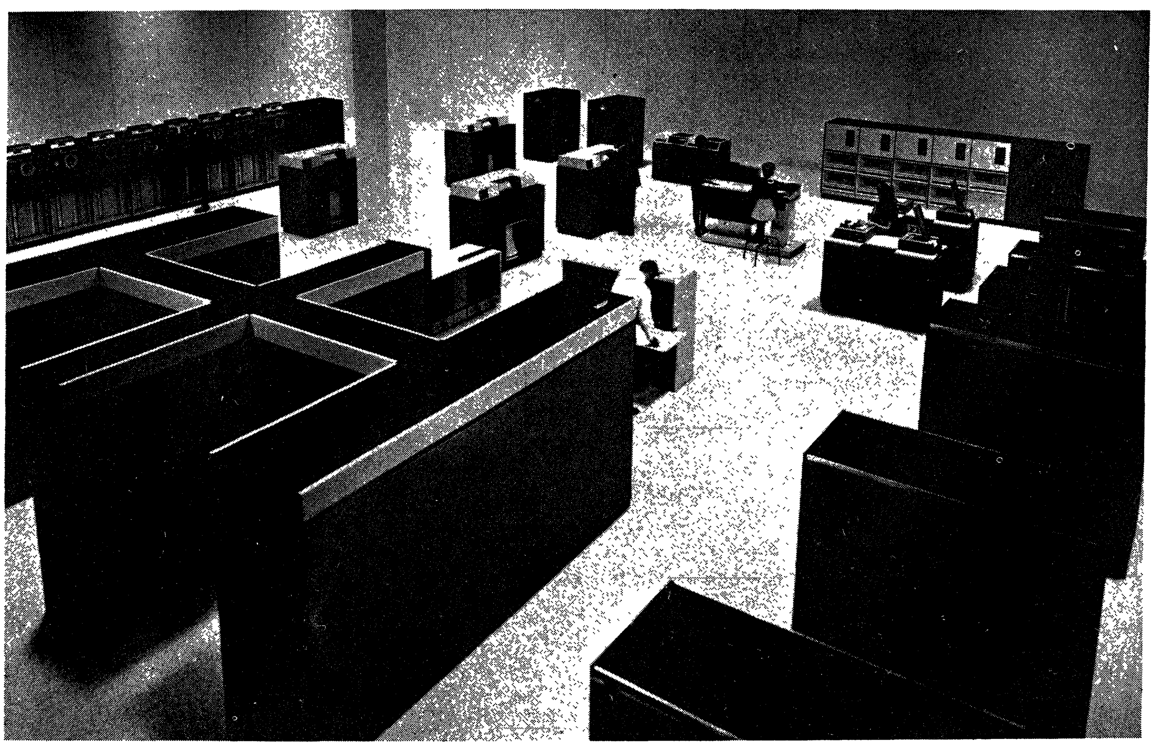

Figure 1: The Model 85 Processing Unit (the double-H-shaped unit at left) has a console with a CRT display and two microfiche viewers, used primarily for maintenance work.

TABLE I: MODEL 85 CORE STORAGE CHARACTERISTICS

Processing Unit Model	I	J	K	L
Storage Capacity, bytes	524,288	1,048,576	2.097,152	4,194,304
Cycle Time, microseconds	1.04	1.04	0.96	0.96
Bytes Accessed per Cycle	16	16	16	16
Storage Interleaving	2-way	4-way	4-way	4-way

HARDWARE (Contd.)

Though the Model 85 Processing Unit is program-compatible with the other general-purpose System/360 models, the implementation of many processor functions is significantly different in the Model 85. Principal functional components of the Model 85 Processing Unit include an instruction unit, an execution unit, local storage, a storage control unit, buffer storage, and control storage.

The instruction unit can concurrently prepare several instructions for execution. Using multiple registers, it handles the fetching and decoding of instructions, calculation of addresses, fetching of required operands, and issuance of instructions to the execution unit.

The execution unit performs arithmetic and logical operations in a 64-bit parallel adder, an 8-bit serial adder, a 32-bit logical unit, and a 64-bit shifter. Controlled primarily by microprograms, the execution unit processes one instruction at a time, in program sequence.

Local storage contains the standard System/360 complement of 16 four-byte general registers and 4 eight-byte floating-point registers. These registers are used by both the instruction unit and the execution unit, and they are designed to permit data to be fetched from four general registers and stored into a fifth during a single 80-nanosecond machine cycle.

The storage control unit interfaces and controls all data transfers between main core storage and the processing unit, buffer storage, and I/O channels.

Buffer storage has a standard capacity of 16,384 bytes, which can optionally be expanded to 24,576 or 32,768 bytes. It is used to hold the currently-active portions of main storage for rapid reference, thereby greatly reducing the effective storage access time in most applications. From the programmer's viewpoint, the buffer storage is completely "transparent"; its operations are carried out automatically, and the programmer cannot address it directly.

Both main and buffer storage are partitioned into 1024-byte pages, and each page is subdivided into 16 blocks of 64 bytes each. For each fetch operation, the buffer storage control determines whether there is a page in buffer storage that corresponds with the addressed page in main storage. If so, the data is fetched from buffer storage. If not, the data is fetched from main storage, and one of the buffer pages is automatically assigned to hold the addressed main storage page so that subsequent references to the same page can be handled efficiently. Store operations cause both main and buffer storage to be updated at the same time.

To minimize processor delays when a new buffer page is assigned, the particular 64-byte block that was referenced by the fetch operation is always the first block loaded into buffer storage. Subsequently, as fetch operations referencing other blocks in the same page are encountered, those blocks are also loaded into the appropriate buffer storage locations.

The Model 85 Processing Unit automatically keeps track of the last time each page in buffer storage was referenced. Whenever a new page is loaded into buffer storage, it replaces the page that has gone unused for the longest period of time. As a result of this technique, IBM estimates that the required operands will be present in buffer storage for about 95 per cent of all fetch operations in typical programs.

Control storage holds the microprograms that control most operations of the Model 85 Processing Unit. It consists of approximately 2000 control-word locations of read-only storage (ROS) and 500 locations of writable control storage (WCS), each with an 80-nanosecond cycle time.

The Model 85 Processing Unit provides all the facilities of the System/360 Universal Instruction Set, including the Store and Fetch Protection, Direct Control, and Interval Timer features. Other standard features — unique to the Model 85 — are extended-precision floating-point arithmetic, which uses 16-byte operands and offers 112-bit precision, and a byte-oriented operand feature, which enables programmers to ignore many of the boundary constraints that normally complicate System/360 programming (though extensive use of the feature leads to a significant reduction in execution speed). Also standard is an instruction retry capability; when the processor detects an error during the execution of an instruction, it will in many cases automatically retry the instruction.

Optional features available for the Model 85 include: (1) Buffer Expansion, which extends the capacity of buffer storage from 16K to either 24K or 32K bytes; (2) High-Speed Multiply, which enables fixed-point and long-format floating-point multiply instructions to be executed in less

(Contd.)

HARDWARE (Contd.)

than 450 and 600 nanoseconds, respectively; and (3) 709/7040/7044/7090/7094/7094 II Compatibility, which enables a Model 85 system to emulate the operations of the indicated second-generation IBM computer systems. IBM expects the internal performance of a Model 85 in the emulation mode to be up to twice that of a 7094 II.

A system control console on the Model 85 Processing Unit provides, in addition to a typical complement of switches and lights, a CRT display and two microfiche viewers. The CRT is used to display the contents of data and address registers, while the microfiche viewers are used mainly to facilitate system maintenance. Various optional features and peripheral units can be added to provide extended or duplicate console I/O facilities.

The Model 85 requires a supply of chilled water, for system cooling, and a 400-cycle motor-generator set, which can be located in a separate room.

I/O devices are connected to a Model 85 system via Multiplexor or Selector Channels. One Multiplexor Channel and/or up to six Selector Channels can be used in a Model 85 system — the same maximum channel complement as in the slower Model 65 and 75 systems. Each of the 2860 Selector Channels has 8 control unit positions and can control one I/O operation at a time, at a data rate of up to 1,300,000 bytes per second. The 2870 Multiplexor Channel has 192 subchannels and can handle overlapped I/O operations with an aggregate data rate of up to 110,000 bytes per second. The 2870 can optionally be equipped with up to four Selector Subchannels, each capable of handling one I/O operation at a time.

Most of the I/O and mass storage units in the System/360 line can be used in a Model 85 system, though magnetic character readers, optical readers, and the low-speed 2415 Magnetic Tape Unit cannot be connected. Devices that can be connected only to a Selector Channel include 2301 and 2303 Drum Storage, 2311 Disk Storage, 2314 Direct Access Storage, and the high-performance 2420 Magnetic Tape Unit. The Multiplexor Channel is required for connection of a 2702 or 2703 Transmission Control or a 7770 or 7772 Audio Response Unit.

SOFTWARE

The Model 85 maintains program compatibility with the smaller general-purpose System/360 processing units even though the manner in which many of the processor functions are implemented is significantly different in the Model 85. As a result, Model 85 systems can take full advantage of the software already developed for the other System/360 models.

Most Model 85 installations are expected to operate in a multiprogramming mode and to utilize the MVT (Multiprogramming with a Variable number of Tasks) version of the Operating System/360. The other versions of OS/360 — MFT (multiprogramming with a Fixed number of Tasks) and PCP (Primary Control Program) — can also be used.

Additional software support to be provided specifically for the Model 85 includes:

- Support of the extended-precision floating-point feature in OS/360 Assembler F.
- Support of the Operator's Console feature under OS/360.
- The Recovery Management Program (RMP), an optional extension of the MVT and MFT versions of OS/360 that will support the extensive error-checking and diagnostic facilities of the Model 85 hardware.

PRICE DATA

Please refer to the general System/360 Price Data section, beginning on page 420:221.101, for prices of the 2085 Processing Unit and the optional features, channels, and I/O units that can be used with it.

SUMMARY

The IBM System/360 Model 25, announced in January 1968, is intermediate in price and performance between the earlier Models 20 and 30. Rental prices for typical Model 25 systems will range from approximately \$3, 500 (for a small card system) to \$10, 000 (for a disk/tape system) per month, and deliveries will begin in January 1969.

Unlike the smaller Model 20, the Model 25 is program-compatible with the larger general-purpose System/360 processors and can use most of the standard System/360 software. Moreover, the Model 25 can be equipped with compatibility features that enable it to execute most programs written for IBM 1401, 1440, or 1460 systems. Instruction execution speeds of the Model 25 Processing Unit are approximately five to ten times as fast as the Model 20 and one-third to two-thirds as fast as the Model 30, depending upon the type of program.

Thus, the Model 25 is much more closely related to the Model 30 than to the Model 20; it can reasonably be characterized as an updated version of the Model 30 that has been modestly reduced in both price and performance. Some restrictions on Model 25 configurations, however, will force users who need fast magnetic tape units or large-capacity mass storage to move up to the more expensive Model 30.

HARDWARE

The Model 25 Processing Unit, unlike other System/360 models, has a core storage unit that is divided into three distinct areas called program storage, control storage, and auxiliary storage.

- Program storage corresponds to the main storage in other System/360 models and holds the instructions and data for all programs written by users. Processing units with the following program storage capacities are available:

  Model D — 16, 384 bytes
  Model DC — 24, 576 bytes
  Model E — 32, 768 bytes
  Model ED — 49, 152 bytes.

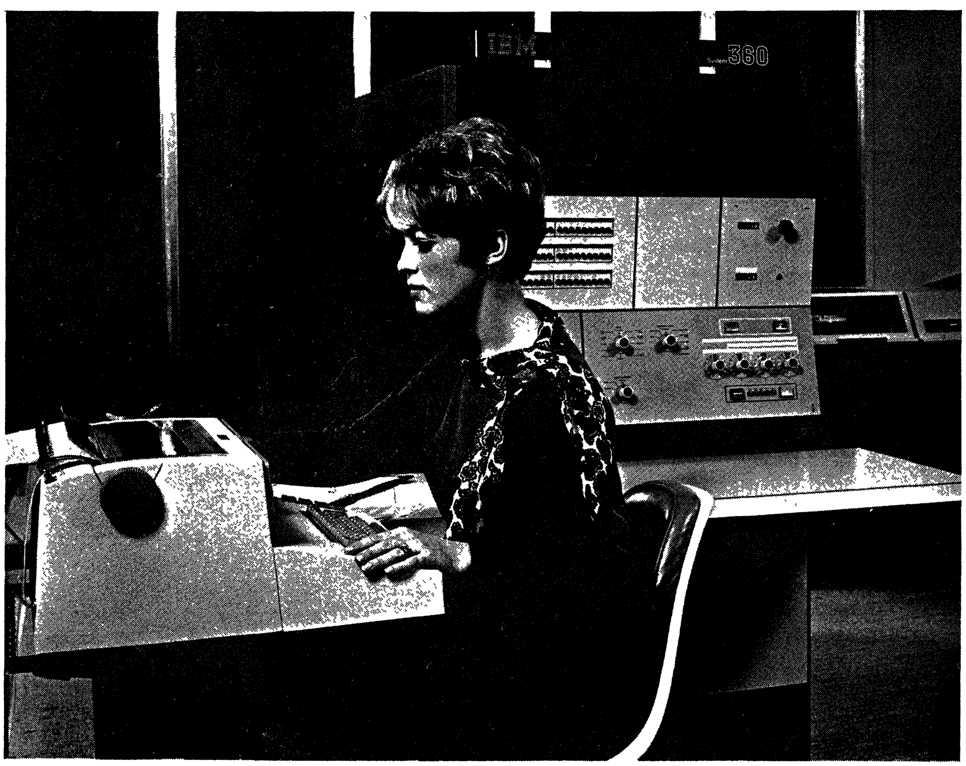

Figure 1. The Model 25 Processing Unit Features a Simplified Control Panel and Uses the 1052 Printer-Keyboard (Left) for Many Console I/O Functions.

HARDWARE (Contd.)

- Control storage holds the microprograms which interpret the instructions and control all system functions in a Model 25. This 16,384-byte area is reserved for the control programs and may not be directly accessed by users' routines. The control storage area is reloadable, and a different control program must be loaded to switch from the normal System/360 mode of operation to the 1400 Series compatibility mode.

- Auxiliary storage holds the 16 general registers, the 4 floating-point registers, I/O control words, and temporary work areas for various processor functions. Its capacity ranges from 2,048 to 4,096 bytes, depending upon the processor model.

The cycle time for all three areas of core storage is 900 nanoseconds, but two cycles (1.8 microseconds) are required to read or write either a byte or a halfword (two bytes) in either program or auxiliary storage. The first cycle of each pair obtains information needed to control the data-access cycle that follows. In processing the microprogram steps in control storage, however, only one 900-nanosecond cycle is required to read out each 2-byte control word.

The Model 25 Processing Unit also contains 64 bytes of "local storage," a 180-nanosecond, monolithic-circuit, "scratchpad" memory unit. Local storage holds the data being operated on by the current microprogram step, as well as addresses and other information required for internal processing and I/O operations.

Fixed-point binary and decimal arithmetic instructions (i.e., the System/360 Standard and Commercial Instruction Sets) are standard features of the Model 25. The instruction set can be extended through inclusion of the optional Floating-Point Arithmetic, Direct Control, and Storage Protection features. Other available options include the Interval Timer, External Interrupt, Emergency Power-Off Control, and 1400 Series Compatibility.

When operating in the 1400 Series compatibility mode, a Model 25 Processing Unit will execute a typical mix of commercial instructions somewhat faster than the original 1401 or 1440 system. Overall job performance will naturally vary with the type of program and the complement of I/O devices used. A 16K Model 25 system equipped with appropriate I/O devices and optional features can emulate a 1401, 1440, or 1460 system with up to 16,000 storage positions (the maximum 1400 Series storage capacity), all standard instructions, most optional features, and the following I/O devices:

1402 or 1442 Card Read-Punch
1403 or 1443 Printer
1407 or 1447 Console Inquiry Station
1311 Disk Storage Drives
729, 7330, or 7335 Magnetic Tape Units.

Error-detection circuits in the Model 25 Processing Unit check the validity of core storage addresses, the parity of data transferred within the processor and to and from I/O devices, and other possible malfunctions. The microprograms include error recovery routines which attempt to overcome the error condition when possible.

A vertical control panel on the front of the processing unit contains the switches, keys, and lights needed to operate a Model 25 system. A 1052 Model 7 Printer-Keyboard, connected via an Integrated 1052 Attachment Feature, is required for console I/O use. Many functions that were keyed in by separate buttons in earlier System/360 consoles are entered through the keyboard in the Model 25.

Among the most distinctive aspects of the Model 25 are its system configuration capabilities and limitations. Any or all of the following I/O units can be connected directly to a Model 25 Processing Unit — without their usual control units or channels — via the appropriate Integrated Attachment Features:

- One 1403 Printer, Model 2 (600 lpm, 132 print positions) or Model 7 (600 lpm, 120 print positions).
- One 2540 Card Read-Punch (reads 1000 cpm, punches 300 cpm).
- Up to four 2311 Model 1 Disk Storage Drives (7.25 million bytes each).

Other I/O devices can be connected to a Model 25 system via either an optional Multiplexor Channel or Selector Channel, only one of which may be used in a system. Both types of channels have 8 control unit positions, and the Multiplexor Channel has 32 subchannels. Most System/360 I/O units can be used on either type of channel, but there are some significant restrictions:

- Magnetic tape units can only be connected to the Selector Channel.
- The 1259 and 1412 Magnetic Character Readers, 2702 and 2703 Transmission Controls, and 7770 and 7772 Audio Response Units can only be connected to the Multiplexor Channel.
- No mass storage units other than the 2311 Disk Drives can be used in a Model 25 system.

(Contd.)

HARDWARE (Contd.)

- Although the "integrated" 2311 Disk Drives have a data transfer rate of 156,000 bytes per second, no other I/O unit with a data rate exceeding 30,000 bytes per second can be used in a Model 25 system.

The "integrated" 1403 Printer, 2540 Card Read-Punch, and 1052 Printer-Keyboard are programmed and controlled as if they were connected to the Multiplexor Channel, though they do not require the presence of this channel. Similarly, the 2311 Disk Drives are programmed and controlled as if they were connected to the Selector Channel, though they do not require its presence.

I/O operations on the various subchannels of the Multiplexor Channel can be overlapped with one another, with operations of the "integrated" I/O devices, and with internal processing — though there are aggregate data rate limitations which restrict the number of devices that can operate simultaneously. The Selector Channel can control only one I/O operation at a time, but internal processing and operations of the "integrated" I/O devices other than 2311 Disk Drives can be overlapped with a Selector Channel operation.

SOFTWARE

The Model 25 maintains program compatibility with the larger general-purpose System/360 processing units even though the manner in which many of the processor functions are implemented is significantly different in the Model 25. As a result, Model 25 systems can make use of most of the software developed for the larger System/360 models.

Model 25 systems with adequate core storage capacities and I/O equipment will be able to use the extensive software facilities that IBM provides within the Disk Operating System (DOS), Tape Operating System (TOS), Basic Operating System (BOS), and Basic Programming Support (BPS). For a list of these facilities, see Table V in the System/360 Summary, Section 420:011. Because of the 49K-byte maximum storage capacity, it will not be practical for Model 25 systems to use the large-scale Operating System/360 software.

PRICE DATA

Please refer to the general System/360 Price Data section, beginning on page 420:221.101, for prices of the 2025 Processing Unit and the optional features and I/O units that can be used with it.

SUMMARY

The Model 44 is a special-purpose scientific data processing system that was officially added to the IBM System/360 family in August 1965. The Model 44 brings to the System/360 line a computer that has been custom-tailored for performing high-speed binary arithmetic operations in scientifically-oriented applications. Capabilities are included in the Model 44 that permit its use in process control, data acquisition, and real-time operations. IBM advertises that the System/360 Model 44 offers the internal speed of the IBM 7094 at substantially less cost.

A basic Model 44 system with card read-punch and printer rents for $5,330 per month, but typical system rentals will be in the $7,000 to $11,000 range. A Model 44 processor can perform internal computations faster than a System/360 Model 50 processor, and has a monthly rental that is less than half that of the Model 50. First deliveries of the Model 44 occurred during the third quarter of 1966.

The Model 44 uses the same basic data and instruction format as the System/360 Models 30 through 75. The 32-bit (4-byte) binary word is the basic unit of internal data manipulation. The standard Model 44 instruction repertoire is a compatible subset of the full System/360 repertoire, though certain optional features add instructions which are unique to the Model 44. There are no instructions for performing decimal arithmetic, editing, code translation, or radix conversion operations. Floating-point arithmetic can be provided, but only as an optional feature — though it will certainly be included in most Model 44 installations. Extensive interrupt facilities are also available, but only as optional features. The Commercial Feature, announced in March 1968, promises compatibility with other System/360 models through trapping and emulation of the instructions which are not included in Model 44's standard repertoire.

The Model 44 Processor can contain 32,768, 65,536, 131,072, or 262,144 bytes (8K to 64K 32-bit words) of core storage that is addressable to the individual byte. Core storage cycle time is 1 microsecond per 4-byte word. The 16 general-purpose registers are normally implemented in an extension of the 1-microsecond core storage. However, if the optional High-Speed General Registers feature is installed, the standard registers are replaced by 16 registers implemented in "solid logic technology" circuitry that has a cycle time of 250 nanoseconds per word. Use of this feature substantially reduces the address generation time of all instructions and the basic execution time of all fixed-point instructions.

Included in the Model 44 Processor as standard features are a console printer-keyboard and a single-disk storage drive housed in the processor cabinet. The disk drive uses a replaceable single-disk IBM 2315 Disk Cartridge that can store up to 1,171,200 bytes of data.

Figure 1. The Model 44 Processor, designed for scientific applications, features an integrated disk storage drive that uses interchangeable single-disk cartridges.

The drive has an average random access time of 70 milliseconds. A second single-disk storage drive can be installed as an optional feature, doubling the on-line storage capacity. Seek overlap is possible when both drives are installed, but simultaneous reading and writing cannot be performed by the two drives. The primary function of the Model 44's built-in single-disk storage drive is to provide residence for the system's software support.

The Model 44 Processor is optimized to perform high-speed fixed- and floating-point binary arithmetic. Fixed-point arithmetic uses the 32-bit binary word (1 sign and 31 integer bits) as its basic operand. Fixed-point binary half-word operations can also be performed. When the optional high-speed general registers are installed, the basic fixed-point arithmetic instruction execution times can be reduced by more than 50 percent. For example, the basic register-to-register add time is 3.75 microseconds; the same operation performed with the high-speed registers takes only 1.75 microseconds.

The optional Floating-Point Arithmetic feature provides single-length (24-bit precision) and double-length (56-bit precision) arithmetic and comparison operations. Use of the 16 high-speed general registers will reduce by 0.75 microsecond the instruction execution time of each floating-point instruction that references core storage. When the full 56-bit precision is not required in specific problems, use of a rotary switch on the processor's control panel can adjust the precision of the floating-point fraction down to 48, 40, or 32 bits. Each progressively lower setting considerably reduces the time required to execute all double-length floating-point instructions. The 56-bit fraction length must be used if programs are expected to be run on other System/360 models and produce identical results.

Peripheral devices are connected to a Model 44 system by means of either a standard Multiplexor Channel and/or one or two High-Speed Multiplexor Channels. These channels share many of the functional characteristics of similarly-designated I/O channels used with the System/360 Models 30 through 75. The standard Multiplexor Channel provides up to 64 subchannels, and each of the High-Speed Multiplexor Channels provides up to 4 subchannels, setting the theoretical limit of simultaneous input-output data transfer operations at 72. Selector Channels are not available for Model 44 systems, but the High-Speed Multiplexor Channels can provide equivalent capabilities.

Most of the standard System/360 peripheral devices can be connected to a Model 44 system, subject in most cases to the general configuration rules of the System/360 computer family. One important difference in configuration possibilities lies in the fact that the Model 44 permits only the IBM 2311 Model 1 Disk Storage Drive — in addition to the built-in Single Disk Storage Drive — for use as auxiliary, random-access storage. Other System/360 models can use up to seven different random-access storage devices, offering a wide range of storage capacities and access times. The Model 44 cannot use the high-performance 2420 Magnetic Tape Unit or 7340 Hypertape Drive, but it can use both the 800 and 1,600 bpi models of the IBM 2401 Magnetic Tape Units. Display devices (Models 2250 and 2260) and data communications devices (2701 and 2702 Transmission Control Units) can also be connected to a Model 44 system, but no provisions have been included for use of System/360 optical readers, MICR readers, or audio response units.

The peripheral device flexibility of the Model 44 is increased by its capability to be connected to an IBM 1800 Data Acquisition and Control System via the standard I/O channels. The IBM 1800 brings to the Model 44 the specialized facilities required to perform process control and high-speed data acquisition tasks. An optional Direct Data Channel feature in the Model 44 system permits exchange of data with an external device or system — such as the IBM 1800 — at speeds up to 4,000,000 bytes per second.

Because of its restricted instruction repertoire, and because of its specialized built-in disk drive, the Model 44 uses a custom-designed software package — integrated through use of the system disk — that is generally not compatible with the extensive array of standard System/360 software. Designated the Model 44 Programming System, the software centers around a Supervisor program that controls the sequential execution of batched jobs in a non-multiprogramming environment. Input-output device control routines are also included within the Supervisor. A disk-resident USA Standard FORTRAN compiler with extensive capabilities, an assembler, and an array of disk-resident utility routines are also provided. The FORTRAN language is fully compatible with the FORTRAN H-level language used with the IBM Operating System/360; the Model 44 assembly language is a generally compatible subset of the assembly language used with the Operating System/360.

The Model 44 Programming System, released in June 1967, can be used by any Model 44 system that includes at least 65,536 bytes of core storage, one Multiplexor Channel, one card reader, card punch, and line printer, and the standard Single Disk Storage Drive.

Users of Model 44 systems with only 32,768 bytes of core storage can use the restricted software of the Model 44 Basic Programming Support (BPS). The BPS package is basically card- and tape-oriented and includes a USA Standard Basic FORTRAN compiler, a basic assembler, a group of input-output subroutines, and a set of basic utility programs. Released in October 1966, the BPS software does not utilize the Model 44's Single Disk Storage Drive and is far less efficient than the integrated Model 44 Programming System described above.

IBM SYSTEM/360 MODEL 44

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	2044		Processing Unit (includes core storage):			
			Model E - 32,768 bytes	3,570	119,890	200.00
			Model F - 65,536 bytes	4,805	174,310	220.00
			Model G - 131,072 bytes	6,455	249,970	250.00
			Model H - 262,144 bytes	10,370	428,450	350.00
			Processing Unit Standard Features:			
			Single Disk Storage Drive (1,171,200 bytes)	-	-	-
			Console Printer-Keyboard	-	-	-
			Processing Unit Optional Features:			
	3895		External Interrupt.	31	1,220	1.00
	4427		Floating Point Arithmetic	283	11,200	11.00
	4583		High-Speed General Registers	720	28,520	28.00
	5248		Multiplexor Channel	360	14,240	17.75
	4598		High-Speed Multiplexor Channel (first)	670	26,480	29.25
			Additional High-Speed Multiplexor Subchannels:			
	4560		First	129	5,090	6.00
	4561		Second	129	5,090	6.00
	4562		Third	129	5,090	6.00
	4599		High-Speed Multiplexor Channel (second)	370	14,650	18.00
			Additional High-Speed Multiplexor Subchannels:			
	4565		First	129	5,090	6.00
	4566		Second	129	5,090	6.00
	4567		Third	129	5,090	6.00
	3275		Direct Data Channel	825	32,590	30.00
	3288		Direct Word	283	11,200	3.00
	3621		Emergency Power-Off Control	NC	NC	NC
	4555		High Resolution Interval Timer	103	4,070	2.00
	9509		Pin Feed Platen	NC	NC	NC
	5625		Priority Interrupt	410	16,300	10.00
	8501		Commercial Feature	620	19,590	?
			Store and Fetch Protection, for:			
	7531		Model E	232	9,170	4.00
	7531,7532		Model F	283	11,210	4.75
	7531-7533		Model G	334	13,250	5.50
	7531-7534		Model H	411	16,310	7.00
	2251		Console Printer-Keyboard Multiplexor Channel Attachment	NC	NC	NC
	2252		Console Printer-Keyboard High-Speed Multiplexor Channel Attachment	NC	NC	NC
	7500		Single Disk Storage Drive Multiplexor Channel Attachment	NC	NC	NC
	7501		Single Disk Storage Drive High-Speed Multiplexor Channel Attachment	NC	NC	NC
	6415		Second Single Disk Storage Drive	237	9,485	40.00
	2315		Disk Cartridge	-	90	-

NOTES:

(1) For peripheral devices, see System/360 Price Data Sheet.

IBM SYSTEM/3

.1 SUMMARY

The IBM System/3 announced on July 30, 1969, represents IBM's serious entry into the small-scale business-oriented computer market. The new system is designed to accommodate the needs of first-time, computer users who more than likely are currently operating with an EAM installation. The System/3 is not directed at the replacement market, nor is it intended as a terminal system. Large companies wishing to decentralize their peripheral operations represent another prospective market.

The System/3 is offered in two basic Configurations; a card system starting at a monthly rental of $945, and a disk system for $1,345 per month. A full complement of peripheral devices are offered; on-line equipment including a multi-function card unit, a printer and keyboard-printer attachment, and a keyboard-entry station; off-line equipment including a data recorder and a card sorter.

Of greatest interest to the industry at this time is the introduction of the new System/3 punched card. The card is approximately one-third the size of the old standard 80-column card, holds 20 percent more information (96 characters), uses 6-bit BCD codes rather than the standard Hollerith code, and provides four lines of engraved printing at the top of the card. The new card lessens the space requirements for off-line storage and permits more compact card handling equipment.

The System/3 is relatively fast-operates at a cycle time of 1.52 microseconds. A good example of its processing speed may be made by comparing the ability of the System/3 to add two five decimal digits in 31.9 microseconds as opposed to the same operation performed on an IBM System/360 Model 40 in 39 microseconds.

IBM offers an optional Application Customizer Service to support the System/3 user. The user defines his application specifications on a questionnaire, and then IBM prepares at one of its Basic System Centers a tailored application package of sample reports, flowcharts, cross-listings, record layouts, etc., which enables the user to proceed to program with a fully-defined application analysis.

Extensive software support includes a new RPG II language, a disk assembler, and an assortment of card and disk, sort and utility routines. All of these programs operate under a system control program with executive and job control facilities.

In addition, IBM offers system engineering support for assistance in the preparation of the user programs. System/3 customer training courses are also available. All of the above-mentioned support (SE services, education, software except for the control program, and the application customizer service) is separately priced. The program products are licensed to a specific CPU number and may not be used with any other system.

Likely competition for the System/3 will fall in the range of small-scale systems including the UNIVAC 9200, the NCR Century Series 100, the GE 100 Series, and the Honeywell 110.

The first delivery of the System/3 card configuration is scheduled for January, 1970, and the expected first installation of a System/3 disk configuration will be in September, 1970. IBM anticipates a period of no more than six months for delivery after the receipt of an order.

This report was prepared immediately after the public announcement of the System/3. It will be refined and enhanced in a subsequent issue.

.2 HARDWARE

.21 Data Structure

The basic unit of data storage in the System/3 is the eight-bit (plus one parity bit) byte. This data structure is common in many competitive systems following the lead of the IBM System/360. A byte can represent one alphanumeric character or a portion of a binary field.

Bytes can be addressed and manipulated individually, or consecutive memory locations can be grouped to form variable length binary fields up to 256 bytes in length. The internal code is EBCDIC (Extended Binary Coded Decimal Interchange Code). Data may be conveniently represented by hexidecimal notation. Decimal data consists of one digit per byte. The zone portion of the byte or the leftmost four bits contains the sign of the field when the byte is located in the units position of the field. Decimal operations are performed on fields of up to 16 digits in length with the resultant field up to 31 digits long.

Instructions are either 3, 4, 5, or 6 bytes long and specifiy one or two memory addresses.

.22 System/3 Punched Card

The System/3 punched card represents the most important innovation introduced with the new system. It is approximately one-third the size of the standard 80-column hollerith code card. The new card features 96 characters of punched data (20 per cent more data storage) arranged in three tiers of 32 columns each of round-holed 6-bit BCD character codes. The card measures 2 3/4 by 1 1/4 inches. Four lines of engraved printing at the top of the card interpret the BCD code content.

Besides the advantage of more unit record storage and interpreting, the new card requires less off-line storage space, is easier to handle by operations, and allows a more compact card handling device (the Multi-Function Card Unit). In addition, processing is enhanced by lessening the hardware overhead conversion to internal processor codes. That is, BCD to EBCDIC code conversion is faster and easier to accomplish than hollerith to EBCDIC.

.231 System/3 Card System; Configuration I

Equipment	Rental
1- 5410 Processor with 8,192 bytes of memory	$310
1- 5424 Multi-function Card Unit, Model 2: reads 500 cpm, punches 120 cpm, prints 120 lpm.	405
1- 5203 Printer, Model 2; 200 lpm	280
1- 5496 Data Recorder; punches 60 cols, per sec.	155
1- 5486 Card Sorter; 1,000 cpm	85
1- 5701RGI RPG II Compiler: Card System	35
1- 5701 UTI Card Sort and Utilities	10
Total Rental:	$1,280

.232 System/3 5-Million-Byte Random Access System; Configuration III R

Equipment	Rental
1- 5410 Processor with 12,288 bytes of memory	$535
1- 5424 Multi-Function Card Unit; Model 2: reads 500 cpm, punches 120 cpm, prints 120 lpm	405
1- 5203 Printer, Model 2; 200 lpm	280
1- 5444 Disk Storage Drive; Model 2: 4.9 million characters	255
1- 5702 RGI II Compiler: Disk System	45
1- 5702 SMI Disk Sort	10
1- 5702 UTI Disk Utilities	10
Total Rental:	$1,540

.24 Internal Storage

.241 Core Memory

Working Storage for the System/3 is provided by magnetic core memory. The processor can access one 8-bit byte per cycle of 1.52 microseconds. A system/3 configuration can have any of the following capacities: 8,192; 12,288; 16,384; 24,396; or 32,768 bytes.

Each memory location is individually addressable and can hold one byte, consisting of eight bits plus a parity bit. Each byte can represent one alphanumeric character or an 8-bit portion of a binary field.

A parity bit is generated wherever a byte is stored and checked for validity when the byte is read. A check is also made for memory addresses larger than the physical memory size. All of the core storage is available for user programs or system software. No hardware protected or dedicated areas are locked out.

.242 Disk Unit

The 5444 Disk Storage comprises both removable and non-removable storage. The unit is an integral part of the standard disk configuration and may not be acquired separate and apart from the package configuration. Two disk units can be on-line, both of which are housed in a compact compartment located directly below the 5424 Multi-Function Card Unit. In a non-disk configuration, drawer space is provided in its place.

Three Models of the 5444 Unit offer storage capacities ranging up to 4.9 million bytes or 9.8 million packed decimal digits. Data stored in packed-decimal form (two 4-bit BCD digits per byte) are transferred to and from main memory intact and RPG II subroutines are available to process this data organization due to the absence of standard decimal arithmetic operations.

The 5440 Disk Cartridge, unlike most of the other recently-announced disk packs, is not compatible with the IBM 2316 Disc Pack. The 5440 consist of one 14-inch disc platter with two metallic recording surfaces, both of which are used for storage.

.242 Disk Unit (Contd.)

Each 5444 Disk Storage Unit has a standard non-removable pack offered without charge: the user must purchase the removable storage. Model I provides 100 cylinders of removable storage and 100 cylinders of non-removable storage (2 tracks per cylinder) with a storage capacity of 2.45 million bytes or 4.9 million packed-decimal digits. Model 2 provides twice the storage, with 200 cylinders each of removable and non-removable storage and a capacity of 4.9 million bytes or 9.8 million packed-decimal digits. Model 3 makes available the same storage as Model I, concentrating all the data on the removable storage.

The System/3 disk configuration incorporates the I/O control for the 5444 within the processor, thereby avoiding a separate disk controller. Data is transferred at a rate of 199,000 bytes per second. Access time ranges from 39 to 395 milliseconds averaging 153 milliseconds for the Model I, and 39 to 750 milliseconds for Models 2 and 3. The disks rotate at a speed of 1,500 RPM.

A one-disk-drive configuration can include either Model 1 or Model 2: a two-disk-drive configuration combines either Model 2 and Model 3, or two Model 2's. Consequently, the maximum disk storage on-line is 9.8 million bytes or 19.6 million packed-decimal digits.

Parity checking is performed for each byte during read and write operations. All detected error conditions are handled by the RPG software.

.25 Central Processor

The design of the System/3 processor is conventional in its organization with the exception that the control of the standard I/O devices (Multi-Function Card Unit, Printer, and Disc Storage Device in a disc configuration) is incorporated into the processor hardware. In addition to the I/O device control unit, the processor consists of three basic units:

- An arithmetic/logic unit (ALU) which contains the circuitry for computations and logical decisions.
- A CPU I/O control unit which supervises the transfer of data between the peripheral equipment and main memory.
- A magnetic core memory unit, as described in Paragraph .231, Core Memory.

.251 Processing

There are three types of instruction formats which are represented as follows:

Command format	OP	Q	B	
One-address formats	OP	Q	B	
	OP	Q	B	
Two-address formats	OP	Q	B	A
	OP	Q	B	A
	OP	Q	B	A
	OP	Q	B	A

Where OP =1-byte operation code; indicating the addressing mode of both operands and the type of operation to be performed

Q = 1-byte utility byte; indicating explicit lengths of one or more of the operands, immediate data, a bit mask, register address, branching conditions, etc.; and in I/O commands, specifies device involved.

A, B = 1 or 2-byte address operands.

There are two methods of addressing: direct and indexing. Direct addressing involves a two-byte instruction address field in which the real address is extracted directly from the instruction and loaded into the address register. Indexing takes place with a one byte address field. The OP code incorporates the indicators that specifies whether or not indexing is to take place, and which one of the two index registers are to be used.

The instruction repertoire consists of 28 separate instructions providing arithmetic, logical, and device command capabilities. Because data may be stored on disk in packed-decimal format (two 4-bit BCD characters per byte), pack and unpack routines are provided in the RPG software to process the packed-decimal operations.

.26 Input-Output Equipment

The IBM System/3 offers a broad range of peripheral devices to accomplish the needs of card-and disk-oriented systems. No magnetic tape or paper tape devices are offered. The card-handling device and printer are integral parts of the basic hardware configurations. Up to two disk units can be incorporated in the disk configuration. These three devices cannot be acquired separately, nor can additional units be attached. The logical control for all of the System/3 devices is in the processor.

.261 Card Equipment

The 5224 Multi-Function Card Unit covers the entire gamut of card handling operations including reading, punching, interpreting, sorting and collating. Two models are offered: Model A1 reads 250 cards per minute, punches 60 cards per minute, and prints at a speed of 60 lines per minute; Model A2 operates at double these reading, punching, and printing speeds.

The 5224 provides four 2,000-card stackers. Other features include a photoelectric read, punch verify controls, error checking and engraved printing (raised characters).

.262 Printer

The 5203 Printer is available in two Models: Model I prints 100 lines per minute and Model 2, twice the speed or 200 lines per minute. The standard print line contains 96 columns, which can optionally be expanded to 108, 120, or 132 columns. A universal character set of 64 characters can also optionally replace the standard 48 character set.

There is no paper tape loop control and all paper advance including spacing, skipping and page eject is under program control. The 5203 is also capable of optionally printing two forms simultaneously.

The 5741 Printer-Keyboard functions both as an inquiry device and as a second printer. Inquiry statements may be keyed directly into core storage. Printing takes place under program control at a speed of 15.45 characters per second on a 12 1/2 inch writing line with a density of 10 characters per inch.

.263 On-Line Data Recording Equipment

The 5475 Data-Entry Keyboard provides on-line data recording and verification. It functions in a manner similar to the off-line 5496 Data Recorder with the exception that it operates under the processor I/O control.

.264 Off-Line Equipment

The 5496 Data Recorder operates off-line and is, in effect, a combination key-punch and verifier. The two operations can take place simultaneously because of a 96 position buffer that holds the previous card for verification and punching while the data from the current card is keyed in.

A self-checking feature permits a check digit to be added to the basic code number for internal hardware verification. The check digit is always in the unit position of the field and more than one self-checking field can be checked per card.

The 5496 has a 64 character keyboard and operates at a speed of 60 columns per second.

The 5486 Card Sorter permits off-line sorting of the new IBM System/3 punch cards. The Sorter is available in two models: Model 1 reads the new cards at 1,000 cards per minute and Model 2 is fifty per cent faster at 1,500 cards per minute. The card hopper can accommodate 2,000 cards and there are six 600-card stackers.

.3 SOFTWARE

The System/3 software support is designed to simplify the user programming tasks. It includes the following elements, all operating under the supervision of the System/3 Control Program:

- Card Programming System: RPG II Card Compiler, Card Utility Package.
- Disk Programming System: RPG II Disk Compiler, Disk Assembler, Disk Sort Program, Disk Utility Package.

The System Control Program includes such functions as supervisor, executive, and job control routines. The Control Program is available with the hardware without charge. All of the other programs are priced separately in line with IBM's new separate pricing policy.

.31 RPG II

The Report Program Generators for both card and disk systems are designed to provide the user with an easy method of writing programs. The new RPG compilers have 37 major functional improvements over previous RPG's including such features as internal debug facilities, more flexible tables, a look-ahead facility, communications areas, program and file control, automatic overlays, square root subroutines, sort and collate routines, etc. For example, the disk sort is capable of sorting indexed file by key. There is a roll in-roll out capability to service inquiry messages.

The fixed core requirements for the disk RPG II is 3K memory with 4K required in a multiprogramming environment. Card RPG II requires 3K memory.

(Contd.)

.32 Disk Assembler

The Disk Assembler is a standard assembler package permitting the user, who does not wish to utilize the RPG facilities, to write directly in either machine or symbolic language. The Assembler translates the assembly language instructions into machine instructions, assigns storage locations, and performs other functions that eventually result in an executable, machine-language program.

The minimum system requirements for the Disk Assembler consist of 12,288 bytes of main storage in the 5410 Processing Unit, one 5203 printer with universal character set and interchangeable chain cartridge features, one 5424 Multi-Function Card Unit, and one 5444 Disk Drive.

.33 Sort and Utilities

A comprehensive package of sort and utility software is offered for both the card and disk systems. In the card system, all of these functions are concentrated in one program. For a disk system, the functions are broken up into separate programs.

The card utility package includes five basic programs: reproduce-interpret, sort, collate, a 96 column list, data recording and data verifying.

.4 APPLICATION CUSTOMIZER SERVICE

The IBM Application Customizer Service was developed specifically for System/3 users. The user fills out a questionnaire relating to a particular application. He specifies the content and layout of the records and reports, identifies the calculations required, and then chooses among the variety of processing procedures. Related jobs can be linked into an integrated family. The user then prepares punched cards from the questionnaire and IBM feeds the job specifications into an IBM/360 Model 20 at one of its Basic System Centers. The user must either have additional equipment to punch the 80-column input cards for the 360 program or may engage the services of IBM to do the job.

The specifications are checked for accuracy and completeness and the following tailored application aids are produced for the user:

- Edit Listings indicating the accuracy and consistency of the specifications.
- Flowcharts defining the processing and clerical steps involved in each application.
- A Data Dictionary defining the terms used in the particular application.
- A Record Listing showing record formats.
- A File Cross-Reference Listing referencing each record and the pertinent application.
- Program Descriptions specifying detailed input specifications, calculation logic, and output printing requirements for the programs to be eventually coded in RPG or assembler language.
- Sample Reports showing the format of the final report according to the original specifications.

The user then has the materials necessary to prepare the computer programs at his installation. The preparation of these programs, the compiling and assembling, and the actual running of the jobs is done at the user site. The customizer service is prepared at the Basic System Center.

Six major business application areas are provided through the customizer service (all of which are separately priced):

- Order Writing and Invoicing; pre-billing or post-billing, automatic backordering, automatic selection of item prices or discounts.
- Accounts Receivable; open item or balance forward method
- Inventory Accounting: stock status reports
- Sales Analysis: reports classified by item, product class, customer or salesman.
- Payroll: registers, paychecks, earning statement, etc.
- General Ledger Accounting: internal or client accounting.

.4 APPLICATION CUSTOMIZER SERVICE (Contd.)

Besides the Application Customizer Service, IBM also offers comprehensive customer training courses and system engineering services to accomodate the needs of the IBM System/3 users. All of these services are separately priced. The education courses provide a good grounding in basic System/3 concepts, application design, disk system design, RPG II programming fundamentals, etc. System engineers are ready to do the job in its entirety for the user who does not wish to acquire a programming staff or who do not wish to assign System/3 programming tasks to his current programming staff. In addition, system engineers are available for assisting the user in the preparation of the reports.

IBM SYSTEM/3

CLASS	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	5410		Processing Unit* (Card Configuration):			
		A2	With 8K bytes of core memory	310	15,200	27
		A3	With 12K bytes of core memory	410	20,100	29
		A4	With 16K bytes of core memory	525	22,575	29
		A5	With 24K bytes of core memory	755	37,000	30
		A6	With 32K bytes of core memory	985	48,275	30
	5410		Processing Unit (Disk Configuration):			
		A12	With 8K bytes of core memory	435	21,325	73
		A13	With 12K bytes of core memory	535	26,225	75
		A14	With 16K bytes of core memory	650	28,700	75
		A15	With 24K bytes of core memory	880	43,125	76
		A16	With 32K bytes of core memory	1,110	54,400	76
MASS STORAGE	5444		Disk Storage Drive*			
			Model 1: 2.45 million bytes	155	8,075	47
			Model 2: 4.90 million bytes	255	9,700	47
			Model 3: 2.45 million bytes	155	8,075	47
	5440		Disk Cartridge	—	175	—
INPUT-OUTPUT	5424		Multi-Function Card Unit*:			
			Model A1: reads 250 cpm, punches 60 cpm, prints 60 lpm	270	9,450	140
			Model A2: reads 500 cpm, punches 120 cpm, prints 120 lpm	405	12,575	200
	5203		Printer*:			
			Model 1: prints 100 lpm	230	10,600	67
			Model 2: prints 200 lpm	280	11.775	76
			Options:			
		3475	Dual feed carriage	75	3,675	20
		4730	Interchangeable chain carriage	75	3,675	1
		5559	12 additional print positions	25	750	—
		5558	24 additional print positions	50	1,500	2
		5560	36 additional print positions	75	2,250	2
		8639	Universal character set	10	300	1
	5496		Data Recorder: punches 60 col. per sec.	155	7,600	54
			Options:			
		7061	Modulus 10 self check first digit	30	900	1
		7062	Modulus 11 self check first digit	30	900	1
	5486		Card Sorter:			
			Model 1: reads 1,000 cpm	85	4,425	38
			Model 2: reads 1,500 cpm	165	5,075	58

* The 5410, 5444, 5424 and 5475 units are standard components of IBM System/3 card and disk configurations, and these units cannot be ordered separately. Additional units also cannot be ordered.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT OUTPUT (Contd.)			Options:			
		1275	Alpha sort	7	210	1
		2370	Auxiliary card counter	10	490	3
		7245	Sort suppress/digit select	10	490	1
	5471		Printer-Keyboard: prints 15.45 characters per second.	100	4,700	32
	5475		Data Entry Keyboard	40	2,250	7
SYSTEM SOFTWARE			Card Programming System:			
	5701	RGI	RPG II Card Compiler	35	—	—
	5701	UTI	Card Utility Program	10	—	—
			Disk Programming System:			
	5702	RGI	RPG II Disk Compiler	45	—	—
	5702	ASI	Disk Assembler	75	—	—
	5702	SMI	Disk Sort Program	10	—	—
	5702	UTI	Disk Utility Program	10	—	—
APPLICATION PROGRAMS			Customized Application Packages:			
			Order Writing and Invoicing	250	—	—
			Accounts Receivable	225	—	—
			Inventory Accounting	225	—	—
			Sales Analysis	205	—	—
			Payroll	265	—	—
			General Ledger Reporting	180	—	—

HONEYWELL, INC.

AUERBACH
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INTRODUCTION

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The H-400 is a small to medium scale business-oriented computer. It has a fair range of conventional input-output and auxiliary storage units. Only one real option (Multiply/Divide) exists so far as the central processor is concerned, so the computing power of the unit is the same for most configurations. The H-400 was first delivered in 1961 and is mainly used as an independent computer rather than as a supporting satellite for larger systems. The system can be used to support the larger H-800 but such an application is comparatively unusual. Monthly rentals range from $5,000 to $14,000 and typical systems are approximately $8,000.

Compatibility

The H-400 is the smallest of the Honeywell computers. The larger Honeywell systems are the H-800 I and II (502:), the H-1400 (505:) and the H-1800 (503:).

There is complete programming compatibility between the H-400 and H-1400 systems, which also share the same peripheral units, but there is no direct programming compatability between the H-400 and the H-800/1800 systems. However, an H-400 simulator is optionally available for use with the H-800 to permit H-400 programs to be run on the H-800.

Hardware

The basic system, with no optional facilities, operates almost entirely serially (i.e., computation, input, and output are handled one process at a time and do not overlap). Simultaneous tape read and tape write operation is the only exception. Optionally, the printer can be buffered so that the central processor can operate while the printer is operating.

The processor, which has optional multiply/divide capabilities, uses binary or decimal arithmetic. Three address instructions ("ADD A, B, C" means ADD (A) to (B) and place the result in C) are used and operands are in fixed word lengths (12 decimal characters including sign, or 48 binary bits). The instruction repertoire is comprehensive and includes especially good editing commands for translation of the 6-bit alphanumeric codes to and from their decimal and binary equivalents. There is a powerful move command which allows n words to be moved at a time. "n" can be of any size up to 4,095.

No variable length operations are possible. The processor also serves as the input-output controller. The system requires no additional controllers or buffers (beyond the printer buffer) for this reason.

The core storage is available with 1,024, 2,048, 3,072, or 4,096 48-bit words. Each 24-bit half of a word has a parity bit which is checked whenever the data is moved. The store can accept words with incorrect parity from input-output devices. The processor is made aware of this condition by a forced transfer of control to a fixed location. A parity-checking instruction is provided to find the incorrect word and correct its parity. Other instructions are provided to implement techniques to correct the incorrect data. They are part of an internal program-executed system called Orthotronic Control.

Up to eight magnetic tape units can be connected. The three magnetic tape unit models available operate at 32,000 characters or 48,000 digits per second, 64,000 characters or 96,000 digits per second, and 88,666 characters or 133,000 digits per second. These units have pneumatic drives which handle tape more gently than mechanical drives. A feature of the H-400 (Orthotronic Control) enables it to ignore a faulty track when reading a

INTRODUCTION (Contd.)

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tape and to regenerate the correct data. Orthotronic Control is an error correction system designed particularly to catch errors caused by tape skew. In contrast to read-after-write error detection systems, Orthotronic Control has the advantage that it can cover errors occurring during or after recording, either in storage or during reading. On the other hand, it does not notice recording errors until later reading.

The printer operates at 900 lines per minute. A print storage option is available for this unit that frees the processor for 98 per cent of the printing time. The IBM 1402 reader/punch is now the card equipment normally used with the H-400, although some older installations are still using the converted version of the IBM 088 collator. The 1402 reads 800 cards per minute and punches 250 cards per minute.

Punched tape equipment is also available; the reader operates at 500 or 1,000 characters per second, the punch at 110 characters per second.

Software

A number of programming aids are available for the H-400 system. These include:

(1) EASY I, a basic symbolic assembler for systems with 1,024-word stores.

(2) EASY II, a more complete assembler for systems with stores of 2,048 or more words. This includes an input-output macro which is also used in other software systems, such as AUTOMATH and COBOL.

(3) A Sorting Generator and Merging Generator Routine. These are based on the polyphase method, which has been pioneered by Honeywell.

(4) Disc File Programs which are presently under development.

(5) A COBOL-61 compiler for the H-400, which has just been released. This compiles on a 2K machine with a minimum of four tape units. The compilation time is approximately one-half hour, which is good for a machine of this size. The language facilities are fairly complete. The object programs are reported to require approximately the same running time as those produced using normal (EASY II) techniques.

(6) FORTRAN II (called AUTOMATH 400), a FORTRAN II compiler which has also just been released. It includes a non-FORTRAN statement, OVERLAY, which helps to overcome some of the limitations of systems with small storage (like the H-400). It does a small amount of analysis of the coding and its context before creating the machine language and thereby improves the object time speed of the programs. Subscripts are only allowed to two levels and error control of the running program is not as strong as would be liked. Compilation times are very good, approximately one hundred statements per minute. Object running times are slowed down by the need to simulate the floating point arithmetic.

HONEYWELL H-400

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	401-1		Central Processor (includes 1,024 words of core storage, console, and power unit (1) (2)	3,975	178,875	347
	401A-1		Central Processor (includes 1,024 words of core storage, console and power unit; accepts 404-1 or 404-3 tape units) (2)	4,215	189,675	347
	401A-2		Central Processor (includes 1,024 words of core storage, console and power unit; accepts 404-2 tape units) (1)	5,215	234,675	448
	402-1		Additional Memory Module (1,024 words)	650	29,250	36
	402-2		Additional Memory Module (2,048 words)	1,300	58,500	73
	402-3		Additional Memory Module (3,072 words) (3)	1,850	83,250	104
			Optional features:			
		*413-3	Elapsed Time Clock	35	1,575	4
		*413-4	Real Time Clock	155	6,975	14
		451	Multiply-Divide Option	250	11,250	13
MASS STORAGE			Disc Storage			
	460-0		Random Access Storage and Control (12.5 million characters) (1)	1,990	89,550	239
	460-1		Random Access Storage and Control (25 million characters) (1)	2,490	112,050	299
INPUT-OUTPUT			Magnetic Tape (4)			
	404-1		Magnetic Tape Unit (maximum number of tape units per 400 system is 8)	900	43,200	176
	404-2		High-Density Magnetic Tape Unit (maximum number of tape units per 400 system is 8)	900	43,200	176
	404-3		Economy Magnetic Tape Unit (maximum number of tape units per 400 system is 8)	450	20,250	112
	436-1		Tape Control Unit (1)	1,380	62,100	152
	405		Magnetic Tape Switching Unit	75	3,600	5
			Punched Card			
	423-2		High-Speed Card Reader (650 cards/min) (IBM 088 Model 3)	325	14,700	91
		*423-2A	Pocket Selection Feature for the Model 423-2	15	675	1
	424-1		Standard-Speed Card Punch (1)	119	6,585	52
	424-2		High-Speed Card Punch (1)	540	20,575	48
	427		Card Reader/Card Punch (1)	550	30,000	132
	427-1		Card Reader/Card Punch (reads 800 cards/min; punches 250 cards/min; includes Early Card Read Feature) (5)	560	30,215	132
	427-2A		Pocket Selection Feature	15	675	1
			Paper Tape			
	409		Paper Tape Reader and Control (1,000 rows/sec)	540	24,300	60
	*410		Paper Tape Punch and Control (110 rows/sec; Model 1 accommodates 11/16-inch tape; Model 2 accommodates 7/8- or 1-inch tape)	540	24,300	60

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (contd.)			Printers			
	*418		Off-Line Printer Control (to be used with one Model 404-1, 404-2 or 404-3 and one Model 422-3 or 422-4)	1,550	69,750	120
	422-3		High-Speed Printer (900 lines/min; 120 out of 160 printing positions)	1,550	74,400	347
		422-3A	Vertical Spacing Option for the Model 422-3 (Allows spacing of six lines per inch or eight lines per inch) (6)	100	4,800	20
		*422-3B	Two-Speed Printing Option for the Model 422-3 (allows printing of 600 or 900 lines/min) (6)	40	1,920	8
	422-4		High-Speed Printer (900 lines/min; 120 fixed printing positions)	1,050	47,250	236
		422-4A	Vertical Spacing Option for Model 422-4 (Allows spacing of six lines per inch or eight lines per inch) (6)	100	4,800	20
		*422-4B	Two-Speed Printing Option for the Model 422-4 (allows printing of 600 or 900 lines/min) (6)	40	1,920	8
		450	Print Storage Option (for full simultaneous operation of on-line printer with any other Honeywell 400 operation)	390	17,550	20
			Optical Reader			
	440		Optical Scanning Unit and Control (1)	2,530	121,440	426
COMMUNI-CATIONS	481		Single-Channel Communication Control (1)	300	13,650	24
	484-3		Multi-Channel Communication Control (4 Bays) (1)	1,210	54,450	121
		485-IR	Communication Adapter (1)	25	1,125	3
		485-IT	Communication Adapter (1)	25	1,125	3
		485-IH	Communication Adapter (1)	30	1,350	3

NOTES:

*No longer in production

(1) Not available on new orders.

(2) Not more than one card reader, one printer, one card punch, and/or one random access unit may be attached to a Honeywell 400 system.

(3) Maximum memory capacity available on the Honeywell 400 is 4,096 words.

(4) 404-1, 404-2, and 404-3 Magnetic Tape Units cannot be intermixed on a single central processor.

(5) The 427-1 is an IBM 1402 and will be supplied only if available.

(6) An installation charge of $250 will be made if this feature is field installed.

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The H-800 is a medium to large computer system designed to process more than one program at a time *. This is an attempt to reduce the inefficiencies of individual programs, which are usually input-output or central processor limited. In any installation, the degree of success of multi-program operations depends upon how well the programs selected balance the sum of the demands on the central processor with the demands on the peripheral units. In practice, installations with time-sharing programs operate an average of two programs at a time, with peaks of five or six. (The hardware is capable of sharing the central processor time among up to eight programs.)

The H-800 rents for between $18,000 and $40,000 a month, depending on the configuration, and size, is intermediate between the H-400 and the new H-1400 on the one hand, and the H-1800 on the other. The H-800 uses the same data-codes as the H-400 and the H-1400, and thus, magnetic tapes can be interchanged between these systems. The H-1800 can run H-800 programs, as the H-800 order code is a subset of the H-1800 code.

The multi-running* feature of the H-800 is particularly valuable where large volume input-output files are processed with either relatively little or peaked internal processing. Typical applications of this character are found in the insurance and utility fields. This approach also permits a program mix which includes a series of scientific (low volume input-output) computation programs.

The manufacturer has undertaken the development of software which should encourage more use of multi-running. A package has been released for controlling up to seven simultaneous conversions between cards, paper tape, magnetic tape, and hard copy. The elimination of the separate "program testing" executive system has been proposed because many installations tend to retain it after testing has been completed rather than convert to the different operating requirements of the standard production executive system.

The H-800 has the capacity to execute 30,000 three-address instructions per second. The computer uses a 48-bit word, either as 44 bits plus sign character, 11 decimal digits plus sign character, or 12 unsigned decimal digits. Alphameric characters can be stored eight to a word, but cannot be used in arithmetic.

Decimal and binary computing facilities are available in the H-800, as are multi-word transfers, which allow economical programming. However, the computer has no facility for easy conversion of external data codes to internal code, or vice versa. All shifts are right end-around shifts, so that editing is costly. An edit generator and several standard routines are available, but most routines appear to be written for individual cases.

The H-800 storage is divided into two parts, a Control Memory with eight "program groups," and a Main Memory which is divided into banks of 2,048 48-bit words. The basic H-800 has two of these banks; larger units can contain up to 14. The eight program groups are included in all cases. Each of these eight groups can control a separate program. A total of 64 (eight per group) index registers are provided. The addressing structure is such that while any program can reach or use any location in storage, it is necessary to use one of a number of special addressing methods when referring to addresses in other program groups or other banks. The index registers have restricted utility in that any base address can be modified by no more than 256 positions.

*"Multi-running" is used in these Reports to describe the operation of a computer that is simultaneously processing two or more independent programs. "Parallel programming" and other terms are currently used to describe the same concept.

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There are 8 input and 8 output channels, all of which can operate concurrently with each other and the central processor. The peripheral units of the H-800 can be arranged as the user requires, with little restriction as to type or quantity. Honeywell-manufactured units include a 900 line per minute printer (which is very similar to the Anelex Printer) and magnetic tape units with character rates varying from 32,000 to 133,000 alphameric characters per second. Data communication units are being designed but no specifications have been released.

The Honeywell printer is unusual in that it has 160 printing positions, any 120 of which can be used at a time. Character and format selection is by plugboard. A paper tape loop located in the printer provides paper feeding control. These features enable printing two forms side by side and, where appropriate, the use of standardized print routines.

The Honeywell magnetic tape system is designed to allow the recovery of data lost during writing, storage, or upon re-reading. This recovery is effected by forming and checking "orthotronic control words" which are appended to each record on tape. The overheads involved in forming these words place an additional load on the central processor when writing is in process. The size of this additional load varies from $2\frac{1}{2}$ per cent to 10 per cent, depending on the tape unit in use. No additional load is present during reading operations.

Other available peripheral equipment includes: paper tape equipment capable of reading 1,000 characters per second and punching 110 characters per second; card readers which operate at 250, 650, or 800 cards per minute; card punches which punch either 100 or 250 cards per minute, and mass-storage discs with capacities of up to 800 million alphameric characters.

The software provided with the H-800 includes an assembly language (ARGUS), a FORTRAN II translator (AUTOMATH-800), and a business compiler (FACT). A COBOL compiler and FORTRAN IV translator (AUTOMATH-1800) have been announced for 1963. All of these are described in the language and translator sections.

The FACT compiler can handle files arranged as individual items, similar to COBOL files; or files with "hierarchical" structure. This arrangement saves tape space by recording identical data in a number of consecutive items only once instead of a number of times.

A Sort package, using the cascade sorting method, is available for the H-800. Cascade sorting merges strings from all except one of the tape units available, thereby providing faster sorting.

An executive system able to control the operation of all program translators and production programs is provided.

The executive system presently in use is designed for batch processing through assembly, and then running either serially under program testing methods, or in parallel in production. The ordering and control during a production run is controlled by a schedule which is created by a special run, but which relies very considerably upon the human skills of the scheduler who sets up the basic data. The things to be considered vary considerably from one installation to another, and the return which can be obtained from multi-running depends in no small measure on the ability of the scheduler.

Running under the executive system causes no actual loss of time during production running, as the executive program is not operating at this time. However, preparatory runs consume approximately 15 minutes of running time to set up the schedule and program tapes.

HONEYWELL H-800

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
			800			
	801		Central Processor (includes 4,096 words of core storage, console, and power unit)	8,550	410,400	476
		801-A	Floating-Point Option (1)	1,250	60,000	112
		801-B	Floating-Point Option	2,100	100,800	112
		813-3	Elapsed Time Clock	35	1,600	3
		813-4	Real Time Clock	155	7,500	9
	802		Additional Memory Module (available in units of 4,096 words; maximum of seven 802 units per system.)	1,600	76,800	90
			800-II (1)			
	800-II		Data processing system (consists of 801 Central Processor and Input-Output Control Center (IOCC), which includes 201, 202-1, 203A-1 or B-1, 207, 208, 212 and control for the 822-3 printer)	10,500	498,000	696
		801-B	Floating-Point Option	2,100	100,800	112
		802	Additional Memory Module	1,600	76,800	90
			800-III (1)			
	800-III		Data processing system (consists of 801 Central Processor, console, and Power Unit; 212 On-Line Adapter; 201 Central Processor)	10,000	475,650	602
MASS STORAGE			Disc Storage			
	860-1		Random Access Storage and Control (50 million characters)(1)	6,100	275,000	730
	860-2		Random Access Storage and Control (100 million characters)(1)	8,100	365,000	920
INPUT-OUTPUT			Magnetic Tape			
	804-1		Magnetic Tape Unit	900	43,200	176
	804-2		High-Density Magnetic Tape Unit	900	43,200	176
	804-3		Economy Magnetic Tape Unit	450	20,250	112
	*805		Magnetic Tape Switching Unit	75	3,600	5
	803-1		Tape Control	2,000	96,000	105
	803-2		High-Density Tape Control	3,100	148,800	163
	803-3		Economy Tape Control	2,000	96,000	105
	*836		Tape Control Unit (Controls one IBM 729II Tape Unit)	1,950	93,600	215

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Cards			
	823-1		Standard-Speed Card Reader (240 cards/min., IBM 085)(1)	125	6,900	33
	823-2		High-Speed Card Reader (650 cards/min., IBM 088 Model 3)(1)	325	14,700	91
	824-1		Standard-Speed Card Punch(1)	154	7,335	68
	824-2		High-Speed Card Punch(1)	490	20,575	48
	827		Card Reader-Card Punch(1)	550	30,000	132
	827-1		Card Reader-Card Punch (reads 800 cards/min., punches 250 cards/min., includes Early Card Read Feature)(2)	560	30,215	132
	807-1		Card Reader Control(1)	950	45,600	50
	807-2		Card Reader Control(1)	1,100	52,800	60
	807-3		Card Reader Control (for 827-1)	1,100	52,800	60
	808-1		Card Punch Control(1)	1,050	50,400	60
	808-2		Card Punch Control(1)	1,150	55,200	65
	808-3		Card Punch Control (for 827-1)(1)	1,150	55,200	65
			Paper Tape			
	809		Paper Tape Reader and Control (1,000 rows/sec)	690	33,120	76
	*810		Paper Tape Punch and Control (110 rows/sec) Model 1 accommodates 11/16-inch tape; Model 2 accommodates 7/8- or 1-inch tape)	690	33,120	76
			Printer			
	806-1		Printer Control(1)	1,050	50,400	55
	806-2		Printer Control(1)	1,250	60,000	100
	806-3		Printer Control (for 822-3)	1,450	69,600	115
	*822-3		High-Speed Printer (900 lines/min)	1,550	74,400	347
		822-3A	Vertical Spacing Option for the Model 822-3 (allows spacing of six lines per inch or eight lines per inch)	100	4,800	20
		*822-3B	Two-Speed Printing Option (600 or 900 lines/min)	40	1,920	8
	811-1		Printer - Card Reader - Card Punch Control(1)	1,700	81,600	85
	811-3		Printer - Card Reader - Card Punch Control(1)	1,950	93,600	150
	811-4		Printer - Card Reader - Card Punch Control(1)	1,700	81,600	85
	811-6		Printer - Card Reader - Card Punch Control(1) (for use with 822-3, 827-1)	1,950	93,600	150
	*822-1		Standard-Speed Printer (150 lines/min; IBM 407)(1)	(3)	(3)	164
			Magnetic Link Character Reader			
	833		Magnetic Link Character Sorter-Reader Input Control Unit(1)	1,300	62,400	97
			Controls			
	815		Off-Line Output Auxiliary Control(1)	700	33,600	50
	817		Off-Line Input-Output Auxiliary Control(1)	950	45,600	70
COMMUNI-CATIONS			Real-Time Controls			
	812-1		Real-Time Control Unit (non-simultaneous input-output)(1)	1,250	60,000	63

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Real-Time Controls (Contd.)			
	812-2		Real-Time Control Unit (simultaneous input-output)(1)	1,800	86,400	90

NOTES:

*No longer in production.

(1)Not available on new orders.

(2)The 827-1 is an IBM 1402 and will be supplied only if available.

(3)Honeywell provides maintenance only.

INTRODUCTION

§ 011.

The Honeywell 1800 is a large scale solid-state computer system designed to process more than one program at a time. Based on the fast H-1801 central processing unit, the 1800 is program-compatible with the Honeywell 800 (Computer System Report 502:) and uses the same peripheral devices and software systems. The principal differences between the two systems are that the basic central processing unit is three times as fast on the Honeywell 1800 as on the 800, has twice as much core storage (8, 192 words), and has been increased in price by 90 per cent. The increased internal processing capacity (some 90, 000 three-address instructions per second) will be particularly useful when the system is simultaneously processing two or more independent programs.

The optional floating point hardware has been redesigned to use significantly fewer memory cycles than its equivalent on the Honeywell 800. This places the Honeywell 1800 in the category of very fast scientific processors, on a par with the IBM 7094 Model II. New instructions are available for conversions between fixed point decimal and floating point binary formats.

The Honeywell 1800 rents for between $30, 000 and $60, 000 per month, depending upon the system configuration and size. The 1800 uses the same data codes as the smaller Honeywell 400 and 1400 systems, so magnetic tapes can be interchanged between them. There is, however, no program compatibility between the 1800 and the 400 and 1400. The Honeywell 1800 can run Honeywell 800 programs without alteration, because the 800's instruction repertoire is the same as the 1800's repertoire.

An optional central processor, the Honeywell 1800-II, permits four magnetic tape units, a card reader/punch, and a printer to be connected directly to the central processor without intermediate adapters. These units can be used for off-line or on-line transcription. More details on the 1800-II are given in the Summary Analysis which follows this Introduction.

The multi-running* feature of the Honeywell 1800 is an attempt to reduce the inefficiencies of individual programs, which are usually input-output or central processor limited, by processing more than one program at a time. In any installation, the degree of success of multi-program operations depends upon how well the programs selected balance the sum of the demands on the central processor with the demands on the peripheral units. The hardware is capable of sharing the central processor time among up to eight programs. In practice, Honeywell 800 installations with time-sharing programs operate an average of two programs at a time, with peaks of five or six.

The multi-running capabilities are particularly valuable where large volume input-output files are processed with either relatively little or peaked (i.e., unevenly distributed) internal processing. Typical applications of this character are found in the insurance and utility fields. Multi-running also permits efficient processing of a program mix which includes a series of scientific (low volume input-output) computation programs.

The manufacturer has undertaken the development of software which should encourage more use of multi-running. A package has been released for controlling up to seven simultaneous conversions between cards, paper tape, magnetic tape, and hard copy. The elimination of the separate "program testing" executive system has been proposed because many installations tend to retain it after testing has been completed rather than convert to the different operating requirements of the standard production executive system.

The Honeywell 1800 uses a 48-bit word, either as 44 bits plus sign character, 11 decimal digits plus sign character, or 12 unsigned decimal digits. Alphameric characters can be stored eight to a word, but cannot be used in arithmetic.

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* "Multi-running" is used in these reports to describe the operation of a computer that is simultaneously processing two or more independent programs. "Parallel programming" and other terms are currently used to describe the same concept.

§ 011. INTRODUCTION (Contd.)

Decimal and binary arithmetic facilities and multi-word transfers allow economical programming. However, the computer has no facility for easy conversion of external data codes to internal code, or vice versa. All shifts are right end-around shifts, so that editing is costly. An edit generator and several standard routines are available, but most routines appear to be written for individual cases. Floating point arithmetic hardware is optional.

The H-800 storage is divided into two parts, a Control Memory with eight "program groups," and a Main Memory which is divided into banks of 2,048 48-bit words. The basic Honeywell 1800 has 4 of these banks; larger units can contain up to 32. The eight program groups are included in all cases. Each of these eight groups can control a separate program. A total of 64 index registers (8 per group) are provided. The addressing structure is such that while any program can reach or use any location in storage, it is necessary to use one of a number of special addressing methods when referring to addresses in other program groups or other banks. The index registers have restricted utility in that any base address can be modified by no more than 256 positions.

There are eight input and eight output channels, all of which can operate concurrently with each other and the central processor. The peripheral units can be arranged as the user requires, with few restrictions as to type or quantity. Honeywell-manufactured units include a 900 line per minute printer (which is very similar to the Anelex Printer) and magnetic tape units with character rates varying from 32,000 to 133,000 alphameric characters per second. Data communication units are being designed, but no specifications have been released.

The Honeywell printer is unusual in that it has 160 printing positions, any 120 of which can be used at a time. Character and format selection is by plugboard. A paper tape loop provides paper feeding control. These features facilitate printing of two forms side by side and, where appropriate, the use of standardized print routines.

The Honeywell magnetic tape system is designed to allow the recovery of data lost during writing, storage, or upon re-reading. This recovery is effected by forming and checking "Orthotronic control words" which are appended to each record on tape. The overheads involved in forming these words place an additional load on the central processor when writing is in process. The size of this additional load varies up to 3 per cent, depending upon the tape unit in use. No additional load is present during reading operations.

Other available peripheral equipment includes: paper tape equipment capable of reading 1,000 characters per second and punching 110 characters per second; card readers which operate at 250 or 800 cards per minute; card punches which punch either 100 or 250 cards per minute; and mass-storage discs with capacities of up to 800 million alphameric characters.

The software provided with the Honeywell 800 can also be used with the Honeywell 1800. It includes an assembly language (ARGUS), a FORTRAN II translator (AUTOMATH-800), a FORTRAN IV translator (AUTOMATH-1800), and a business compiler (FACT). A COBOL-61 compiler has been announced for 1963. Software is described in the Honeywell 800 report, Sections 502:161 through 502:191.

The FACT compiler can handle files arranged as individual items, similar to COBOL files, or files with "hierarchical" structure. This arrangement saves tape space by recording identical data in a number of consecutive items only once instead of a number of times.

A Sort package, using the cascade sorting method, is available for the Honeywell 1800. Cascade sorting merges strings from all except one of the available tape units, thereby providing faster sorting. However, even with this increased sorting speed and the fast tape units, it would be very inefficient to sort large files on the Honeywell-1800 unless other programs were proceeding in parallel.

An executive system able to control the operation of all program translators and production programs is provided.

The executive system presently in use is designed for batch processing through assembly, and then running either serially under program testing methods, or in parallel in production. The ordering and control during a production run is controlled by a schedule

§ 011. INTRODUCTION (Contd.)

which is created by a special run, but which relies considerably upon the human skills of the scheduler who sets up the basic data. The things to be considered vary considerably from one installation to another, and the return which can be obtained from multi-running depends in no small measure on the ability of the scheduler.

Running under the executive system causes no actual loss of time during production running, because the executive program is not operating at this time. However, preparatory runs consume approximately 15 minutes of running time to set up the schedule and program tapes.

HONEYWELL H-1800

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			1800			
	1801		Central Processor (includes 8,192 words of core storage, console, and power unit)	16,050	770,400	920
	*1801B		Floating-Point Option	4,300	206,400	241
		*019	Memory Barricade	250	12,000	14
		*1813-3	Elapsed Time Clock	35	1,600	3
		*1813-4	Real Time Clock	155	7,500	9
	1802		Additional Memory Module (available in units of 8,192 words; maximum of three 1802 units per system.)	3,200	153,600	180
	1802-1		Additional Memory Module (available in units of 16,384 words; maximum of two units per system; basic requirement of three 1802 units)	7,500	360,000	421
			1800-III (2)			
	1800-III		Data Processing System (includes 1801 Central Processor with console, and power unit; 212 On-Line Adapter; and 201 Central Processor	17,500	835,650	1,046

NOTES:

*No longer in production.

(1) For peripheral equipment see Honeywell 800.

(2) Not available on new orders.

INTRODUCTION

§ 011.

The Honeywell 1400 is a medium scale computer system oriented primarily toward business data processing applications. Recent hardware developments make it possible to adapt the system to a variety of real-time applications. Monthly rentals for H-1400 systems range from about $9,000 to $18,000 and average around $13,000. Initial customer deliveries were made in January, 1964.

Compatibility

The H-1400's throughput capacity places it in the middle of Honeywell's expanding line of computers. The larger Honeywell systems are the H-800 (Computer System Report 502) and the H-1800 (Report 503). The smaller systems are the H-200 (Report 507) and the H-400 (Report 501).

The Honeywell 400 and 1400 are fully program-compatible and, with a few exceptions, offer the same range of peripheral units. There is no direct program compatibility between H-400/1400 systems and either H-200 or H-800/1800 systems, though a simulation routine permits H-1400 programs to be run on an H-800 or H-1800.

All Honeywell computers can communicate with one another (but not with most competitive equipment) by means of a line of magnetic tape units using three-quarter inch tape.

Hardware

The central processor has facilities for both binary and decimal arithmetic. Both multiply-divide instructions and floating point arithmetic are optional facilities, and all floating point arithmetic is performed in the decimal mode. Three-address instructions are used (e.g., "ADD A, B, C" means "add the contents of A to the contents of B and place the result in location C"). The instruction repertoire is comprehensive and includes especially good editing commands for translation of the 6-bit alphanumeric codes to and from their decimal and binary equivalents. Except for the editing instructions, operand lengths are fixed at one 48-bit word. A Honeywell 1400 word can hold one instruction, eight 6-bit alphanumeric characters, twelve 4-bit decimal digits (or eleven digits plus sign), sixteen octal digits, or a single 48-bit binary data item. A powerful "move" command permits the contents of up to 4,095 word locations to be moved by one instruction.

The effective core storage cycle time, 13 microseconds per 48-bit word, is 30 percent faster than that of the Honeywell 400, providing an internal processing capacity for 10,000 to 12,000 typical three-address instructions per second. Other improvements over the H-400 include an increase in core storage capacity from the H-400 maximum of 4,096 words to the H-1400 maximum of 32,768 words, addition of the Floating Point and Card Storage options, and increases in the number of printers (now 2, previously 1) and magnetic tape units (now 16, previously 8) that can be connected.

The core storage is available in multiples of 4,096 48-bit word locations; maximum size is 32,768 words. Each 24-bit half of a word has a parity bit which is checked whenever the data is moved. The store accepts words with incorrect parity from input-output devices. The processor is made aware of this condition by a forced transfer of control to a fixed location. A parity-checking instruction is provided to find the incorrect word and correct its parity. Other instructions are provided to implement techniques to correct the incorrect data. They are part of a system called Orthotronic Control, which is used primarily with magnetic tape units and disc files.

The central processor serves as the main input-output controller in H-1400 systems, thereby minimizing the need for additional controllers or buffers. A special central processor model, however, must be used with the fastest magnetic tape units (88,666 six-bit characters per second).

§ 011. INTRODUCTION (Contd.)

The basic H-1400 system without optional facilities has very limited capabilities for simultaneous operations. Except for a simultaneous tape reading and writing operation, computation, input, and output are handled one at a time and do not overlap. Optional buffer features called Print Storage and Card Storage permit internal processing to be overlapped with printing and/or card reading or punching.

Up to 16 magnetic tape units can be connected. The three available magnetic tape unit models operate at 32,000 characters (or 48,000 digits) per second, 64,000 characters (or 96,000 digits) per second, and 88,666 characters (or 133,000 digits) per second. These units have pneumatic drives which handle the tape more gently than mechanical drives. The Orthotronic Control feature enables the H-1400 to ignore a faulty track when reading a tape and to regenerate the correct data. In contrast to read-after-write error detection systems, Orthotronic Control can correct errors occurring during recording, in storage, or during reading. On the other hand, it does not notice recording errors until a later reading.

The printer operates at 900 lines per minute. The Print Storage option frees the processor for 98 percent of the printing time. The IBM 1402 Card Read Punch is the card equipment normally used with the H-1400. It reads 800 cards per minute and punches 250 cards per minute. The Card Storage option allows card reading or card punching (but not both) to be overlapped with processing.

Up to 5 input and 4 output general-purpose peripheral trunks are available for connecting any of the following devices:

- Magnetic disc files (random access storage for up to 100 million alphameric characters per file unit).
- Communication controls (process messages to or from remote equipment).
- Paper tape reader (500 or 1,000 characters per second).
- Paper tape punch (110 characters per second).
- Optical scanner (196 to 312 documents per minute).

Real-Time Processing

The basic Honeywell 1400 system is designed primarily for standard batch processing applications. Through the addition of communication controls and magnetic disc files, the H-1400 can handle inquiry, data collection, and management control functions as well. Batch-type production programs can be interrupted as necessary to process incoming messages and transmit the replies.

Three types of communication control units are available. Up to five such control units, in any combination, can be connected to an H-1400. The 484 multi-channel control can accommodate up to 56 communication channels and handle several messages simultaneously to or from remote devices with speeds of up to 300 characters per second. The 481 single-channel control is designed for lower message volumes and handles only one channel. The 480 control handles the transfer of data between an H-1400 and another computer or a high-speed remote device. The central processor's interrupt facility is used to initiate a transfer of data between core storage and a buffer in the communication control whenever the buffer has been filled (during input) or emptied (during output). Priorities can be established so that some routines will be interrupted freely, other routines will be interrupted only to handle selected functions of higher priority, and still other routines will never be interrupted.

A wide variety of remote input-output devices can be used in Honeywell 1400 real-time systems. Virtually any business data transmitter that can be connected to a telephone or teleprinter circuit can be used. The remote equipment can be connected to the computer either through a standard switched telephone network or through leased lines.

Software

Software for the H-1400 is the same as for the program-compatible H-400, with minor modifications. Programs and programming systems available from Honeywell include:

- EASY II, a standard assembler with symbolic addressing and relocatable output. It includes an input-output macro facility which is also used in other systems, such as COBOL-61 and AUTOMATH.

§ 011. **INTRODUCTION (Contd.)**

- A COBOL-61 compiler which can be used on any H-1400 system with a minimum of four tape units. The compilation time for typical programs is approximately one-half hour, which is good for a machine of this size. The language facilities are fairly complete. The object programs are reported to require approximately the same running time as those produced using normal (EASY II) symbolic coding techniques.

- A FORTRAN II compiler (called AUTOMATH 400) that includes a non-FORTRAN statement, OVERLAY, which helps to overcome some of the limitations of systems with limited internal storage (like the H-400). The compiler does a small amount of analysis of the coding and its context and thereby improves the execution speed of the object programs. Only two levels of subscripting are allowed, and the facilities for detecting and handling errors at execution time are limited. Compilation speed is high: approximately one hundred statements per minute. Object program execution times are slowed down by the need to simulate the floating point arithmetic on all H-400 machines, but should be much improved when the Floating Point option is available on H-1400 computers.

- Sort Generator and Merge Generator Routines. These are based on the polyphase method, which has been pioneered by Honeywell.

- Disc File Programs, which are currently under development to facilitate the programming of disc file operations.

- THOR (Tape Handling Option Routine), a general routine for locating, copying, comparing, editing, and correcting information on magnetic tape.

- TABSIM, a "load-and-go" program that simulates the functions of conventional punched card tabulating equipment, using a source language that is compatible with IBM 1401 FARGO.

- Mathematical and statistical routines, which handle functions, conversions, programmed multiply-divide and floating point arithmetic, and curve fitting.

- PERT and Linear Programming Packages.

HONEYWELL H-1400

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
	1401-1		Central Processor (includes 4,096 words of core storage, console, power unit; accepts 404-1 or 404-3 magnetic tape units) (1)	7,350	330,750	659
	1401-2		Central Processor (includes 4,096 words of core storage, console, and power unit; accepts 404-2 magnetic tape units)	8,100	364,500	726
	1401-3		Central Processor (includes 2,048 words of core storage, console, and power unit; accepts 404-1 or 404-3 magnetic tape units)	6,550	294,750	587
	1401-4		Central Processor (includes 2,048 words of core storage, console, and power unit; accepts 404-2 magnetic tape units)	7,300	328,500	654
		1402-0	Additional Memory Module (2,048 words; must be first module added to 1401-3 and 1401-4; not more than one 1402-0 may be added)	800	36,000	45
		1402	Additional Memory Module (4,096 words; (1402-0 is a prerequisite on 1401-3, 1401-4); maximum of 7 modules per system)	1,600	72,000	90
			Optional Features:			
		*1401-B	Floating-Point Option (requires 1451 Option)	150	6,750	14
		1451	Multiply/Divide Option	250	11,250	13
			Optional features for peripheral devices: (3)			
		1403	Extended Tape Control (required to control the 9th through 16th tape units) (2)	100	4,500	9
		*1406	Storage & Control for Second Printer (for on-line operation; requires 1450 option on the first printer).	625	28,125	50
		*1411	Card Storage Option (to be used with one Model 423-2 or one Model 427)	490	22,050	39
		1423-2A	Pocket Selection Feature for the Model 423	15	675	1
		*1427-2A	Pocket Selection Feature for the Model 427-1	15	675	1
		1450	Print Storage Option	390	17,550	20

NOTES:

*No longer in production.

(1) A 1400 System must include a central processor and one magnetic tape unit.

(2) Up to 16 magnetic tape units may be controlled by a 1401 Central Processor that includes a Model 1403 Extended Tape Control.

(3) These features are used in place of, or in addition to corresponding features for the Honeywell 400 peripherals. The 1400 can accommodate all Honeywell 400 peripherals; see the Honeywell 400 Price Data Sheet.

SUMMARY

.1 BACKGROUND

The Honeywell Series 200 line of computers consists of nine program-compatible central processors - Models 110, 120, 125, 200, 1200, 1250, 2200, and 4200. The ninth processor in the Series, the large-scale Honeywell 8200, offers compatibility not only with other members of the Series 200, but also with the earlier Honeywell 800 and 1800 systems.

The Series 200 family of computer systems - with the exception of the Model 8200 - is based upon an improved version of the original Honeywell 200 system, first delivered in July 1964. The Honeywell 2200 system was the second entry in what has since become the Series 200 family. Announced in 1964, the 2200 was first delivered in December 1965. The Honeywell 120, 1200, and 4200 systems were announced in February 1965. The 120 was first delivered in February 1966 and the 1200 in January 1966. Delivery of the first 4200 system was made in March 1968.

Three additional models, fitting into the small-to-medium-scale ranges of the Series 200, were announced in October 1967. The new Model 125 was delivered first in December 1967, and both the 110 and 1250 in August 1968.

The Honeywell 8200 formally joined the Series in June 1965. It provides compatibility with the H-800 and H-1800 systems through use of a 48-bit word processing subsystem. The word processor in the Model 8200 provides the hardware capability to run up to eight independent user programs concurrently. A second 8200 subsystem, the variable-length field (VLF) processing subsystem, provides compatibility with other members of the Series 200. First delivery of the Honeywell 8200 is scheduled for 2nd quarter, 1969. Throughout the remainder of this Computer System Report, all general statements concerning the Series 200 refer to the H-8200's VLF processor only. Separate paragraphs are devoted to descriptions of the word processor and to the overall performance of the Honeywell 8200.

The Honeywell 200, and the computer family that grew from it, had as a major marketing goal the replacement of the slower, "second generation" IBM 1400 Series systems. With such a goal, certain advances in computer system design, such as 8-bit character codes and extensive multiprogramming facilities, were not seen as necessary inclusions in the line. To a large extent, the instruction complement of the 1400 Series was incorporated in the Honeywell 200 Series, and software routines were developed to resolve the minor incompatibilities between the instruction sets of the two series. In order to keep abreast of its competition, Honeywell has since substantially expanded its hardware and software product line and currently competes favorably with most third generation small-to-medium-scale computers manufactured by its competitors.

The key software package released with the original Honeywell 200 centered around a program called Bridge, the "Liberator" for 1400 Series users. This program accepted IBM 1401 object programs as input and generated Series 200 object programs after a fairly straightforward translation process. Linkages to simulation subroutines were generated to resolve most discrepancies between the two machines. This program is still supported by Honeywell, to the extent it is used.

Honeywell currently stresses a symbolic assembly language translator program called Easytran as an alternative to the Bridge translator approach to conversion of IBM 1400 Series programs. Through the use of Easytran, almost 100 per cent of the 1400 Series source language statements can be correctly translated to Honeywell's Easycoder assembly language, which can be readily modified as part of normal program maintenance. Honeywell maintains that programs so translated from IBM 1400 Series assembly languages will operate on Honeywell Series 200 systems at least 80 per cent as efficiently as programs originally written for execution on Series 200 systems. Honeywell's current Easytran translator converts IBM 1401 and 1460 programs for use with any Series 200 system. A similar translator, Easyauto Symbolic Translator translates IBM 1410 and 7010 assembly language programs into source-language programs which can be assembled to run either on an IBM 1410/7010 computer system or on a Model 1200, 1250, 2200, or 4200 computer system.

The Disk Liberation System enables users of IBM 1401, 1440, and 1460 disk systems to convert to Honeywell Series 200 disk systems. Disk Liberation includes routines for both translation of 1401/1440/1460 programs to Honeywell Type 258, 259, or 259A Disk Pack Drives.

A user of IBM 1400 Series equipment who wants to "trade up" to new equipment is faced with many important considerations when comparing offerings by Honeywell in its Series 200 and by IBM in its System/360. Among these considerations are the following:

- Decimal arithmetic in Honeywell Series 200 processors is in many cases faster than that in comparable processor models of the IBM System/360.
- Conversion to Honeywell Series 200 computer systems can be accomplished with little reprogramming via the program translation process - without sacrificing many processing facilities in the new system. Conversion to IBM System/360 computers can involve either total reprogramming or "emulation" of the 1400 Series object programs. With the emulation technique, the full potential of the emulating system cannot be utilized (although it is paid for), and the 1400 Series programs must be maintained in their original languages.
- The equipment delivery period for a Series 200 is generally shorter than for a System/360.
- The retraining of personnel familiar with 1400 Series equipment will be minimal when converting to Series 200 equipment, since the processors within this series use the same data structure and largely the same instruction sets as the IBM 1400 Series processors. Use of the System/360 will require extensive retraining of personnel.

In this Introduction, a number of important topics are discussed. Each topic is independent, and can be read separately if desired. The topics are:

.1 Background.

.2 Central Processors.

.3 Peripheral Units.

.4 Software.

.5 Compatibility with the IBM 1400 Series.

.6 Compatibility within the Honeywell Series 200 and with the Honeywell 800 and 1800.

.7 Pricing Policy.

.2 CENTRAL PROCESSORS

Nine central processors currently form the nucleus of the Honeywell Series 200. Honeywell considers that these processors - Models 110, 120, 125, 200, 1200, 1250, 2200, 4200 and 8200 - span a range equivalent to that spanned by the IBM System/360 Models 20 through 65. Listed in Table I are certain central processor tasks and the times required to perform these tasks for each Series 200 processor. Comparable execution times for the System/360 processors can be found in Table I of the IBM System/360 report, Section 420:011.

All of the character-oriented Series 200 central processors use add-to-storage logic. There is no addressable accumulator. Both instructions and operands can be of variable length. Operand lengths are not specified in Series 200 instructions; instead, most operations are terminated when the processor senses a word mark, item mark, or record mark in the operand field. Table II summarizes the principal distinguishing characteristics of the nine central processors of the Series 200.

.21 Model 110

The Honeywell Model 110 is a card, tape or disk - oriented computer system, which can handle one or two input-output operations simultaneously with computing. It has 6 index registers; the basic core storage capacity is 4,096 characters, and is expandable to 32,768 characters. Core storage cycle time is 4 microseconds per character. The Model 110 Disk system, consisting of one Disk Pack Control and one or two Disk Pack Drives, provides 9.2 million characters of on-line storage, and can transfer data at the rate of 147KC. Peripheral equipment which can be connected to the Model 110 Processor consists of a printer, card equipment, and up to four tape units with a tape control unit. The console, which is a control and communication center for use with the Model 110 system, includes a typewriter which transmits and records instructions and data between the operator and the computer. The Model 110 Processor can be connected to another Series 200 computer, or to a data communications network. The rental for standard Model 110 systems ranges from about $2,405 per month for a 8K card system to about $4,520 per month for a 16K, 2-disk system. Deliveries of the Model 110 Processor started in August, 1968.

.22 Model 120

The Honeywell Model 120 is primarily a tape- or disk-oriented computer system with the ability to control two or three input-output operations concurrently with processing. Automatic processor interrupt facilities are also provided. The Model 120 has 6 index registers and a core storage capacity of 2,048 to 32,768 characters. Core storage cycle time is 3 microseconds per character. The Model 120 Processor can be connected to any of the Series 200 peripheral devices, to another Series 200 computer, or to a data communications network.

The Model 120 is a general-purpose data processing system, able to operate either as an independent, stand-alone system or as a satellite in an integrated operation. The rental for typical Model 120 systems ranges from about $3,800 per month for a 8K card system to about $3,400 per month for a 8K, 4-tape system. Deliveries of the Model 120 Processor started in February 1966.

The Model 120 contains built-in peripheral device control units to regulate the operations of a 450-line-per-minute printer, a 400-card-per-minute reader, and a 100 to 400 card-per-minute card punch. A built-in magnetic tape control unit is optionally available to control up to four 13.3KC magnetic tape units. In addition to the control units already mentioned, either of two optional features permits the connection of up to six more standard Series 200 peripheral device control units.

.23 Model 125

The Model 125 is a faster version of the Model 120. It has a 2.5 microsecond cycle time and can control up to four input-output operations concurrently with processing. The Model 125 has up to six index registers and a core storage capacity of 4,096 to 32,768 characters.

Like the Model 120, the Model 125 is a general-purpose data processing system, able to operate either as an independent stand-along system or as a satellite in an integrated operation. Monthly rental for a Model 125 Processor is about $600 higher than that of the corresponding Model 120 Processor. Delivery of the Model 125 is 90 days from the date of order.

The Model 125 contains integrated controls for printers and card devices. In addition, both magnetic tape units and disk devices are available with this processor. Among the available magnetic tape units are the new Honeywell 204B-15 and 204B-16 magnetic tape units, which transfer data at a rate of 26,700 characters per second.

.24 Model 200

The Model 200 is a card-, tape- or disk-oriented computer system with the ability to control either three of four input-output operations concurrently with processing. It has 15 index registers and a core storage capacity of 4,096 to 65,536 characters. Core storage cycle time is 2 microseconds per character. The Model 200 Processor can be connected to any of the Series 200 peripheral devices, to another Series 200 computer, or to a data communications network.

The Model 200 is suitable for use either as an independent, stand-alone system or as a satellite system in an integrated operation. The rental for typical Model 200 systems ranges from about $4,000 per month for a 8K card system to $14,600 per month for a 32K, 8-tape system. Deliveries of the

TABLE I: ARITHMETIC EXECUTION TIMES FOR THE SERIES 200 PROCESSORS

TASK (Times expressed in microseconds)	CENTRAL PROCESSOR MODEL 110	120	125	200	1200	1250	2200	4200	8200**
Fixed Point Binary									
c=a+b	156	123	103	84	63	63	51	12 to 16	3.12 to 4.62
c=axb	#	#	#	#	#	#	#	#	7.37 to 8.00
c=a/b	#	#	#	#	#	#	#	#	17.12 to 18.62
Fixed Point Decimal									
c=a+b	156	123	103	84	63	63	51	12 to 16	3.12 to 0.62
c=axb	#	3,100 (s)	2,580 (s)	480	360	360	244	82 to 86	7.37 to 8.00
c=a/b	#	3,700 (s)	3,080 (s)	1,148	900	900	600	59 to 63	18.12 to 18.75
Floating Point Binary									
c=a+b	#	#	#	#	84*	84*	56*	9 to 13	4.0 to 11.75
c=axb	#	#	#	#	120*	120*	81*	13 to 20	8.75 to 9.37
c=a/b	#	#	#	#	149*	149*	99*	18 to 22	16.50 to 18.00
Radix Conversion									
Decimal to Binary	#	#	#	#	60*	60*	40*	14	15.75 to 17.25
Binary to Decimal	#	#	#	#	60*	60*	40*	9	11.50 to 13.00

(s) Subroutine times; hardware facility not available.
Hardware facility not available; subroutine times not provided.
* With optional feature.
** Times are for 8200 Word Processor Subsystem; range of times reflects the use of maximum memory bank interleaving to the use of no interleaving.
Note: All decimal operands are considered to be five digits in length.

TABLE II: SUMMARY OF SERIES 200 PROCESSOR CHARACTERISTICS

Processor Model	Main Memory Speed (cycle time)	Memory Capacity (thousands of characters)	Maximum Number of Peripheral Controllers Accepted	Max. No. of I/O Operations Simultaneous with Computing	Advanced Programming Instructions	Financial Edit Instruction	Multiply and Divide Instructions	Scientific Processing Instructions	Memory Protect Facility	Extended Multiprogramming and 8-Bit Transfer Capability
110	4 microseconds	4 to 32	1	2	*	*	-	-	-	-
120	3 microseconds per character	2 to 32	9	3	*	*	-	-	-	-
125	2.5 microseconds per character	4 to 32	9	4	*	*	-	-	-	-
200	2 microseconds per character	4 to 65	16	4	*	*	Standard	-	-	-
1200	1.5 microseconds per character	16 to 131	16	4	Standard	Standard	Standard	*	*	.
1250	1.5 microseconds per character	32 to 262	32	6	Standard	Standard	Standard	*	*	.
2200	1 microsecond per character	16 to 262	32	8	Standard	Standard	Standard	*	*	*
4200	750 nanoseconds per 4 characters	131 to 524	96	16	Standard	Standard	Standard	*	*	*
8200 word processor	750 nanoseconds per 8 characters	262 to 1,048	96	34	-	-	Standard	*	Standard	*

- Feature not available on this model.
* Feature optionally available.

new Model 200 Processor began in November 1965. The noteworthy changes between the original Model 200 Processor and this version are the inclusion of automatic interrupt facilities, an 8-bit compatibility feature, and multiply/divide instructions as standard equipment.

.25 Model 1200

The Model 1200 is a tape- or disk-oriented computer system with the ability to control four input-output operations concurrently with processing. It has 15 or 30 index registers, an automatic interrupt system, and a core storage capacity of 16,384 to 131,072 characters. Core storage cycle time is 1.5 microseconds per character. A floating-point arithmetic option is available. The Model 1200 Processor can be connected to any of the Series 200 peripheral devices, to another Series 200 computer, or to a data communications network.

The Model 1200 is a general-purpose data processing system, able to operate either as a stand-alone system or as part of a larger, integrated operation. The rental for typical Model 1200 systems falls between $5,000 per month for a 16K, card system and $16,000 per month for a 98K, 10-tape system. Deliveries of the Model 1200 Processor began in January 1966. Compared to the Model 200 Processor, the Model 1200 offers increased core storage speed and capacity, the optional availability of floating-point instructions for scientific applications, optional table look-up facilities that permit IBM 1410 "Liberation," a Memory Protect facility that provides 15 additional index registers, and an extended multi-programming and 8-bit transfer hardware feature.

.26 Model 1250

The Model 1250 adds to the capabilities of the Model 1200 with a main memory capacity ranging from 32,768 to 262,144 characters. Expanded I/O capabilities enable the 1250 to perform up to six input-output operations concurrently with processing. Core storage cycle time is 1.5 microseconds. In addition, the Model 1250 includes a 16- to 37- register control memory with a cycle time of 500 nanoseconds. Monthly rental for a Model 1250 Processor is about $200 higher than that of the corresponding Model 1200 Processor. Deliveries of the Model 1250 began in July 1968.

.27 Model 2200

The revised Model 2200 is primarily a tape- or disk-oriented computer system with the ability to control either four or eight input-output operations concurrently with processing. It has either 15 or 30 index registers, an automatic interrupt system, and a core storage capacity of 16,384 to 262,144 characters. Core storage cycle time is 1 microsecond per character. All options currently available with the Model 1200 are also available with Model 2200. The Model 2200 Processor can be connected to any of the Series 200 peripheral devices, to another Series 200 computer, or to a data communications network.

The Model 2200 is a general-purpose system, able to operate either as a stand-alone system or as part of a larger, integrated operation. The rental for typical Model 2200 systems ranges from about $8,900 per month for a 16K, 6-tape system to about $17,700 per month for a 70K, 10-tape system. Deliveries of the Model 2200 Processor started in December 1965.

.28 Model 4200

The Honeywell Model 4200 is a medium-scale disk-oriented computer system with the ability to control either 8 or 16 input-output operations simultaneously with processing. It has either 15 or 30 index registers, automatic interrupt capabilities, and a core storage capacity of 131,072 to 525,288 characters.

The core storage cycle time is 0.75 microsecond, and 4 characters are accessed in parallel. All options currently available with the Models 1200, 1250 and 2000 are also available with the Model 4200, although the table lookup instructions are included as standard equipment with the 4200. Additional features in the Model 4200 include an electronically alterable read-only memory with an access time of 0.125 microseconds; interleaving of addresses across main memory modules; overlapping of main memory accesses; and true simultaneous memory access by both the central processor and the input-output controller. A separate maintenance processor monitors peripheral operations and automatically assumes control of malfunctioning input-output equipment without affecting the rest of the system.

The Model 4200 is designed as a general-purpose system, able to operate either as a stand-alone system or as the master system in an integrated operation. The rental for typical Model 4200 systems ranges from approximately $25,000 to $36,000 per month. Deliveries of the Model 4200 Processor started in September 1968.

.29 Model 8200

The 8201 Central Processor consists of five independent functional units: a 48-bit word-oriented processor, a variable-length-field (VLF) processor, a memory subsystem, an input/output controller, and a hardware/software master control facility that coordinates the activity of the other units. Communication between units is effected by means of program interrupts and control instructions.

The word-oriented processor utilizes a three-address instruction similar to that used with the older Honeywell 800 and 1800 processors. Each instruction can consist of either one 48-bit word (normal mode) or one 96-bit double word (extended mode), depending on whether 12-bit or 24-bit operands have been specified. Performance of the 8200 is substantially higher than that achieved by the 800 or 1800, because of the faster main memory of the 8200 (750 nanoseconds as compared to 6 microseconds and 2 microseconds) and because of interleaved memory accesses among up to eight independent memory modules.

Eight independent groups of control registers, with 32 registers per group, permit up to eight independent user programs to be run concurrently, with minimal switching time required when transferring control between programs. Such transfer of control is performed entirely by hardware, with no central processor delay imposed. The 24-bit length of all control registers enables explicit referencing of all main memory locations (from 262,144 to 1,048,576 characters), and also provides facilities for indexed and/or indirect addressing.

The master control facility of the Honeywell 8200 is the ninth group of word processor control registers. Master control consists of independent, specialized control registers that, together with the master control program, coordinate the overall activities of the system. The master control facility controls and monitors the interactions of the word and VLF processing subsystems and the input-output controller. This facility also sets memory partitions so as to allocate blocks of memory (512 word or 4,096 characters) to individual program control groups as part of an effective memory protect scheme. In addition, the master control facility supervises the issuing of peripheral commands and device assignments, diagnoses program and memory usage violations, and maintains identification information regarding protected memory areas.

The variable-length-field (VLF) processor within the 8201 Central Processor qualifies the 8200 as a multiprocessor system whose facilities are shared by the two main (word and character) processors. The VLF processor is identical in most respects with the Honeywell 4200 Processor (see .27 above) and provides the only real relationship with the remainder of the Honeywell Series 200. Model 4200 programs that are not time-dependent can be executed directly by the Model 8200 VLF processor without reassembly or recompilation. The VLF processor contains a single group of 45 program control registers, and permits the concurrent operation of multiple character-oriented programs through interrupt-controlled multiprogramming. The VLF processor can serve the 8200 word processor by controlling all input-output operations in a data communications system in the manner of a powerful data communications controller. Except for this case, Honeywell does not expect the Model 8200 word and VLF processors to work in constant communication while executing a single program. However, it is entirely possible and highly desirable for all slow-speed input-output data transfers and associated character-manipulation operations to be performed by the VLF processor. The powerful processing capabilities of the word processor can then be better utilized by handling input-output data batched on high-speed magnetic tape or mass storage devices.

Like the Model 4200, the Model 8200 includes a separate maintenance processor to allow maintenance and repair of peripheral devices without interference with central processor and other system operations.

One of Honeywell's design goals for the Model 8200 is to provide a powerful "third generation" system for users of its earlier 800 and 1800 computer systems. However, its powerful multiprogramming facilities and the concurrent, independent operations of its major system component have already attracted new Honeywell customers. The rental prices for typical Model 8200 systems are expected to parallel those of the IBM System/360 Model 65 (i.e., between $39,000 and $51,000 per month). Deliveries of the Model 8200 system will start in the second quarter of 1969.

.3 PERIPHERAL UNITS

With the exeeption of the Model 110, the main peripheral units available for use in Honeywell Series 200 systems are listed in Table III. Any of the peripheral devices can be used with any of the Series 200 processors, except Types 111, 113, and 114. Each peripheral device or controller requires one or two unit power loads and one or two address assignments: one address assignment for input or output only; two address assignments for two-way data transfers. Table II shows the maximum number of peripheral controllers accepted by each processor model.

Four different series of magnetic tape units are available for Series 200 systems. The 204A Series units are compatible with the 3/4-inch tape used in Honeywell 400, 1400, 800, and 1800 systems, while the 204B Series units provide compatibility with the 1/2-inch, 7-track tape used in IBM 1400 and 7000 Series systems. The 204B-17 and 18 Tape Drives are for use with the Model 110 only. The 204C Series units are 1/2-inch 9-track tape units that are compatible with the IBM 2400 Series magnetic tape units used with the System/360. The 204D Series consists of 1600 BPI, 9-channel tape units. The 204D-3 Magnetic Tape Unit is designed for use on the entire Series 200 line; the 204D-5 is for use with the Model 4200 and 8200 systems, while the 204D-1 can be used either on small, self-contained systems or on satellite systems of larger computers.

Mass Storage facilities are provided by the large Model 261/262 Disk Files, Models 155, 257, 258, 259, 273, and 275 Disk Pack Drives, Model 270A Random Access Drum, and Models 265, 266 and 267 High-speed Drums. The disk devices provide between 3.68 and 300 million characters of storage with average access times ranging between 62.5 to 117.5 milliseconds. The Model 270A Drum Storage Unit has an average access time of 31 milliseconds and a data transfer rate of 111,000 characters per second.

The Model 288 Data Station consists of a remote terminal that can provide console typewriter input and output, paper tape equipment, punched card and optical code readers, and a line printer. Its function is to connect remote locations directly to the computer room and, potentially, to provide direct connections between the computer itself and programmers or operators at the remote locations. Such a data communications link, which permits the processing of considerable volumes of data without involving the costs of a full computer system at the remote location, clearly can be used in many ways and can lead to major changes in a firm's data processing operations. The implications of this unit in any particular situation require special consideration on a systems level.

In addition to the Model 235 Optical Journal Reader Control, the Model 238 Control Unit for the IBM 1287 Optical Reader, and the Honeywell Teller Terminal Equipment, recent significant additions to the Honeywell Series 200 line of peripheral devices include the Model 232 MICR Reader/Sorter and Control, Model 233-2 MICR Control Unit for the Burroughs B103 Sorter/Reader, the Model 234 Control for the Calcomp Series 500 Plotter, the Model 237 Bill Feed Control for the IBM 1404 Alphanumeric Printer, and the 289 Series of Data Communication Station units.

The Model 235 Optical Journal Reader Control permits a National Cash Register Model 420-1 or 420-2 Optical Journal Reader to operate on-line with any Honeywell Series 200 processor. The NCR Model 420 Readers read printed journal tapes from cash registers, accounting machines, and adding machines at a maximum speed of 26 printed journal tape lines per second for the Model 420-1 and 52 lines per second for the Model 420-2. Data is transferred from the Journal Reader memory to the Series 200 processor by the Model 235 Control, which has a maximum data transfer rate of 83,300 characters per second.

The Model 238 Control Unit allows either Model 1 or Model 2 of the IBM 1287 Optical Reader to be operated on-line with any Honeywell Series 200 processor. The Model 1287, when equipped with appropriate optional features, can read intermixed handwritten, machine-printed, imprinted, and optical-mark fields. It is described in detail in Paragraph 420:105.127 of the IBM System/360 Report.

The Model 232 MICR Reader/Sorter and Control reads and sorts documents printed with magnetic ink in standard E-13B font; the reading speed is 600 documents/minute.

The Honeywell Teller Terminal Equipment for banking applications operates on-line with any Honeywell Series 200 processor, and consists of one or two Model 375 Junction Control Units which can connect up to 6 or 10 Model 370 Teller Registers to a transceiver that relays the information to the central processor in 10-bit modified ASCII code. Transmission speed at distances of up to 200 feet is 120 characters per second. In addition, a remote connection can be used for asynchronous transmission at up to 1200 bits per second over half-duplex communication lines. The Teller registers optionally can operate off-line to perform cross-footing and to maintain teller transaction accumulations.

The display equipment available for the Series 200 is manufactured by Bunker-Ramo Corporation and marketed by Honeywell. The line consists of five Display Stations. Models 303, 304, 311, and 312 feature keyboard input and cathode-ray tube alphameric data display capabilities. The fifth Display Station, the Model 317, does not have a keyboard and cannot be used to generate inquiries. Editing features permit a non-destructive cursor or entry marker to be moved to any character position on the display screen for character correction or deletion purposes. From 32 to 768 characters can be displayed at one time, with the exact display size determined by unit model number and display arrangement. Each displayed character is regenerated on the screen more than 40 times per second.

The data communications equipment available for the Series 200 includes single-line and multi-line communication controls compatible with TELEX, TWX, and voice-grade lines. Although the Series 200 uses 6-bit characters as its basic data format, a special pair of instructions in all processors allows for the use of ASCII (7-bit) codes or other codes with up to 12 bits per character. Instruction facilities are also available for defining message control characters at the time the message is being transmitted. This permits simple matching of codes with most currently available data communications equipment.

.4 SOFTWARE

Software for the Honeywell Series 200 is currently organized in five principal levels of support, which are designated in order of increasing power and comprehensiveness: Basic Programming System, Operating System - Extended Mod 1, Operating System - Mod 2 Extended, Operating System - Mod 4, and Operating System - Mod 8. Within each of these five levels of software, several system control routines, language processors, and service routines are included. Moreover, there are in many cases several versions of the same basic software program within each major level. One reason for the provision of multiple versions of a basic software program within each operating system is the use of two-, three-, or four-character addresses within Honeywell Series 200 instructions, depending upon the number of core storage locations that must be accessed in a particular system. As a result, the same assembly language, for example, can have one or more assembler programs associated with it, depending on the size of the instruction addresses to be generated. Users of small-scale systems can choose to use exclusively software programs that generate two-address instructions, and thus they can conserve core storage space by always using instructions of relatively short length.

In addition, two levels of the Operating System - Extended Mod 1 and the Operating System - Mod 2 Extended are available: one to operate on tape-oriented systems and another for systems which include mass storage devices.

Most of the components of the Basic Programming System and the magnetic tape version of Operating System - Mod 1 have been available and in steady use with Series 200 systems for three years or more. In view of new and powerful software facilities offered by its competitors, Honeywell has gone on and developed versions of the Operating System - Mod 1 and Operating System - Mod 2 Extended to take advantage of the software flexibility and power inherent in mass storage devices. Also, a message-mode facility for data communications applications has been developed to enhance the real-time processing capabilities of both the Mod 1 and Mod 2 Extended Operating Systems by permitting the transmission of entire message sequences, as opposed to character-by-character transmission.

Operating System - Mod 1, Operating System - Extended Mod 1, and Operating System - Mod 2 Extended are available and in use. The new Operating System - Mod 4 provides a multiprogramming system for Honeywell's large scale computers, while the Operating System - Mod 8 supports the Honeywell Model 8200 system.

.41 Basic Programming System

Programs within the Basic Programming System are designed to operate within from 4K to 12K characters of core storage; these programs can utilize up to 32K characters of core storage. Versions of the component programs are provided in either the two- or three-character addressing mode. The Basic Programming System is designed for punched card-oriented Series 200 users. Operator intervention is generally required to effect transition from one program to the next.

The principal programs offered with the Basic Programming System are listed below.

- A software system called Easytab permits efficient transition from off-line tabulating equipment to a Series 200 computer system. Easytab consists of a number of utility routines that perform common functions of unit record equipment, and a "built-in" compact COBOL compiler that operates in an 8K-character storage environment.

- The Bridge and Easytran program translators, described in Paragraph .5, provide program compatibility with the IBM 1401.

- The Easycoder Assemblers provide close source-language compatibility with the assembly programs offered with the larger Series 200 operating systems. Eventual transition to the larger operating systems is therefore simplified.

- The Simultaneous Media Conversion A program permits the concurrent operation of up to three data transcription routines. Use of this program increases the efficiency of small Series 200 systems that serve as satellites to larger computer systems. File-to-file transcription facilities are included for the following devices: both 3/4-inch and 1/2-inch magnetic tape units, line printers, punched card units, and paper tape equipment.

- A Report Program Generator (RPG) provides report-writing capabilities that are similar to those provided with IBM 1401 Report Generators. The report format specification sheets are also similar to those used with the 1401 system.

.42 Operating System - Mod 1

The Honeywell Series 200 Operating System - Mod 1 functions within from 12K to 65K characters of core storage. Honeywell currently provides two significantly different versions of this software package.

The magnetic tape-oriented version was announced with the original H-200 system as a package called PLUS (Program Loading, Updating, and Selection System). The larger tape-oriented version of Operating System - Mod 1 contains many more facilities than the original PLUS package. Independent programs are included within this new software to control automatic job sequencing, program retrieval and loading, overlay handling, and program library maintenance. Some programs within the Operating System - Mod 1 are supplied in two or three versions. This variety is provided because of the three- and four-character addressing options, the presence or absence of floating-point hardware (for FORTRAN processors), and the desire to make available a choice of language facilities at various program design levels. COBOL D, for example, operates in a 16K-character memory environment and offers 270 language elements; COBOL H, by contrast, operates in a 32K environment and offers 346 language elements.

The second and newer version of Operating System — Mod 1 makes extensive use of an auxiliary mass storage device in its centralized software control system. The core-resident portion of the Mass Storage Resident Operating System — Mod 1 requires only 1,500 characters of core storage. Approximately 2.9 million characters of random-access auxiliary storage are also required to utilize this system.

TABLE III: PRINCIPAL SERIES 200 PERIPHERAL UNITS

PERIPHERAL TYPE	MODEL NO.	NAME	CHARACTERISTICS
Random Access Storage	155	Disk Pack Drive	3.68 million characters of storage; 117.5 msec.average access time.
	257	Disk Pack Drive	4.6 million characters of storage; 77.5 msec average access time.
	261	Disk Files	150 million characters of storage; 78 msec average access time.
	262	Disk Files	300 million characters of storage; 78 msec average access time.
	258	Disk Pack Drive	4.6 million characters of storage; 92 msec average access time.
	259	Disk Pack Drive	9.2 million characters of storage; 92 msec average access time.
	259A	Disk Pack Drive	9.2 million characters of storage; 97 msec average access time.
	273	Disk Pack Drive	18.4 million characters of storage; 62.5 msec average access time.
	275	Disk Pack Drive	18.4 million characters of storage; 62.5 msec average access time.
	270A	Random Access Drum	2.6 to 20.4 million characters; 25 msec average access time.
	265	High-speed Drum	2.1 million characters of storage; 8.6 msec average access time.
	266	High-speed Drum	4.2 million characters of storage; 8.6 msec average access time.
	267	High-speed Drum	4.2 million characters of storage; 8.6 msec average access time.
Punched Card Equipment	123	Card Reader	reads 400 cpm.
	123-2	Card Reader	reads 600 cpm.
	227	Card Reader/Punch	reads 800 cpm; punches 250 cpm.
	223	Card Reader	reads 800 cpm.
	223-2	Card Reader	reads 1,050 cpm.
	224-1	Card Reader/Punch	reads 300 cpm; punches 50 to 270 cpm.
	224-2	Card Reader/Punch	reads 400 cpm; punches 91 to 360 cpm.
	214-1	Card Punch	punches 100 to 400 cpm.
	214-2	Card Reader/Punch	reads 400 cpm; punches 100 to 400 cpm.
Punched Paper Tape Equipment	209-2	Paper Tape Reader	reads 600 char/sec.
	210	Paper Tape Punch	punches 110 char/sec.

(Contd.)

TABLE III: PRINCIPAL SERIES 200 PERIPHERAL UNITS (Contd.)

PERIPHERAL TYPE	MODEL NO.	NAME	CHARACTERISTICS
Printers	122 Series	Printers	print 300, 450 lpm.
	222 Series	Printers	print 450, 650, 950 or 1100 lpm.
	229	Printer	prints 400 lpm; available to Educational market only.
Magnetic Tape Units	203A Series	Magnetic Tape Control Units	for use with 204A-series tape.
	204A Series	Magnetic Tape Units	use 3/4-inch tape; compatible with H-400/1400 and H-800/1800 systems; transfer rates of 32, 64, and 88 KC.
	204B Series	Magnetic Tape Units	use 1/2-inch tape; compatible with IBM 729 series; transfer rates of 4.8 to 144 KC.
	204C Series	Magnetic Tape Units	use 1/2-inch tape; compatible with IBM 2400 series; transfer rate of 28.9 KC.
	204D Series	Magnetic Tape Units	9 channel-transfer rates of 77, 154, and 224 KC.
Data Communication	281	Single-Channel Communication Control	controls 1 half-duplex line at up to 5,100 char/sec.
	286	Multi-Channel Communication Control	controls up to 63 lines, at up to 300 char/sec per line; maximum aggregate data rate is 7,000 char/sec.
	288-1	Central Control Unit	transmission speed, 120 characters/second.
	288-3	Central Control Unit	transmission speed, 250 or 300 characters/second.
	289-2	Printer and Keyboard	transmission speed, 10 characters/second (100 wpm).
	289-2A	Central Control Unit Keyboard	transmission speed, manual typing speed input; no output.
	289-3	Printer	transmission speed, 40 characters/second (400 wpm) input; manual typing speed output.
	289-4	Paper Tape Reader and Spooler	transmission speed, 120 cps max.
	289-5	Paper Tape Punch and Spooler	transmission speed, 120 cps max.
	289-7	Card Reader	transmission speed, approximately 100 cards/min max.
Other	220 Series	Console with Typewriter	10 cps typing rate; 64 characters/line.

TABLE III: PRINCIPAL SERIES 200 PERIPHERAL UNITS (Contd.)

PERIPHERAL TYPE	MODEL NO.	NAME	CHARACTERISTICS
	232	MICR Reader/Sorter and Control	reading speed, 600 documents/minute
	233-2	MICR Control	allows Burroughs B103 Sorter/Reader to operate with Series 200 Central Processor. Up to 1,560 documents/minute.
	234	Plotter Control	enables Colcomp series 500 Plotters to operate with Series 200 Central Processor.
	235	Optical Journal Reader Control	directs operation of NCR 420 Optical Journal Reader with Series 200 Central Processor.
	237	Bill Feed-Printer Control	enables IBM 1404 alphanumeric printer to operate with Series 200 Central Processor.
	238	Optical Reader Control	controls the IBM 1287 Optical Scanner when used with the Series 200 system.

Provided with the Mass Storage Resident version of Honeywell's "Mod 1" software are assemblers, COBOL and FORTRAN language processors, and general utility programs that are comparable to offerings in the Tape Resident version of the same operating system. The chief difference between the two versions lies in the fact that the Mass Storage Resident operating system provides integrated system control routines. Among the functions performed by these routines are the following:

- Program loading.
- Automatic job stacking.
- Data management of sequential, indexed sequential, and direct access files.
- Generating of common output from all assemblers and compilers.

All versions of the Operating System — Mod 1 are currently in use with Honeywell Series 200 systems.

.43 Operating System - Extended Mod 1

The Extended Mod 1 (MSR) Operating System is designed to provide foreground/background multiprogramming for Honeywell Models 1200, 1250, and 2200. When used in the multiprogramming mode, program protection is provided through the hardware. The system is completely compatible with existing Mod 1 (MSR) and Mod 1 (TR) programs. The Mod 1 (MSR) systems programs operate in the background; only 8K characters of memory are required by the Extended Mod 1 (MSR) Supervisor.

Both FORTRAN and COBOL Compilers are available for the Extended Mod 1 (MSR) Operating System. The FORTRAN Compiler is an improved version of the FORTRAN Compiler H in the Mod 1 (MSR) Operating System; it compiles as a background program, and has object-time disk I/O. The COBOL Compiler is an improved version of the Mod 1 (MSR) COBOL Compiler I; the source and library update functions and compilation are executed as background programs, while the object code generated by the compiler can be a background or foreground program. The addition of the USASI standard CALL and CANCEL verbs eliminate the need for link loading under the Extended Mod 1 Operating System.

System generation is facilitated by the fact that two tapes are provided with each system, a Binary Run Tape (BRT), and a source tape. By specifying the system functions desired, a user can generate his particular system at system load time; the appropriate executable modules (pre-assembled by Honeywell), are prepared for transcription to the disk and bootstrapped into memory. Updating or modifying is accomplished by updating the source code tape, assembling the appropriate modules and placing them on the BRT. Specific system tailoring for different configurations is achieved easily by generating memory resident linkage tables; lengthy assemblers are not necessary.

.44 Operating System — Mod 2 Extended

The Mod 2 Extended medium-scale software system operates with Models 1200, 1250, 2200, and 4200 computer systems that have at least 49K and 64K characters of core storage, respectively, and Honeywell's Optional Instruction Package.

Mod 2 Extended operates in a combined tape and mass storage environment, using a minimum of one disk device and three magnetic tape units. It can supervise the concurrent processing of two independent stacked job streams.

FORTRAN and COBOL compilers and an assembler are provided in improved versions with Mod 2 Extended, offering additional language facilities and efficiencies that are possible only with large core memories. The output of all system programs is produced in common-format relocatable program blocks. An Easyauto translator program converts IBM 1410 and 7010 assembly language programs into source-language programs which can be assembled and run either on an IBM 1410/7010 system or a Honeywell Series 200, Model 1200, 1250, 2200, or 4200 system. In addition, Operating System — Mod 2 Extended provides a high-performance sort routine for use on magnetic tape or mass storage devices, and several utility routines to facilitate the use of mass storage devices.

The components of Operating System — Mod 2 Extended are divided into those of a supervisory nature and those of a processing nature. The supervisory components include a Resident Monitor, Transitional Monitor, Input/Output Control System, Communications Supervisor, and Data Transcription Supervisor. Processing components comprise Language Processors for Assembler L, Easycoder L, COBOL Compiler L, FORTRAN Compiler L, and Report Generator L. The important aspects of the system are stacked-job processing, program modularity, mass storage support, and multiprogramming. Three methods of file access are available: sequential, direct, and indexed sequential.

.45 The Operating System — Mod 4

The Mod 4 Operating System is an integrated, modular, multiprogramming system which can execute up to 20 independent programs concurrently. The system maintains dependent program and data compatibility with the Mod 2 Extended Operating System. Programs written in COBOL, FORTRAN, Easycoder, Assembler and RPG for the Mod 2 (Extended) can be run under Mod 4 without modification. The Mod 4 job control language and messages are compatible with those of Mod 2 (Extended). Jobs can be entered from a remote terminal into any user partition. A basic accounting routine, which the user incorporates into his system, is provided as a standard feature. Four kinds of restarts are offered: system, job, job step, and checkpoint. Dynamic resource allocation is performed on a job basis. The user can allocate time to partitions on a linear, round-robin, or combination basis.

Memory in the Mod 4 Operating System is divided into two principal areas — one for the user, one for the system. The system resident area can be as small as 40K.

The job control function in the Mod 4 Operating System is performed by four nonresident system components, in conjunction with the resident components. These nonresident components are: Input Reader, Scheduler, Transitional Monitor, and Output Writer. The Input Reader can run in any available partition of 12K or more characters. When a job is initiated in a partition by the Scheduler, the Transitional Monitor is brought into the partition to prepare the job for the execution of its first job step. The Output Writer transcribes the contents of the Job Output Files onto the device specified by the user.

The Mod 4 Input/Output File Control System consists of program modules which supervise all input/output processing in the system and provide the overlapping of I/O operations necessary in a multiprogramming environment.

The standard access method of Mod 4 services three types of file organizations: sequential, indexed sequential, and direct.

.45 Operating System — Mod 8

The fifth level of software available for Honeywell Series 200 systems is designated the Operating System — Mod 8. Mod 8 is specially designed for use with the hybrid Model 8200 system. Facilities included within the Mod 8 control system will supervise the operations of both the word processor of the Model 8200 and the variable-length-field (VLF) character processor (which bears close resemblance to a Model 4200 processor). Mod 8 will function primarily as a mass storage resident system, requiring at least two Type 259 Disk Pack Drives. The system also requires the use of about 8,192 48-bit words of internal core storage for permanent residence. Other peripheral devices required for operation of Mod 8 include at least six 1/2-inch magnetic tape units, one card reader, and one printer.

Among the more important functions of the Operating System — Mod 8 are the following:

- Multiprogramming control for up to nine user programs.
- Dynamic scheduling of computer usage according to job priorities and equipment availability.
- Automatic allocation of memory; special register groups, and peripheral equipment to the scheduled programs.
- Handling remote batch processing and data communications operations.
- Loading and relation of program segments.

.46 Applications Software

Honeywell offers users of Series 200 computer systems an exceptionally large selection of applications packages for use in the manufacturing, education, hospital, banking, utilities, insurance, retailing, petroleum, and transportation industries. Honeywell estimates that approximately 70 such programs are currently available. The core storage requirements for use of these programs generally range between 8K and 32K characters, although some programs performing very large and complex tasks can require as much as 65K characters of core storage. Use of these application programs is not restricted to any one operating system; in general each application will run under any Series 200 operating system provided the program's minimum core storage and configuration requirements are met.

Many of Honeywell's application programs constitute completely integrated management information and control systems composed of modular subroutines which can be selectively chosen according to the specific needs of each user.

Some examples of Honeywell-supplied applications software include the following:

Manufacturing —

FACTOR: an integrated Factory Management System which includes subroutines for performance accounting, inventory control, sales forecasting, management planning, production scheduling and control, and on-line data collection.

General Distribution —

SALE: a package developed to direct the even flow of merchandise from warehouse to retail store.

TIP and LIMIS: a comprehensive system of programs for processing life insurance transactions. LIMIS has random access and data communication capabilities.

HOSPITAL INFORMATION SYSTEM: will include approximately 100 subprograms to perform business functions common to most hospitals.

(Contd.)

TRUMP: a teller-register unit monitoring program controlling more than 80 on-line banking operations and peripheral devices.

GENPAY: an application package consisting of 13 programs which handles an entire multi-payroll operation in one cycle.

.5 COMPATIBILITY WITH THE IBM 1400 COMPUTER SERIES

The IBM 1400 Series of computers, consisting of the 1401, 1410, 1440, and 1460 processors, is still the most widely-used computer family in the world. All of the 1400 Series processors use a similar data format and instruction set, although each system has certain pecularities designed to make it more suitable for particular functions; e.g., the larger memory size and overlapping operations of the 1410, the orientation toward removable "Disk Pack" cartridges of the 1440, and the higher internal speed of the 1460 relative to the basic 1401.

In the Series 200, Honeywell uses a basic instruction set that is largely identical with the basic IBM 1400 Series instruction set. Honeywell has also adopted the 6-bit character structure used in the 1400 Series, but uses eight bits plus a parity bit to store each 6-bit character. The added bit provides improved punctuation facilities (record marks and item marks in addition to the 1400 Series word marks).

Execution of an IBM 1400 Series program on a Honeywell Series 200 processor can be performed by means of a machine-aided conversion of the program and a subsequent manual checking operation. Normally, the program can then be run on any equivalent Series 200 system that has at least 4,096 extra core storage locations beyond those used by the original IBM 1400 Series program. Production programs, compilers, assemblers, and industry packages can all be converted in this manner. Sorts, data transcription operations, report programs compiled by means of Report Program Generators, and COBOL and FORTRAN programs are more commonly converted by using the original source programs or control cards to derive the necessary input to the equivalent Honeywell software routines; this allows for more efficient use of the capabilities of the Honeywell Series 200 hardware.

Two major types of machine-aided program conversion routines are available from Honeywell: The Bridge and Easytran systems. Bridge conversions can be performed only upon machine-language 1401 or 1460 programs. The program is loaded into the Series 200 computer's core storage in the normal way and is then processed by the special Bridge program. This results in the production of a new program input deck and supporting documentation. The new deck replaces the old program deck when the program is run on the Honeywell System, and otherwise operation continues as before.

By contrast, Easytran conversions are performed upon assembly-language programs. The IBM assembly input deck is processed and converted into a Honeywell assembly-language (Easycoder) deck, and a supporting diagnosis of possible incompatibilities and other problems is produced. After these potential problems have been investigated and the necessary actions have been taken, the amended assembly deck is assembled by the standard Easycoder assembler. The resulting Series 200 program can then be run in the normal manner. Honeywell currently recommends the Easytran conversion process rather than the Bridge machine-language translation technique.

Both Bridge and Easytran conversion routines have already been widely and successfully used for converting IBM 1401 and 1460 programs into Series 200 programs. Easytran routines that enable IBM 1410 and 7010 programs to be run on Honeywell 1200, 1250, 2200, and 4200 systems are available. An Easyauto routine also converts IBM 1410 and 7010 programs to Mod 2 Extended assembly language, but also enables the converted program to be assembled and run on either the IBM 1410 or 7010 processors. Disk Sort C is a key sort which sorts items from a mass storage file. Extracted fields of the input item can be sorted, stored, and retrieved with the key fields. An RPG-to-COBOL translator produces Series 200 COBOL source programs from 360-20 cards. These programs are capable of execution within a tape or disk environment.

.6 COMPATIBILITY WITHIN THE HONEYWELL SERIES 200

With the exception of the 110, all the character-oriented computer systems in the Series 200 use the same data format, the same instructions, the same peripheral units, and the same software. As a result, there is a fairly high degree of upward-downward program compatibility, subject to the usual limitations such as the availability of sufficient memory, peripheral equipment, and peripheral address assignments and the degree of time-dependency within the programs.

Three areas of potential incompatibility do exist:

- The addressing system. Different Series 200 processors use two-, three-, or four-character addressing. This provides economies in both storage space and execution time when addressing memory locations with short absolute addresses. However, in moving a program from a small processor to a larger one — particularly when the operating system requires the program to be relocatable — all address sizes and all address constants may need to be changed by hand if the user wishes to make use of the extra storage space for larger tables or other purposes.

- The index registers. Different Series 200 processors may have none, 6, 15, or 30 index registers, depending on the model, the size of core memory, and the inclusion of certain optional features. No provision has been made for simulating the operation of index registers not present in the hardware, so this factor may lead to incompatibilities in moving programs from a larger system to a smaller one.

- The instruction repertoire. A number of instructions are unavailable in the small systems, optional in the medium-price systems and standard in the larger systems. Any program written for a system that includes these instructions may be unable to run on a Series 200 system that either cannot or does not have all the necessary instructions provided in the hardware. No provision has been announced for automatically "trapping" these instructions and using software routines to perform their functions.

The Honeywell Model 8200 computer system is compatible with the rest of the Series 200 systems to the extent that its VLF character-oriented processor can execute directly most non-time-dependent programs that were originally written for execution on a Model 4200 system. The 8200 VLF processor does not have hardware for floating-point arithmetic operations. Therefore, when Model 4200 programs attempt to perform floating-point arithmetic on a Model 8200 system, the instructions involved will be trapped and their operations simulated by software.

In addition, the Model 8200 provides direct machine-language program compatibility with the earlier Honeywell 800 and 1800 computer systems. All non-I/O instructions in H-800/1800 programs can be executed directly by the word processor of the Model 8200; all H-800/1800 input-output instructions are trapped and interpreted by the master control facility of the Model 8200 and reissued in a format acceptable to the 8200.

.7 PRICING

In October 1966, Honeywell announced a major revision of its pricing policy for Series 200 equipment. Notable changes in the new price schedule include a 2 to 4 per cent increase in monthly rental charges, the establishment of uniform equipment purchase prices regardless of when purchased, and an increase in the purchase price for some equipment. Monthly maintenance charges were not increased.

The single purchase price replaces Honeywell's former policy of giving discounts for the outright purchase of equipment, or for purchase during the first year of rental. The new purchase prices, however, remain below those previously charged for purchase of equipment after one year of rental. Moreover, a credit of a percentage of rentals paid to date can still be applied toward the purchase of equipment.

HONEYWELL SERIES 200

CLASS	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
			Processing Units(1)				
PROCESSOR			Model 110:				
	111-1		4,096 Characters	910	810	39,600	93
	111-2		8,192 Characters	1,055	940	45,900	105
	111-3		12,288 Characters	1,310	1,170	57,150	118
	111-4		16,384 Characters	1,575	1,405	68,625	130
	111-5		20,480 Characters	1,780	1,590	77,625	140
	111-6		24,576 Characters	1,990	1,775	86,625	150
	111-7		28,672 Characters	2,195	1,960	95,625	160
	111-8		32,768 Characters	2,400	2,145	104,625	170
		1111	Features for 111 Processors:				
			Advanced Programming Instructions	75	75	3,240	6
		1113	Editing Instructions	50	50	2,160	4
		1119	Simultaneity for Second R/W Channel	225	200	9,900	15
			Model 110-2:				
	114-2		8,192 Characters	1,085	970	47,250	190
	114-3		12,288 Characters	1,345	1,200	58,500	203
	114-4		16,384 Characters	1,605	1,435	69,975	215
	114-5		20,480 Characters	1,815	1,620	78,975	225
	114-6		24,576 Characters	2,020	1,805	87,975	235
	114-7		28,672 Characters	2,225	1,990	96,975	245
	114-8		32,768 Characters	2,430	2,175	105,975	255
			Model 110-3:				
	113-2		8,192 Characters	1,385	1,235	60,300	190
	113-3		12,288 Characters	1,640	1,465	71,550	203
	113-4		16,384 Characters	1,905	1,705	83,025	215
	113-5		20,480 Characters	2,110	1,885	92,025	225
	113-6		24,576 Characters	2,320	2,070	101,025	235
	113-7		28,672 Characters	2,525	2,255	110,025	245
	113-8		32,768 Characters	2,730	2,440	119,025	255
			Model 120:				
	121-1		2,048 Characters	880	795	37,155	86
	121-2		4,096 Characters	1,000	910	42,555	93
	121-3		8,192 Characters	1,270	1,140	53,355	105
	121-4		12,288 Characters	1,520	1,375	64,155	118
	121-5		16,384 Characters	1,780	1,605	74,955	130
	121-6		20,480 Characters	1,980	1,790	83,595	140
	121-7		24,576 Characters	2,190	1,975	92,235	150
	121-8		28,672 Characters	2,390	2,160	100,875	160
	121-9		32,768 Characters	2,600	2,345	109,515	170
			Features for 121 Processors:				
		1011	Advanced Programming Instructions	75	75	3,240	6
		1013	Editing Instructions	50	50	2,160	4
		1014	8-Bit Code Handling Instruction	25	25	1,080	2
		1015	Series 200 Control Unit Adapter	160	140	6,480	15
		1016	Series 200 Control Unit Adapter and R/W Channel	315	280	12,960	30
			Model 120-0:				
	121-0-1		2,048 Characters	830	745	34,905	86
	121-0-2		4,096 Characters	950	860	40,305	93
	121-0-3		8,192 Characters	1,220	1,090	51,105	105
	121-0-4		12,288 Characters	1,470	1,325	61,905	118
	121-0-5		16,384 Characters	1,730	1,555	72,705	130
	121-0-6		20,480 Characters	1,930	1,740	81,345	140

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
			Processing Units (Contd.)				
PROCESSOR (Contd.)			Model 120-0: (Contd.)				
	121-0-7		24,576 Characters	2,140	1,925	89,985	150
	121-0-8		28,672 Characters	2,340	2,110	98,625	160
	121-0-9		32,768 Characters	2,550	2,295	107,265	170
			Features for 120-0 Processors:				
		011-0	Advanced Programming Instructions	75	75	3,240	6
		013-0	Editing Instructions	50	50	2,160	4
		1015-0	Series 200 Control Unit Adapter	160	140	6,480	15
		1016-0	Series 200 Control Unit Adapter and R/W Channel	315	280	12,960	30
			Model 120-3:				
	121A-3		8,192 Characters	1,595	1,440	66,865	205
	121A-4		12,288 Characters	1,850	1,670	77,615	218
	121A-5		16,384 Characters	2,110	1,900	88,365	230
	121A-6		20,480 Characters	2,315	2,085	96,965	240
	121A-7		24,576 Characters	2,520	2,270	105,565	250
	121A-8		28,672 Characters	2,725	2,455	114,165	260
	121A-9		32,768 Characters	2,930	2,640	122,765	270
			Features for 121A Processors:				
		1015-3	Series 200 Control Unit Adapter	160	140	6,480	15
		1016-3	Series 200 Control Unit Adapter with R/W Channel	315	280	12,960	30
			Model 125(2):				
	126-1		4,096 Characters	1,270	1,150	53,535	118
	126-2		8,192 Characters	1,540	1,380	64,335	130
	126-3		12,288 Characters	1,790	1,615	75,135	143
	126-4		16,384 Characters	2,050	1,845	85,935	155
	126-5		20,480 Characters	2,305	2,080	96,775	165
	126-6		24,576 Characters	2,515	2,265	105,415	175
	126-7		28,672 Characters	2,715	2,450	114,055	185
	126-8		32,768 Characters	2,925	2,635	122,695	195
	126-2-9		40,960 Characters	3,405	3,045	138,600	210
	126-2-10		49,152 Characters	3,870	3,460	157,500	225
	126-2-11		57,344 Characters	4,190	3,745	170,520	240
	126-2-12		65,536 Characters	4,505	4,025	183,330	255
			Features for 126 Processors:				
		1011	Advanced Programming Instructions	75	75	3,240	6
		1013	Editing Instructions	50	50	2,160	4
		1014	8-Bit Code Handling Instructions	25	25	1,080	2
		1017	Simultaneity for Third R/W Channel	160	140	6,480	15
		1018	Auxiliary R/W Channel (Requires Feature 1017)	60	50	2,160	4
			Model 125-3:				
	127-2		8,192 Characters	1,945	1,755	81,485	230
	127-3		12,288 Characters	2,200	1,985	92,235	243
	127-4		16,384 Characters	2,455	2,215	102,985	255
	127-5		20,480 Characters	2,720	2,455	113,950	265
	127-6		24,576 Characters	2,925	2,640	122,550	275
	127-7		28,672 Characters	3,130	2,825	131,150	285
	127-8		32,768 Characters	3,335	3,010	139,750	295
			Features for 127 Processors:				
		1017	Simultaneity for Third R/W Channel	160	140	6,480	15
		1018	Auxiliary R/W Channel (Requires 1017)	60	50	2,160	4
			Model 200:				
	201		2,048 Characters	1,000	895	41,040	76
		202-1	2,048 Character Memory Module. (must be first module added to 201; not more than one 202-1 may be added)	130	120	5,400	6

CLASS	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
			Processing Units (Contd.)				
PROCESSOR (Contd.)			Model 200: (Contd.)				
		202-2	4,096 Character Memory Module (202-1 is a prerequisite; maximum of seven 202-2 Memory Modules per system)	265	235	10,800	13
	201-1		2,048 Characters (multiply/ divide capability)	1,265	1,130	51,840	96
		202-3	2,048 Character Memory Module (must be first module added to the 201-1; not more than one 202-3 may be added)	130	120	5,400	6
		202-4	4,096 Character Memory Module (202-3 is a prerequisite maximum of seven 202-4 Memory Modules per system)	265	235	10,800	13
		202-5	8,192 Character Memory Module (seven 202-4 Modules are a prerequisite; maximum of four 202-5 Memory Modules per system)	320	285	12,960	15
	201-2-1		4,096 Characters	1,410	1,255	57,240	106
	201-2-2		8,192 Characters	1,680	1,500	68,040	119
	201-2-3		12,288 Characters	1,940	1,735	78,840	131
	201-2-4		16,384 Characters	2,205	1,970	89,640	144
	201-2-5		20,480 Characters	2,470	2,205	100,440	156
	201-2-6		24,576 Characters	2,735	2,440	111,240	169
	201-2-7		28,672 Characters	3,005	2,680	122,040	181
	201-2-8		32,768 Characters	3,270	2,920	132,840	194
	201-2-9		40,960 Characters	3,585	3,200	145,800	209
	201-2-10		49,152 Characters	3,905	3,485	158,760	224
	201-2-11		57,344 Characters	4,225	3,775	171,720	239
	201-2-12		65,536 Characters	4,540	4,055	184,680	254
			Features for 201 and 201-1 Processors:				
		011	Advanced Programming Instructions	115	105	4,320	8
		012	Program Interrupt (standard on 201-1)	60	50	2,160	4
		013	Editing Instructions	105	95	3,890	7
		015	Eight Additional Unit Loads of Power	160	145	6,480	12
		016	One Auxiliary Read/Write Channel	60	50	2,160	4
			Features for 201-2 Processors:				
		010	Advanced Programming	115	105	4,320	8
		013	Editing Instructions	105	95	3,890	7
		015	Eight Additional Unit Loads of Power	160	145	6,480	12
		016	One Auxiliary Read/Write Channel	60	50	2,160	4
			Model 1200:				
	1201-1		16,384 Characters	2,775	2,480	112,320	196
	1201-2		32,768 Characters	3,745	3,345	146,880	236
	1201-3		49,152 Characters	4,495	4,015	177,120	271
	1201-4		65,536 Characters	5,305	4,735	205,200	304
	1201-5		81,920 Characters	5,780	5,160	224,640	326
	1201-6		98,304 Characters	6,210	5,545	241,920	346
	1201-7		114,688 Characters	6,585	5,880	257,040	369
	1201-8		131,072 Characters	6,960	6,210	272,160	386
			Features for 1201 Processors:				
		0191	Optional Instruction Package	60	55	2,160	4
		1100	Scientific Unit(3)	460	410	19,350	40
		1100A	Scientific Unit	580	530	24,750	40
		1114	Storage Protection	60	55	2,160	4

CLASS	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
			Processing Units (Contd.)				
PROCESSOR (Contd.)			Features for 1201 Processors: (Contd.)				
		1120	Extended Multiprogramming and 8-Bit Transfer (Requires Feature 1114)	225	200	9,900	35
			Model 1250:				
	1251-1		32,768 Characters	3,975	3,545	156,880	252
	1251-2		49,152 Characters	4,725	4,215	187,120	287
	1251-3		65,536 Characters	5,535	4,935	215,200	320
	1251-4		81,920 Characters	6,010	5,360	234,640	342
	1251-5		98,304 Characters	6,440	5,745	251,920	362
	1251-6		114,688 Characters	6,815	6,080	267,040	385
	1251-7		131,072 Characters	7,190	6,410	282,160	402
	1251-8		163,840 Characters	8,000	7,135	319,400	442
	1251-9		196,608 Characters	8,640	7,705	354,400	482
	1251-10		229,376 Characters	9,205	8,210	390,000	526
	1251-11		262,144 Characters	9,725	8,675	424,000	566
			Features for 1251 Processors:				
		0191	Optional Instruction Package	60	55	2,160	4
		1100	Scientific Unit(3)	460	410	19,350	40
		1100A	Scientific Unit	580	530	24,750	40
		1114	Storage Protection	60	55	2,160	4
		1120	Extended Multiprogramming and 8-Bit Transfer (Requires Feature 1114)	225	200	9,900	35
			Model 2200:				
	2201-1		16,384 Characters	3,775	3,370	153,360	284
	2201-2		32,768 Characters	4,835	4,315	196,560	334
	2201-3		49,152 Characters	5,785	5,170	235,440	379
	2201-4		65,536 Characters	6,695	5,975	272,160	422
	2201-5		81,920 Characters	7,545	6,735	306,720	462
	2201-6		98,304 Characters	8,285	7,395	336,960	497
	2201-7		114,688 Characters	8,820	7,875	358,560	527
	2201-8		131,072 Characters	9,345	8,345	380,160	552
	2201-9		163,840 Characters	10,355	9,245	421,200	599
	2201-10		196,608 Characters	11,155	9,960	453,600	637
	2201-11		229,376 Characters	11,680	10,430	475,200	662
	2201-12		262,144 Characters	12,215	10,910	496,800	687
			Features for 2201 Processors:				
		0191	Optional Instruction Package	60	55	2,160	4
		1100	Scientific Unit(3)	460	410	19,350	40
		1100A	Scientific Unit	580	530	24,750	40
		1115	Second Input/Output Sector (additional four R/W Channels, 16 I/O Address Assignments, and 16 Unit Loads of Power)	115	105	4,320	8
		1117	Storage Protection	60	55	2,160	4
		1121	Extended Multiprogramming and 8-Bit Transfer (requires Feature 1117)	115	100	5,000	17
			Model 4200:				
	4201-3		131,072 Characters	13,285	12,300	567,005	590
	4201-4		196,608 Characters	15,410	14,270	657,725	680
	4201-5		262,144 Characters	17,535	16,240	748,445	770
	4201-5A		262,144 Characters Two-way Interleaving	17,975	16,650	767,160	790
	4201-6		327,680 Characters	19,660	18,205	839,165	860
	4201-7		393,216 Characters	21,785	20,175	929,885	950
	4201-8		458,752 Characters	23,915	22,140	1,020,605	1,040
	4201-9		524,288 Characters Four-way Interleaving	26,040	24,110	1,111,325	1,130

CLASS	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
			Processing Units (Contd.)				
PROCESSOR (Contd.)			Features for 4201 Processors:				
		1101	Scientific Unit	535	495	22,685	40
		1116	Third Input/Output Sector (additional 8 R/W Channels, 16 I/O Address Assignments, and 16 Unit Loads of Power)	535	495	22,685	40
		1118	Extended Multiprogramming and 8-bit Transfer	155	145	6,810	12
		4214A	Two Buffered Input/Output Sectors (requires 1116)	405	375	17,625	19
		4214B	Two Additional Buffered Input/ Output Sectors (requires 1116 and 4214A)	355	325	15,275	17
		4215	High Speed Third Input/Output Sector (requires 1116)	155	140	6,580	18
			Model 8200:				
	8201-1		262,144 Characters	26,520	24,555	1,161,220	1,920
	8201-2		524,288 Characters	35,465	32,835	1,552,900	2,560
	8201-3		786,432 Characters	44,725	41,415	1,958,400	3,230
	8201-4		1,048,576 Characters	53,670	49,695	2,350,080	3,880
			Features for 8200 Processors:				
		8205-1	Adapter for one 3/4-Inch Tape Control (803-1, -2, or -3)	360	335	12,000	30
		8205-2	Adapter for two 3/4-Inch Tape Controls (803-1, -2, or -3)	670	620	20,000	55
		8201-B	Scientific Unit	790	730	34,560	60
		8214	Expanded Input/Output Capability (additional 18 Simultaneous R/W Channels, 48 I/O Address Assignments, and 48 Unit Loads of Power)	1,580	1,465	69,120	120
		8215	High-Speed Third Input/Output Sector	205	190	8,930	24
		8272	Standby Console Typewriter	325	290	13,500	30
			Features for all Models except 110:				
	212		On-line Adapter (for connection of Series 200 processor and 801 or 1801)	530	475	22,500	50
	212-1		Central Processor Adapter (for connection of any two Central Processors in the Series 200)	425	380	18,000	40
	213-3		Interval Times	95	85	3,600	8
		071	Interval Selector	60	55	2,250	5
	213-4		Time-of-Day Clock	215	190	9,000	20
	215		Communication Switching Unit	90	80	3,375	8
	220-2		Console (replaces control panel)(5)	325	290	13,500	30
	220-3		Console (replaces control panel; also for Model 110	325	290	13,500	30
		008	Pin-Feed Drive	25	25	1,125	5
			Disk Storage				
MASS STORAGE	155		Disk Pack Drive (3.6 million char.)(6)	370	330	14,910	55
	157B		Disk Control (for up to two 258B Disk Pack Drives)(6)	610	545	24,925	60
	258B		Disk Pack Drive (4.6 million char.)(6)	410	365	17,100	60
	257		Control for 258 and 259 Disk Pack Drives	610	545	24,925	60
	257-1		Control for 258 and 259 Disk Pack Drives (6- and 8-bit transfer modes)	670	595	26,800	75

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Disk Storage (Contd.)				
	*257A		Control for 259A Disk Pack Drive	610	545	24,925	60
	257B		Control for 259B Disk Pack Drive	610	545	24,925	60
	257B-1		Control for 259B Disk Pack Drives (6- and 8-bit transfer modes)	670	595	26,800	75
	258		Disk Pack Drive (4.6 million characters)	410	365	17,100	60
		074	Write Protect Switch	20	20	900	2.50
		079	Central Processor Finished	30	30	1,350	4.00
	259		Disk Pack Drive (9.2 million characters)	575	515	24,000	75
		074	Write Protect Switch	20	20	900	2.50
		079	Central Processor Finished	30	30	1,350	4.00
	*259A		Disk Pack Drive (9.2 million characters)(3)	575	515	24,000	75
	259B		Disk Pack Drive (9.2 million characters)	575	515	24,000	75
		074	Write Protect Switch	20	20	900	2.50
		079	Central Processor Finished	30	30	1,350	4.00
	M4005		Disk Pack for use in 258, 259, 259A, and 259B Disk Pack Drives	15	15	490	--
	260		Control for 258 and 259 Disk Pack Drives and for 261 and 262 Disk Files	675	600	26,100	90
		077	8-bit Transfer Mode	60	50	2,475	10
	261		Disk File (150 million characters)	4,270	3,825	166,000	610
		078	Heat Exchanger	130	115	5,500	15
	262		Disk File (300 million characters)	7,260	6,500	297,000	760
		078	Heat Exchanger	130	115	5,500	15
	273		Disk Pack Drive (18.4 million char.)	775	695	31,500	70
	275		Disk Pack Drive and Control (147.2 million char.)	4,235	3,780	172,200	615
	278		Disk Pack Drive and Control (280 million char.)	5,370	4,795	218,400	615
			Drum				
	265		High-Speed Drum (2.1 million characters)	1,340	1.195	54,600	156
	266		High-Speed Drum (4.2 million characters)	2,270	2,025	92,400	264
	267		High-Speed Drum (4.2 million characters)	2,425	2,165	98,700	282
	260-1		Control for 265 and 266 High-Speed Drums	825	735	33,600	96
		072	Angular Position Indicator	205	180	8,400	24
	260-2		Control for 267 High-Speed Drums	1,340	1,195	54,600	156
		073	Angular Position Indicator	310	275	12,600	36
	270		High-Speed Drum	1,150	1,030	50,070	166
		075	Track Protect (3)	30	25	1,125	4
	*270-1		Random Access Drum Storage and Control (2.6 million characters)	985	880	41,625	138
	*270-2		Random Access Drum Storage and Control (5.2 million characters)	1,665	1,490	70,425	233

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Drum (Contd.)				
	*270-3		Random Access Drum Storage and Control (7.8 million characters)	2,345	2,095	99,225	328
		075	Track Protection[3]	30	25	1,125	5
	270A-1		Random Access Drum Storage and Control (2.6 million characters)[7]	1.150	1,030	50,070	166
	270A-2		Random Access Drum Storage and Control (5.2 million characters)[7]	1,950	1,740	84,630	280
	270A-3		Random Access Drum Storage and Control (7.8 million characters)[7]	2,745	2,450	119,400	394
		075A	Track Protection	35	30	1,370	5
INPUT-OUTPUT			Magnetic Tape				
	103D		Tape Control (for up to four 204B-17 and 204B-18 Tape Units; includes one 204B-17 Unit)[6]	310	275	13,500	60
		056	Dynamic Tape Addressing	25	25	1,050	2
		1056	IBM Magnetic Tape Compatibility	60	50	2,160	5
		1059	Density Switch[9]	20	15	670	2
	204A-1		Magnetic Tape Unit (3/4-inch tape; 31,760 char./sec.)	450	450	20,250	100
	204A-2		Magnetic Tape Unit (3/4-inch tape; 63,520 char./sec.)	900	900	43,200	155
	204A-3		Magnetic Tape Unit (3/4-inch tape; 88,800 char./sec.)	900	900	43,200	155
	204B-1		Magnetic Tape Unit (1/2-inch tape; primary unit; 200/556 bits/inch; 7,200/19,980 char./sec.)	375	335	15,120	74
	204B-2		Magnetic Tape Unit (1/2-inch tape; secondary unit; 200/556 bits/inch; 7,200/19,980 char./sec.)	325	290	12,960	63
	204B-3		Magnetic Tape Unit (1/2-inch tape, primary unit) (200/556 bits/inch) (16,000/44,400 char./sec.)	530	475	21,600	105
	204B-4		Magnetic Tape Unit (1/2-inch tape, secondary unit) (200/556 bits/inch) (16,000/44,400 char./sec.)	480	425	19,440	95
	204B-5		Magnetic Tape Unit (1/2-inch tape) (200/556 bits/inch) (24,000/66,600 char./sec.)	750	670	30,240	147
	204B-7		Magnetic Tape Unit (1/2-inch tape) (556/800 bits/inch) (19,980/28,800 char./sec.)[8]	425	380	17,280	84
		055	1200 Bits/inch Recording Density	50	50	2,100	5
	204B-8		Magnetic Tape Unit (1/2-inch tape) (556/800 bits/inch) (44,400/64,000 char./sec.)[8]	640	570	25,920	126
	204B-9		Magnetic Tape Unit (1/2-inch tape) (556/800/1200 bits/inch) (66,600/96,000/144,000 char./sec)[8]	850	760	34,560	168
		054	1800 Bits/inch Recording Density	25	25	1,300	2
	204B-11		Magnetic Tape Unit (1/2-inch tape, primary unit) (200/556 bits/inch) (4,800/13,320 char/sec)[3]	295	265	12,375	58
	204B-12		Magnetic Tape Unit (1/2-inch tape, secondary unit) (200/556 bits/inch) (4,800/13,320 char/sec)[3]	235	210	10,125	48
		1059	Density Switch[9]	20	15	670	2

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)				
	204B-18		Magnetic Tape Unit (1/2-inch tape; secondary unit)(6)	175	155	7,650	45
	204B-14		Magnetic Tape Unit (1/2-inch tape; secondary unit; 556/800 bits/inch; 13,300/19,200 char./	280	255	12,175	58
	204B-16		Magnetic Tape Unit (1/2-inch tape; secondary unit; 200/556 bits/inch; 9,600/26,700 char./sec.)(10)	320	295	14,400	67
	204C-13		Magnetic Tape Unit (1/2-inch tape; nine-channel, primary unit; 800 bits/inch; 28,800 eight-bit char./sec.)	480	425	20,250	95
	204C-14		Magnetic Tape Unit (1/2-inch tape; nine-channel, secondary unit; 800 bits/inch; 28,800 eight-bit char./sec.)	480	425	20,250	95
	204D-1		Magnetic Tape Unit (1/2-inch tape; 9 channel; 800/1600 bits/inch; 38,400/76,800 char/sec)	395	350	15,960	76
	204D-3		Magnetic Tape Unit (1/2-inch tape; 9 channel; 800/1600 bits/inch; 38,400/76,800/153,600 char/sec)	570	510	23,100	110
	204D-5		Magnetic Tape Unit (1/2-inch tape; 9 channel; 800/1600 bits/inch; 38,400/112,000/224,000 char/sec)	825	740	33,600	160
	203A-1		Tape Control (for up to four 204A-1 units)	295	265	12,375	28
	203A-2		Tape Control (for up to four 204A-2 units)	295	265	12,375	28
	203A-3		Tape Control (for up to four 204A-3 units)	425	380	18,000	40
	203B-1		Tape Control (for up to eight 204B-1 and 204B-2 or 204B-3 and 204B-4 units)	455	405	18,360	42
		050	IBM Format Feature (provides end of file recognition)	60	55	2,250	5
		051	IBM Code Compatibility Feature (BCD code translation)	60	55	2,250	5
		056	Dynamic Tape Addressing	25	25	1,050	2
	203B-2		Tape Control (for up to eight 204B-5 units; no interrupt)	455	405	18,360	42
		050	IBM Format Feature (provides end of file recognition)	60	55	2,250	5
		051	IBM Code Compatibility Feature (BCD code translation)	60	55	2,250	5
		056	Dynamic Tape Addressing	25	25	1,050	2
	203B-2A		Tape Control (for up to eight 204B-5 units)	455	405	18,360	42
		056	Dynamic Tape Addressing	25	25	1,050	2
	203B-4		Tape Control (for up to eight 204B-7 or 204B-8 units)	455	405	18,360	42
		050	IBM Format Feature (provides end of file recognition)	60	55	2,250	5
		051	IBM Code Compatibility Feature (BCD code translation)	60	55	2,250	5
		056	Dynamic Tape Addressing	25	25	1,050	2

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)				
	203B-5		Tape Control (for up to four 204B-11 and 204B-12 units)	325	290	12,960	30
		057	IBM Magnetic Tape Compatibility	60	55	2,250	5
		059	Density Switch	20	15	670	2
		056	Dynamic Tape Addressing	25	25	1,050	2
	203B-6		Tape Control (for up to eight 204B-9 units)	455	405	18,360	42
		050	IBM Format Feature (provides end of file recognition)	60	55	2,250	5
		051	IBM Code Compatibility Feature (BCD code translation)	60	55	2,250	5
		056	Dynamic Tape Addressing	25	25	1,050	2
	203C-7		Tape Control (for one 204C-13 unit and one 204C-14 unit)	390	350	15,750	35
	203D-1		Tape Control (for up to eight 204D-1 units)	725	645	29,400	70
	203D-3		Tape Control (for up to eight 204D-3 units)	825	740	33,600	80
	203D-5		Tape Control (for up to eight 204D-5 units)	930	830	37,800	90
	103		Tape Control (for up to four 204B-11 and 204B-12 Tape Units; includes one 204B-11 Unit)(10)	470	420	19,440	63
	103A		Tape Control (for up to four 204B-13 and 204B-14 Tape Units; includes one 204B-13 Unit)(10)	515	465	21,490	73
	103B		Tape Control (for up to four 204B-15 and 204B-16 Tape Units; includes one 204B-15 Unit)(10)	555	505	24,300	75
		059	Density Switch	20	15	670	2
		1055	IBM Magnetic Tape Compatibility	60	50	2,160	5
		056	Dynamic Tape Addressing	25	25	1,050	2
			Punched Card				
	123		Card Reader (400 cards/min)(6)	210	185	9,000	50
		1043	51-Column Adapter	30	25	1,125	6
	123		Card Reader (400 cards/min)(10)	210	185	9,000	50
	123-2		Card Reader (600 cards/min)(10)	265	235	11,475	65
		1043	51-Column Adapter	30	25	1,125	6
	*207		Card Reader Control (for read side of 227)	255	225	10,800	24
		*040	Direct Transcription	50	50	2,280	5
		*017	Stacker Select	40	40	1,800	3
		*017-1	Three-Stacker Select (017 prerequisite)	(12)			
	*208		Card Punch Control (for punch side of 227)	225	200	9,450	21
		*017	Stacker Select	40	40	11,800	3
		*017-1	Three-Stacker Select (017 prerequisite)	(12)			
		*060	Direct Transcription	50	50	2,280	5
		*061	Hole-Count Checking	125	125	5,690	13
		*062	Punch-Feed Read (modification of the punch)	35	35	1,350	5
		*062	Punch-Feed Read (modification of the control unit)	100	100	4,565	10

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Card (Contd.)				
	208-1		Card Punch Control (for 224-1 or 224-2 or 214-1)	160	145	6,750	15
		064	Direct Transcription	30	25	1,125	3
		066	High-Speed Skip (214 only)	30	25	1,125	3
	208-2		Card Read/Punch Control (for 224-1 or 224-2 or 214-2)	245	215	10,125	22
		064	Direct Transcription	30	25	1,125	3
		066	High-Speed Skip (214 only)	30	25	1,125	3
	214-1		Card Punch, 100-400 cards/min	325	290	13,500	74
	214-2		Card Reader/Punch, 400 cards/min 100-400 cards/min	375	335	15,750	87
	223		Card Reader and Control, 800 cards/min	325	290	13,500	74
		043	51-Column Adapter	45	45	1,800	4
		044	Direct Transcription	30	25	1,125	3
	223-2		Card Reader and Control, 1050 cards/min	445	395	18,000	90
		045(13)	90-Column Card Reading Capability (requires Feature cards)	125	125	5,025	15
		044	Direct Transcription	30	25	1,125	3
	*224-1		Card Reader/Punch (1442-1), 300 cards/min/50-270 cards/min	320	320	19,900	34
		*065	Reject Stacker	25	25	1,100	1
	*224-2		Card Reader/Punch (1442-2), 400 cards/min/91-360 cards/min	440	440	21,050	41
	*227		Card Reader-Card Punch (800 cards/min/250 cards/min) with Early Card Read Feature	660	660	35,610	140
			Paper Tape				
	*209		Paper Tape Reader and Control (600 frames per second)	295	265	12,375	34
	209-2		Paper Tape Reader and Control (600 frames per second)	350	315	14,625	34
	210		Paper Tape Punch and Control (120 frames per second)	245	215	10,125	28
			Printers				
	122-1		Printer (300 lines/min.)	465	415	20,250	120
		1035	Extension of Print Positions from 120 to 132	60	50	2,250	12
			Models 120, 120-0, and 125:				
	122		Printer (450 lines/min.)	520	465	22,500	124
		1034	Extension of Print Positions from 120 to 132	60	50	2,250	12
	206A		Printer Control for the 822-3	160	145	6,750	15
		031	Extension of Printing Positions from 120 to 132	75	70	2,925	16
		033	Vertical Spacing Feature (6 or 8 lines per inch)	30	25	1,125	3
	*206		High-Speed Printer and Control, 900 LPM, 120 positions	770	695	33,750	186
	222-1		650-LPM Printer and Control (96 print positions)	850	760	36,000	198
		032	Extension of Print Positions from 120 to 132 for the 222-3, -4, -6.	100	100	4,500	25

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printers (Contd.)				
		034	Numeric Print for the 222-1, -2, -3	135	120	5,625	12
		035	Numeric Print for the 222-4	30	25	1,125	3
		036	Print Buffer for the 222-3, -4, -5, -6	225	200	9,100	28
	222-2		650-LPM Printer and Control (108 print positions)	905	805	38,250	211
	222-3		650-LPM Printer and Control (120 print positions)	960	855	40,500	223
	222-4		950-LPM Printer and Control (120 print positions)	1,355	1,210	57,375	316
	222-5		450-LPM Printer and Control (120 print positions)	690	615	29,250	161
		1034	Extension of Print Positions from 120 to 132	60	50	2,250	12
		1036	Eight-Channel Format Tape	30	25	1,125	3
	222-6		1100-LPM Printer and Control (120 print positions)	1,440	1,285	60,975	325
	229(14)		400-LPM Printer and Control (120 print positions)	405	360	15,500	150
		031	Extension of Printing Positions from 120 to 132	75	70	2,925	16
		033	Vertical Spacing Feature (6 or 8 lines per inch)	30	25	1,125	3
			Optical and Magnetic Ink Character Readers				
	232		MICR Reader-Sorter and Control	1,290	1,150	56,250	260
	233-2		MICR Control (B103)	415	370	17,550	39
	234		Plotter Control (Calcomp Plotter)	160	145	6,500	15
	235		Optical Journal Reader Control (NCR 420)	345	310	12,960	30
	237		Bill Feed Printer Control (IBM 1404)	1,140	1,015	45,450	80
	238		Optical Reader Control (IBM 1287, Model 1 or 2)	900	800	39,000	50
			Burroughs B103 MICR Reader-Sorter	N/A	2,100(15)	90,000	600(15)
			Burroughs B103 MICR Reader-Sorter with Endorser	N/A	2,310(15)	99,000	660(15)
			Burroughs B332 Master Lister and Control	N/A	1,815	81,000	400
			Burroughs B333 Slave Lister (2 maximum)	N/A	810	34,000	250
			Console				
	220-1		Console	215	190	9,000	20
	220-3		Console (Replaces Control Panel)(6)	325	290	13,500	30
		008	Pin-Feed Drive	25	25	1,125	5
COMMUNI-CATIONS			Single-Channel Controls				
			For the following remote terminals:				
	281-1A		W.U. Telex	160	145	6,750	22
	281-1B		TWX CE; 8-Level Teletypewriter	160	145	6,750	22
	281-1C		5-Level Teletypewriter	160	145	6,750	22
	281-1D		8-Level Teletypewriter	160	145	6,750	22
	281-1E		TWX CE; IBM 1050	160	145	6,750	22
	281-1H		Voice Lines for use with Data Speed 2	160	145	6,750	22
	281-1K		W.U. 180-Baud; IBM 1050	160	145	6,750	22
	281-1KTP		KEYTAPE/Communicator (private lines)	160	145	6,750	22
	281-1KTS		KEYTAPE/Communicator (switched network)	160	146	6,750	22

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
COMMUNICATIONS (Contd.)			Single-Channel Controls (Contd.)				
	281-1M		Data Station (288-1 Central Control Unit)	160	145	6,750	22
	281-1R		VIP Series Displays, Asynchronous (private lines, switched network, or direct connection)	215	190	8,930	30
	281-1S		VIP Series Displays, Asynchronous (direct connection only)	230	205	9,620	32
	281-2A		Voice-band lines (IBM 7701, 1013)	245	215	10,125	34
	281-2B		Voice-band lines	195	175	8,100	27
	281-2D		Voice-band lines (IBM 7702, 1013)	245	215	10,125	34
	281-2F		Telpak A	245	215	10,125	34
	281-2M		Data Station (288-3 Central Control Unit)	195	175	8,100	27
	281-2R		VIP Series Displays, Synchronous, (private lines, switched network, or direct connection)	260	230	10,765	36
	281-2S		VIP Series Displays, Synchronous, (direct connection only)	265	235	10,995	36
			150 bits/sec (8-level Teletypewriter)				
			Voice-band lines (8-level Teletypewriter)	60	55	2,250	7
	281-137P		Feature for the 281:	160	145	6,750	22
	281-137S	087	Long Check (available only on certain models)	160	145	6,750	22
	287-1		Autodin Communication Control (USASC II Code)	625	(16)	27,000	73
			Multi-Channel Controls				
	286-1		MCCC (for 2-3 Lines)	225	200	9,450	32
	286-2		MCCC (for 4-15 Lines)	340	305	14,400	48
	286-3		MCCC (for 16-23 Lines)	425	380	18,000	60
	286-4		Message-Mode MCCC (for 2-32 half-duplex lines)	850	760	34,000	120
	286-5		Message-Mode MCCC (for 33-63 half-duplex lines)	1,225	1,095	51,750	180
			Features for the 286-1, -2, or -3:				
		086	Parity Check on Reception & Parity Generation on Transmission	60	55	2,250	7
		087	Long Check	60	55	2,250	7
			Adapters for MCCC:				
	285-137P		150 bits/sec (8-level teleprinter)	45	45	1,800	6
	285-137S		Voice-band lines (8-level teletypewriter)	45	45	1,800	6
	285-T		Communication Interval Timer	35	30	1,350	5
	285-1A		W. U. Telex	35	30	1,350	5
	285-1B		TWX CE; 8-Level Teletypewriter	45	45	1,800	6
	285-1C		5-Level Teletypewriter	35	30	1,350	5
	285-1D		8-Level Teletypewriter	45	45	1,800	6
	285-1E		TWX CE; IBM 1050	45	45	1,800	6
	285-1H		Voice lines for use with Data Speed 2	45	45	1,800	6
	285-1K		W. U. 180-Baud/ IBM 1050	45	45	1,800	6
	285-1KTP		KEYTAPE/Communicator (private lines)	45	45	1,800	6
	285-1KTS		KEYTAPE/Communicator (switched network)	45	45	1,800	6
	285-1L		Friden Collectadata 30	115	100	4,500	15
	285-1M		Data Station (288-1 central control unit)	45	45	1,800	6
	285-1N		100 words/min. USASCII TWX Service	45	45	1,800	6
	285-1PD		Communication Adapter (Direct)	100	90	3,930	13

CLASS	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Multi-Channel Controls (Contd.)				
	285-1PM		Communication Adapter (Modem)	80	75	3,130	11
	285-1R		VIP Series Displays, Asynchronous (private lines, switched network, or direct connection)	100	90	3,895	13
	285-1S		VIP Series Displays, Asynchronous (direct connection only)	115	105	4,580	15
	285-2A		Voice Lines IBM 7701, 1013	115	105	4,500	15
	285-2B		Voice Lines	70	65	2,700	9
	285-2D		Voice Lines IBM 7702, 1013	115	105	4,500	15
	285-2M		Data Station (288-3 central control unit)	70	65	2,700	9
	285-2R		Synchronous 2000/2400 bits/sec, remote and local (50 feet max.)	135	120	5,270	18
	285-2S		Synchronous 2000/24000 bits/sec, local (200 feet max.)	140	125	5,500	18
	285-3A		Voice Lines-DATA SPEED 5	95	85	3,600	12
	285-4A		Voice Lines-DATA SPEED 5	95	85	3,600	12
	285-5A		Switched circuits, Automatic Dialing	45	45	1,800	6
	285-7A		Multi-Adapter Unit, Full Drawer (8 Units for D. C. telegraph lines Mod. 285-1A and 1C, in any combination)	225	200	9,450	32
	285-7B		Multi-Adapter Unit, Full Drawer (8 Units for start-stop transmission; Mod. 285-1B, 1D, 1H, 1K, 1M in any combination)	295	265	12,375	42
	285-7C		Multi-Adapter Unit, Full Drawer (8 Units for Series 200 Communication Mod. 285-2B)	440	390	18,450	62
	285-7D		Multi-Adapter Unit, Full Drawer (8 Units, Automatic Dialing Mod. 285-5A)	295	265	12,375	42
	285-7E		Multi-Adapter Unit, Full Drawer (15 Units for D. C. telegraph lines Mod. 285-1A, and 1C, in any combination)	405	360	17,100	57
			Audio Response System				
	285-8		Basic Touch Tone Adapter Module (6 lines)	420	375	16,875	40
	285-8A		Touch Tone Adapter Module Expansion (2 lines)	95	85	3,825	8
	285-8C		Audio Unit (31 Elements; 6 lines)	620	550	24,750	57
	285-8D		2-Line Expansion (31 Elements)	35	30	1,350	3
	285-8F		Audio Unit (63 Elements; 6 lines)	815	725	32,625	73
	285-8G		2-Line Expansion (63 Elements)	45	40	1,800	3
	285-8J		Audio Unit (189 Elements; 6 lines)	1,290	1,150	51,750	117
	285-8K		2-Line Expansion (189 Elements)	50	45	2,050	3
			Features for the 285-8				
		082-1	Tone Answer Back Option (2 lines)	20	15	675	2
		082-2	Voice Answer Back Option (2 Lines)	20	15	675	2
		083-1	Voice Cylinders (31 Elements, phrases only; original and spare)	-	-	2,050	-
		083-2	Voice Cylinders (31 Elements, words and phrases or words only; original and spare)	-	-	2,550	-
		083-3	Voice Cylinders (63 Elements, phrases only; original and spare)	-	-	3,200	-

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
COMMUNICATIONS (Contd.)			Audio Response System (Contd.)				
		083-4	Voice Cylinders - (63 Elements, words and phrases or words only; original and spare)	-	-	3,600	-
		083-5	Voice Cylinders - (189 Elements words only; original and spare)	-	-	3,600	30
			Data Station				
	288-1		Central Control Unit	190	170	6,750	62
		088-1	Buffer	95	85	3,150	30
		088-2	Extended Operation	45	40	1,350	17
	288-3		Central Control Unit	285	255	9,900	92
		088-3	Buffer	95	85	3,150	30
		088-4	Extended Operation	45	40	1,350	17
	289-2		Page Printer (10 char/sec) and Keyboard	90	80	2,925	30
	289-2A		Central Control Unit Keyboard	45	40	1,350	17
	289-3		Page Printer (40 char/sec) and Keyboard	225	200	7,875	72
	289-4		Paper Tape Reader (120 char/sec) and Spooler	85	75	2,700	29
	289-5		Paper Tape Punch (120 char/sec) and Spooler	120	105	3,825	39
	289-7		Card Reader (143 char/sec) (Feature 088-1 required)	95	85	3,150	30
	289-8		Optical Bar Code Reader (Feature 088-1 required)	315	280	11,250	103
	289-9		Remote Line Printer (120 print positions; required 288-3)	910	810	40,500	125
		1034	Extension of Print Positions from 120 to 132	60	50	2,250	12
		089-2	Multi-Line Block (Requires Feature 088-3)	15	15	675	2
			Data Entry and Display Equipment				
	303		Display Station (alpha-numeric teletype keyboard; 7- by 5-inch display area)	81	74	2,600	20
	304		Display Station (alpha-numeric Navcor keyboard; 7- by 5-inch display area)	92	84	3,020	21
	311		Display Station (numeric keyboard 5- by 4-inch display area)	60	55	1,840	16
	312		Display Station (numeric-block alpha keyboard; 5- by 4-inch display area)	65	60	1,980	18
	317		Display Station (alpha-numeric without keyboard, 7- by 5-inch display area)	60	55	1,980	10
	318		Display Station Monitor (without keyboard, 18- by 13-inch display area)	78	71	2,500	14
	323		Universal Control Unit (one to eight expansion modules)	278	255	10,820	60
	331		Communication Interface (asynchronous: 1200 bits/sec)	92	84	3,879	10
	332		Communications Interface (synchronous, 2000/2400 bits/sec)	121	109	5,255	12

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Data Entry and Display Equipment (Contd.)				
	335		High Speed Interface (42,000 char/sec)	138	126	5,590	36
	339		Clock Generator (modem by-pass)	12	11	410	---
	341		Expansion Module (numbers 1, 2, 4, 5, 7, and 8)	75	70	2,810	10
	332		Expansion Module (numbers 3 and 6)	118	109	4,475	15
	343		Expansion Module (for non-display I/O devices only)	28	25	940	5
	351		Logic Module for Message Editing	7	6	260	--
	352		Logic Module for Multi-Message Transactions	Available at No Extra Cost			
	353		Receive Only Printer Control (numbers 1, 4 and 7)	60	55	2,030	8
	353A		Receive Only Printer Control (numbers 2, 3, 5, 6, 8 and 9)	28	25	990	3
	355		Polling Option for Type 332 Communications Interface	17	16	555	2
	360		RO Printer (friction feed: Teletype Model 33)	35	31	550	21
	361		RO Printer (friction feed, Teletype Model 35 AT)	75	67	1,600	36
	362		RO Printer Sprocket Feed (Teletype Model 35 AU)	81	72	1,820	38
	370		Teller Terminal	234	215	8,363	40
	371		Transceiver	229	210	8,570	52
	372		Transceiver (off-line adaption)	245	225	9,225	52
	373		Polling Option	16	16	280	6
	374		Crossfoot Accumulator	32	31	995	8
	375		Junction Control	47	46	1,975	8
	376		Transaction Accumulator (2 accumulators)	37	36	1,420	10
	377		Transaction Accumulator (2 accumulators)	37	36	1,420	10
	386		High Speed Control Unit	460	410	20,025	30
	386-1		Channel Adapter	140	125	5,500	18
			2300 Series:				
	2306		Alphanumeric Keyboard	31	28	1,260	15
	2317A		960-Character Display Station	83	74	3,360	16
	2317B		888-Character Display Station	83	74	3,360	16
	2317C		480-Character Display Station	73	65	2,940	14
	2317D		444-Character Display Station	73	65	2,940	14
	2317E		222-Character Display Station	52	47	2,100	10
	2322A		Multi-Station Control: 960-Character	403	360	16,380	78
	2322B		888-Char	403	360	16,380	78
	2322C		480-Char	367	328	14,910	71
	2322D		444-Char	367	328	14,910	71
	2322E		222-Char	295	263	11,970	57
	2331		Communications Interface	47	42	1,890	9
	2339		Modem Bypass Clock	16	14	630	3
			RO Printer Control:				
	2353A		960-Character	109	97	4,410	21
	2353B		880 Char	109	97	4,410	21
	2353C		480 Char	78	70	3,150	15
	2353D		444 Char	78	70	3,150	15
	2353E		222 Char	67	60	2,730	13

CLASS	IDENTITY OF UNIT			PRICES			
	Model Number	Feature Number	Name	Monthly Rental $ 1-Year	Monthly Rental $ 5-Year	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Data Entry and Display Equipment (Contd.)				
			Local RO Printer Control:				
	2358A		960-Character	114	102	4,620	22
	2358B		880-Char	114	102	4,620	22
	2358C		480-Char	83	74	3,360	16
	2358D		444-Char	83	74	3,360	16
	2358E		222-Char	73	65	2,940	14
	2323		960-Character Single Display Station & Control	258	230	10,500	65
	2354		Printer Control for Single Display Station	11	10	420	2
	2343		Print Buffer for Single Display Station	16	14	630	4
	2390		Model 33 RO Printer (friction feed)	52	47	1,100	25
	2391		Model 35 RO Printer (friction feed)	78	70	2,100	37
	2392		Model 35 RO Printer (sprocket feed)	83	74	2,250	40

NOTES:

* No longer in production.

(1) Central Processor Units include memory, control panel, and power supply.

(2) Field upgrade of memory from processor models 126-1 through 126-8 to models 126-2-9 through 126-2-12 requires exchange of processors.

(3) Not available on new orders.

(5) Available only with 201 and 201-1 processors.

(6) For Model 110 only.

(7) Prices for larger drum configurations will be quoted on request.

(8) Can be changed to read/write 200/800 bpi.

(9) Two hundred bits/inch density available only with feature 059 or 1059.

(10) Models 120, 120-0, and 125 only.

(11) Density of 556 bpi available only with feature 059.

(12) One time charge of $500 if factory or field installed.

(13) Minimum installation and rental charge of $100 is made for six months or less usage, more than six months is at $125/month rate.

(14) Restricted to educational institutions.

(15) Plus maintenance surcharge of $150 if located outside a Honeywell Service area.

(16) Quoted on request.

INTRODUCTION

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The Monrobot XI is a compact, solid-state data processing system that is suitable for a variety of fairly complex but low-volume business and scientific applications. It is also being used in small instrumentation and process control systems. The basic system, consisting of computer, input-output typewriter, and paper tape reader and punch, can be purchased for $24,500 or leased for $700 per month. This makes it one of the lowest priced internally programmed data processing systems currently available.

The central processor is housed in a desk-size cabinet and weighs only 375 pounds. Most of the peripheral devices are housed in matching cabinet modules of desk height that can be arranged in a number of ways for maximum operating efficiency. There are no special power or air conditioning requirements.

A magnetic drum provides 1,024 word locations of working storage; a 2,048-word drum is a recently-announced option. Each 32-bit location can hold two single-address instructions, one binary data word, or from four to six alphameric characters. Seven of the addressable storage locations are Fast Access Registers with a constant access time of 0.73 milliseconds. Average access time for all other storage locations is 5.85 milliseconds.

The small but convenient instruction repertoire includes addition, subtraction, and multiplication of single word-length, fixed point binary data. Division can only be accomplished by subroutines. Binary and decimal shifts and a repetitive subtraction ("detract") instruction facilitate the programmed radix conversions that usually must be performed upon input and output data. Neither index registers nor indirect addressing are provided, so a large proportion of the instructions in many programs will be devoted to "housekeeping" operations. Program execution speed will usually average 60 to 80 instructions per second. Somewhat higher speeds can be achieved if operand addresses are optimized where possible, but the increase in speed will seldom justify the extra coding time.

Up to three separate input devices and three output devices can be connected to the Monrobot XI and selected under program control. Each input or output instruction initiates the transfer of a single character between the processor and the addressed peripheral device. Overlapping of input-output operations and internal processing is possible.

Paper tape or verge-punched cards with 5- or 8-level codes can be punched and read mechanically at a peak speed of 20 characters per second. A photoelectric reader provides maximum input speeds of 40 to 50 characters per second. IBM 024 or 026 Card Punches can be connected through special couplers and used for on-line punched card input, output, or both. Standard 80-column cards are read and punched at 16 columns per second.

Printed output can be produced at up to 10 characters per second by either a modified IBM electric typewriter or a Teletype printer; either unit can also be used for manual entry of data. A 16-key keyboard is useful for rapid entry of all-numeric data.

The Monroe-Card Processor reads and records information on magnetizable cards. Up to 1,566 decimal digits or 1,044 alphameric characters can be stored on each card. Monroe-Cards will be useful for master file storage in a variety of data processing applications.

The Monrobot XI software situation, when viewed by potential users with a strong desire to minimize programming time and effort, leaves much to be desired. Routines currently available from the manufacturer are limited to general utility routines, a user-developed symbolic assembly system, and a group of scientific routines (floating point

INTRODUCTION–Contd.

§ 011.

arithmetic, functions, matrix inversion, etc.). No compiler systems, interpretive systems, or report generators are available or under development.

Most coding is done in machine language; the coder writes four hexadecimal digits per instruction, or eight per word. The hexadecimal addressing scheme is easy to master, but the operation codes have no mnemonic relationship to their effects. Generalized subroutines are available to handle division, loop control, address modification, and input-output with radix conversions, but the manufacturer encourages the use of individually-tailored, user-coded routines for greater efficiency.

A Monrobot XI users' group is now being formed, under Monroe's auspices, to encourage and control the publication, standardization, and distribution of routines developed by users and by the manufacterer.

PRICE DATA

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CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Annual Maintenance $	Purchase $
Central Processor		Monrobot XI - Basic System	700.00	1,200.00	24,500.00
		Includes the following units:			
		Computer and control unit			
		Input-Output Typewriter			
		Paper Tape Reader			
		Paper Tape Punch			
		Knee-hole Desk			
		2 Input-Output Buffers			
		Optional Features			
		Oscilloscope View Box	NA	5.25	105.00
		Input-Output Buffer	20.00	30.00	600.00
		Cabinet (2 legs)	12.50	0	400.00
		Table (2 legs)	NA	0	60.00
		2,048-word Drum	185.00	?	5,250.00
		Note: For punched card input-output, 24 and 26 Couplers can be substituted for Paper Tape Reader and Punch on a one-for-one basis; 024 or 026 Card Punches must be ordered from IBM.			
Input-Output		Paper Tape Reader (includes Cabinet)	60.00	82.50	1,650.00
		Paper Tape Punch (includes Cabinet)	33.00	55.00	1,100.00
		Paper Tape Reader and Punch, in single Cabinet	81.00	125.00	2,500.00
		Edge-Punched Card Reader	70.00	97.50	1,950.00
		Edge-Punched Card Punch	43.00	70.00	1,400.00
		Optional Features			
		5-8 Channel Switch	5.00	4.50	90.00
		Paper Tape Unwind Reel	NA	0	20.00
	24	Coupler (for punched card input)	25.00	40.00	800.00
	26	Coupler (for punched card output)	25.00	40.00	800.00
		Input-Output Typewriter	120.00	165.00	3,300.00
		Output Typewriter	80.00	123.75	2,475.00
		Optional Features			
		20-inch Carriage	NA	0	100.00
		20-inch Pinfeed Platen	NA	0	100.00
		16-inch Pinfeed Platen	NA	0	100.00
		Form Aligner (tracter feed)	NA	0	100.00
		Form Stand (paper tray)	NA	0	65.00
		Special keys (each)	NA	0	75.00
		Teletype Printer:			
		In lieu of basic Typewriter	50.00	50.00	1,000.00
		As additional output unit	120.00	165.00	3,300.00
		Monroe-Card Processor:			
		96 words/card	230.00	?	6,500.00
		174 words/card	290.00	?	8,500.00

PRICE DATA–Contd.

§ 221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Annual Maintenance $	Purchase $
Input-Output		16-Key Keyboard	12.50	20.00	400.00
Data Origination		Synchro-Monroe Punch Tape Adding Machine:			
		One-register model	88.00	110.00	1, 950.00
		Two-register model	98.00	120.00	2, 175.00

Notes: NA in rental column means unit or feature is available for purchase only.
Maintenance charges apply only to purchased equipment.
Prices do not include Manufacturers' Excise Tax of 6 percent on purchase or 10 percent on rental.

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SUMMARY

.1 SUMMARY

The NCR 315 is a small to medium scale, solid-state computer system oriented toward business data processing applications. A library of floating point subroutines equips the 315 to handle modest scientific computational loads as well. System rentals range from $2,850 to over $25,000 per month, with most installations falling within the $5,000 to $15,000 range. First customer deliveries of the NCR 315 were made in the Fall of 1961, and more than 500 systems have been installed to date.

.2 COMPATIBILITY

The NCR computer line was expanded in July 1963 by the announcement of the 315-100 series (Report 602:), in July 1964 by the announcement of the 315 RMC (Report 603:), and again in September 1966 by the announcement of a new Multiprogramming Processor for the RMC system (Report 603:).

The 315-100 is essentially an economy version of the 315 which uses the same processor, except that many of the features (such as multiply/divide and the capability to connect magnetic tape units) are optional. A line of low-performance, low-cost peripherals originally announced solely for the 315-100 is now available for the 315. This greatly reduces the effective differences between the two systems.

The NCR 315 RMC (Rod Memory Computer), on the other hand, uses a completely new central processor and internal storage. The 315 RMC uses the first commercially-available complete thin-film memory and performs internal operations from 3 to 10 times faster than the original NCR 315. The instruction repertoire includes all the instructions of the 315 and features several extensions — primarily floating-point arithmetic hardware.

The new RMC Multiprogramming Processor provides additional hardware, including separate operating modes and registers for the Executive program and the users' programs, for facilitating the concurrent execution of several programs in a multiprogramming fashion. Except for minor differences (and the added commands of the 315 RMC), all of the processors in the 315 series are program-compatible and utilize the same software.

There is no program compatibility between the 315 line and NCR's other second-generation computers — the NCR 304 (a medium-scale system which is no longer in production), the NCR 310 (an adaptation of the Control Data 160 oriented toward MICR sorter-reader operations), and the NCR 390 and 500 Series (small-scale data processing systems built around the concept of magnetic ledger cards). The third-generation NCR Century Series, however, offers a 315 Emulation Unit as an optional feature for the Century 200 Processor.

The NCR 315 is tape-compatible with the IBM 729 series and other "IBM-compatible" magnetic tape handlers. Because code translation for most NCR 315 peripheral devices is performed by the stored program, a wide variety of data codes can be accommodated on punched tape and cards.

.3 HARDWARE

.31 Central Processors and Main Memory

The basic addressable unit of internal storage in NCR 315 systems is the "slab," which consists of 12 data bits and 1 parity bit. Each slab can hold two 6-bit alphameric characters or three 4-bit decimal digits. Instructions are provided to convert information from the alphameric to the decimal mode, and vice versa. All arithmetic operations are performed upon data stored in the 4-bit decimal mode. Arithmetic operands can be from 1 to 8 slabs (or 3 to 24 digits) in length, as specified in the instruction. A minus sign requires one digit position, whereas a plus sign does not. The results of most arithmetic operations are developed in a variable-length accumulator.

Instructions occupy either two or four slabs each; most are of the one-address type, but others function as two-address instructions. The repertoire of approximately 150 instructions plus variations includes fixed point multiplication and division, add-to-storage, binary addition, three-way comparison, shifting, and block transfer facilities. Literal operands up to three digits in length can be specified in many instructions. Edit, Suppress, and Scan instructions facilitate format control and character manipulation. Internal instructions are executed at the rate of about 16,000 per second in typical NCR 315 routines.

.31 Central Processors and Main Memory (Contd.)

Interrupt facilities aid in achieving efficient utilization of the NCR 315's input-output capabilities by informing the central processor when a peripheral device is ready to deliver or receive information. When the master Demand Permit Flag is on, any peripheral unit whose individual Unit Demand Flag is also on will generate an interrupt signal whenever it is ready to accept another input or output instruction. When the central processor receives the interrupt signal, it completes execution of the current instruction and then jumps to a special routine. This routine tests all active peripheral units to determine which one caused the interrupt, and then initiates the appropriate action.

Core storage is available in module sizes of 5,000, 10,000, or 15,000 slabs. Up to four of the 10,000-slab modules can be used in a system, providing a maximum core storage capacity of 40,000 slabs, 80,000 characters, or 120,000 decimal digits. Cycle time is 6 microseconds for each access to one 12-bit slab. A parity check is performed upon all internal data transfers.

An auxiliary core storage bank, which functions independently of the main core store, holds 32 index registers, 32 jump registers, the accumulator, and a number of program-testable "flags" which indicate the result of a comparison, an arithmetic overflow, or an interrupt condition. Because only 1,000 storage locations can be directly addressed by the 3-digit instruction address, nearly every NCR 315 instruction utilizes index register modification. (Indexing requires no additional execution time.) The 32 jump registers are used primarily to store "jump tables," which transfer control to specified locations when specific conditions (errors, end-of-tape marks, etc.) arise in the execution of certain instructions.

.32 Auxiliary Storage

CRAM (Card Random Access Memory) is a key feature of the NCR 315 system that combines many of the advantages of magnetic tape and disc storage units. The CRAM storage medium is a deck of flexible magnetic cards. A cartridge containing up to 384 cards can be quickly removed from the CRAM Unit, replaced by another cartridge, stored off-line, and reinserted when necessary, in the same manner as a reel of magnetic tape. Four models of CRAM are available, differing in storage capacity and recording density. From 5.5 million (Model 353-1) to 82.9 million (Model 353-5) characters can be stored in a single CRAM cartridge.

One selected CRAM card at a time is dropped from the on-line cartridge and wrapped around a revolving drum; this takes from 120 to 235 milliseconds, depending on the model. Then any or all of the data bands (7, 56, or 144, depending on the model) can be read and/or written sequentially. The 353-5 uses a movable head mechanism to record four groups of 36 bands (144 bands total) on each card. Data is transferred at a peak rate of 100,000 characters per second (Model 353-1), 50,000 characters per second (Model 353-5), or 38,000 characters per second (Models 353-2 and 353-3).

Up to 16 CRAM units can be connected to an NCR 315 system, and different models can be intermixed if desired. Card dropping time can be overlapped, but only one CRAM read or write operation can be performed at a time. Both lateral and longitudinal read-after-write parity checks are performed when writing a CRAM record.

The only non-CRAM random access storage device available for 315 systems is the C365 Disc Unit, which offers fast access to relatively small volumes of data. The C365 features a head-per-track design with four fixed discs per unit. Average access time is 16.7 milliseconds, peak data transfer rate is 120,000 characters per second, and maximum data capacity is 2,000,896 characters per unit.

.33 Peripheral Equipment

NCR offers a large array of peripheral equipment for 315 systems, but complex configuration rules limit the selection of components for a particular installation. Several of the peripheral devices previously offered by NCR have been discontinued from production. Some of these units are still available; others are not available at all. However, NCR states that it will continue to support all devices in existing installations.

Magnetic tape units are available with peak transfer rates ranging from 12,000 to 120,000 characters per second (tape speeds of 60 to 150 inches per second). NCR has discontinued the 333-bits-per-inch recording density and now uses the IBM 729-compatible densities of 200, 556, and 800 bits per inch. In all models, block length is variable, and a read-after-write parity check is performed upon recording.

Up to eight magnetic tape handlers can be connected directly to an NCR 315 central processor, in which case no overlapping of magnetic tape reading or writing with computation is possible. Alternatively, Magnetic Tape Simultaneity Controllers can be used to provide either read-compute and write-compute overlapping (with one controller) or full read-write-compute simultaneity (with two controllers), through time-sharing of accesses to core memory. Up to eight tape handlers can be connected to each controller. A mix of up to 16 tape handlers can be connected directly and via a controller. Tape handlers of different tape speeds can be intermixed in a 315 system.

(Contd.)

.33 Peripheral Equipment (Contd.)

Two card readers (400 or 2,000 cards per minute), two card punches (both with completely buffered operation at 100 or 250 cards per minute), and two card read-punch units (which read at 300 or 400 cards per minute) provide punched card input-output. The 100-cpm punch and the card read-punches are the IBM 523, 1442 Model 1, and 1442 Model 2 units, respectively. The 250-cpm card punch is an adaptation of a Control Data unit. All these devices handle standard 80-column cards, and the slower card reader is also available in a 90-column version. A maximum of one card reader or two card read-punch units can be connected on-line to an NCR 315 system. A total of four card punches and printers, in any combination, can be connected.

Two paper tape readers (600 and 1,000 characters per second) and two paper tape punches (120 and 110 characters per second) provide paper tape input-output. All models are unbuffered. Only one paper tape reader and one punch can be connected on-line at a time.

A number of printers are available for the NCR 315, including several recently-announced units. Buffered and unbuffered units are available with peak printing rates of up to 1,000 lines per minute for numeric or alphanumeric data, and with 120 or 132 print positions. One recently-announced printer can optionally be equipped to function as a lister for numeric data at up to 2,000 lines per minute. A total of four printers and card punches, in any combination, can be connected to an NCR 315.

Documents encoded in magnetic ink can be read and sorted at the rate of 750 or 1,200 documents per minute. An optical character reader can read journal tapes produced by cash registers, adding machines, and accounting machines at up to 1,664 characters per second. Up to four buffered MICR and optical readers, in any combination, can be connected to an NCR 315.

The Model 321 Central Communication Controller enables an NCR 315 computer system to handle up to 99 narrow-, voice-, or broad-band lines in any combination. The 321 Controller supersedes the various models of the 356 Inquiry Buffer previously used with NCR 315 computers. The Controller accesses memory directly, sharing memory cycles with the processor. Various adaptors are provided to accomodate low-, medium-, and high-speed terminals using start/stop synchronization and to accommodate NCR's banking terminals. NCR provides a set of specialized communications subroutines which can be tailored to fit individual applications. These subroutines provide control of the message flow in a data communications system and are assembled into suitable Supervisory programs by individual installations.

The 795 Data Display System, a modified version of the Sanders 720 system, adds important remote data entry and retrieval capabilities to the NCR 315 line. The CRT display unit provides a 7.5-by-9.5-inch image area and can display 256, 512, or 1024 characters. A keyboard permits data to be entered into the computer system from the display terminal locations.

.4 SOFTWARE

The NEAT Compiler is an advanced symbolic assembly system designed for use in NCR 315 systems with at least 10,000 slabs of core storage, a punched tape or card reader, a printer, and either 1 CRAM unit or 4 magnetic tape handlers. (A special NEAT Compiler is available for systems with 5,000 slabs of core storage and 4 magnetic tape units.) References to an extensive library of macro instructions cause the insertion of in-line and/or closed subroutines in the object program. User-defined macros can be added to the library. The data to be processed by the object program is defined in terms of its hierarchical structure of files, records, groups, and fields, using COBOL-like level indicators. Standard forms are provided for tape or CRAM file specifications and compiler control. All object programs produced by the NEAT Compiler are compatible with the STEP and PACE operating systems described below.

The NEAT Assembler is a basic symbolic assembly system designed for small NCR 315 installations. It requires only 5,000 slabs of core storage, punched tape or card input-output, a printer, and 1 magnetic tape or CRAM unit. The coding format is fixed, and none of the macro instructions or data definition facilities of the NEAT Compiler are available. All the facilities of the target computer can be utilized.

BEST (Business EDP Systems Technique) is a technique developed by NCR to speed the programming and debugging of programs to perform routine business data processing functions. A job is defined in terms of BEST functions (41 are currently provided), and a series of parameter sheets is filled out. Cards, key-punched from the parameter sheets, are input to the BEST program generator, where the calls for BEST functions are replaced with subroutines coded in symbolic language (NEAT). The NEAT compiler is then used to produce a machine-language program. Facilities provided by the currently-offered set of BEST functions include such operations as input-output, file control, arithmetic, paper tape code translation, report writing, and sorting. The minimum configurations required to utilize the BEST program generator is 10,000 slabs of memory and either five magnetic tape units or two CRAM units (any model).

.4 SOFTWARE (Contd.)

The NEAT COBOL Compiler accepts nearly all of Required COBOL-61 (there are minor exceptions) and most of the COBOL-61 Electives. The compiler requires at least 10,000 slabs of core storage and either 2 CRAM units or 5 magnetic tape units. COBOL source statements are translated into NCR 315 machine language object programs at an average rate of 10 to 20 statements per minute. A useful, non-standard addition to the COBOL language is the LOCATE verb, which enables the COBOL programmer to utilize CRAM units for file storage. Object program efficiency is strongly influenced by the data arrangements in core storage and in the files. These data arrangements are prescribed by the COBOL programmer, and guidelines are available which help him to maximize efficiency by arranging the data in accordance with the NCR 315's internal structure. NCR states that a version of COBOL 65 will be available in November 1968.

STEP (Standard Tape Executive System) is an input-output control and supervisory routine for NCR 315 magnetic tape systems; PACE (Packaged CRAM Executive) is its counterpart for systems that utilize CRAM memory. Both systems are capable of controlling run-to-run changeovers, program loading, restarts, and overlays, as well as all routine tape and CRAM input-output operations. The Librarian routine creates and maintains a program library tape or CRAM deck in which each program includes all the information required by STEP or PACE.

The Tape and CRAM Sort Generators utilize parameters specified in control cards to generate sorting routines that use from 4 to 8 tape units or 1 to 4 CRAM units, respectively. Either fixed- or variable-length records can be sorted according to either fixed- or variable-length keys. The user can insert his own coding to add, delete, or edit selected records during the first and/or last pass. Restart points are established at the end of each merge pass.

Other available software for the NCR 315 includes a well-planned library of Scientific and Engineering Subroutines; a FORTRAN II compiler; a FORTRAN IV compiler; FAST (a load-and-go algebraic compiler); a variety of diagnostic and printout routines; and a set of "canned" programs for specific applications such as demand deposit accounting, on-line savings, accounts payable, inventory management, and PERT.

NCR 315

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	315-3		File Processor	1,400	90,000	180
	315-4		Bank File Processor	1,500	95,000	190
	315-35		File Inquiry Processor	1,650	100,000	200
			Unbuffered Inquiry Adapter	75	3,250	10
			Automatic Recovery Option	100	5,000	5
			Main Memory			
	316-2		Memory (10,000 characters)	1,100	55,000	20
	316-301		Memory (20,000 characters)	1,600	75,000	20
	316-302		Memory (additional 20,000 characters)	1,800	80,000	20
	316-4		Memory (30,000 characters)	2,800	132,000	40
PERIPHERAL DEVICES			All Units: See NCR 315-100 (1)			

NOTES:

(1) The 315 can accommodate all 315-100 peripheral devices except the unbuffered 402-4 MICR Sorter Reader. The Processor model determines which of the peripheral devices can be connected. No additional adapters are required.

INTRODUCTION

The NCR 315-100 was announced in July, 1963, as an economy version of the NCR 315 computer system using essentially the same central processor and core memory. The multiply-divide facility and various input-output control features of the 315 were made optional, and a low-cost, low-performance line of peripheral devices was made available for the 315-100. The purpose of this, of course, was to reduce the cost of obtaining an installation's first computer system from NCR. Recently, the full line of NCR 315 peripheral equipment was made available for 315-100 systems. This has greatly reduced the effective differences between the 315 and 315-100.

The performance of the 315-100 central processor and core storage is essentially identical with the performance of the corresponding components of the original NCR 315 system. Thus, programs can be freely interchanged between a 315 system and a 315-100 system having equivalent facilities, peripheral equipment, and core memory. All of the software available for the 315 can be used with 315-100 systems.

To emphasize the close relationship between the NCR 315 and 315-100 computer systems, this report presents only the information that pertains specifically to the 315-100. See the NCR 315 report (page 601:011.100) for descriptions of the facilities and characteristics of the various hardware and software components of the 315 line.

NCR 315-100

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit and Main Storage			
	315-101		Central Processor, including Memory Unit:			
			316-102 (10,000 characters)	1,600	82,600	190
			316-103 (20,000 characters)	2,200	104,400	190
			316-104 (30,000 characters)	3,000	144,100	265
	316-302		Additional 20,000-Character Memory	1,800	80,000	20
			Automatic Recovery Option	100	5,000	5
			Low-Speed File Adapter (1)	100	5,000	15
			High-Speed File Adapter (2)	400	20,000	25
			CRAM-File Adapter (3)	100	5,000	10
			Simultaneity Adapter (4)	100	5,000	10
			Multiply-Divide	200	9,200	20
			MICR Buffer Adapter (5)	100	5,000	10
			Inquiry Buffer Adapter (6)	250	10,000	10
			Unbuffered Inquiry Adapter (7)	75	3,250	10
MASS STORAGE			Disc Storage			
	365-101		Disc Controller with one Disc Unit	1,340	57,500	140
	365-102		Disc Controller with two Disc Units	2,140	92,000	240
	365-103		Disc Controller with three Disc Units	2,940	126,500	340
	365-104		Disc Controller with four Disc Units	3,740	161,000	440
			Magnetic Card Storage			
	*353-1		100KC CRAM (5.5 Million Characters)	950	19,900	158
	353-2		38KC CRAM (8.0 Million Characters)	700	30,600	120
	353-3		38KC CRAM (16.1 Million Characters)	825	35,500	150
	353-5		38KC CRAM (82 Million Characters)	1,350	63,000	120
			Automatic Recovery Option	30	1,500	15
INPUT-OUTPUT			Magnetic Tape			
	334-101		Magnetic Tape Unit (with controller; 12KC; controls up to four 334-102's)	300	12,400	70
	334-102		Magnetic Tape Unit (without controller; 12KC)	225	9,100	60
	334-131		Magnetic Tape Unit (with controller; 33KC; controls itself and up to four 334-132's)	400	16,000	80
	334-132		Magnetic Tape Unit (without controller; 33KC)	300	12,500	70
	333-101		Magnetic Tape Unit (120KC)	975	40,000	140
	333-102		Magnetic Tape Unit (83.4KC)			
	324-1		Magnetic Tape Simultaneity Controller	695	32,000	58
			Punched Card and Punched Tape			
	*472-1		Input/Output Console (includes 1,000 char/sec paper tape reader and 110 char/sec paper tape punch)	450	15,000	50
	*472-2		Input/Output Console (includes 400 card/min card reader)	450	20,000	83
	*472-3		Input/Output Console (includes paper tape reader, paper tape punch, and card reader)	900	35,000	133
			90-column adapter for console reader	—	200	—

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Card and Punched Tape (Contd.)			
	361-201		Paper Tape Reader (600 char/sec)	250	9,800	50
	371-201		Paper Tape Punch (120 char/sec)	250	9,800	50
	376-7		Card Read Punch (300/50 cards/min; requires 354-601 controller)	375	23,900	21.50
	376-8		Card Read Punch (400/88 cards/min; requires 354-601 controller)	500	25,200	27.50
	354-601		Card Read Punch Controller	150	6,600	10
	380-3		Card Reader (2000 cards/min)	750	35,000	125
			IBM Translator feature	35	1,400	5
	*376-2		Card Punch (100 cards/min; reqires 354-101 buffer)	125	—	16.25
	376-101		Card Punch (250 cards/min; requires 354-101 buffer)	400	22,500	90
	354-101		Card Punch Buffer	450	25,000	30
			Printers			
	340-503		Printer - Unbuffered (805 lines/min)	650	30,000	90
	340-601		Printer (1000 lines/min; includes buffer)	1,350	55,000	125
			Special characters, per character	—	350	—
	340-532		Printer - Unbuffered; (620 lines/min)	750	35,000	110
	340-632		Printer - Buffered (100 lines/min)	1,450	60,000	150
	340-644		Printer - Buffered with Lister Adapter (100 lines/min)			
	644-1		Lister Attachment	150	8,000	24
			MICR Sorter Readers			
	402-3		MICR Sorter Reader (750 documents/min; requires 355-1 Buffer)	1,700	45,000	458
	402-4		MICR Sorter Reader (750 documents/min; unbuffered)	1,700	45,000	458
	355-1		MICR Sorter Buffer (controls up to four 402-3 Sorter-Readers)	450	23,500	30
	407-101		MICR Sorter-Reader (1200 documents/min; requires 355-3 Buffer)	2,100	95,000	417
	355-3		MICR Sorter Buffer (controls up to 4 407-101 Sorter-Readers)	250	15,000	30
			Optical Readers			
	*420-1		Optical Journal Reader	1,450	60,000	184
	420-2		Optical Journal Reader	1,950	80,000	265
			Display Unit			
	795-100		Display Controller (includes 795-101 Edit Module and 795-102 I/O Module)	190	6,650	18
	795-151		Memory Module (1x1024 characters)	80	2,800	7
	795-152		Memory Module (2x512 characters)	80	2,800	7
	795-153		Memory Module (4x256 characters)	80	2,800	7
	795-201		Display Controller Cabinet (for one controller)	40	1,400	2
	795-202		Display Controller Cabinet (for up to 3 controllers)	40	1,400	2
	795-300		Display Screen	100	3,500	14
	795-400		Keyboard	20	700	2
		795-500	Split Screen	22	770	3
		795-510	315 Interface	150	5,250	3
		795-521	Multi I/O Channel (one per controller)	175	6,125	12
		795-401	Keyboard Adapter (each keyboard)	7	245	2

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Other			
	435-201		Universal Interconnecting Device (1 module)	125	5,000	9
	435-202		Universal Interconnecting Device (2 modules)	190	7,500	13
	435-203		Universal Interconnecting Device (3 modules)	250	10,000	18
COMMUNICATIONS	321-1		Central Communication Controller (includes space for 3 Adapter Cages)	850	36,000	100
			Auxiliary Cabinet (contains space for 4 Adapter Cages)	250	10,000	30
			Adapter Cage (contains space for 10 Adapters)	30	1,200	6
	359-302		Asynchronous Character Adapter	60	2,500	3
	359-303		Bit Adapter	15	600	3
	359-304		Bank Adapter	60	2,500	10
	356-1		Central Inquiry Buffer (1 character; alphanumeric; controls up to 8 adapters)	675	28,200	60
	356-3		Central Inquiry Buffer (17 digits; numeric; controls up to 8 adapters)	975	40,500	6
	*359-3		Communication Line Adapter —Teletype	175	7,100	19
	*359-4		Communication Line Adapter —Monitor	130	5,500	20
	358-3		Auxiliary Cabinet	160	6,450	10
	428-3		Window Machine Controller	25	1,000	6
			Branch Controller for:			
	438-318		1 to 8 window machines	220	9,500	40
	438-320		9 to 16 window machines	260	11,500	40
	438-428		Single Window Controller	180	7,300	32

NOTES:

* No longer in production.

(1) Required for 334 Series Magnetic Tape Units.

(2) Required for 333 Series Magnetic Tape Units and 353-1 CRAM unit.

(3) Required for all CRAM units and for 365 Disc units.

(4) Required for 324-1 and 324-2 Magnetic Tape Simultaneity Controllers.

(5) Required for 355-1 MICR Sorter-Reader Buffer.

(6) Required for 356-1 and 356-3 Central Inquiry Buffers and 321-1 Central Communications Controller.

(7) Required for connection of unbuffered Teletype devices.

INTRODUCTION

.1 SUMMARY

The NCR 315 Rod Memory Computer was announced in July, 1964, as the first commercially-available, general-purpose computer system utilizing a thin-film storage medium for the entire working memory. The higher speed of this memory makes the 315 RMC about 7.5 times as fast internally as the older NCR 315 and 315-100 central processors, with which it is program-compatible. The 315 RMC also offers additional processing capabilities beyond those of the other two systems in the 315 line and is a logical candidate for replacement of an NCR 315 system when the needs of the installation outgrow the capabilities of the 315 central processor. A new Processor, the 315-502 Multiprogramming Processor was announced on September 22, 1966; this processor includes hardware provisions to facilitate multiprogramming operations. Systems rentals for the NCR 315 RMC range from approximately $8,000 to over $20,000 per month.

To emphasize the similarities between the NCR 315 and the 315 RMC, only the information that pertains uniquely to the 315 RMC is presented in this report. Material common to both systems is presented in the NCR 315 report (Section 601:011).

.2 COMPATIBILITY

The 315 RMC is the third in the NCR 315 line of program-compatible computer systems. Non-time-dependent programs originally written for a 315 or 315-100 system can be run by a 315 RMC system having equivalent memory and peripheral equipment. Programs written for the 315 RMC which make use of its added hardware capabilities will need modification before they can be run on either a 315 or 315-100.

.3 HARDWARE

The Rod Memory is composed of beryllium-copper "rods", 0.015 inch in diameter, coated with an iron-nickel substance and wound with solenoids at periodic intervals along the rod. Each memory location is called a "slab" and is composed of 12 data bits and 1 parity bit — the same arrangement as in the NCR 315. Each slab can hold two 6-bit characters or three 4-bit decimal digits. Cycle time for each memory access of one slab is 800 nanoseconds (0.8 microsecond), making NCR's Rod Memory one of the fastest units currently available in its price range. Each Rod Memory unit has a storage capacity of 20,000 slabs. Up to four of these units can be used in a 315 RMC system, for a maximum storage capacity of 80,000 slabs (160,000 characters or 240,000 digits).

Two models of the 315 RMC Central Processor are offered, and each contains control logic for all peripheral devices. The control and processing functions, including interrupt facilities, for the standard 315 RMC Processor have been implemented in the same manner as in the 315. The auxiliary memory containing the accumulator, index registers, jump registers, and processor flags is of the same thin-film type as the main working storage and can be accessed simultaneously with the main memory.

The new Multiprogramming Processor is identical to the standard RMC Processor except for the hardware provided to facilitate multiprogramming operations. These provisions include:

- Three processor operating modes — Executive, SERF (Special Executive Routine Functions), and User;
- Indirect addressing;
- Separate sets of index and jump registers for the Executive and User operating modes;
- Memory protection in the User Mode via limit registers;
- Processor polling and control of peripheral interrupts;
- Restriction of input-output and certain other operations to the Executive Mode; and
- Internal interval timer with interrupt.

A configuration incorporating the 315-502 Multiprogramming Processor must have at least 40,000 slabs of memory and at least one CRAM unit (any model).

The instruction repertoire is composed of the original NCR 315 instruction repertoire plus some additional facilities. The added instructions include data movement instructions that aid in handling data communications input and output, floating-point arithmetic operations, and several control instructions. The data movement instructions provide automatic conversion between the one-character-per-slab or one-digit-per-slab format of Teletype input and output and the internal format of the 315 RMC. The floating-point

.3 HARDWARE (Contd.)

operations include add, subtract, multiply, divide, and normalize. All floating-point results can be automatically rounded. Special instructions are included in the Multiprogramming Processor to control the registers reserved for the Executive Mode.

The instruction format of the 315 RMC is identical with that of the 315. Addresses in the instructions themselves can be no larger than 999; the index registers permit addressing up to 80,000 locations.

Two special instructions, Memory Expand and Memory Protect, are provided for compatibility with the NCR 315 and to facilitate the dual operation of one batch program and one inquiry program. The operator can set a manual switch to select either the Compatibility Mode or the Real Time Mode. In the Compatibility Mode, the two special instructions are used to permit addressing the full memory or to restrict addressing to the lower 40,000 locations — the maximum memory size of the original NCR 315. In the Real Time Mode, these two instructions allow the separation of an inquiry program located in the upper half of memory from a batch program in the lower half of memory. The program in upper memory is protected from interference by the program in lower memory.

Other control instructions provide facilities for automatically storing the contents of the accumulator and the status of the processor flags in a specified 14-slab area, and for loading the accumulator and setting the processor flags from the contents of a specified 14-slab area.

Other capabilities of the 315 RMC are the same as those of the NCR 315. A brief description of the basic characteristics of the 315 is contained in the NCR 315 report (Section 601:011).

.4 PERIPHERAL EQUIPMENT

All of the peripheral devices available for the NCR 315, except the Input/Output Consoles, are also available for 315 RMC computer systems. The configuration rules for attaching peripheral devices to the 315 RMC are the same as for the 315. The NCR 315 report (Section 601:011) describes the available equipment.

.5 SOFTWARE

All of the software described in Section 601:011 of the NCR 315 report is also available for the 315 RMC. In addition, NCR has developed a supervisory program, Executive, that enables a 315 RMC system with the Multiprogramming Processor to run several programs simultaneously in a multiprogramming mode; detailed specifications are not available to date.

NCR 315-RMC

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	315-501		Central Processor (includes console, I/O Typewriter) and:			
			One 316-501 20,000-character Rod Memory Unit	4,700 (1)	211,500	210
			One 316-502 40,000-character Rod Memory Unit	5,800 (1)	270,000	220
	315-502		Multiprogramming Processor; includes two 316-502 40,000-character Rod Memory Units, console, and I/O Typewriter	10,000 (1)	460,000	270
			Optional Features			
			Automatic Recovery Option (2)	100	5,000	5
			Mixed File Adapter	75	3,000	-
			Main Memory			
	316-504		Additional Rod Memory (40,000 characters; a maximum of three 316-504 units can be added to the basic 316-501 unit and a maximum of two to the basic 316-502 unit)	2,200 (1)	100,000	40
PERIPHERAL DEVICES	324-3		Magnetic Tape Simultaneity Controller	695	32,000	58
	333-501		Magnetic Tape Unit (120 KC)	800	36,000	140
	333-502		Magnetic Tape Unit (83.4 KC)	750	33,750	140
	354-602		Card Read-Punch Controller	300	13,500	12
	321-3		Central Communication Controller (includes space for 3 Adapter Cages) (3)	850	36,000	100
			Other units: see NCR 315-100 (3)			

NOTES:

(1) Extended term rental agreements are available for these components for a two- or a three-year period. The reduction in monthly rental for the 315-501 Processor with 20,000 characters of memory is 8% for the two-year arrangement and 15% for the three-year plan. The reduction for the other components is 10% for the two-year agreement and 15% for the three-year plan.

(2) Required on all "On-Line" bank systems; the feature is required on the processor and each CRAM unit.

(3) The 315-RMC can accommodate all NCR-100 peripheral devices except the 333-101 and 333-102 Magnetic Tape Units, the 354-601 Card Punch Controller (replaced by the 354-602), the 402-4 unbuffered MICR Sorter Reader, the 321-1 Communications Controller (replaced by the 321-3), and the 472 series punched card and punched tape console units. All communications adapters for the 321-1 can be used with the 321-3.

INTRODUCTION

.1 GENERAL

The Class 395, 400, and 500 Electronic Accounting Machines are the top models of NCR's extensive line of adding and calculating machines. These three systems bridge the gap between completely manual data handling and full-power electronic data processing. They are oriented primarily toward accounting and bookkeeping applications, and within this realm, sales have fared quite well, with more than 10,000 machines installed to date.

All three systems are related in their incorporation of the proven NCR Class 33 Accounting Machine* as a primary system component. Supplementary to this device, each machine offers increasing relief from the necessity of performing manual operations, beginning with the Model 395; progressing thru the Model 400, which widens the applications possibilities; to the Model 500, with its solid-state logic, stored-program feature, and automatic input-output units. None, however, offers quite as much general-purpose processing power, performance, or flexibility as the best-known small-scale data processing systems such as the GE-115, Honeywell 120, IBM 360/20, RCA Spectra 70/15, or UNIVAC 9200 and 9300.

Application possibilities range from simple invoicing and statement preparation to the production of incentive payrolls and summary reporting. To this end, magnetic-stripe ledger card reading and writing facilities play an important role in the Model 400 and 500 systems. All systems can use punched card input and provide punched card output. In accommodating large data files, therefore, the external storage medium for the three systems is either punched cards or magnetic ledger cards.

.2 HARDWARE AND PROGRAMMING

All of the models can handle alphanumeric input-output data, but only the NCR 500 can internally process alphabetic data. Each machine uses a similarly-structured data word; word length is 14, 13, and 12 BCD digits for the 395, 400, and 500, respectively. The 395 and 400 can punch paper tape; the 500 can read and punch paper tape; and all can handle punched cards. Magnetic-stripe ledger cards can be written and read by Models 400 and 500 but cannot be used with Model 395. Printout (including continuous forms) can be printed by the accounting machine itself, or, in the case of the 500 system, by using an optional 125-lpm line printer.

Magnetic disc storage that contains from 40 to 200 13- or 14-digit words is available for use with Model 395 or 400. Up to 20 words can be stored on each disc track; average access time is 19 milliseconds.

Core memory with a 22.5-microsecond cycle time and a capacity of 200 or 400 12-digit (BCD) words is provided with the Model 500. Processing and input/output characteristics of the three systems are summarized in Table I.

From 12 to 43 basic operations (e.g., add, clear memory, check-digit verify) can be programmed on the various models. NCR supplies the programs and assembles the stop control bars for customer applications. Complete operating instructions are also provided.

.3 OPERATION

In general use, variable data is entered on the Class 33 type keyboard, and varying amounts of constant data, such as item prices and descriptions, can be read by the input units. Carriage movement and initiation of processing activities are controlled by a combination of stops located on a control bar on the accounting machine carriage, by the wiring of a rear program panel, or by a punched paper tape program control. In addition, the Model 500 allows stored-program control of activities.

In most updating operations, the operator need only pull the proper ledger card from a file, insert it in the carriage, key variable data in the correct columns, and refile the card. Carriage movement and arithmetic operations (e.g., total charges and credits, develop new balance, test for limits) are controlled automatically. Ledgers, posted at any desired frequency, provide individual audit trails that cannot readily be produced by tab equipment or a computer system. If the ledgers are updated frequently, they provide a visual, up-to-date activity record that is immediately available.

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*Detailed reports on the NCR Adding Machines and mechanical Accounting Machines are included in AUERBACH Data Handling Reports, another looseleaf reference service published by AUERBACH Info., Inc. AUERBACH Data Handling Reports is a comprehensive, two-volume guide to selecting and applying the wide range of support equipment and supplies used in conjunction with computer systems.

TABLE I: CHARACTERISTICS OF THE NCR SMALL COMPUTERS

COMPUTER SYSTEM		NCR 395	NCR 400	NCR 500
DATA STRUCTURE	Numeric digit size, bits Alphabetic char. size, bits Word length, BCD digits	4 --- 14	4 --- 13	4 8 12
STORAGE	Memory capacity, words Type of storage Access time	20, 40, 100, or 200 Disc 19 msec	40, 80, 120, 160, or 200 Disc 19 msec	200 or 400 Core 22.5 μsec
PROCESSOR PERFORMANCE	Timing (fixed-point), msec: c = a + b c = ab c = a/b	 22 265 238	 22 265 238	 11 161 189
PROGRAMMING FEATURES	Instruction repertoire No. of addresses Indexing	12 5 Yes	42 1 Yes	75 4 No
INPUT	Console Punched cards Punched paper tape Magnetic ledger cards	Yes 100 cpm --- No	Yes 100 cpm --- 37 cpm	Yes 100 cpm 650 cps 37 cpm
OUTPUT	Printed copy Line printer Punched cards Punched paper tape Magnetic ledger cards	Yes --- 100 cpm 30 cps ---	Yes --- 100 cpm 30 cps Yes	Yes 125 lpm 100 cpm 120 cps Yes
MONTHLY RENTAL	Minimum system Average system Expanded system	$290 $355 $830	$450 $600 $795	$ 795 $1,250 $2,000

.3 OPERATION (Contd.)

From two to four magnetic stripes, functionally similar to magnetic tape, can be stamped on the ledger cards processed by the NCR 400 and 500. Posting line indicators are stored on one stripe. Stripes read by the 400 can contain up to 20 numeric words. Automatic zero suppression allows the 500 to record up to 324 digits per stripe. The magnetic-stripe data is automatically read and the card is automatically positioned for posting when the card is aligned between the front-feed forms guides. The magnetic-stripe data is rewritten as the card is ejected after posting. The magnetic-striped cards are a form of external storage that provides a basis for master file updating systems. Earnings, interest paid, sales, and other totals can be computed and stored on the stripes for later processing.

The processing speeds of the 395, 400, and 500 are limited by the manual operations that are required, and most of the models are not well suited for applications that require a high volume of printing. One model of the 500 includes a medium-speed printer and enough punched card input and output units to qualify it as a basic card system. One or two punched card readers, one or two punched tape readers (only one tape reader if the optical journal tape reader is used), and a magnetic-stripe ledger reader can be connected as input units; and a card punch, a paper tape punch, and a line printer can be connected as output units.

SUMMARY: NCR 395

.1 BACKGROUND

The NCR 395 Electronic Accounting Machine was announced in May 1964. It combines the features of the NCR Class 33 Accounting Machine with an electronic computing unit. More than 7,000 NCR 395 Systems have been installed to date.

The NCR 395 features console and punched card input, and punched card, punched paper tape, and console printer output. A magnetic disc storage device provides either 20, 40, 80, or 200 14-digit word locations of storage for use by the user's program. Programming is performed through a rear program panel and a front stop control bar which are installed on the 395 carriage. Programs are "loaded" for execution by exchanging program panels and bars. A flexible command repertoire permits twelve discrete functional operations to be programmed, including add, subtract, multiply, divide, compare, and copy.

All computation in the NCR 395 is performed though transistorized logic. There are no mechanical memory units. The only mechanical elements within the console are those required for printing and carriage control, and a mechanical buffer.

NCR 395 Electronic Accounting Machines were first delivered in July 1964; deliveries are normally made from three to five months after placement of order.

.2 HARDWARE

.21 Data Structure

Each NCR 395 data word consists of 14 digits, stored as four binary bits per digit. Full alphabetic information can also be handled, but only in input-output operations. Access to any storage location normally obtains a full 14-digit word, but partial words can also be manipulated by programming.

.22 Main Storage

All data entering the NCR 395 system passes through a single-word mechanical buffer, from which it is directed either to the electronics portion of the machine or to an output device. The principal storage device in the 395 is a built-in single-disc drive used to store all amounts or totals. Housed in a work-level cabinet to the left of the 395 Console, the disc drive contains a cobalt-coated aluminum disc that is nine inches in diameter and 7/16 inch in thickness. The disc rotates in a horizontal plane at 1750 revolutions per minute. Each storage track is serviced by its own read/write head, permitting average access times as low as 19 milliseconds.

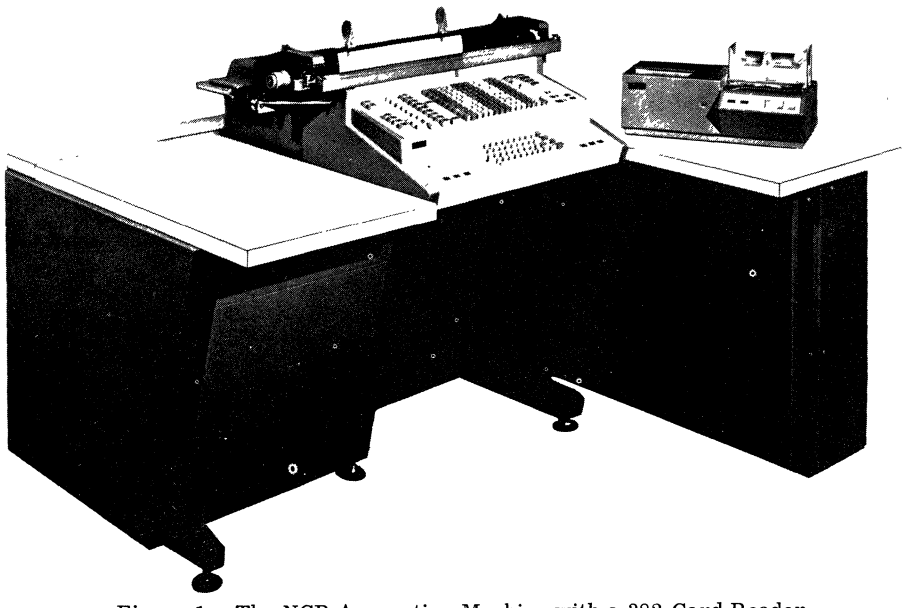


Figure 1. The NCR Accounting Machine with a 382 Card Reader.

.22 Main Storage (Contd.)

The NCR 395 Electronic Accounting Machine is available in four models: those with 20, 40, 80, and 200-word disc memories. Up to twenty words of data can be stored on each disc track. One disc track is reserved as an "Electronic Buffer Channel" to retain in temporary storage the last amount transacted.

.23 Processing Unit

The central control and processing unit in NCR 395 systems is the 395 Console. In outward appearance the Console resembles the NCR Class 31 and 33 Accounting Machines. Externally, the Console features a split-carriage, multi-form printer, a 72-character twin-shift typewriter, a 14-row adding-machine-style keyboard, a rear control panel, a front program bar, and various control keys and indicators. Internally, the 395 Console contains the solid-state logic necessary to perform all electronic calculations and to initiate input-output operations.

The Console printer contains 260 carriage positions, and all processing is performed on a single-stop basis; up to five discrete operations (I/O, arithmetic, compare, etc.) can be performed at each carriage stop. All processing at a given carriage stop can be performed in a single machine cycle (or within 400 milliseconds). As directed by the rear program panel (described in Paragraph .3, Programming), the Console uses a "five-address" command structure to perform its operations at each stop.

The operations that can be performed (many within the same machine cycle) include add and subtract, multiply and divide (rounded or unrounded), selective stores, copy shift, compare for equality, test comparison indicators, and table lookup. Positive and negative values determined by the Test command cause forward or reverse carriage movement to programmed stops on the front program bar of the carriage. The new stop position then initiates the next machine cycle and its five-part machine instruction.

All internal processing is performed directly on values in storage; e.g., an Add instruction adds the value of an amount, just entered into the system and stored in the mechanical buffer, to another value in storage where the sum is accumulated. Information enters the mechanical buffer either through the Console keyboard or an on-line card reader. The Multiply command takes the value in the mechanical buffer, multiplies it by the contents of a specified storage location, and stores the product in another specified storage location ($c = a \times b$). As examples of the processing speed of the NCR 395 Console, a 14-digit multiply is completed in 265 milliseconds, and a 14-digit divide is completed in 238 milliseconds.

Optional features in the NCR 395 include the Divide command, a special "IVS" package that is standard on the Model 395-303, and the new 80- and 200-word models. The IVS package includes a "step rate" feature that automatically performs a table lookup to obtain appropriate tax rates, depending on salary, for payroll applications. The same feature is also useful in billing applications. The IVS package also includes an automatic check-digit verifier for modulo-10 account numbers, and a card search feature that causes consecutive card reading until a specified account number or other control field is discovered.

.24 Input-Output

The basic input device in NCR 395 systems is the 395 Console keyboard, as shown in Figure 2. Each keyboard entry can represent a variable amount to be added or subtracted (charges, credits, etc.) or descriptive information not to be included in the totals (salesman number, sales terms, etc.). An entry is recorded by depressing keys representing the data and a motor bar. The middle motor bar is used for recording normal entries (e.g., add from the charge column, multiply times price from the quantity column), and the upper and lower motor bars are used for exception entries.

The amount keyboard (in the style of a full-keyboard adding machine) provides 14 amount rows with two implied decimal points. Accuracy is provided to three decimal places. Numeric information can be keyed into the amount keyboard for use as an immediate operand or as a stored constant, depending on the program. Alphabetic information can be entered in upper case only via the electric typewriter keyboard where it is printed and, optionally, sent to the card punch or paper tape punch as alphanumeric output. The 48-key twin-shift keyboard has a 72-character set.

As an option, NCR 395 machines can also be equipped with a Model 382-1 Card Reader. The 382-1 is a compact, 25-pound, desk-top unit that can read punched cards at a peak rate of 100 cards per minute (reading 14 columns per card). Selected fields within each card can be read under the direction of a user-prepared program disc within the card reader's cabinet. Hollerith-coded alphanumeric information is read by star wheels, converted to binary code, and transmitted to the system's main storage.

Constant data such as employee name and wage data can be punched into cards from the keyboard. Payroll checks and a payroll journal (including year-to-date and deduction information) can then be prepared by reading constant data from the cards and entering variable data from the keyboard. Updated cards are punched as the checks and journal are printed.

(Contd.)

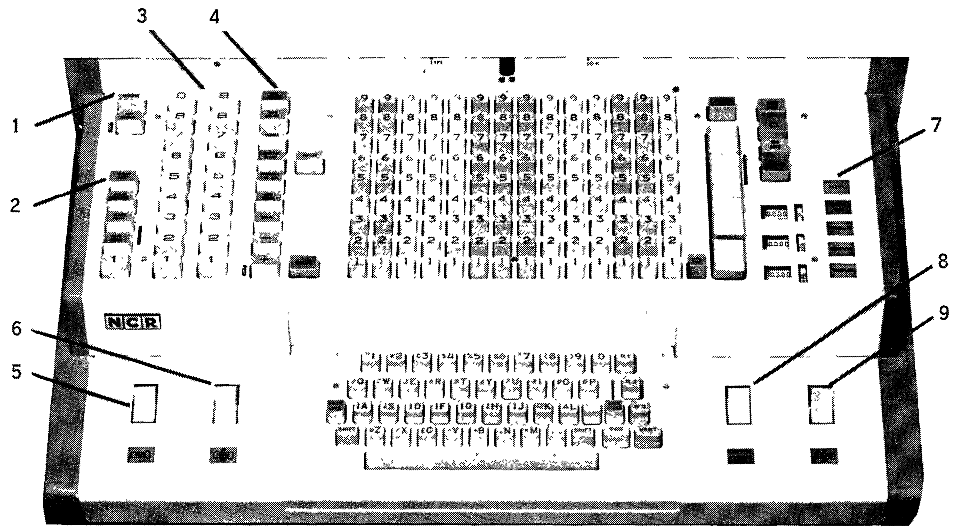


Figure 2. The NCR 395 Console.

.24 Input-Output (Contd.)

The standard output device of the NCR 395 Electronic Accounting Machine is the dual printing mechanism of the Console's adding machine and typewriter. The adding machine printer consists of a block of 18 print bars, 14 of which can print the numeric character set plus three special symbols. Three print bars in the block are used for printing of commas, and a fourth bar for the decimal point. The typewriter's stationary printing mechanism is located about five inches to the left of the numeric print block. Both printers can print at any of the 260 print locations along the 26-inch carriage on the Console. However, for any given application only 65 stops can be programmed because of the minimum tabbing distance of four spaces. Removable stops in the control bar regulate the horizontal movement of the carriage at each print position and control forms spacing. The control bars are exchangeable to fit the specific application.

The print platen is split into 10-inch and 16-inch sections, and each is capable of independent operation using different ledger cards, statement forms, journal forms, checks, etc., as the printing media. Individual carbon-backed or NCR paper forms (such as customer statements) can be inserted in front of forms already in the carriage, or data can be printed on a form in the left side of the carriage and all or part of it can be automatically repeated on a form in the right side of the carriage.

A statement, ledger, invoice, and journal printed by the 395 are shown in Figure 3.

The Forms Feeder option permits use of fan-fold continuous forms with a maximum width of 26 inches. With this feature, vertical spacing is performed under control of user-prepared carriage-control tapes. The 395 Console also provides control keys for horizontal carriage control and vertical paper spacing.

Punched card output is available as an option with the NCR 395. The NCR 376-6 card punch (an IBM 26 Printing Card Punch) can be connected to the NCR 395 system through couplers. It typically punches cards at about 18 columns per second. By front program-bar programming and the use of a wired selection board, numeric data from the 395's main storage can be punched. Alphabetic information originating from the Console typewriter or the card reader can also be transferred to the on-line punch for punched card output.

Punched card output can also be obtained through use of the NCR C-465-202 Alpha-Numeric Keypunch, manufactured by Bull-GE, which connects directly to an NCR 395 and punches at 25 columns per second.

The only other available output device for NCR 395 systems is the NCR 462-1 Punched Paper Tape Recorder. The 462-1 can punch data in 5-, 7-, or 8-level code at a peak rate of 30 characters per second. Tape reels can hold up to 1,000 feet of paper tape. Control of paper tape punching is programmed by a wired NCR 395 selection board in conjunction with preset stops on the front program bar of the Console's carriage. Punching of alphanumeric information requires use of a 434-2 Alpha Tape Coupler and a 434-1 Universal Switch Bank (to generate alphanumeric impulses from the typewriter keys).

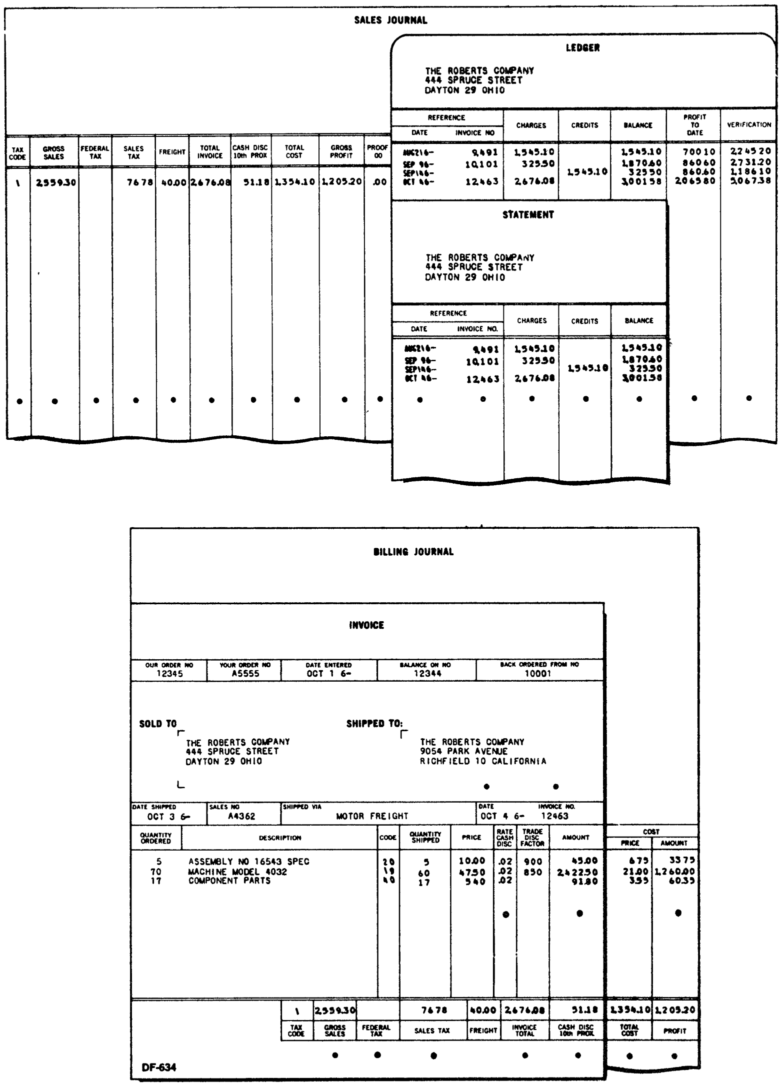


Figure 3. Printed output from the NCR 395.

.24 Input-Output (Contd.)

Monthly statements, posted at any desired frequency, provide individual audit trails that cannot readily be produced by tab equipment or computer systems. If the ledgers are updated frequently, they provide a visual, up-to-date record that is immediately available. A master file on ledger cards is particularly well suited for low-activity updating applications. However, the processing speed of the 395 is limited by the manual operations that are required, and the 395 is not well suited for applications that require a high volume of printing.

.3 PROGRAMMING

Programming the NCR 395 is performed primarily through use of an interchangeable control panel on the rear of the Console. All programmed operations are performed relative to individual positions or stops along the front carriage of the printer (i.e., at each carriage stop, several programmed operations can be performed). Carriage movement to the stops is initiated by the depression of a motor bar or control key.

The rear control panel consists of 260 programmable stop positions that correspond to the 260 print positions along the carriage of the printer. Each programmable position consists of a row of 57 slots, into which plastic selector plates can be inserted to activate up to 57 sensing switches. Each activated sensing switch initiates a discrete operation or specifies an operand address in disc storage.

The 57 switches that can be programmed at each carriage stop of the printer are logically grouped into six segments: one master command segment and five "address" segments.

(Contd.)

.3 PROGRAMMING (Contd.)

The command segment provides ten switches, among which are those that specify multiply, divide, copy, table lookup, and test operations. A positive or negative result of a test operation sends the printer's carriage in forward or reverse direction to the next carriage stop preset on the front program bar; when the carriage arrives at the preset stop, another set of programmed operations is performed.

The five remaining segments in a given stop position on the rear control panel can be specified to perform such operations as keyboard and card reader input, storage clear, and add/subtract. A segment consists of from 4 to 11 programmable switches. Each segment can be programmed to perform either one simple and discrete operation or to combine with other segments to perform a more complex operation. Since a single operation can be performed by each of five segments at a given stop position, NCR refers to the machine as a computer with a "five-address" instruction.

For example, an amount entered into the keyboard (via Segment I) can be added to another amount at an address in disc storage that is specified in Segment II; the same keyboard-entered amount can be added to a second, third, and fourth accumulator by so programming Segments III, IV, and V. By contrast, a multiply operation utilizes several segments to perform the single operation: the Command segment specifies the multiply operation; Segment I specifies the location of the multiplicand; Segment II specifies the location of the multiplier; and Segment III specifies the location of the product.

Four of the segments can directly address any of the 120 words of disc storage by means of a modified binary addressing scheme. Eight switch positions within each segment are weighted as follows: 80, 40, 20, 10, 8, 4, 2 and 1. Any operand can be directly addressed by inserting plastic selector plates in the particular combination of switch positions whose total of weighted values equal the operand address. For example, disc storage address 96 can be specified by inserting selector plates in switch positions with weights 80, 10, 4 and 2.

Operations programmed via the rear control panel are often performed in conjunction with carriage control and input-output operations programmed via the front program bar. The interchangeable front program (or control) bars are similar to those used with NCR Class 31, 32, 33 and 35 Accounting Machines. The bar is programmed by setting removable metal plates or "tab stops" at selected print positions. The front program bar controls formatting of printed output, forms spacing, date printing, etc. Inserting special plates at specific locations along the bar can also control input card reading and output card punching after these operations are initiated by the rear control panel.

Because of the combination of mechanical and electronic functions and the dual function of many of the control keys, programming the NCR 395 is rather complex. Carriage movement must be coordinated with the arithmetic and input-output operations. However, many users of this equipment will not concern themselves with programming considerations, since NCR supplies its 395 machines already programmed to the specifications of the users' principal applications.

.4 PRICE DATA

Component or Feature	Monthly Rental (1-Year Lease) $	Purchase Price $	Monthly Maintenance $ (1)
NCR Electronic Accounting Machine:			
Model 395-100	460 to 560	15,900 to 18,900	71
Model 395-200	495 to 595	17,400 to 20,400	92
Model 395-300	310 to 395 (2)	10,900 to 12,500	45
Options			
465 Alpha-Numeric Keypunch	150	6,990	27
376 Card Punch	87	5,150	26
Numeric Card Coupler	40	1,240	12
Alpha Output Switch Bank	25	1,000	4
Alpha Card Coupler	15	240	7
IVS Feature	40 (2)	600	6

NOTE: The machine prices do not include the optional input-output units. IBM Card Punch prices range from $2,000 to $4,500.

(1) Slightly higher in rural areas.

(2) Also available on a three-year lease at lower rates.

SUMMARY: NCR 400

.1 BACKGROUND

Announced in January 1967, the NCR 400 Electronic Accounting Machine adds magnetic-stripe reading and writing ability to the capabilities of the NCR 395, as described in Report 612. In addition, programs and constants can be read from punched tape, allowing greater flexibility.

The NCR 400 features keyboard and punched card input; punched card, punched tape, and console printer output; and magnetic-stripe read and write heads on the console carriage. The front stop control bar controls carriage movement and printing. From 40 to 200 13-digit words of disc storage are available in increments of 40 words. The NCR 400 Electronic Accounting machines were first delivered in December 1967, and over 100 systems were delivered during that month. Deliveries are normally made from five to seven months after an order is placed.

.2 HARDWARE

All NCR 400 hardware is identical to that of the 395 (Report 612), except for a wider choice of internal storage sizes (40, 80, 120, 160, or 200 words of disc storage), two 16-digit arithmetic registers, a smaller word and keyboard size (13 digits), a magnetic-stripe capability, and the ability to read punched program tapes. The principal characteristics of the NCR 400 are compared with those of the NCR 395 and 500 systems on page 610:011.100.

.21 Magnetic Ledger Card Input-Output

The dimensions and capacities of ledger cards that can be processed through the magnetic-stripe carriage are shown in Table I and Figure 2. Two magnetic stripes are stamped on the back of the cards; one stripe is for data storage and the other is for line-finding indicators. Front-feed forms guides are included on the carriage so that individual magnetic and non-magnetic forms can be inserted in front of a continuous journal. The cards are aligned between the guides, the magnetic stripe data is read, and the cards are automatically positioned for posting the next line. Data is written on the stripes in a 4-bit binary code at 20 numeric digits per inch. When the last posting line is printed, an indicator is lit. The required heading and cumulative data is automatically printed and encoded on a new ledger card when it is inserted in the carriage.

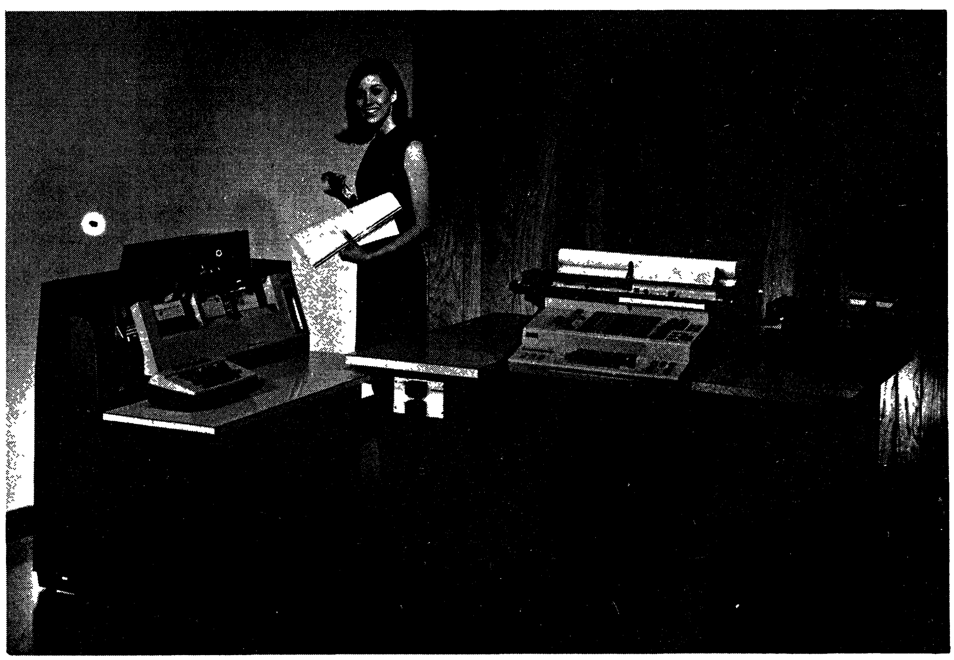
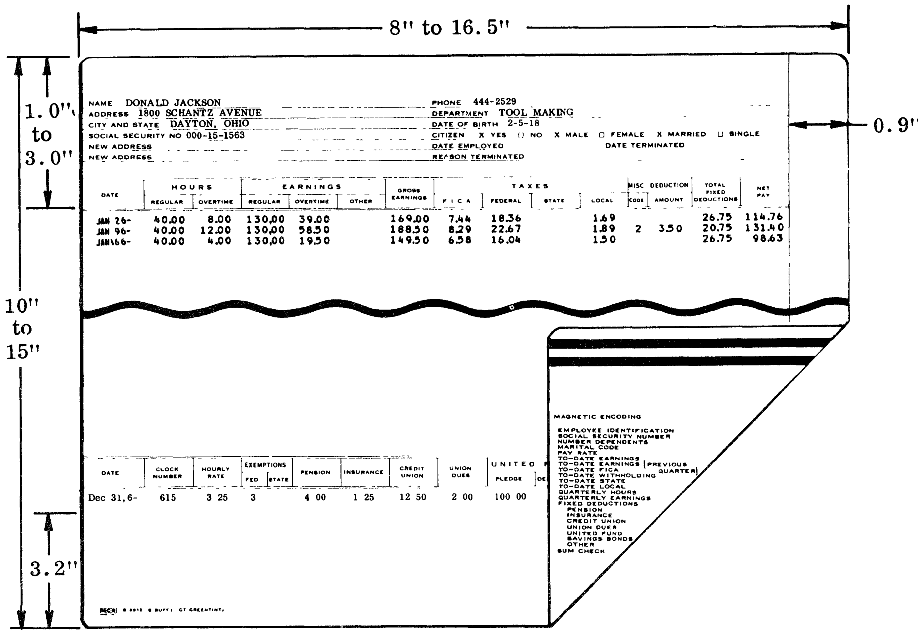


Figure 1. The NCR 400 Electronic Accounting Machine with the 465 Keypunch (left) and 382 Card Reader (right).

TABLE I: CAPACITIES OF NCR MAGNETIC-STRIPE LEDGERS

Capacity	Magnetic-stripe ledger length (inches)					
	10	11	12	13	14	15
13-digit magnetic-stripe words	15	17	19	20	20	20
Posting lines (with 1/2- to 3-inch headings)	33 to 22	39 to 27	45 to 33	52 to 40	58 to 45	64 to 51

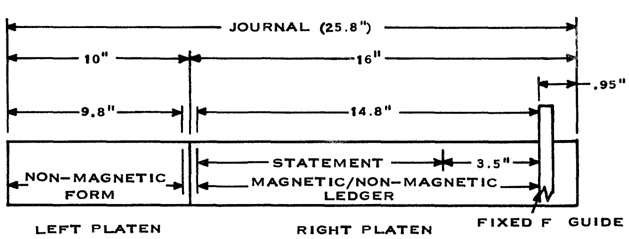


NOTE: Data cannot be printed in the bottom or right margin.

Figure 2. Ledger card printed by the NCR 400.

.21 Magnetic Ledger Card Input-Output (Contd.)

Magnetic-stripe ledger cards are a form of external storage that provides a basis for an elementary master-file updating system. Earnings, interest paid, sales, and other totals can be computed and stored on the magnetic stripes for later updating. Continuous single- or multiple-part forms, up to 26 inches in width, including 1/2 inch on either side for pinfeed holes, can be fed through the console carriage by the optional Continuous Forms Feeder (CFF). The forms can be from 3 1/2 to 12 inches in length. The dimensions of forms that can be processed through the 26-inch carriage are shown in Figure 3. A



NOTE: An 8"/18" split is also available.

Figure 3. Specifications of the NCR 400 split platen.

(Contd.)

.21 Magnetic Ledger Card Input-Output (Contd.)

3-channel carriage tape and two console keys control forms spacing and skipping when the CFF is used. Depression of the Field Position Switch causes the carriage to open and space to the next printing line. Depression of the Home Position Switch causes the carriage to open and to skip to the first line to be printed on the next continuous form.

.22 Punched Tape Input-Output

The optional 462-1 Punch Paper Tape Recorder provides paper tape output punched with any 5-, 6-, 7-, or 8-level code. It provides up to six punching formats. The formats can be modified by wiring through switches actuated by an add, subtract, or non-add condition. The character set is limited to 10 digits and 12 special characters. With the zero suppression option, non-significant zeros are not punched and a character is emitted to identify the starting position of the entry in the data field.

The paper tape may be 7/8, 11/16, or 1 inch in width. Paper tape reels contain 900 feet of blank tape, and the take-up reels hold 350 feet of punched tape.

A tape reader is provided to read the aluminum-coated Mylar program tape.

.3 PROGRAMMING

The NCR 400 is controlled by programs read from punched tape and by a front stop bar. Commands such as add, subtract, multiply, divide, test, clear, and print are read from the program tape and executed. Constant data can also be punched into and read from the program tape. A sample section of a program tape is shown in Figure 4. Representative commands and their execution times are shown in Table II. The machine cycle time is approximately 400 milliseconds. Computing and program tape reading can occur concurrently during the last 135 milliseconds of a cycle. The program tape is read and searched photoelectrically at 118 characters per second. The front stop bar controls carriage movement and printing. Carriage movements of up to 0.4 inch can be performed during a cycle.

TABLE II: NCR 400 COMMAND TIMES

Command Name	Execution Time in Milliseconds
ADDRESS	19 (average)
ADD	13.6 to 41 (average, 22)
ADD PUT AWAY	24 to 56 (average, 38)
ALPHA (Read from punch card)	100 per typed character, 7 per skipped character
CLEAR MEMORY	19
CLEAR MEMORY STRING	27 + 1.7 per address cleared
DELETE	8.5
DIVIDE	238 (quotient = 55555) average
EJECT (Read punch card)	17 not time-shared, 7 per column time-shared
EXTRACT	22 to 90, (average = 48)
KEYBOARD ENTRY	275, not time-shared.
LEDGER FULL (TEST)	25 + 8.5 per step skipped
MODIFY ADDRESS Ø	35
MODIFY ADDRESS, POSITIVE	35
MULTIPLY	265 (multiplier = 55555) average
READ LEDGER — NEW	Approximately 1.5 seconds for an 11" card
CHECK DIGIT VERIFY	265 (same as multiply)
READ PUNCH CARD (NUM)	17 + 7 per digit read
READ PROG. TAPE — Start	17 + 8.5 per digit read
READ PROG. TAPE — End	17 + 8.5 per digit read
PAPER FEED	Approximately 150
PRINT	275 (not time-shared)
PRINT AUTOMATIC	275 (not time-shared)
READ LEDGER	2 seconds average (11" card), plus operator time
SEARCH PROG. TAPE	Forward = 8.5 per step skipped Reverse = 8.5 + 8.5 per step skipped
SELECT ADDRESS	19 (average)
SUBTRACT	13.6 to 41 (average, 22)
SUBTRACT PUT AWAY	24 to 56 (average, 38)
COMPARE FOR ZERO OR POSITIVE	25 + 8.5 per step skipped if branch
TRANSFER	8.5
READ LEDGER — EJECT	2.5 seconds average, plus operator time
WRITE LEDGER	2 seconds (average)

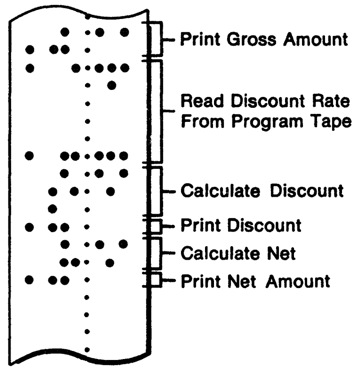


Figure 4. Sample section of an NCR 400 program tape.

.3 PROGRAMMING (Contd.)

The NCR 400 console includes: on-off switches, peripheral control switches and indicators, error-correction control keys, and keys for manually controlling most of the programmable functions. Memory words can be addressed through the use of the Load Address key, the middle motor bar, keys in columns 1, 2, and 3, and the Z key (for the second arithmetic register).

.4 PRICE DATA

Component or Feature	Monthly Rental $ (1)	Purchase Price $	Monthly Maintenance $
NCR 400 Electronic Accounting Machine:			
Model 400-100; 40-word memory	430 to 480	15,200 to ?	(2)
Model 400-200; 80-word memory	525 to 630	17,500 to 21,800	83.33 to 101.67
Model 400-300; 120-word memory	575 to 680	19,500 to 23,800	87.50 to 105.83
Model 400-400; 160-word memory	625 to 730	21,500 to 25,800	91.66 to 110.00
Model 400-500; 200-word memory	675 to 780	23,500 to 27,800	95.83 to 114.17

NOTE: The above prices include the basic accounting machine and specified memory. Prices for optional input-output units are shown in Paragraph .4 of Report 612.

(1) Prices shown are for one-year leases; monthly rates for three-year leases range from $375 to $730.

(2) Not currently available.

SUMMARY: NCR 500

.1 BACKGROUND

The NCR 500 Computing System allows the gradual implementation of automatic accounting and bookkeeping techniques within small business environments. Companies whose gross volume is in the $8,000,000 to $65,000,000 range are primary market prospects for this small-scale data processing system. NCR delivered the first 500 system in October 1965 and has installed about 1600 of them to date. Although the 500 has the capability for automatic processing, over half of the present installations maintain a mix of manual and automatic operation; this mix continues because the magnetic-stripe ledger cards are popular with NCR customers.

The NCR 500 system is primarily used for billing, payroll, cost accounting, inventory, banking, and sales analysis applications.

Monthly rentals can range from $795 for the minimum configuration to $2,620 for the full system with all peripherals. Average rental for all installed systems is about $1,500 per month.

The NCR 500 Computing System utilizes a C-517-1 Processor using discrete transistor and diode circuitry, 200 or 400 12-digit (BCD) words of magnetic core memory, one of three console models, and peripheral devices that can include paper tape reader and punch, punched card reader and punch, a magnetic-stripe ledger card reader, an optical journal tape reader, and a line printer. The system operates under the control of a program stored in memory. The instruction repertoire consists of 19 basic instructions that can be modified to produce over 100 individual instructions. Some of these instructions can be used with mechanical devices, paper program tapes, and program discs on the peripheral devices to produce a wide range of input and output data formats.

Each instruction occupies one word in memory and consists of a 2-digit command code, a 1-digit modifier, a 1-digit register code, and four 2-digit addresses. The four addresses normally specify the memory locations of the first operand (A), the second operand (B), the result (C), and the next instruction (NI). In order to address all 400 memory locations using only two BCD digits, the register code selects digits of an address register to find the plane in which the address is located. (The memory consists of 2 or 4 planes, with each plane containing 100 12-digit words.)

The three console models available for use with the C-517 Processor are: the relatively simple C-521-1 numeric console with journal tape printing; the C-590-2 alphanumeric console, with a 26-inch carriage that can perform a wide range of functions controlled by programmed instructions, keys on the console, the block assembly, and mechanical inserts; and the C-590-1 console, which can read and write magnetic-stripe ledger cards in addition to the functions of the C-590-2.

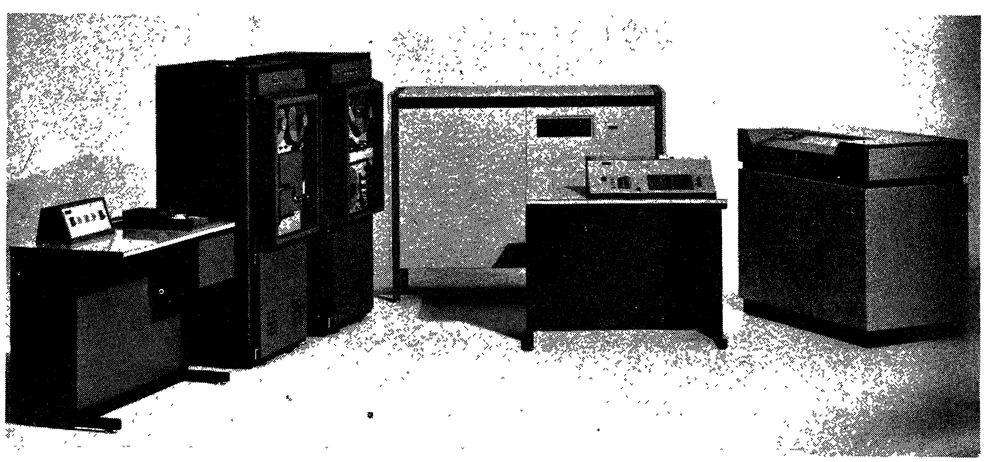


Figure 1. A typical NCR 500 Computing System. Shown from left to right: C-562 Strip Tape Reader, C-571 Tape Punch, C-561 Tape Reader, C-517 Processor, C-521 Console, and C-541 Line Printer.

.1 BACKGROUND (Contd.)

One useful, but complex, feature of the C-590 consoles is the ability to override carriage tab stops with programmed instructions from the processor. This feature eliminates the need for mechanical changes in the carriage controls between jobs if all job formats are planned when the carriage assembly is made up. This overriding feature is also used with the C-541-1 Line Printer to allow mixed alphabetic and numeric printing across fields.

Although these features indicate that varied formats are possible, data in a fixed format can be processed more efficiently; editing routines are costly in both time and memory space.

The variety of functions that can be performed on the consoles is an attractive feature of the NCR 500 systems. But, in order to fully utilize the processor and the stored program, the console should be used sparingly and primarily to initiate the internally stored program that obtains input data automatically from tape, punched cards, or magnetic-stripe ledger cards and produces output automatically on the tape punch, card punch, and/or line printer. Since magnetic-stripe ledger cards can be updated only in the carriage of the console, at comparatively low speeds, their use should be carefully thought out when including them in the system.

The NCR Series 500 Computing System is well suited for small-volume accounting applications. The variety of tasks it can perform is large, but the overall speed of the system (see Table I) is significantly lower than those of most stored-program computers.

The programming of the processor is relatively easy, but the organization of processing runs, formatting of data, and making up of the carriage assembly requires well-trained personnel. Although NCR has more than a hundred preprogrammed routines covering

TABLE I: EXECUTION TIMES FOR REPRESENTATIVE INSTRUCTIONS

Instruction	Explanation of Operation	Time, msec
Add	Two 12-digit numbers and store sum	11.29
Multiply	12-digit multiplicand by 5-digit multiplier, store rounded 12-digit product	32.30
Divide	12-digit dividend by 5-digit divisor, store unrounded 12-digit quotient	160.57
Read Punch Card	All 80 columns, numeric	583.45
Punch Card — Serial	All 80 columns, numeric	3595.24
Punch Card — Parallel (uses C-551 Buffer)	All 80 columns numeric, or 48 columns, alphanumeric Processor time Available buffer time	600.00 77.40 37.00
Read Paper Tape	One 12-digit word Field of five 12-digit words	50.04 130.20
Punch Paper Tape	One 12-digit word Field of five 12-digit words	112.69 512.53
Line Print (uses C-551 Buffer)	One line of 96 numeric digits or 48 alphanumeric characters	480.00
Read Ledger Card	10-inch-long ledger card Processor time for five 12-digit words	1400.00 448.00
Manual Ledger Card Handling*	Per ledger, any allowable size	2000.00
Read Console	12-digit word	Operator speed
Print on Console	12-digit word	Tab time +540.00
Tab Time	0.5 inch 1.5 inches 4.0 inches 20.0 inches	120.00 260.00 500.00 2030.00

*Depends on operator's speed.

(Contd.)

.1 BACKGROUND (Contd.)

a wide range of small business applications, NCR recommends that each installation have at least one operator-programmer who can change these routines to fit the specific applications. The help NCR provides in this respect varies from area to area; in large metropolitan areas, NCR has programming staffs available to set up the entire installation; in rural areas, a salesman may not have the expertise to provide this help. NCR feels that the best results are generally obtained in installations in which the customer's staff assumes at least 50 percent of the programming responsibility.

The first NCR 500 Computing System was delivered in October 1965. They are now available for immediate delivery.

.2 HARDWARE

Each NCR 500 Computing System consists of a C-517-1 Processor, a Console, a C-551 Buffer (if a C-541-1 Line Printer or a C-577-1 Parallel Punch is used), and the selected peripheral devices. Figure 1 shows a typical installation.

Input to the C-517-1 Processor can come from:

- One or two C-561-1 or -2, C-562-1, or C-563-1 Paper Tape Readers;
- One C-420-2 Optical Journal Tape Reader (instead of one C-562-1 Reader);
- One or two C-582-1 Punched Card Readers;
- One C-586-1 Magnetic Ledger Reader; and
- One C-521-1, C-590-1, or C-590-2 Console.

Paper tape can be punched off-line with a C-464-2 Alpha-Numeric Printing Tape Punch or with a Class 31, 32, 33, or 35 Accounting Machine coupled, via a C-434-5 Alpha Tape Coupler, to a C-462 Punched Paper Tape Reader. Punched cards can be produced off-line with any keypunch using the Hollerith code. Magnetic-stripe ledger cards cannot be produced off-line.

Output from the C-517-1 Processor can be produced on:

- One C-576-1 Serial Card Punch or one C-577-1 Parallel Card Punch (requires the C-551 Buffer);
- One C-541-1 Line Printer (requires the C-551 Buffer);
- One C-571-1 or C-472-1 Paper Tape Punch; and
- One C-590-1 (with magnetic stripe ledger card reader and writer) or C-590-2 Console.

.21 Data Structure

The C-517 Processor uses a 12-digit (BCD) word as the basic unit of data. The word does not include a sign; negative numbers are expressed as nine's complements. Each alphanumeric character is expressed by 2 BCD digits; thus, each memory location can hold six alphanumeric characters.

When words of less than 12 digits are entered into the memory, an end-of-word signal is generated by the input device to fill out the balance of the word with zeros. The output device can suppress insignificant zeros transferred from memory. A negative symbol will fill out the word with nines when negative numbers of less than 12 digits are read into memory.

The core memory consists of 2 or 4 planes of 100 words each; the planes are labeled "0", "2", "4" and "6". Memory location 99 of plane 0 is adjacent to location 00 of plane 2; location 99 of plane 6 is adjacent to location 00 of plane 0; but, in the 200-word memory, location 99 of plane 2 is not adjacent to location 00 of plane 0. Most instructions that use consecutive memory locations can operate across adjacent planes.

Each instruction consists of one word, decoded in the following manner:

Command			R	Addresses								
NI	Code	Mod.	Sel.	A		B		C		NI		
12	11	10	9	8	7	6	5	4	3	2	1	Digit

.21 Data Structure (Contd.)

Digits 11 and 12 designate the code of the basic instruction. Since there are only nineteen basic instructions, the 12th digit is a "0" or "1" for all instructions. To utilize further the 12th digit, it also designates the plane in which the address of the next instruction is located.

The tenth digit modifies the basic instruction to select the peripheral device in input and output instructions, to override mechanical stops in the console instructions, or to qualify the instruction in some way.

The ninth digit is a register select code that selects digits of a memory register to identify the plane in which the A, B, and C addresses are located. The memory register must be set by an instruction each time any of the addresses refers to a new plane other than "0"; addresses in the "0" plane can be referenced without using the memory register.

Digits 3 through 8 specify the memory locations of the A, B, and C addresses within the plane specified by the R Sel code and the memory register. Digits 3 and 4 are used as an alternate exit for comparison instructions and as a control code in some instructions not requiring a C address.

Digits 1 and 2 select the address, within the plane specified by the 12th digit, of the next instruction.

Data is transferred to and from the peripheral devices in a 4-bit BCD code; see Table II. Numerics use one BCD digit, and alphanumerics use two. The binary numbers 10, 11, 13, 14, and 15 in each BCD digit are used as control codes:

10 = AI — alternate instruction. When read, the next instruction is not specified by NI but by the C address. Used by the operator at the console to reach a recovery routine for error correction.

11 = EOT — end-of-tape. When read, the next instruction is specified by the C address and not by NI.

TABLE II: NCR 500 ALPHANUMERIC DATA CODE

MEMORY DIGIT CODES	LINE PRINTER	TYPE-WRITER	PUNCHED CARD	
			CHAR-ACTER	PUNCH FORMAT
10	0	0	0	0
11	1	1	1	1
12	2	2	2	2
13	3	3	3	3
14	4	4	4	4
15	5	5	5	5
16	6	6	6	6
17	7	7	7	7
18	8	8	8	8
19	9	9	9	9
20	*	&	&	12
21	A	A	A	12-1
22	B	B	B	12-2
23	C	C	C	12-3
24	D	D	D	12-4
25	E	E	E	12-5
26	F	F	F	12-6
27	G	G	G	12-7
28	H	H	H	12-8
29	I	I	I	12-9
30	space	space	none	blank
33	space	(.)	(.)	12-3-8
40	$	space		11-0
41	J	J	J	11-1
42	K	K	K	11-2
43	L	L	L	11-3
44	M	M	M	11-4
45	N	N	N	11-5
46	O	O	O	11-6
47	P	P	P	11-7
48	Q	Q	Q	11-8
49	R	R	R	11-9
53	space	tab/EOR	$	11-3-8
54	space	tab	*	11-4-8
61	,	space	/	0-1
62	S	S	S	0-2
63	T	T	T	0-3
64	U	U	U	0-4
65	V	V	V	0-5
66	W	W	W	0-6
67	X	X	X	0-7
68	Y	Y	Y	0-8
69	Z	Z	Z	0-9
73	space	ret/EOR	,	0-3-8
74	space	ret	%	0-4-8

(Contd.)

.21 Data Structure (Contd.)

13 = EOW — end-of-word. Signals the processor to zero-file the rest of a word.

14 = EOR — end-of-record. Used with instructions that read from punched paper tape, punched cards, or the console to signal the end of a variable-length record.

15 = DEL — delete. Used for error correction. This code is ignored by the processor.

The alphanumeric character set includes the numerals 0-9, upper-case letters, control codes, and special characters. The special characters are listed below:

Memory Digit Code	Line Printer	Typewriter	Punched Card	Punch Format
20	*	&	&	12
30	space	space	none	blank
33	space	(.)	(.)	12-3-8
40	$	space		11-0
53	space	tab/EOR	$	11-3-8
54	space	Tab	*	11-4-8
61	(,)	space	1	0-1
73	space	ret/EOR	(,)	0-3-8
74	space	ret	%	0-4-8

.22 Console

The C-521-1 Console has a numeric keyboard with journal tape printing and control keys for operating the computing system. Its main function is to access the memory for initiating, debugging, and correcting the program. Instructions or numeric data can be entered into the processor from the keyboard. Normally, this keyboard is used in an application where all of the input and output data is on punched paper tape or punched cards and the printing is done on the C-541-1 Line Printer.

The C-590 consoles have a 26-inch carriage with a split platen, a continuous forms feed, and an alphanumeric keyboard with processor controls. The C-590-1 has a magnetic-stripe ledger card reader and writer built into the carriage; the read/write heads have the automatic line-find feature. The ledger cards can be read and updated by a program stored in memory. An indicator on the console tells the operator when the processor is on a magnetic ledger card read instruction; once the processor is finished with the ledger card, the program can automatically eject it. On new C-590 Models, the typewriter keyboard can enter alphabetic data into memory.

The stop block combined with plates inserted in the carriage assembly provides a wide range of formats that can be printed by programmed instructions. The modifier (10th digit) of the console print instruction can override some of the plates in the carriage assembly to effect a change in the pre-set format; e.g., a carriage return to a #1 insert can be overridden by a "4" modifier to skip to a #2 block.

Continuous fanfold forms can be printed on the C-590 Consoles by means of a Continuous Forms Feeder controlled by a disc. The disc size is determined by the number of lines printed per fold. Since the spacing on the carriage is 6 lines to the inch, the length of all forms must be divisible by 1/6 inch.

.23 Punched Paper Tape Input and Output

The paper tape readers and punches use 1-inch paper tape with eight channels plus a sprocket channel. Of the eight channels, only five are used: four for the BCD code and one for the odd parity check bit.

Numeric data is stored one digit per row; alphanumeric data requires two rows per character. Each word ends with an EOW (13 or 1101) code. When the tape is read for internal processing, the EOW code signals the processor to complete the word with zeros, and the EOR code signals the processor to fill the record with zeros. If the EOW code does not follow every 12th digit, the processor halts and indicates an error. If the tape read instruction tries to terminate before the EOR code is received, meaning the record is too long for the allotted space in memory, the processor halts and indicates an error.

Tape on the 561-1 or 561-2 can be rewound by a programmed instruction; all tape units except the C-562-1 have a manual rewind control.

Paper tape input can be prepared off-line by using an NCR C-464-2 Alpha-Numeric Printing Tape Punch or by coupling, via a 434-5 Alpha Tape Coupler, any NCR Class 31, 32, 33 or 35 adding machine, with a 48- or 72- character typewriter, to a 462 Punched Paper Tape Recorder.

.23 Punched Paper Tape Input and Output (Contd.)

The C-420-2 Optical Journal Tape Reader can be connected to the processor by using the circuitry normally used for the C-562-1 Reader.

See Table III for the characteristics of the paper tape readers and punches.

TABLE III: CHARACTERISTICS OF PAPER TAPE INPUT AND OUTPUT UNITS

Device	Rate, Char/sec	Max. Length of Tape, Feet
C-561 Paper Tape Reader:		
Model C-561-1	400	1000
Model C-561-2	600	1000
C-562-1 Paper Tape Strip Reader*	650	1000
C-563-1 Paper Tape Reader	50	350
C-571-1 Paper Tape Punch	120	1000
C-572-1 Paper Tape Punch	30	1000

* No provision for rewind, backspace, or take-up.

.24 Punched Card Input and Output

The punched card input and output equipment uses the standard Hollerith code. One or two C-582-1 Readers can be connected to the C-517-1 Processor, via a C-581-1 Controller. A program disc for each reader supplies the EOW signal to the processor, thus fixing field lengths. Since alphabetic data requires two BCD digits and numeric data only one, the program disc must be punched after every six columns in fields that may contain either numeric or alphabetic data. This limits the numeric data fields to six digits or requires an editing routine to reformat the fields. Consequently, two punched card readers are required for efficient processing in any application that uses more than one card format.

An 11-punch in any column of a numeric field will cause the number to be stored in memory as a 12-digit nine's complement. If the negative number is punched in the card as a nine's complement, as is the case when the card was punched as output from the 500 system, and if the number is less than 12 digits, the programmed instructions must fill out the word with nines to form the true complement.

One C-577-1 Parallel Punch or one C-576-1 Serial Card Punch can be connected as output from the C-517-1 Processor.

The C-577-1 Parallel Punch uses the C-551 buffer; thus, the processor can continue with the next instruction once the data has been transferred from the memory to the buffer. One card is punched for each punch instruction. The data must be stored in adjacent memory cells; all digits are punched; and negative numbers are punched as nine's complements.

Since each punch instruction specifies whether the data is alphanumeric or numeric, mixed data must be in the alphanumeric code. This means that the numeric data must be edited prior to punching. Editing is facilitated by an Expand instruction that converts one word of numeric data into two words in the alphanumeric code. Alternatively, the alphabetic data could be punched on one card and the numeric data on the following card.

The C-576-1 Serial Card Punch is controlled by a drum card and by instructions stored in memory. The drum card controls the punching or suppression of insignificant zeros in specified fields, non-printing in specified fields, and the skip stop. The instructions that control punching on the C-576-1 are: Punch Numeric, Punch Alphanumeric, Skip, and Release.

All 80 columns of a card can be punched from adjacent memory locations with one instruction if all the data is numeric and the fields are of the same length. If all the data is in the alphanumeric code, only 48 columns can be punched with one instruction.

The Punch Numeric instruction specifies the field length; thus, insignificant zeros are not transferred from the memory to the buffer. If the field length varies from field to field, several Punch Numeric instructions are required to punch one card, with one instruction required for each change in length of adjacent fields. For example, if a record has fields of 12, 12, 10, 10, 5, 5, 6, 10, 4, and 6 digits, seven Punch Numeric instructions are required to punch the card. On the other hand, if the fields are rearranged into the format 12, 12, 10, 10, 10, 5, 5, 6, 6, and 4, five instructions are needed to punch the card.

When all 80 columns are not punched in the card, a skip or a release instruction must be used to move the card from the punching station. Skip instructions are controlled by a 12-punch in the drum card; when the C-576-1 receives a Skip instruction, it skips all succeeding columns to the column preceded by a 12-punch in the drum card.

Table IV summarizes the characteristics of the punched card equipment.

TABLE IV: CHARACTERISTICS OF PUNCHED CARD INPUT AND OUTPUT UNITS

Device	Hopper Capacity, Cards		Speed
	Input	Output	
C-582-1 Punch Card Reader	500	450	100 cards/min
C-576-1 Serial Card Punch:	500	500	
Punch			25 columns/sec
Skip			80 columns/sec
C-577-1 Parallel Card Punch	800	800	100 cards/min

.25 Line Printer

The C-541-1 Line Printer is used to print high-volume alphanumeric output from the NCR 500 Computing System. It uses the C-551 Buffer, enabling the processor to proceed to the next instruction once the data has been transferred from the memory to the buffer.

The C-541-1 prints 96 characters per line at the rate of 125 lines per minute for numeric data and 62 (or 125 on a new model) lines per minute for alphanumeric data. The maximum width of paper that can be handled is 20 inches. The printing format can be controlled both horizontally and vertically. The 40-symbol character set consists of the numerals 0-9, the 26 upper-case letters, a $ sign, a comma, and an asterisk (the 40th character is an extra zero).

The Line Printer is controlled by zero edit levers, by a Printer Control Tape, and by programmed instructions.

The zero edit levers suppress the printing of insignificant zeros to the left of significant digits in a field and insert zeros to the right of significant digits in a numeric field. These levers operate in conjunction with the Line Print instruction that specifies whether the data is alphanumeric or numeric.

The Printer Control Tape is a 1 5/16-inch 8-channel, punched paper tape used to control the vertical spacing of forms. The Line Print instruction itself can space the form up to 3 spaces. If the forms must be moved more than three spaces, the C address in the Line Print instruction is used to select Track #1, 2, 3, or 4 to control vertical spacing. Track #4 is reserved to find the first line on a form. Tracks #5 and 6 are not used at the present time. Track #7 identifies the last printing line on a form and switches control to track #4 to advance to the first line of the next form. Track #8 senses the absence of paper and sets the Paper Out Indicator.

The Line Print instruction specifies: whether the data is numeric or alphabetic; which half (left or right) of the 96-character line is to be printed; how many spaces (0-3) to move the form before printing; which track of the program control tape has vertical spacing control (if the form must move more than 3 spaces); and how the instruction will terminate (by printing a line or by sensing a special code in the digits transferred to the buffer).

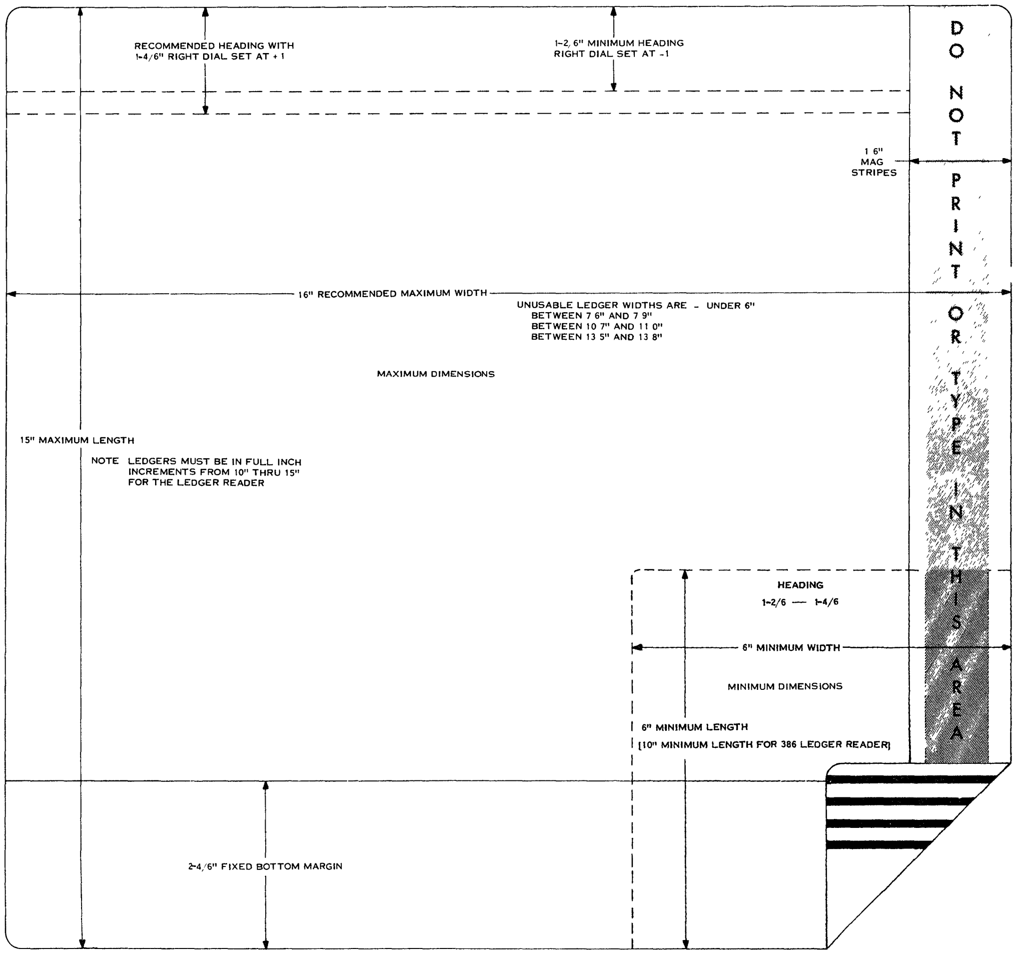
Since the C-551 Buffer holds only 96 digits and each alphanumeric character is composed of 2 digits, the Line Printer can print only 48 alphabetic characters during one cycle. (The new models with an expanded C-551 Buffer can print 96 alphabetic characters per cycle.) In general, alphabetic and numeric data, except for identification purposes, should be printed separately; formatting the data for mixed printing is costly in memory space and processor time.

Since negative numbers are stored in the processor in nine's complement form, the program must convert all negative numbers to positive numbers and affix an alphabetic CR symbol.

.26 Magnetic-Stripe Ledger Cards

The magnetic-stripe ledger cards can be read by a C-586-1 Ledger Feeder Reader or read and updated in the carriage of the C-590-1 Console. The reader on the Console has an automatic line find to locate the posting line on the ledger.

The ledger cards can vary in length from 10 to 15 inches in 1-inch increments, and in width from 6 to 20 inches except that widths from 7.6 to 7.9, 10.7 to 11.0, and 13.5 to 13.8 inches are disallowed. The cards are made of paper and are either #32 or #36 No. 1 Sulphite Regular Finish or #36, 50% Rag Ledger Regular Finish. All ledger cards in an installation should be of the same stock. See Figure 2 for ledger card dimensions.



Caution: Unusable ledger widths are — under 6", between 7.6" & 7.9", between 10.7" & 11.0", and between 13.5" & 13.8".

Note: Ledger length must be in full inch increments for the C-586-1 Ledger Reader, such as 10", 11", 12". Width however, may be any dimension from 6" to 16".

Ledger Proportions: (Required for 586 Ledger Reader)	Length: 10"	Width: 6" to 11"
	11"	8" to 14"
	12"	8" to 16"
	13, 14", 15"	10" to 16" (16" - 20" special construction)

Figure 2. Magnetic-stripe ledger card dimensions.

.26 Magnetic-Stripe Ledger Cards (Contd.)

Cards can be posted on both sides. No posting or typing is allowed on the magnetic stripes; thus, 1.6 inches are reserved along the right side for the magnetic stripes.

The size of ledger card selected for an application is determined by the number of posting lines needed and the number of digits per posting line. Recording density on the magnetic stripes is approximately 10 BCD digits per inch. The heading requires 1-1/3 inches minimum, and the bottom margin must be at least 2-2/3 inches. Thus, a ledger card 14 inches long by 20 inches wide is required for an application that needs 20 posting lines of 190 digits per line.

The C-590-1 Consoles now in the field can record a maximum of 216 BCD digits on a 15-inch long ledger card. NCR has announced that new models can record up to 324 BCD digits on a 15-inch card; this feature can be added to all C-590-1 Consoles for a one-time cost of $200. This additional capacity allows the recording of information not posted but needed for processor runs using the 586-1 Ledger Feeder Reader as input and the 541-1 Line Printer as output.

(Contd.)

.26 Magnetic-Striped Ledger Cards (Contd.)

The data is recorded on the magnetic stripes in the same BCD code used by the processor; two rows are used for each numeric digit and four rows for each alphanumeric character. The four stripes are used in the following manner:

- Stripe #1 contains the line-find bit;
- Stripe #2 contains the 2^0 bit of the BCD digit on row #1 and the 2^1 bit of the BCD digit on row #2;
- Stripe #3 is the clock channel and contains a "1" bit for every row containing data;
- Stripe #4 contains the 2^2 bit of the BCD digit on row #1 and the 2^3 bit of the BCD digit on row #2.

Each word concludes with an EOW code to signal the processor to fill out the word with zeros. As with the other peripheral devices, negative numbers are recorded as nine's complements, and the program must insert nines in words of less than 12 digits to form the true complement.

The recording on the magnetic stripes is checked by adding the number of 1 bits in the record and recording this sum on the magnetic stripes. When the card is read, the 1 bits are added, and this sum is checked with the recorded sum. If they do not agree, the computer halts and indicates an error.

.3 SOFTWARE

NCR has more than 100 routines available at branch offices to cover a wide range of accounting applications. The following list gives the major headings in the library of routines.

Accountant's Plan	P & L, Balance Sheet
Appropriation Accounting	Bill & Charge
Contractors	Conversions
Customer Account	Department Stores
Hospital	Installment Loans
Inventory	Mortgage
Payroll	Route Accounting
Savings	Taxes
Utility Billing	Water and Sewer

NCR has many routines for what it calls the 5900 system: the C-517-1 Processor with the C-590-1 Console. In this system, the master file is held on magnetic-stripe ledger cards. These routines cover hospital, inventory, payroll, and utility billing applications.

All programs for the NCR 500 system are normally written in machine language. NCR has software for assembling programs written in its own SLIP language, but recommends its use only after programmers have a thorough knowledge of the machine language.

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental (1) $	Monthly Maintenance $	Purchase (2) $
PROCESSOR	517-1	Central Processor with 400 words of core memory	455	40	18,400
		Adapter for:			
		Low-speed tape input	25	4	850 (4)
		Low-speed tape output	10	2.50	450 (4)
		High-speed tape input	175	20	8,000 (3)
		High-speed tape output	40	4	1,375 (3)
		Punched card input	40	6	1,450
		Punched card output — low-speed	25	3	1,050
		Punched card output — high-speed	20	3	700
		Type-to-memory	40	8	850
		Alphanumeric from console	25	4	1,700
		Magnetic ledger feature	130	20	1,250
CONSOLES	521-1	Console	30	9	2,300
	590-1	Console (magnetic ledger)	250	88	7,700
	590-2	Console (without magnetic ledger)	150	48	6,200
PRINTER	541-1	Line Printer (requires 551-1 or -2 controller)	280	60	11,600
	551-1	Printer Controller	125	20	5,200 (5)
PUNCHED CARD INPUT AND OUTPUT	551-2	Punched Card & Printer Controller (551 Buffer)	130	23	5,600 (3)
	581-1	Punched Card Input Controller	65	15	4,200
	582-1	Punched Card Reader	35	15	1,200
	576-1	Serial Card Punch	90	16	3,852
	577-1	Parallel Card Punch (Requires 551-2 Controller)	125	50	4,900
PAPER TAPE INPUT AND OUTPUT	561-1	Paper Tape Reader (400 cps)	215	42	7,600
	561-2	Paper Tape Reader (600 cps)	240	42	8,450
	562-1	Paper Tape Strip Reader (650 cps)	185	35	6,800
	563-2	Paper Tape Reader (50 cps)	35	15	1,350
	571-1	Paper Tape Punch (120 cps)	140	67	3,250
	572-1	Paper Tape Punch (30 cps)	60	13	1,800
	420-2	Optical Journal Tape Reader	1,450	184	—
LEDGER CARDS	586-1	Ledger Feeder Reader	140	30	4,200
	464-2	Alpha-Numeric Printing Paper Punch	75	15	3,740

(1) The minimum rental for an NCR 500 System is $765; rental includes maintenance.
(2) The minimum purchase price for an NCR 500 System is $27,350.
(3) Six hours labor charge to add or delete in the field.
(4) Four hours labor charge to add or delete in the field.
(5) Eight hours labor charge to add or delete in the field.

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SUMMARY: NCR CENTURY SERIES

.1 BACKGROUND

The NCR Company, on March 6, 1968, released their new Century Family of computer systems. It is NCR's avowed intent to become a strong number two among computer manufacturers and they strongly believe that the Century Series is the vehicle which will vault NCR into that position. The first two members of the family, the 100 and the 200 are available on the market today. The Century 100 is a general purpose, business and scientific, low cost magnetic-file processing system. The Century 200 is an intermediate range machine with multiprogramming capabilities permitting concurrent execution of up to 30 programs (depending on configuration, operating system and requirements). On the average the internal performance of the Century 200 is about five times faster than that of the Century 100. Another member of the family, the Century 400, will enter the market place in the near future.

Perhaps the most significant factors about the Century Series are its low cost and magnetic disc file approach. Each and every system within the Century family contains an integrated, dual-spindle, removable disc unit which has a capacity of 8.4 million characters. The inclusion of this disc unit in each system has allowed NCR to standardize the basis of their operating system software thereby achieving not only a cost savings by avoiding the development of multi-media based software system, but also by providing true upward compatibility not just in programming but more importantly, within software systems. The basic Century 100 system with the configuration, 16,384 bytes memory (800 nanosecond cycle time per byte), a dual spindle disc unit with a capacity of 8.4 million characters and an average access time of 65.5 milliseconds (movement and latency), a printer at 450 alphanumeric and 900 numeric lines per minute (132 positions) and a 300 card per minute card reader or a 1,000 character per second paper tape reader, will rent for $2250 per month on a one-year contract. This is a stand alone system, fully supported by operating and applications software which should prove to be quite attractive to both the small businessman as a complete system and to larger concerns which require strong satellite processing capability at minimum cost. However, NCR will rent the same system for only $2025 per month with a three-year contract and $1910 per month on a five-year contract. This same basic system can be purchased for $112,000. Century 100 deliveries began November 1968.

The basic Century 200 system with the configuration 32,768 byte memory (800 nanosecond cycle time per two bytes), the dual spindle disc unit containing 8.4 million characters, a printer at 1500 alphanumeric and 3000 numeric lines per minute, and the 300 cards per mir ute reader or 1000 characters per second paper tape reader, will be offered for $3,950 per month on a one-year contract.

The low cost and high performance of the Century Series is made possible not only through the standardization of software but also as a result of other factors. The NCR Century Series uses a thin-film, short-rod memory, a modification of the rod memory used on the NCR 315 RMC (the first commercial use of this storage technique), which is not only superior in speed and lower in cost than conventional core memories, but also lends itself to time- and cost-saving automated manufacture.

NCR is the first manufacturer to use monolithic integrated circuits throughout the entire system, not just in the central processor. The speed and cost advantages of monolithic technology are well known, however, NCR has carried the art of monolithics one step further by standardizing the methods in which they are used in the system. The Century Series uses only one monolithic integrated circuit as the base element for all processor and peripheral logic. Six configurations of this circuit handle all logical functions for processing data. The entire Century 100 uses only 81 different circuit boards, of which 80% are the six standard configurations.

The low cost and high speeds of the Century Series indeed make it a formidable competitor.

.2 HARDWARE

.21 System Configuration

The basic Century 100 System includes a 16,383 byte processor with integrated controls for a dual-spindle disc unit, a 450 line per minute printer, a card or paper tape reader and a display console. The base system features two input/output trunks, having eight positions each, which will allow connection of additional peripherals or peripheral controllers to the system. The basic 16,383 byte memory may be optionally expanded to 32,768 bytes. The full line of peripherals and data communications equipment, specified later in this summary, may be attached to the base system.

Some peripherals require freestanding controllers to be attached to the system while others do not. "Level 1" peripherals, slow speed devices such as additional card or paper tape readers, do not require a separate controller. "Level 2" peripherals, such as high speed magnetic files and communications devices generally require external controllers.

The basic Century 200 system includes 32,768 byte memory, a dual spindle disc unit, a 1500 line per minute alphanumeric and 3000 line per minute numeric printer, a display console I/O writer and a card or paper tape reader. The base system offers four trunks, two of which contain eight positions that accommodate the attachment of additional peripherals. The other two trunks are dedicated to the integrated card or paper tape reader, the printer, and the display I/O writer. The trunk system may be optionally expanded to eight. Memory may be increased in varying increments up to a maximum of 524,288 bytes.

Please see the "System Configuration" section :031.100, and the summary on each peripheral for the specific rules governing the attachment of additional equipment to the basic Century Series systems.

.22 Central Processors

All Century processors are comprised of three basic units:

- An arithmetic/logic unit (ALU) which contains the circuitry for computations and logic decisions.
- An Input/Output Control Unit which supervises the transfer of data between peripherals and main memory.
- Main memory.

Century logic is such that, when the ALU and the I/O Control request a memory cycle at the same time, the I/O Control takes priority. Since peripheral servicing does not require all the memory cycles available within a given time frame, the ALU "steals" available cycles and continues processing during data transfer. This approach provides each Century system with a degree of effective simultaneity. The Century 100, for example, combines two I/O operations with processing to achieve an effective 3-way simultaneity. Larger systems are planned with individual clocking schemes for individual sections of the processor that will achieve up to 18-way simultaneity.

The peripheral configurations possible with any given system depend upon the bandwidth of that system. Bandwidth is a measure of character (byte) transfer rate. One of the two trunks on the Century 100, for example, has a bandwidth of 40,000 bytes per second; the other, a bandwidth of 120,000 bytes per second. This means that the Century 100 can transfer data at the maximum rate of 40,000 characters (bytes) per second on the low-speed and 120,000 characters per second on the high-speed trunk. Bandwidths vary from system to system, with the more sophisticated systems offering high-speed quadraplex (4-trunk) and octaplex (8-trunk) configurations having significantly higher system bandwidths.

One of the most surprising features of the Century Series is the existence of 63 index registers even on the smallest system. This number of registers usually is found only in much larger and more expensive systems.

Table I summarizes the characteristics of the Century 100 and 200 processors.

TABLE I: CENTURY PROCESSOR SPECIFICATIONS

	Characteristic	Functional Specifications	
		Century 100	Century 200
MEMORY	Size	16,383 Bytes - Std. 32,768 Bytes - Opt.	32,768 Bytes 65,536 Bytes 131,072 Bytes 262,144 Bytes 393,216 Bytes 524,288 Bytes
	Cycle Time	800 Nanoseconds	800 Nanoseconds
	Index Registers	63	63
	Organization	Byte (8 bits + par)	Byte
	Internal Operations	1 Byte Readout 1 Byte Arithmetic Operation	2 Byte Readout 1 Byte Arithmetic Operation
ALU	Command Set	18 Commands + I/O	39 Commands Including Entire 100 Set 27 Optional Commands for Specific Applications
	Command Format	1 or 2 Address	1 or 2 Address
	Addressing	Binary Byte Addressable Incremental Indexing	Binary Byte Addressable Incremental Indexing Indirect Addressing
	Internal Code	USASCII	USASCII
	Arithmetic	Unpacked, Unsigned Decimal or Binary	Packed or Unpacked Signed or Unsigned Decimal or Binary
I/O CONTROL	Simultaneity	2 I/O Plus Compute	4 I/O Plus Compute Standard 8 I/O Plus Compute Optional for Multi-Programming
	Trunks	2 Trunks, 8 Positions Each	4 Trunks: 2 Trunks, 8 Positions Each 1 Trunk for Integrated Printer 1 Trunk for COT, I/O Writer, and Console
	Integrated Peripherals	Disc, Printer, COT Console	Printer, COT, Console with I/O Writer
	I/O Options	Additional Dual Spindle, Integrated Disc Integrated I/O Writer	Extended Bandwidth, 3 Additional Dual Spindle Disc Units 1 or 2 High-Speed Trunks

.22 Central Processors (Contd.)

Instruction formats in the Century Series are basically two-address. However, all commands may appear in either a one-address or two-address form. The one-address format requires four bytes, and the two-address format requires eight bytes.

The format of the one-address command is:

Q	R_a	A_2	A_1

The two-address format is:

Q	R_a	A_2	A_1	T	R_b	B_2	B_1

Q = 1 byte command code

R_a = 1 byte index register specification

A_2A_1 = 2 byte address of the A operand

T = 1 byte specification of the length of the A and B operands

R_b = 1 byte index register specification

B_2B_1 = 2 byte address of the B operand

.22 Central Processors (Contd.)

Many two operand instructions can be "chained," i.e., coded in one address format with the second address and the operand length implied from the previous instruction. When programmed successfully in this manner, significant savings can be realized in memory requirements and execution times.

Data in the Century Series is stored in binary form with eight bits constituting a byte. Numeric data may be packed two digits per byte (BCD format). Each byte can be individually addressed and can represent any number or character in the USASCII code. Consecutive memory locations can be grouped to form fields up to 256 characters in length.

Processing facilities in the Century Series includes an instruction repertoire that combines hardware and software commands in a manner which not only permits ease of programming but also accomplishes internal and peripheral operations efficiently. The 19 hardware instructions recognized by the Century 100 are augmented by over 90 software instructions which are programmer oriented. Although the more than 90 software instructions more than compensate for limited hardware facilities, some processing efficiency is sacrificed.

Multiply and a full complement of logical, Boolean hardware instructions are optional on the Century 200. Multiply and Edit facilities are provided by software subroutines on the Century 100. The Edit hardware instruction is standard on the Century 200 as are complete decode and scan capabilities. Divide ability is provided by software on both the 100 and 200. Indirect addressing to five levels and interrupt under programmed control are also standard abilities on the Century 200.

.23 Internal Storage

The Thin-film, short-rod memory developed by NCR for the Century Series provides a higher storage density per unit volume at a very low cost per information bit. Short-rod memory cycles at 800 nanoseconds. This modular internal memory is available in sizes ranging from the 16,384 bytes for the basic system to 524,288 bytes in the Century 200.

Rods are made by depositing a thin metallic film and a protective coating on 5-mil copper wire. The process produces a plated wire 0.006 inch in diameter. This plated wire is then cut into 0.110 inch lengths to form the bit rods. The basic memory plane is formed by inserting the bit rods into solenoid coils wound on a plastic frame. The entire plane is then sealed between two sheets of plastic.

.24 Random Access File Storage

Disc File Storage on the Century Series consists of disc units which have two spindles, each of which drives a disc pack with 6 recording surfaces, and retractable arm mechanism for each pack that accesses each pack for read/write operations. Each disc pack is independently mounted, accessed, and removed. The packs come with dust covers hermetically sealed until the packs are physically mounted and lowered into the operating position.

Each of the three discs that make up a pack is plated on both sides with a magnetic recording surface and a protective film. By plating the discs with a nickel-cobalt compound, NCR hopes to achieve a much greater bit and track density and a more efficient signal-to-noise ratio than can be attained with oxide-coated discs.

Each recording surface is accessed by its own set of 12 read and 12 write heads. Head assemblies actually float above the disc surface during operation, reducing the need for critical adjustments and minimizing the possibility of damage to the media and loss of data. The 12 read/write heads for each recording surface provide almost immediate access to 1/16 of the total file.

The average arm movement time on the disc is 44.7 milliseconds and the transfer rate is 108,000 bytes per second. An optional disc unit having a transfer rate of 180,000 bytes per second, with the same capacity and low arm movement time as the basic disc, is available on the Century 200.

NCR's CRAM is a high capacity storage device designed for large-file, random access applications on all Century Systems. Data is recorded on oxide-coated mylar cards. Each card is notched with an individual binary configuration that permits the processor to select only that card containing the required information. Up to eight CRAM units, each having a capacity of 145 million bytes and a transfer rate of 84,000 bytes per second, can be attached through each controller, providing access to approximately 1 billion characters per trunk position.

.25 Sequential Input/Output Equipment

NCR offers a wide variety of input/output equipment for use with the Century Series.

A wide range of CDC-built magnetic tape units are available in both seven and nine channel modes with recording densities of 200/556/800 bits per inch NRZ and 1600 bits per inch phase encoded. Transfer rates range from 10, 000 up to 240, 000 bytes per second.

All NCR Century printers have 132 print positions as standard equipment and offer 160 positions as an option. Printer speeds offered are 450, 600, and 1500 alphanumeric and 900, 1200 and 3000 numeric lines per minute. The 450/900 lines per minute printer is the standard device on the Century 100, while the 1500/3000 lines per minute printer is the standard device on the Century 200.

Paper tape equipment available on the Century Series are a 1000 or 1500 characters per second paper tape reader and a 200 character per second paper tape punch. All of the paper tape equipment is designed to accommodate 5, 6 or 8 channels and either paper or mylar tape.

Punched card capability with the Century Series is afforded by a 300 or 800 card per minute reader and an 82-240 card per minute punch.

Two MICR Sorter/Readers are available with the Century Series. The 670-101 sorts 600 documents per minute into eleven pockets while the 671-100 reads at the rate of 1200 documents per minute into 18 pockets.

The NCR 420 Optical Character Reader inputs data to the Century Series processor via paper tape which is output from cash registers, adding machines, and accounting machines. The two models of the 420 can read up to 32 characters per line at rates of 26 or 52 lines per second.

Magnetic tape encoders serve a dual purpose on the Century Series. They function as a low cost input/output tape unit to and from the processor in addition to providing keyboard entry from source document to verified magnetic tape.

An input/output writer is standard equipment on the Century 200 and is optional on the Century 100.

Communications controls expand the range of the Century System. The Century Series includes two communications control units to provide low-cost communication capability for the Century Series. The 621-101 Communications Controller provides for up to 15 communications lines. The basic unit includes an interval timer that can be set, reset, and read by the program and can cause a program interrupt. A complete line of adapters and optional features extends the unit's capabilities to a wide variety of applications. The 621-201 Communications Multiplexer is the base for a line of control units that provide the Century Series with extremely flexible communication capabilities. The multiplexer provides the Century System with an interface for up to 256 communication lines using a stored-program processor with a 16, 384 or 32, 768 byte memory. This approach relieves the central processor of a significant burden by handling polling, error correction, message verification, and message compilation within the controller itself. The generality of the stored-program approach also allows each unit to be used for a wide variety of applications as a communication switcher, a line concentrator, or a free-standing, real-time processing system.

TABLE II: CENTURY SERIES PERIPHERALS

Device	Speed	Comments
Discs		
655-101	108, 000 bytes/sec	8.4 million characters on
102		two spindles — 44.7 ms
201		average arm movement time.
655-202	180, 000 bytes/sec	Same as 655-102.
Magnetic Tapes		
9-channel, 1600bits/inch		
633-111	80, 000 bytes/sec	Single Unit — 50 inches/sec
633-121	80, 000 bytes/sec	Dual Unit — 50 inches/sec
633-211	144, 000 bytes/sec	Single Unit — 90 inches/sec
633-221	144, 000 bytes/sec	Dual Unit — 90 inches/sec
633-311	240, 000 bytes/sec	Single Unit — 150 inches/sec

TABLE II: CENTURY SERIES PERIPHERALS (Contd.)

Device	Speed	Comments
633-119 (9-channel, 800 bits/inch)	40,000 bytes/sec	Single unit — 50 inches/sec
633-117 (7-channel, 200/556/800 bits/inch)	10,000/28,000/ 40,000 bytes/sec	Single unit — 50 inches/sec
Printers —		
640-102	450/900 lines/min	132 columns
640-200 210	1500/3000 lines/min	132/160 columns
640-300	600/1200 lines/min	132 columns
Card Equipment —		
682-100	300 cards/min	Reader
686-101	800/82-240 cards/min	Reader/Punch
201	800 cards/min	Reader
301	100 cards/min	Punch
Paper Tape —		
662-100	1000 char/sec	Reader
660-100	1500 char/sec	Reader
665-100	200 char/sec	Punch
CRAM —		
653-101	84KB	145 million characters per unit — 125 ms access
MICR —		
670-101	600 doc/min	11 Pockets
671-101	1200 doc/min	18 Pockets
OCR —		
420-2	26 or 52 lines/sec	Up to 32 characters per line
Communications Controller —		
621-101		Up to 15 lines
621-201		Up to 256 lines

.26 Simultaneous Operations

Simultaneity in the Century Series is a function of the number of input/output trunks attached to the central processor. Since the Century 100 has two input/output trunks, two peripheral operations plus computing may be occurring simultaneously within the system. The Century 200 has four trunks as standard equipment, so four peripheral operations in addition to computing may be in process concurrently. Optionally, eight trunks may be attached to the Century 200, providing eight-way peripheral simultaneity plus compute.

.3 SOFTWARE

A major factor in the operation of the Century series computers is its disc-oriented and inter-dependent software. Software programs are highly integrated, reducing duplication of sub-routines and achieving a degree of efficiency which is usually not possible with independently operating programs. The software is modular in design and is primarily disc-resident with only small segments memory-resident at any given time. As segments are required, they are called to memory from the disc making a large percentage of memory available for customer programs. The Century software provides complete upward compatibility with no reprogramming or recompilation required. However, if a system is upgraded, recompilation may result in more efficient operation.

There are four software systems for the Century series, B1 (Basic), B2, B3 and B4. B1 is the basic system containing an input-output executive, monitor, NEAT/3 compiler, COBOL and FORTRAN compilers (subsets), system disc log, disc management, and a full range of utility routines. B2, B3 and B4 are extensions of the Basic (B1) System and provide various levels of multi-programming, communications peripherals support, and on-line capabilities.

.31 B1 - Basic Software System

The I/O Executive handles all input and output functions and contains the necessary subroutines to permit simultaneity of these functions. The I/O executive employs two major concepts:

- Capture I/O Instruction — The simple I/O instructions in the user's program do not interface directly with the hardware. Instead, they call software subroutines to perform the desired functions.

- Hierarchical Subroutines Organization — Any program logic that is common to two or more subroutines is organized into a lower level subroutine avoiding duplication and saving memory space.

I/O Executive functions are controlled by file specification data. The programmer fills out parameter sheets for each program and includes them in his source program for compilation. The I/O Executive uses these parameters in their compiled form to automatically direct all I/O operations including processor/peripheral simultaneity, error recovery (as necessary), and such file functions as Open, Close, and Label Checking.

The Monitor provides the user with the means necessary to load, link and control programs in the Century System.

- Program Loading and Linking — The Monitor facilitates the loading of individual programs and permits the automatic linking of a predetermined series of programs. This automatic program linking provides efficient operation of the Century System with a minimum need for operator intervention.

- Dating Scheme — The Century software permits the user to generate a 3-year calendar for software use. He may then run any program selectively, depending on calendar information or other information in memory. The user-defined calendar also permits the use of relative dating. For example, the programmer may specify the number of work-days a magnetic file is to be protected for backup purposes.

- Communication — The user enters all operational information under the control of the Monitor. The operational information for system control includes such items as current dates, peripheral unit assignment to trunk positions, request for certain programs, etc. This information may be entered via the console, punched cards, punched paper tape, or disc.

System Log Maintenance — The operating system maintains a system log on the system disc packs. The system log of the Century System serves to:

- Maintain chronological entries regarding daily operations.

- Record normal or abnormal operating conditions.

- Record equipment functions or malfunctions at the time of their occurrence.

- Assist in system failure diagnosis.

- Provide printed reports describing the above conditions.

The operating software automatically maintains the system log for one working day. However, software is available to copy daily logs to another disc file, enabling the user to accumulate system log data over any length of time. Also, the programmer is permitted to make entries into the system log at any time during the running of a program.

Disc Management — The operating software controls the changing of disc packs. When the operator replaces one of the two disc packs which contain identical copies of the software, the Century System software automatically updates the newly mounted disc pack. The Century software compares the versions of the software programs and system-oriented data on the two system disc packs and selectively copies the latest versions to the newly mounted disc pack.

Before the operator removes the system disc containing the current system log, the software copies the log to the remaining system disc.

.31 B1 - Basic Software System (Contd.)

Utility Routines — A full range of utility routines is available for the Century Series including:

- General Sort Program — To use the General Sort Program, the programmer specifies the sorting operation on special preprinted specification sheets and inputs his punched specification entries to the General Sort Program. Each sort program is generated at program running time for the system configuration being used and for the data being sorted as defined on the specifications sheets. The easy and fast operation of the General Sort Program eliminates the need to retain many individual sort programs on discs.

- Data Utilities — Provides normal copy routines, compares two data files, generates program test data.

- Source Program Utility Routines (SPUR) — Accepts source program input and checks the statements for format errors and illegal characters.

- Object Program Utility Routines (OPUR) — Copies object programs from one file to another, creates a library of programs, and generates alphabetical cross-reference listings of programs.

- Automatic Flowcharting — At the programmer's option, the Century System can produce cross-referenced, machine-drawn flowcharts of any program or segment of a program using FLOWRITE, an automatic flowchart program.

- Symbolic Debugging — The Century software has been developed to permit the programmer to debug and correct all programs, symbolically, at the source language coding which lessens the possibility of compounding programming errors. Symbolic debugging may be applied to an entire program, a segment, or a specific branch path of a program.

Multiprogramming software for the Century Series is implemented in three stages.

- The "B2" system provides multiprogramming ability for the Century 100 and small Century 200's. Minimum memory required is 32,768 bytes. Multiprogramming hardware options are not required for this system and, if present, are not used. The B2 system contains all the features of the basic executive plus the ability to handle communication peripherals and multi-tasking.

- The "B3" system provides multiprogramming ability for medium and large scale Century 200's. Minimum memory size is 65, 536 bytes and the multiprogramming hardware option is required. The B3 system includes all the functions of B2 and in addition allows scheduling into all partitions, and provides spooling of printer output. The system will accommodate from two to nine partitions depending on requirements, memory size, and number of disc units available.

- The "B4" system furnishes a superior multiprogramming ability for larger Century 200's and is primarily designed for large-scale on-line operations. The multiprogramming hardware option is required and the minimum memory size is 128,072 bytes. The B4 system provides full multi-task control for up to 240 active tasks at one time.

Century Compilers bridge the gap between machine language (object program) and the programmer with three programming language compilers, NEAT/3, COBOL, and FORTRAN. Developed concurrently, the three compilers share common techniques, and are controlled by the same operating systems.

NCR's NEAT/3 compiler accepts instructions written in descriptive NEAT/3 language and compiles a complete object program for use with the Century System. Usually, one simple instruction suffices to initiate the generation of all object coding required for a given task (NCR defines a task as any asynchronous function common to a single program). In addition, major business functions — such as collating, validating, updating, and reporting — have been included to ease the programmer's task. He simply fills out clearly defined parameter and data definition sheets and incorporates these into his source program. Complete program sections for these functions are then generated by the compiler.

.31 B1 - Basic Software System (Contd.)

In addition to simple language, major functions, relative addressing, and supplementary software, the NEAT/3 compiler system also offers the user precise program generation, independent overlay compilations, and macro and diagnostic subsystems.

- Precise Program Generation — Generated programs can be readily relocated and used by the basic operating system or by more dynamic and sophisticated systems such as B2 and B3. Library routines may also be relocated and are modular in concept.

- Independent Overlay Compilation — Individual overlays from large, multi-overlay programs can be compiled separately. This feature significantly reduces the time required to alter or correct large programs.

- Macro Subsystem — The macro subsystem, comprising the macro generator and subroutine library files, is used dynamically by the compiler in generating the object program. New or modified macro generators or servicing subroutines can be added easily without having to gain access to the compiler.

- Diagnostic Subsystem — Interfacing with the generator library, this subsystem contains the error directory file and servicing utility routine. Standard error codes and caution codes are defined for a variety of programming situations. The Error Directory contains a list of all compilation comments, each code having a notation that describes the error. Where necessary, the error code is supplemented by text explaining what caused the error and what corrective steps can be taken.

Century COBOL has been implemented in three stages. The first, a subset of basic COBOL, is designed to comprise the basic set of language features for the minimum system. The second, a more comprehensive set of elements, is recommended for use with mid-range configurations and includes the elements defined by USASI as well as features that are compatible with NCR 315-COBOL. The third stage is the full implementation of the COBOL specifications for the Century Series.

The modular design of the system permits the efficient and economical use of the compiler on the 16,384 byte Century 100, affording the smallest installation the advantages of COBOL. At the same time, the user of larger memory configurations in the Century Series continues to realize the full power and flexibility built into the language.

Century FORTRAN II translates programs written in basic FORTRAN language into an object program acceptable to the Century System. Like Century-COBOL, FORTRAN II can be used on a minimum computer configuration.

In addition, FORTRAN IV will be available for use on the Century 200 and 400.

.4 COMPATIBILITY

All Century Series processors are completely upward compatible in hardware, software, and programming. In addition, low cost emulators for the NCR-315 as well as the IBM-1401 and 1440 are offered on the Century 200.

.5 APPLICATION SYSTEMS

NCR has placed a tremendous effort into the development of Applied Systems for the Century Series. Their intent is to get the user on the air as quickly and as efficiently as possible. Applied Systems are available for areas such as:

General Payroll

Order Billing (Distribution Industries)

General Accounts Payable

Retail Accounts Payable

Central Information File

Student Scheduling Grade and Attendance Reporting

Law Enforcement, Traffic

.5 APPLICATION SYSTEMS (Contd.)

Production Scheduling

Hospital Payroll and Personnel Management

General Accounts Receivable

Retail Accounts Receivable

Utility Billing

Hospital In-Patient Records

Life Insurance

Budgetary Accounting

.6 PRICING AND CONTRACTS

In addition to the normal one-year contract, NCR also offers a three-year and a five-year contract. The three-year contract gains the user a 10% discount on the monthly rental of the basic Century 100 or 200 system. A five-year contract affords a 15% discount per month to the user. This means that the small company can enjoy the benefits of a powerful magnetic file system for less than $2000 per month.

All of the above contracts entitle the customer to 200 hours of use per month. An unlimited use contract is available for a nominal charge over the normal monthly rental.

NCR CENTURY SERIES

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	615-100		Century 100 Processor:			
			With 16K bytes of rod memory	1,100	55,000	60
			With 32K bytes of rod memory	1,475	73,750	65
		6101	I/O Writer for Century 100	100	4,800	15
	615-200		Century 200 Processor:			
			With 32K bytes of rod memory	2,075	99,000	70
			With 64K bytes of rod memory	3,025	140,000	80
			With 128K bytes of rod memory	4,925	220,000	110
			With 256K bytes of rod memory	8,725	373,000	165
			With 384K bytes of rod memory	12,525	526,000	220
			With 512K bytes of rod memory	16,325	680,000	275
			Optional Features for Century 200:			
		6201	Command (Logic & Table Compare)	50	2,350	5
		6202	Multiply	50	2,350	5
		6204	Floating Point	150	7,050	10
		6205	315 Compatability	100	4,700	5
		627-101	315 Emulation unit	250	11,750	25
		6206	1401 Compatibility	125	5,875	10
		6207	Trace (Console Debug)	25	1,175	5
		6209	Multiprogramming (includes Octaplax)	300	14,100	10
		6210	One High-Speed Trunk	50	2,350	5
		6211	Two High-Speed Trunks	100	4,700	5
		6212	Octaplex (includes Two High-Speed Trunks)	200	9,400	5
MASS STORAGE			Disc Storage			
	655-101		Integrated Disc Unit (108KB, for Century 100 only)	475	23,500	75
	655-102		Integrated Disc Unit (108KB, second unit on a Century 100 only)	600	28,750	75
	655-201		Disc Unit (108KB)	550	26,500	80
	655-202		Disc Unit (180KB)	650	31,250	85
	625-101		Disc Control Unit (not required for Century 100 Integrated Disc Units)	300	14,000	15
			Magnetic Card Storage			
	653-101		CRAM Unit (125 Million bytes)	1,250	60,000	85
	623-201		CRAM Control Unit	300	14,000	20
			Magnetic Storage Media			
			Disc Pack (for all NCR Disc Units)	11.50	350	-
			CRAM Cartridge	-	450	-
INPUT-OUTPUT			Magnetic Tape			
			9-track, 1600-bpi units:			
	633-111		80KB Single Drive	450	21,750	60
	633-121		80KB Dual Drive	800	38,750	90
	633-211		144KB Single Drive	650	31,500	60
	633-221		144KB Dual Drive	200	56,500	100
	633-311		240KB Single Drive	850	40,000	60

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	633-119		9-track, 800-bpi, 40KB Single Drive	350	17,000	65
	633-117		7-track, 200/556/800 bpi, 10/28/40KC Single Drive	350	17,000	65
	624-111		80KB Control Unit	450	21,000	20
	624-211		144KB Control Unit	550	25,500	20
	624-311		240KB Control Unit	650	30,000	20
	624-119		40KB 9-track Control Unit	300	14,000	20
	624-179		10/28/40KC 7/9-Track Control Unit	350	16,500	20
	622-201		735/736 Data Recorder Control Unit	175	8,250	10
			Punched Card			
	682-100		Integrated Card Reader (300 cards/min)	125	6,000	30
	686-101		Card Reader/Punch (reads 750 cards/min) punches 82-240 cards/min)	450	22,000	80
	686-201		Card Reader (750 cards/min)	300	14,750	50
	686-301		Card Punch (82-240 cards/min)	350	17,000	80
			Paper Tape			
	662-100		Integrated Paper Tape Reader (1000 char/sec)	125	6,000	15
	660-101		Paper Tape Reader (1500 char/sec)	300	14,750	30
	665-101		Paper Tape Punch (200 char/sec)	375	18,000	55
			Printers			
	640-102		Printer (450/900 lines/min.; 132 positions)	550	27,500	60
	640-200		Printer (1500/3000 lines/min.; 132 positions)	900	43,000	85
	640-210		Printer (1500/3000 lines/min.; 160 positions)	1,000	47,750	85
	640-300		Printer (600/1200 lines/min.; 132 positions)	900	43,000	60
	644-201		Multi-Tape Lister Attachment (for 640-210 Printer)	250	12,500	25
	626-101		Printer Control Unit (not required for integrated printer)	300	14,000	20
			Optical and Magnetic Ink Character Reader			
	670-101		MICR Sorter (600 documents/min; 11 Pockets)	990	45,000	150
	622-401		MICR Sorter Control Unit	200	15,100	10
	671-101		MICR Sorter (1200 documents/min; 18 Pockets)	2,350	117,500	530
		6711	Endorser Feature	300	12,000	45
	420-1		Optical Character Reader	1,200	** 48,000	184
	420-2		Optical Character Reader	1,700	68,000	265
	622-301		OCR Control Unit	150	7,000	10
COMMUNI-CATIONS			Multiplexors			
	621-101		Communications Multiplexor (15 lines)	300	15,000	40
	690-101		621-101 Auxiliary Cabinet	50	2,500	-
	621-201		Communications Multiplexor (16K Memory; 254 lines)	1,250	62,500	75
	621-202		Communications Multiplexor (32K Memory; 254 lines)	1,625	81,250	80
	697-100		615/621 Intercoupler	75	3,750	10
	690-201		621-201/202 Auxiliary Cabinet	250	12,500	5
		692-100	Asynchronous Character Adapter	65	3,250	10
		692-200	Simple Bit Adapter (4 Lines)	100	5,000	15
		692-300	Complex Bit Adapter (2 Lines)	100	5,000	10
		692-401	Asynchronous Polling Adapter (1 Line)	100	5,000	10
		692-402	Asynchronous Polling Adapter (2 Lines)	140	7,000	15
		692-403	Asynchronous Polling Adapter (3 Lines)	165	8,250	20

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INTRODUCTION

§ 011.

The RCA 301 is a small to medium scale, solid-state data processing system oriented toward business and scientific applications. The wide range of optional features which are available provide for expansion and simultaneous operations. System configuration rentals range from $3, 500 to $25, 000 per month, with typical systems renting for $9, 000. The purely business-oriented processor is available with three sizes of core storage: 10, 000, 20, 000, or 40, 000 alphameric characters (Model 303, 304, or 305, respectively). The Model 354 and 355 processors (for business and scientific applications) can perform automatic floating point operations and automatic eight-digit fixed point operations in addition to having all the facilities of the Model 303, 304, and 305 processors. The Model 354 and 355 processors are available with 20, 000 and 40, 000 alphameric characters of core storage, respectively. The 301 system is available with a wide range of peripheral equipments, including auxiliary disc storage. Its fixed length, 10-character instructions use a 2-address add-to-storage logic. In the standard processor, the data fields, which are variable-length (up to 44 characters), are processed serially by character.

Model 303, 304, and 305 Processors

The speed of the standard arithmetic unit (i.e., Models 303, 304, and 305) makes it suitable for general data processing but it performs mathematical operations slowly. Multiplication, division, and floating-point operations can be performed only by means of subroutines. Indexing is not available, but indirect addressing is provided. While there is no integrated editing facility, edit routines are rapid and straightforward, and a sufficient number of variable-length operations for handling alphameric items are available. These include convenient code translation operation and Boolean operations. Arithmetic operations are executed through the use of sum and difference tables which occupy 200 characters of core storage.

Model 354 and 355 Processors

The Model 354 and 355 processors contain additional high speed arithmetic circuits which allow automatic fixed and floating point operations to be performed on eight-digit operands in a two-address format. A double-length accumulator is provided. The operations which are possible are: add, subtract, multiply, divide, and indexing operations for fixed and floating point data. Additional instructions are provided for shifting and storing the contents of the accumulator and for incrementing the index registers. The index registers permit address modification, and loop control is provided by the Tally instruction or by other coding.

Processor Speeds

The time required for the Model 303, 304, and 305 processors to add 2 eight-digit numbers (including instruction access) is 273 microseconds, a rate of 3, 660 additions per second. The same operation on the Model 354 and 355 processors requires 98 microseconds (no indexing; results left in accumulator), a rate of 10, 200 additions per second.

Simultaneous operations can be carried out only through the use of optional equipment. The Simultaneous Mode Control permits two operations to proceed at a time. The device (any peripheral device) controlled via the Simultaneous Mode Control delays the Processor for 7 microseconds per character transferred. The second operation can be another peripheral device data transfer, or internal processing.

The 7-microsecond core store can be supplemented by Data Record Files (juke-box type discs) with up to 27.6 million characters or by Data Disc Files with up to 176 million characters of storage. While access to data in the Record Files can take several seconds, access to Disc File data requires approximately 0.1 second. Remote inquiry operations to the Data Record or Data Disc Files can be handled through the Interrogating Typewriter.

INTRODUCTION (Contd.)

§ 011.

Programming for the 301 is relatively straightforward except where dynamically variable length fields require continual adjustment of the N character used to specify operand length. Also, the programmer is restricted by the limited simultaneous operation facilities, which normally permit only one data transfer to be overlapped with internal processing.

Standard paper tape and punched card equipment is available, as well as a fast paper tape reader which reads at 1, 000 characters per second. Paper tape is normally read and punched at 100 characters per second. Punched card equipment can include two card readers, which operate at rates of up to 600 cards per minute, and a card punch which operates at 100 cards per minute. More recently, a card read punch unit (an IBM 1402) has become available as part of the equipment line. This unit can read 800 cards per minute and punch 250 cards per minute. Hollerith code to RCA 301 code translation is performed automatically. Two models of line printers are available, one with 120, the other with 160 character positions per line; these printers are capable of maximum speeds of 1, 000 and 1, 075 lines per minute, respectively.

A variety of magnetic tape units can be used with the 301 system. One or 2 cabinets of low-cost magnetic tapes are available, which operate at 10, 000 characters per second; each cabinet contains 3, 4, or 6 tape stations. Higher performance tape stations (33, 333 and 66, 667 characters per second) are available for use by the 301, and up to 14 such stations, which are also used on the RCA 501 system, can be connected.

RCA has recently announced an Optical Character Reader (Videoscan) which can read up to 1, 500 documents per minute. The Burroughs Magnetic Ink Character Reader can be connected to the 301 system to provide for input of magnetic ink documents at speeds of up to 1, 560 per minute. Adapters are available for connecting two IBM 729II Magnetic Tape Units.

The software for the 301 can accommodate three different situations; the program library can be held on cards, magnetic tape, or Data Records. In addition to standard assembly routines, subroutines, mathematical functions, and diagnostic routines, there is an elementary operating system appropriate for this size of computer, and an integrated testing procedure. COBOL-61 for the 301 magnetic tape system is available, as is the RCA 301 version of UMAC, the University of Miami Algebraic Compiler. A scientific interpreter is also available.

AUERBACH / BNA

RCA 301

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
	303		Processor (10,000 characters)	1,785	89,400	140.50
	304		Processor (20,000 characters)	2,395	112,900	179.00
	305		Processor (40,000 characters)	3,515	172,500	325.00
	354		Processor (20,000 characters; Hi-Speed Arithmetic Unit)	3,410	167,500	315.00
	355		Processor (40,000 Characters; Hi-Speed Arithmetic Unit)	4,535	222,500	421.00
			Features for Models 303, 304, 305, 354, 355:			
		55	382/582 Feature	(1)	(1)	(1)
		66	160 Column Printer Feature	(1)	(1)	(1)
		128	Buffered Printer Feature	(1)	(1)	(1)
		197	Input/Output Expansion Feature	155	7,500	25.50
		237-11	301 Speed-Pak Feature (for Models 303, 304, 354)	248	6,000	23.50
		237-21	301 Speed-Pak Feature (for Models 305, 355)	124	3,000	11.75
		*T-237-31	301 Speed-Pak Feature (for Models 305, 355)	248	6,000	23.50
		272	MICR Mode Feature	(1)	(1)	(1)
		423	NNNN Terminate Feature	(1)	(1)	(1)
ATTACHMENTS, ADAPTERS, AND CHANNELS	392		Simultaneous Mode Control	600	27,900	52.50
		56	382/582 Feature	(1)	(1)	(1)
		67	160 Column Printer Feature	(1)	(1)	(1)
		129	Buffered Printer Feature	(1)	(1)	(1)
		280	I/O Expansion Feature	(1)	(1)	(1)
	K-347		Expansion Kit	6	275	.40
	348-10		Allotter Control	410	18,400	37.00
	348-20		Allotter Control	615	27,600	58.00
	377-1		Data Exchange Control	400	17,900	35.00
	377-2		Data Exchange Control	400	17,900	35.00
	385		Adapter	460	22,500	42.25
		172	Tape Switching Feature	41	2,000	3.50
	*390-1		729-II Adapter	840	37,100	77.50
	*390-2		729-II Adapter	840	37,100	77.50
	*390-15		Adapter	840	37,100	77.50
		117	Tape Switching Feature	175	7,600	16.00
	*390-25		Adapter	840	37,100	77.50
		92	729-V Feature	52	2,300	5.25
		117	Tape Switching Feature	175	7,600	16.00
	393-1		581 Adapter	325	15,900	29.00
		87	CMC Feature	31	1,400	3.00
	393-2		581 Adapter	375	18,500	33.25
		87	CMC Feature	31	1,400	3.00
	394-1		581 Adapter	650	31,800	59.00
		181	CMC Feature	36	1,600	3.25
	394-2		581 Adapter	750	36,600	70.00
		181	CMC Feature	36	1,600	3.25
			Channels			
	341		Dual Tape Channel	1,020	49,000	101.75
		84	CMC Feature	36	1,600	3.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Contd.)			Channels (Contd.)			
	342		Dual Tape Channel	1,480	71,100	148.00
		84	CMC Feature	36	1,600	3.25
	351		Dual Tape Channel	2,035	98,000	199.00
		182	CMC Feature	36	1,600	3.25
	352		Dual Tape Channel	2,545	122,500	250.00
		183	CMC Feature	36	1,600	3.25
	399-11		Dual Tape Channel	1,000	48,100	93.75
		185	CMC Feature	36	1,600	3.25
	399-21		Dual Tape Channel	1,395	67,100	127.75
		186	CMC Feature	36	1,600	3.25
	380-14		Channel	645	32,500	60.75
	380-24		Channel	645	32,500	60.75
	384-16		Tape Channel	740	33,100	66.75
		454-1	Tape Station Feature	(1)	(1)	(1)
		456-1	CMC Feature	36	1,600	3.25
	384-26		Tape Channel	740	33,100	66.75
		454-2	3485 Tape Station Feature	(1)	(1)	(1)
		456-2	CMC Feature	36	1,600	3.25
MASS STORAGE			Disc			
	*361		Data Record File	305	14,900	145.00
	363-2		Data Disc File	2,665	122,900	641.00
	363-3		Data Disc File	4,195	193,400	977.00
	363-4		Data Disc File	6,230	287,400	1,422.00
	363-5		Data Disc File	7,250	334,400	1,648.00
	*363-23		Data Disc File	3,689	170,150	866.00
	*363-31		Data Disc File	5,238	241,650	1,211.00
	*363-34		Data Disc File	5,836	269,100	1,337.00
	*366-1		Data Disc File and Control	3,055	141,000	677.00
	*366-2		Data Disc File and Control	4,585	211,500	1,013.00
	*366-3		Data Disc File and Control	6,620	305,500	1,458.00
	*366-4		Data Disc File and Control	7,640	352,500	1,684.00
	397 Series		Data Disc File Controls (any model)	390	18,100	36.00
	*317-1		Data Record File Control	128	6,250	13.00
	*317-2		Data Record File Control	244	11,900	22.50
	*391		Data Record File Mode Control	705	32,800	65.25
			Magnetic Card Storage			
	3488-1		Random Access Computer Equipment	3,000	127,500	528.00
	3488-2		File Expansion Assembly	1,625	65,000	314.00
INPUT-OUTPUT			Magnetic Tape			
	381		Hi-Data Tape Group (6 tapes)	1,504	74,900	515.00
	381-3		Hi-Data Tape Group (3 tapes)	806	40,200	276.00
	381-4		Hi-Data Tape Group (4 tapes)	999	49,900	343.00
	382-3		Hi-Data Tape Group (3 tapes)	1,454	66,200	500.00
		130	382 Simo Feature	60	2,700	20.50
	382-4		Hi-Data Tape Group (4 tapes)	1,751	79,700	602.00
		130	382 Simo Feature	60	2,700	20.50
	382-6		Hi-Data Tape Group (6 tapes)	2,275	103,500	782.00
		130	382 Simo Feature	60	2,700	20.50
	581		Tape Station	544	26,900	163.00
	582		Tape Station	865	36,750	163.00
	*681		Tape Station	950	39,850	171.00
	3484		Tape Station	565	26,900	114.00
	3485		Tape Station	800	37,200	164.00
	318		Hi-Data Tape Group Control	380	17,900	32.50
		83	CMC Feature	36	1,600	3.25
	319		Hi-Data Tape Group Control	380	17,900	32.50
		83	CMC Feature	36	1,600	3.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	399-1		Hi-Data Tape Group Control	560	25,300	51.00
		189	CMC Feature	36	1,600	3.25
	399-2		Hi-Data Tape Group Control	560	25,300	51.00
		189	CMC Feature	36	1,600	3.25
	347		Tape Switching Units	265	11,900	24.50
			Punched Card			
	*323		Card Reader	355	15,850	51.50
	*329-1		Card Reader	440	23,000	91.50
	*329-2		Card Reader	710	29,800	119.25
		400	51-Column Read Feature	36	1,500	5.75
	330		Card Reader/Punch	550	30,000	120.00
		78	Early Card Read	10	215	-
		79	51-Column Read Feed	50	3,175	31.75
		80	Punch Feed Read	25	935	4.00
	*334		Card Punch	204	8,900	29.00
	*336		Card Punch	484	21,100	70.00
	*313-1		Card Punch Control	410	19,800	41.00
	*314-1R		Card Reader Control	133	6,900	13.00
	*315		Card Punch Control	280	13,750	25.50
	*358-1		Card Reader Control	204	9,950	19.00
		188	51-Column Read Feature	15	690	1.00
		245	CMC Feature	52	2,300	5.25
	369-1		Card Reader/Punch Control	590	30,200	54.00
		54	Punch Feed Read	98	4,400	9.00
		70	51-Column Read Feed	41	1,800	3.50
		86	CMC Feature	52	2,300	5.25
			Paper Tape			
	321		Paper Tape Reader/Punch	173	7,800	29.50
		24	5- and 7-Level Tape Read Feature	108	4,400	19.75
		25	5- and 7-Level Tape Punch Feature	82	3,360	14.50
		95	Advanced Sprocket 6-Level Punch	25	1,100	3.50
		97	Advanced Sprocket 6-Level Read	52	2,100	9.25
		137	Extended Cable Feature	98	4,000	16.50
		152	5-7-8 Level Read-Punch Feature	170	7,600	28.00
	322		Paper Tape Reader	355	14,500	44.50
		96	Advanced Sprocket 6-Level Read	52	2,100	9.25
		103	Extended Cable Feature	82	3,600	10.25
	331		Paper Tape Punch	159	7,150	28.00
		25	5- and 7-Level Tape Punch Feature (Also requires Feature 71 in Model 311)	82	3,360	14.50
		95	Advanced Sprocket 6-Level Punch	25	1,100	3.50
		136	Extended Cable Feature	82	3,400	14.00
	332		Paper Tape Punch	675	28,500	194.00
		63	Advanced Sprocket 6-Level Punch	175	7,300	49.25
		104	Extended Cable Feature	46	1,700	12.75
	311		Paper Tape Reader/Punch Control	123	5,900	11.75
		64	CMC Feature	31	1,400	3.00
		71	Gapless Paper Tape Feature	(2)	(2)	(2)
		132	5-7-8 Level Read-Punch Feature	31	1,400	3.00
		135	Extended Cable Feature	15	700	1.00
		259	Allotter Control Feature	(1)	(1)	(1)
	312		Paper Tape Reader/Punch Control	142	6,900	13.00
		105	Extended Cable Feature	57	2,600	5.50
		106	Extended Cable Feature	46	2,100	4.00
	325		Tapewriter	111	4,500	22.00
	326		Tapewriter-Verifier	153	6,200	28.50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printers			
	333		On-Line Printer	715	32,200	149.00
		39	Variable 6 or 8 lines/inch Spacing Feature	36	1,480	7.25
		42	Variable 6 or 10 lines/inch Spacing Feature	36	1,480	7.25
	335		On-Line Printer	1,140	51,500	234.00
		39	Variable 6 or 8 lines/inch Spacing Feature	36	1,480	7.25
		42	Variable 6 or 10 lines/inch Spacing Feature	36	1,480	7.25
	338		Monitor Printer	194	7,300	30.75
	316-1		On-Line Printer Control	153	7,850	14.25
		85	CMC Feature	36	1,600	3.25
	316-2		On-Line Printer Control	345	15,500	29.50
		85	CMC Feature	36	1,600	3.25
	308		Monitor Printer Control	168	8,100	15.75
	345-1		Printer Buffer and Control	660	29,900	58.50
		119	CMC Feature	36	1,600	3.25
	345-2		Printer Buffer and Control	660	29,900	58.50
		119	CMC Feature	36	1,600	3.25
	346-1		Printer Buffer and Control	740	33,400	69.50
		119	CMC Feature	36	1,600	3.25
	346-2		Printer Buffer and Control	740	33,400	69.50
		119	CMC Feature	36	1,600	3.25
	396-1		On-Line Printer Control	260	13,400	24.00
		294	CMC Feature	36	1,600	3.25
	396-2		On-Line Printer Control	590	26,500	53.00
		294	CMC Feature	36	1,600	3.25
			Listers			
	340-6		Multiple Tape Lister and Control	1,630	85,000	270.00
	340-12		Multiple Tape Lister and Control	3,260	170,000	544.00
			Typewriter			
	328		Interrogating Typewriter	249	9,960	36.00
	398-1		Interrogating Typewriter Control	239	11,500	22.25
			Magnetic Ink Character Reader			
	371		MICR Sorter/Reader Control	325	15,700	28.50
	373		MICR Mode Control	615	28,000	58.00
			Optical Character Reader			
	*5820		Video Scan Document Reader	3,555	145,900	588.00
		102-10	Mark Read-10 Row-Vertical	113	4,700	18.50
		102-11	Mark Read-10 Row-Slant	113	4,700	18.50
		102-15	Multiple Mark Read-10 Row-Vertical	385	15,900	18.50
		102-16	Multiple Mark Read-10 Row-Slant	385	15,900	18.50
COMMUNI-CATIONS			Controls			
	376-11		Communications Control	340	15,200	31.00
	376-12		Communications Control	340	15,200	31.00
	376-34		Communications Control	360	16,200	32.25
	378		Communications Mode Controls: (3)			
		378-21	Single Scan (20-line)	515	23,000	47.00
		378-41	Single Scan (40-line)	565	25,300	50.25
		378-61	Single Scan (60-line)	615	27,600	53.50
		378-81	Single Scan (80-line)	670	29,900	61.50
		378-22	Dual Scan (20-line)	565	25,300	50.25
		378-42	Dual Scan (40-line)	615	27,600	53.50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Controls (Contd.)			
		378-62	Dual Scan (60-line)	670	29,900	61.50
		378-82	Dual Scan (80-line)	720	32,200	64.75
			Features for Dual Scan:			
		144	Unshift Feature	20	900	1.25
		250	NNNN Terminate Feature	77	3,450	6.75

NOTES:

* No longer in production.

(1) Furnished on request, when required, at no extra charge.

(2) Furnished on request with Feature 25, at no extra charge.

(3) For prices of the various 6000 series communications buffers see the RCA 3301 Price List.

INTRODUCTION

§ 011.

The RCA 3301 REALCOM is a medium-scale general purpose computing system. It can be used as a data processor, as a real-time processor, or as a switching center in a message switching system, depending upon the equipment complement selected. Hardware and software facilities are being provided that enable these functions to be combined as needed, to allow for more economic operations. This flexibility will be particularly advantageous when functional processing requirements (such as real-time operations) are being phased in or phased out.

Monthly rentals for the RCA 3301, as a conventional data processor, range from about $11,000 to $30,000 per month, with a median rental of about $15,000. When real-time or communications facilities are added, the minimum system rental is about $14,000 per month and the median rental is around $20,000. Initial customer deliveries were made in July, 1964.

As a data processor, the 3301 has adequate input-output control capabilities to serve a complement of peripheral devices chosen from among the following:

- 1 or 2 high-speed printers, rated at 800 or 1,000 lines per minute, depending upon the size of the character set used.
- 1 or 2 80-column card readers, rated at 900 or 1,470 cards per minute.
- 1 or 2 card punches, rated at 300 cards per minute.
- 1 or 2 paper tape readers, rated at 100 or 1,000 characters per second.
- 1 or 2 paper tape punches, rated at 100 characters per second.
- Up to 24 magnetic tape stations, described on the next page.
- Up to 8 Model 3488 Random Access Computer Equipment units, each with a maximum capacity of 681 million characters and an average access time of about 300 milliseconds.
- 1 Model 3465 Data Drum Memory, with a maximum capacity of 2.6 million characters and an average access time of 8.6 milliseconds.

These peripheral devices are serviced by two (or at most three) data channels that provide for time-sharing of High Speed Memory (the main core storage). Except for the printers and card punches, which are buffered, each of these units monopolizes a data channel throughout an input or output operation.

In addition, the RCA 3301 has available hardware and software capabilities to accept and transmit information via up to 160 telegraph or telephone lines. It is expected that these facilities will be used to serve real-time processing requirements. while most of the peripheral units will remain available for conventional batched processing.

The CMC (Communications Mode Control) connects the RCA 3301 system to these communications lines, scanning and servicing them as often as required. Two models are available: the Single Scan CMC, which scans all lines with equal frequency; and the Dual Scan CMC, in which some of the lines are scanned more frequently than the others. Internally, the CMC transmits the data from each line to a separate 100-character block in High Speed Memory, called a "line slot".

Periodic peaks of activity occur in most real-time applications, and to satisfy them a certain volume of processing power must be instantly available. Since the peak loads are so much higher than the normal usage, it is often impossible to justify the exclusive use of the full equipment complement by the real-time process. In such cases, a system that can process a normal data processing installation workload, can be interrupted with small cost, and can operate both real-time programs and "production programs" (RCA's term) simultaneously is highly desirable.

§ 011.

The RCA 3301, following these ideas, incorporates two levels of interrupts (real-time interrupts being separated from all others, such as normal I/O terminations); two sets of operating registers (held in the 214-nanosecond Micro Magnetic "scratch-pad" or control memory); and a single operating system which handles either real-time programs or production programs, or both types concurrently. The difficulties that arise (mainly in arranging smooth change-overs between programs) have been simplified by making this operating system solely responsible for handling all functions involved in these change-overs.

In addition to the real-time remote networks, the RCA 3301 can be connected to:

- 1 or 2 other adjacent RCA 301 or 3301 computers (by means of the Data Exchange Control).
- 1 or 2 300 or 5,100 character-per-second lines via Dataphone or equivalent equipment (by means of the Communications Control).

Either of two central processors can be used in an RCA 3301 system: the basic Model 3303 or the Model 3304, which features a parallel adder for 8-character fields. The 3301 system and both its central processors are developments of, and largely upward-compatible with, the RCA 301 system and its character-oriented central processor (see Section 701:051). In the basic Model 3303 Processor, the serial character-by-character processing is continued as the normal mode of operation, so that each comparison or arithmetic operation takes a fixed number of memory cycles for each character. A decade (10-character field) transfer instruction is included to facilitate data manipulation operations. In the more powerful Model 3304 Processor, a fixed, 10-character word format is generally adopted in order to take full advantage of the high speed parallel adder.

The basic Model 3303 Processor has an approximate capacity of 22,000 two-address arithmetic instructions per second. This capacity can be increased to approximately 100,000 instructions per second by use of the High Speed Arithmetic Unit in the Model 3304 Processor.

Floating point arithmetic operations are handled automatically in the Model 3304 Processor. No simulator of the Model 3304 is presently available for the Model 3303 Processor.

The basic 40,000 character positions of High Speed Memory can be expanded to a maximum of 160,000 characters in increments of 20,000 characters. One, two, or ten characters car be read from or written into High Speed Memory during each 1.5 or 1.9 microsecond cycle, depending upon the specific function being performed.

Three index registers and indirect addressing are available in both processors. Tally facilities (used for loop control in the RCA 303 Processor, which has no index registers) are retained in the 3301 system, so an unusually wide choice of control methods is available.

The editing and code translation functions both make effective use of the character orientation of the processors and yield very favorable times for the standard performance measures that use them. Code translation is particularly efficient where various five- or six-level codes are in use; codes with more than six data levels cannot be directly handled by the code translation instruction.

A "time-of-day" clock that reads to one second on a 24-hour basis is available. While this clock does not appear to be fully adequate for recording the time used by the real-time programs for cost accounting purposes, it is very useful for general purposes.

Regarding the peripheral units available for RCA 3301 systems, the major innovation is the introduction of magnetic tape units which are tape-compatible with the IBM 729 series and with equivalent units produced by other manufacturers. The Model 3485 provides peak data transfer rates of 30,000, 83,400, or 120,000 characters per second, and the Model 3487 (with a tape speed of 75 inches per second compared to 150 inches per second for the 3485) has peak rates of 15,000, 41,700 and 60,000 characters per second.

Three other magnetic tape stations are available. The Model 581, 582, and 681 Tape Stations were used in earlier RCA data processing systems and have peak data transfer rates of 33,333, 66,667, and 120,000 characters per second, respectively. Each of these three models has its own recording system, density, and gap length; only Models 582 and 681 can produce mutually compatible tapes, through the use of special recording modes.

The other peripheral units are mainly products designed or manufactured by outside suppliers to RCA's specifications. Two come from Europe — the ICT 900-card-per-minute card reader and the Bull 300-card-per-minute punch. Others are the RCA adaptations of the Anelex printer and the Uptime card reader. RCA-manufactured paper tape equipment is available for five- through eight-channel tapes, and for the advanced-sprocket tapes found in some applications. No optical or magnetic character readers are currently offered.

§ 011.

The software for the RCA 3301, when used solely as a data processor, is organized exactly as if it were to be used as a combined data processing, real-time processing, and message switching system. There is only one comprehensive operating system, and individual installations (or occasions) use only those parts of the system which are applicable.

The needs of the full system are naturally complex, and these needs have been met by the introduction of a new concept of writing programs. The writing of the actual coding for different parts of programs has been separated from the interconnections between them, and the control of all input and output functions has been placed solely in the operating system.

In this new method, all coding, in the form of separate routines, is assembled and placed on tape. Input-output instructions in the form of macros are used in the routines. A series of "task descriptions" is prepared after assembly, which lays out the logical relationships between these routines (which together comprise all of the coding). When a program is executed, this complete subdivision of the program into logical units is used by the operating system to allocate the available storage space in the most advantageous way, considering the other tasks that are running in the system at the same time.

Under this system, several programs (tasks) can be independently run, with each task receiving storage space and processing ability according to the possibilities of the moment. It makes no difference (except in the allocation of priorities) whether the particular task is a real-time or batch process.

Three properties of this operating system are of particular interest:

(1) It appears to be practical. Using the special hardware facilities, the change-over from one program to another is expected to take between 0.1 and 1.0 millisecond, which is relatively fast.

(2) It appears to reduce the need for reprogramming due to changing circumstances. If a processing method is to be used which differs from the one originally implemented, then rewriting of the "task descriptions" is usually all that will be required. Changing over to real-time operations, for permanent or experimental purposes, would likewise require no more than reforming of the task descriptions.

(3) It appears to allow economical interruptions of normal batch processing to handle priority work.

The special software used for real-time and communication functions (scheduling, message compilation, etc.) is incorporated into the operating system, together with routine functions such as checking for errors.

No specialized functions, such as separate accounting or totally reliable inter-program protection, are included in the operating system. The clock, which works in units of one second, and the lack of stopper registers which positively prevent one program from overwriting another are hardware factors which would make it difficult to include such functions effectively. The current pricing structure, which is based on continuous full use of the equipment, does not reflect the potential use of the system on a demand basis (e.g., to handle infrequent real-time requests outside the normal business hours).

The question of compatibility between the RCA 3301 and its earlier, less powerful predecessor, the RCA 301, has two important facets:

(1) The operating programs of an RCA 301 user can be run on a 3301 in an interpretive mode. This means, however, that the greatly improved input-output facilities of the 3301 will not normally be employed. A number of specific hardware configurations are not directly compatible, but most 301 configurations which are in the field can be simulated in this manner. In particular, there is no compatibility between the 301 Scientific Processor and any RCA 3301 system.

(2) RCA 301 programs and programming systems are being used to back up the 3301 system. These include the 301 FORTRAN II and COBOL-61 compilers, which run under the 301 compatibility program for both compilation and execution. In this mode of operation, the compiler user may have to tolerate considerable inefficiencies in his object program input-output.

§ 011.

The execution of FORTRAN object programs in the 301 compatibility mode will be especially inefficient; the RCA FORTRAN program which runs on the 301 system includes a simulation of the RCA Scientific 304 Processor, so that at some points a double level simulation may be in operation.

Software that has been announced for the RCA 3301 includes the REALCOM Assembly System, a report program generator, sort/merge programs for magnetic tapes and for the Model 3488 Random Access Computer Equipment, and a COBOL-61 Extended compiler. A FORTRAN IV compiler has been announced for the RCA 3304 system, which has automatic floating point instructions, but this will not be available on the basic 3301 system.

In summary, the RCA 3301 is an advanced, powerful, and flexible system that can effectively handle the problems of real-time processing concurrently with those of normal batched processing. A top limit for message switching appears to be in the region of 1,000 40-character messages per second, and this function would use up approximately 25 per cent of the system's computational capacity. Similarly, processing 3 real-time transactions per second, including a reference to a file held in the Random Access Computer Equipment, would probably demand the use of one of the two (or at most three) data channels and some 5 to 10 per cent of the computational capacity. This is probably well beyond most actual anticipated loadings. However, a number of difficult problems have been solved (notably the ability to make use in other programs of the time spent in waiting for access to mass-storage and magnetic tape devices), so that such operational magnitudes can be seriously contemplated.

RCA 3301

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage			
	3303		Processor (40,000 characters)	5,150	250,000	300.00
		422	NNNN Terminal Feature	(1)	(1)	(1)
		584-1	System Automatic Recovery	(1)	(1)	(1)
	3304		Processor (40,000 characters; high-speed arithmetic unit)	6,570	320,000	386.00
		164	Simultaneous Mode #3	310	15,600	19.00
		422	NNNN Terminal Feature	(1)	(1)	(1)
		584-1	System Automatic Recovery	(1)	(1)	(1)
	3313-2		Supplemental Power Supply	415	20,000	27.00
	6793		Power Supply	6	250	0.50
	6080		Power Supply	103	4,600	9.50
			Main Storage			
	3361-2		High-Speed Storage (expands to 60,000 characters)	1,030	50,000	60.00
	3361-3		High-Speed Storage (expands to 80,000 characters)	1,545	75,000	90.00
	3361-4		High-Speed Storage (expands to 100,000 characters)	2,165	105,000	128.00
	3361-5		High-Speed Storage (expands to 120,000 characters)	2,780	135,000	161.00
	3361-6		High-Speed Storage (expands to 140,000 characters)	3,400	165,000	199.00
	3361-7		High-Speed Storage (expands to 160,000 characters)	4,120	200,000	240.00
ATTACHMENTS, ADAPTERS, AND CHANNELS			Attachments			
	164		Simultaneous Mode #3	310	15,600	19.00
	3416		Digital Clock	57	2,750	7.00
	3446-1		Peripheral Switching Unit	88	3,900	8.50
	3446-2		Peripheral Switching Unit	175	7,800	16.00
			Channels			
	3383-6		Dual Tape Channel	415	24,000	35.00
	3383-12		Dual Tape Channel	465	27,000	37.50
	3384-6		Dual Tape Channel	815	39,500	64.50
	3384-12		Dual Tape Channel	875	42,500	67.50
	3385-6		Dual Tape Channel	815	39,500	64.50
	3385-12		Dual Tape Channel	875	42,500	67.50
	3388-4		3488 Channel	645	32,500	51.25
MASS STORAGE			Drum Storage			
	3464-1		Data Drum Memory	1,080	49,800	205.00
	3464-2		Data Drum Memory	1,405	64,600	259.00
	3464-3		Data Drum Memory	2,055	94,200	367.00
	3464-4		Data Drum Memory	2,625	120,300	460.00
	3464-5		Data Drum Memory	2,915	133,500	509.00
	3464-6		Data Drum Memory	3,490	159,900	603.00
	3364		Data Drum Control	325	19,900	26.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Magnetic Card Storage			
	3488-1		Random Access Computer Equipment	3,000	127,500	528.00
	3488-2		File Expansion Assembly	1,625	65,000	314.00
	581		Tape Station	544	26,400	163.00
	582		Tape Station	865	36,750	163.00
	*681		Tape Station	950	39,850	171.00
	3484		Tape Station	565	26,400	114.00
	3485		Tape Station	800	37,200	164.00
INPUT-OUTPUT			Punched Card			
	329-1		Card Reader	440	23,000	91.50
	329-2		Card Reader	710	29,800	119.25
	*3436		Card Punch	515	24,000	105.00
	*3336		Card Punch Buffer and Control	490	23,750	38.75
	3329		Card Reader Control	206	10,000	16.00
	3330-1		Card Reader/Punch Buffer and Control	1,370	57,550	159.00
	3330-2		Card Reader/Punch Buffer and Control	1,370	57,550	159.00
			Paper Tape			
	322		Paper Tape Reader	355	14,500	44.50
	331		Paper Tape Punch	159	7,150	28.00
	321		Paper Tape Reader-Punch	173	7,800	29.50
	3321		Paper Tape Control	196	9,500	15.50
			Printer			
	333		On-Line Printer	715	32,200	149.00
	335		On-Line Printer	1,140	51,500	234.00
	3333		Printer Buffer and Control	490	23,750	38.75
	3335		Printer Buffer and Control	805	39,780	64.00
			Optical Reader			
	5820		Videoscan Document Reader(1)	3,555	145,900	588.00
		102-10	Mark Read–10 Row–Vertical	113	4,700	18.50
		102-11	Mark Read–10 Row–Slant	113	4,700	18.50
		102-15	Multiple Mark Read–10 Row–Vertical	385	15,900	62.50
		102-16	Multiple Mark Read–10 Row–Slant	385	15,900	62.50
		102-20	Mark Read–12 Row–Vertical	129	5,300	21.50
		102-21	Mark Read–12 Row–Slant	129	5,300	21.50
		102-25	Multiple Mark Read–12 Row–Vertical	410	17,000	66.00
		102-26	Multiple Mark Read–12 Row–Slant	410	17,000	66.00
		102-259	Mark Read Feature	635	26,400	106.00
			Display Units			
	*6050-11		Video Data Terminal	283	11,600	46.50
	*6050-12		Video Data Terminal	283	11,600	46.50
	*6050-13		Video Data Terminal	283	11,600	46.50
	*6050-21		Video Data Terminal	258	10,600	43.00
	*6050-22		Video Data Terminal	258	10,600	43.00
	*6050-23		Video Data Terminal	258	10,600	43.00
	*6051-1		Video Data Interrogator	46	1,900	7.25
	*6051-2		Video Data Interrogator	46	1,900	7.25
	*6051-3		Video Data Interrogator	46	1,900	7.25
COMMUNICATIONS			Buffers and Controls			
	3376-11		Communications Control	415	20,000	35.00
	3376-12		Communications Control	415	20,000	35.00
	3376-34		Communications Control	415	20,000	35.00

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Buffers and Controls (Contd.)			
	3378		Communications Mode Controls:			
		3378-21	Single Scan (20 line)	445	21,500	36.50
		3378-41	Single Scan (40 line)	465	22,500	37.50
		3378-61	Single Scan (60 line)	485	23,500	38.50
		3378-81	Single Scan (80 line)	505	24,500	39.50
		3378-101	Single Scan (100 line)	535	26,000	41.00
		3378-121	Single Scan (120 line)	555	27,000	42.00
		3378-141	Single Scan (140 line)	575	28,000	43.00
		3378-161	Single Scan (160 line)	595	29,000	44.00
		3378-22	Dual Scan (20 line)	470	22,750	37.75
		3378-42	Dual Scan (40 line)	485	23,500	38.50
		3378-62	Dual Scan (60 line)	500	24,250	39.25
		3378-82	Dual Scan (80 line)	515	25,000	40.00
		3378-102	Dual Scan (100 line)	555	27,000	42.00
		3378-122	Dual Scan (120 line)	570	27,750	42.75
		3378-142	Dual Scan (140 line)	585	28,500	43.50
		3378-162	Dual Scan (160 line)	605	29,250	49.25
	6071		Communications Rack	62	2,800	5.75
	6072		Buffer Frame	31	1,400	3.00
			Features for Model 3378 Series:			
		249	NNNN Terminate Feature	82	4,000	6.00
		493	Expanded Character Recognition	82	2,500	—
		584-2	System Automatic Recovery	(1)	(1)	(1)
			Buffers for 3378 Series:			
		6002-11	Telegraph Buffer	15	700	1.00
		6002-12	Telegraph Buffer	20	900	1.25
		6002-21	Telegraph Buffer	15	700	1.00
		6003	Telegraph Buffer	82	3,650	7.00
		6013	Telegraph Buffer	82	3,650	7.00
		6015	Telegraph Buffer	82	3,650	7.00
		6016	Parallel Buffer	62	2,800	5.75
		3377	Data Exchange Control	400	17,900	29.50
		6009-1	Communication Buffer	1,133	50,900	103.50
		6009-2	Communication Buffer	1,133	50,900	103.50
		6009-3	Communication Buffer	1,133	50,900	103.50
		6010-21	Communication Buffer	77	3,400	7.00
		6010-22	Communication Buffer	118	5,300	10.50
		6010-23	Communication Buffer	201	8,900	18.75
		6011-10	Communication Buffer	196	8,500	18.25
		6011-11	Communication Buffer	206	8,800	19.00
		6011-12	Communication Buffer	227	9,900	21.25
		6012-11	Communication Buffer	180	8,100	16.25
		6012-12	Communication Buffer	180	8,100	16.25
		6012-21	Communication Buffer	180	8,100	16.25
		6012-22	Communication Buffer	180	8,100	16.25
		6020-11	Communication Buffer	72	3,200	6.50
		6020-12	Communication Buffer	129	5,800	12.25
		6020-13	Communication Buffer	221	9,900	20.00
		6020-14	Communication Buffer	155	6,900	14.75
		6020-15	Communication Buffer	258	11,500	24.25
		6092	Communication Buffer Switch	77	3,500	7.00
		6025-10	Buffer Interface Unit	62	2,800	5.75
		6025-15	Buffer Interface Unit	72	3,200	6.50
		6025-20	Buffer Interface Unit	72	3,200	6.50
		6025-25	Buffer Interface Unit	82	3,700	7.00
		6027	Line Termination Assembly	46	2,100	4.00
		6041	Time Generator	82	3,700	7.00
		6042	Code Translator	57	2,500	5.50

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Terminals			
	6220-3		EDGE Data Input Station	69	2,600	(2)
	6228-3		EDGE Auxiliary Card Reader	35	1,500	(2)
	6235-3		EDGE Line Concentrator	215	7,440	(2)
	6240-3		EDGE Central Recorder	400	14,800	(2)
	*5936-1		Teletypewriter (KSR)	72	1,500	14.50
		445	Special Typewheel Feature			
			First Typewheel	200(3)	200	–
			Additional Typewheels	75(3)	75	–
			Addtiional Keycaps	0.90(3)	0.90	–
	*5940-1		Teletypewriter (ASR)	82	1,800	16.50
		242	Special Typewheel/Keycap Feature			
			First Typewheel	200(3)	200	–
			Additional Typewheels	75(3)	75	–
			Keycap	0.90(3)	0.90	–
		565	Data Set Coupler	8	350	1.75
	*5941-1		Teletypewriter (KSR)	67	1,300	12.75
		242	Special Typewheel/Keycap Feature			
			First Typewheel	200(3)	200	–
			Additional Typewheels	75(3)	75	–
			Keycap	0.90(3)	0.90	–
		565	Data Set Coupler	8	350	1.75
	*5942-1		Teletypewriter (RO)	57	1,100	12.00
		403	Special Typewheel/Keycap Feature			
			First Typewheel	200(3)	200	–
			Additional Typewheels	75(3)	75	–
		565	Data Set Coupler	8	350	1.75
	6740-11		Teletypewriter (ASR, Friction Feed)	140	5,650	25.25
		563	Data Set Coupler	45	350	1.50
	6740-21		Teletypewriter (ASR, Sprocket Feed)	145	5,850	26.00
		563	Data Set Coupler	45	350	1.50
		564	Wide Carriage	45	250	1.00
	6741-11		Teletypewriter (KSR, Friction Feed)	90	3,650	16.25
		563	Data Set Coupler	45	350	1.50
	6741-21		Teletypewriter (KSR, Sprocket Feed)	95	3,850	17.00
		563	Data Set Coupler	45	350	1.50
		564	Wide Carriage	45	250	1.00
	6742-11		Teletypewriter (RO, Friction Feed)	80	3,250	14.50
		563	Data Set Coupler	45	350	1.50
	6742-21		Teletypewriter (RO, Sprocket Feed)	85	3,450	15.25
		563	Data Set Coupler	45	350	1.50
		564	Wide Carriage	45	250	1.00
	6077		Interrogator Control Terminal	1,195	48,700	197.00

NOTES:

*No longer in production

(1) Furnished on request, when required, at no extra charge.

(2) To be quoted on request for each specific system and location.

(3) Single use charge.

REPORT UPDATE

RCA ANNOUNCES NEW DISC SYSTEM

RCA is going to be manufacturing its own magnetic disc memory units. The 70/590-8 Direct Access Storage Systems represents storage as it will be available to the user only as a pack consisting of the Direct-Access Controller and nine Direct Access Disc Units, one of which is a spare. Each Drive Unit holds more than 29 million bytes, a total of over 233 million bytes for the eight on-line units.

Each Unit uses the RCA-built 70/593 disc pack which is interchangeable with the 70/590 or IBM 2314 units. The IBM 2316 can be used in place of the 70/593. Files employing Index Sequential are not interchangeable, however, between 70/590 and IBM 2314.

The 70/590-8 system is offered in a "one-by" configuration. This allows one selector channel to: Read, Write, or Search on any one of the eight on-line units. The multichannel Switch Feature, 5518-2, permits either of two selector Channels to share in operating the basic "one-by" configuration. The Selector Channels can be on the same or different processors.

Software support is provided at the physical and logical levels for the Tape-Disc Operating System (TDOS) and at the logical level for the Time Sharing Operating System (TSOS). This includes systems residency, Indexed Sequential, and Disc Sort.

The characteristics of the 70/590-8 system can be summarized as follows:

Capacity

Track-7,294 bytes (one record per track)
Cylinder-20 tracks or 145,88 bytes
Unit-200 cylinders or 29,176,000 bytes
System-8 units on-line, 233,408,000 bytes

Access time

Minimum-25 ms (one position more)
Average-75 ms
Maximum-135 ms

Rotational latency

Minimum-0.0 ms
Average-12.5 ms
Maximum-25.0 ms.

The rental costs of the 70/590-8 system will be $5410 per month for the system with an additional $144 per month for the Multichannel Switch Feature, 5519-2. Purchase prices will be $249,4000 for the 70/590-8 and $5,770 for the 5519-2. Monthly maintenance charges have been announced as $615 per month and $11.50 per month respectively. RCA includes maintenance charges in its monthly rental figures. Initial deliveries are scheduled for December 1969.

REPORT UPDATE

RCA ANNOUNCES 70/61 TIME-SHARING SYSTEM

RCA announced the 70/61 time-sharing system on September 8, 1969. The 70/61 is intended to compete in the large-scale time-sharing market, although the facilities for background batch processing concurrent with time sharing will also be emphasized. The new computer bears the same relationship to the 70/60 as the earlier 70/46 system has to the 70/45.

The 70/61 has a main memory of from 524,288 to 1,048,576 bytes, with a cycle time of 765 nanoseconds for a 4-byte access. The instruction execution rate will be more than three times that of the 70/46. Up to 128 concurrent time-sharing users can be supported. Among other improvements in the 70/61 over the 70/46 are a larger virtual memory storage capacity (up to 3200 pages) and enhanced failure-tolerant and diagnostic facilities, including the use of switchable main memory banks for fail-soft operation.

The 70/61 is fully upward compatible with the 70/46. User tasks written for the 70/46 can be transferred to the 70/61 without change provided no shared code is used. 70/46 tasks using shared code will need recompilation before they can be used on the 70/61 since the details of the implementation of shared code are different in the two systems; the 70/61 implementation of shared code removes the restriction on the amount of shared code, which is inherent in the 70/46 implementation. RCA is developing the OS61 operating system for use with the 70/61. OS61 is an enlarged and enhanced version of the Time-Sharing Operating System (TSOS) used with the 70/46, and will contain all the facilities of TSOS as a subset while taking advantage of the improved hardware features of the 70/61.

Detailed price information for the 70/61 will be available shortly — a typical system including 524,288 byte of main storage, 233 million bytes of Direct Access Storage, 2 Drum Memories holding 800 pages each, and line buffers for 64 remote terminals rents for about $51,000 per month. The first customer deliveries of the Spectra 70/61 and OS61 are scheduled for the first quarter of 1971.

RCA ANNOUNCES 'UNBUNDLING' OF RENTAL AND MAINTENANCE PRICES

A new price schedule for RCA computer equipment became effective on September 1, 1969. The standard monthly rental prices now quoted by RCA do not include maintenance. While the purchase prices for the equipment are unchanged, the new price schedules indicate that, when the rental and maintenance prices are combined, most of the equipment will be slightly more expensive to rent (with maintenance by RCA) than under the previous schedule of rental prices which included maintenance. The rental price information in the published Reports will be updated to reflect the new pricing as soon as complete information on the new schedules is available. Maintenance prices for 70/60 Processors are also included for the first time and range from $585 per month for a 70/60-F Processor with 131,072 bytes of main storage to $1,770 per month for a 70/60-N Processor with 1,048,576 bytes of storage.

NEW PRINTER FOR SPECTRA 70 COMPUTERS

RCA has introduced the 70/246 Train Printer for use with Spectra 70 computer systems. This train printer has a horizontal line of 132 characters spaced at 10 characters per inch; the vertical line spacing is 6 or 8 lines per inch and is set by the operator. The printing speed varies with the number of characters in the character set as shown in the table below. Printing at higher rates than those given in the table can be sustained for short periods — for example, a printing speed of 2400 lines per minute can be maintained for up to 5 minutes when a 16-character set is used. The RCA 64-character set is standard, but 10 different character sets are available including FORTRAN-COBL, PL/1, Text Printing, and a Hi-Speed Alphanumeric set. Each character set contains 288 positions, and up to 254 different characters can be used in special-purpose character sets. The unit is fully compatible with the existing Spectra 70 printers.

The purchase price for the 70/246 Train Printer is $77,600. Two optional features are available — the 5262-5 Document Processing Option, which allows the interconnection of the IBM 9364 Document Roll Input Unit and the IBM 9361 Document Converter, and the 5278-40 Special Format Control, allowing 1401 type format control.

TABLE SHOWING SPEEDS OF RCA 70/246 TRAIN PRINTER

Character Set Size, Characters	Speed, Lines/Minute
240	264
144	470
96	670
64	860
48	1100
24	1500
16	1500

SUMMARY

.1 SUMMARY

Spectra 70 is the "brand name" for RCA's third-generation family of central processors, peripheral devices, and supporting software. Noteworthy characteristics of the Spectra 70 include:

- The high degree of program compatibility, both upward and downward, among six of the eight Spectra 70 processor models. Compatibility is also achieved with the IBM System/360 processors through similar hardware design and compatible source languages.
- The wide range of input-output and storage devices.
- The numerous arithmetic modes and data forms, and the resulting complexity of machine-language coding.
- The emphasis upon software support through several levels of integrated operating systems.
- The use of true monolithic integrated circuits in the 70/35 and higher-numbered processors.
- The availability of optional features that enable certain Spectra 70 processor models to emulate a number of second-generation RCA and IBM computers.

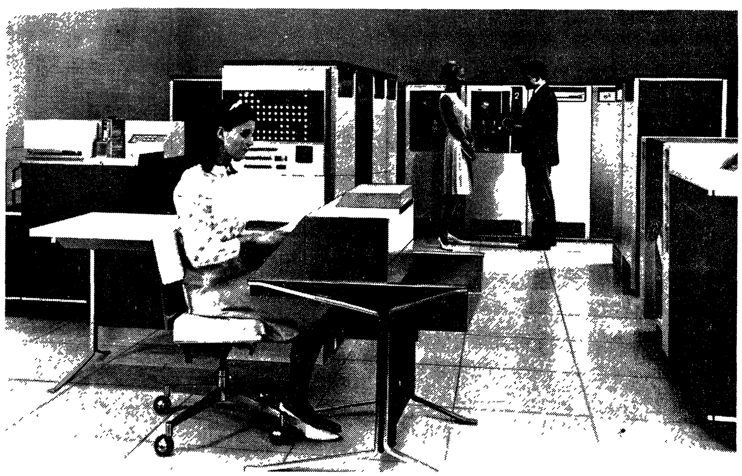

Figure 1. A typical RCA Spectra 70/45 System Configuration

This Summary is divided into five independent sections, each of which describes and (where pertinent) analyzes some particular facet of the Spectra 70 series. Each section is independent and can be read as your needs and interests warrant. The five sections are:

.1 Summary
.2 Data Structure
.3 Hardware
.4 Software
.5 Compatibility

.2 DATA STRUCTURE

Spectra 70's data structure is identical in all respects with that of the IBM System/360. The basic unit of data storage is the "byte," which consists of eight data bits plus (in most system components) one parity bit. The eight data bits in a byte can represent one alphameric character, two decimal digits, or a portion of a binary field.

Bytes can be handled individually or grouped together into fields. A "halfword" is defined as a group of two consecutive bytes, or 16 bits. A "word" in the Spectra 70 is a group of four consecutive bytes, or 32 bits. A "double word" consists of two consecutive words, or 64 bits. The location of any field or group of bytes is specified by the address of its leftmost byte.

.2 DATA STRUCTURE (Contd.)

Every fixed-length field (halfword, word, or double word) must be located in main storage on an "integral boundary"; i.e., the storage address of the field must be a multiple of the length of the field in bytes. This restriction is particularly important for efficient operation of the Spectra 70/55, 70/60, and 70/61 Processors, which access up to four bytes in parallel, and the same restriction has been applied to the smaller processors in order to maintain compatibility. Variable-length (decimal) fields are processed serially by byte in all models, so they may start at any byte location.

At the low end of the Spectra 70 line of processors, the 70/15 and 70/25 Processors can perform arithmetic operations on two basic types of operands: fixed-point binary and variable-length decimal. The larger Spectra 70 processor models can perform arithmetic operations on four basic types of operands. In addition to fixed-point binary and variable-length decimal, these models can also perform arithmetic operations on two sizes of floating-point binary operands. The basic arithmetic operand size is the 32-bit fixed-point binary word. Most fixed-point instructions can alternatively specify the use of 16-bit halfword operands.

Floating-point numbers can be represented in either a "short" (32-bit) or "long" (64-bit) format. The fractional part occupies 24 bits in the short format and 56 bits in the long format. The hexadecimal character occupies 7 bits in both formats and permits representation of numbers ranging from 10^{-78} to 10^{75}.

Decimal arithmetic is performed upon 4-bit BCD digits packed two to a byte, with a sign in the rightmost four bits of the low-order byte. Decimal operands can be up to 16 bytes (31 digits and sign) in length

The 8-bit byte structure has certain basio advantages over the 6-bit data format: decimal digits can be packed more conveniently, the standard 7-bit ASCII code and the Extended BCD Interchange Code can be used, and today's familiar character sets can be conveniently expanded.

.3 HARDWARE

.31 Central Processors

Eight processor models currently form the nucleus of the Spectra 70 Series. Six of the processor models are program-compatible for a broad range of business and scientific applications: 70/35, 70/45, 70/46, 70/55, 70/60, and 70/61. The 70/15, with its restricted instruction repertoire, may be of primary interest as a satellite or remote terminal system for the larger Spectra 70 processors. The 70/25 also has a limited instruction repertoire, but its expanded throughput capability for magnetic tape-oriented applications makes it suitable for certain single-processor installations. The 70/25 is no longer manufactured by RCA but is marketed as available. During 1969, the original version of the 70/45 was replaced in the Spectra 70 product line by the 70/45 Type II. The 70/45 Type II differs from the Type I in having slightly enhanced Selector Channel capabilities and one additional instruction (Test and Set). Other minor differences include the availability of certain sizes of main memory, change in power supply buffering, and the availability of Memory Protect on the 70/45 Type II. All information presented here for the Spectra 70/45 applies to both types unless indicated otherwise.

The 70/46 and 70/61 Processors are time-sharing versions of the 70/45 and 70/60 Processors, respectively.

Comparative arithmetic execution times for the various Spectra 70 processors are illustrated in Table I. Table II shows the various core storage capacities that can be obtained with each of the basic processor models.

The Spectra 70 processors which are larger than the 70/25 Processor are designed to facilitate achieving program compatibility with the IBM System/360 computers. The remainder of this discussion of Central Processors concerns itself exclusively with the processors associated with the Spectra 70/35 and higher-numbered systems. These processors offer the full System/360 instruction repertoire except for the "privileged" instructions, which are normally reserved for operating system use and are not permitted in users' programs. Thus, RCA expects to achieve two-way program compatibility — to a limited extent at the machine-language level and to a much greater extent at the assembly, COBOL, and FORTRAN language levels.

(Contd.)

.31 Central Processors (Contd.)

The Spectra 70 processors contain facilities for addressing main storage, for fetching and storing information, for executing stored-program instructions in the desired order, for arithmetic and logical processing of data, and for initiating all communication between main storage and peripheral devices. Each program uses sixteen 32-bit general registers and four 64-bit floating-point registers. The general registers can be used as fixed-point accumulators or as index registers. In the 70/45 and higher-numbered processors, these registers are contained in a scratchpad memory, whose cycle time is 300 nanoseconds per four-byte word for the 70/45, 46, and 55 Processors. The scratchpad memory used in the 70/60 and 70/61 Processors has an access time of 85 nanoseconds. In lieu of scratchpad memory, the Spectra 70/35 Processor provides 128 words of additional core storage for use as general registers. Different parts of these memory units are used as the operational registers depending upon which processor state is being used.

Instructions can be two, four, or six bytes in length. A 2-byte instruction causes no reference to main core storage. A 4-byte instruction causes one reference to main storage, while a 6-byte instruction causes two storage references.

Main storage addresses are formed by adding a 12-bit "displacement" contained in the instruction to a 24-bit "base address" contained in one of the 16 general registers. The addresses in many instructions (including most binary arithmetic and logical instructions) can be further modified by adding a 24-bit "index" contained in another general register; this effectively provides a double indexing capability. The base-register technique of address formation facilitates program relocation and segmentation, at the expense of increased programming complexity.

The basic arithmetic mode of these processors is fixed-point binary, using 32-bit operands and two's-complement notation. Most instructions can alternatively specify the use of 16-bit "halfword" operands to improve storage utilization. Most products and all dividends are 64 bits long. Fixed-point arithmetic and comparison instructions specify

TABLE I: ARITHMETIC EXECUTION TIMES FOR THE RCA SPECTRA 70 PROCESSORS

	Processor Model					
	70/15	70/25	70/35	70/45*	70/55	70/60*
Fixed Point Binary						
c = a + b	62	23.3	51.2	25.2	7.8	6.1
c = ab	#	#	163.2	81.9	17.9	15.6
c = a/b	#	#	243.2	111.2	25.0	23.7
Fixed Point Decimal						
c = a + b	83	46.5	76.5	39.2	18.4	19.3
c = ab	#	106.5	223.9	109.1	51.8	22.0
c = a/b	#	351.3	377.7	174.0	41.5	25.0
Floating Point — Short						
c = a + b	#	#	80.9	37.4	13.2	7.7
c = ab	#	#	202.6	67.6	23.0	14.6
c = a/b	#	#	445.5	101.2	28.4	20.7
Floating Point — Long						
c = a + b	#	#	115.9	52.6	18.5	10.0
c = ab	#	#	536.4	211.5	50.0	37.2
c = a/b	#	#	1282.1	305.2	83.8	55.3

NOTE: All times are expressed in microseconds. The fixed-point decimal times are based on 5-digit (3-byte) decimal operands. The floating-point times are based on both the short-form (32 bits) and the long-form (64 bits) binary operands. The 70/15 and 70/25 do not require programmer-initiated operand movement to a fixed accumulator register.

Facility not available.

* Times for the Spectra 70/46 and Spectra 70/61 Processors are identical to those shown for the Spectra 70/45 and Spectra 70/60 Processors, respectively.

.31 Central Processors (Contd.)

one operand in a general register and a second operand in either main storage or a general register; these instructions are 4 bytes long when they specify an operand address in main storage and 2 bytes long when both operands are in registers.

The System/360-compatible instruction set includes instructions which perform fixed-point arithmetic, comparison, branching, moving, loading, storing, shifting, radix conversion, code translation, packing, unpacking, and Boolean operations. The radix conversion operations perform automatic conversions between signed, packed decimal fields up to 15 digits in length and 32-bit signed binary integers. The code translation instruction uses a table to translate any 8-bit data code to any other 8-bit code. The packing and unpacking instructions convert numeric BCD data between the one-character-per-byte format used in most input-output devices and the two-digits-per-byte format used for decimal arithmetic.

The decimal arithmetic facility provides additional instructions for addition, subtraction, multiplication, division, comparison, and editing of decimal numbers. Decimal arithmetic is performed upon 4-bit BCD digits packed two to a byte, with a sign in the rightmost four bits of the low-order byte. Decimal operands may be up to 16 bytes (31 digits and sign) in length. The length of each decimal field is specified in the instruction referencing it. Two-address (6-byte) instructions of the storage-to-storage type are used for all decimal operations; the general and floating-point registers are not utilized.

The floating-point arithmetic facility provides additional instructions for addition, subtraction, multiplication, division, loading, storing, and comparison of both "short" (32-bit) and "long" (64-bit) floating-point numbers. Floating-point instructions specify one operand in a floating-point register and a second operand in either main storage or a floating-point register.

The optional Storage Protection feature can protect the contents of specified 2,048-byte blocks of core storage from being altered as a result of program errors or misguided input data. This feature prevents overwriting by unauthorized programs, but it does not guarantee privacy since any program can still read the contents of any desired portion of core storage. 2,048-byte blocks of core storage can be protected both from reading and from writing with the Memory Protect feature, which is available for the Spectra 70/45 Type II, 70/46, 70/60, and 70/61 Processors.

TABLE II: SPECTRA 70 MAIN CORE STORAGE CHARACTERISTICS

Core Storage Capacity, Bytes	70/15	70/25	70/35	70/45	70/46	70/55	70/60	70/61
4,096	15-A							
8,192	15-B							
16,384		25-C		45-C*				
32,768		25-D	35-D	45-D*				
49,152			35-DC					
65,536		25-E	35-E	45-E		55-E		
131,072				45-F		55-F	60-F	
196,608				45-FE**				
262,144				45-G	46-G	55-G	60-G	61-G
393,216							60-H	61-H
524,288						55-H	60-J	61-J
655,360							60-K	61-K
786,432							60-L	61-L
917,504							60-M	61-M
1,048,576							60-N	61-N
Cycle Time, μsec	2.0	1.5	1.44	1.44	1.44	0.84	0.765	0.765
Bytes Accessed per Cycle	1	4	2	2	2	4	4	4
Effective Cycle Time per Byte, μsec	2.0	0.38	0.72	0.72	0.72	0.21	0.19	0.19

* 70/45 Type I only - no longer manufactured.
** 70/45 Type II only.

(Contd.)

.32 Internal Storage

Table II indicates the range of core storage sizes and speeds available with the various Spectra 70 processor models.

Three different types of auxiliary storage devices are available in the form of magnetic drums, discs, and cards. The storage capacity of these devices ranges from less than 0.8 million bytes for a drum unit to over 530 million bytes for the magnetic card mass storage unit. Similarly, average access times can range from 8.6 milliseconds to 488 milliseconds for the same two devices, respectively. The single controller used for all three types of storage devices allows an installation to tailor its complement of storage devices according to specific capacity and access time requirements. Table III lists the various Spectra 70 auxiliary storage devices with their principal functional characteristics. None of these devices can be used with the small-scale 70/15 or 70/25 Processors.

TABLE III: SPECTRA 70 AUXILIARY STORAGE UNITS

Device	Capacity Range (Millions of Bytes per Control Unit)	Average Access Time (msec)	Data Transfer Rate (bytes/sec)
70/564 Disc Storage Unit*	7.25 to 58.0	98	156,000
70/568 Mass Storage Unit	536.9 to 4,295	488	70,000
70/565 Drum Memory Unit	0.8 to 3.2	8.6	210,000
70/567 Drum Memory Unit	4.1 to 16.4	8.6	333,000

* This is RCA's designation for the IBM 2311 Disk Storage Drive, which RCA is currently marketing for use with Spectra 70 systems.

.33 Time-Sharing Systems

RCA has entered the full-scale time-sharing market with the 70/46 and 70/61 Processors, based on the 70/45 and 70/60 respectively. The systems include hardware paging facilities, a special drum unit, and a specialized software package.

The Spectra 70/46 Processor hardware is largely that of the Model 70/45, with several improvements to facilitate time-shared operation. The 70/61 Processor is similarly based on the 70/60. Significantly, the addition of hardware logic for program paging and segmentation provides up to 2,097,152 bytes of virtual storage and assists in the dynamic reallocation of memory. The 70/46 and 70/61 feature a fast associative memory for translation of all virtual memory addresses to real core storage addresses. Other improvements include changes in the interrupt logic and the use of read-only memory to implement the address translation tables and to provide by hardware the special instructions frequently used by the software system to manipulate the various translation tables. Program pages in 4,096-byte blocks will be loaded either from disc or from the drum system, which is capable of storing up to 16 (70/46) or 32 (70/61) million bytes of data. The drum has an average access of time of 8.6 milliseconds and a peak data transfer rate of 333,000 bytes per second.

A most significant fact is that the Spectra 70/46 and Spectra 70/61 are designed primarily for batch processing in a multiprogramming, random-access environment, with the facility for time-sliced, remote time-sharing operations expected to consume less than 20 per cent of the system's capacity. For this reason the specialized Spectra 70/46 Time Sharing Operating System (TSOS) provides not only dynamic interactive processing capabilities, but also efficient multiprogramming capabilities for up to four concurrent background jobs. TSOS is 100 per cent compatible with the Spectra 70 Tape Operating System (TOS), permitting the user to progress easily from the tape-oriented system to the more powerful TSOS random-access-oriented operating system. An enhanced version of TSOS, OS61, will be available for Spectra 70/61.

All source program written for Spectra 70/35, 70/45, 70/55, and 70/60 systems will operate on the 70/46 and 70/61 systems. Most object programs written for the non-time-sharing processors will also run on the time-sharing processors when the time-sharing processors are run in the Direct (i.e., non-translate) mode in which hardware paging is not used. Programs intended for use on more than one processor should, however, be timing-independent and avoid the use of hardware features peculiar to one machine. Because of this intra-family compatibility, software systems such as

.33 Time Sharing Systems (Contd.)

FORTRAN, COBOL, Assembler, Report Generator, and Sort/Merge, which are originally developed for use with the Tape Operating System (TOS), can also be used with the time-sharing processors.

The 70/61 has larger main memory and virtual memory storage capacities than the 70/46 and handles up to 128 remote users concurrently compared with 48 for the 70/46. Full upward software compatibility between the systems will be maintained, the 70/61 software containing all the 70/46 software features as a subset. Shared code, however, will be compatible only at the source level between the two systems; this restriction is necessary to increase the amount of virtual memory available for shared code on the 70/61.

.34 Sequential Input-Output Units

RCA has announced a wide range of input-output units for the Spectra 70 computer family. Some of the more significant units are:

- 9-track System/360-compatible magnetic tape units with transfer rates of up to 120,000 bytes per second.
- A fast card reader (1,435 cards per minute) with optional mark-sensing capabilities at a slower rate.
- A triple-purpose optical scanner with optional mark-sensing and punched-hole reading capabilities.

Recent additions to the product line include a MICR controller, a high-speed paper tape reader, new printer models with 96-character drum sets, and 7-track magnetic tape units and controllers to facilitate compatibility with earlier RCA 301 and 501 systems. Table IV summarizes the capabilities of the available sequential input-output units.

TABLE IV: SPECTRA 70 SEQUENTIAL INPUT-OUTPUT UNITS

Unit	Models Available	Peak Speed
70/237 Card Reader		1,435 cpm
70/234 Card Punch		100 cpm
70/236 Card Punch		300 cpm
70/221 Paper Tape Reader-Punch		200 cps (reader) 100 cps (punch)
70/224 Paper Tape Reader	Bi-directional reading	1,000 cps
70/242 Printer	132 or 160 columns	625 lpm
70/243 Printer	132 or 160 columns; 64- or 96-character print drums	1,250 lpm
70/248 Bill Feed Printer		600 lpm 400 cpm
9-track Magnetic Tape Units	30, 60 or 120 KB versions; seven-track adapters	120,000 bytes/sec
7-track Magnetic Tape Units	16.6 or 25KB versions	25,000 bytes/sec
70/251 Videoscan Document Reader		1,600 doc/min.

.35 Display Equipment

Display devices are a means for presenting information either to a camera or directly to man. They generally hold only a small amount of data for only a short time; their value is in the variety and speed at which they can display the appropriate information.

RCA provides a display device called the 70/752 Video Data Terminal. This combination entry and display device can be used for both local and remote operations. Up to 1,080 characters can be displayed on a 12-inch rectangular cathode-ray-tube screen.

.36 Data Communications Equipment

The RCA 70/668 Communications Controller — Multichannel (CCM) operates on the 70/35 and higher-numbered processors and terminates from 1 to 48 communications lines serving a wide variety of remote terminals. Each of the 1 to 48 scan positions requires a communications buffer, and in some cases a data set, to interface with the communications line. The CCM is connected to the Spectra computer by one trunk of the Multiplexor Channel. Each scan position of a CCM uses one Multiplexor subchannel. The maximum total communications data rate that one 70/668 CCM can handle is 6,000 characters per second.

The RCA Communication Controls (Single Channel) permit remote half-duplex communications between an RCA Spectra 70 computer system and an RCA 301,3301, or Spectra 70 computer system that is equipped with the appropriate communications equipment. Different models of these Controls permit communication over the public switched telephone network, a common-carrier leased voice-band line, or a common-carrier leased broadband line. Some models offer facilities for programmed automatic dialing over the public telephone network through use of a Bell System Automatic Calling Unit.

The RCA 70/510 Voice Response System is an on-line inquiry/response system that delivers recorded human-voice responses to an inquirer at a Bell System Touch-Tone telephone. A basic Voice Response Unit (VRU) can handle up to 10 communication lines; optional features permit the maximum number of communication lines per VRU to be expanded to 50. Various models of the Voice Response Unit offer vocabularies that range in capacity from 31 to 189 words, all of which can be user-specified.

The RCA 70/630 Data Gathering System (DGS) is an on-line data collection system designed for gathering information at remote, point-of-transaction terminals and transmitting this data to a central Spectra 70/35, 70/45, 70/46, or 70/55 system. DGS connects to the central system via a 70/725 DGS Buffer and the 70/668 Communication Controller — Multichannel. DGS input stations can consist of 70/6321 Badge Readers, 70/6331 Card Readers, and 70/6341 Variable Data Readers with 10 decks of numeric pushbutton keys.

.37 System Configuration

The Spectra 70 peripheral devices and their controllers are connected to the 70/25 and larger systems through input-output channels of various types and capacities. A single Multiplexor Channel is provided as standard equipment for the 70/35 and higher-numbered processors and as optional equipment for the 70/25 Processor. The Multiplexor Channel of the Spectra 70/45 and larger systems can control up to 256 low-speed devices. Selector Channels are provided as standard equipment for the 70/15 and 70/25, and two Selector Channels are supplied as standard equipment with the 70/60 and 70/61 systems; Selector Channels for all the systems are available optionally. A Selector Channel provides direct control of one high-speed input-output operation at a time. Table V shows the various combinations and capacities of Multiplexor and Selector Channels possible for all Spectra 70 systems, together with the maximum number of simultaneous I/O operations per system.

.38 Simultaneous Operations

An RCA Spectra 70 Central Processor (except for the small-scale Model 70/15) can concurrently execute:

- One machine instruction; and
- Up to eight high-speed input-output operations (one per Selector Channel); and
- Multiple slower input-output operations via a Multiplexor Channel.

Table V summarizes the mix possibilities and simultaneous operations capabilities of the various Spectra 70 input-output channels.

In general, the relationships between RCA Spectra 70 peripheral devices and input-output data channels are determined at installation time and cannot be altered under program control except by the inclusion of special optional features. Since it is not normally possible to assign by program any free channel to any available peripheral device, the number of input-output operations that can actually occur simultaneously can in many cases be considerably fewer than the theoretical maximum. However, special features are available to switch a limited number of devices to free data channels under program control.

.4 SOFTWARE

RCA's software systems for the Spectra 70 series, in general, closely parallel the structure and contents of the software supplied by IBM for its System/360 series. Since announcement of the Spectra 70, RCA has greatly improved its standard software by adding "third-generation" software facilities such as disc-oriented control systems, disc file language facilities, automatic on-line file management techniques, comprehensive data communications control routines, and time-sharing processing support. Multiprogramming control

.4 SOFTWARE (Contd.)

for up to six jobs is provided for Spectra 70 systems that have a minimum of 65K bytes of core storage. A small-scale multiprogramming system called Primary Communications Oriented System is also available for basic two-level multiprogramming with systems as small as 16K bytes.

The principal levels of RCA Spectra 70 software are designated Primary Operating System, Tape Operating System, and Tape/Disc Operating System, in order of increasing complexity and capability. Software for the small-scale Spectra 70/15 system, however, is a specially-designed, card-oriented set of routines that provides assembly language, Report Program Generator, I/O control, and service routine facilities at 4K- and 8K-byte core storage design levels. The system can also be supplied in a magnetic tape-oriented version. The more powerful Spectra 70/25 system functions with an integrated operating system, similar to RCA's Primary Operating System (see below), that provides an assembler, RPG, Sort/Merge, and standard utility programs. The 70/25 can also use a special stand-alone simulator program to simulate IBM 1401 programs.

The Spectra 70/25 operating system offers basically the same supervised facilities as the Primary Operating System (POS) for the larger Spectra 70 systems and functions with a minimum hardware configuration of 16K bytes of core storage, four magnetic tape units, console typewriter, printer, and card reader and punch. The principal limitation of 70/25 POS facilities in comparison to the POS facilities for the 70/35, 70/45, and 70/55 systems is the omission of a COBOL language processor. (Random-access mass storage devices cannot be used with 70/25 systems, constituting a significant hardware difference between the 70/25 and the larger members of the Spectra 70 family). The method of implementation of POS programs for use with the Spectra 70/25 differs from that used with the larger Spectra 70 systems due to the fact that the 70/25 Processor has a somewhat restricted instruction set.

.41 Primary Operating System (POS)

The Primary Operating System for use with the Spectra 70/35, 70/45, and 70/55 systems is a magnetic tape-oriented software system that provides basic supervisory control for the sequential execution of programs, interrupt control, and input-output control, as well as a COBOL compiler, assembler, report program generator, and standard utility routines. POS COBOL is a subset language of full COBOL 65 and requires a minimum of 32K bytes of core storage for compilations. The POS Assembler also requires use of

TABLE V: SPECTRA 70 INPUT-OUTPUT CHANNEL COMBINATIONS

Standard Channel Complement	Processor Model							
	70/15	70/25	70/35	70/45	70/46	70/55	70/60	70/61
Selector Channels —	1	4	0	0	0	0	2	2
Trunks per channel	6	1	-	-	-	-	1	1
Number of simultaneous data transfer operations	3	4	-	-	-	-	1	1
Multiplexor Channels —	0	0	1	1	1	1	1	1
Number of devices	-	-	192	256	256	256	248	248
Number of simultaneous data transfer operations	-	-	7	8	8	8	16	16
Fully Expanded Channel Complement	**70/15**	**70/25**	**70/35**	**70/45**	**70/46**	**70/55**	**70/60**	**70/61**
Selector Channels —	1	8	2	3	4	6	6	6
Trunks per channel	6	1	2	2	2	4	3	3
Number of simultaneous data transfer operations	3	8	2	3	4	6	6	6
Multiplexor Channels —	0	1	1	1	1	1	1	1
Number of devices	-	115	192	256	256	256	248	248
Number of simultaneous data transfer operations	-	8	7	8	8	8	16	16
Combined total of possible simultaneous data transfer operations	3	16	9	11	12	14	22	22

(Contd.)

.41 Primary Operating System (POS) (Contd.)

32K bytes of core storage. Other POS facilities are designed to permit operation in a minimum environment that includes 16K bytes of core storage and four magnetic tape units. No FORTRAN or PL/I processors are provided under POS, nor are any routines supplied for the automatic control of random-access devices, although the operation of these devices can be programmed at the assembly-language level. The only forms of multiprogramming supported by POS are the RCA-provided Peripheral Control Routine, which permits concurrent operation of up to three data transcription routines, and the Primary Communications Oriented System for basic two-level multiprogramming.

.42 Tape Operating System (TOS)

The second major level of Spectra 70 software support designed for use with the 70/35 and higher-numbered systems is designated the Tape Operating System (TOS). TOS is a magnetic tape-oriented integrated software package that provides supervisory control programs, language processors, and utility programs for installations that have a minimum hardware configuration of 65K bytes of core storage, five magnetic tape units, console typewriter, card reader, and line printer. The facility to control multiprogrammed operation of up to six programs concurrently is the primary feature of TOS software. The basic TOS Executive program requires a minimum of 16K bytes of core storage. The Monitor program that coordinates the operations of stacked-job processing requires an additional 4K bytes, and the File Control Processor for input-output device and file control requires another 4K to 8K bytes of core storage. Although the theoretical maximum number of problem and control programs that can be processed concurrently is six, the actual limit will frequently be fewer than six, limited by the amount of available core storage and number of available peripheral devices. As many as five magnetic tape units can be dedicated to system control and library functions when processing in a stacked-job, multiprogramming environment.

In addition to a comprehensive assembly system, TOS offers a COBOL language similar to IBM's Operating System/360 COBOL F, as well as full-scale FORTRAN IV language that includes all Operating System/360 FORTRAN IV facilities except random-access device control statements. No PL/I language processor has been scheduled for implementation to date.

.43 Tape/Disc Operating System (TDOS)

RCA's Tape/Disc Operating System (TDOS) is an improved and extended version of its Tape Operating System (TOS). An enhanced version of TDOS, OS60, will be available for the 70/60. In addition to all TOS software facilities, TDOS offers options that permit system control routines, problem programs, and library subroutines to reside on either the 70/564 Disc or 70/565 Drum units in order to improve the Spectra 70's throughput capabilities. As a result, TDOS offers more efficient multiprogrammed operations than does the tape-oriented Tape Operating System. Also, with TDOS the number of Job Control Language statements required to prepare and compile object programs is reduced, increasing the efficiency of program preparation. Another significant addition to the TDOS software package is a comprehensive set of input-output routines for control of data communication devices. This communications package, called the Multichannel Communication Program (MCP), offers most of the same facilities as the IBM System/360 Queued Telecommunications Access Method (QTAM) software for data communications control. The MCP system can accept remote messages either as they are entered or as polled, in contrast to the polled-only acceptance technique of QTAM.

The minimum Spectra 70 core storage requirements for use of TDOS remains at 65K bytes, of which 16K bytes are permanently reserved for the Executive. Both the Executive Monitor and the optional data communications package require 4K bytes of storage. The Monitor, however, is a transient routine and does not require permanent residence in core; the data communications control routines are permanently resident. The principal software components of the Tape and Tape/Disc Operating Systems are listed in Table VI, where the scheduled availability date for each element is also shown.

.44 Time Sharing Operating System (TSOS)

The Time Sharing Operating System (TSOS) is a specialized software system designed for control and support of the RCA Spectra 70/46 time-sharing processor. An enhanced version of TSOS, OS61, will be available for the 70/61. The system is scheduled to provide advanced time-sharing capabilities, as well as improved facilities for handling batch processing in a multiprogramming mode.

Provided within the TSOS Executive program are routines for handling task scheduling (capable of using a time-slicing algorithm), memory management, device allocation, physical-level input-output, and a combination command and job control language. Also

.44 Time Sharing Operating System (TSOS) (Contd.)

provided as a TSOS system program will be a File Control Processor (FCP) with extensive automatic data management capabilities. In addition to all of the language processors and utility routines used with TOS and TDOS, TSOS also provides a full conversational FORTRAN compiler, plus conversational text editor and desk calculator programs. Conversational syntax checking will also be provided for the FORTRAN, COBOL, and Assembler languages.

The minimum equipment required to use the Time Sharing Operating System includes a Spectra 70/46 processor with at least 262K bytes of core storage, a 70/567 Drum Memory Unit, two 70/564 Disc Units, two 9-track magnetic-tape units, one card reader, and one printer. To support conversational users, the system must also include a 70/668 Communications Controller — Multichannel and from 1 to 48 (70/46) or 128 (70/61) remote terminal units.

.45 Basic Time-Sharing System (BTSS)

The Time-Sharing Operating System (TSOS) should not be confused with another Spectra 70 time-sharing system called the Basic Time-Sharing System (BTSS). BTSS is a much more restricted software system than TSOS, and is designed to run on the general-purpose Spectra 70/45 hardware. BTSS is a full operating system, designed to permit up to 16 concurrent users at remote terminals to use a conversational, interpretive FORTRAN compiler, and to perform library maintenance functions on data and program files, which can then be processed under another general-purpose Spectra 70 operating system.

The Basic Time Sharing System requires a Spectra 70/45 system with either 131K or 262K bytes of core storage, a minimum of one 70/564 Disc Storage Unit, one 70/668 Communications Controller — Multichannel, and from 1 to 16 remote terminal devices.

.46 Disc Operating System (DOS)

This system is not the same as the previously rumored system of the same name. Rather than being competitive with the IBM System/360 DOS, this system tries to make available to the user of a 32K Spectra 70/35 most of the features of the larger TOS/TDOS systems. Completely disc oriented, it eliminates the need of the random access-oriented user to have magnetic tape handlers solely for software use.

.5 COMPATIBILITY

.51 Program Compatibility Within the Spectra 70 Line

RCA emphasizes the high degree of program compatibility, in both the upward and downward directions, among Spectra 70/35 and higher-numbered processors.

Among these four models, any valid program that runs on configuration A will run on configuration B and produce the same results if:

- Configuration B includes the required amount of main storage, the same or compatible input-output devices, and all required special features.
- The program is independent of the relationships between instruction execution times and input-output rates.
- The Spectra 70/46 or 70/61 is run in the non-translate mode.

These limitations indicate that there will be a high degree of effective upward compatibility, making it easy to expand an installation, but that the concept of downward compatibility will be useful mainly in making possible the common use of subroutines and software, rather than in making it feasible to "shrink" an installation as its workload decreases or to back up a large computer with a smaller one.

A Spectra 70/15 object program can be run on a 70/25 if the following rules are adhered to:

- The 70/15-70/25 Program Loader must be used to preset 70/25 Processor conditions;
- The 70/15 program must provide for only legal 70/15 interrupt conditions; and
- The 70/15 software must be used in the manner in which it was designed.

.51 Program Compatibility Within the Spectra 70 Line (Contd.)

A Spectra 70/25 program can be run on a 70/35, 70/45, or 70/55 system after reassembly or recompilation if:

- The 70/25 program abides by the Addressing, Data, and Specification restrictions placed on 70/35, 70/45, and 70/55 programs; and
- The general requirements mentioned above in regard to configuration similarity and time-dependent I/O devices are observed.

Compatability between the 70/46 and 70/61 time-sharing processors is discussed in Paragraph .33.

.52 Program Compatibility with the IBM System/360

RCA provides, through its Spectra 70 source languages, program compatibility with the IBM System/360. The Spectra 70 COBOL and FORTRAN languages are in many cases identical to their System/360 counterparts. Furthermore, since the instruction repertoire of the large Spectra 70 processors is virtually identical with that of the similar-sized IBM processors, RCA has been able to develop System/360 program compatibility at the assembly-language level as well. The differences in the "privileged" instructions, however, make it impossible to run machine-language System/360 programs on a Spectra 70 system without alteration. Therefore, to execute programs written for an IBM System/360 on a Spectra 70 system, program recompilation or reassembly is always required. In many situations, the System/360 operational control cards can be retained and used directly in the Spectra 70 program input stream.

At present, there is only one major area of incompatibility with IBM System/360 programming languages. During the fourth quarter of 1966, IBM delivered a modest PL/I compiler, but RCA has not announced a PL/I compiler to date, although it is still considering the advisability of providing one.

When RCA Spectra 70 software was first delivered during 1966, the lack of source-language-level support of random-access storage devices was a significant limitation in comparison to IBM System/360 software. RCA has since developed COBOL and RPG software with capabilities for directly controlling random-access devices. A FORTRAN compiler with similar capabilities is presently under development.

RCA's adoption of many of the System/360 concepts and facilities in the areas of source languages, operational methods, and basic instruction sets marked the first such acceptance of the IBM System/360 by another major computer manufacturer, and reinforced the establishment of the System/360 as a de facto standard for the design of data processing systems for the next few years.

.53 Program Compatibility With Second-Generation RCA and IBM Computers

RCA offers a series of Emulator Features that will enable certain models of the Spectra 70 to run object programs written for certain second-generation RCA and IBM computer systems. The earlier computers whose programs can be run by the various Spectra 70 systems (when properly equipped) are as follows:

Spectra 70 System*	Systems Emulated
70/35	IBM 1401/1460 RCA 301
70/45	IBM 1401/1460 IBM 1410/7010 RCA 301 RCA 501
70/60, 70/61	to be announced

Emulation, in general, requires a Spectra 70 system with an equivalent array of peripheral equipment, more processing power, and more core storage than the second-generation system to be emulated. The functions of most of the common peripheral devices (e.g., card readers and punches, printers, magnetic tape units, and console typewriters) can be emulated, but the less common devices (e.g., optical and magnetic character readers, paper tape units, data communications devices, and random-access storage devices) cannot be emulated. Time-dependent programs and programs not written in accordance with RCA and IBM programming manuals, when emulated, may yield results which differ from those obtained in the original system; the handling of

*The Spectra 70/25 system can utilize an all-software IBM 1401 Simulator program.

.53 Program Compatibility With Second-Generation RCA and IBM Computers (Contd.)

many console operations and error conditions will differ; and a variety of specific program restrictions and limitations apply to each Emulator Feature. Nevertheless, it is likely that most users of second-generation RCA and IBM computers will be able to run most of their programs on a Spectra 70 system with little or no need for immediate reprogramming.

The principal value of the Emulator Features is that they enable users of second-generation RCA and IBM computers to spread the task of reprogramming for the Spectra 70 system over an extended period of time. In nearly every case, the emulation mode will involve additional equipment costs and will fall short of fully utilizing the performance capabilities of the Spectra 70 system. Therefore, for maximum efficiency, most users will want to recode all of their principal applications for the Spectra 70 system as soon as possible. The cost of the additional core storage and of the optional features required for emulation must be borne until all of the user's programs have been recoded.

RCA SPECTRA 70

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			Model 70/15:			
	70/15-A		Processor (4,096 bytes)	800	38,000	48.00
	70/15-B		Processor (8,192 bytes)	1,000	47,500	60.00
			Model 70/25:			
	*70/25-C		Processor (16,384 bytes)	1,850	89,750	110.00
	*70/25-D		Processor (32,768 bytes)	2,750	133,400	165.00
	*70/25-E		Processor (65,536 bytes)	3,950	191,600	237.00
		*5010	Hi-Speed Selector Channel Feature	75	3,700	4.50
		*5011	Selector Channel Expansion Feature	100	4,850	6.00
		*5012	Multiplexor Channel	140	6,800	8.50
		*5014	Multiplexor Channel Expansion Feature	175	8,550	10.50
			Model 70/35:			
	70/35-D		Processor (32,768 bytes)	2,560	145,500	185.50
	70/35-DC		Processor (49,152 bytes)	3,410	180,700	240.00
	70/35-E		Processor (65,536 bytes)	3,990	203,700	259.50
		5001-35	Memory Protect	129	6,100	7.75
		5002-35	Elapsed Time Clock	52	2,450	3.00
		5003-35	Direct Control	206	9,700	12.25
		5005-35	301 Emulator	415	19,400	25.00
		5006-35	1401 Emulator	100	15,800	20.00
		5030	Selector Channel	181	8,550	11.00
		5031	Selector Channel	283	13,400	17.00
		*5051	Keyboard Interlock	10	470	0.50
			Model 70/45:			
	70/45-C		Processor (16,384 bytes), Type I	3,710	174,600	222.50
	70/45-D		Processor (32,768 bytes), Type I	4,325	203,700	259.50
	70/45-E		Processor (65,536 bytes), Type I	5,560	261,900	333.50
	70/45-E		Processor (65,536 bytes), Type II **	5,560	261,900	333.50
	70/45-F		Processor (131,072 bytes), Type I	7,210	339,500	432.50
	70/45-F		Processor (131,072 bytes), Type II **	7,210	339,500	432.50
	70/45-FE		Processor (196,608 bytes), Type II **	9,300	439,000	558.00
	70/45-G		Processor (262,144 bytes), Type I	11,125	523,800	667.50
	70/45-G		Processor (262,144 bytes), Type II **	11,125	523,800	667.50
		*5001-45	Memory Protect	129	6,100	7.75
		*5002-45	Elapsed Time Clock	52	2,450	3.00
		5003-45	Direct Control	206	9,700	12.25
		5005-45	301 Emulator	515	24,250	31.00
		5006-45	1401 Emulator	515	24,250	31.00
		5007-45	501 Emulator	670	31,550	40.25
		*5015	Selector Channel	227	10,650	13.75
		*5016	Selector Channel	385	18,250	23.00
		5043-45	Selector Channel-2	1,200	56,500	72.00
		5044-45	Selector Channel-3	1,800	84,750	108.00
		5045-45	Selector Channel-4	2,400	113,000	144.00
		5019-45	Elapsed Time Clock	125	5,900	7.50
		5026-45	1410 Emulator	565	26,700	34.00
		5036-45	301/501 Emulator	875	41,250	52.50
		5046-45	1401/1410 Emulator	825	38,800	49.50
		*5051	Keyboard Interlock	10	470	0.50
		5056	Store and Fetch Protection	200	9,400	12.00
			Model 70/46:			
	70/46-G		Processor (262,144 bytes)	14,125	665,300	848.00
		5001-46	Memory Protect	129	6,100	7.75
		5002-46	Elapsed Time Clock	52	2,450	3.00

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR (Contd.)			Processing Unit (includes core storage) (Contd.)			
		5003-46	Direct Control	206	9,700	12.25
		5019-46	Elapsed Time Clock	125	5,900	7.50
		5040	Selector Channel	950	44,700	57.00
		5041	Selector Channel	1,400	65,900	84.00
		5042	Selector Channel	1,800	84,800	108.00
		*5051	Keyboard Interlock	10	470	0.50
			Model 70/55:			
	70/55-E		Processor (65,536 bytes)	8,600	405,000	516.00
	70/55-F		Processor (131,072 bytes)	10,250	482,600	615.00
	70/55-G		Processor (262,144 bytes)	14,165	666,900	850.00
	70/55-H		Processor (524,288 bytes)	23,225	1,093,700	1,393.50
		5001-55	Memory Protect	155	7,300	9.25
		5002-55	Elapsed Time Clock	52	2,450	3.00
		5003-55	Direct Control	258	12,150	15.50
		5019-55	Elapsed Time Clock	125	5,900	7.50
		5020	Selector Channel	465	21,850	28.00
		5022	Selector Channel	825	38,800	49.50
		5024	Selector Channel	1,185	55,800	71.00
		5051	Keyboard Interlock	10	470	0.50
			Model 70/60:			
	70/60-F		Processor (131,072 bytes)	11,700	549,900	(12)
	70/60-G		Processor (262,144 bytes)	15,600	733,200	(12)
	70/60-H		Processor (393,216 bytes)	19,000	893,000	(12)
	70/60-J		Processor (524,288 bytes)	22,000	1,034,000	(12)
	70/60-K		Processor (655,360 bytes)	25,800	1,212,600	(12)
	70/60-L		Processor (786,432 bytes)	28,800	1,353,600	(12)
	70/60-M		Processor (917,504 bytes)	32,400	1,522,800	(12)
	70/60-N		Processor (1,048,576 bytes)	35,400	1,663,800	(12)
		5002-60	Elapsed Time Clock	52	2,450	(12)
		5003-60	Direct Control	206	9,700	(12)
		5019-60	Elapsed Time Clock	125	5,900	(12)
		5057	Selector Channel	1,440	67,700	(12)
		5058	Selector Channel	2,880	135,400	(12)
		5059	Memory Protect	200	9,400	(12)
ATTACH-MENTS, ADAPTERS, AND CHANNELS	70/310-21		Standard Interface Switch	80	4,150	7.00
	70/310-22		Standard Interface Switch	176	8,350	14.00
	70/310-23		Standard Interface Switch	264	12,500	21.00
	70/310-24		Standard Interface Switch	350	16,700	28.00
	70/310-25		Standard Interface Switch	440	20,850	35.00
	70/310-26		Standard Interface Switch	525	25,050	42.00
	70/310-27		Standard Interface Switch	615	29,200	49.00
	70/310-28		Standard Interface Switch	700	33,350	56.00
		5305	Cascaded Switch Connector	41	1,950	3.25
	K-310			200(3)	200	200.00
	Series		Switch Expansion Kit			
	70/325-2		Telegraph Switch Unit	25	1,250	2.00
	70/326-2		Data Set Switch Unit	100	4,700	8.00
	70/326-3		Data Set Switch Unit	100	4,700	8.00
	70/327-2		Data Gathering Switch Unit	110	5,175	8.75
	70/350-2		Switch Controller	490	23,100	39.00
	70/350-3		Switch Controller	590	27,950	46.00
	70/350-4		Switch Controller	695	32,800	54.00
	70/356		Communication Line Switch Adapter	77	3,700	6.25
MASS STORAGE			Disc Storage			
	70/563		Disc Pack	15	490	1.50
	70/564		Disc Storage Unit	590	25,510	55.00
	70/590-8		Direct Access Storage System	5,410	244,400	615.00
		5519-2	Multichannel Switch	144	5,770	11.50

(Contd.)

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Drum Storage			
	*70/565-12		Drum Memory	1,545	72,750	216.00
	*70/565-13		Drum Memory	2,575	121,250	361.00
	70/567-8		Drum Memory	2,885	135,800	404.00
	70/567-16		Drum Memory	5,770	271,600	808.00
	70/568-11		Mass Storage Unit	3,175	130,000	569.00
	70/551		Random Access Controller	540	25,500	43.25
		5501-1	Input/Output Attachment Feature to use Model 70/564	180	8,550	14.50
		5502-1	Input/Output Attachment Feature to use Model 70/568-11	410	19,400	32.75
		*5503-11	Input/Output Attachment Feature to use Model 70/565	465	21,850	37.25
		*5503-12	Input/Output Attachment Feature to use Model 70/565	515	24,250	41.25
		*5503-14	Input/Output Attachment Feature to use Model 70/565	103	4,850	8.00
		5508	Input/Output Attachment Feature to use Model 70/567	36	1,750	3.00
		5511	Off-Line Scan Feature	10	500	0.75
		5512	Record Overflow Feature	103	4,850	8.25
		5513-2	Multichannel Switch			
INPUT-OUTPUT			Magnetic Tape			
	70/432-1		Magnetic Tape Units(1)	620	27,350	104.00
	70/432-2		Magnetic Tape Units(1)	620	27,350	104.00
	70/441-1		Magnetic Tape Unit	770	34,250	129.00
	70/441-2		Magnetic Tape Unit	770	34,250	129.00
	70/442-1		Magnetic Tape Units(1)	925	41,050	155.00
	70/442-2		Magnetic Tape Units(1)	925	41,050	155.00
	70/445-1		Magnetic Tape Station(1)	800	34,300	134.00
	70/445-2		Magnetic Tape Station(1)	800	35,300	134.00
	70/451-1		Magnetic Tape Unit	790	35,900	135.00
	70/451-2		Magnetic Tape Unit	810	36,900	138.00
	70/451-12		Magnetic Tape Unit	840	38,200	143.00
	70/451-22		Magnetic Tape Unit	860	39,200	146.00
	70/453-1		Magnetic Tape Unit	1,100	50,100	187.00
	70/453-2		Magnetic Tape Unit	1,120	51,000	191.00
	70/453-12		Magnetic Tape Unit	1,150	52,300	196.00
	70/453-22		Magnetic Tape Unit	1,170	53,300	199.00
	70/461-208		Tape Controller—Dual Channel	1,650	62,100	132.00
		5420	301 Code Translation	(2)	(2)	(2)
		5421	301/501 Code Translation	25	950	2.00
	70/461-216		Tape Controller—Dual Channel	2,320	87,300	186.00
		5420	301 Code Translation	(2)	(2)	(2)
		5421	301/501 Code Translation	25	950	2.00
	70/463-108		Tape Controller—Single Channel	875	41,200	70.00
		5414-1	382 Tape Mode Feature	15	750	1.25
		5415-1	Pack/Unpack Feature	52	2.450	4.25
		5449-1	Word Mark Mode	(2)	(2)	(2)
	70/463-116		Tape Controller—Single Channel	1,440	67,900	115.00
		5414-1	382 Tape Mode Feature	15	750	1.25
		5415-1	Pack/Unpack Feature	52	2,450	4.25
		5449-1	Word Mark Mode	(2)	(2)	(2)
	70/463-208		Tape Controller—Dual Channel	1,160	54,600	92.75
		5414-2	382 Tape Mode Feature	31	1,450	2.50
		5415-2	Pack/Unpack Feature	88	4,150	7.00
		5449-2	Word Mark Mode	(2)	(2)	(2)
	70/463-216		Tape Controller—Dual Channel	1,880	88,550	150.00
		5414-2	382 Tape Mode Feature	31	1,450	2.50
		5415-2	Pack/Unpack Feature	88	4,150	7.00
		5449-2	Word Mark Mode	(2)	(2)	(2)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	70/472-108		Tape Controller—Single Channel	720	33,950	57.50
	70/472-116		Tape Controller—Single Channel	1,390	65,500	111.00
	70/472-208		Tape Controller—Dual Channel	1,005	47,350	80.50
	70/472-216		Tape Controller—Dual Channel	1,800	84,900	144.00
	70/473-108		Tape Controller—Single Channel	770	36,400	61.50
		5402-1	Pack-Unpack Feature	52	2,450	4.25
		5450-1	Word Mark Mode	(2)	(2)	(2)
	70/473-116		Tape Controller—Single Channel	1,440	67,900	115.00
		5402-1	Pack-Unpack Feature	52	2,450	4.25
		5450-1	Word Mark Mode	(2)	(2)	(2)
	70/473-208		Tape Controller—Dual Channel	1,080	51,000	86.50
		5402-2	Pack-Unpack Feature	88	4,150	7.00
		5450-2	Word Mark Mode	(2)	(2)	(2)
	70/473-216		Tape Controller—Dual Channel	1,880	88,550	150.00
		5402-2	Pack-Unpack Feature	88	4,150	7.00
		5450-2	Word Mark Mode	(2)	(2)	(2)
	70/476-108		Tape Controller—Single Channel	825	38,900	66.00
		5431-1	Nine Channel NRZ Feature	260	12,300	20.75
		5452	Word Mark Mode	(2)	(2)	(2)
	70/476-116		Tape Controller—Single Channel	1,500	70,800	120.00
		5431-1	Nine Channel NRZ Feature	260	12,300	20.75
		5452	Word Mark Mode	(2)	(2)	(2)
	70/476-208		Tape Controller—Dual Channel	1,215	57,400	97.00
		5431-2	Nine Channel NRZ Feature	310	14,700	24.75
		5452	Word Mark Mode	(2)	(2)	(2)
	70/476-216		Tape Controller—Dual Channel	2,015	95,100	162.00
		5431-2	Nine Channel NRZ Feature	310	14,700	24.75
		5452	Word Mark Mode	(2)	(2)	(2)
			Punched Card			
	70/234-10		Card Punch	465	21,850	83.75
		5213	Scored Card Feature	10	500	1.75
	70/234-11		Card Punch	580	27,450	104.00
		5213	Scored Card Feature	10	500	1.75
	70/236-10		Card Punch	770	36,400	139.00
		5215-1	Scored Card Feature	10	500	1.75
		5216-1-2	Programmed Stacker Select	20	1,000	2.75
	70/236-11		Card Punch	890	42,000	160.00
		5215-1	Scored Card Feature	10	500	1.75
		5216-1-2	Programmed Stacker Select	20	1,000	2.75
	*70/236-20		Card Reader/Punch	1,030	48,500	185.00
		*5215-2	Scored Card Feature	10	500	1.75
	*70/236-21		Card Reader/Punch	1,150	54,150	207.00
		*5215-2	Scored Card Feature	10	500	1.75
	70/237-10		Card Reader	670	31,550	121.00
		5202	51-Column Card Feature	10	500	1.75
		5204	Column Binary Feature	31	1,450	5.50
		5211-1	End-of-File Feature	(2)	(2)	(2)
		5269	Column 81 Inhibit	50(3)	50	-
	70/237-21		Card-Mark Reader	850	40,050	153.00
		5202	51-Column Card Feature	10	500	1.75
		5204	Column Binary Feature	31	1,450	5.50
		5211-1	End-of-File Feature	(2)	(2)	(2)
		5269	Column 81 Inhibit	50(3)	50	-
	70/237-72		Card-Mark Reader	850	40,050	153.00
		5202	51-Column Card Feature	10	500	1.75
		5204	Column Binary Feature	31	1,450	5.50
		5211-1	End-of-File Feature	(2)	(2)	(2)
		5269	Column 81 Inhibit	50(3)	50	-
	*70/238-30		Card Reader	920	43,300	166.00
		*5270	90-Column Verified Cards	120	5,650	20.75

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Paper Tape (Contd.)			
	70/221-10		Paper Tape Reader/Punch	515	24,250	92.75
		5219-10	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5219-11	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5256	Long Block Indicator	20	950	3.50
	70/221-11		Paper Tape Reader/Punch	540	25,500	97.25
		5219-10	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5219-11	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5256	Long Block Indicator	20	950	3.50
	70/221-20		Paper Tape Reader/Punch	570	26,950	103.00
		5219-10	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5219-11	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5256	Long Block Indicator	20	950	3.50
	70/221-21		Paper Tape Reader/Punch	595	28,250	107.00
		5219-10	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5219-11	Advanced Sprocket 6-Level Read	46	2,250	8.25
		5256	Long Block Indicator	20	950	3.50
		5292	4N Terminate (10)	40	1,900	8.00
		5296	Read Kleinschmidt Format (10)	40	1,900	8.00
		5297	End of Tape (10)	10	475	2.00
		5298	Gapless Mode (10)	10	475	2.00
		5299	Punched Kleinschmidt Format (10)	35	1,650	7.00
	70/224-10		Paper Tape Reader	565	26,700	102.00
		5264	Long Block Indicator	20	950	3.50
		5273	Supply Reel Reverse	20	950	3.50
	70/224-11		Paper Tape Reader	590	27,950	106.00
		5264	Long Block Indicator	20	950	3.50
		5273	Supply Reel Reverse	20	950	3.50
		5293	4N Terminate	49	1,900	8.00
			Printers(4)			
	*70/242-10		Printer, Medium Speed	720	33,950	126.00
		5221	Dual Speed Form Advance	103	4,850	17.00
	*70/242-20		Printer, Medium Speed	1,030	48,500	180.00
		5221	Dual Speed Form Advance	103	4,850	17.00
	70/242-30		Printer, Medium Speed	720	46,100	172.00
		5221	Dual Speed Form Advance	103	4,850	17.00
	70/242-40		Printer, Medium Speed	1,030	60,650	226.00
		5221	Dual Speed Form Advance	103	4,850	17.00
	*70/243-10		Printer, Hi-Speed	1,030	48,500	180.00
	*70/243-20		Printer, Hi-Speed	1,340	63,050	235.00
	70/243-30		Printer, Hi-Speed	1,080	50,950	189.00
	70/243-40		Printer, Hi-Speed	1,390	65,500	243.00
	70/243-51		Hi-Speed Printer	1,290	60,650	226.00
	70/243-61		Hi-Speed Printer	1,595	75,200	279.00
	70/248-11		Bill Feed Printer	1,725	84,750	395.00
		5216	Interchangeable Chain Cartridge	75	3,125	—
	70/249-11		Bill Feed Printer Control	1,065	50,250	85.25
		5262-1	Document Processing Operation(5)	25	1,200	3.50
		5262-2	Document Processing Operation(6)	25	1,200	3.50
		5262-3	Document Processing Operation(7)	25	1,200	3.50
		5274	Line Counter(8)	15	700	2.75
		5278-30	Special Format Control(9)	45	2,100	4.75
			Console			
	70/97		Console	340	16,050	20.50
	70/216		Input/Output Typewriter	185	8,800	33.25
		5259	Form Supply Box	50(3)	50	—
		5260	Special Type Slug and Key Cap	50(3)	50	--
		5276-1	Paper Tape Reader	25	1,200	4.50
		5276-2	Paper Tape Reader	30	1,450	5.50
		5277-1	Paper Tape Punch	85	4,050	15.25
		5277-2	Printing Paper Tape Punch	90	4,300	16.25

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT OUTPUT (Contd.)			Magnetic Ink Character Reader			
	70/272-10		MICR Sorter-Reader Controller	620	29,100	49.50
	70/272-20		MICR Sorter-Reader Controller	620	29,100	49.50
	70/272-30		MICR Sorter-Reader Controller	620	29,100	49.50
			Video Data Systems			
	70/751-10		Video Data Terminal	75(11)	3,525	13.00(11)
	70/751-11		Video Data Terminal	75(11)	3,525	13.00(11)
	70/751-12		Video Data Terminal	75(11)	3,525	13.00(11)
	70/752		Video Data Terminal	190	8,325	23.50
		5707	Station Selection	20	850	2.50
		5710	Data Format	20	850	2.50
		5711	Printer Adapter	40	1,700	5.00
		5733-01	Special Symbol Set (Puerto Rican)	Exchange basis at no charge		
	70/755		Video Data Switch	125	5,900	13.75
	70/756-11		Video Data Generator	275(11)	12,925	47.50(11)
	70/756-21		Video Data Generator	225(11)	10,575	39.00(11)
	70/756-31		Video Data Generator	200(11)	9,400	34.50(11)
		5716	Data Format	10(11)	470	1.75(11)
		5721	Variable Start of Transmission	10(11)	470	1.75(11)
	70/759-11		Video Data Controller	600(11)	28,200	104.00(11)
	70/759-21		Video Data Controller	400(11)	18,800	69.00(11)
		5715	Station Selector	35(11)	1,175	4.50(11)
COMMUNI-CATIONS			Voice Response Unit			
	70/510-11		Voice Response Unit	515	24,250	51.50
		5514-11	Line Expansion Feature	160	7,550	16.00
		5518-10	Custom Vocabulary	1,275(3)	1,200	1.25
		5518-20	Custom Vocabulary	1,650(3)	1,550	1.50
	70/510-21		Voice Response Unit	620	29,100	62.00
		5514-21	Line Expansion Feature	206	9,700	20.50
		5518-30	Custom Vocabulary	2,100	2,000	2.00
		5518-40	Custom Vocabulary	2,350	2,225	2.25
	70/510-26		Voice Response Unit	825	38,800	82.50
		5514-26	Voice Line Expansion	273	12,900	27.25
		5518-50	Custom Vocabulary	2,350(3)	2,225	2.25
			Controls			
	70/627-10		Data Exchange Control	465	21,900	37.25
	*70/652-25		Communications Control — Single Channel	103	4,850	8.25
	*70/652-26		Communications Control — Single Channel	103	4,850	8.25
	70/653-25		Communication Control — Single Channel	310	14,550	24.75
	70/653-26		Communication Control — Single Channel	310	14,550	24.75
	70/653-34		Communication Control — Single Channel	310	14,550	24.75
	70/656		Communication Controller — Single Channel	440	20,700	46.00
		5628	Auto-call Feature	25	1,175	2.50
		5630-1	Line Adapter	(2)	(2)	(2)
		5630-2	Line Adapter	(2)	(2)	(2)
	70/658-11		Autodin Communications Controller	1,100	57,625	200.00
	70/658-12		Autodin Communications Controller	1,370	59,400	238.00
	70/658-13		Autodin Communications Controller	1,450	63,000	250.00
	70/658-132		Autodin Communications Controller	1,450	63,000	250.00
	70/668-11		Communications Controller — Multichannel	720	33,950	86.50

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Contd.)			Controls (Contd.)			
		5617-1	Telex Operation	50	2,350	5.00
		5618	USASCII Block Check Character	20	940	2.00
		5620	Timer Restart/Interval Selector	15	700	1.50
		5622	Message Separation	10	470	1.00
		5623	OW-Unshift	10	470	1.00
		5624	Timer Reset	15	700	1.50
		*5632	STR Operation	(2)	(2)	(2)
		5635	Synchronous Full-Duplex Operation	20	940	2.00
	70/668-21		Communications Controller — Multichannel	925	43,650	111.00
		5617-1	Telex Operation	50	2,350	5.00
		5618	USASCII Block Check Character	20	940	2.00
		5620	Timer Restart/Interval Selector	15	700	1.50
		5622	Message Separation	10	470	1.00
		5623	OW-Unshift	10	470	1.00
		5624	Timer Reset	15	700	1.50
		*5632	STR Operation	(2)	(2)	(2)
		5635	Synchronous Full-Duplex Operation	20	940	2.00
	70/668-31		Communications Controller — Multichannel	1,135	53,350	136.00
		5617-1	Telex Operation	50	2,350	5.00
			Communications Adapters:			
	70/710		Telegraph Buffer	27	1,300	2.75
	70/712		Telegraph Low Level Buffer	38	1,850	2.75
	70/715		Parallel Buffer	38	1,850	3.75
	70/720 Ser.		ADS Buffer	43	2,050	4.25
		5705	Auto-Call Feature	20	950	2.00
	70/721		SDS Buffer	43	2,050	4.25
		5705	Auto-Call Feature	20	950	2.00
		5714-2	Full Duplex Operation	10	475	1.00
	*70/722		STR Buffer	175	8,550	17.50
	*70/724		EDGE Demodulator Buffer	52	2,450	5.25
	70/725		DGS Buffer	110	5,175	8.75
		5707	Station Selection	20	850	2.50
		5710	Data Format	20	850	2.50
		5711	Printer Adapter	40	1,700	5.00
		5713	Keyboard Cable Extension	75	75	-
		5725	Data Set Cable Extension	75	75	-
	70/780		Time Generator/Buffer	113	5,350	11.25

NOTES:
- * No longer in production.
- ** Type II Processors not available until after June 30, 1969.
- (1) 7-Channel Feature available at no extra cost.
- (2) Furnished on request, when required, at no additional charge.
- (3) Single use charge.
- (4) Various options are available for altering the standard character set. These options are available on a "one-time" usage charge or sale-only basis. Typical charges are $150. per special character, $1,940 for a drum tooling charge, and $2,000 or $2,230 for a print drum segment set.
- (5) For all 242 series Printers.
- (6) For 242-10, 242-20, 243-10, and 243-20 Printers.
- (7) For 243-51 and 243-61 Printers.
- (8) For 242-30, 242-40, 243-30, and 243-40 Printers.
- (9) For 242-30, 242-40, 243-30, 243-51, and 243-61 Printers.
- (10) For all 70/221 series models.
- (11) Rental and monthly maintenance charges are higher in remote areas; charges stated are for metropolitan areas.
- (12) Charges have not yet been released.

SUMMARY

The Spectra 70/15 is a small-scale general-purpose computer with a restricted instruction repertoire. Its primary though not exclusive function is to serve either as a satellite system for larger computers or as a remote communications terminal unit. Most peripheral units available for the Spectra 70 series can be connected to the 70/15, with the exception of all random-access devices. (Please refer to the main RCA Spectra 70 report, behind tab 710, for descriptions of the available peripheral devices.) Rentals for typical Spectra 70/15 systems fall between $2,500 and $5,000 per month.

The 70/15 was announced in December 1964. The first customer delivery was made during the last quarter of 1965, and the Spectra 70/15 software package was also supplied at this time. Descriptions and representative performance timings of the various software elements are included within this subreport, in Section 712:151.

Every 70/15 system includes a central processor and either 4,096 or 8,192 bytes of core storage with a cycle time of two microseconds per byte. Section 712:051 provides a detailed description of the 70/15 Processor's capabilities.

The input-output facilities of the Spectra 70/15 computer system consist of one input-output channel with six subchannels. Each subchannel can control up to 16 peripheral devices. Normal use of the I/O channel prevents operation of the central processor while the channel is in use. However, an auxiliary mode of operation allows either a read or write operation to occur in parallel with central processor operations. Such auxiliary read/write operations are unsupervised by the processor and come to a halt only when the input-output data is exhausted or when the I/O device finishes its operation cycle. This mode can be used to advantage by the unbuffered card reader and by the magnetic tape units. Section 712:111 provides details of the demands placed upon the Spectra 70/15 Processor during the operation of the individual peripheral units. A total System Performance analysis is presented in Section 712:201.

The System Configuration section (712:031) shows two typical Spectra 70/15 equipment configurations, including monthly rental prices. Configurations shown are a typical punched-card system and a four-tape business system, arranged according to the standard rules set forth in the Users' Guide, page 4:030.120.

The Spectra 70/15 Software Package has been developed to function with a minimum complement of hardware, including 4,096 bytes of core storage, an on-line printer, card reader and card punch. The use of magnetic tape units and 8,192 bytes of core storage expands the power of each entry in the basic software package and reduces inter-job setup time by making available a Program Library Tape. The entries within the software package for the Spectra 70/15 are described in detail in Section 712:151. Included are a two-pass assembly system, an input-output control system, a sort/merge generator, a report program generator, a group of utility routines, a Single-Channel Communications Control System, and a Program Binder that helps to alleviate the restrictions on program size imposed by the 4K or 8K memory size. No compiler for COBOL, FORTRAN, or any other process-oriented language has been announced for the Spectra 70/15.

SUMMARY

The Spectra 70/25 is a sequential processor that uses parallel input-output channels to obtain overlapped operations. It can be connected to any of the Spectra 70 peripheral units except the random access storage units. The restricted machine instruction repertoire includes decimal add, subtract, multiply, and divide operations; binary add and subtract operations; editing and other data handling operations; logical instructions; 11 decision and control instructions; and 7 I/O instructions. (See the Instruction List, Section 710:121, for details.) No automatic facilities for conversion between binary and decimal radices or for any floating-point operations are included. The processor registers are stored as addressable parts of the main core storage. Interruption facilities are standard.

The 70/25 Processor can contain from 16,384 to 65,536 bytes of core storage. The core cycle time is 1.5 microseconds per four bytes for internal operations. Input-output operations take place one byte at a time, so the effective core cycle for input-output purposes is 1.5 microseconds per byte.

Although no longer in production, this system is still obtainable on an as-available basis.

Rentals for typical Spectra 70/25 systems range from about $4,000 to $8,000 per month for unlimited use.

The Spectra 70/25 software includes an assembly language, a report program generator, and various utility systems, including a communication control system for single-line data communication operations. An operating system based on the same principles as the Primary Operating System (POS) for the larger Spectra 70 computers is available, and concurrent data transcription operations are possible where there are at least 32K bytes of core storage. No COBOL, FORTRAN, or other compilers are available for the 70/25.

All of the Spectra 70/25 software is designed to work exclusively with the 70/25; it is not possible, for instance, to compile a FORTRAN program on the Spectra 70/45 for operation on the Spectra 70/25. In the opposite direction, a Compatibility Support Package is being provided to assist in checking over 70/25 programs so that they can be safely run on the Spectra 70/45 or other larger Spectra 70 systems.

This report concentrates upon the characteristics and performance of the Spectra 70/25 system in particular. All general characteristics of the Spectra 70 hardware are described in Computer System Report 710: RCA Spectra 70 — General.

The System Configuration section which follows shows the Spectra 70/25 in the following standard System Configurations:

II: 4-Tape Business System
III: 6-Tape Business System
IV: 12-Tape Business System.

These configurations were prepared according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed.*

Section 713:051 provides a detailed description of the central processor capabilities and timings for the Spectra 70/25.

The input-output channel capabilities of the Spectra 70/25, and the demands upon the processor during input-output operations, are described in Section 713:111.

The software that can be used with Spectra 70/25 systems is described in Sections 710:151, 710:171, and 710:191.

The overall performance of any Spectra 70 system is heavily dependent upon the processor model used. A full System Performance analysis of the 70/25 is provided in Section 713:201.

Four input-output Selector Channels and an Elapsed-Time Clock are standard features of the Spectra 70/25. Optional processor features include an input-output Multiplexor Channel, four more Selector Channels, and the option to use two High-Speed Selector Channels. A High-Speed Selector Channel replaces two standard Selector Channels and has a maximum data rate of 500,000 bytes per second, as compared with the 200,000-bytes-per-second rate of each of the replaced channels.

* Spectra 70/25 systems do not permit use of random access storage devices, so our several random access-oriented standard configurations cannot be shown.

SUMMARY

The Spectra 70/35 computer system was formally announced by RCA in September 1965, nine months after the original announcement of the Spectra 70 line. First delivery of a 70/35 system occurred in February 1967. The 70/35 Processor is the least expensive of the program-compatible Spectra 70/35, 70/45, and 70/55 processors. The performance of the Spectra 70/35 system generally falls somewhere between that of IBM System/360 Models 30 and 40.

Internal storage capacity of Spectra 70/35 systems can range from 32,768 to 65,536 bytes of core storage. In addition, "Non-Addressable" core storage is supplied to provide control registers for each input-output device. Non-Addressable core storage also provides the processor's general registers, floating-point registers, and various other control registers. The core storage cycle time is 1.44 microseconds per two bytes.

The rental for typical Spectra 70/35 systems ranges between $5,000 and $13,000 per month. A Spectra 70/35 system arranged in AUERBACH's Standard Configuration III, with 32K bytes of core storage, six 30KB magnetic tape units, printer, card reader and punch, rents for $7,616 per month (see Report Section 714:031).

To hold the optional emulators that enable it to execute machine-language programs written for IBM 1401/1460 or RCA 301 computer systems, the Spectra 70/35 utilizes a read-only memory unit similar to that used in the Spectra 70/45. Each 54-bit word of read-only memory holds two processor "elementary operations," twice the capacity of the Spectra 70/45's read-only memory. As a result, the Spectra 70/35 emulators will require less memory and will generally perform more efficiently than the emulators used with the Spectra 70/45 system. Detailed descriptions of the emulators for the 70/35 can be found in Sections 710:131 and 710:134.

This subreport concentrates upon the characteristics and performance of the Spectra 70/35 system in particular. All general characteristics of the Spectra 70 hardware and software are described in Computer System Report 710: RCA Spectra 70 — General.

The System Configuration section which follows shows the Spectra 70/35 in the following standard System Configurations:

- I: Typical Card System
- II: 4-Tape Business System
- III: 6-Tape Business System
- IIIR: 5-Million-Byte Random Access System
- IVR: 20-Million-Byte Random Access System
- VI: 6-Tape Business/Scientific System
- VIIA: 10-Tape General System (Integrated).

These configurations were prepared according to the rules in the Users' Guide, Pages 4:030.120 and 4:200.600, and any significant deviations from the standard specifications are listed.

Section 714:051 provides detailed central processor timings for the Spectra 70/35. See Section 710:051 for all the other characteristics of the Spectra 70 processors.

The input-output channel capabilities of the Spectra 70/35, and the demands upon the processor during input-output operations, are described in Section 714:111, Simultaneous Operations. The Selector Channels used with the Spectra 70/35 have a 60 per cent greater transmission-rate capability than those used with the faster 70/45 Processor. However, the effective 70/35 Multiplexor Channel transmission-rate capabilities are 50 per cent slower than those possible with the 70/45 Multiplexor Channel.

The software that can be used with a given Spectra 70 system configuration depends upon the amount of core storage and the number and type of peripheral devices that are available. A detailed description of the software that can be used with the Spectra 70/35 and other Spectra 70 systems can be found in Sections 710:151 through 710:193.

The overall performance of any Spectra 70 system is heavily dependent upon the processor model used. A full System Performance analysis of the 70/35 system is provided in Section 714:201 of this subreport.

The Multiplexor Channel, with seven subchannels, is a standard feature of the RCA Spectra 70/35 Processor. Memory Protect, an Elapsed-Time Clock, Direct Control, an RCA 301 Emulator, an IBM 1401/1460 Emulator, and up to two Selector Channels are optional features.

SUMMARY

The Spectra 70/45 Processor can be connected to any of the Spectra 70 peripheral units, can control a communications network, and can handle a read/write Direct Control channel. Sharing of core memory between different processors is not currently possible in the Spectra 70/45, but memory-to-memory transfers can be made by means of the Data Exchange Control.

The 70/45 Processor contains from 16,384 to 262,144 bytes of core storage for program data, in addition to some non-addressable core storage used for input-output purposes. The core cycle time is 1.44 microseconds per two bytes.

The rental for typical Spectra 70/45 systems will generally fall between $8,500 and $15,000 per month, with Standard Configuration III (16K core, six 30KC magnetic tape units, reader, punch, and printer) renting at $8,717 per month for unlimited use.

The Spectra 70/45 uses a read-only memory as an internal control system, which can be expanded to permit the "emulation" of other computer machine languages. The characteristics of the 70/45 as an emulator for RCA 301 and 501 programs, as well as for IBM 1401 and 1410 programs, are discussed in Sections 710:131 through 710:135.

This report concentrates upon the characteristics and performance of the Spectra 70/45 in particular. All general characteristics of the Spectra 70 hardware and software are described in Computer System Report 710: Spectra 70 — General.

The System Configuration section which follows shows the Spectra 70/45 in the following standard System Configurations:

III:	6-Tape Business System
IIIR:	5-Million-Byte Random Access System
IV:	12-Tape Business System
IVR:	20-Million-Byte Random Access System
VI:	6-Tape Business/Scientific System
VIIA:	10-Tape General System (Integrated)
VIIB:	10-Tape General System (Paired).

These configurations were prepared according to the rules in the Users' Guide, pages 4:030:120 and 4:200.600, and any significant deviations from the standard specifications are listed. As a matter of general interest, the rentals that would be incurred if faster magnetic tape units were installed are listed on the diagrams for Configurations VIIA and VIIB.

Section 715:051 provides detailed central processor timings for the Spectra 70/45. See Section 710:051 for all the other general characteristics of the Spectra 70 processors.

The input-output channel capabilities of the Spectra 70/45, and the demands upon the processor during input-output operations, are described in Section 715:111.

Three integrated software systems are available for use with the Spectra 70/45: the Primary Operating System, Tape-Tape/Disc Operating System and the Disc Operating System. The Primary Operating System offers small-scale software (16K-byte design level) that includes an assembler, report program generator, and COBOL compiler (requiring 32K bytes of core storage) for use in a sequential processing environment. The Tape-Tape/Disc Operating System is designed at a 65K-byte level, offering more extensive and more powerful software than the Primary Operating System. The Tape-Tape/Disc Operating System features multiprogramming control for up to six concurrently-operating programs. COBOL and FORTRAN compilers and a full assembly system are also provided. The Disc Operating System (DOS), scheduled for release on November 29, 1968, will enable the user of a totally random-access oriented system to do away with the tape units heretofore required for the operation of the RCA Spectra Operating Systems. Among the components planned for release in the near future are a 32K COBOL Compiler, a 22K Assembler, and a 65K FORTRAN. The DOS system will offer multiprogramming capabilities similar to those currently offered by TOS and TDOS, along with a Report Program Generator and a full complement of utility programs. The Disc Operating System is designed to operate in a minimum of 32K of storage. Please refer to Sections 710:151 through 710:193 for descriptions of the principal software elements supplied for use with the Spectra 70/45 system.

The overall performance of any Spectra 70 system is heavily dependent upon the processor model used. A full System Performance analysis of the 70/45 is provided in Section 715:201.

The Multiplexor Channel, with eight subchannels, is a standard feature of the RCA Spectra 70/45 processor. Memory Protect, an Elapsed-Time Clock, Direct Control, and up to three Selector Channels are optional features.

RCA has recently announced that the current model of the 70/45 Processor will be replaced by the 70-45 Type II. The Type II will differ from its predecessor in the following areas:

1. Due to the incorporation of multiple byte buffering, the maximum selector channel throughput rate will be increased, when more than one selector channel is installed, from 520 KBS to 1000 KBS. The maximum rate for a single channel remains at 465 KBS.

2. The maximum number of optional selector channels will be increased from three to four.

3. The Model FE, with a core-storage capacity of 196,608 bytes will be added to the product line.

4. The Memory Protect Feature will be expanded to include read/write protection as well as write protection.

5. The Test and Set instruction will be added to the Spectra 70/45 instruction list to maintain compatibility with the Spectra 70/46 and IBM System/360.

6. Power supply buffering will be improved to minimize power line transience.

7. The 70/45-C (16K) and 70/45-D (32K) will no longer be manufactured.

Production cutover from the Type I to the Type II is scheduled for the early part of the third quarter of 1969. After this date, the Type I will be marketed on an as available basis.

INTRODUCTION

The Spectra 70/55 Processor can be connected to any of the Spectra 70 peripheral units, can handle a read/write Direct Control channel, and can control a data communications network. Communication between different computers can be via memory-to-memory transfers or via core memory modules shared with another Spectra 70/55 processor.

Processor control is not by read-only memory, as in the Spectra 70/35 and 70/45; conventional wired circuits are used for control purposes. It is not possible to add read-only memories to the 70/55 Processor, so there is no compatibility between previous RCA or IBM systems and the Spectra 70/55 through the compatibility technique called "emulation."

The 70/55 Processor contains from 65,536 to 524,288 bytes of core storage for program data, in addition to some non-addressable core storage which is used for input-output purposes. The core cycle time is 0.84 microseconds per four bytes.

The rental for typical Spectra 70/55 systems will generally fall between $13,000 and $30,000 per month, with standard Configuration VIIB (65K core, eight 60KC magnetic tape units, and a satellite Spectra 70/15 Processor) renting at $19,620 per month for unlimited use.

This report concentrates upon the characteristics and performance of the Spectra 70/55 in particular. All general characteristics of the Spectra 70 hardware and software are described in Computer System Report 710: RCA Spectra 70 — General.

The System Configuration section which follows shows the Spectra 70/55 in the following standard System Configurations:

III:	6-Tape Business System
IIIR:	5-Million-Byte Random Access System
IV:	12-Tape Business System
IVR:	20-Million-Byte Random Access System
VI:	6-Tape Business/Scientific System
VIIA:	10-Tape General System (Integrated)
VIIB:	10-Tape General System (Paired)
VIIIB:	20-Tape General System (Paired).

These configurations were prepared according to the rules in the Users' Guide, pages 4:030.120 and 4:200.600, and any significant deviations from the standard specifications are listed. As a matter of general interest, the rentals that would be incurred if faster magnetic tape units were installed are listed on the diagrams for Configurations VIIA and VIIB.

Section 716:051 provides detailed central processor timings for the Spectra 70/55. See Section 710:051 for all the other general characteristics of the Spectra 70 processors.

The input-output channel capabilities of the Spectra 70/55, and the demands upon the processor during input-output operations, are described in Section 716:111.

Three integrated software systems are available for use with the Spectra 70/55: the Primary Operating System, the Tape-Tape/Disc Operating System and the Disc Operating System. The Primary Operating System offers small-scale software (16K-byte design level) that includes an assembler, report program generator, and COBOL compiler (requiring 32K bytes of core storage) for use in a sequential processing environment. The Tape-Tape/Disc Operating System is designed at a 65K-byte level, offering more extensive and more powerful software than the Primary Operating System. The Tape-Tape/Disc Operating System features multiprogramming control for up to six concurrently-operating programs. COBOL and FORTRAN compilers and a full assembly system are also provided. The Disc Operating System (DOS), scheduled for release on November 29, 1968, will enable the user of a totally random-access oriented system to do away with the tape units heretofore required for the operation of the RCA Spectra Operating Systems. Among the components planned for release in the near future are a 32K COBOL Compiler, a 22K Assembler, and a 65K FORTRAN. The DOS system will offer multiprogramming capabilities similar to those currently offered by TOS and TDOS, along with Report Program Generator and a full complement of utility programs. The Disc Operating System is designed to operate in a minimum of 32K bytes of storage. Please refer to Sections 710:151 through 710:193 for descriptions of the principal software elements supplied for use with the Spectra 70/55 system.

The overall performance of any Spectra 70 system is heavily dependent upon the processor model used. A full System Performance analysis of the 70/55 is provided in Section 716:201.

The Multiplexor Channel, with eight subchannels, is a standard feature of the RCA Spectra 70/55 processor. Memory Protect, an Elapsed-Time Clock, Direct Control, and up to six Selector Channels are optional features.

SUMMARY

INTRODUCTION

RCA's entry in the competition for the time-sharing market, the Spectra 70/46, was announced on May 4, 1967. This medium-scale system is based on three new components: the 70/46 processor, largely a modification of the 70/45 processor; the 70/567 high-speed magnetic drum unit; and a software system (TSOS) especially designed for time-sharing applications. Both the hardware and the initial release of the software are scheduled for delivery on January 31, 1969.

The 70/46 represents RCA's first entry into the full-scale commercial time-sharing computer market, joining such competition as the GE-625/635, IBM System/360 Model 67, and SDS Sigma 7 computer systems. However, RCA has designed its time-sharing system with more modest goals than those of GE and IBM. The apparent intention of RCA is to remain competitive in all areas of the small-to-medium class commercial computer market, without enduring the frustrations of the more ambitious pioneers in the large-scale commercial time-sharing business.

The monthly rental of an RCA Spectra 70/46 time-sharing processor with 262,144 bytes of core storage is $14,125 (see Section 710:221, Price Data). RCA estimates that typical 70/46 system configurations will rent for between $25,000 and $30,000 per month. Contributing to the relatively modest prices of planned Spectra 70/46 systems are the facts: (1) that the 262K-byte 70/46 Processor is basically an expanded version of the $11,125-per-month Spectra 70/45 262K-byte Processor; (2) that only single-processor systems have been announced to date; and (3) that a maximum of 48 on-line remote terminal units can be controlled by the system.

According to its design goals, the Spectra 70/46 Time Sharing System will be an efficient batch processing system with advanced multiprogramming capabilities; remote, conversational time-shared operations in time-sliced mode will be a powerful available facility that may, in some installations, consume only a limited amount of the system's total processing capacity.

Noteworthy features of the 70/46 Time Sharing System include:

- Hardware logic within the processor to facilitate program paging and segmentation, providing simultaneous system access for up to 48 users at remote terminals.
- Up to 2,097,152 bytes of virtual memory available to programmers.
- A fast associative memory for translation of all virtual memory addresses to real core storage addresses.
- The use of read-only memory to provide by hardware frequently-used routines required to manipulate the contents of the various translation tables.
- A conversational FORTRAN IV compiler with interpretive execution capability.
- Full compatibility with the systems programs and language processors of the RCA Spectra 70 general-purpose Tape Operating System (TOS), Tape/Disc Operating System (TDOS), and Disc Operating System (DOS).

The initial release of the Time Sharing Operating System will consist of a cross section of the programs necessary for the operation of the system. In addition to the Executive, the following components will be available:

- Assembler, version 1 of a modified TOS/DOS Assembler.
- COBOL, version 1 of a modified TOS/DOS COBOL.
- COBOL Syntax Checker.

- FORTRAN, version 1 of a modified TOS/DOS FORTRAN.
- Terminal Diagnostic Routine for FORTRAN.
- IDA (Interactive Debugging Aid).
- Interactive BASIC.
- Report Program Generator.
- Sort/Merge.
- File Editor.
- Data Management.
- Linkage Editor.
- Dynamic Linkage Editor.
- System Generator.
- Hardware Diagnostic Routines.
- All TOS Utility Programs.

Five subsequent releases, at approximately two month intervals, are planned by RCA. These enhancements will make the full Time Sharing Operating System available during the fourth quarter, 1969.

This subreport concentrates upon the specialized characteristics of Spectra 70/46 Systems and the supporting software. All general characteristics of the Spectra 70 hardware are described in Computer System Report 710: RCA Spectra 70—General.

SUMMARY

With the announcementof the Spectra 70/60 in February 1969 the computing capabilities of the top end of the Spectra 70 family of computers were substantially extended. The performance of the Spectra 70/60 has been further enhanced since the original announcement, and recently, RCA announced the 70/61 time-sharing system, which bears much the same relationship to the 70/60 as does the 70/46 to the 70/45. The 70/60 is a fully upward-compatible member of the Spectra 70 family of computers and uses the standard Spectra 70 peripherals — no new peripheral devices were introduced with the 70/60.

The basic 70/60 processor includes 131,072 bytes of main memory, which can be increased in 131,072-byte increments to a maximum size of 1,048,576 bytes. The main memory cycle time is 765 nanoseconds for a four-byte access, the fastest of any Spectra 70 computer. Besides the main memory, the 70/60 includes a scratch-pad memory, with an access time of 85 nanoseconds per 32-bit word. The non-addressable memory used in input-output operations on the 70/35 and higher-numbered processors has its 70/60 analog in the "shaded memory"; shaded memory is provided with the first 131,072-byte module of each 262,144-byte bank of main memory and is addressable by two additional privileged instructions (Load Shaded Memory and Store Shaded Memory), which have been provided as a part of the general policy of supplying improved diagnostic and maintenance facilities on the 70/60 compared with the earlier Spectra 70 computers.

The read-only memory in the 70/60 provides an internal control system and consists of 3072 72-bit words with a cycle time of 255 nanoseconds for a 72-bit access. Space is provided for one emulator; no information is currently available on which machine(s) will be emulated. The emulators already developed for the 70/35 and 70/45 processors cannot be used on the 70/60.

The 70/60 is fully upward compatible with the 70/35 and higher-numbered processors. It includes the full Spectra 70 instruction set, together with the two extra instructions already mentioned and the Test and Set instruction included in the 70/45 Type II. The 70/60 basic processor includes a Multiplexor Channel with up to 16 trunks and two Selector Channels with three trunks each; four more Selector Channels can be added in two groups of two. The maximum input-output transfer rate is 216,000 bytes per second for the Multiplexor Channels and 900,000 bytes per second for each Selector Channel, with an overall maximum of 5,240,000 bytes per second for the whole system. Among the processor options available are two types of Memory Protect (both write only and read/write, as announced for the 70/45 Mark II), two Elapsed-Time Clocks (decrementing at 16-2/3 or 1-millisecond intervals), and the Direct Control feature.

This report concentrates upon the characteristics and performance of the Spectra 70/60 in particular. All general characteristics of the Spectra 70 hardware and software are described in Computer System Report 710: RCA Spectra 70 — General.

The System Configuration section which follows shows the Spectra 70/60 in standard System Configurations:

III:	6-Tape Business System
IIIR:	5-Million-Byte Random Access System
IV:	12-Tape Business System
IVR:	20-Million-Byte Random Access System
VI:	6-Tape Business/Scientific System
VIIA:	10-Tape General System (Integrated)
VIIB:	10-Tape General System (Paired)
VIIIB:	20-Tape General System (Paired).

These configurations were prepared according to the rules in the Users' Guide, pages 4:030.120 and 4:200.600, and any significant deviations from the standard specifications are listed. As a matter of general interest, the rentals that would be incurred if faster magnetic tape units were installed are listed on the diagrams for Configurations VIIA and VIIB.

Section 718:051 provides detailed central processor timings for the Spectra 70/60. See Section 718:051 for all the other general characteristics of the Spectra 70 processors.

The input-output channel capabilities of the Spectra 70/60, and the demands upon the processor during input-output operations, are described in Section 718:111.

Software for the 70/60 is provided by the operating systems already introduced for the 70/35-45-55 processors; the Primary Operating System (POS), the Tape-Tape/Disc Operating System (TDOS) and the Disc Operating System (DOS). The facilities of TOS and TDOS are fully discussed in Sections 710:151 through 710:193; DOS is a small-scale random-access operating system mainly intended for 70/35 users and will be of only passing interest to most 70/60 users. An enhanced version of TDOS, OS60, will be provided for the 70/60 but details of this are not yet available. RCA expects that most, if not all, 70/60 installations will use OS60, (TDOS), which offers COBOL, FORTRAN, and assembly language programming capabilities with multiprogramming of up to six programs and extensive data communications capabilities.

The overall performance of the Spectra 70/60 system is roughly double that of the IBM System/360 Model 50. The purchase price for the basic processor ranges from $549,900 for the 70/60-F processor with 131,072 bytes of core storage to $1,663,800 for the 70/60-N processor with 1,048,576 bytes of core storage. The first customer delivery of the 70/60 is scheduled for the second half of 1970.

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REPORT UPDATE

SDS ADDS FAST FIXED-HEAD DISC SYSTEM TO SIGMA LINE

Scientific Data Systems has announced a new Rapid Access Data (RAD) disc-file storage system for use with its Sigma 5 and 7 computers. The basic configuration consists of a Model 7211 Controller and from one to four Model 7212 Storage Units.

Storage Capacity

The Model 7212 contains 64 bands of storage. Each band is made up of eight tracks which are read and recorded in parallel. The basic addressable unit of data is a sector of 1024 bytes. Eighty-two sectors are recorded in each band. Each 7212 Storage Unit has a capacity of 5.3 million 8-bit bytes.

Performance

The primary attribute of the new RAD system is its high-speed data transfer at a rate of up to 3 million bytes per second. Head positioning delays are eliminated by the use of a fixed read/write head for each track. The average access time, or rotational delay, required to access any disc location is 17 milliseconds (34 milliseconds maximum). The rotational delay can be reduced by a program feature that senses the unit's current rotational position before initiating a read or write operation, and then transfers to the next sector that can be accessed. This feature allows a complete band of 83,968 bytes to be read or written in approximately 34 milliseconds, including access time.

Data Protect Features

Recorded data is protected by two standard features: manually-set write-protect switches, and a power fail-safe feature that prevents data loss during periods of transient primary power fluctuations or primary power loss.

Applications

This system is well suited for high-speed, high-volume applications such as telemetry data processing, real-time control, data communications and message-switching, and time-sharing systems. Problems requiring a large number of passes at the data, as in seismic data processing, are facilitated by the speed of RAD. Adequate storage is available for programs and data files.

Price

The Model 7211 Controller sells for $18,000, and each Model 7212 Storage Unit sells for $50,000.

Initial deliveries are scheduled for the third quarter of 1968.

REPORT UPDATE

SIGMA 7 GETS NEW CARD READER, PLOTTERS, AND DISPLAY UNITS

During the past few months SDS announced the availability of several new peripheral devices for the Sigma computers with the apparent intention of expanding the applications flexibility of these systems.

Model 7140 Card Reader

The SDS 7140 Card Reader reads standard 80-column punched cards in either EBCDIC or binary code at a peak speed of 1,500 cards per minute. The 7140 Card Reader is a photoelectric, serial-by-column reader that includes two program-selectable output stackers and a built-in controller. The present 1,500-cpm version of the 7140 Card Reader replaces (at no increase in price) the formerly available 800-cpm version.

The 7140 occupies one control unit position in the 8471 Multiplexor Input-Output Processor. Data is transferred to the central processor one byte at a time. When reading in the EBCDIC mode, the reader transfers one 8-bit byte for each 12-bit column read; each character is automatically checked for validity prior to transmission. When reading is performed in binary mode, the readers transmit three 8-bit bytes to the computer for every two 12-bit columns read.

Deliveries of the new 7140 Card Reader are scheduled to begin during the fourth quarter of 1967.

Models 7530 and 7531 Graph Plotters

The SDS Graph Plotters provide the capability to plot digital data in two axes. The plotters operate on the digital incremental principle using decoded commands from the central processor. The incremental ink-on-paper plotting steps can be performed in either direction along both axes. The basic motions used in plotting are: movement of the pen horizontally across the surface of the drum, drum rotation (with resulting paper motion), and pen up and down.

The Model 7530 Graph Plotter includes a 12-inch wide drum with a maximum plot size of 11 inches by 120 feet; incremental speed is 300 steps per second. The Model 7531 Graph Plotter includes a 30-inch-wide drum with a maximum plot size of 29.5 inches by 120 feet; incremental speed is 200 to 300 steps per second. Both models offer a choice of the following step sizes: 0.01 inch, 0.005 inch, or 0.1 millimeter.

Each incremental command from the Sigma 7 central processor (via the standard Multiplexor or Selector Channel) is transmitted as one 8-bit byte. The byte configuration specifies paper and/or pen movement and the direction of this movement. A single Start Input/Output (SIO) command can specify that a virtually unlimited string of bytes be used as consecutive incremental commands.

The SDS Graph Plotters are manufactured by Calcomp.

Models 7550 and 7555 Multipurpose Keyboard Display Units

The SDS Model 7550/7555 Multipurpose Keyboard Display Unit is a self-contained buffered I/O device featuring keyboard input and alphanumeric CRT output capabilities for use at local or remote locations. This device should prove invaluable to the Sigma computers in time-sharing, inquiry/response, and text editing applications.

The Model 7550 is a low-speed keyboard display device capable of transmitting data at a 15-character-per-second maximum rate; the Model 7555 is generally identical to the 7550 in characteristics and functions, but, with an optional feature, can transmit data at speeds up to 180 characters per second.

The video unit has a 7- by 11-inch screen, organized in 32 lines of 86 characters each. Character display is refreshed at a rate of 50 frames per second to ensure flicker-free viewing. A self-contained 2,048-character buffer enables a full page of text to be displayed and manipulated without excessive demands on the central processor. Through use of versatile cursor control and other standard features, the display device has the capability to replace, erase, or roll text; insert or delete data from any point in the text; and to combine or separate lines of displayed data. A half-line spacing capability facilitates the use of subscripts, exponents, and underscores.

The keyboard is compatible with the standard Teletype Model 37 KSR key set; it can generate 96 ASCII graphic and 32 ASCII control characters. Special keys permit generating frequently used control codes, and an automatic-repeat function permits repetition of data being entered (at a rate of approximately 15 characters/second).

The standard Model 7550/7555 Display can be operated in full-duplex mode over standard data communications networks, eventually connecting to a centrally located SDS 7611 Character-Oriented Communications Controller (COC). Up to 1,024 Keyboard Display Units can operate concurrently over lines controlled by the maximum complement of 16 Sigma 7 COC's — 64 lines per COC.

As an optional feature, either model of the display unit can use feature 7551 — Message-Mode Option — which enables the operator to prepare messages through use of the Transmit code. Feature 7153, the Hard-Copy Option, is also available to either display unit model. This feature permits a Teletype "receive only" printer unit to be attached to the 7550/7555 Keyboard Display to provide hard-copy records of the visually displayed data.

Feature 7556, the High-Speed Option, is available only for Model 7555 Keyboard Display Units. This option permits data transmission at speeds up to 180 characters per second. Type 202 Data Sets provide the interface with remotely located Keyboard Display Units that are equipped with the High-Speed transmission feature.

PRICES

	Unit	Monthly Rental 1-year lease	Monthly Rental 4-year lease	Monthly Maintenance	Purchase
7140	Card Reader, 1500 cpm	$665	$540	$150	$24,000
7530	Graph Plotter	415	340	75	13,000
7531	Graph Plotter	?	?	?	?
7550	Keyboard Display	280	225	50	10,000
7555	Keyboard Display	350	285	65	12,500
7551	Message Mode Feature	23	18	5	750
7553	Hard-Copy Option	17	13	N/C	500
7556	High-Speed Option	45	35	10	1,500
7611	Character-Oriented Communication Controller (controls 8 full-duplex lines)	284	241	45	10,500
7613	Line Interface Unit (up to 7 7613's can be added to 7611 to control 64 full-duplex lines)	44	36	N/C	1,500

SUMMARY REPORT: SDS SIGMA 7

.01 INTRODUCTION

.011 Sigma 7

Scientific Data Systems announced a new computer system, Sigma 7, on March 15, 1966. Sigma 7 was heralded as the first of a new family of Sigma computers from SDS that would provide "at least two times more computations per dollar than any other machine in the industry". With the announcement of the general-purpose Sigma 7, SDS has begun a gradual expansion of its marketing goals to include not only scientific-oriented computing (where SDS has earned a fine reputation), but also business data processing.

Sigma 7 is a medium-scale computer that is compatible with the IBM System/360 in internal data structure, external data codes, input-output media, and FORTRAN and PL/I languages. Source language compatibility is facilitated by internal fixed-point and floating-point arithmetic formats that are virtually identical with those used in the System/360 processors.

Sigma 7 makes extensive use of monolithic integrated circuitry in a central processor whose internal design is radically different from that of the IBM System/360. Monthly rental prices for typical Sigma 7 system configurations range from $5,000 to $25,000. Core storage sizes range from 4,096 to 131,072 32-bit words, with a cycle time of 1.2 microseconds per word.

Sigma 7 is a general-purpose, highly modular system designed to function in a wide variety of application areas and in several different processing modes. The primary design goal is to produce a fast, responsive real-time system that can provide the full services of the computer to multiple user programs. In small-scale configurations, Sigma 7 can function as a relatively inexpensive but powerful scientific processor that executes one program at a time. In somewhat larger configurations, Sigma 7 can serve as a medium-scale business/scientific system capable of multiprogrammed processing of one "background" production program and one "foreground" real-time inquiry program. Configurations with mass storage devices and at least 12K words of main memory can provide full hardware/software control of the operating environment and multiprogrammed operation for three concurrent programs. In large-scale disc-oriented configurations, Sigma 7 can handle remote, interactive time-sharing operations for up to 200 competing users, concurrently with processing background production programs. Sigma 7 hardware and software also permit multiple central processors to share common core storage and peripheral units.

The central components of every Sigma 7 system — central processor, core storage, and I/O control system — feature flexibility, expandability, and capability for asynchronous independent operations. The instruction set is large and powerful, and the input-output system (which can include up to eight channel controllers of the selector and/or 32-subchannel multiplexor variety) is comparable to the I/O systems in higher-priced, large-scale computers. Up to eight core storage modules are capable of independent operation, and up to six of the modules can be accessed simultaneously. Sigma 7 core storage is large in capacity (up to 524,288 bytes) and among the least expensive in the industry.

SDS currently offers a limited number and variety of input-output devices for use with Sigma 7, although it is expected that interface units will be announced to permit connection of I/O devices from other manufacturers. The Price Data section (page 740:221.101) lists the current peripheral devices and their rated speeds. At present SDS offers one Sigma 7 mass storage device: a 1.5 million-byte, fast-access unit of comparatively high price. However, SDS has indicated that several low-cost, head-per-track disc files of various capacities and speeds are under development and due for release in the near future. Apart from manufacturing its own disc files and magnetic tape units, SDS does not appear interested in competing at this time in the development of a broad range of special-purpose peripheral devices.

Software for Sigma 7 is provided at four levels, all upward-compatible, and features real-time multiprogramming and disc-oriented operating systems. Table I summarizes the software facilities and their availability dates. FORTRAN IV and PL/I compilers will be supplied in three different versions: debug, high-efficiency, and conversational. Assemblers will be provided with the first systems delivered, beginning in the fourth quarter of 1966. Although the availability of a COBOL compiler was not announced in the earliest Sigma 7 software

.011 Sigma 7 (Contd.)

schedules, it is expected that SDS will shortly announce a COBOL, probably supplied on a lease or purchase basis. An IBM 1401 Simulator program is also expected to be announced in the near future. SDS states that the Sigma 7 software development effort began almost two years ago and that all published delivery schedules are being adhered to. More than half of the initially scheduled software systems will be written by outside software contractors.

TABLE I: SIGMA 7 SOFTWARE AVAILABILITY

Class	Name	Availability
Monitors	Basic Control Monitor	1st Qtr. 1967
	Batch Processing Monitor	2nd Qtr. 1967
	Universal Time-Sharing Monitor:	
	Standard version	4th Qtr. 1967
	Extended version	1st Qtr. 1968
Compilers	Basic FORTRAN IV	4th Qtr. 1966
	Debug FORTRAN IV	2nd Qtr. 1966
	High Efficiency FORTRAN IV	2nd Qtr. 1967
	Conversational FORTRAN IV	4th Qtr. 1967
	Debug PL/I	3rd Qtr. 1967
	High Efficiency PL/I	4th Qtr. 1967
	Conversational PL/I	4th Qtr. 1967
	COBOL	to be announced
Assemblers	Basic Symbol Assembler	4th Qtr. 1966
	Meta-Symbol Assembler	2nd Qtr. 1967
Services	ADAPT Application Package	2nd Qtr. 1967
	Sort/Merge	to be announced
	MANAGE with RPG	to be announced
	IBM 1401 Simulator	to be announced
	Application Programs	to be announced

Price/performance comparisons between Sigma 7 and the IBM System/360 Model 50 indicate that in comparable central configurations (i.e., with equivalent central processors, core storage, and I/O control facilities), Sigma 7 is approximately 10 to 20 per cent less expensive than the Model 50 and the basic processing power of Sigma 7 is approximately 40 to 50 per cent greater than that of the Model 50. There are indications that this advantage in basic processing speed will increase still further, as SDS contemplates improving the Sigma 7 core storage unit by reducing the cycle time from 1.2 to 0.9 microsecond per 32-bit word.

.012 Sigma 2

On August 1, 1966, Sigma 7 officially became a family member when SDS announced the small-scale Sigma 2 computer system. Sigma 2 is a low-cost computer system designed for scientific, engineering, and process control applications. Sigma 2 has good real-time processing capabilities and hardware facilities that will permit multiprogrammed operation of a background production program and a foreground real-time program. The purchase price of a basic Sigma 2 configuration (consisting of a processor with four I/O channels, 4,096 words of core storage, and a keyboard/printer device with slow-speed paper tape reader and punch) is $26,000; the same configuration under terms of the standard 4-year lease contract rents for $875 per month. Deliveries of the Sigma 2 systems are expected to begin during the first quarter of 1967.

Sigma 2 contains an internal core storage unit that ranges in size from 4,096 to 16,384 16-bit words. Core storage access time is 0.9 microsecond per word. The core storage capacity can be increased to 65,536 words by the addition of Sigma 7 memory modules. Thus the Sigma 2 can share core storage with the Sigma 7, permitting multiprocessing operations. Real-time processing is facilitated by an interrupt system than can service up to 148 different interrupt levels, and memory protection is available to safeguard programs and data in core storage.

The instruction set of the Sigma 2 is limited to 35 standard 16-bit instructions, with multiply and divide instructions optional. All arithmetic is performed in fixed-point binary format, and no radix conversion nor code translation instructions are provided. Add, subtract, load, and store instructions can be executed in 2.25 microseconds, and 16-bit binary multiply in 10.35 microseconds. Comprehensive software that will be provided to utilize the Sigma 2 computation speeds includes two monitor-controlled operating systems, a Basic FORTRAN and a FORTRAN IV compiler, two assemblers, and a number of library and utility programs. Consistent with the design and scope of Sigma 2, no business data processing software will be provided. Sigma 2 can use all of the peripheral units announced for use with Sigma 7 (and listed in the Price Data section). There is no program compatibility between the two current Sigma systems.

The SDS Sigma family is expected to increase by the addition of still another computer system within a few months. The new system will probably be smaller and less expensive than the Sigma 7, but completely compatible.

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES			
	No.	Name	Monthly Rental $ 1-year lease	Monthly Rental $ 4-year lease	Monthly Maintenance $	Purchase $
SIGMA 7 CENTRAL SYSTEM		Central Processor				
	8401	Sigma 7 Central Processing Unit with 2 real-time clocks, control panel, and power supplies	3,030	2,475	450	110,000
		Processor Options				
	8411	Two Additional Real-Time Clocks	30	20	5	1,000
	8413	Power Fail Safe	30	20	5	1,000
	8414	Memory Write Protect	140	115	20	5,000
	8415	Memory Map	665	540	80	20,000
	8416	Additional Register Block	85	65	10	2,500
	8418	Floating Point Arithmetic	835	675	100	25,000
	8419	Decimal Arithmetic	1,000	810	120	30,000
	8421	Interrupt Control Chassis	60	50	10	2,200
	8422	Priority Interrupt, 2 levels	10	8	NC	350
	8495	System Supervisory Console	695	565	100	25,000
		Core Storage				
	8451	Memory Module: 4,096 words	1,110	900	160	40,000
	8452	Memory Increment: 4,096 words	495	400	40	17,500
	8456	Three-Way Access	130	115	20	5,000
	8457	Six-Way Access	335	270	50	10,000
		Input-Output Processors				
	8471	Multiplexor Input-Output Processor, with 8 Multiplexor Channels	555	450	80	20,000
	8472	Additional 8 Multiplexor Channels	130	110	15	4,000
	8481	Selector Input-Output Processor	415	340	60	15,000
	8482	Additional Selector Channel	280	215	40	10,000
INPUT DEVICES	7120	Card Reader, 400 cpm	445	360	100	16,000
	7140	Card Reader, 800 cpm	665	540	150	24,000
	7061	Paper Tape Controller and Equipment Cabinet	200	610	30	7,000
	7062	Paper Tape Reader, 300 cps	55	45	15	2,000
	7064	Paper Tape Spooler	45	35	10	1,500
OUTPUT DEVICES	7160	Card Punch, 300 cpm	890	720	210	32,000
	7063	Paper Tape Punch, 120 cps	65	55	25	2,500
	7440	Buffered Line Printer, 600 lpm	970	790	230	35,000
	7445	Buffered Line Printer, 1,000 lpm	1,110	900	255	40,000
INPUT-OUTPUT DEVICES	7010	Keyboard/Printer	165	135	35	6,000
	7020	Keyboard/Printer, with Paper Tape Reader and Punch	220	180	50	7,500
	7060	Paper Tape Reader (Model 7062), with 7063 Paper Tape Punch, 7064 Spooler, and 7061 Controller	335	270	80	12,000
		Mass Storage Devices				
	7201	RAD Controller	220	180	35	8,000
	7205	RAD Storage Unit, 1.5 million bytes	745	610	155	27,000
		Magnetic Tape Units				
	7321	Magnetic Tape Controller	280	225	40	10,000
	7322	Magnetic Tape Unit, 9-channel, 800 bpi, 60KB	720	585	185	27,000
	7371	Seven-Channel Magnetic Tape Controller	335	270	50	12,000
	7372	Magnetic Tape Unit, 7-channel, 200/556/800 bpi, 60KC max.	720	585	185	27,000

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INTRODUCTION

§ 011.

The UNIVAC 1004 is a compact, plugboard-programmed computer. Its two basic models, the 1004 I and 1004 II, can process punched card input at speeds of about 340 and 600 cards per minute, respectively, including the necessary allowances for a typical amount of computation and for I/O interlocks. (Card reading and printing can proceed simultaneously, but cannot be overlapped with computation.)

Rentals for the basic 1004 system (consisting of processor, card reader, and printer in a single cabinet) range from $1,150 to $1,625 per month. Additional peripheral equipment that can be connected includes a card punch, a second card reader, a card read/punch unit, paper tape equipment, and data communication terminals. A special processor model, the 1004 III, can control one or two magnetic tape units in addition to the above equipment.

First deliveries of the UNIVAC 1004 I were made in January 1963, and over 1,300 systems have been installed to date. The faster 1004 II and 1004 III were announced in March 1964.

The 1004 is most commonly used as an independent data processing system for small business applications. As such, it is attractive to many organizations considering a step upward from conventional tabulating installations because the 1004 requires less retraining of their staffs than a stored-program computer system would require. Furthermore, the 1004 offers economic advantages over stored-program systems for many applications whose processing and internal storage requirements are relatively small.

The 1004 can serve as a satellite system for a larger computer, such as a UNIVAC 490 or 1107. It is also suitable for use as a small computer in a branch office, communicating with a larger, home-office computer either by means of direct communication lines or simply through physical interchange of card decks or tape reels.

Where the 1004 is used as a complete data processing installation, there is no larger program-compatible computer system into which the installation can grow as its workload increases. UNIVAC, however, has announced provisions for connecting a 1004 system to its larger 1050 series of computers (described in Computer System Report 777:). The 1050 can then be used in conjunction with, and perhaps eventually replace, the 1004.

The UNIVAC 1004 can be used with more than one coding system. It normally operates with either the standard UNIVAC XS-3 code or with the Remington Rand 90-column card code. Which code is to be used is program-selectable, so it is possible to use both codes within a single program. This allows, for instance, reading a mixture of 80-column and 90-column cards, or reading 80-column cards and punching 90-column cards.

Codes other than the XS-3 and 90-column codes can be automatically translated to either of these codes by a special Translate Feature, provided that there are no more than 6 data bits per character in the original code. In particular, the IBM BCD codes used on the 1401 and other IBM systems can be translated, thus allowing the 1004 to be used as a satellite to many non-UNIVAC computer systems.

The UNIVAC 1004 has 961 alphameric character positions of core storage. Each core position contains six data bits. Core storage cycle time is 8.0 microseconds in the UNIVAC 1004 I and 6.5 microseconds in the UNIVAC 1004 II and III.

The plugboard of the basic machine has a capacity for 31 program steps (expandable to 62). Each step can specify two operand addresses, and multiple operations can be performed in a single program step. Arithmetic operations include add and subtract (both algebraic and absolute) and compare. Multiply and divide operations require the use of wired subroutines. Seven types of transfer processes are provided, including several with editing facilities. Input-output areas are assigned fixed locations in core storage. Input-output commands can be combined in the same step with other operations.

Operands can be of any length up to the capacity of core storage. Operand length is specified by the operand addresses wired in each program step. Instructions are executed at the rate of about 6,500 instructions per second in the 1004 I processor and about 8,000 instructions per second in the 1004 II and III.

§ 011. INTRODUCTION (Contd.)

The 1004 can read cards and print simultaneously, but neither of these operations can be overlapped with computation. Card punching can overlap either computing or other peripheral operations. The optional peripheral devices may:

(1) be able to overlap both computing and card reading and/or printing (e.g., the paper tape punch or the card read/punch operations);

(2) be able to overlap computing but not card reading or printing (e.g., the auxiliary card reader or the paper tape reader); or

(3) be unable to overlap any other operation (e.g., the Data Line Terminals).

The 1004 is available in 80-column, 90-column, or 80/90-column models. The basic system consists of a card reader, central processor with plugboard control, and printer. All are housed in a single compact cabinet. The card reader in the 1004 I Processor has a rated speed of 300 cards per minute, and the printer has a rated speed of 300 lines per minute. These rated speeds include an allowance for 35 milliseconds of computation per card or line, which has been found to be quite conservative. In typical applications, computation time is about 5 milliseconds per card, and reading and/or printing speeds of about 340 cards/lines per minute are obtained.

In the 1004 II and III, the card reader operates at a speed of 615 cards per minute, and the printer operates at 600 lines per minute; both these speeds are based on 5 milliseconds of computation per record.

A card punch can be connected to the UNIVAC 1004. It punches at a speed of 200 cards per minute. The card punch is available in a read/punch model which reads and/or punches cards at a speed of 200 cards per minute. The read/punch enables a 1004 system to read data from and punch results into the same card. A 400-card-per-minute Auxiliary Card Reader can also be used with the 1004 Processor.

Two different Data Line Terminals are available. The Data Line Terminal, Type 1, can be used to communicate with a UNIVAC 1050, 490, 1107, or another 1004. The Data Line Terminal, Type 2, permits communication with magnetic-tape terminals such as the Digitronics Dial-O-Verter.

A 400-character-per-second paper tape reader and a 110-character-per-second paper tape punch can be used with the 1004.

One or two Uniservo magnetic tape units can be connected to the UNIVAC 1004 III processor only. Three density levels — 200, 556, and 800 pulses per inch — provide speeds of 8,000, 23,000, and 34,000 characters per second, respectively. These magnetic tapes can be written in a mode compatible with either UNIVAC or IBM standards, although programmed translation may be required.

The software available with the 1004 is naturally limited. It consists primarily of short subroutines for handling multiplication, division, and a number of common commercial problems. These include suggested methods for handling reconciliations, deleting subtotals where there has only been a single card to be totaled, handling missing numbers in a matching operation, checking the sequence of alphanumeric identification numbers, and verifying check digits.

In addition, a number of complete programs are available. These include standard listing and transcription programs, and at least one General Purpose Program, which is a report writer that can facilitate setting up the equipment for new reports. A start has been made on supplying some scientific routines, such as sine-cosine and square root routines, and a Critical Path Method routine has been announced.

Software routines are circulated by the UNIVAC Division to 1004 users.

UNIVAC 1004

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
			1004-I-Processors (include 400-line/min printer, 400-card/min reader, and 8 μsec core memory):			
	*2010-00		1004-I - Processor (31, 30, 10, 40, 80 45, 6)(1)	1,200	46,000	225
	*2012-74		1004-I - Processor (47, 45, 15, 65, 120, 63, 8)(1)	1,460	56,000	250
	*2012-72		1004-I - Processor (62,60,20,105,160, 80,10)(1)	1,565	60,000	260
			1004-II Processors (include 600-line/min printer, 615-card/min reader and 6.5 μsec core memory):			
	*2010-06		1004-II-Processor (31,30,10,40,80,45, 6)(1)	1,335	51,000	300
	*2010-86		Card Processor Mod II C	2,045	79,500	390
	*2012-70		1004-II-Processor (47,45,15,65,120, 63,8)(1)	1,595	61,000	325
	*2012-68		1004-II-Processor (62,60,20,105,160, 80, 10)(1)	1,700	65,000	335
			Features for 1004 I and II Processors:			
		*F0743-00	Selectors (group of 5)	5	200	—
		*F0743-01	Program Selects (group of 5)	15	600	—
		*F0743-02	Collectors (group of 5)	5	200	—
		*F0594-00	Expansion Set (Expands 2010-00 to 2012-74 or 2010-06 to 2012-70)	260	10,000	25
		F0595-00	Expansion Set (Expands 2012-74 to 2012-72 or 2012-70 to 2012-68	105	4,000	10
		*F0624-00	Expansion Set (Expands 2010-00 to 2010-06, 2012-74 to 2012-70, or 2012-72 to 2012-68)	135	5,000	75
		*F0624-97	Expansion Set (Expands 1004-IC to 1004-II C	125	6,200	65
		F0675-00	Memory Expansion (Expands memory to 1,922 characters)	70	2,600	5
			1004-III Processor (includes 600-line/min printer, 615-card/min reader, and 6.5 μsec core memory):			
	*2010-06		1004 - III Processor (31, 30, 10, 40, 80, 45, 6)(1)	1,335	51,000	300
	*2012-70		1004 - III Processor (47, 45, 15, 65, 120, 63, 6)(1)	1,595	61,000	325
	*2012-68		1004- III Processor (62, 60, 20, 105, 160, 80, 10)(1)	1,700	65,000	335
			Features for 1004 III Processors:			
		*F0743-00	Selectors (group of 5)	5	200	—
		*F0743-01	Program Selects (group of 5)	15	600	—
		*F0743-02	Collectors (group of 5)	5	200	—
		*F0594-00	Expansion Set (expands 2010-06 to 2012-70)	270	10,000	25
		F0595-00	Expansion Set (expands 2012-70 to 2012-68)	105	4,000	10
		*F0624-00	Expansion Set (expands 2010-00 to 2010-06, 2012-74 to 2012-70, or 2012-72 to 2012-68)	135	5,000	75
		F0675-00	Memory Expansion (expands memory to 1,922 characters)	70	2,600	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental	Purchase	Monthly Maint.
INPUT-OUTPUT			Magnetic Tape (1004 III Processors only)			
	*0858-04		Mag Tape Unit and Control (Uniservo VI C; 7-Track 8,540, 23,741, or 34,160 char/sec)	515	17,350	115
	*7915-02		Mag Tape Unit and Control (Uniservo A; 8-Track)	500	17,700	115
	0858-01		Mag Tape Unit (Second Uniservo VI C unit)	310	10,470	70
	*7915-04		Mag Tape Unit (Second Uniservo A unit)	300	10,680	70
			Paper Tape			
	*0902-00		Paper Tape Reader (400 char/sec)	160	6,000	20
	*F0606-00		Paper Tape Punch (110 char/sec)	260	10,000	35
			Punched Card			
	*0704-00		Card Reader (400 cards/min)	190	7,200	40
		F0587-00	Code Image Read	27	1,000	7
		F0785-00	Invalid Code Check	25	960	10
	2009-00		Card Punch (200 cards/min)	315	12,000	100
	*2009-01		Card Read/Punch (200 cards/min)	470	18,000	150
	*2011-00		Card Punch (90 Column, 200 cards/min)	300	11,760	90
		F0591-00	Double Punch Detector	15	600	—
		F0588-00	Code Image Punch	28	1,000	5
		F0592-00	Punch Stacker Select	5	200	—
		*F0620-00	Punch Read Conversion	155	6,000	50
			Other			
		*F0757-00	Adapter (1004/Card Controller)	35	1,200	5
		*F0793-00	Adapter (DLT-3/Card Controller)	35	1,200	5
COMMUNI-CATIONS		*F0585-00	Data Line Terminal (DLT-1)	210	8,000	60
		F0753-00	Data Line Terminal (DLT-1B)	300	11,600	60
		*F0753-01	Data Line Terminal Option (low speed)	25	1,000	—
		*F0611-00	Data Line Terminal (DLT-2)	210	8,000	60
		*F0765-00	Data Line Terminal (DLT-2B)	290	11,600	55
		F0792-00	Data Line Terminal (DLT-3)	210	8,000	60
		*F0555-00	Data Line Terminal			
			DLT 5(1004/XS-3, 80 character blocks)	575	22,000	165
			DLT 6(1004/AUTODIN)	690	26,000	60
			DLT 7(1005/XS-3, continuous)	210	8,000	60
		*F0555-01	Dual DLT 5 (two DLT-5's)	1,150	44,000	330
		*F0556-01	Data Line Terminal (DLT-8)	685	29,250	200
		*F0863-00	Data Line Terminal (DLT-9)	375	15,000	55
		*F0863-01	Data Line Terminal (DLT-9)	375	15,000	55
		*F0863-02	Data Line Terminal (DLT-9A)	350	14,000	50
		*F0863-03	Data Line Terminal (DLT-9B)	400	16,000	60

NOTES:

* No longer in production.
(1) The numbers in parentheses indicate the number of Program Steps, Selectors, Program Selects, Collections, Distributors, Address Combines, and Comparators, respectively.

SUMMARY: UNIVAC SS 80/90 MODEL I

.1 BACKGROUND

The UNIVAC Solid-State 80/90 Model I system, introduced in 1958, uses a magnetic drum main memory. As a result, its internal processing speeds are significantly lower than those of most of the newer, third-generation computers. The Solid-State 80/90, however, included two significant advances over earlier drum-oriented computers: solid-state circuitry, which reduced installation and maintenance costs, and a fully buffered card reader, card punch, and line printer, which provided increased simultaneity.

The Solid-State 80 is designed to use standard 80-column cards, while the Solid-State 90 uses Remington-Rand 90-column cards. Therefore, there are differences in the I/O buffering and in the code translation instructions. In most other respects, including price, the two types of equipment are identical.

The Solid-State 80/90, as originally announced, was a punched-card-oriented computer system with a fixed drum storage capacity of 5000 ten-digit words. Four significant improvements during the next few years were the introduction of:

- Magnetic tape input-output.
- Large-capacity RANDEX drum storage.
- Main memory drums of varying storage capacities, ranging from 2600 to 9200 words.
- The Solid-State 80/90 Model II Central Processor, which features a combination of drum and core storage (see Report 772).

First deliveries of Solid-State 80/90 Model I systems were made in August 1958. The faster (and more expensive) Solid-State 80/90 Model II Processor, described in the following report, was initially delivered in June 1962. A total of more than 500 Solid-State 80/90 systems were installed, and approximately 100 are still in use at this writing. Both systems went out of production in 1965.

.2 HARDWARE

The Solid-State 80/90 Model I Processor handles data in words of 10 digits plus a sign. Each digit consists of four information bits plus an odd parity bit. Parity is checked during all data movements to or from storage.

The central processor normally handles only numeric data, whereas the peripheral units handle alphanumeric data in Hollerith or 90-column card code. This difference is resolved by splitting each group of 10 alphanumeric characters into two computer words, with one word holding the zone bits and the other word holding the numeric bits for all of the 10 characters.

The processor has three one-word arithmetic registers, designated A, X, and L. Register A is the accumulator, and Registers A and X together form a double-length register that is used in shifting and multiplication operations.

Programming for the Solid-State 80/90 Model I is similar to programming for the widely-used IBM 650. As in most drum-memory computers, coding is complicated by the desirability of locating instructions and operands in "optimum" drum locations that will minimize lost time due to latency delays.

The instruction format is "one plus one." Each instruction occupies one word and consists of a two-digit operation code, two four-digit addresses, and a one-digit index register designator. The first address normally specifies the location of an operand, while the second specifies the location of the next instruction to be executed. Three index registers can be used to modify the first address in an instruction; the second (or next-instruction) address cannot be modified by indexing.

There are 62 instructions, including fixed-point arithmetic, comparison, logical masking, right and left shift, zero suppress, and automatic code translation instructions. All of the instructions operate on full words. Character manipulation is performed by a combination of shifts and logical AND and OR instructions. Multiplication and division instructions are an extra-cost option on the modular STEP (Simple Transition to Economical Processing) processor and a standard feature on the larger processors. Program Interrupt is an optional feature for all processors.

Data is stored on the magnetic drum in 200-word "bands" of two types. Each so-called "fast" band is served by one read/write head and has access times of 0 to 3.4 milliseconds; the average for randomly-located data is 1.7 milliseconds. Each "high-speed" band is

.2 HARDWARE (Contd.)

served by four read/write heads spaced equidistantly around the drum's circumference, so the access time ranges from 0 to 0.875 millisecond. These access times are much longer than the basic instruction execution times; addition, for example, takes only 0.085 millisecond. Thus, there is a great deal to be gained through optimum allocation of the instructions and operands so as to minimize drum access times. This optimization is largely an automatic function of the UNIVAC-supplied assembly routines, X-6 and S-4.

Solid-State 80/90 Model I Central Processors are available with three basic capacities of drum storage, as summarized in the following table.

Processor Model	"Fast" Storage	"High-Speed" Storage
STEP	2400 words*	200 words**
Standard	4000 words	1000 words
Expanded	7600 words	1600 words

* Expandable in increments of 400 words; maximum of 4 increments.
** Expandable in increments of 200 words; maximum of 4 increments.

A central processor, a 600-cpm reader, a 150-cpm card read/punch, and a 600-lpm printer make up the basic Solid-State 80/90 system. Other units that can be included are: up to 10 magnetic tape units, up to 10 RANDEX drums, and a 500-cps paper tape reader and 100-cps paper tape punch. The tape units and/or RANDEX drums are controlled by a Tape-RANDEX Synchronizer.

Effective drum buffering of I/O operations enables the card reader, punch printer, and one tape unit or RANDEX drum to operate simultaneously with computing. Simultaneous magnetic tape reading and writing, however, is not possible.

The card reader operates at 600 cards per minute and is available in 80- and 90-column versions. Each card is read at two separate read stations. The two readings are not compared in the reader itself, but both images are transferred to the drum and compared there for accuracy.

The card read/punch operates at 150 cards per minute, has a single card feed path, and is available in 80- and 90-column models. The unit can include two read stations, one that reads before and one that reads after punching. All checking must be performed by the stored program.

The line printer, rated at 600 lines per minute, uses a conventional drum-type, on-the-fly printing mechanism. There are 51 printable characters, and the printed line can be 100, 110, 120, or 130 characters in length. There is no paper tape loop, so all vertical format control must be effected by the stored program.

Up to 10 Uniservo magnetic tape units can be connected, though only one unit can read or write at a time. The tape units are rated at 25,000 characters per second, but the fixed block length (normally 1100 characters) leads to a maximum effective speed of 16,400 characters per second at the maximum density of 250 bpi. Alternative block lengths of 720 or 120 characters and/or a lower density of 125 bpi lead to even lower effective speeds. A row parity check is performed upon reading operations.

Up to 10 RANDEX drum units can be used to add random-access storage to a Solid-State 80/90 system. Each RANDEX unit stores 24 million digits and consists of two large drums, mounted one above the other and served by a single movable read/write head assembly. Drum revolution time is 70 milliseconds, and head repositioning (when required) takes from 125 to 540 milliseconds. Records composed of 48 ten-digit words (one RANDEX sector) can be accessed within 600 milliseconds regardless of their position on the drums.

.3 SOFTWARE

Development of software for the Solid-State 80/90 systems suffered from a number of false starts. The Model I was originally advertised as being designed for programming in UNIVAC's Flowmatic language (a forerunner of COBOL), but the Flowmatic compiler did not live up to expectations. A COBOL-60 compiler was also announced for the system but was later withdrawn. FORTRAN I and II compilers were made available to users in field-test form but were never formally released.

UNIVAC-supplied software for the Solid-State 80/90 systems includes two assemblers (X-6 and S-4), a sort routine, about 25 I/O control routines, some program testing routines, a group of mathematical functions and routines, a linear programming package, and a CPM system.

X-6 is a basic symbolic assembly system for the Model I, while S-4 is a somewhat more advanced assembler that can be used on both models. X-6 is a card-oriented assembler, while S-4 can use magnetic tape units, when available, to speed up the assembly process. Neither assembler provides facilities for macro-instructions, though S-4 permits the creation and use of a program library on magnetic tape. Programs coded in the X-6 symbolic language can, with minor revisions, be assembled by the S-4 translator.

(Contd.)

UNIVAC SS 80/90 I

Manufacture of this equipment has been discontinued. Orders will be accepted for available equipment on hand. The list purchase prices below are shown for informational purposes only. Selling prices will be quoted by UNIVAC upon request.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes main memory)			
			Step Central Processors:			
	7944		90-Column Card Only			
	7934		80-Column Card Only	1,735	110,000	336
	7947		90-Column Card and Tape			
	7937		80-Column Card and Tape			
			Standard Equipment:			
			2400 words of fast drum storage			
			200 words of high speed drum storage			
			3 Index Registers			
			Options:			
			Program Interrupt	60	3,000	0
			Multiply and Divide	400	12,000	70
			400 Additional Words of Fast Drum Storage (1600 words max.)	400	12,500	25
			200 Additional Words of High-Speed Drum Storage (800 words max.)	275	10,250	20
			Standard Central Processors:			
	7907		90-Column Card Only			
	7909		80-Column Card Only	4,835	213,000	576
	7933		90-Column Card and Tape			
	7913		80-Column Card and Tape			
			Standard Equipment:			
			4000 words of fast drum storage			
			1000 words of high-speed drum storage			
			Multiply and Divide			
			3 Index Registers			
			Option:			
			Program Interrupt	60	3,000	0
			Expanded Central Processors:			
	7940		90-Column Card and Tape	5,635	248,200	620
	7930		80-Column Card and Tape			
			Standard Equipment:			
			7600 words of fast drum storage			
			1600 words of high-speed drum storage			
			Multiply and Divide			
			3 Index Registers			
			Option:			
			Program Interrupt	60	3,000	0
MASS STORAGE			RANDEX II Drum Storage Systems:			
	7965		First Storage Drum Cabinet; 12 million digits (2)	1,900	125,000	565
	7957		First Storage Drum Cabinet; 24 million digits (2)	1,850	140,000	650
	7966		Additional Storage Drum Cabinet; 24 million digits	1,705	85,000	195

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
INPUT/ OUTPUT			Magnetic Tape			
	7914		Tape/RANDEX Synchronizer	1,000	50,000	250
	7915		Uniservo Magnetic Tape Unit	450	20,000	112
			Punched Card			
			High Speed Reader (600 cards/min):			
	7935		80-Column	255	11,200	55
	7945		90-Column			
			Options:			
			Stacker Select (for 7935 or 7945)	50	2,300	10
			90-Column Read (for 7935)	35	1,350	18
			80-Column Read (for 7945)	35	1,350	18
			Read/Punch Unit (150 cards/min):			
	7936		80-Column	725	32,000	200
	7946		90-Column			
			Options (for 7936 or 7946):			
			Pre-Read	100	4,200	20
			Post-Read	100	4,200	20
			Stacker Select	50	2,300	10
			Paper Tape			
	-		Paper Tape System (500 char/sec reader and 100-char/sec punch)	900	45,000	170
			Printer			
	7912		High-Speed Printer (600 lines/min):	935	41,100	335
			10 Additional Print Positions	20	800	5
			20 Additional Print Positions	30	1,320	10
			Variable Line Spacing (6 or 8 per inch)	0	275	15
			Continuous Paper Feed	0	0	0

NOTES:

(1) These rentals do not include monthly maintenance charges.

(2) First RANDEX cabinet in a system can be either a 7965 or 7957; prices for both include a Synchronizer and Power Control.

SUMMARY: UNIVAC SS 80/90 MODEL II

.1 BACKGROUND

The UNIVAC Solid-State 80/90 Model II system adds a 1280-word magnetic core memory to the facilities of the Solid-State 80/90 Model I system described in Report 771. The core memory, despite a fairly slow cycle time of 17 microseconds, significantly increases the Model II's internal processing speed and can eliminate many of the coding complexities involved in minimizing drum latency times in the Model I. The Model II central processor can control two simultaneous magnetic tape or RANDEX drum read/write operations (versus one for the Model I), and its monthly rental is $1,500 higher than that of a comparably-equipped Model I. In most other respects — including the complement of peripheral equipment they can use — Models I and II are nearly identical.

Solid-State 80 systems are designed to read and punch standard 80-column cards, while Solid-State 90 systems use Remington-Rand 90-column cards. Therefore, there are differences in the I/O buffering and in the code translation facilities. Otherwise, there are few significant differences between the 80- and 90-column systems.

First deliveries of Solid-State 80/90 Model II systems were made in June 1962, nearly four years after Model I systems began reaching users. A total of more than 500 Solid-State 80/90 systems were installed, and approximately 100 are still in use at this writing. Both systems went out of production in 1965.

.2 HARDWARE

The Solid-State 80/90 Model II Processor handles data in words of 10 digits plus a sign. Each digit consists of four information bits plus an odd parity bit. Parity is checked during all data movements to or from storage.

The central processor normally handles only numeric data, whereas the peripheral units handle alphanumeric data in Hollerith or 90-column card code. This difference is resolved by splitting each group of 10 alphanumeric characters into two computer words, with one word holding the zone bits and the other word holding the numeric bits for all of the 10 characters.

The Model II Processor can have from 2600 to 8800 words of drum storage. In addition, every Model II Processor contains 1280 words of 17-microsecond magnetic core storage and 9 index registers (versus 3 in Model I) as standard equipment. Model II also has an expanded instruction complement that permits block transfers of data between core and drum memories, simplifies packing of data, and facilitates coding of alphanumeric operations. Otherwise, Model II uses the same instruction repertoire and the same "one-plus-one" instruction format as Model I (see Report 771).

The recommended programming technique for the Solid-State 80/90 Model II is an extension of the Model I technique. Instruction operands (i.e., data) are preferentially held in core storage, as are any sequences of instructions that would operate inefficiently if they were held on the drum. (Such inefficiencies could result from non-optimized coding or from use of the multiplication or division instructions, whose execution times are variable and data-dependent.)

Computation can be as much as 10 times faster than on the Model I (depending upon the degree of program optimization), and is frequently faster than on an IBM 1401 system. In fact, computational speeds of the Model II Processor are high enough (e.g., 51 microseconds for a 10-digit addition) so that the system's performance in typical business applications is usually limited by the speeds of the input-output devices, all of whose operations can be overlapped with internal processing.

On the magnetic drum, data is stored in 200-word "bands" of two types. Each so-called "fast" band is served by one read/write head and has access times of 0 to 3.4 milliseconds. Each "high-speed" band is served by four read/write heads spaced equidistantly around the drum's circumference, so the access time ranges from 0 to 0.875 millisecond.

Model II Processors are available in two versions. The Basic Processor has 2400 words of "fast" drum storage and 200 words of "high-speed" drum storage, which can be expanded in increments of 400 words of fast storage and/or 200 words of high-speed storage. The Expanded Processor has 7600 words of fast drum storage and 1200 words of high-speed drum storage. Both versions have 1280 words of core storage. Multiply and divide instructions are optional in the Basic Processor and standard in the Expanded Processor. A program interrupt facility is optional for both versions. No hardware facilities for floating-point arithmetic are offered.

.2 HARDWARE (Contd.)

A Solid-State 80/90 Model II system can include the same peripheral devices as the Model I. A central processor, a 600-cpm card reader, a 150-cpm card read/punch, and a 600-lpm printer make up the basic system. Other units that can be included are: up to 20 magnetic tape units, up to 20 RANDEX drums, and a 500-cps paper tape reader and 100-cps paper tape punch. All of these devices are described in Report 771. Up to 10 tape units and/or 10 RANDEX drums can be controlled by a Tape-RANDEX Synchronizer, and a maximum of 2 synchronizers can be connected to a Model II Processor.

Effective drum buffering of I/O operations enables the card reader, punch, printer, and one tape unit or RANDEX drum per synchronizer to operate simultaneously with computing. Simultaneous tape reading and writing can be performed in systems that include two synchronizers.

.3 SOFTWARE

Development of software for the Solid-State 80/90 systems suffered from a number of false starts. The Model I was originally advertised as being designed for programming in UNIVAC's Flowmatic language (a forerunner of COBOL), but the Flowmatic compiler did not live up to expectations. A COBOL-60 compiler was also announced for the system but was later withdrawn. FORTRAN I and II compilers were made available to users in field-test form but were never formally released.

UNIVAC-supplied software for the Solid-State 80/90 systems includes two assemblers (X-6 and S-4), a sort routine, about 25 I/O control routines, some program testing routines, a group of mathematical functions and routines, a linear programming package, and a CPM system.

X-6 is a basic symbolic assembly system for the Model I, while S-4 is a somewhat more advanced assembler that can be used on both models. X-6 is a card-oriented assembler, while S-4 can use magnetic tape units, when available, to speed up the assembly process. Neither assembler provides facilities for macro-instructions, though S-4 permits the creation and use of a program library on magnetic tape. Programs coded in the X-6 symbolic language can, with minor revisions, be assembled by the S-4 translator.

UNIVAC SS 80/90 II

Manufacture of this equipment has been discontinued. Orders will be accepted for available equipment on hand. The list purchase prices below are shown for informational purposes only. Selling prices will be quoted by UNIVAC upon request.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes main memory)			
			Basic Central Processor			
	7961		90-Column	3,235	177,500	560
	7962		80-Column			
			Standard Equipment:			
			2400 words of fast drum storage			
			200 words of high-speed drum storage			
			1280 words of core storage			
			9 Index Registers			
			Options:			
			Program Interrupt	60	3,000	0
			Multiply and Divide	400	12,000	70
			400 Additional Words of Fast Drum Storage (1600 words max.)	400	12,500	25
			200 Additional Words of High-Speed Drum Storage (800 words max.)	275	10,250	20
			Expanded Central Processors:			
	7963		90-Column	7,135	315,700	797
	7964		80-Column			
			Standard Equipment:			
			7600 words of fast drum storage			
			1200 words of high-speed drum storage			
			1280 words of core storage			
			9 Index Registers			
			Multiply and Divide			
			Option:			
			Program Interrupt	60	3,000	0
MASS STORAGE			RANDEX II Drum Storage System:			
	7965		First Storage Drum Cabinet: 12 million digits(2)	1,900	125,000	624
	7957		First Storage Drum Cabinet; 24 million digits(2)	1,850	140,000	650
	7966		Additional Storage Drum Cabinet; 24 million digits	1,705	85,000	195
			Magnetic Tape			
	7914		Tape/RANDEX Synchronizer	1,000	50,000	240
	7915		Uniservo Magnetic Tape Unit	450	20,000	108
INPUT-OUTPUT			Punched Card			
			High-Speed Card Reader (600 cards/min):			
	7935		80-Column	255	11,200	53
	7945		90-Column			
			Options:			
			Stacker Select (for 7935 or 7945)	50	2,300	10
			90-Column Read (for 7935)	35	1,350	18
			80-Column Read (for 7945)	35	1,350	18

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Read/Punch Unit (150 cards/min):			
	7936		80-Column	725	32,000	192
	7946		90-Column			
			Options (for 7936 or 7946):			
			Pre-Read	100	4,200	19
			Post-Read	100	4,200	19
			Stacker Select	50	2,300	10
			Paper Tape			
			Paper Tape System (500-char/sec reader and 100-char/sec punch)	730	45,000	170
			Printer			
	7912		High-Speed Printer (600 lines/min):	935	41,100	322
			10 Additional Print Positions	20	800	5
			20 Additional Print Positions	30	1,320	10
			Variable Line Spacing (6 or 8 per inch)	0	275	15
			Continuous Paper Feed	0	0	0

NOTES:

(1) These rentals do not include monthly maintenance charges.

(2) First RANDEX cabinet in a system can be either a 7965 or 7957; prices for both include a Synchronizer and Power Control.

INTRODUCTION

§ 011.

The UNIVAC III is a large scale data processing system suitable for both business and scientific applications. System rentals range from approximately $19,000 to $40,000 per month, and most installations will probably fall within the $25,000 to $35,000 range. By means of the software operating system, it is possible to utilize hardware facilities for simultaneous processing of a number of independent programs. Hardware facilities that have been incorporated to help achieve this objective are:

- A series of interrupt levels which permit varied peripheral equipments to make their demands on the central processor.
- Provision of scatter-read and gather-write facilities through the use of function specification words to specify address assignments.
- Availability of 9 or 15 index registers plus indirect addressing.
- Four one-word arithmetic registers, which may be used individually or in combination in ascending order only.
- Control of all input-output operations by independent input-output channels. Up to 13 channels can be connected, and all channels can operate simultaneously with each other and with the central processor.

The central processor can perform additions or subtractions on binary or decimal operands. These operands can be distributed over one to four words of 27 bits each. Each UNIVAC III word uses two bits for modulo 3 checking. The remaining 25 bits can contain an instruction word, four 6-bit alphameric characters plus a sign bit, six 4-bit numeric characters plus a sign bit, or 24 binary data bits plus a sign.

Multiplication and division can be performed on decimal data only. The UNIVAC III can perform logical AND and inclusive OR functions and binary comparison operations. Branching, alphameric-to-decimal and decimal-to-alphameric conversion, and zero suppression capabilities ease data manipulation and program control; however, most editing functions, floating point arithmetic, and conversion of data to floating point format must be handled by subroutines. Scatter-read and gather-write facilities provide fast means of assembling data into and disseminating data from core storage.

Core storage capacity ranges from 8,192 to 32,768 word locations in increments of 8,192. Cycle time is 4 microseconds per word, but the majority of instructions take 8 microseconds.

A wide range of input-output equipment is offered for the UNIVAC III. A system can include a maximum of 32 Uniservo IIIA Magnetic Tape Units, 6 Uniservo IIA Magnetic Tape Units, and a total of 8 units of the following equipments in any combination: High Speed Card Readers, High Speed Printers, Card Punch Units, Punched Paper Tape Units, and Uniservo IIIC Magnetic Tape Synchronizers controlling from 2 to 8 tape units each.

Two models of both card readers and card punches are available. Cards can be read at a peak rate of 800 cards per minute and punched at a peak rate of 300 cards per minute. Punched paper tape can be read at 250, 500, or 1,500 characters per second, and punched at 110 characters per second. The line printer has 128 print positions and a set of 51 characters, and can print 700 alphameric or 922 numeric single-spaced lines per minute.

INTRODUCTION (Contd.)

§ 011.

Three types of Uniservo Magnetic Tape Units are available for the UNIVAC III system, the Uniservo IIIA, IIA, and IIIC.

The Uniservo IIIA Magnetic Tape Unit operates at peak data transfer rates of 133,000 alphameric characters or 200,000 numeric digits per second with a density of 1,000 frames (1,330 characters or 2,000 digits) per inch. Tape can be read forward or backward, but data can be recorded in the forward direction only. Tape can be read or written in either the Start-Stop mode or the Non-Stop mode. A read-after-write check is made upon recording.

The Uniservo IIA Magnetic Tape Unit operates at peak data transfer rates of 25,000 or 12,500 characters per second at densities of 250 or 125 characters per inch respectively. When recording at 250 characters per inch, the format is compatible with the UNIVAC II; the 125 character per inch recording makes the format compatible with the UNIVAC I.

The Uniservo IIIC Magnetic Tape Unit operates at peak data transfer rates of 22,500 or 62,500 characters per second at densities of 200 and 556 characters per inch. The block lengths are variable and the format is IBM-compatible. Tape can be read or written either with or without translation. When translation is specified, the six-bit IBM tape code is converted to six-bit excess three code or vice versa. A read-after-write check is made upon recording.

Major emphasis has been placed on development of software packages to achieve the maximum throughput capabilities of the system and to simplify programming. These packages provide complete input-output control, the means of associating and running independently prepared programs simultaneously, the ability to call many routines and subroutines, and the ability to incorporate new routines or subroutines in the library. Program testing aids such as SNAPshot, DUMP, and TRACE have also been incorporated in the software packages. Data sorting and merging are provided by a sort generator which generates the instructions for the sort or merge from a set of parameters outlined by the user. The original input and final output routines are the responsibility of the user. Input-output routines provided for the intermediate collating pass use any available tape in the system (even the unused portion of data tapes).

Two complete machine oriented software packages are available for the UNIVAC III; however, no compatibility exists between them. One package consists of SALT, a machine oriented language; DUTY, a library of routines and subroutines; and CHIEF, an executive routine. The other consists of UTMOST, a machine-oriented language; SUPPORT III, a library of routines and subroutines; and BOSS III, an executive routine. New developments and innovations will be incorporated in the already more sophisticated UTMOST, SUPPORT III, and BOSS III package; however, both packages will be maintained.

Both SALT and UTMOST provide an easily understandable mnemonic representation of instructions, pseudo operations for directing the assembler, and the ability to perform operations to develop the operand address. UTMOST is more extensive than SALT in the functions that it provides.

DUTY and SUPPORT III each provide the ability to update and maintain a library of routines and subroutines, and an independent library of object programs for the system.

Both CHIEF and BOSS III are comprehensive operating systems that control the scheduling, loading, and multi-running of programs; handle most errors; and permit two-way communication between the operator and the system. All functions of these executive routines are initiated by and closely integrated with the hardware interrupt facilities.

Both COBOL-61 and FORTRAN IV have been implemented for the UNIVAC III. Object programs produced by both the COBOL and FORTRAN compilers can be run under the control of BOSS III.

INTRODUCTION (Contd.)

§ 011.

UNIVAC III COBOL is essentially Required COBOL-1961. Several useful electives have been implemented, including segmentation of the object program and arithmetic operands up to 18 digits in size. Extensions to COBOL-61 include a SORT facility, a MONITOR verb that facilitates program testing, and the ability to add independently compiled COBOL subprograms to a main program at run time.

The UNIVAC III FORTRAN language is largely compatible with the IBM 7090/7094 implementation of FORTRAN IV. Most FORTRAN II statements will also be accepted and correctly interpreted by the translator. Double precision and complex variables, however, are not permitted.

UNIVAC III

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
	*4121		Central Processor (8 K word memory)	8,300	390,000	575
	*4120		Central Processor (16 K word memory)	9,755	457,500	680
	*4119		Central Processor (24 K word memory)	11,410	534,000	750
	*4118		Central Processor (32 K word memory)	12,475	583,500	805
		*F0622-00	Programmable Clock	210	10,000	45
		*F0623-00	Index Register Expansion	300	15,000	15
INPUT-OUTPUT			Magnetic Tape			
	5302-00		Mag Tape Control (controls 1 to 6 Uniservo IIA Tape Units)	2,005	92,500	175
	4135		Mag Tape Control (Uniservo III Tape Control)	3,015	145,000	275
	*5303-00		Mag Tape Control (controls 1 to 8 Uniservo IIIC Magnetic Tape Unit)	2,125	102,500	125
	*0950-00		Tape Adapter Cabinet (used with Uniservo IIIC Tape units to provide NRZ Tape format)	1,040	48,000	60
	*5300-00		Mag Tape Control (controls 1 to 16 Uniservo IIIA Tape Units)	3,010	145,000	230
	*5303-00		Mag Tape Control (controls 1 to 8 Uniservo IIIC Tape Units)	2,125	102,500	125
	*0851-00		Mag Tape Unit (Uniservo IIIC)	780	28,360	70
	*0850-00		Mag Tape Unit (Uniservo IIIA)	790	36,500	175
	0854-00		Mag Tape Unit (Uniservo IIA)	475	20,000	110
	*4126		Mag Tape Unit (Uniservo III)	530	24,000	150
	*1350-00		Power Supply	350	17,500	30
	*1350-02		*Power Supply	365	17,500	35
	*1350-03		*Power Supply	365	17,500	35
	*1350-04		*Power Supply	365	17,500	35
	*1350-05		*Power Supply	365	17,500	35
	*4123-00		*Uniservo Power Supply	350	17,500	30
			Paper Tape			
	*0901-00		Paper Tape Subsystem (reads 250/500/1500 char/sec; punches 110 char/sec)	1,665	80,000	165
			Punched Card			
	*0703-00		Card Reader (700 cards/min)	795	35,000	175
	*4133-00		High Speed Reader (700 cards/min; 80 column)	750	35,000	150
	*0652-00		Card Punch (300 cards/min)	905	40,000	325
	*4127-00		Card Punch Unit (300 cards/min.; 80 column)	850	40,000	285
	*4183-00		Card Punch Unit (300 cards/min.; 90 column)	850	40,000	285
			90 Column Read Feature	35	1,350	20
			Stub Card Feature	60	3,000	20
			Printer			
	*0752-00		Printer (700 lines/min)	1,740	79,000	400
	*4152-00		High Speed Printer (700 lines/min)	1,650	79,000	350

NOTES:

*No longer in production.

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SUMMARY

The UNIVAC 1050 is a small to medium scale, solid-state computer that is oriented toward business data processing applications. The Model III, with internal processing rates of about 8,500 instructions per second is the only model available. The Model IV, which would have been about 3.5 times as fast, was never produced.

The UNIVAC 1050 was conceived several years ago as a contender for the IBM 1401-class market. For marketing reasons, it was first announced in May 1962 as an off-line input-output processor, with a maximum of two magnetic tape units, for larger UNIVAC systems. An expanded version, the UNIVAC 1050-II, was developed which included communications and Fastrand mass storage equipment. This system was eminently successful — 152 systems were ordered by the U.S. Air Force in November 1963. Finally, in March 1964, the UNIVAC 1050 Model III and Model IV were announced as general-purpose, commercial EDP systems, with a complete line of peripheral equipment and software. The first delivery of the Model III Processor was made in 1963.

While the UNIVAC 1050 offers many useful features and is a relatively easy machine to program, its earlier origin is apparent in some performance comparisons of the Model III against other recently-announced computer systems in the same price class.

A wide range of peripheral devices is offered for the UNIVAC 1050, permitting effective use of the system as an off-line input-output processor for larger, tape-oriented computers and as a control center for a data communications network. A novel feature (the 1050-1004 Adapter) permits the UNIVAC 1050 to be used as an "expansion package" to increase the processing capacity of UNIVAC 1004 installations. UNIVAC 1050 system rentals range from approximately $1,400 to over $20,000 per month, but most installations probably fall within the $5,000 to $12,000 rental range.

Hardware

UNIVAC 1050 systems can have from 4,096 (included with the processor) to 32,768 character positions of core storage in 4,096-character modules. Each core storage location contains six data bits and one parity bit. Cycle time is 4.5 microseconds per character.

The 1050 processor has typical single-address logic, with the addition of add-to-storage capabilities. Two 16-character accumulators and 7 index registers are provided. Facilities for indirect addressing are not provided. Arithmetic is basically decimal, but binary add and subtract instructions are provided to facilitate address modification and binary arithmetic. (The core storage addressing mode is pure binary.) All operations are performed serially by character.

The basic instruction format is a 30-bit "binary word" (5 consecutive characters) which usually contains a 5-bit operation code, a 3-bit index register specification, a 16-bit address, and a 6-bit modifier. The External Function (input-output) instruction uses the 30 bits in a slightly different manner. Operand length is variable and can range from 1 to 16 characters for most instructions, as specified in the instruction. All instructions except the multiply and divide instructions and the input-output instructions can be indexed.

Extensive editing facilities, including character insertion, floating dollar, and check protection, are provided. A block transfer instruction can cause the transfer of up to 1,024 characters from one location in core storage to another. A translate instruction can automatically translate up to 64 different characters from one 6-bit code to any other 6-bit code defined by a table supplied by the programmer. The only optional hardware facility is the decimal multiply-divide feature. Floating-point arithmetic hardware is not available for the 1050 Processors.

An extensive system of interrupts and testable indicators provides program control. Interrupts are divided into three priority levels and may occur upon detection of such conditions as internal parity errors, operator request, decimal overflow, successful completion of an input-output operation, or malfunction of an input-output device. All interrupts except the one for internal parity errors can be program-inhibited. Recognition of an interrupt signal causes a transfer of control to a specific location, depending on the type of interrupt, which can contain a branch to a routine to handle the condition.

Testable indicators which enhance the interrupt system include indicators for decimal overflow and for the status of the device on a particular input-output channel. The results of comparisons and arithmetic functions are also indicated by testable indicators. Conditions that can be tested include equal, not-equal, greater-than, and less-than after comparisons, and result-zero, result-negative, and decimal or binary overflow after arithmetic operations.

There are eight input-output channels available for the 1050 Central Processor, each of which is assigned to a single peripheral subsystem (i.e., there are no facilities for programmed switching of the channel assignments). Three (any three) channels are included in the basic price of the processor. The synchronizers (control units) for the card reader, card punch, and printer are internal to the main frame of the processor, each using one input-output channel. Two other channels are reserved for a magnetic tape subsystem, leaving three general-purpose input-output channels.

The peripheral subsystems available for use in UNIVAC 1050 systems are summarized below. Each peripheral subsystem requires the full use of one input-output channel, except that a magnetic tape subsystem requires the use of two. Additional synchronizers will be required (on special order) to add a second card reader, card punch, or printer to the system.

- Card Reader: column reader; 800/900 or 600 cards per minute; 80 or 90 columns.
- Card Punch: row punch; 300 or 200 cards per minute; 80 or 90 columns.
- Printer: 700/922 or 600/750 lines per minute; 128 (132 optional) print positions; 63 printable characters.
- Uniservo III A Magnetic Tape Subsystem: 1 to 6 tape handlers; up to 133,000 characters per second; read-compute or write-compute overlap; read-after-write modulo-3 check; read-backward capability.
- Uniservo IV C Magnetic Tape Subsystem: 1 to 6 tape handlers; up to 90,000 characters per second, read-compute or write-compute overlap; read-after-write parity check; IBM 729- compatible.
- Uniservo VI C Magnetic Tape Subsystem: 1 to 16 tape handlers; up to 34,100 characters per second; read-write-compute overlap; read-after-write parity check; IBM 729-compatible; relatively low-cost.
- Fastrand II Mass Storage Subsystem: 1 to 8 storage units; over 132 million characters per storage unit; 93 milliseconds average access time; up to 185,000 characters per second data transfer rate; search feature; read-compute, write-compute, or position-compute overlap.
- UNIVAC 1004 Subsystem: connects a UNIVAC 1004 Model I, II, or III (Computer System Report 770:) on-line with the UNIVAC 1050.
- Punched Paper Tape Subsystem: 1,000 or 300 characters-per-second reader; 110 characters-per-second punch; 5-, 6-, 7-, or 8-level tape.
- Standard Communications Subsystem: Communications Multiplexer controls 1 to 32 Communication Line Terminals; console typewriter can monitor messages; messages on all lines can be handled simultaneously; will accept various telephone and teletypewriter communications services with data transfer rates of up to 800 characters per second.

In typical business data processing systems using the Uniservo VI C tape handlers, simultaneity of input-output operations can be quite good; but in systems using the faster Uniservo III A or IV C tape handlers or Fastrand II, simultaneity can be severely restricted. The complete picture of the UNIVAC 1050's capabilities for simultaneous operations is complex and is presented in detail in Section 777:111 of this report.

Software

UNIVAC has developed a generously large array of software for the 1050 system. All of the programming systems and routines summarized below are scheduled for delivery before or during the first quarter of 1965.

- PAL JR: Basic symbolic assembly system, usable on minimum UNIVAC 1050 configurations with card input-output units and 4,096 character positions of core storage.
- PAL CARD: Basic symbolic assembly system, usable on expanded UNIVAC 1050 card-oriented systems with at least 8,192 positions of core storage. PAL CARD features more versatile input-output control routines than PAL JR.

(Contd.)

- PAL 1004: A basic assembly utilizing the UNIVAC 1004 for input and output.
- PAL TAPE: A more advanced assembly system requiring two magnetic tape units, card punch (optional if tape-only output is desired), card reader, printer, and at least 8,192 positions of core storage on the translating computer. Macro, file control, and library facilities are provided.
- PAL DRUM: A Fastrand-oriented version of PAL TAPE; a Fastrand magnetic drum replaces the magnetic tape units.
- PATCH Assembler: Provides the capability for patching object programs without the need for full reassembly. Facilities are provided for addition, deletion, or alteration of sections of coding. Input and output are on cards only.
- COBOL: The COBOL compiler for the 1050 consists of a limited subset of the COBOL-65. It includes almost none of the features that distinguish COBOL-65 from COBOL-61 among these omissions are SORT, REPORT-Writer, COMPUTE, any facilities for program segmentation or access to library routines. The result is a simple compiler that was obviously introduced when UNIVACS plans for offering a full COBOL-61 Extended compiler did not come off. The minimum configuration for COBOL compilation include:
    - Three magnetic tape units (must all be of the same type).
    - Card reader
    - Printer
- the FORTRAN Operating System: Consists of a series of programs and subroutines which translate other programs and subprograms written in FORTRAN IV source language into object code capable of execution on the UNIVAC 1050 system. Object programs produced by the FORTRAN Operating System are relocatable, relative programs which will operate singly or concurrently under the control of the OPR Executive Routine. The minimum configuration required for compilation includes:
    - 4 or more memory modules (16,384 positions of storage).
    - Multiply and divide hardware feature
    - Four tape units
    - Printer
    - Card reader
- REGENT CARD: Provides facilities for generating report programs for card-oriented systems. Sections of the user's own coding in PAL symbolic language can be included.
- REGENT TAPE: Generates report programs for tape-oriented systems. Sections of the user's own coding in PAL symbolic language can be included.
- UNIVAC 1050 SORT Routine: Performs tape sorting operations, using decimal, binary, or alphanumeric keys, on a system with 3 to 6 magnetic tape units. The Sort routine can be used with as little as 8,192 core storage positions, but additional storage will increase its efficiency. Sections of the user's own coding can be incorporated.
- OPR: An executive routine for the UNIVAC 1050, which provides the linkages between the "worker program" and routines from the PAL Library. OPR can be modified to control data communications devices. One version of OPR provides for the loading and execution of two programs in parallel.

UNIVAC 1050

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CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	*0500-02		Central Processor (including 8,192 characters of core storage)	1,930	68,600	215
	*0500-01		Core Memory Expansion (4,096 character modules; maximum total storage is 32,768 characters)	625	23,400	40
INPUT-OUTPUT			Magnetic Tape			
	*0551-00		Mag Tape Control (controls 1 to 16 Uniservo III A Tape Units)	1,245	47,000	70
			Mag Tape Control (controls 1 to 12 Uniservo III C Tape Units)	1,250	46,400	90
	*0850-00		Mag Tape Unit (Uniservo III A)	790	36,500	175
	*0851-00		Mag Tape Unit (Uniservo III C)	780	28,360	70
	*0851-04		Mag Tape Unit (Uniservo IV C)	835	29,050	110
	*1353-00		Power Supply	225	7,400	40
			Punched Card			
	*0701-31		Card Reader (1,000 cards/min)	425	13,000	100
	*0650-21		Card Punch (300 cards/min)	750	19,400	265
			Printer			
	*0751-03		Printer Buffer	370	12,400	60
	*0751-04		Printer (700/922 cards/min)	818	26,000	168

NOTES

*No longer in production.

UNIVAC 1050-A CARD PROCESSING SYSTEM

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR	*0500-05		Central Processor (includes 4,096 characters of core storage)	1,230	44,000	130
		*F0593-00	Memory Expansion (4,096 - character module; maximum total storage is 32,768 characters)	335	12,800	15
		*F0726-00	I/0 Channel Expansion (1 I/0 channel; 5 additional maximum)	45	1,600	5
		*F0725-00	Multiply and Divide	155	6,000	5
		*F0701-00	Inquiry Typewriter	100	3,200	20
	*4002-01		Console (desk type)	75	2,800	5
		*F0727-00	Console (integrated)	45	1,600	5
	*0670-00		Power Supply Expansion	160	5,600	20
INPUT-OUTPUT			Punched Card			
	*0706-00		Card Reader (800/900 cards/min)	415	12,985	115
	*0706-01		Card Reader (600 cards/ min)	240	7,000	65
	*0600-00		Card Punch (300 cards/min)	715	21,560	230
	*0600-12		Card Punch (200 cards/min)	425	13,570	130
			Printer			
	*5003-00		Printer Control (for second printer)	570	21,640	30
		*F0663-03	Printer Buffer	195	7,000	20
	*0755-05		Printer (700/922 lines/min)	870	25,970	275
	*0755-01		Printer (600/750 lines/min)	615	17,940	225

Notes:

*No longer in production

UNIVAC 1050-III

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*0500-05		1050-III Processor (includes 4,096 characters of core storage and 3 I/0 Channels)	1,230	44,000	130
		*F0593-00	Memory Expansion - 4K (4,096 character module; maximum total storage is 32,768 characters)	335	12,800	15
		*F0725-00	Advanced Logic (multiply and divide)	155	6,000	5
		*F0726-00	I/0 Channel Expansion (1 I/0 channel; maximum of 8 total)	45	1,600	5
	*4002-01		Free Standing Console	75	2,800	5
	*4002-03		Free Standing Console	75	2,800	5
		*F0727-00	Integrated Console	45	1,600	5
		*F0710-00	Inquiry Typewriter	100	3,200	20
	*1353-00		Power Supply	225	7,400	40
	*1353-01		Power Supply	225	7,400	40
	*1353-02		Power Supply	225	7,400	40
	*1353-03		Power Supply	225	7,400	40
		*F0670-00	Power Supply Expansion	160	5,600	20
		*F0635-00	1004 Control (used with 1004 or 1005 processor)	215	7,840	20
MASS STORAGE			Drum Storage			
	6010-00		Fastrand II Unit (132, 120, 576 characters per unit)	4,050	164,640	300
		F0688-01	Write Lockout	30	1,040	5
		F0686-01	Fastbands	215	8,235	25
	*5002-02		Drum Control (controls up to 2 Fastband II units or 8 modular Fastband units)	995	39,800	100
	*5002-03		Fastrand Control (Controls up to 8 Fastrand II Units)	1,035	36,880	115
	*F0710-00		Search All Words	55	2,225	-
INPUT-OUTPUT			Magnetic Tape			
	*0853-16		Uniservo VIC Master (7-track; 200/556/800 bpi; handles up to 3 Uniservo Vic Slaves)	515	17,350	115
	*0858-00		Uniservo VIC Master (7-track; 200/556/800 bpi; reads backward; handles up to 3 Uniservo VIC Slaves)	515	17,350	115
	0858-01		Uniservo Slave (7-track; 200/556/800 bpi)	310	10,470	70
	*5307-00		Uniservo VIC Control (controls 1 to 4 Uniservo VIC Master units; maximum total units per control is 16)	620	23,480	35
	*0551-01		Mag Tape Control (controls 1-6 Uniservo III A tape units)	1,025	38,920	55
			Punched Cards			
	*0706-00		Card Reader (80 column; 800/900 cards/min)	415	12,985	115
	*0706-01		Card Reader (80 column; 600 cards/min)	240	7,000	65
	0600-00		Card Punch (80 column; 300 cards/min)	715	21,560	230
	*0600-12		Card Punch (80 column; 200 cards/min)	425	13,570	130
	*0600-02		Card Reader/Punch (80 column; 300 cards/min)	870	24,320	260
	*0600-14		Card Reader/Punch (80 column; 200 cards/min)	585	17,320	150

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Printer			
	*0755-05		Printer (700/922 lines/min)	870	25,970	275
	*0755-01		Printer (600/750 lines/min)	615	17,940	225
	*5003-00		Printer Control (control for second printer)	570	21,640	30
		*F0663-03	Printer Buffer (128 characters)	195	7,000	20
		*F0663-01	Printer Buffer (132 characters)	210	7,680	20
			Paper Tape			
	*0903-00		Paper Tape Reader (1,000 char/sec)	415	10,320	155
	*0903-01		Paper Tape Reader (300 char/sec)	215	5,360	80
		*F0606-02	Paper Tape Punch (110 char/sec)	175	4,400	65
	*5005-00		Paper Tape Control (control and cabinet for paper tape reader or punch)	225	6,900	95
		*F0636-00	Reader Spooler	95	2,280	35
		*F0637-00	Punch Take Up Reel	5	200	-
COMMUNICATIONS		*F0900-03	Multiplexer (8 simplex positions)	770	21,640	230

NOTES:

*No longer in production.

SUMMARY: UNIVAC 1107

.1 BACKGROUND

The UNIVAC 1107 Thin-Film Memory Computer, first delivered in September 1962, is a large-scale data processing system suitable for both scientific and commercial applications. The 1107 was the solid-state successor to the vacuum-tube UNIVAC 1105 and 1103 scientific processors; it provided greatly increased speed and flexibility in both internal processing and input-output operations. Program compatibility with previous UNIVAC systems was not maintained. Monthly rentals for most 1107 systems originally fell within the $40,000 to $70,000 range.

In July of 1964, the 1108, a largely compatible but faster and more powerful version of the 1107, was announced (see Computer System Report 785). Shortly after delivery of the first 1108 system in December 1965, UNIVAC placed the 1107 on a "discontinued" basis, although 1107 production facilities, to date, have not been dismantled. UNIVAC 1107 central processor prices were revised downward approximately 20%, while prices of peripheral units common to both 1107 and 1108 systems were not reduced. The Price List included in this Summary Report reflects guideline prices only; actual sales or rentals are individually negotiated when machines become available. Many of the 40-plus existing 1107 systems have been purchased outright, so the present availability of 1107 equipment is difficult to assess. UNIVAC is continuing normal software maintenance for its 1107 customers, although no new software releases are expected.

The UNIVAC 1107 features both multiprocessing and limited multiprogramming capabilities, an efficient central processor with a comprehensive instruction repertoire, and a powerful input-output and communications capability.

Many of the features of third-generation computers, such as advanced interrupt facilities, a separate, high-speed control memory, and a high degree of hardware modularity, were provided in the UNIVAC 1107.

Chief deficiencies of the 1107 with respect to its successor, the 1108, include:

- Core memory capacity is limited to a maximum of 65,536 36-bit words.
- Basic cycle time is 4.0 microseconds.
- Double-precision arithmetic facilities are not provided.
- Memory protection features are lacking.
- A maximum multiprocessor system is limited to two 1107 central processors.

.2 HARDWARE

A basic UNIVAC 1107 system consists of a central processor with console and 8, 12, or 16 input-output channels; 16,384, 32,768, 49,159, or 65,536 36-bit words of core storage; and peripheral subsystems as required. Tables I and II summarize the subsystems and the number of I/O channels that each subsystem requires.

Each core memory location can hold one instruction, one single-precision floating-point data item, from one to six fixed-point data fields, four alphanumeric eight-bit bytes, or six alphanumeric characters in 1107 internal code. No provision exists for recording or checking parity of data words held in core storage. The memory can consist of dual asynchronous banks. Read access time is 1.8 microseconds and cycle time, including data regeneration, is 4.0 microseconds for each 36-bit word. By storing instructions in one bank and data in another, it is possible to overlap the operation of the two banks; this reduces the effective cycle time by a factor of two. The "alternate banks" storage allocation technique decreases the execution time for most instructions by 4.0 microseconds; e.g., each add, subtract, load, or store instruction takes 8.0 microseconds when the operand and corresponding instruction are in the same bank and only 4.0 microseconds when they are in alternate banks.

The 128-word Thin-Film Memory, used by the 1107 for control purposes, has a read access time of 0.333 microsecond and a cycle time of 0.667 microsecond, allowing references to be made at rates approaching 1.5 million cycles per second. Specific functions are assigned to 63 of the 128 Film Memory locations; 15 locations serve as index registers and 16 as arithmetic registers (accumulators). This abundance of arithmetic and index registers contributes heavily to the power and flexibility of 1107 programming. The remaining 65 Thin-Film Memory locations are available as general-purpose working storage, but there are certain programming restrictions on their use.

TABLE I: UNIVAC 1107 MAGNETIC DRUMS

Characteristic	FH-880	Fastrand
Average access time, msec	17	92
Peak transfer rate, words/sec	60,000	25,625
Maximum storage per subsystem, 36-bit words	6,291,456	176,160,768
Maximum drum units per subsystem	8	8
Number of input-output channels per subsystem	1 or 2	1 or 2

TABLE II: UNIVAC 1107 INPUT-OUTPUT SUBSYSTEMS

Subsystem	Number of I/O Channels per Subsystem	Maximum Number of Devices per Subsystem	Peak Speed
Uniservo IIA Magnetic Tape	1	12	25,000 char/sec.
Uniservo IIIA Magnetic Tape	1 or 2	16	100,000 char/sec.
Uniservo IIIC Magnetic Tape	1	12	62,500 char/sec.
Punched Card	1	1 reader; 1 punch	read 600 cpm; punch 300 cpm.
Printer	1	4	900 lpm.
Punched Paper Tape	1	1 reader; 1 punch	read 400 char/sec; punch 110 char/sec.
UNIVAC 1004	1	1	cards: read 615 cpm, punch 200 cpm; print 600 lpm; paper tape: read 400 char/sec, punch 110 char/sec; magnetic tape: 34,200 char/sec.
Communications (multi-line)	1	4 multiplexors, each serving up to 32 half- or full-duplex lines	4800 bits/sec per line; 51,000 char/sec total.
Communications (single-line)	1	1 1	40,800 bits/sec.

.2 HARDWARE (Contd.)

The UNIVAC 1107 Central Computer can perform fixed-point and floating-point arithmetic on one-word binary operands. The 16 arithmetic registers, 16 index registers, a versatile repertoire of 7-part instructions, recursive indirect addressing, and a partial-word transfer facility permit efficient processing of most scientific problems. Commercial processing is somewhat less efficient because the 1107 lacks automatic facilities for editing, decimal arithmetic, and radix conversions.

Although the 1107 uses a 1-address instruction format, a limited 2-address capability is provided since most instructions can specify the use of any one of the 16 arithmetic registers.

(Contd.)

.2 HARDWARE (Contd.)

The partial-word load and store instructions can transfer any half, third, quarter, or sixth of a word to or from the least significant bit positions of any arithmetic register. A wide variety of logical, shift, search, and block transfer operations can be performed. All instructions can be indexed, and each index register can be automatically incremented or decremented each time it is referenced. Indirect addresses can be "chained", and indexing can be performed upon each address in the chain.

A program interrupt facility causes a transfer of control to one of 74 fixed core locations upon completion of an input-output operation, upon detection of a processor or input-output error, or upon count-down to zero of the real-time clock (its contents are decremented by 1 every millisecond). The interrupt facility permits full utilization of the Central Computer and all peripheral devices under the control of an integrated operating system that handles multiprogramming.

The 1107 has 16 input-output channels, and each channel is capable of transmitting data in one direction at a time. One channel is normally occupied by the Control Console, which provides keyboard input and typed output at 10 characters per second. Each of the remaining 15 channels can accommodate 1 peripheral subsystem, and each subsystem can consist of any of the following groups of devices and their associated control units.

- 1 to 8 Flying Head 880 Magnetic Drums. Each drum stores 786,432 words, with an average access time of 17 milliseconds. Peak data transfer rate is 60,000 words per second. This rapid-access auxiliary storage plays an important role in the operation of several of the software systems.
- 1 to 8 Fastrand Mass Storage Units. Each unit has 2 drums served by 64 movable heads, and stores 12,976,128 words with an average access time of 92 milliseconds. Peak data transfer rate is 25,000 words per second.
- 2 to 16 Uniservo IIIA Magnetic Tape Handlers. Read forward or backward at a peak transfer rate of 100,000 rows per second. Nine tracks are recorded on ½-inch-wide tape at a density of 1,000 rows per inch, with read-after-write row parity checking.
- 2 to 12 Uniservo IIA Magnetic Tape Handlers. Read forward or backward at a peak transfer rate of 12,500 or 25,000 rows per second. Eight tracks are recorded on ½-inch-wide tape at a density of 125 or 250 rows per inch; there is no read-after-write checking.
- 2 to 12 Uniservo IIIC Magnetic Tape Handlers. Read forward only at a peak transfer rate of 22,500 or 62,500 rows per second. Seven tracks are recorded on ½-inch-wide tape at a density of 200 or 556 rows per inch, with read-after-write checking of longitudinal and row parity. The tape format is fully compatible with the IBM 727, 729, and 7330 Magnetic Tape Units.
- 1 Card Reader and 1 Card Punch. These units read standard 80-column cards at 600 cards per minute and punch them at 150 or 300 cards per minute. Reading and punching can be performed in alphameric, row binary, or column binary mode.
- 1 High-Speed Printer. Two models are available: one uses a 51-character set and prints up to 600 alphameric lines per minute; the other uses a 63-character set and prints up to 700 alphameric lines per minute (or up to 922 lines per minute when a restricted set of 40 characters is used).
- 1 Paper Tape Reader and 1 Paper Tape Punch. These units (housed in a single cabinet) can read standard 5-, 6-, 7-, or 8-track punched tape at up to 400 characters per second and punch it at 110 characters per second.

As the above summary indicates, three different types of magnetic tape handlers are available for the 1107, and there is no format compatibility between any two of them. This situation resulted from the manufacturer's decisions to provide a tape handler compatible with earlier UNIVAC systems (the Uniservo IIA), a tape handler compatible with IBM systems (the Uniservo IIIC), and a high-performance tape handler for use where compatibility is not a primary concern (the Uniservo IIIA).

.3 SOFTWARE

Two different basic software packages have been developed for the UNIVAC 1107, and there is little or no compatibility between them. UNIVAC states that maintenance for both packages will continue, but they will not be expanded to include new facilities. The "SLEUTH I Package," also called the "A Package," was developed by UNIVAC's Scientific Computer Department in St. Paul; it includes the following routines:

- SLEUTH I — a symbolic assembly system with macro instruction facilities that translates symbolic source programs into either relocatable or absolute machine language object programs.

.3 SOFTWARE (Contd.)

- EXEC I — an operating system designed to facilitate effective use of 1107 systems by providing the means for automatically processing a scheduled set of jobs with a minimum of operator intervention.
- CLAMP — a Relative Load Routine that loads either absolute or relocatable object programs independently or under control of EXEC I.
- Librarian — a library maintenance routine that creates a library tape and adds, deletes, corrects, resequences, lists, and catalogs programs on existing library tapes.
- LION (Library of Input-Output Numerical Subroutines) — a set of subroutines, called by SLEUTH macro instructions, that perform the following functions in connection with EXEC I:

  Opening and closing of files and reels;
  Input and output on tape, drum, cards, or printer;
  Conversions between decimal and binary radix;
  Data transcriptions (cards to tape or drum, tape or drum to cards, and tape or drum to printer).

- MIDAS (Macro Instructions for Dumping Areas of Store) — a set of subroutines designed to aid debugging by providing printed listings of the contents of specified areas of storage. A valuable option permits listing only the contents that have been altered during execution of the program being tested.
- Sort/Merge — a generalized, relocatable subroutine for sorting or merging files into ascending or descending order. Control parameters are supplied on cards. From 4 to 12 magnetic tape units can be used, and FH-880 Magnetic Drums provide increased sorting speed when available.

The "SLEUTH II Package," also called the "B Package," was developed by Computer Sciences Corporation and includes the following routines:

- SLEUTH II — a symbolic assembly system with macro instruction facilities, that translates symbolic source programs into relocatable machine language object programs. A magnetic drum is required, but magnetic tape is not. (There is no compatibility between SLUETH I and SLEUTH II; even the mnemonic codes for machine instructions are totally different.)
- EXEC II — an operating system designed to monitor the compilation and execution of programs, maximize utilization of the available hardware, and minimize operator intervention. The system utilizes an FH-880 Magnetic Drum as a high capacity buffer store to keep the card readers, punches, and printers fully occupied and as a fast access auxiliary store for program segments. An integrated set of diagnostic aids and library maintenance facilities is included.
- COBOL — a compiler for COBOL-61 source programs that operates under control of EXEC II. Language facilities include nearly all of Required COBOL-61 (there are a few minor deficiencies); several COBOL-61 electives (but not the extremely useful COMPUTE verb); a MONITOR verb (which provides dynamic printouts of the values of specified items); and a SORT facility (but not the one defined as part of Extended COBOL-61). A magnetic drum is required for COBOL compilations, but magnetic tape is not.
- FORTRAN — a compiler for FORTRAN IV source programs that operates under control of EXEC II. Language facilities are largely compatible with those of FORTRAN IV as defined for the IBM 7090/7094. FORTRAN II source programs can be converted to FORTRAN IV by means of the SIFT Translator, which has been compiled and successfully run on the 1107. The FORTRAN compiler achieves rapid compilation speeds through use of an FH-880 Magnetic Drum.
- SORT II — a generalized sort/merge routine that will operate under control of EXEC II.

The SLEUTH II Package is the more widely used of the two software packages because it includes the COBOL and FORTRAN compilers. Most UNIVAC 1107 users belong to USE, the UNIVAC Scientific Exchange, which distributes user-developed programs. Furthermore, the FORTRAN compiler and the SIFT Translator enable 1107 users to utilize the extensive libraries of FORTRAN-coded routines that are now available.

UNIVAC 1107

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*7200		Central Processor	20,590	888,750	2,365
			Main Storage			
	*7230		Core Memory (16 K words, one bank)	4,925	213,750	325
	*7231		Core Memory (16 K words, two banks)	7,215	315,000	480
	*7232		Core Memory (32 K words, two banks)	9,330	405,000	540
	*7233		Core Memory (49 K words, two banks)	13,985	607,500	775
	*7234		Core Memory (65 K words, two banks)	18,380	798,750	955
ATTACHMENTS, ADAPTERS, AND CHANNELS	*8048		Transfer Switch (single)	65	2,700	5
	*8049		Transfer Switch (dual)	125	5,400	10
	*8158		Cabinet (houses 8048 or 8049)	50	2,250	—
	*2502-01		Cabinet (same as 8049 but with integral operator panel)	335	13,000	—
		*F0597-03	*Adapter (for connection to UNIVAC 1004/1005)	205	7,840	20
MASS STORAGE			Drum Storage			
	*7427		Drum Control (controls 1 to 8 FH-880 Drums)	1,550	58,800	190
	*7433		Drum Control (controls up to 8 Fastrand I or II Drums)	2,845	135,000	115
	*0900-00		Drum Fastrand I Mass Storage Unit	3,430	160,000	290
	*7432		Drum FH-880 Magnetic Drum	2,150	85,165	190
INPUT-OUTPUT			Magnetic Tape			
	*7214		Mag Tape Control (controls 1 to 6 Uniservo IIA Tape Units)	1,615	77,500	150
	*7273		Mag Tape Control (controls 1 to 12 Uniservo IIIC Tape Units)	2,700	124,800	230
	*8003-08		Mag Tape Control (controls 1 to 16 Uniservo IIIA Tape Units)	3,935	182,400	195
	*0952-00		Mag Tape Control (for Uniservo IIIC Controls)	1,025	35,460	100
	*8003-99		Mag Tape Control Dual	5,180	240,000	300
	*7424		Tape Adapter Cabinet (for Uniservo IIIC Control)	1,040	48,000	60
	*0850-02		Mag Tape Unit (Uniservo IIIA; 1,000 bpi; 133,000 char/sec)	790	36,550	175
	*0851-03		Mag Tape Unit (Uniservo IIIC; 200/556 bpi)	780	28,360	70
	*0854-02		Mag Tape Unit (Uniservo IIA Magnetic Tape Unit)	475	20,000	110
	*7274-02		Translate Option	260	10,000	30
	*0851-04		Mag Tape Unit (Uniservo IVC Tape Unit; 200/556/800 bpi)	835	29,050	110
		*F0684-00	800 PPI Option	105	3,600	5
	*8142		Power Supply	570	25,300	45
			Paper Tape			
	*7423-02		Paper Tape Subsystem	675	25,350	125

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Punched Card			
	*7240		Card Control (controls one 7906 Reader and one 7224 Punch)	2,335	83,250	265
	*7277		Card Control (controls one 7906 Reader and one 0650 Punch)	2,335	83,250	265
	*0650-01		Card Punch (300 cards/min)	1,320	57,500	340
	*7224-00		Card Punch (150 cards/min)	535	25,000	205
	*7906-01		Card Reader (600 cards/min)	365	17,500	85
			Printers			
	*7299-00		Printer Control (controls one 0751-01 Printer)	1,825	80,000	185
	*7299-01		Printer Control Dual (controls two 0751-01 Printer)	2,855	125,000	245
	*7319		Printer Control (controls one 7400-01 Printer)	2,085	90,000	245
	*0751-01		Printer (700/922 lines/min)	850	36,000	275
	*7400-01		Printer (scientific printer) (102 - symbol character set including upper and lower case alphabetics)	955	40,500	275

NOTES:

*No longer in production.

AUERBACH ®

REPORT UPDATE

▶ UNIVAC ANNOUNCES 1100 INPUT/OUTPUT SYSTEM FOR 1108 SYSTEMS

UNIVAC on December 9, 1968 announced the 1100 INPUT/OUTPUT System (IOS). This, declared by the manufacturer to be "a major new product enhancement", is a new processing unit designed to assume input/output processing for the large-scale UNIVAC 1108 including servicing on-site peripherals and remote terminals. These processing functions could include card handling, line printing, requests for retransmission, communication line termination, message buffering, translation, data formatting and editing.

The hardware is compatible with the 1108. It has a 900 nanosecond main memory of 32K to 131K 36-bit words, an instruction subset of the 1108 and a typical add time of less than 2 microseconds. Other features include hardware tabling of communications interrupts, buffer chaining, and up to 16 bi-directional channels with a total channel rate in excess of 2 million words per second.

The instruction subset includes the instructions necessary for the IOS to perform computation on its own, but does not include such features of the 1108 set as floating point and double precision which would be of doubtful value.

The various tasks to be performed by the 1100 IOS such as message switching, data reduction and data manipulation will be programmed by the user. UNIVAC will provide an Assembler for this purpose.

UNIVAC's marketing strategy is focused on the 1108 user that needs additional input/output capability. The 16 bi-directional channels provide the high channel rate needed and reduced usage of the 1108 for I/O. They, UNIVAC, conceive of this device as being a logical step upward for the users of their Input/Output Controllers (IOC), providing all of the functions of the IOC plus the formatting, editing and translating that was handled by the 1108 processor. UNIVAC considers that the 1100 IOS will be an effective counter to competitors who would probably propose a small-to-medium scale general purpose system to serve the same purposes.

The only pricing information released to date is that the purchase prices are set to start at approximately $185,000. UNIVAC has scheduled initial deliveries for the fourth quarter of 1969.

REPORT UPDATE

UNIVAC INTRODUCES 1100 FAMILY

On March 28, 1969 UNIVAC announced a new addition to their product line — the 1106. The 1106 heralds the development of the 1108 into a full family of computers that will include the new 1106 and the 1108 together with more powerful models to be announced in the future. The UNIVAC 1106 is a medium to large scale computer with the capability to execute most instructions in one memory cycle (1.5 microseconds). Like the 1108, the 1106 is based around a binary single-address processor. Memory will be available in capacities of 65,536, 98,034, 131,072, 196,608 or 262,144 36-bit words. The Control Memory consists of 128 integrated-circuit registers with a cycle time of 166 nanoseconds. From both a hardware and a software point of view UNIVAC has maintained compatibility with the more powerful 1108 with the exception of multi-processing which is not available on the 1106. This will not only make it possible for the 1106 user to graduate to the larger system, but may prove attractive to the 1108 user who needs an "1108-and-a-half."

In the competitive market, the 1106 will be confronting the IBM 360/50. UNIVAC would appear to have a significant price/performance ratio advantage based on internal speeds. The 1106 has four standard and up to twelve optional I/O channels each within a capacity of 333,000 words per second or a total system capacity of 667,000 words per second. This is more than twice as fast as the capacity of the 360/50. UNIVAC, however, does not have available a multiplexer channel, which means that a low-speed subsystems, such as card reader/punch, will have to be connected through a high-speed channel, thus negating some of this advantage. Another deficiency of the 1106 with respect to the Model 50 is a direct result of using the 1108 architecture; it lacks hardware editing, decimal arithmetic, and radix conversion capabilities. This will necessitate the use of either software routines or a "front-end" processor, especially in the commercial market, which is the province of the IBM system.

All peripherals currently available with the 1108 will be available on the 1106.

The basic Control Console will include a Display Console (incorporating a CRT display and keyboard); a Day Clock showing the time of day in hours, minutes and hundredths of minutes; and the Operator Control and Indicator panel. Instead of the Display Console, a keyboard and printer may be specified. Other features available are an auxiliary console to accommodate Communications subsystems and the UNIVAC Pagewriter.

Because of the compatibility of the 1106 with the 1108, all software created for the 1108 is directly executable on the 1106. This includes both EXEC 2 and EXEC 8 operating systems. UNIVAC expects that systems dedicated to batch processing, as well as those smaller than 131K, will use EXEC 2.

EXEC 2 is part of a package that was, in its original form, offered to 1107 users as the "B" software package. Since then it has undergone several enhancements. EXEC 2 is an operating system that is designed to control the compilation and execution of programs, maximize utilization of the available hardware, and minimize operator intervention. The system uses a magnetic drum as a high-capacity buffer store to keep the card readers, card punches, and printers fully occupied and as a fast-access auxiliary store for program segments. One notable characteristic of EXEC 2 is its lack of facilities for true multiprogramming; concurrent program execution is limited to one main program plus multiple data transcriptions (Symbionts). The EXEC II package also includes, an assembler, a FORTRAN V compiler, LIFT (a FORTRAN II to FORTRAN V translator), a COBOL '65 compiler, a sort/merge program, a tape pre-mount package, and a variety of applications packages. The minimum configuration required to operate EXEC 2 on the 1106 is:

- 1 1106 CPU with 65K of memory;
- 1 Operator's console with:

  Keyboard and Printer or

  Display Console and UNIVAC Pagewriter;

- 1 FH-432/1782 Magnetic Drum Subsystem with:

  3 FH-432 Drums or

  1 FH-1782 Drum;

- 1 UNISERVO Magnetic Tape Subsystem with:

  2 UNISERVO VI C Magnetic Tape Units or

  2 UNISERVO VIII C Magnetic Tape Units;

- 1 Online UNIVAC 9300 System with:

  8K storage

  132 print position Printer

  Multiplexer I/O channel

  600 Card/min card reader with Multi-Strobe Read-Feature

  Inter-Computer Control Unit

  200 Card/min card punch.

The EXEC 8 Executive System, the chief component of the EXEC 8 package, is a comprehensive group of routines designed to control all activities of an 1106 computer system, including job scheduling, hardware allocation, I/O control, and run supervision in a multiprogramming environment. Other facilities provided by EXEC 8 include library facilities, I/O control, file control, automatic writing of checkpoints and segmentation. The principal orientation of the EXEC 8 system is toward maximizing the throughput of batch operations, while providing facilities for handling useful amounts of real-time and demand processing. Program areas are protected from the actions of another program (except for I/O operations) by hardware provisions, under control of the Executive. Protection of program areas from the input-output operations of other programs is accomplished through software checks. In addition to the Executive, other components of the EXEC 8 system include an assembler, FORTRAN V and conversational FORTRAN compilers, a COBOL '65 compiler, LIFT (a FORTRAN II to FORTRAN V translator), a JOVIAL compiler, a sort/merge program, and a large variety of applications packages. BASIC is available from the UNIVAC Program Library Interchange, but is not supported by UNIVAC. ALGOL and PL/1 compilers are not available. The minimum configuration required to operate EXEC 8 on the 1106 is:

- 1 1106 CPU with 131K of memory;

- 1 Operator console with:

  Keyboard and Printer or

  Display Console and UNIVAC Pagewriter;

- 1 FH432/1782 Magnetic Drum Subsystem with:

  3 FH432 Drums or

  1 FH1782 Drum;

- 1 FASTRAND Subsystem with:

  1 FASTRAND II or

  1 FASTRAND III;

- 1 UNISERVO Magnetic Tape Subsystem with:

  2 UNISERVO VIC Magnetic Tape Units or

  2 UNISERVO VIIIC Magnetic Tape Units.

UNIVAC plans to begin deliveries of the 1106 to customers in the first quarter of 1970.

UNIVAC 1106 PRICE DATA

Type/Feature Number	Name	Monthly Rental (1-Year), $ **	Purchase, $	Monthly Maintenance, $
3011-20	1106 Processor: includes 128 word control memory; Double Precision Floating Point; four I/O Channels with ESI; and Power Distribution Center. Quarter word ESI logic may be selected at time of installation. Display Console Type 4009-99 is required.	7,065	283,230	1,165
F0680-99	I/O Channel Expansion: four additional I/O Channels; maximum of three Expansions may be added per 1106 Processor	545	21,000	60
F1272-00	Conversion Kit: permits Processor Type 3011-20 to be converted to Type 3011-95, 1108-II, Processor (field installable; storage units must be exchanged for Types 7005-70, -71, -72, and -73)	9,660	346,170	1,160
4009-99	Display Console: includes Control Console, Entry Keyboard, a CRT Display capable of displaying 16 lines of 64 characters each and a freestanding Pageprinter capable of printing 80 character lines at 25 characters per second	1,000	32,625	250
*7005-60	Multi-Module Storage - 65K: 65,536 36-bit words (2 modules of 32,768 words. 1.5-microsecond cycle time; includes cabinet and power supply)	4,665	205,875	375
*7005-59	Multi-Module Storage - 98K: 98,304 36-bit words (3 modules of 32,768 words; 1.5-microsecond cycle time; includes two cabinets and power supply. Not field upgradable to 131K; one cabinet and module must be exchanged for Type 7005-09 Multi-Module Storage Unit)	7,000	308,815	565
*7005-58	Multi-Module Storage - 131K: 131,072 36-bit words (4 modules of 32,768 words; 1.5 microsecond cycle time. Includes two cabinets and power supply)	9,325	411,750	745
*7005-57	Multi-Module Storage - 196K: 196,608 36-bit words (6 modules of 32,768 words; 1.5-microsecond cycle time; includes 3 cabinets and power supply)	13,985	617,625	1,120
*7005-56	Multi-Module Storage - 262K: 262,144 36-bit words (8 modules of 32,768 words; 1.5 microsecond cycle time; includes 4 cabinets and power supply)	18,645	823,500	1,490

* 1.5-microsecond core with overlap capability.
** UNIVAC does not include maintenance prices in the rental charges in their published price data; for convenience of comparison, maintenance charges have been included in the monthly rental column.

SUMMARY: UNIVAC 1108

.1 BACKGROUND

The UNIVAC 1108 computer system is a large-scale data processing system, oriented toward both scientific and business applications, that features multiprogramming and multiprocessing capabilities for increased hardware utilization. Monthly rentals for typical single-processor 1108 configurations generally fall in the $45,000 to $60,000 range. The cost of an 1108 system is typically lower than the original price of an equivalent UNIVAC 1107 system — the 1108's predecessor in the UNIVAC line — despite the 1108's five-fold advantage in internal speeds. Typical multiple-processor configurations rent for upwards of $100,000 per month.

The UNIVAC 1108 was originally announced in July 1964 as a faster, expanded version of the UNIVAC 1107 (see Computer System Report 784). Shortly afterward, UNIVAC stated that the development of multiple-processor hardware for the 1108 was under way. This hardware was first documented and described to prospective users in August 1965, but its official announcement was delayed until December 1965, when the multiple-processor version was introduced as the UNIVAC 1108-II. This, however, is only a marketing designation; the single-processor and multiple-processor versions of the 1108 use the same hardware components, and both versions are described in this report. The first single-processor 1108 system was delivered in December 1965, and the first multiple-processor configuration was delivered in the third quarter of 1967.

The 1108 is currently enjoying widespread acceptance within the large-scale computer market. Certainly, some of this success is due to the setbacks suffered by other manufacturers in implementing large and complex programming systems on their third-generation computers. Another factor significantly enhancing acceptance of the 1108 is its time-tested software and proven ability to function effectively in a variety of scientific and commercial applications.

UNIVAC has had several years of experience in multiprogramming (i.e., the capability to maintain several independent programs in core storage at the same time and to switch control among them to more fully utilize the hardware). This experience was gained with the UNIVAC III, 490, and 1107 computer systems. Many new features in the 1108, not found in other UNIVAC systems, are oriented toward optimizing the use of the hardware through multiprogramming.

The 1108 is largely program-compatible with the 1107, although existing 1107 programs will need to be reassembled or recompiled to run under control of the 1108 EXEC 8 Operating System. Most existing 1107 object programs can be run directly on an 1108 under control of a modified version of EXEC II, one of the standard operating systems for the 1107.

Figure 1. An 1108 System showing main operator's console.

.1 BACKGROUND (Contd.)

Chief extensions of the 1108 with respect to its predecessor, the 1107, include:

- Expanded core memory capacity — up to 262,144 36-bit words.
- Significantly faster core memory and internal processing speeds — basic cycle time is 0.75 microsecond.
- Double-precision fixed-point and floating-point arithmetic facilities.
- Greatly improved memory protection and addressing techniques.
- Provisions for I/O Controller units that can access memory independently of the Central Processor(s).
- Capability for up to five Central Processors and I/O Controllers to share a common core memory.
- Provisions for up to eight independent core memory modules.

.2 HARDWARE

.21 System Configuration

A single-processor 1108 configuration consists of one 1108 Central Processor with console and 8, 12, or 16 input-output channels; two, four, six, or eight 32,768-word modules of core memory (a maximum of 262,144 words); and peripheral subsystems as required. Tables I and II summarize the available subsystems and the number of input-output channels that each subsystem requires. The console also requires one input-output channel. In addition, up to three I/O Controller units, each having 4, 8, 12, or 16 input-output channels, can be included.

A multiprocessor (1108-II) configuration consists of up to five 1108 Central Processors and I/O Controllers in any combination; four, six, or eight 32,768-word modules of core memory (a maximum of 262,144 words); and peripheral subsystems as required. The input-output channels provided by the I/O Controllers are in addition to the Processor I/O channels.

Normally, in a multiprocessor configuration, critical peripheral subsystems such as magnetic drums are connected to both an I/O Controller channel and a Processor channel to provide redundant data paths for increased reliability. Although up to five Central Processors can share the same core memory, the operating system being provided by UNIVAC for the 1108 will contain provisions for a maximum of three Processors and two I/O Controllers.

.22 Core Memory

Core memory can consist of up to 262,144 word locations in increments of 65,536 words. Each 36-bit word location can hold one instruction, one single-precision floating-point data item, from one to six fixed-point data fields, four 8-bit bytes (quarter-words), or six alphameric characters. Unlike the UNIVAC 1107, which has no checking provisions for data stored in core memory, the 1108 records a parity bit with each half-word of memory. Each 32,768-word module can be accessed independently.

The basic cycle time of the 1108's memory is 0.75 microsecond — over five times as fast as the 1107's 4-microsecond cycle. Like the 1107, the 1108 Central Processor can simultaneously access two different memory modules. If instructions and operands are stored in separate modules, the effective execution time for most instructions can be reduced by one memory cycle (0.75 microsecond). In all multiprocessor (1108-II) configurations, the physical address locations are interleaved within each pair of memory modules; the even locations are in one module and the odd locations in the other. Such interleaving reduces the frequency of conflicts when two Central Processors are executing programs that are physically located in the same memory modules.

.23 Control Memory

The 1108's Control Memory, which corresponds to the 1107's Thin-Film Memory, consists of 128 36-bit word locations. The Control Memory utilizes integrated circuits and has a cycle time of 0.125 microsecond. In the 1108, 70 of the 128 locations are reserved for use by supervisory routines; these reserved locations include a separate complete set of index registers, arithmetic registers, and control registers, as well as the Input/Output Access Control Registers. The 48 locations available to the user's program include 15 index registers, 16 arithmetic registers, and 4 control registers; the remaining 17 locations can be used by the programmer for intermediate storage. In both the reserved and user's area of Control Memory, four locations can be used as either index registers or arithmetic registers, permitting some unusual and powerful address modification operations.

.24 Central Processor

The UNIVAC 1108 Central Processor can perform fixed-point and floating-point arithmetic on one-word or two-word binary operands (although double-precision fixed-point arithmetic

(Contd.)

.24 Central Processor (Contd.)

is limited to addition and subtraction). The 16 arithmetic registers, 15 index registers, a versatile repertoire of 7-part instructions, recursive indirect addressing, and a partial-word transfer facility permit efficient processing of most scientific and commercial applications, although commercial processing will be somewhat less efficient because the 1108, like the 1107, lacks automatic facilities for editing, decimal arithmetic, and radix conversions.

Although the 1108 uses a one-address instruction format, a limited two-address capability is provided since most instructions can specify the use of any one of the 16 arithmetic registers. The partial-word load and store instructions can transfer any half, third, quarter, or sixth of a word to or from the least significant bit positions of any arithmetic register. A wide variety of logical, shift, search, and block transfer operations can be performed. All instructions can be indexed, and each index register can be automatically incremented or decremented each time it is referenced. Indirect addresses can be "chained," and indexing can be performed upon each address in the chain. Straightforward programming of the UNIVAC 1108 is not unusually complex, but only skilled, highly-trained programmers will be able to take full advantage of the powerful optional elements offered in most instructions.

A program interrupt facility causes a transfer of control to one of 42 dynamically reassignable core memory locations upon completion of an input-output operation, upon detection of a Processor or input-output error, or upon count-down to zero of the real-time clock (whose contents are decremented every 200 nanoseconds). A programmable day clock that can interrupt the executive system is also provided. The interrupt facility permits full utilization of the Central Processor and all peripheral devices under the control of an integrated operating system that handles multiprogrammed operations.

Like other recent computer systems designed for multiprogramming, the 1108 Central Processor can operate in one of several modes, which vary in the facilities they make available to the program.

In the Guard mode, relative addressing is in effect; i.e., program addresses are modified by the contents of Basing Registers prior to all operations that require access to core memory. The upper and lower program address limits are specified by the contents of the Storage Limits Register. Any reference to the reserved set of registers in the Control Memory, any attempt to read or write into areas outside the program limits, or any attempt to execute a reserved instruction results in an interrupt. The reserved instructions include loading of certain control registers and all input-output instructions. All users' programs are executed in the Guard mode.

The Privileged mode is similar to the Guard mode, except protection is provided only against writing, not against reading. Thus, programs stored in protected locations can be executed but cannot be overwritten.

In the Open mode, the complete facilities of the processor are available; there are no restrictions on the core locations accessed or on the instructions used, and relative addressing is not in effect. Only the supervisory routines are allowed to operate in this mode.

.25 Peripheral Equipment

Three different magnetic drum units are available for use in 1108 systems. Two, the FH-432 and FH-1782, are rapid-access, word-addressable units designed to facilitate the rapid exchange of programs or routines between core storage and drum storage. One FH-432 drum subsystem or equivalent with at least 786,000 words of storage is required for use of the standard EXEC 8 Operating System. The third drum storage unit, Fastrand II, is also used with several other UNIVAC computer systems. Fastrand II employs movable access mech-

TABLE I: UNIVAC 1108 MAGNETIC DRUMS

Characteristic	FH-432	FH-1782	Fastrand II
Average access time, msec	4.25	17	92
Peak transfer rate, words/sec	240,000	240,000	25,625
Maximum storage per subsystem, 36-bit words	2,097,152	16,777,216	176,160,768
Maximum drum units per subsystem	9*	8*	8
Number of input-output channels per subsystem	1 or 2	1 or 2	1 or 2

* Up to 8 FH-432 and FH-1782 drum units, in any combination, can be connected to the same controller.

.25 Peripheral Equipment (Contd.)

anisms to provide somewhat slower access to much larger quantities of data than the head-per-track FH-432 and FH-1782 drums. A summary of the principal characteristics of each of these drum units is contained in Table I. Notably absent from the current UNIVAC line of random-access peripheral devices is a changeable-cartridge unit.

UNIVAC now offers only IBM-compatible magnetic tape units in the standard line of peripheral devices for the 1108. The characteristics of the Uniservo VIC and VIIIC Magnetic Tape Handlers are summarized in Table II. Both tape handlers are available in 9-track versions compatible with IBM's 2400 Series Magnetic Tape Units, as well as in the more common, IBM 729-compatible 7-track versions.

UNIVAC offers both multi-line and single-line controllers to serve as interfaces between an 1108 computer system and communications lines. The Communication Terminal Module Controller is capable of controlling up to 32 half-duplex or full-duplex narrow-band or voice-band lines. Various Communication Terminal Modules permit communications with remote terminals operating at up to 4,800 bits per second, synchronously or asynchronously, and utilizing transmission codes of up to eight levels. Up to four Communication Terminal Module Controllers can be included in a Communications Subsystem, via a Scanner/Selector Unit; each Communications Subsystem fully occupies one 1108 input-output channel. All communications lines can be active simultaneously, subject to a maximum data rate of 51,000 characters per Communications Subsystem.

The Word Terminal Synchronous (WTS) and Communications Terminal Synchronous (CTS) are single-line controllers capable of controlling data communications over a single voice-band line at 2,000 or 2,400 bits per second, or over a broad-band line at 40,800 bits per second. Each Terminal fully occupies one 1108 input-output channel. The chief difference between the two Terminals is that the WTS transfers data in units of one 36-bit word between the 1108 and the controller, whereas the CTS transfers data in units of one character. With

TABLE II: UNIVAC 1108 INPUT-OUTPUT SUBSYSTEMS

Subsystem	Number of I/O Channels per Subsystem	Maximum Number of Devices per Subsystem	Peak Speed
Uniservo VIC Magnetic Tape	1 or 2	16	34,200 char/sec.
Uniservo VIIIC Magnetic Tape	1 or 2	16	96,000 char/sec.
Punched Card	1	1 reader; 1 punch	read 900 cpm; punch 300 cpm.
Printer	1	4	1600 lpm.
Punched Paper Tape	1	1 reader; 1 punch	read 1000 char/sec; punch 240 char/sec.
UNIVAC 1004	1	1	cards: read 615 cpm, punch 200 cpm; print 600 lpm; paper tape: read 400 char/sec; punch 110 char/sec; magnetic tape: 34,200 char/sec.
Communication Controller (multi-line)	1	4 multiplexors, each serving up to 32 half- or full-duplex lines	4800 bits/sec per line; 51,000 char/sec total.
Communication Controller (single-line)	1	1	40,800 bits/sec.
UNISCOPE 300 Visual Communication Terminal	1	24 (16-line) 48 (8-line)	400 char/sec.

(Contd.)

.25 Peripheral Equipment (Contd.)

appropriate adapters or features, any of these communications controllers can operate over the public telephone network and can be equipped for unattended operation and automatic dialing.

The other peripheral devices available for use with an 1108 computer system are listed in Table II.

UNIVAC 1107 users who are installing an 1108 system can carry over the same magnetic drum and magnetic tape units they are currently using with the 1107. Specific provisions are included in the standard 1108 software for handling FH-880 Magnetic Drums and Uniservo IIA, IIIA, IIIC, and IVC Magnetic Tape Handlers, even though these 1107 peripheral units will not be actively marketed with the 1108.

.26 Simultaneous Operations

The 1108's capability for simultaneous operations is high. In addition to the overlapped operations of one or more Central Processors, all input-output channels in the Central Processors and I/O Controllers can be active simultaneously, subject to the peak data rate limitations of each channel and the associated Processor or I/O Controller. Each channel can handle a maximum of 250,000 data transfers per second; maximum capability of each Processor or I/O Controller is 1.33 million transfers per second. Most data transfers consist of one 36-bit binary word (or six 6-bit data characters), in which case each Processor or I/O Controller can handle up to 8 million characters per second. Some peripheral units, such as the Punched Paper Tape Subsystem, Communications Subsystem, and Communications Terminal Synchronous, transfer only one character per data transfer. In general, only one core storage cycle is required for each data transfer.

.3 SOFTWARE

.31 EXEC II Software

Prior to delivery of the full 1108 software package, as outlined in Paragraph .32, UNIVAC is supplying 1108 users with a slightly modified version of the "B" Software Package for the 1107. The principal components of this package are:

- EXEC II — an operating system designed to monitor the compilation and execution of programs, maximize utilization of the available hardware, and minimize operator intervention. The system utilizes a magnetic drum as a high-capacity buffer store to keep the card readers, punches, and printers fully occupied and as a fast-access auxiliary store for program segments. An integrated set of diagnostic aids and library maintenance facilities is included. One notable characteristic of EXEC II is its lack of facilities for true multiprogramming; concurrent program execution is limited to one main program plus multiple data transcriptions.
- SLEUTH II — a symbolic assembly system, with macro-instruction facilities, that translates symbolic source programs into relocatable machine-language object programs. SLEUTH II is synonymous with 1107 Assembler.
- COBOL — a compiler for COBOL-61 source programs that operates under control of EXEC II. Language facilities include nearly all of Required COBOL-61 (there are a few minor deficiencies); several COBOL-61 electives (but not the very useful COMPUTE verb); a MONITOR verb (which provides dynamic printouts of the values of specified items); and a SORT facility (but not the one defined as part of Extended COBOL-61). A magnetic drum is required for COBOL compilations, but magnetic tape is not.
- FORTRAN — a compiler for FORTRAN V source programs that operates under control of EXEC II. Language facilities are largely compatible with those of FORTRAN IV as defined for the IBM 7090/7094. FORTRAN II source programs can be converted to FORTRAN V by means of a LIFT Translator. The FORTRAN compiler achieves high compilation speeds through use of a magnetic drum.
- SORT II — a generalized sort/merge routine that operates under control of EXEC II.
- Applications Packages — a comprehensive set of application programs has been developed for the 1108 by both UNIVAC and users' groups; the set includes: APT III, PERT, Linear Programming, Simscript, Simula, Mathpack, Statpack, and GPSS II General Purpose Simulator. All can run under control of EXEC II or EXEC 8.

With this software, the 1108 will, in effect, perform as an 1107 that is over five times as fast internally as the original 1107; the peripheral performance is determined by the 1108's configuration. UNIVAC states that the majority of 1107 object programs can be executed directly by an 1108 under control of the modified EXEC II system. Significant exceptions

.31 Interim Software (Contd.)

include some 1107 FORTRAN and COBOL programs, because the 1107 FORTRAN and COBOL compilers used "illegal operation code" interrupts to provide entries into certain standard functions. Such programs would not, in general, be executed properly by an 1108.

The "B" Software Package for the 1107 was developed by Computer Sciences Corporation and is serving as a foundation for the 1108 software development program. UNIVAC states that certain portions of the EXEC 8 software package described below, including 1108 COBOL, 1108 FORTRAN V, and 1108 SORT/MERGE, are capable of operation on an 1108 under control of the modified EXEC II operating system.

.32 EXEC 8 Software

The chief component of the standard software being prepared for the 1108 is the EXEC 8 Executive System, a comprehensive operating system designed to control all activities of an 1108 installation. The software support package for the 1108 will include an assembler, compilers for COBOL, FORTRAN, and ALGOL, and several useful application programs. The scheduled delivery date for the full 1108 software package is the first quarter of 1968. Most 1108 software, with the exception of the Executive System, will be similar to, or direct extensions of, 1107 software. Programs written for an 1107 will, in general, need to be recompiled or reassembled on an 1108 in order to run under supervision of the 1108 Executive System.

The EXEC 8 Executive System is a comprehensive group of routines designed to control all activities of an 1108 computer system, including job scheduling, hardware allocation, I/O control, and run supervision, in both a multiprogramming and a multiprocessing enviroment. Other facilities provided by EXEC 8 include library facilities, I/O control, file control, automatic writing of checkpoints, and segmentation.

EXEC 8 recognizes three types or levels of processing: real-time, demand, and batch. Real-time processing is characterized by the need for a computer response to an external event quick enough to achieve a desired goal. Real-time processing is normally, but not exclusively, associated with data communications or process control applications where delay in obtaining computer time could result in lost data or process malfunctions. Demand processing is typified by the need for "conversation" between the computer and the user; i.e., the user will specify the execution of certain tasks dependent on the results of previously-initiated tasks. Batch processing is the normal execution of independent tasks (programs) or groups of tasks that are not highly time-dependent. The order of priority for scheduling and execution, in descending order, is real-time, demand, and batch.

The principal orientation of the EXEC 8 System is toward maximizing the throughput of batch operations, while providing facilities for handling useful amounts of real-time and demand processing. The type of processing is specified in the control statements initiating a run, and sometimes within each task of a run (i.e., the type of processing can vary for each task within a run).

Program areas are protected from the actions of another program (except for I/O operations) by hardware provisions, under control of the Executive. Protection of program areas from the input-output operations of other programs is accomplished through software checks.

The EXEC 8 Executive System can be utilized on any 1108 configuration incorporating at least 786,000 words of FH-432 Magmetic Drum storage or equivalent. The Executive System contains provisions for handling any 1108 configuration that includes up to three Central Processors and two I/O Controllers. The minimum resident core storage requirement is 20,000 words.

The other major items in the software support package for the 1108, which operate under control of the EXEC 8, include:

- 1108 Assembler — a symbolic assembly system that is virtually identical with SLEUTH II for the 1107 (see Paragraph .31), with additional mnemonics for the new 1108 instructions.
- 1108 COBOL — a compiler for programs written in COBOL-61. Language facilities include those of Required COBOL-61, except for a few minor deficiencies, and many COBOL-61 electives, including the COMPUTE verb and the extended version of the SORT verb.
- 1108 FORTRAN — a compiler for programs written in a language that UNIVAC calls "FORTRAN V." The language facilities represent significant extensions of FORTRAN V as implemented for the 1107, including provisions to facilitate the writing and deletion of debug statements, and to assign types implicitly, according to the first letters of variable names. The 1108 FORTRAN V language includes, as proper subsets, all the language facilities of 1107 FORTRAN IV, IBM 7090/7094 FORTRAN IV, and the USASI FORTRAN language.

.32 1108 Software (Contd.)

FORTRAN II source programs can be accommodated through use of the LIFT translator; LIFT converts the source-language statements into 1107 FORTRAN V statements, which can then be compiled by the 1108 FORTRAN V compiler. Two distinct versions of the FORTRAN V compiler are offered for the 1108. One is a fast, efficient compiler for batch programs. The second is an interactive, "conversational mode" compiler for servicing users, who desire statement-by-statement program execution at remote terminals.

- ALGOL — a compiler for programs written in ALGOL 60; its language facilities conform to the ACM and GAMM committee specifications.
- 1108 SORT/MERGE — a generalized subroutine used in conjunction with a series of parameter lists to produce sort programs. The complete program specifications can be entered via the control stream or can be incorporated into a larger program. Fastrand II magnetic drum storage can be utilized to speed sorting.

Application packages available for the 1108 include: Linear Programming, PERT/COST, APT III (for computer-assisted programming of numerically-controlled machine tools), BEEF (an extensive series of subroutines developed by Westinghouse Electric Corporation's Baltimore Defense and Space Center to enhance FORTRAN's capabilities as a scientific processing language), Mathpack routines, Statpack routines, several general-purpose system simulators (GPSS II and SIMULA), a Biomedical Support package (BIOMED), an analog simulator (MIMIC), and a powerful matrix manipulation package (BEMAT).

UNIVAC 1108

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3011-95		1108-II Processor (requires Display Console; includes 8 I/O channels)	16,725	629,400	2,325
		F1053-99	Multiprocessor Capability(2)	200	8,700	-
		F0680-01	I/O Channel Expansion (additional 4 channels; maximum of 16 channel total per Processor)	545	21,000	60
	*3011-99		1108 Central Processor	16,890	633,000	2,400
	*3011-97		1108A Unit Processor	17,225	646,800	2,425
		*F1052-00	Multi-Processor Feature	4,700	204,500	-
		*F1053-00	Multi-Processor Feature	4,700	204,500	-
		*F0680-00	I/O Channel Expansion	545	21,000	60
			Console			
	4009-99		Display Console (includes keyboard, page printer, and CRT display)	1,000	32,625	250
		F0774-00	Auxiliary Console (left- or right-hand addition; accommodates 1 to 4 CTMC's)	165	6,600	10
		F0774-01	Auxiliary Console (same as F0774-00 except located between consoles of two Processors)	165	6,600	10
			Main Storage			
	7005-73		Storage (65K words; for use by EXEC II operating system only)	11,190	457,500	745
	7005-72		Storage (13K words)	22,230	915,000	1,345
	7005-71		Storage (196K words)	33,290	1,372,500	1,965
	7005-70		Storage (262K words)	44,255	1,830,000	2,490
	7005-63		Storage Expansion (65K words; for field expansion from 65K to 131K)	11,040	457,500	600
	7005-64		Storage Expansion (65K words; for field expansion from 131K to 196K)	11,060	457,500	620
	7005-65		Storage Expansion (65K words; for field expansion from 196K to 262K)	10,965	457,500	525
	*7005-94		Core Memory (65K words)	10,975	448,000	735
	*7005-93		Core Memory (131K words)	21,800	897,000	1,325
	*7005-90		Core Memory (65K words)	11,190	457,500	745
	*7005-89		Core Memory (131K words)	22,230	915,000	1,345
	*7005-92		Core Memory (196K words)	33,295	1,372,500	1,965
	*7005-91		Core Memory (262K words)	44,260	1,830,000	2,490

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS			For Multiprocessor Configurations			
	5013-00		I/O Controller (includes 4 I/O channels and 256-word index storage; can address 131K of storage via MMA units)	4,120	174,000	120
		F0778-00	I/O Channel Expansion (additional 4 I/O channels; maximum of 16 I/O channels per I/O Controller)	580	22,620	60
		F0790-00	Storage Expansion (additional 256-word index storage)	705	32,450	-
		F0832-00	Processor Interface (provides interface for second Processor)	120	5,220	-
		F0832-01	Processor Interface (provides interface for third Processor)	120	5,220	-
		F0833-00	MMA Interface (extends core addressing capability to 196K)	60	2,610	-
		F0833-01	MMA Interface (extends core addressing capability from 196K to 262K)	60	2,610	-
	2506-00		Availability Control (ACU) (includes control and console; displays system status and controls system configuration; provides access to 6 SPI's, 4 MMA's, 3 Processors, and 2 I/O Controllers.)	1,315	52,200	115
		F0874-00	ACU Expansion (provides access to 6 additional SPI's; maximum capacity of ACU is 24 SPI's total)	75	2,830	10
	0954-99		Multi-Module Access (MMA) (permits access of 2 Processors and 1 I/O Controller to 1 65K Storage Module)	1,350	56,550	50
		F0879-00	MMA Expansion (increases capability for access to storage Module to 3 Processors and 2 I/O Controllers)	60	2,610	-
			Shared Peripheral Interface (SPI) (36-bit interface that permits control of a peripheral subsystem by multiple Processors or I/O controllers):			
	0955-04		SPI (for control by 2 Processors or I/O controllers; includes cabinet with space for second SPI)	475	19,575	25
	0955-05		SPI (same characteristics as 0955-04 and occupies the extra space)	420	17,400	20
		F0789-00	SPI Expansion (adds third interface)	85	3,480	5
		F0789-01	SPI Expansion (adds fourth interface)	60	2,395	5
		F0597-03	1004 Control (36-bit interface for direct communication with on-site UNIVAC 1004)	205	7,840	20
		F1067-00	Redundant Read Capability	65	2,390	10
		F0597-97	1004 Control (36-bit interface for direct communication with on-site UNIVAC 1004; includes Redundant Read Capability)	270	10,230	30
			Other			
		F0893-00	Transfer Switch (permits manual switching of peripheral subsystems and processors between I/O channels; 36-bit interface; switches can be cascaded if desired)	168	6,540	18
	2508-00		Switch Cabinet (contains power supply, integral operators panel, and control unit for up to 5 Transfer Switches in any combination)	405	12,740	60
	2508-01		Switch Cabinet (same as 2508-00 but with remote operator panel)	405	12,740	60
	2508-02		Switch Cabinet (same as 2508-00 but includes auxiliary power supply and can accommodate only 4 Switches)	598	20,000	88

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Cont'd)			Other (Cont'd)			
	2508-03		Switch Cabinet (same as 2508-01 but includes auxiliary power supply and can accommodate only 4 Switches)	598	20,000	88
MASS STORAGE			Drum Storage			
	7304-01		FH 880 Drum (786,432 36-bit words)	2,150	85,165	190
	7427-03		FH 880 Control (controls 1 to 8 FH 880 Drums)	1,550	58,800	190
	6016-00		FH 432 Drum (bit words)	1,070	42,435	100
	6015-00		FH 1782 Drum (bit words)	2,940	117,210	260
		F0786-01	Dual Channel (for FH 432)	70	2,255	15
		F0767-00	Dual Channel (for FH 1782)	70	2,255	15
	5012-00		FH 432/FH 1782 Control (controls 1 to 8 FH 432 or FH 1782 Drums in any combination)	2,145	82,515	260
		F0929-00	Write Lockout	30	1,040	5
		F0930-00	Shared Peripheral Interface (provides access by multiple Processors or I/O Controllers in a multiprocessor system):	440	17,805	25
		F0930-00	SPI (second interface)	440	17,905	25
		F0930-01	SPI (third interface)	70	2,675	5
		F0930-02	SPI (fourth interface)	55	2,060	5
	6010-00		Fastrand II (44 Million - 18-bit words)	4,050		
		F0686-01	Fastbands	215	8,235	25
		F0688-01	Write Lockout	30	1,040	5
	5009-00		Fastrand II Control (unbuffered control for 1 to 8 Fastrand II Drums)	1,280	51,060	115
	5009-04		Fastrand II Control (buffered control for 1 to 8 Fastrand II Drums)	1,335	53,410	115
	5009-99		Fastrand II Dual Control (dual unbuffered control for 2 to 8 drums includes dual access for first 2 runs)	3,050	122,330	240
	5009-98		Fastrand II Dual Control (dual buffered control for 2 to 8 drums includes dual access for first 2 drums)	3,160	127,030	240
		*F0710-00	Search all words (for buffered controls only)	55	2,255	-
		F0763-00	Control Buffer (for field conversion from unbuffered to buffered control)	55	2,355	-
		F0959-99	Dual Access Drum Adapter (required for attachment all subsequent drums to a Dual Control, except fifth)	50	1,830	10
		F0959-98	Dual Access Drum Adapter (required for attachment of fifth drum to a Dual Control)	50	1,830	10
	6010-10		Fastrand III Drum	4,965	200,800	350
	5009-89		Fastrand III Control	1,565	62,220	135
	5009-85		Fastrand III Dual Control (includes dual access adapter for first drum only)	3,650	147,010	270
	5009-81		Fastrand III Control (Field Upgrade from Single to Dual Access)	2,085	84,790	135
		F0763-01	Control Buffer	55	2,350	-
		F0686-01	Fastband	205	8,235	25
		F0688-01	Write Lockout	30	1,040	5
		F0959-97	Fastrand III Dual Access Drum Adapter (for all subsequent drums except fifth)	50	1,830	10
		F0959-96	Fastrand III Dual Access Drum Adapter (for fifth drum)	50	1,830	10

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT - OUTPUT			Magnetic Tape			
			Uniservo VIC:			
	5008-00		Uniservo VIC Control (controls up to 4 Master units)	745	31,070	35
	5008-98		Uniservo VIC Control (controls up to 4 Master Units; simultaneous read-read/read-write; requires I/O channels)	1,490	62,140	70
		F0627-04	Translator (for 5008-00 or -08)	110	4,410	5
		F0627-99	Translator (for 5008-98 or -91)	220	8,820	10
		F0706-00	9 Track Capability (required in 9-track controls; (1 for non-simultaneous, and 2 for simultaneous controls)	50	1,960	5
	0858-00		Uniservo VIC Master (7-track, 8,540/23,741/34,160 char/sec; can handle up to three 0858-01 slave units)	515	17,350	115
	0858-08		Uniservo VIC Master (Same as 0858-00 but with provisions for simultaneous read-read/read-write)	570	19,800	115
	0858-01		Uniservo VIC Slave (7-track)	310	10,470	70
	0858-10		Uniservo VIC Master (9-track; 800 bpi; 34,160 bytes/sec; handles up to three 0858-14 Slave units)	515	17,350	115
	0858-12		Uniservo VIC Master (same as 0858-10 but with provisions for simultaneous read-read/read-write)	570	19,800	115
	0858-14		Uniservo VIC Slave (9-track)	310	10,470	70
		F1021-00	7 to 9 Track Conversion (converts 7-track tape unit to 9-track unit)	-	-	-
		F1072-00	Simultaneous Capability (converts 0858-00 to 0858-08)	55	2,450	-
		F1072-01	Simultaneous Capability (converts 0858-10 to 0858-12)	55	2,450	-
			Uniservo VIIIC:			
	5008-12		Uniservo VIIIC Control (controls 1 to 16 Uniservo VIIIC units)	1,550	62,430	120
	5008-89		Uniservo VIIIC Control (controls 1 to 16 Uniservo VIIIC units; provides read-read, read-write, write-read, and write-write simultaneously; require 2 I/O channels)	3,100	124,860	240
	5008-83		Control Expansion (converts 5008-12 to 5008-89)	1,550	62,430	120
	5008-79		Control Expansion (converts 5008-20 to 5008-87)	1,550	62,430	120
		F0704-00	VIC Capability (allows 7-track VIC and VIIIC units to be intermixed on a 5608-12 control)	85	3,385	5
		F0706-00	9 Track Capability (1 required for non-simultaneous, 9-track controls; 2 required for simultaneous, 9-track controls)	50	1,960	5
		F0627-04	Translator (for 5008-12)	110	4,410	5
		F0627-98	Translator (for 5008-89)	220	8,820	10
	0859-00		Uniservo VIIIC (7-track; 24,000/66,720/96,000 char/sec; non-simultaneous)	860	32,735	110
	0859-04		Uniservo VIIIC (9-track; 800 bpi; 96,000 bytes/sec; non-simultaneous)	875	33,390	110
	0859-08		Uniservo VIIIC (7-track; same as 0859-00, but for simultaneous controls)	890	34,045	110
	0859-10		Uniservo VIIIC (9-track; same as 0859-04, but for simultaneous controls)	905	34,700	110
		F0999-00	7 to 9 Track Conversion (converts 0859-00 to 0859-04)	15	655	-
		F0999-04	7 to 9 Track Conversion (converts 0859-08 to 0859-10)	15	655	-

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Cont'd)			<u>Punched Card</u>			
	5010-00		Card Control (controls one 0600 Card Punch and one 0706 Card Reader)	920	28,620	265
	0706-97		Card Reader (900 cards/min; includes check read feature and alternate stacker)	480	15,385	125
	*0706-99		Card Reader (900 cards/min)	415	12,985	115
		F1022-00	Check Read (second read station for checking)	65	2,400	10
	0600-00		Card Punch (300 cards/min)	715	21,560	230
			<u>Printer</u>			
	5011-00		Printer Control (controls one printer)	885	30,015	200
		F0751-00	Printer Control Expansion (provides control for second printer)	630	23,055	100
			Shared Peripheral Interchange (SPI):			
		F0933-00	SPI (provides interface for second processor or I/O Controller in multi-processor system)	440	17,905	25
		F0933-01	SPI (provides third interface)	70	2,675	5
		F0933-02	SPI (provides fourth interface)	55	2,060	5
	*7299-03		Printer Control (controls one 0755 printer)	810	27,400	180
		F0965-00	Printer Control Capability (permits 7299-03 Control to handle 0758-00 Printer)	75	2,575	20
	*7299-04		Printer Control (used with 7299-04 to control second printer)	810	27,440	180
	0758-00		Printer (1,600 lines/min with 43-character set; 1,200 lines/min with 63-character set)	1,250	43,500	305
	*0755-00		Printer (700 lines/min alphanumeric; 900 lines/min numeric)	870	25,970	275
COMMUNICATIONS		F0900-06	Communication Terminal Module Controller (CTMC)	705	24,700	135
		F0906-06	Spare CTM Controller	260	9,020	50
		F0901-04	CTM-LS Low Speed	65	2,255	15
		F0902-02	CTM-MS Medium Speed	85	2,895	15
		F0903-02	CTM-HS High Speed	100	3,630	15
		F0905-00	Automatic Dialing	20	635	5
		F0904-00	Parallel Output	40	1,315	10
		F0904-01	Parallel Input	40	1,315	10
		F0988-00	CTM VII High Speed	80	3,050	10
		F0988-01	CTM VII High Speed (includes block parity checking)	95	3,480	15
		F0991-00	CTM VI High Speed	125	4,570	20
		F0989-00	CTM VII Medium Speed	60	2,175	10
		F0989-01	CTM VII Medium Speed	70	2,610	10
		F0989-02	CTM VII Medium Speed	80	3,050	10
		F1027-00	CTM IV Low Speed	80	3,050	10
		F1048-00	CTM VI Low Speed	95	3,480	15
		F1018-02	HS Interface Module (for 6 full-duplex lines)	60	2,175	10
		F1018-03	HS Interface Module (for 4 full duplex lines)	40	1,525	5
		F1018-05	Expansion Kit (capability for handling 2 additional lines)	20	650	5
		F1019-01	HS Interface Module (for 8 full-duplex lines)	80	3,050	10
		F1019-03	HS Interface Module (for 4 full-duplex lines)	40	1,525	5
		F1019-05	Expansion Kit (capability for handling 4 additional lines)	40	1,525	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
COMMUNICA-TIONS (Cont'd)			Word Terminal Synchronous (Wts):			
	8552-01		Basic Cabinet (space for up to 2 WTS Modules)	270	8,380	80
		F0614-00	Power Supply (for first Module)	110	3,335	30
		F0614-01	Power Supply (for second Module)	110	3,335	30
		F0771-00	Wts Module	485	14,210	160
		F0772-00	Voice Band Interface	5	225	-
		F0772-01	Unattended Answering	5	225	-
		F0772-02	Automatic Dialing	55	1,670	15
		F0772-03	Broad Band	5	225	-
			Communication Terminal Synchronous (CTS)			
	8552-00		Basic Cabinet (space for up to 6 CTS Modules)	270	8,380	80
		F0614-00	Power Supply (first 3 Modules)	120	3,335	30
		F0614-01	Power Supply (second 3 Modules)	120	3,335	30
		F0615-00	CTS Module	270	8,380	80
		F0616-00	Broad Band	120	3,335	30
		F0617-00	Unattended Answering	5	225	-
		F0618-00	Automatic Dialing	56	1,670	15

NOTES:

* No longer in production.

(1) UNIVAC will extend rental agreements to a five-year term for systems in current production at a monthly rental of 85 percent of the figure shown in this column.

(2) Required on each Processor in multiprocessor system. A minimum of 65K core storage is required for each Processor and each I/O Controller in system; maximum core storage per system is 262K.

SUMMARY: UNIVAC 418 SERIES

.1 INTRODUCTION

There are currently three systems which carry the UNIVAC 418 designation. All three are medium-scale, solid-state systems oriented primarily toward real-time and data communications applications. The UNIVAC 418-I and -II systems are virtually identical and have been successfully operating in customer installation since mid 1963. UNIVAC no longer offers the UNIVAC 418-I; however, the faster UNIVAC 418-II is being marketed. The UNIVAC 418-III is a new and significantly different system announced on 5 June 1968.

The following summary is oriented primarily to the UNIVAC 418-II with some discussion of the UNIVAC 418-III in order to better highlight the significant improvements contained in this system. Section 792:011 provides a summary of the UNIVAC 418-III and highlights the many significant features of this system which make it an outstanding system in the real-time and communications fields. The UNIVAC 418-III also provides a competitive capability for business and scientific applications.

The UNIVAC 418-I and 418-II evolved from the UNIVAC CUT (Control Unit Tester), a special-purpose computer designed to test peripheral equipment for the larger UNIVAC computer systems. A modified version of this 418 processor serves as the central processor in the Westinghouse PRODAC 510 and 580 process control systems. The UNIVAC 418-III is a greatly improved design utilizing design features and components successfully employed in the UNIVAC 1108 system.

The UNIVAC 418-I and -II processors are virtually identical, with the primary difference being core storage cycle time. The cycle time for Model I is 4 microseconds, while that of Model II is 2 microseconds. The UNIVAC 418-III is significantly different from the other models. It includes a Command/Arithmetic unit and up to two I/O Modules. These units are independently operating and collectively perform the functions commonly found in a single processor unit. It has a core cycle time of 0.75 microseconds and uses the peripheral devices of the faster UNIVAC 1108. It is, however, compatible with the UNIVAC 418-II at the source language level and can utilize UNIVAC 418-II peripheral devices.

A wide range of magnetic drum units, magnetic tape units, and communications devices permit the UNIVAC 418 systems to serve as versatile message switching and/or data collection units in real-time environments. In these applications it is essential that the system be able to store and retrieve message data rapidly in order to provide continuous and timely service to terminals.

While the UNIVAC 418-I and -II systems are well suited for real-time applications, their use in scientific applications will generally not be economical due to the short word length (18 bits) and the absence of instructions for double-precision and floating-point arithmetic operations. The UNIVAC 418-III, on the other hand, being significantly faster and including an optional floating point arithmetic feature will be a strong competitor in scientific applications, although the short word length can still be a slight handicap.

Figure 1. A large UNIVAC 418-III installation.

.1 INTRODUCTION (Contd.)

The principal characteristics that make the UNIVAC 418 systems suitable for real-time or communications applications are:

- High-capacity random-access storage for master-file data or in-transit message storage.
- A variety of magnetic tape units which provide storage capabilities appropriate for backup data sets such as reference storage and for record-keeping such as ledger and journal storage.
- Program interrupt facilities which permit concurrent processing of several levels of programs.
- Flexible communications linkages to virtually any common carrier for transmission of data between the computer and remote terminals.
- Two electronic chronometers, which make the system time-conscious.

In addition to the above, the UNIVAC 418-III system includes:

- Up to three-way truly simultaneous I/O data transfers and processing.
- An advanced multiprogramming Executive including job control, file control, and file access facilities.
- A Real-Time Communications Controller for user ease of handling of communications data.
- Multiple interrupt levels and communications interrupt tabling features for rapid efficient handling of interrupts.

.2 HARDWARE

.21 Data Structure

The UNIVAC 418 systems are word-oriented, with each word consisting of 18 data bits and a parity bit. Each 18-bit word is individually addressable and may contain one instruction, two 8-bit alphameric characters, three 6-bit alphameric characters, or an 18-bit binary data item.

.22 System Configuration

The UNIVAC 418 Models I and II are identical with respect to system configuration possibilities and components. The basic system consists of 4,096 words of core storage, an operator's console, a power supply, and eight I/O channels. Additionally, a magnetic tape unit is required by the executive routine, and a UNIVAC 1004 card subsystem is required if punched card input-output is desired. Core memory can be expanded in 4,096-word increments to a maximum of 16,384 words of 4-microsecond core for the Model I and 65,536 words of 2-microsecond core for the Model II. In both systems, eight additional I/O channels can be obtained in four-channel increments.

Any peripheral subsystem can be connected to any input-output channel, with the exception of the Programmer's Console, which includes a keyboard-printer. If the Programmer's Console is used, it must be connected to channel 0. Two types of input-output transfers are performed in the UNIVAC 418. One type uses one input-output channel to transfer data in units of 18 bits; the second uses two input-output channels to transfer data in units of 36 bits.

The following subsystems require two 418-I/II input-output channels and transfer data in units of 36 bits:

- FH-880 Magnetic Drum Subsystem.
- Fastrand II Mass Storage Subsystems.

The following subsystems require one 418-I/II input-output channel and transfer data in units of 18 bits:

- FH-330 Magnetic Drum Subsystem.
- Uniservo VIC Magnetic Tape Subsystem.
- UNIVAC 1004 Central Processor.
- Programmer's Console Keyboard-Printer.
- Paper Tape Subsystem: 1 reader and 1 punch. This subsystem uses the same channel as the Programmer's Console.

An unusual case is the Communications Terminal Module Controller (CTMC). This subsystem requires two channels, but only one channel is used to transfer data. The second channel transmits Externally Specified Index (ESI) addresses.

(Contd.)

.22 System Configuration (Contd.)

The UNIVAC 418-III, differs significantly from the UNIVAC 418-II in system configuration possibilities. Memory is organized into up to four banks, each of which may consist of 16,384 or 32,768 words of 0.75-microsecond core. I/O operations are controlled by one or two input-output modules, each of which may have 8, 12, or 16 I/O channels. The basic UNIVAC 418-III central system consists of a Command/Arithmetic Section with operator's console, one input-output module with 8 I/O channels, and two 16,384-word banks of core memory.

While the Model III can accommodate the peripheral devices utilized with Models I and II, its greatly increased I/O data rates make the use of faster devices currently available on the UNIVAC 1108 preferable. The rules for connecting peripheral devices to the 418-III I/O channels follow those given above for the slower models. When two channels are required for the subsystem, the channels must be an even-numbered channel and the next higher channel. The standard peripheral subsystems for the UNIVAC 418-III system and their channel requirements are as follows:

- FH-432 Magnetic Drum Subsystem; 2 channels.
- FH-1782 Magnetic Drum Subsystem; 2 channels.
- FH-880 Magnetic Drum Subsystem; 2 channels.
- Fastrand II Magnetic Drum Subsystem; 2 channels.
- Uniservo VI C Magnetic Tape Subsystem; 1 or 2 channels.
- Uniservo VIII C Magnetic Tape Subsystem; 1 or 2 channels.
- UNIVAC 9000 Series Computing System; 1 channel.
- 0758 High Speed Printer; 1 channel.
- Punched Tape Subsystem; 1 channel.
- Communications Terminal Module Controller (CTMC); 2 channels.
- Word Terminal Synchronous (WTS); 2 channels.

.23 Internal Storage

.231 Core memory

Working storage in the UNIVAC 418 systems is provided by ferrite-core memory. In the Model I, 4,096 to 16,384 18-bit words are available in 4,096-word increments. The cycle time for the Model I core memory is 4 microseconds. From 4,096 to 65,536 words of 2-microsecond core are available in 4,096-word increments in the Model II. Core storage in the Model III is organized into up to four independently functioning banks, each of which may contain 16,384 or 32,768 18-bit words. The minimum system consists of two banks of 16,384 words each, for a total of 32,768 words, while the maximum available is 131,072 words in four banks of 32,768 words each. The memory cycle time for the Model III core memory is 0.75 microsecond.

In the UNIVAC 418-I and -II, one data path to core memory is shared by the processor and I/O transfers. By contrast, each bank of 418-III memory has three data paths, one data path is used by the Command/Arithmetic section, and one is used by each of the two possible I/O modules. While the three data paths must share the available memory cycles if they are referencing the same bank, three peak-rate data transfers could occur truly simultaneously and without mutual interference, if each was carried out in a separate memory bank from the others.

.232 Random-access storage

The random-access storage available on the UNIVAC 418 systems consists of the following magnetic drum subsystems:

- FH-330 Magnetic Drum Subsystem. Each subsystem has a capacity of from 786,432 to 3,932,160 alphanumeric characters and an average access time of 8.5 milliseconds. The subsystem is connected via the FH-330 Drum Control and Synchronizer Unit to one input-output channel.
- FH-880 Magnetic Drum Subsystem. Each subsystem has a capacity of from 4.7 million to 37.7 million alphanumeric characters and an average access time of 17 milliseconds. The subsystem is connected via the FH-880 Drum Control and Synchronizer Unit to two input-output channels.
- Fastrand II Mass Storage Subsystem. Each subsystem has a capacity of from 132 million to 1,056 million alphanumeric characters and an average access time of 92 milliseconds. The subsystem is connected via the Fastrand II Control and Synchronizer Unit to two input-output channels.

.232 Random-access storage (Contd.)

- FH-432 Magnetic Drum Subsystem (418-III only). Each subsystem has a capacity of from 1,572,864 to 12,592,912 alphanumeric characters and an average access time of 4.27 milliseconds. The subsystem is connected via the FH-432/1782 Drum Control and Synchronizer Unit to two input-output channels.
- FH-1782 Magnetic Drum Subsystem (418-III only). Each subsystem has a capacity of from 12,582,912 to 100,663,296 alphanumeric characters and an average access time of 17.0 milliseconds. The subsystem is connected via the FH-432/1782 Drum Control and Synchronizer Unit to two input-output channels.

.24 Central Processors

From the standpoint of electronics and operating speed, the UNIVAC 418-III differs significantly from the 418-I and II. The UNIVAC 418-I and -II systems contain a single processing unit than contains all processor controls and functions as well as I/O controls. The UNIVAC 418-III system includes two separate and independently functioning units that combined perform the functions commonly included in the Central Processor. The Command/Arithmetic unit contains all processing facilities and controls while the independently operating I/O Module contains all controls necessary for proper I/O data transfer.

.241 Instruction formats

The instructions of the UNIVAC 418 systems are of three types, and these types are also grouped in two classes — privileged and nonprivileged. The privileged instructions are reserved for use by the Executive and basically consist of the instructions associated with input-output and storage protection.

The Type I instructions are those commands which reference main storage and are sensitive to the SR Active bit. The format of Type I instructions is:

f	u
17 12	11 0

f = six-bit function code (02-27, 32, 33, 40-47)

u= 12-bit displacement

When a Type I instruction is executed and the SR Active bit is set to 1, the high-order five bits required for a 17-bit main storage address are obtained from the Special Register. If the SR Active bit is not set to 1, the required five bits are obtained from the high-order five bits of the Instruction Address Register.

The Type II instructions are those commands which reference main storage and are not sensitive to the SR Active bit, and those which supply an immediate operand.

The format of Type II instructions is:

f	u
17 12	11 0

f = six-bit function code (30, 31, 34-37, 51-76)

u= 12-bit displacement or immediate operand

When a Type II instruction is executed, the high-order five bits required for a 17-bit main storage address are obtained from the high-order five bits of the Instruction Address Register.

If the instruction is one which supplies an immediate operand, the u portion is handled in a manner specified by the function code. An immediate operand is a constant contained in the u portion of the instruction itself. The function code specifies the method of creating an 18-bit operand from the 12-bit u portion. Either zero extension or sign extension is used. In the case of zero extension, the high-order six bits of the operand are arbitrarily set to 0's. In the case of sign extension, the high-order bit of the u portion is used to fill the high-order six-bit portion of the operand.

Type III instructions are those that contain special parameters which must be supplied to internal circuitry for control of certain functions. The basic format of Type III instructions is:

f	m	k
17 12	11 6	5 0

f = six-bit function code (always 50)

m = six-bit minor function code (00-77)

k = special parameters (e.g., shift count, channel number, etc.)

(Contd.)

.241 Instruction formats (Contd.)

Some Type III instructions require an additional one or two storage locations in order to convey parameters. For example, the commands which are used to supply Buffer Control Words to the I/O module use the two storage locations immediately following the Type III instruction for these parameters. The optional Floating-Point and Binary/Decimal instructions for the 418-III are Type III instructions.

.242 Registers and Interrupts

The UNIVAC 418 systems utilize several special registers and interrupts to effect efficient system operation. Six primary special registers are used as follows:

- Three Arithmetic Registers, each of which is 18 bits long, are used in the arithmetic section for immediate working storage. The A-upper (AU) and A-lower (AL) registers are independently loadable (and storable) under program control, but they also operate as a pair (A) for double-precision operations. The third is the adder, which cannot be directly referenced by the program.
- The Instruction Address Register (IAR) is a 16-bit register which is part of the control action and is used to control program flow.
- The Special Register (SR) is a 6-bit register used for address augmentation when the 12-bit address of an instruction is insufficient to address the desired location. The high-order bit of this register is used to indicate address augmentation activity; the one (1) condition indicates active. When the SR is active, its low-order 5 bits become the high-order 5 bits of a 17-bit address whose low-order 12 bits are obtained from the instruction.
- The Index Control Register is a 3-bit register which designates the index register currently in use. (There are eight index registers in reserved core storage locations, but only one register at a time, as selected by a special instruction, can be used for address modification.)

The occurrence of an interrupt in a UNIVAC 418-I or -II system causes all other interrupts to be disabled until they are re-enabled by a special instruction. Then control is transferred to a common interrupt location where a routine (supplied by EXEC when in use) must determine the cause and effect the cure. The primary interrupts are divided into two principal categories:

- Internal interrupts — those interrupts which do not involve input-output, and including illegal function code, Delta Clock underflow, and Day Clock interval completion.
- External interrupts — input-output-related interrupts, consisting primarily of I/O termination and drum head-positioning completion.

The UNIVAC 418-III Command/Arithmetic section includes a powerful interrupt system. There are 14 discrete internal interrupt levels and 96 additional levels for the I/O channels. The significance of this large number of interrupt levels is that upon encountering an interrupt condition, control can be automatically transferred to the specific location in main memory corresponding to that interrupt condition. This eliminates the time and space consuming test routines required to determine the type and source of the interrupt. Additionally, the UNIVAC 418-III I/O control system can automatically accept and store interrupt information from any number of communications lines without interfering in any way with the Executive which may be busy servicing a prior interrupt. This permits acceptance of concurrent interrupts while permitting the Executive to perform its critical functions uninterrupted.

.243 Processing facilities

The UNIVAC 418 systems contain a full complement of instructions for fixed-point arithmetic, logical, comparison, and shifting operations on 18-bit binary operands. Double-precision addition, subtraction, and shifting operations can also be performed, and the Model III can include an optional floating-point feature. A full line of Boolean instructions operate on 18-bit quantities usually contained in the A-lower register.

The Model III processor includes a slightly expanded instruction set. Notable among the added instructions are a block transfer, which enables movement of up to 64 words from core to core in a block, and optional data conversion instructions for binary-to-decimal and decimal-to-binary conversions. No character-handling or editing instructions are provided.

.244 Console

The operator's console of the UNIVAC 418 systems consists of two primary components, a Maintenance Panel and a Programmer's Console. The Maintenance Panel provides direct operational control over the system and is used primarily for system startup and shutdown. This panel can be operated off-line for use in hardware check-out and repair while the remainder of the system continues to operate. The Programmer's Console includes minimum facilities for direct system control; its primary purpose is to provide effective operator-system communications while the system is in operation.

.25 Input-Output Equipment

UNIVAC offers a range of input-output equipment for the 418 System that is somewhat limited in scope, but well suited for the intended system applications.

.251 Magnetic Tape Units

The Uniservo VIC Magnetic Tape Handlers are available with all 418 systems. The high-speed Uniservo VIIIC model is available only with the UNIVAC 418-III system. These models use 2,400-foot reels of 1/2-inch coated Mylar tape and are capable of 7- or 9-track data recording, and are IBM 729-compatible units. The data transfer rates available range from 8,500 characters per second for the Uniservo VIC at 200 bpi to 128,000 characters per second for the Uniservo VIIIC in 9-track mode.

.252 Printers

The 0758 Printer Subsystem is available only on the Model III processor. This printer is a high-speed drum printer connected to I/O channels via the printer controller. It has 132 print positions per line and the character set is the standard 64 character set. Using the full 64 character set, the 0758 printer prints 1200 lines; however, 1600-line-per-minute printing speed is obtained for any 43 contiguous character set. With the alphabetics and numerics being included in a set of 43 characters, the higher 1600 lpm can generally be expected.

.253 Paper tape subsystems

Paper tape subsystems capable of reading or punching 5-, 7-, or 8-level tape are available with all UNIVAC 418 models. Although these units are capable of stand-alone operation, it is expected that when a paper tape subsystem is included in a UNIVAC 418-II configuration, it will effectively be used as part of the Programmer's Console. The Paper Tape Subsystem available with the Model I and II processors is capable of reading 200 rows per second and punching 110 rows per second. The Punched Tape Subsystem for the UNIVAC 418-III is capable of reading 1000 rows per second and punching 240 rows per second. Each has its own control unit and is connected to one input-output channel.

.254 Punched card subsystems

No direct on-line punched card facilities are provided with any UNIVAC 418 System. Punched card facilities, when desired, are obtained through an on-line UNIVAC 1004 or UNIVAC 9000 Series computing system.

.255 Computing subsystems

The primary purpose of a computing subsystem in a 418 configuration is to provide efficient access to slow-speed I/O devices. These systems provide card input-output capabilities for the UNIVAC 418 which are not otherwise available. A printer is available for use in the computing subsystem and it is expected that the printing facilities of the computing subsystem can be used for on-line and off-line printing. This relieves the 418 processor of the slow-speed data load and makes available the print edit facilities of the computing system.

A UNIVAC 1004 Computing System can be used on-line with any UNIVAC 418 system. The UNIVAC 1004 subsystem usually consists of a central processor with 961 characters of 6.5-microsecond core memory, a 600-line-per-minute printer, a 615-card-per-minute card reader, and a 200-card-per-minute card punch.

A UNIVAC 9000 Series Computing System can be connected on-line to a UNIVAC 418-III system. When used in this manner, the UNIVAC 9000 Series system will normally consist of a 9200 or 9300 central processor with plated-wire memory, a high-speed printer, a card reader, and a card punch with these characteristics:

Processor	Storage Capacity	Cycle Time	Printer	Card Reader	Card Punch
9200	8,192 bytes	1.2 μsec/ byte	250 lpm	400 cpm	75/200 cpm
9300	8,192 bytes	0.6 μsec/ byte	600/1200 lpm	600 cpm	75/200 cpm

.26 Data Communications Facilities

The UNIVAC 418 systems are primarily intended for real-time and communications applications. A wide range of flexible data communications equipment is available for use in these systems. The Communications Terminal Module Controller (CTMC) is the primary communications control unit provided for use in UNIVAC 418 systems. These controllers interface with Communication Terminal Module (CTM) units, which in turn interface with the appropriate adapters through communications lines to terminal devices. A wide variety of commercially available terminal devices can be used.

(Contd.)

.26 Data Communications Facilities (Contd.)

The Communications Terminal Module Controller (CTMC) and its associated transmission adapters form a UNIVAC Communications Subsystem that can be used to connect a wide variety of UNIVAC computer systems to multiple narrow-band and voice-band lines. Different interfaces are provided for connection to a UNIVAC 418, 490 Series, 1050, or 1108 Computer.

Several types of transmission adapters, called Communication Terminal Modules (CTM), are available for handling different ranges of transmission speeds: up to 300 bits per second, up to 1,600 bits per second, and up to 50,000 bits per second. These adapters accomodate 5-, 6-, 7-, or 8-level codes and transmit data serially by bit. Other adapters transmit or receive data in parallel-by-bit fashion at up to 75 characters per second and are compatible with the Bell System 402 Series Data Sets.

A CTMC has 32 input and 32 output line positions and can control up to 16 transmission control modules. Each module can accomodate 4 simplex lines (2 input and 2 output), or 2 half-duplex or full-duplex lines.

A special adapter permits programmed automatic dialing in conjunction with a common-carrier Automatic Calling Unit. One Dialing Adapter is required for each line utilizing automatic dialing; four Dialing Adapters occupy one module space.

UNIVAC also offers two single-line controllers, each of which is capable of controlling communications between a UNIVAC 418 system and a remote terminal at 2000 bits per second over the public telephone network, at 2400 bits per second over a leased voice-band line, or at 40,800 bits per second over a leased broad-band facility. These two controllers, the Word Terminal Synchronous (WTS) and the Communication Terminal Synchronous (CTS), are essentially two versions of the same unit.

A special UNIVAC 418 feature is the Externally Specified Index (ESI), which allows a number of communications networks to operate concurrently on a single pair of input-output channels by providing automatic sorting of incoming data and automatic collation of outgoing data.

Virtually any commercially available terminal device can be used with UNIVAC 418 systems. The preferred terminal devices are those manufactured by UNIVAC: the Uniscope 300 Visual Communications Terminal, the DCT 2000 Data Communications Terminal, the UNIVAC 1004 and 9000 Series Computing Systems, and Teletype ASR/KSR terminals.

.27 Simultaneous Operations

The simultaneity obtainable within UNIVAC 418 systems is a function of the system itself. The UNIVAC 418-III permits up to three-way true simultaneity because of its independently operating memory banks and C/A and I/O Modules. In the UNIVAC 418-I and -II, the number of I/O trunks available on the system, the data transfer rate of each device in operation, and the numbers of non-data-transfer operations, determine the simultaneity obtainable.

Each I/O channel in a 418 system is capable of an input or output data transfer operation simultaneously with all other I/O channels and internal processing, provided that the cumulative gross transfer rate does not exceed the gross data rate capability of core storage. Additionally, any number of magnetic tape rewind operations may be occurring, and each magnetic drum synchronizer may be controlling a drum positioning operation.

In UNIVAC 418-I and -II systems, each data word transferred to or from core storage in the 18-bit interface mode requires 4 core cycles, while each pair of words transferred in the 36-bit interface mode requires 5 core cycles. Thus, the gross data transfer rate obtainable between core storage and all simultaneously operating peripheral devices cannot exceed the following values:

Model I Processor —
18-bit interface: 62,500 words or 187,500 characters per second.
36-bit interface: 100,000 words or 300,000 characters per second.

Model II Processor —
18-bit interface: 125,000 words or 375,000 characters per second.
36-bit interface: 200,000 words or 600,000 characters per second.

The increased capability for simultaneity provided by the UNIVAC 418-III is one of its strongest competitive advantages. Each memory bank is capable of fully simultaneous operation with every other memory bank, and each transfer of an 18-bit word requires only one 0.75-microsecond memory cycle. Thus, each memory bank can support a gross data transfer rate of 1.33 million words or 4 million characters per second.

In the UNIVAC 418-III system, the Command/Arithmetic section and the two possible I/O Modules each have a separate data channel to core memory. Each memory bank has three independent data paths, enabling independent access by each of these data channels. Thus, the Command/Arithmetic section can be performing internal processing and each of the I/O Modules can be performing I/O data transfers without interfering with each other, so long as they are all referencing different memory banks.

.27 Simultaneous Operations (Contd.)

Gross data transfer rates obtainable in the UNIVAC 418-III range from a minimum of 0.87 million words per second with a demand on the processor of 67 per cent (if all operations reference the same memory bank) to a maximum of 2.66 million words per second in addition to processing and with no demand on the processor (if the processor and the two I/O Modules all reference different memory banks).

.3 SOFTWARE

.31 UNIVAC 418-I and 418-II Software

The software packages available for use with the UNIVAC 418-I and -II systems can be summarized as follows:

- ART — An assembly system that translates symbolic source programs into machine-language object programs in relocatable or absolute form. ART is a two-pass assembler unless a magnetic tape unit or drum is available for intermediate storage.
- EXEC — An operating system capable of controlling four levels of programs: critical, real-time, batch, and computational, all operating concurrently. EXEC is designed to provide efficient utilization of the available system components and process scheduled jobs with a minimum of operator intervention.
- FORTRAN IV — A subset of IBM 7090/7094 FORTRAN IV that permits the use of most of the facilities available in the 7090/7094 version, including integer, real, and a form of double-precision constants and variables. Complex and logical constants and variables, however, are not permitted.
- Sort/Merge — A three-phase program that utilizes the polyphase method of merge sorting with 3 to 12 Uniservo IIA or IIIC Tape Handlers or a Fastrand Mass Storage Unit. A 12K 418 is required, and additional core storage can be utilized when available.
- Utility Routines — include data transcription functions, dump and trace routines, tape and drum maintenance, and inspect and change routines.

.32 UNIVAC 418-III Software

The UNIVAC 418-III software has been designed specificially for the unique characteristics of the UNIVAC 418-III hardware, and both the hardware and software have been designed primarily for the unique characteristics of real-time applications. The software provided for the UNIVAC 418-III includes:

- UNIVAC 418-III Executive, an executive system which provides multiprogramming capability with job control, file control and file access facilities together with I/O Handlers;
- Real-Time Communication Control designed to provide the user with a convenient interface to real-time input/output operations;
- Language processors which include COBOL, FORTRAN, and UNIVAC 418-III Assembler; and
- Systems Support Libraries which provide system support services of data file maintenance, program file maintenance, testing, and utility programs:

  Sort/Merge

  Program Monitor and Trace

  Program Maintenance

  General Tape/Drum Print

  Common Procedures

  Data Tape File Maintenance

  Executive Independent Utilities

UNIVAC 418-I/II

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (Includes Core Storage)			
	*3010-11		418-I Processor (4,096 words of core storage; 8 I/O Channels; Control Console	1,300	79,200	305
	*3010-12		418-I Processor (4,096 words of core storage; 8 I/O Channels)	2,040	70,200	290
	3010-13		418-II Processor (4,096 words of core storage; 8 I/O channels; integrated console with keyboard printer)	2,400	82,800	305
	3010-14		418-II Processor (4,096 words of core storage; 8 I/O channels)	2,145	73,800	290
		F0631-00	Memory Expansion-4K (4,096 word module for 418-I Processors; maximum of 16,384 words)	260	9,000	45
		F0604-00	Memory Expansion-4K (4,096 word module for 418-II Processors; maximum of 65,536 words)	365	12,600	45
		F0724-00	Console Alarm	30	900	5
		F0633-00	Day Clock	60	2,400	5
		F0632-00	I/O Channel Expansion (additional 4 channels for 418-I and II Processors)	210	7,200	20
		F0632-01	I/O Channel Expansion (second set of 4 additional Channels for 418-I and -II Processors)	210	7,200	20
ATTACHMENTS, ADAPTERS, AND CHANNELS		*F0662-02	I/O Channel Expansion (for 418-I Processors)	210	7,200	20
		*F0632-03	I/O Channel Expansion (for 418-I Processors)	210	7,200	20
		F0597-01	1004 Control	105	4,000	15
		*F0664-98	Intercomputer Coupler (with UNIVAC 1108)	465	19,410	45
		F0664-99	Intercomputer Coupler (with another 418)	625	25,575	70
		F0721-C^	Transfer Switch	155	6,670	10
	2503-01		Switch Cabinet	335	13,000	—
MASS STORAGE			Drum Storage			
	7304-01		FH 880 Drum (1,572,864 18-bit words per unit)	2,150	85,165	190
	7427-02		FH 880 Control (controls 1 to 8 drums)	1,550	58,800	190
	6002-00		FH 330 Drum and Control (includes 1 drum and control for up to a maximum of 5 drums; 262,144 words per drum)	2,075	87,400	175
	6002-01		FH 330 Drum and Cabinet (includes one drum and space for second)	1,250	53,085	95
		F0625-00	FH 330 Drum	1,250	53,085	95
	6010-00		Fastrand II (44 million words)	4,050	164,640	300
		F0686-01	Fastbands	215	8,235	25
		F0688-01	Write Lockout	30	1,040	5
	5009-04		Fastband Control (controls 1 to 8 units)	1,335	53,410	115
		F0710-00	Search All Words	55	2,255	0
	*6010-02		Drum (29 million, 18-bit words)	3,637	154,000	287
	*6010-04		Drum (14 million, 18-bit words)	2,192	—	287
	*5009-xx		Drum Control	1,035	36,000	35

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental	Purchase	Monthly Maint.
INPUT-OUTPUT(2)			Magnetic Tape			
	0858-00		Uniservo VIC Master (7 track; handles up to 3 slaves)	515	17.350	115
	0858-08		Uniservo VIC Master (7-track; handles up to 3 slaves; simultaneous read-read/read-write)	570	19,800	115
	0858-01		Uniservo VIC Slave (7-track)	310	10,470	70
	5008-08		Uniservo VIC Synchronizer (controls up to 4 0858-00 VIC Master units)	745	31,070	35
	5008-91		Uniservo VIC Synchronizer (controls up to 4 0858-08 VIC Master units)	1,490	62,140	70
	*5008-09		Uniservo VIC Auxiliary Synchronizer	745	31,000	35
	*0952-00		Magnetic Tape Control	1,025	35,460	100
	*1345-01		Power Supply	235	8,600	40
	*0952-01		Magnetic Tape Control	1,130	39,060	105
		F0627-04	Translate Option (for 5008-08)	110	4,410	5
		F0627-99	Translate Option (for 5008-91)	220	8,820	10
		*F0627-03	Translate Option (for 5008-09)	110	4,410	5
			Paper Tape			
		F0603-00	Paper Tape Subsystem	160	5,980	30
COMMUNICATIONS		F0900-05	Communication Terminal Module Controller (CTMC)	705	24,700	135
		F0901-04	CTM-LS	65	2,255	15
		F0902-02	CTM-MS	85	2,895	15
		*F0903-00	Communications Line Terminal	50	1,360	15
		*F0903-01	Communications Line Terminal	50	1,360	15
		F0903-02	CTM-HS	100	3,630	15
		F0905-00	Automatic Dialing	20	635	5
		F0904-00	Parallel Output	40	1,315	10
		F0904-01	Parallel Input	40	1,315	10
		F0906-05	Spare CTMC	260	9,020	50
			Word Terminal Synchronous (WTS):			
	8552-01		Basic Cabinet (space for up to 2 WTS Modules)	270	8,380	80
		F0614-00	Power Supply (first Module	110	3.335	30
		F0614-01	Power Supply (second Module)	110	3,335	30
		F0771-00	WTS Module	485	14,210	160
		F0772-00	Voice Band Interface	5	225	--
		F0772-01	Unattended Answering	5	225	--
		F0772-02	Automatic Dialing	55	1,670	15
		F0772-03	Broad Band	5	225	--
			Communication Terminal Synchronous (CTS):			
	8552-00		Basic Cabinet (space for up to 6 CTS Modules)	270	8,380	80
		F0614-00	Power Supply (first 3 Modules)	110	3,335	30
		F0614-01	Power Supply (second 3 Modules)	110	3,335	30
		F0615-00	CTS Module	270	8,380	80
		F0616-00	Broad Band	110	3,335	30
		F0617-00	Unattended Answering	5	225	--
		F0618-00	Automatic Dialing	56	1,670	15

NOTES:

*No longer in production.

(1) UNIVAC will extend rental agreements to a five-year term for systems in current production at a monthly rental of 85 percent of the figure shown in this column.

(2) Additional input-output units are normally implemented by attachment of a UNIVAC 1004.

UNIVAC 418-III

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3020-00		418-III Processor (includes 8 I/O channels)	2,410	92,875	275
		F1083-00	Floating Point	125	5,220	5
		F1082-00	Decimal Binary Conversion	60	2,395	5
		F0676-09	Use Time Meter	—	525	5
	4010-00		Operator's Console (required for 3020-00)	280	11,310	20
		F1086-00	Day Clock	135	5,655	5
		F0774-00	Auxiliary Console (accommodates two to four CTMC's left- or right-hand addition to Console)	165	6,600	10
		F0774-01	Auxiliary Console (same as F0774-00 but located between Consoles of two Processors)	165	6,600	10
			Main Storage			
	7009-00		Storage (-16K words; includes power for up to 65K words and cabinetry for up to 32K words)	1,950	76,995	180
		F1087-00	Storage Expansion (16K words; permits operation of memory in two 16K bands)	1,290	50,895	120
	7009-02		Storage Expansion (16K words; includes cabinetry for 32K words; permits operation of memory in one 32K and one 16K band)	1,400	54,595	145
		F1087-01	Storage Expansion (16K words; permits operation of memory in two 32K bands)	1,290	50,895	120
ATTACHMENTS, ADAPTERS, AND CHANNELS		F1084-00	Second I/O Module (includes additional 8 I/O channels)	800	31,540	75
		F1084-01	I/O Channel Expansion (includes 4 additional channels)	120	4,785	10
		F1084-02	I/O Channel Expansion (includes 4 additional channels; requires F1084-01)	120	4,785	10
			Shared Peripheral Interface (SPI):			
	0955-04		SPI (permits 2 paired channels from one processor or 1 paired channel from each of two Processors to share the units of a peripheral subsystem; includes, cabinet with space for second SAI)	475	19,575	25
	0955-05		SPI (additional SPI; fits into cabinet included with 0955-04)	420	17,400	20
		F0789-00	SPI Expansion (adds third Processor paired channel capability to 0955-04 or -05)	85	3,480	5
		F0789-01	SPI Expansion (adds fourth Processor paired channel capability to 0955-04 or -05 with F0789-00)	60	2,395	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
ATTACH-MENTS, ADAPTERS, AND CHANNELS (Contd.)			System Interconnections:			
	5309-00		Intercomputer Coupler (provides 36-bit interface for direct communication with a second 418-III Processor via 2 I/O channels)	625	25,575	70
	5309-02		Intercomputer Coupler (permits communication with a second 418-III Processor via 1 I/O channel)	625	25,575	70
		F1095-00	418/9000 1 CCU (provides 18-bit interface for on-site communication with UNIVAC 9000 series computer)(2)	205	8,050	20
		F0893-00	Transfer Switch (permits manual switching of peripheral subsystems and processors between pairs of I/O channels; (36-bit interface; switches can be cascaded if desired).	168	6,540	18
		F0893-02	Transfer Switch (Same as F0893-00, except with 18-bit interface for switching 1 I/O channel)	168	6,540	18
	2508-00		Switch Cabinet (contains power supply, integral operators panel, and control unit for up to 5 transfer switches in any combination)	405	12,740	60
	2508-01		Switch Cabinet (same as 2508-00 but with remote operator panel)	405	12,740	60
	2508-02		Switch Cabinet (same as 2508-00 but includes auxiliary power supply and can accommodate only 4 switches)	598	20,000	88
	2508-03		Switch Cabinet (same as 2508-01 but includes auxiliary power supply and can accommodate only 4 switches)	598	20,000	88
MASS STORAGE			Drum Storage			
	7304-01		FH880 Drum (1,572,864 18-bit words)	2,150	85,165	190
	7427-03		FH880 Control (controls 1 to 8 FH880 Drums)	1,550	58,800	190
	6016-00		FH 432 Drum (524,288 18-bit words)	1,070	42,435	100
	6015-00		FH1782 Drum (4,194,304 18-bit words)	2,940	117,210	260
		F0786-01	Dual Channel (for FH432)	70	2,255	15
		F0767-00	Dual Channel (for FH1782)	70	2,255	15
	5012-00		FH432/FH1782 Control (controls 1 to 8 FH432 or FH1782 Drums in any combination)	2,145	82,515	260
		F0929-00	Write Lockout	30	1,040	5
		F0930-00	SPI (allows two processors to access control)	440	17,805	25
	6010-00		Fastrand II (44 Million - 18-bit words)	4,050	164,640	300
		F0686-01	Fastbands	215	8,235	25
		F0688-01	Write Lockout	30	1,040	5
	5009-00		Fastrand II Control (unbuffered control for 1 to 8 Fastrand II Drums)	1,280	51,060	115
	5009-04		Fastrand II Control (buffered control for 1 to 8 Fastrand II Drums)	1,335	53,410	115
	5009-93		Fastrand II Dual Control (dual unbuffered control for 1 to 8 drums; includes dual access for first drum)	3,000	120,495	230
	5009-92		Fastrand II Dual Control (dual buffered control for 1 to 8 drums; includes dual access for for first drum)	3,110	125,195	230
		F0710-00	Search all Words (for buffered controls only)	55	2,255	—
		F0763-02	Control Buffer (for field conversion from unbuffered to buffered control)	55	2,350	—
		F0959-99	Dual Access Drum Adapter (required for attachment of all subsequent drums to a Dual Control, except fifth)	50	1,830	10

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Drum Storage			
		F0959-98	Dual Access Drum Adapter (required for attachment of fifth drum to a Dual Control)	50	1,830	10
	6010-10		Fastrand III Drum	4,965	200,800	350
	5009-89		Fastrand III Control	1,565	62,220	135
	5009-85		Fastrand III Dual Control (includes dual access adapter for first drum only)	3,650	147,010	270
	5009-81		Fastrand III Control (field upgrade from single to dual access)	2,085	84,790	135
		F0763-01	Control Buffer	55	2,350	-
		F0686-01	Fastband	205	8,235	25
		F0688-01	Write Lockout	30	1,040	5
		F0959-97	Fastrand III Dual Access Drum Adapter (for all subsequent drums except fifth)	50	1,830	10
		F0959-96	Fastrand III Dual Access Drum Adapter (for fifth drum)	50	1,830	10
		F0710-01	Search All Words	25	2,255	-
INPUT-OUTPUT			Magnetic Tape			
			Uniservo VIC:			
	5008-00		Uniservo VIC Control (controls up to 4 Master units; requires 2 I/O channels)	745	31,070	35
	5008-98		Uniservo VIC Control (controls up to 4 Master units; simultaneous read-read/read-write; requires 4 I/O channnels)	1,490	62,140	70
	5008-08		Uniservo VIC Control (same as 5008-00 but requires only 1 I/O Channel)	745	31,070	35
	5008-91		Uniservo VIC Control (same as 5008-98 but requires only 2 I/O Channels)	1,490	62,140	70
		F0627-04	Translator (for 5008-00 or 08)	110	4,410	5
		F0627-99	Translator (for 5008-98 or -91)	220	8,820	10
		F0706-00	9 Track Capability (required in 9-Track Controls, for non simultaneous and 2 for simultaneous controls)	50	1,960	5
	0858-00		Uniservo VIC Master (7-Track; 8,540/23, 741/ 34,160 char/sec; can handle up to three 0858-01 Slave units)	515	17,350	115
	0858-08		Uniservo VIC Master (Same as 0858-00 but with provisions for simultaneous read-read/ read-write)	570	19,800	115
	0858-01		Uniservo VIC Slave (7-Track)	310	10,470	70
	0858-10		Uniservo VIC Master (9-Track; 800 bpi; 34,100 bytes/sec; handles up to three 0858-14 slave units)	515	17,350	115
	0858-12		Uniservo VIC Master (Same as 0858-10 but with provisions for simultaneous read-read/ read-write)	570	19,800	115
	0858-14		Uniservo VIC Slave (9-Track)	310	10,470	70
		F1021-00	7 to 9 Track Conversion (converts 7-Track tape unit to 9-Track unit)	-	-	-
		F1072-00	Simultaneous Capability (converts 0858-00 to 0858-08)	55	2,450	-
		F1072-01	Simultaneous Capability (converts 0858-10 to 0858-12)	55	2,450	-

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Cont'd)			Magnetic Tape (Cont'd)			
			Uniservo VIIIC:			
	5008-12		Uniservo VIIIC Control (controls 1 to 16 Uniservo VIIIC units; requires 2 I/O channels)	1550	62,430	120
	5008-20		Uniservo VIIIC Control (same as 5008-12 but requires 1 I/O channel)	1550	62,430	120
	5008-89		Uniservo VIIIC Control (controls 1 to 16 Uniservo VIIIC units; provides read-read, read-write, write-read, and write-write simultaneously; requires 4 I/O channels)	3100	124,860	240
	5008-87		Uniservo VIIIC Control (same as 5008-89 but requires only 2 I/O channels)	3100	124,860	240
	5008-83		Control Expansion (converts 5008-12 to 5008-89)	1550	62,430	120
	5008-79		Control Expansion (converts 5008-20 to 5008-87) 7-track	1550	62,430	120
		F0704-00	VIC Capability (allows VIC and VIIIC units to be intermixed on 5608-12 or 5008-20 controls)	85	3,385	5
		F0706-00	9 Track Capability (1 required for non-simultaneous, 9-track controls; 2 required for simultaneous, 9-track controls)	50	1,960	5
		F0627-04	Translator (for 5008-12 or -20)	110	4,410	5
		F0627-98	Translator (for 5008-89 or -87)	220	8,820	10
	0859-00		Uniservo VIIIC (7-track; 24,000/66,720/96,000 char/sec; non-simultaneous)	860	32,735	110
	0859-04		Uniservo VIIIC (9-track; 800 bpi; 96,000 bytes/sec; non-simultaneous)	875	33,390	110
	0859-08		Uniservo VIIIC (7-track; same as 0859-00, but for simultaneous control)	890	34,045	110
	0859-10		Uniservo VIIIC (9-track; same as 0859-04, but for simultaneous controls)	905	34,700	110
		F0999-00	7 to 9 Track Conversion (converts 0859-00 to 0859-04)	15	655	—
		F0999-04	7 to 9 Track Conversion (converts 0859-08 to 0859-10)	15	655	—
			Printer			
	5011-12		Printer Control (controls 0708-99 one printer)	500	18,490	75
		F0751-99	Printer Control Expansion (for control of second printer)	400	14,790	60
	0758-99		Printer (1600 lines/min. with 43-character set; 1,200-lines/min. with 63-character set)	1265	43,935	310
			Paper Tape			
	0917-00		Reader and Control (1000 char/sec; requires 2 I/O channels)	600	19,575	150
	0917-02		Reader and Control (1000 char/sec; requires 1 I/O channel)	600	19,575	150
	0918-00		Punch (240 char/sec; requires Reader)	250	8,700	50
	0918-01		Punch with Verifier (240 char/sec; requires Reader; includes post-punch photo-electric read check)	300	9,350	85
		F0962-00	Spoolers (for 0917-00 or -02 Readers)	150	5,000	35
COMMUNI-CATIONS		F0900-06	Communication Terminal Module Controller (CTMC)	705	24,700	135

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $(1)	Purchase $	Monthly Maint. $
COMMUNI-CATIONS		F0906-06	Spare CTM Controller	260	9,020	50
		F0901-04	CTM-LS	65	2,255	15
		F0902-02	CTM-MS	85	2,895	15
		F0903-02	CTM-HS	100	3,630	15
		F0905-00	Automatic Dialing	20	635	5
		F0904-00	Parallel Output	40	1,315	10
		F0904-01	Parallel Input	40	1,315	10
		F0988-00	CTM VII High Speed	80	3,050	10
		F0988-01	CTM VII High Speed (includes black parity checking)	95	3,480	15
		F0991-00	CTM VI High Speed	125	4,570	20
		F0989-00	CTM VII Medium Speed	60	2,175	10
		F0989-01	CTM VII Medium Speed	70	2,610	10
		F0989-02	CTM VII Medium Speed	80	3,050	10
		F1027-00	CTM IV Low Speed	80	3,050	10
		F1048-00	CTM VI Low Speed	95	3,480	15
		F1018-02	HS Interface Module (for 6 full-duplex lines)	60	2,175	10
		F1018-03	HS Interface Module (for 4 full duplex lines)	40	1,525	5
		F1018-05	Expansion Kit (capability for handling 2 additional lines)	20	650	5
		F1019-01	HS Interface Module (for 8 full-duplex lines)	80	3,050	10
		F1019-03	HS Interface Module (for 4 full duplex lines)	40	1,525	5
		F1019-05	Expansion Kit (capability for handling 4 additional lines)	40	1,525	5
			Word Terminal Synchronous (WTS):			
	8552-01		Basic Cabinet (space for up to 2 WTS Modules)	270	8,380	80
		F0614-00	Power Supply (for first Module)	110	3,335	30
		F0614-01	Power Supply (for second Module)	110	3,335	30
		F0771-00	WTS Module	485	14,210	160
		F0772-00	Voice Band Interface	5	225	-
		F0772-01	Unattended Answering	5	225	-
		F0772-02	Automatic Dialing	55	1,670	15
		F0772-03	Broad Band	5	225	-

NOTES:

(1) UNIVAC will extend rental agreements to a five-year term for systems in current production at a monthly rental of 85 per cent of the figure shown in this column.

(2) UNIVAC 900 series computers Systems can be connected to the 418-III via the Intercomputer Control Unit (F1095-00) to provide additional peripheral units.

SUMMARY: UNIVAC 418-I/II

.1 INTRODUCTION

The UNIVAC 418 Models I and II were the first two models in the UNIVAC 418 Series. A fully detailed Summary of this series is presented in section 790:011; this section briefly summarizes those factors which relate specifically to the UNIVAC 418-I and II systems. The UNIVAC 418-II is currently being marketed by UNIVAC; however, the UNIVAC 418-I is no longer available.

The UNIVAC 418-I/II is a medium-scale, solid-state computer that is oriented primarily toward real-time and message switching applications. Two central processors and associated core memories are available for use in 418 systems: the Model I and the Model II. Both models have the same set of instructions and, given the same peripheral equipment and input-output channel assignments, are completely program-compatible. The core storage cycle time is 4 microseconds for Model I and 2 microseconds for Model II.

A wide range of magnetic drum units, magnetic tape units, and communication devices permit UNIVAC 418-I/II systems to serve as versatile message switching centers and for real-time commercial applications. Use of the 418 in scientific applications will generally not be economical due to its short word length (18 bits) and the absence of instructions for double-precision or floating-point arithmetic. UNIVAC 418-II system rentals range from approximately $7,000 to $18,000 per month and average around $11,000.

Although UNIVAC 418-I systems have been operating in customer installations since June 1963, their general availability to commercial users was not announced until August 1964. This 418 is closely related to the UNIVAC 1218 Military Computer. Both the 418 and the 1218 evolved from the UNIVAC CUT (Control Unit Tester), a special-purpose computer designed to test peripheral equipment for the larger UNIVAC computer systems. A modified version of the 418 serves as the central processor in the Westinghouse PRODAC 510 and 580 process control systems.

The principal characteristics that make the UNIVAC 418-I/II systems suitable for real-time or message switching applications are:

- High-capacity random access storage for master file data or messages in transit.
- A variety of magnetic tape units, which provide storage of slower access and greater capacity for use as a reference store, a journal, and intercept and overflow storage.
- Program interrupt facilities which permit concurrent processing of several levels of programs.
- Flexible communications linkages to any common carrier for two-way transmission of data between the computer and remote points.
- Two electronic chronometers, which make the systems "time-conscious."

.2 HARDWARE

UNIVAC 418 systems using the Model I Processor can have from 4,096 (included with the basic processor) to 16,384 word locations of 4-microsecond core storage in 4,096-word modules. Systems using the Model II Processor can have from 4,096 (included with the basic processor) to 65,536 word locations of 2-microsecond core storage in 4,096-word modules. Each core storage word contains 18 data bits and one parity bit. Each 18-bit word can hold one instruction, three alphameric characters, or an 18-bit binary data item. Thirty-two locations of core storage contain a permanently-wired "bootstrap" routine to facilitate program loading and error recovery.

The Central Processor can perform a full complement of fixed-point arithmetic, Boolean, comparison, and shifting operations on 18-bit binary operands. Double precision addition, subtraction, and shifting are also provided. The UNIVAC 418-I/II has no automatic facilities for double-precision multiplication and division, floating-point arithmetic, decimal arithmetic, editing operations, multi-word internal transfers, or radix conversion. There are eight index registers, with instructions to step and test, increment, store, and load them. Only one of the eight index registers at a time, as selected by a separate instruction, can be used for address modification. Indirect addressing is not provided except for "Jump Indirect" instructions.

Instructions which reference core storage contain a single 12-bit address. This restricts the number of locations directly accessible at any time to one module of 4,096 words unless indexing is used. The particular module being addressed is indicated by a special register, by the Program Address Counter, or by an index register.

.2 HARDWARE (Contd.)

Average execution time for UNIVAC 418 instructions is about 4 microseconds for the Model II Central Processor and 8 microseconds for the Model I Processor. The longest instruction — Divide — requires 24 microseconds (48 microseconds for Model I), while a few instructions require as little as 2 microseconds (4 microseconds for Model I).

The program interrupt facility causes a transfer of control to one of 51 fixed core locations upon completion of an input-output operation, upon detection of an illegal operation code or input-output error, upon underflow of the Delta Clock, or upon an interrupt from the Day Clock.

The UNIVAC 418-I/II Processors can have 8, 12, or 16 input-output channels. If the Console keyboard-printer is used, it must be assigned to channel 0; the remaining channels are for general input-output use. Many of the standard peripheral subsystems require two channels, as indicated below. In general, each subsystem can handle one data transfer operation at a time. The maximum gross data transfer rate (or "saturation rate") for all simultaneously-operating peripheral devices ranges from 135,000 to 200,000 words per second for the Model II Central Processor, depending upon the channel requirements of the various subsystems. The gross data rate for the Model I Processor ranges from 62,500 to 100,000 words per second.

Two types of peripheral interfaces are used in the 418 system, depending upon the channel requirements of the subsystem used. Subsystems which use one input-output channel require 4 core memory cycles to transfer 18 bits (one word) of data. Subsystems using two input-output channels require 5 memory cycles to transfer 36 bits (two words) of data.

Each UNIVAC 418-I/II peripheral subsystem can consist of any of the following groups of input-output devices and their associated control units:

- 1 to 5 Flying Head 330 Magnetic Drums. Each drum stores 262,144 words with an average access time of 8.5 milliseconds. Peak data transfer rate is 30,000 words per second with an interlace factor of 2. Interlace factors of 4, 8, or 16 can alternatively be used to achieve lower effective transfer rates. One input-output channel is required.
- 1 to 8 Flying Head 880 Magnetic Drums. Each drum stores 1,572,864 words with an average access time of 17 milliseconds. Peak data transfer rate is 60,000 words per second. Interlace factors of 2, 4, 8, or 16 can be used for lower effective transfer rates. Two input-output channels are required.
- 1 to 8 Fastrand II Mass Storage Units. Each unit has 2 drums, served by 64 movable read/write heads, and stores 44,040,192 words with an average access time of 93 milliseconds. A single Fastrand I Subsystem can store up to 528 million characters. Peak data transfer rate in UNIVAC 418 systems is 52,685 words per second with an interlace factor of 3. Interlace factors of 5, 7, and 9 can be used for lower transfer rates. Two input-output channels are required.
- 2 to 16 Uniservo VIC Magnetic Tape Handlers. These units can read forward only, at a peak transfer rate of 8,500, 24,000, or 34,00 rows per second. The tape format is fully compatible with the IBM 729 and 7330 Magnetic Tape Units. One input-output channel is required; two channels must be used if simultaneous read/read or read/write operations are desired.
- 1 Paper Tape Reader and 1 Paper Tape Punch. These units (housed in a single cabinet on the console desk) can read punched tape of up to 8 levels at up to 200 characters per second and punch standard 5-, 6-, 7-, or 8-level punched tape at 110 characters per second. One input-output channel (the same channel as used by the console keyboard-printer) is required.
- 1 UNIVAC 1004 Central Processor and associated peripherals. The 1004 provides the UNIVAC 418 with punched card input at 400 or 600 lines per minute. An optional card punch is available which punches cards at the rate of 200 per minute. The 1004 can also be equipped with magnetic tape and paper tape units. See Computer System Report 770 for full details. The 1004 subsystem requires one 418 input-output channel.
- Communications Terminal Module Controller, consisting of up to 32 input and 32 output Communication Line Terminals connected to a Communication Multiplexer. These units enable the 418 to send and receive data via any common carrier at transmission rates of up to 4,800 bits per second. Two input-output channels are required.

(Contd.)

.3 SOFTWARE

Programs which are available for use with the UNIVAC 418-I/II systems can be summarized as follows:

- ART — An assembly system that translates symbolic source programs into machine language object programs in relocatable or absolute form. ART is a two-pass assembler unless a magnetic tape unit or drum is available for intermediate storage. An 8K 418 is required, with a program input and program output device, a card reader or magnetic tape unit for control input, and a 1004 printer. Assembly speed is approximately 400 lines per minute for a 12K 418-I Processor with Uniservo IIIC Tape Handlers.
- EXEC — An operating system capable of controlling four levels of programs: critical, real-time, batch, and computational, all operating concurrently. EXEC is designed to provide efficient utilization of the available system components and process scheduled jobs with a minimum of operator intervention. EXEC requires at least 1,491 words of core storage plus about 208 words per I/O handler routine. Times required to perform the EXEC functions associated with each input-output operation range from 0.52 to 1.19 milliseconds.
- FORTRAN IV — A subset of IBM 7090/7094 FORTRAN IV that permits the use of most of the facilities available in the 7090/7094 version, including integer, real, and a form of double-precision constants and variables. Complex and logical constants and variables, however, are not permitted.
- Sort/Merge — A three-phase program that utilizes the polyphase method of merge sorting with 3 to 12 Uniservo IIA or IIIC Tape Handlers or a Fastrand Mass Storage Unit. A 12K 418 is required, and additional core storage can be utilized when available.
- Utility Routines — include data transcription functions, dump and trace routines, tape and drum maintenance, and inspect and change routines.

SUMMARY: UNIVAC 418-III

.1 INTRODUCTION

The UNIVAC 418-III Real-Time System was announced on 5 June 1968. In basic processing characteristics, the UNIVAC 418-III is similar to the UNIVAC-II, but greatly increased speed and I/O capability has been obtained by a system design that utilizes concepts and technology successfully employed in the UNIVAC 1108.

The UNIVAC 418-III is a medium-scale computer system designed primarily for data communications and real-time applications but with sufficient power to permit concurrent scientific and business data processing. This system provides: up to 131,072 eighteen-bit words of 0.75 microsecond core storage; truly simultaneous processing and input-output data transfers; capability to handle up to 2.66 million word per second input-output data; storage protection; Externally Specified Indexing (discrete communication line buffering); and automatic tabling of communications interrupts.

The peripheral devices available with the UNIVAC 418-III system include a wide range of magnetic drum systems and magnetic tape units, as well as a flexible communications capability that permits use of virtually any commercially available terminal device. With respect to peripheral equipment, the UNIVAC 418-III is compatible with all peripheral equipment used in the UNIVAC 1108 system, as well as that used in the UNIVAC 418-II system.

Key features and components of the UNIVAC 418-III system include:

- Independence of central components — central processor, I/O channels, and main memory modules, leading to optimized performance through minimal component interference.
- Input/output and interrupt control mechanisms implemented in automatically functioning hardware.
- Core memory access speed of 750 nanoseconds per 18-bit word.
- Up to four independently accessible main memory banks of 16K or 32K 18-bit words of storage per bank.
- Up to 32 I/O channels controlled by two independently functioning I/O Modules (Up to 16 channels per module).
- A hardware/software memory protection scheme.
- Extensive data communications capabilities, permitting control of more than 400 active duplex communication lines per UNIVAC 418-III system.
- High transfer rate, low access time magnetic drum subsystem.
- A real-time operating system designed to exploit the functional independence of the hardware components and to permit concurrent execution of multiple real-time jobs in conjunction with scientific and commercial background processing.
- A sophisticated Real-Time Operating System that consists of a set of control programs, programming aids, and utility services.

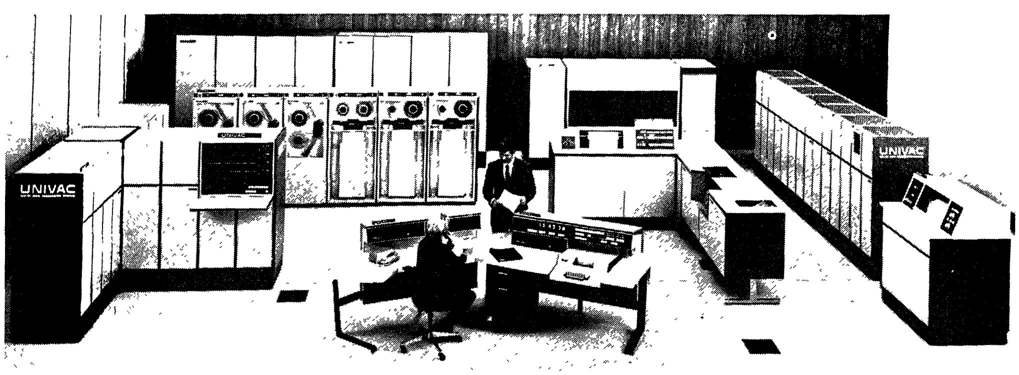

Figure 1. A Large UNIVAC 418-III Installation

.2 HARDWARE

The basic unit of data in the UNIVAC 418-III is an 18-bit word which can contain one instruction, two 8-bit alphameric characters, three 6-bit alphameric characters, or a fixed point, floating point or absolute binary quantity.

Core memory is organized into four banks each of which can contain 16K or 32K words of storage and each of which is controlled separately from the others. The vertical/horizontal expansion capabilities of the UNIVAC 418-III core memory allow the user to expand his memory capacity either by adding banks to provide more simultaneity or expanding within a bank to provide more storage capacity or both.

Figure 2 illustrates the maximum storage unit and referencing unit configuration. The minimum configuration is the Command/Arithmetic (C/A) Unit, IOM#0 and memory units m0 of Bank 0 and m1 of Bank 1. This provides two-way simultaneity with 16K core storage in each bank. Three-way simultaneity capability is achieved by adding memory unit m4 of Bank 2 and IOM#1. The addition of memory unit m5 of Bank 3 then provides greater flexibility of storage allocation to ensure as much as possible the achievement of three-way simultaneity.

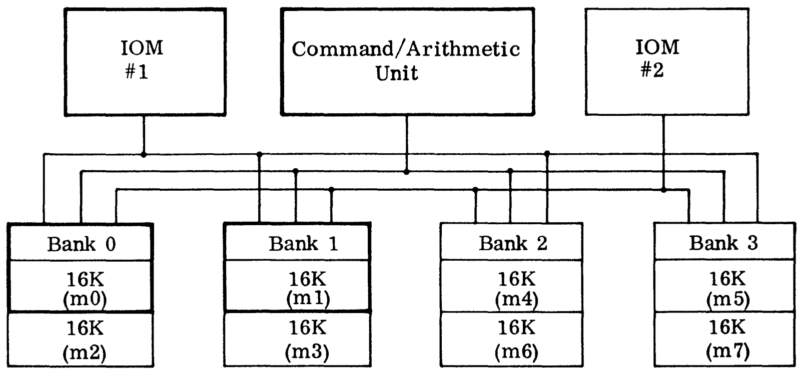

Figure 2. Storage Unit Assignment in a Maximum Storage Configuration

Increased core storage capability can also be obtained by the addition of memory unit m2 of Bank 0 instead of or in addition to memory units m4 of bank 2 or m5 of Bank 3. Indeed, each existing bank can be expanded to 32K by adding the second 16K memory unit without first having subsequent banks added.

The main storage of the UNIVAC 418-III System is constructed so that the banks of storage have a physical unit/logical unit relationship. This is accomplished by a series of address switches on the maintenance panel of each storage cabinet. These switches are used to assign the bank number to each of the memory modules.

Another significant feature of the UNIVAC 418-III is the storage protection capability offered. A Guard Limits Register is employed that enables storage protection of core memory in 256 word increments. The Executive determines required limits, sets the Guard Limits Register and activates Guard Mode before giving control to a particular program. When the Executive regains control, the Guard Mode is de-activated. Thus, in a multiprogramming environment, the accidental alteration of one program area by another program, even one being tested, is prevented.

The Command/Arithmetic Unit and I/O Module of the UNIVAC 418-III System are independently operating units which collectively perform the functions normally found in one central processor unit. The Command/Arithmetic Unit contains all necessary controls for program execution while the I/O Module contains the controls necessary for proper input-output data transfers. This separation of controls into independently operating units enables the establishment of independent data paths between the control units and the core storage banks which allows the truly simultaneous operation of the UNIVAC 418-III not found in systems with a single central processing unit.

The minimum UNIVAC 418-III system consists of the Command/Arithmetic Unit, one I/O Module with 8 I/O channels, and two banks of 16K words of core memory. A second I/O Module with 8 I/O channels can be added and increased simultaneity capability from two-way to three-way can then be obtained by adding an additional memory bank. An additional four or eight I/O channels can be added to either or both of the I/O Modules providing a maximum of 32 I/O channels in the fully expanded system. Memory can be increased from the initial 32K words up to 131K words as previously indicated.

The UNIVAC 418-III Command section includes a powerful interrupt system. There are 14 discrete internal interrupt levels and 96 additional levels for the I/O channels. The significance of this large number of interrupt levels is that upon encountering an interrupt condition, control can be automatically transferred to the specific location in main memory

(Contd.)

.2 HARDWARE (Contd.)

corresponding to that interrupt condition. This eliminates the time- and space-consuming test routines required to determine the type and source of the interrupt. Additionally, the UNIVAC 418-III I/O control system can automatically accept and store interrupt information from any number of communications lines without interfering in any way with the Executive which may be busy servicing a prior interrupt. This permits acceptance of concurrent interrupts while permitting the Executive to perform its critical functions uninterrupted.

The following is a list of the peripheral subsystems used in a UNIVAC 418-III system. A peripheral subsystem can consist of any of the following groups of input-output devices and their associated control units.

- 1 to 8 Flying Head 432 Magnetic Drums. Each drum stores 524,288 words with an average access time of 4.25 milliseconds. Peak data transfer rate is 474,000 words per second. Interlace factors of 2, 4, 8, or 16 can be used to obtain lower effective transfer rates. Two input-output channels are required.
- 1 to 8 Flying Head 1782 Magnetic Drums. Each drum stores 4,194,304 words with an average access time of 17.0 milliseconds. Peak data transfer rate is 454,000 words per second. Interlace factors of 4, 8, or 16 can alternatively be used to achieve lower effective transfer rates. Two input-output channels are required.
- 1 to 8 Flying Head 880 Magnetic Drums. Each drum stores 1,572,864 words with an average access time of 17 milliseconds. Peak data transfer rate is 60,000 words per second. Interlace factors of 2, 4, 8, or 16 can be used for lower effective transfer rates. Two input-output channels are required.
- 1 to 8 Fastrand II Mass Storage Units. Each unit has 2 drums, served by 64 movable read/write heads, and stores 44,040,192 words with an average access time of 93 milliseconds. A single Fastrand II Subsystem can store up to 1,056 million characters. Peak data transfer rate in UNIVAC 418 systems is 52,685 words per second with an interlace factor of 3. Interlace factors of 5, 7, and 9 can be used for lower transfer rates. Two input-output channels are required.
- 2 to 16 Uniservo VIC Magnetic Tape Handlers. These units can read forward only, at a peak transfer rate of 8,500; 24,000; or 34,000 characters per second. The tape format is fully compatible with the 7-track IBM 729 and 7330 Magnetic Tape Units, and an optional feature permits operation in the 9-track mode. One input-output channel is required; two channels must be used if simultaneous read/read or read/write operations are desired.
- 2 to 16 Uniservo VIII C Magnetic Tape Handlers. These units can read forward only, at a peak transfer rate of 24,000; 67,000; or 96,000 characters per second. The tape format is fully compatible with the 17-track IBM 729 and 7330 Magnetic Tape Units, and an optional feature permits operation in the 9-track mode. One input-output channel is required; two channels must be used if simultaneous read/read or read/write operations are desired.
- 1 0758 High-Speed Printer. This unit uses a 63-character set and prints up to 1600 alphameric lines per minute. One input-output channel is required
- 1 Paper Tape Reader and 1 Paper Tape Punch. These units can read punched tape of up to 8 levels at up to 1000 characters per second and punch standard 5-, 6-, 7-, or 8-level punched tape at 270 characters per second. One input-output channel (the same channel as used by the console keyboard-printer) is required.
- 1 UNIVAC 9000 Series Central Processor and associated peripherals. The 9000 Series Computer provides the UNIVAC 418-III with punched card input at 400 or 600 lines per minute and printed output at up to 600 lines per minute. An optional card punch is available which punches cards at the rate of 200 per minute. The 9000 Series Computer can also be equipped with magnetic tape and paper tape units. See Computer System Report 810 for full details. The 9000 Series Computer subsystem requires one 418 input-output channel.
- 1 Communications Terminal Module Controller (CTMC). Each CTMC can control up to 16 Communications Terminal Modules (CTM) each of which will control a varying number of communications lines depending upon the line speed. The CTMC operates at a peak data transfer rate of 80,000 characters per second and requires two I/O channels.

Figure 3 shows a UNIVAC 418-III System with each of preferred peripheral systems. The minimum system is shown in heavy lines in the figure and consists of the Command/Arithmetic Section, one I/O Module including 8 I/O channels, and two banks of 16K words of core memory.

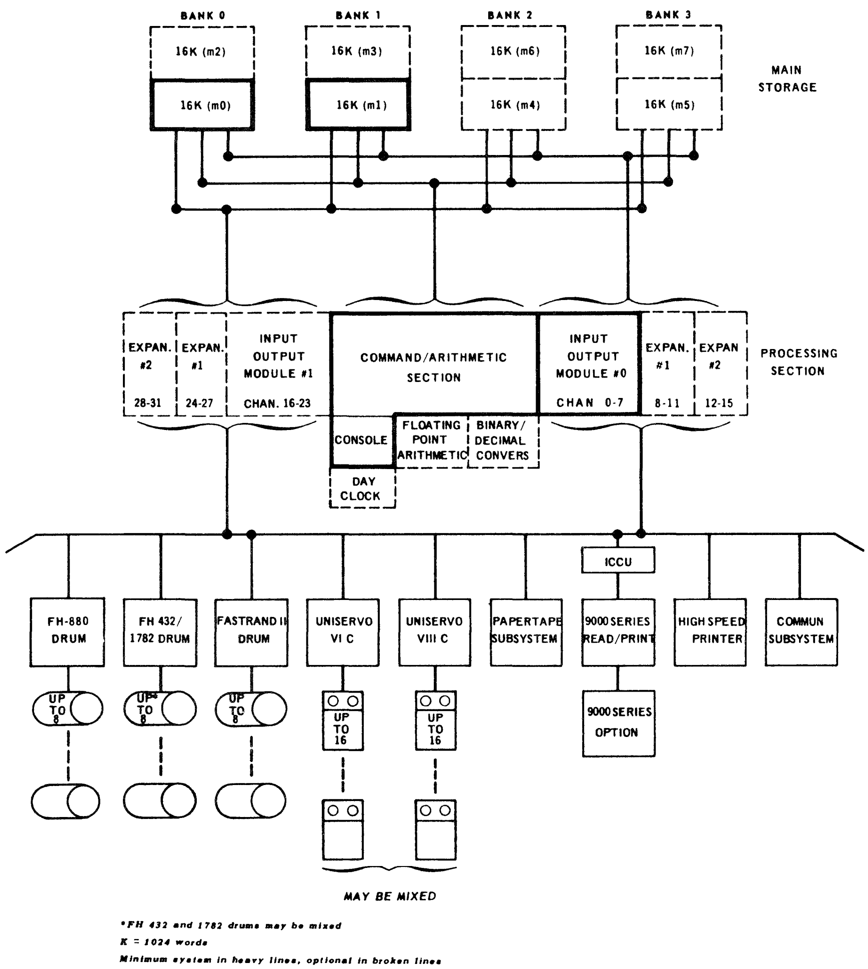

Figure 3. UNIVAC 418-III System Components

.3 SOFTWARE

The UNIVAC 418-III software has been designed specifically for the unique characteristics of the UNIVAC 418-III hardware and both the hardware and software have been designed primarily for the unique characteristics of real-time applications. The software provided for the UNIVAC 418-III includes:

- UNIVAC 418-III Executive, an executive system which provides multiprogramming capability with job control, file control and file access facilities together with I/O Handlers;
- Real-Time Communication Control that has been designed to provide the user with the same level of interface to real-time input/output operations that he has to standard peripheral input/output;
- Language processors which include COBOL, FORTRAN, and UNIVAC 418-III Assembler; and
- Systems Support Libraries which provide system support services of data file maintenance, program file maintenance, testing, and utility programs:

    Sort/Merge

    Program Monitor and Trace

    Program Maintenance

    General Tape/Drum Print

    Common Procedures

    Data Tape File Maintenance

    Executive Independent Utilities

(Contd.)

.31 UNIVAC 418-III Real-Time Executive

The Executive provided with the UNIVAC 418-III will be an advanced executive system providing multiprogramming capabilities and including job control, file control, and file access facilities.

The UNIVAC 418-III Real-Time Executive is expected to provide four levels of priority:

- Critical,
- Real-Time,
- Batch, and
- Computational;

and to allow the user to time-share each level with multiple programs. Further, it will process all interrupts, including suspension and relocation of active jobs, as well as assignment of control to the proper handling routine when an interrupt occurs. Scheduling will be by priority and first-in-first-out within each priority level. Facilities allocation has been extended to included dynamic acquisition and release of computer system facilities.

The Input/Output service provided by the UNIVAC 418-III Real-Time Executive will include the normal input/output control and device handler routines. Additionally, three methods of file access will be provided, each consisting of a comprehensive set of macro instructions. Details of these access methods are not yet available.

.32 UNIVAC 418-III Real-Time Communications Control

The UNIVAC 418-III Real-Time Communications Control (RTCC) provides an interface to remote communication facilities which is free from the continuing influence of specific devices. It provides control over internal routing of messages received from or destined to remote communication terminals.

RTCC places an input message in a drum storage queue and delivers it to the user on a GET basis. Similarly, RTCC takes an output message on a PUT basis and causes it to be transmitted to its destination. Remote Communications terminals initially supported by RTCC are:

- UNIVAC DCT 2000 Data Communications Terminal
- UNIVAC Uniscope 300 Cathode Ray Tube Display
- UNIVAC 1004 System
- UNIVAC 9200 Computer System
- UNIVAC 2300 Computer System
- Teletype ASR/KSR Units.

.33 Programming Languages and Compilers

UNIVAC 418-III users will have both FORTRAN and COBOL available as well as the Assembly system. The UNIVAC 418-III Assembler is a machine oriented language compatible with the ART Assembler of UNIVAC 418-II. Both FORTRAN and COBOL are compatible with the UNIVAC 1108. FORTRAN and COBOL languages permit easy growth into the larger UNIVAC 1108 system should the UNIVAC 418-III user encounter such a need.

.331 FORTRAN

The UNIVAC 418-III FORTRAN is expected to consist of the current IBM 7090/7094 FORTRAN language, and to include the USASI FORTRAN of 7 March 1966 as a subset. No compatibility with FORTRAN II is expected. However, full compatibility with the FORTRAN IV available on the UNIVAC 418-I/II and UNIVAC 1108 systems is expected.

.332 COBOL

COBOL for the UNIVAC 418-III is expected to be developed in accordance with the requirements of the proposed USASI standard for COBOL. Language characteristics provided in the UNIVAC 418-III COBOL are from the following modules:

- Nucleus module
- Sequential Access module
- Table Handling module
- Random Access module
- Library module

.333 UNIVAC 418-III Assembler

ASSEMBLER is the machine oriented assembly system provided with the UNIVAC 418-III system. ASSEMBLER is source code compatible with ART, the assembly system of the UNIVAC 418-I/II system, with expanded facilities to include instructions available on the UNIVAC 418-III only. For all intents and purposes, the language of ASSEMBLER is the same as that of ART.

One significant difference between ASSEMBLER and ART is that ASSEMBLER allows sixteen different location counters to be designated and used. This added feature of ASSEMBLER enables effective programmer organization of program, data and buffer areas within the memory banks. Proper use of this facility enables effective use of memory in order to take full advantage of the higher data transfer rates and increased processing time available when I/O data transfers and processor activity are occurring in different memory banks from one another.

.34 System Support Library

The UNIVAC 418-III user will have available a System Support Library that provides services in the areas of data file maintenance, data file sorting, program maintenance, and program testing. Included in this Library are also a number of common procedures as well as independent utility programs.

.341 Sort/Merge

The Sort/Merge package will provide a generalized Sort/Merge capability accepting parametric information specifying input and output file descriptions and devices as well as key size and position in the records. The Sort/Merge program can utilize UNISERVO VI C or VIII C Magnetic tape handlers or FASTRAND II magnetic drums for input, intermediate, and/or output data storage.

.342 Program Maintenance Routing

The Program Maintenance routine provides the UNIVAC 418-III Operating System user with a method of performing maintenance services in the following major areas:

- The creation of new source and/or object code libraries using both worker and systems software programs as input.
- The generation of updated libraries constructed by selecting desired portions of one or more existing libraries.
- The creation of control information and source input for the Assembler.
- The ability to copy a program, one or more segments of a program, or any number of programs.
- The maintenance and correction of source programs.

.343 Data Tape File Maintenance

The Data Tape File Maintenance program provides a utility routine which updates and makes corrections to a data file. Several options are incorporated in the program to facilitate maintenance of a file.

The program is designed to provide one compact program which allows for adjustments that must be made to a data file in daily use. Corrections may be applied to segments or an entire file. The file may be copied to another tape or printed; segments of the data file may be compared to those on another tape, or the file may be positioned to a given segment. The type of maintenance desired is specified by parameter cards.

The Data Tape File Maintenance program provides several options to the user. These options are correct, copy, compare, print, and position.

- Correct Option

  The correct option allows the user to

  — delete files or blocks
  — replace files, blocks, or words
  — insert corrections into files or blocks

- Copy Option

  The copy option provides the user with the ability to copy all or part of a data file to another tape.

- Compare Option

  The compare option allows the user to compare all or part of two data files.

(Contd.)

.343 Data Tape File Maintenance (Contd.)

- Print Option

  The print option prints the first five words of the specified files or blocks, or the number of words specified in a file or block.

- Position Option

  The position option allows the user to position a tape to the file or block specified.

.344 General Print and Punch Routine

The General Print and Punch (GPP) routine provides the user with a means of printing and punching from magnetic tape or drum storage without restriction by format conventions. Additionally, the user has a choice of five conversion codes for display of the data on the printer. The GPP routine operates in two modes:

- the testing mode, where all the information to be output is edited including tape block numbers or drum addresses;
- the data mode, where only edited print or punch images are output.

The codes are:

USASCII (United States of America Standard Code for Information Interchange)

BAUDOT

FIELDATA

XS-3

OCTAL

The five conversion codes are available only in the testing mode.

.345 Program Trace Routine

The Program Trace routine provides a testing aid designed to protect operational real time programs that are running concurrently with program testing by monitoring each instruction executed by the program placed under Program Monitor Control.

.346 Common Procedures

These routines are a number of procedures and subroutines designed to facilitate programming for batch applications. The Common Procedures are usually on the library tape in symbolic format and must be merged with the worker program through a library run.

The Common Procedures offered may be divided into five groups:

- Two- and Four-Word Compare

  Simulation of 36-bit or 72-bit registers for comparison purposes.

- Conversion Routines

  These provide single-word; double-word (36 bits) or four-word (72 bits) conversion as follows:

  Binary to XS-3

  Binary to Fieldata

  XS-3 to Binary

  Fieldata to Binary

- Edit Routines

  These routines provide the user with aids to clear any area in storage, to left or right shift, and to complement data in four simulated 36-bit registers.

- Main Storage Search

  This routine permits the operator to search any area of main storage for a specific bit pattern. This routine is controlled by specifying a mask containing the bit pattern desired and the beginning and ending addresses of the storage area to be searched. If an equal comparison between the mask and a word of storage within the parameters is found, the address and contents are printed.

- Storage Dump to Tape

  This routine permits the operator to dump an area of main storage to a magnetic tape. Any area of main storage may be dumped by specifying the beginning and ending addresses of the storage area to be dumped. The tape is written in a format having a predetermined block size and density which can be initially loaded.

.346 Common Procedures (Contd.)

- Tape Copy

  This routine permits the operator to copy any magnetic tape regardless of format, density, and block size. This routine is controlled by specifying the format, density, and block size of the tape to be copied.

- Drum Storage Dump

  This routine permits the operator to dump an area of the drum to the systems printer. Any drum area may be dumped by specifying the beginning and ending addresses of the area desired.

- Logical Routines

  These aid the user by providing simulated 36-bit logical sum, logical product, and logical difference instructions.

- Double Precision Arithmetic

  Through simulation of auxiliary 36-bit and 72-bit registers, the following arithmetic services are offered:

  Two-word addition or subtraction

  Four-word addition or subtraction

  Multiplication

  Division

.347 Executive Independent Utilities

The Executive Independent Utilities are a collection of routines which provide the user with service routines for initial program testing and for initial software systems installation. As the name implies, these routines do not run under the control of the Executive. The routines included in the Executive Independent Utilities package are:

- Main Storage Inspection and Change

  This routine permits the operator to display any main storage address and change the contents of that address if so desired.

- Main Storage Fill

  This routine permits the operator to place a specific data pattern in consecutive addresses in any area of main storage. The parameters for this routine are the data pattern to be entered in storage and the beginning and ending addresses of the storage area to be filled.

- Utilities Move

  This routine permits the operator to move the entire Executive Independent Utilities package from one storage area to another. The utility package resides within one storage area and is designed to operate in any storage area.

- Program Loader

  This is a simple load routine which makes it possible to load the relocatable binary coded output of the Assembler. Magnetic tape or punched cards may be used as the load medium. Programs loaded by this routine are loaded absolutely and are not relocated.

- Main Storage Dump

  This routine permits the operator to dump any area of main storage to the systems printer. This routine is controlled by specifying the beginning and ending addresses of the storage area to be printed.

SUMMARY

.1 SUMMARY

The UNIVAC 490 Series consists of three newer medium-to-large-scale computer systems (the 491, 492, and 494) and one older system (the 490) which was initially delivered in December of 1961. The three more recent systems, announced in June of 1965, are also known as the "UNIVAC Modular 490 Real-Time Systems."

The original UNIVAC 490 system is no longer being actively marketed. The 491 and 492 systems are no longer in production but are available on an "as returned" basis. The 494 system, at this writing, is still in production and offered in UNIVAC's standard product line.

The 490 Series is designed primarily for applications that require control based upon continuously updated records. Examples of this type of real-time application, in which it is essential or highly desirable to reduce the time lag between the occurrence of a transaction and the corresponding updating of one or more master files, include airline reservation systems, savings bank operations, production scheduling, inventory control, and order processing. Message switching is another important application. The 490 Series is also suitable for commercial applications of the more conventional batch processing type, particularly when they are run as "background" programs to use the processor time periods that would otherwise be idle between real-time transactions.

The principal characteristics that make the UNIVAC 490 Series suitable for real-time applications are:

- A variety of fast, large-capacity random-access storage units for master-file data and systems programs.
- Hardware and software facilities that permit concurrent processing (multi-programming) of real-time and batch programs.
- Flexible data communications equipment that facilitates two-way communications between the computer and remote points.

Figure 1. Control Console of the UNIVAC 494 Real-Time System.

.1 SUMMARY (Contd.)

The original UNIVAC 490 system evolved as a commercial outgrowth of UNIVAC's Defense Systems computer development work. Originally conceived as a special-purpose system for airline reservations, the 490 was later successfully applied to a wide range of other commercial applications. A major factor in enhancing the saleability and effectiveness of the 490 was the development of REX, an integrated, drum-oriented operating system capable of controlling the concurrent operation of one real-time program and one or more batch-type programs. REX is used by the majority of 490 installations, and serves as the standard operating system for the newer UNIVAC 491 and 492 as well.

The major change in the original UNIVAC 490 system during its four-year production cycle was the introduction of an optional feature that improves its basic memory cycle time from 6 to 4.8 microseconds, with proportional increases in internal processing speeds. About 60 UNIVAC 490 systems were delivered.

The three more recent members of the 490 Series follow the industry trend by offering significantly more performance per dollar than their predecessor. Using a typical 10-tape system (our Standard Configuration VIIA) as a basis for comparison, the original UNIVAC 490 system, with a 6-microsecond cycle time, rents for $31,270 per month. The newer UNIVAC 491, with a 4.8-microsecond cycle time, rents for $23,715 per month — a 24% reduction in rental. The UNIVAC 492 is identical to the 491 except that the 492 provides six more I/O channels at a rental increase of $1,750 per month. The powerful UNIVAC 494, with twice the core storage capacity and with actual and effective cycle times of 0.75 and 0.375 microseconds, respectively, rents for $40,045 per month, or only 29% more than the much slower 490. The 494 also provides an expanded instruction repertoire and improved multiprogramming capabilities. It is clear that UNIVAC's marketing strategy in announcing the three new systems was to attract new customers through the lower price tags on the 491 and 492, while retaining present customers by enabling them to trade up to the more powerful but program-compatible 494 at modest increases in cost.

.2 CENTRAL PROCESSORS AND CORE STORAGE

In all four of the UNIVAC 490 Series processors, each 30-bit word location in core storage can hold one instruction, one 30-bit or two 15-bit binary data items, or up to five alphameric characters. Core storage capacity can range from a minimum of 16,384 words (in all models) to a maximum of 32,768 words in the 490, 65,536 words in the 491 or 492, and 131,072 words in the 494. Parity checks upon internal operations are performed only in the 494. Cycle times and other features of the 490 Series processors and core storage units are summarized in Table I.

TABLE I: CHARACTERISTICS OF THE UNIVAC 490 SERIES PROCESSORS

Processor Model	UNIVAC 490	UNIVAC 491	UNIVAC 492	UNIVAC 494
Maximum No. of I/O Channels	14 (12 available)	8 (6 available)	14 (12 available)	24 (23 available)
Core Storage Cycle Time, μsec	6.0 (4.8 optional)	4.8	4.8	0.75 (0.375 effective)
Core Storage Capacity, 30-bit words	16,384 or 32,768	16,384 to 65,536	16,384 to 65,536	65,536 to 131,072
Core Storage Protection	No	Yes; 1,024-word increments	Yes; 1,024-word increments	Yes; 64-word increments
Core Storage Overlap	No	No	No	Yes
Core Storage Parity Checking	No	No	No	Yes
Floating-Point Arithmetic	No	No	No	Yes
Double-Precision Arithmetic	No	No	No	Yes
Decimal Arithmetic	No	No	No	Yes
Maximum I/O Data Rate, characters/second	417,000	521,000	521,000	2,747,000

(Contd.)

.2 CENTRAL PROCESSORS AND CORE STORAGE (Contd.)

Facilities common to all of the 490 Series processors include a full complement of fixed-point binary arithmetic, Boolean, comparison, and shifting operations. Facilities for editing and radix conversion, however, are conspicuously absent. Any one instruction can be automatically repeated up to 32,767 times, permitting efficient table lookup and accumulate operations. There are seven index registers, with a typical set of related instructions for loading, testing, and storing them. (The 494 has two sets of seven index registers to facilitate operating system control.)

Sixty-two basic single-address instructions are common to all of the 490 Series processors. Each of these basic instructions consists of five distinct parts: a 6-bit operation code; a 3-bit field that can specify a variety of conditions under which a skip or jump shall occur; a 3-bit field that specifies whether the operand shall be a full word, a half word, or a literal; a 3-bit index register designator; and a 15-bit field that can specify an operand address, a literal operand, or a shift count. This flexible instruction format permits numerous variations of each of the 62 basic instructions.

The UNIVAC 494 has an expanded instruction repertoire that provides a full range of double-precision arithmetic, floating-point arithmetic, decimal arithmetic, and enhanced character-handling facilities. The 47 additional instructions which are unique to the 494 exceed the capacity of the 490 Series' 6-bit operation code field, so UNIVAC uses the next 6 bits of the instruction word to specify the operation code for these additional instructions. As a result, the 47 instructions which are unique to the 494 cannot specify the use of partial-word operands or transfers of control based upon the results.

Average execution time per instruction in a basic UNIVAC 490 Processor is about 10 microseconds. The longest instruction — Divide — requires 86.4 microseconds, while a few instructions require as little as 6 microseconds. All instruction times for a 491, 492, or a 490 with the optional 4.8-microsecond memory are exactly 20 percent shorter than the times for the basic 490.

Average instruction execution time for a UNIVAC 494 system can approach the actual cycle time of 0.75 microseconds when odd/even memory-bank overlapping is employed. This means that the next instruction can be read from one memory bank while the processor is executing an instruction that references an operand in the other memory bank.

The 490 Series processors have effective program interrupt facilities which cause a transfer of control to one of 44 to 73 fixed core locations (depending upon the model) upon completion of an I/O operation, upon detection of a processor or I/O error, or upon overflow of either the real-time clock or the day clock. Interrupts from any or all I/O channels can be enabled or disabled by means of special instructions.

Storage protection facilities, which prevent user programs from gaining unauthorized access to specified areas of core storage, are an important factor to consider in evaluating computers with multiprogramming capabilities. The original UNIVAC 490 system has no storage protection facility. The 491 and 492 contain hardware facilities that permit individual 1,024-word blocks to be guarded against unauthorized access. The 494 provides effective protection through a combination of hardware facilities and the Omega operating system. The "Guard Mode," in which user programs will normally operate, prohibits the use of input-output instructions and other instructions reserved for operating system use. Individual 64-word blocks of core storage can be protected against writing only, or against both reading and writing. Attempted violations of storage protection cause program interrupts.

The maximum number of input-output channels available for each of the 490 Series processors is indicated in Table I. In every 490, 491, and 492 system, one channel is reserved for the console and one for the real-time clock. In the 494, a single channel serves both the console and the clock. Each of the remaining channels, in general, can accommodate one peripheral subsystem and can handle one data transfer operation at a time. The gross I/O data rates for all simultaneously-operating peripheral devices are limited to the figures shown in Table I.

.3 PERIPHERAL EQUIPMENT

Probably the most noteworthy aspect of the UNIVAC 490 Series peripheral equipment is the numerous drum storage units and magnetic tape units that are available. Table II summarizes the characteristics of the three head-per-track "Flying Head" drums and the two Fastrand units. The Flying Head drums provide rapid access to moderate amounts of data, while the Fastrand units use movable access mechanisms and store larger amounts of data, but with slower access times and data transfer rates. A smaller, less expensive "Modular Fastrand" subsystem was announced along with the newer 490 Series processors, but it was withdrawn from the line later in 1965. UNIVAC's line of mass storage devices for the 490 Series still lacks a unit with interchangeable-cartridge capabilities.

TABLE II: CHARACTERISTICS OF UNIVAC 490 SERIES DRUM STORAGE UNITS

Device	FH-432 Drum	FH-880 Drum	FH-1782 Drum	Fastrand I	Fastrand II
Storage capacity, 6-bit characters per unit	1.31×10^6	3.93×10^6	10.5×10^6	65.3×10^6	130.7×10^6
Storage capacity, 6-bit characters per subsystem	11.8×10^6	31.5×10^6	83.9×10^6	519×10^6	$1,038 \times 10^6$
Average access time, msec	4.25	17	17	92	92
Data transfer rate, characters/second	240,000	60,000	240,000	25,150	25,150
Usable with 490	No	Yes	No	Yes	No
Usable with 491/492	No	Yes	No	Yes*	Yes
Usable with 494	Yes	Yes	Yes	Yes*	Yes

*Not actively marketed; available as a "compatibility option."

.3 PERIPHERAL EQUIPMENT (Contd.)

Table III summarizes the characteristics of the five magnetic tape units available for 490 Series systems. UNIVAC now encourages use of the Uniservo VIC or VIIIC tape units, which use "industry-compatible" (i.e., IBM 729-compatible) 7-track tape. Optional dual-channel controllers permit read-write simultaneity within a single Uniservo VIC or VIIIC subsystem. The other three tape units were available for the original UNIVAC 490 system, and they are still offered as "compatibility options" to postpone or eliminate the need to convert large existing tape inventories.

Other peripheral equipment available for the 490 Series systems includes the following:

- Punched Card Subsystem: Consists of one Card Control and Synchronizer, one Card Reader, and/or one Card Punch. In UNIVAC 491, 492, and 494 systems, cards are read at the rate of 800 cards per minute (or 900 cpm if only the first 72 columns of each card are read) and punched at 300 cards per minute. Reading and punching can be performed in Hollerith, row binary, or column binary mode. (UNIVAC 490 systems use a 600-cpm card reader and a 150-cpm punch.)
- High-Speed Printer Subsystem: Consists of a Control and Synchronizer Unit and one Printer. Maximum speed is 700 alphanumeric/922 numeric or 1200 alphanumeric/1600 numeric 132-character lines per minute. There are 63 printable characters.

TABLE III: CHARACTERISTICS OF UNIVAC 490 SERIES MAGNETIC TAPE UNITS

Device	Uniservo IIA	Uniservo IIIA	Uniservo IIIC	Uniservo VIC	Uniservo VIIIC
Tape Speed, inches/second	100	100	112.5	42.7	120
Recording Density, rows/inch	125/250	1,000	200/556	200/556/800	200/556/800
Peak Data Transfer Rate, Kilo-characters/second	12.5/25.0	125	22.5/62.5	8.5/23.7/34.1	24.0/66.7/ 96.0
Tape Units per Controller	2 to 12	2 to 16	2 to 12	1 to 16	1 to 16
IBM 729-Compatible	No	No	Yes	Yes**	Yes**
Read Backward Capability	Yes	Yes	No	Yes	Yes
Read-After-Write Checking	No	Yes	Yes	Yes	Yes
Usable with 490	Yes	Yes	Yes	No	No
Usable with 491/492/494	Yes*	Yes*	Yes*	Yes	Yes

* Not actively marketed; available as a "compatibility option."

** Optional feature provides compatibility with the 9-track IBM 2400 Series Magnetic Tape Units used with System/360.

(Contd.)

.3 PERIFERAL EQUIPMENT (Contd.)

- UNIVAC 1004 Subsystem: The 1004 is a small, plugboard-programmed computer that can be connected on-line to a 490 Series system and can perform editing and input-output functions. The 1004 can read cards at 400 or 615 cards per minute and can print at 400 or 600 lines per minute, depending upon the model. Other peripheral equipment that can be connected to the 1004 includes a 200-cpm card punch and one or two magnetic tape units.
- Data Communication Subsystem (For UNIVAC 491, 492, and 494 systems): Consists of 1 Communication Terminal Module Controller and 1 to 16 Communication Terminal Modules, each of which can control a maximum of 2 input lines and 2 output lines. Up to 64 communications lines can thus be multiplexed into a single I/O channel. This multiplexing equipment enables the computer to send and receive data via most common-carrier facilities at transmission rates of up to 50,000 bits per second. The original UNIVAC 490 system uses similar communications equipment, although its nomenclature is different and the cost for small configurations is higher.

.4 SOFTWARE

The introduction of a series of new computer systems that are program-compatible with an earlier system has obvious advantages for the manufacturer as well as for the user. Software developed and perfected for the older system can be supplied with the newer systems, thereby relieving many of the pressures usually associated with the software development process.

UNIVAC 491 and 492 systems can utilize all of the existing UNIVAC 490 software. When operating in the special 490-compatible mode, UNIVAC 494 systems can use the existing software, but this mode does not permit full utilization of the 494's expanded capabilities. For this reason, recent software development work has been concentrated upon new facilities for the 494. UNIVAC has made subset versions of most of the 494 software available for the 490, 491, and 492, as replacements for the software originally developed for the 490. This approach to software development has two advantages for the UNIVAC 490 user who elects to retain his present equipment: he is assured of continued maintenance of the present software, and later he will be able to use a set of completely new, improved software facilities.

.41 UNIVAC 490 Software

Programs developed for the UNIVAC 490, all of which are currently available and usable with UNIVAC 491, 492, and 494 systems as well, can be summarized as follows:

- REX — An operating system capable of controlling a single real-time program and one or more batch programs, all operating concurrently. REX is designed to provide for efficient utilization of the available system components and to process a scheduled set of jobs with a minimum of operator intervention. REX requires a magnetic drum, at least one magnetic tape unit, and an average of about 4,000 core locations.
- SPURT — An assembly system that translates symbolic source programs into machine-language object programs in relocatable or absolute form. At least four magnetic tape units are required. Facilities for user-defined macro-instructions are available only for systems that include a Fastrand or Flying Head Drum.
- COBOL — A compiler for COBOL-61 source programs that operates under control of REX and produces a SPURT-coded symbolic program as output. All of Required COBOL-61 and a number of useful electives and extensions have been implemented. A magnetic drum and at least five magnetic tape units are required for COBOL compilations.
- Sort/Merge — A generalized routine that sorts data on magnetic tape according to programmer-specified parameters. The cascade method is used for the merge passes. From 3 to 12 Uniservo tape units on a single channel can be used, and an FH-880 Drum can be used in the presort phase when available. Sorting can be performed concurrently with a real-time program, under control of REX.
- Utility Routines — A series of generalized routines to perform such functions as:

  Transcribing data from one peripheral medium to another;
  Tracing and monitoring programs;
  Maintaining program libraries on magnetic tape;
  Transcribing programs from a library tape to a Master Instruction Tape in a specified sequence.

.41 UNIVAC 490 Software (Contd.)

- Library Subroutines — Sixty subroutines designed to handle frequently-encountered programming tasks such as:

  Multi-precision arithmetic on binary or Fieldata-coded items;
  Character insertion and extraction;
  Radix conversions between Fieldata and binary formats;
  Editing (zero suppression, floating dollar sign, etc.);
  File control;
  Data movement, scaling, and rounding.

.42 UNIVAC 494 Software

The software being developed especially for the UNIVAC 494 centers around a comprehensive operating system called Omega. If the term "third-generation" can be applied to software, as well as to hardware, then Omega is a true third-generation operating system. The lessons learned in implementing and applying REX, the UNIVAC 490 operating system, were used as foundations for the development of Omega.

Omega is designed to control the scheduling and execution of a mix of independent real-time and batch-type programs in a multiprogramming mode. Assigned priorities and balanced utilization of the system's facilities are the governing factors. Conflicting user programs are "rolled out" of core storage and restarted when the facilities required for their continued operation again become available. Exclusive control and allocation of all system facilities by Omega allows changes in configuration and/or operating procedures without direct impact on user programs. Omega requires 20,000 words of core storage for its resident routines, plus at least 262,143 words of drum storage.

The collection and loading of the routines required for a particular task is facilitated by having all source-language processors produce a common form of relocatable output. An integrated test system facilitates debugging operations and permits testing of new programs concurrently with the real-time operation of other programs.

The processing of batch-type programs is facilitated by Omega's facilities for automatic job-to-job transitions, communication within and between jobs, and services such as logging and accounting. An unusual feature of the batch processing environment is Omega's ability to provide multiprogramming within an individual activity. This "Fork and Join" function allows, for example, the second pass of a sort to begin processing the initial output of the first pass while the first pass is still transcribing data. The ability for computer systems with random-access storage to perform this type of processing is not new, but including this ability as a general software option is quite novel.

The following source-language processors are being developed for use with Omega:

- COBOL — The COBOL compiler for the UNIVAC 494 is based on the language defined in the Department of Defense report, COBOL 1961 Extended. Source-language compatibility with the existing COBOL-61 compiler for the UNIVAC 490 is stressed. The 494 compiler, however, generates a basically "straight-line" form of object coding, whereas the 490 compiler uses generalized subroutines. Compilation times, execution times, and object program memory requirements are said to be reduced by the straight-line method. Additional time is saved by having the compiler's output in the generalized relocatable-loader format, thereby eliminating the separate assembly phase that the 490 COBOL compiler requires. The subset version of the 494 COBOL compiler, for use with UNIVAC 490, 491, and 492 systems, was made available with the initial release in the fourth quarter of 1966. A minimum of four magnetic tape units and one drum are required for compilation.

- FORTRAN IV — This one-pass compiler accepts a source language based upon the A. S. A. working specifications for FORTRAN as published in the Communications of the ACM, October 1964. No complex or logical operations are provided. Object-program execution speeds are much higher on UNIVAC 494 systems than on the other 490 Series members because of the 494's inherent speed advantage and its built-in facilities for floating-point arithmetic.

- UNIVAC 494 ASM — The form of this new symbolic assembly system for the UNIVAC 494 resembles that of the SLEUTH II assembly system for the UNIVAC 1107, which features extensive macro-instruction facilities. The new system facilitates utilization of the 494's expanded facilities. The SPURT assembly system developed for the UNIVAC 490 is still used in 494 installations where program compatibility with the smaller 490 Series processors is considered important.

UNIVAC 490

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	*8186-01		Central Processor (16K words, 4.8-μ sec memory	10,720	460,000	1,570
	*8187-01		Central Processor (32K words, 4.8-μ sec memory	15,100	622,000	1,600
	*8186		Central Processor (16K words, 6.0-μ sec memory	10,470	450,000	1,570
		*F0957-00	Conversion Set (for field conversion of 8186-00 to 8186-01)	250	10,000	-
		*F0957-01	Conversion Set (for field conversion of 8187-00 to 8187-01)	250	20,000	-
			Main Storage			
			Core Memory Expansion (expands 32K words, 4.8-μ sec memory to 40K words)	1,545	60,000	15
			Core Memory Expansion (expands 32K words, 4.8-μ sec memory to 49K words)	2,580	100,000	35
			Core Memory Expansion (expands 32K words, 4.8-μ sec memory to 57K words)	3,920	152,000	50
			Core Memory Expansion (expands 32K words, 4.8 μ sec memory to 65K words)	4,645	180,000	70
ATTACHMENTS, ADAPTERS, AND CHANNELS	*8048-00		Transfer Switch (single)	65	2,700	5
	*8049		Transfer Switch (dual)	125	5,400	10
	*8158		Cabinet (for 8048 or 8049 transfer switches)	50	2,250	-
	*2502-00		Cabinet (for F0700-00)	335	13,000	-
	*2502-01		Cabinet (for F0700-00; contains integral operator panel)	335	13,000	-
		*F0700-00	Transfer Switch (electronic)	155	6,670	10
		*F0700-00	Transfer Switch (electronic)	155	6,670	10
		*F0893-01	Transfer Switch (electronic)	168	6,540	18
	*8056		Special Peripheral Cabinet (central 8-foot cabinet)	75	3,375	21
	*8150		Scanner Selector (4 channel)	800	36,000	154
	*8151		Scanner Selector (8 channel)	1,000	45,000	181
	*8153		Scanner Selector (16 channel)	1,500	67,500	301
	*2510-00		Line Isolator (wide band)	350	-	350
	*0951-00		Intercomputer Coupler (490 to IBM 7094)	1,160	20,500	275
		*F0597-02	Adapter (490 to UNIVAC 1004/1005)	205	7,840	20
MASS STORAGE			Drum Storage			
		*8103-00	Drum Control (buffered control for 1 to 8 FH880 Drums)	1,480	59,340	190
		*8205-00	Drum Control (buffered control for Fastrand I and II units)	2,845	75,000	115
		*0900-00	Fastrand I Mass Storage Unit	3,430	160,000	290
		*8102	FH-880 Drum (786,432 words)	2,150	85,165	190
		6010-00	Fastrand II Mass Storage Unit (25,952,256 words)	4,050	164,640	300

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Punched Card			
	*8104		Card Control	1,675	80,000	265
	*7906-01		Card Reader (600 cards/min)	365	17,500	85
	*8124		Card Punch (150 cards/min)	535	25,000	205
			Paper Tape			
	*8136-00		Paper Tape Subsystem (read 400 char/sec; punch 110 char/sec)	675	25,350	125
			Printer			
	*8106		Printer Control (controls one 8116 Printer)	1,510	72,500	160
	*8120		Printer Control (controls one 0751-01 Printer)	1,820	27,440	180
	*8120-01		Printer Control-Dual (controls two 0751-01 Printers)	2,855	54,880	245
	*8116		Printer (600 lines/min)	530	25,000	150
	*0751-00		Printer (700/922 lines/min)	850	36,000	275
COMMUNI-CATIONS			Multiplexers			
		*F0900-04	Multiplexer (4 simplex positions)	720	20,160	215
		*F0900-03	Multiplexer (8 simplex positions)	777	21,640	230
		*F0900-02	Multiplexer (16 simplex positions)	850	23,880	250
		*F0900-01	Multiplexer (32 simplex positions)	1,065	29,880	315
		*F0900-00	Multiplexer (64 simplex positions)	1,380	38,800	410
		*F0900-97 (XXXX-02)	Multiplexer (32 external positions)	1,050	47,000	285
		*F0900-98 (XXXX-03)	Multiplexer (64 external interrupt)	1,350	60,500	368
		*F0906-04	Multiplexer (4 simplex positions)	215	6,000	65
		*F0906-03	Multiplexer (8 simplex positions)	265	7,400	80
		*F0906-02	Multiplexer (16 simplex positions)	310	9,000	95
		*F0906-01	Multiplexer (32 simplex positions)	370	10,400	110
		*F0906-00	Multiplexer (64 simplex positions	425	12,000	125
		*F0878-00	Comm Line Terminal (high speed output; 5-through 12-level; synchronous)	55	2,475	15
		*F0878-01	Comm Line Terminal (high speed input; 5-through 12-level; synchronous)	65	2,250	15
		*(XXXX-04)	CLT (high speed input; 5-through 12-level; Asynchronous; external interrupt)	55	2,475	15
		*(XXXX-05)	CLT (low speed input; 6-, 7- and 8-level; Asynchronous; external interrupt)	30	1,350	8
		*F0901-00	Comm Line Terminal (low speed output; 5-level; asynchronous)	30	760	10
		*F0901-01	Comm Line Terminal (low speed input; 5-level; asynchronous)	21	560	7
		*F0901-02	Comm Line Terminal (low speed output; 6-, 7-, and 8-level; asynchronous)	33	920	10
		*F0901-03	Comm Line Terminal (low speed input; 6-, 7-, and 8-level; asynchronous)	30	760	10
		*F0902-00	Comm Line Terminal (medium speed output; 5-, 6-, 7-, and 8-level; asynchronous)	38	1,040	12
		*F0902-01	Comm Line Terminal (medium speed input: 5-, 6-, 7-, and 8-level; asynchronous)	30	760	10
		*F0903-00	Comm Line Terminal (high speed output; 5-, 6-, 7-, and 8-level; asynchronous)	50	1,360	15
		*F0903-01	Comm Line Terminal (high speed input: 5-, 6-, 7-, and 8-level; asynchronous)	50	1,360	15
		*F0904-00	Comm Line Terminal (parallel output)	40	1,315	10
		*F0904-01	Comm Line Terminal (parallel input)	40	1,315	10
		*F0905-00	Audodialing	20	645	5

NOTES:

*No longer in production

UNIVAC 491/492

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CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit (includes core storage)			
			491 Processors (include 8 I/O channels):			
	*8187-99		491 Processor (16K words)	7,370	280,000	1,570
	*8187-98		491 Processor (32K words)	11,500	440,000	1,600
	*8187-97		491 Processor (40K words)	13,030	500,000	1,630
	*8187-96		491 Processor (49K words)	14,180	540,000	1,680
	*8187-95		491 Processor (57K words)	15,500	592,000	1,700
	*8187-94		491 Processor (65K words)	16,130	620,000	1,730
			492 Processors (include 14 I/O channels):			
	*8187-93		492 Processor (16K words)	9,190	350,000	1,690
	*8187-92		492 Processor (32K words)	13,310	510,000	1,710
	*8187-91		492 Processor (40K words)	14,860	570,000	1,760
	*8187-90		492 Processor (49K words)	15,890	610,000	1,790
	*8187-89		492 Processor (57K words)	17,230	662,000	1,830
	*8187-88		492 Processor (65K words)	17,950	690,000	1,850
ATTACHMENTS, ADAPTERS, AND CHANNELS		*F0700-00	Transfer Switch (electronic)	155	6,670	10
	*2502-02		Switch Cabinet (for up to 8 Switches; remote operator panel; cables enter through top)	335	13,000	-
	*2502-03		Switch Cabinet (same as 2502-02 except contains integral operator panel)	335	13,000	-
	*2502-04		Switch Cabinet (for up to 8 Switches; remote operator panel; cables enter through bottom)	335	13,000	-
	*2502-05		Switch Cabinet (same as 2502-04 except contains intergral operator panel)	335	13,000	-
MASS STORAGE			Drum Storage			
	*7304-01		FH 880 Drum (786,432 words)	2,150	85,165	190
	*8103-01		FH880 Control (controls 1 to 8 FH #880 Drums)	1,550	58,800	190
	6010-00		Fastrand II (25,952,256 words)	4,050	164,640	300
		F0686-01	Fastbands	215	8,235	25
		F0688-01	Write Lockout	30	1,040	5
	5009-08		Fastrand Control (buffered control for up to 8 Fastrand II units)	1,335	53,410	115
	*5009-09		Drum Control (buffered dual-channel control for up to 8 Fastrand II units)	2,670	106,820	230
		F0763-00	Control Buffer Kit (field conversion unbuffered control to buffered)	60	2,355	-
		F0710-00	Search All Words	55	2,225	-
INPUT-OUTPUT			Magnetic Tape			
	0858-00		Uniservo VIC Master (7-track; 200/556/800 bpi; read backword; handles up to 3 VIC Slaves)	515	17,350	115
	0858-08		Uniservo VIC Master (same as 0858-00 but for simultaneous read-read/read-write operation)	570	19,800	115
	0858-01		Uniservo VIC Slave (7-track; 200/556/800 bpi)	310	10,470	70
	5008-04		Uniservo VIC Control (controls up to 4 VIC Master units)	745	31,070	35
	*5008-05		Uniservo VIC Control (controls up to 4 VIC simultaneous Master units)	745	31,070	35

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
		F0627-04	Translate Option (for 5008-04)	110	4,410	5
		*F0627-03	Translate Option (for 5008-05)	110	4,410	5
	0859-00		Uniservo VIIIC (7-track; 700/556/800 bpi)	860	32,735	110
	0859-02		Uniservo VIIIC (same as 0859-00 but permits simultaneous, read-read/read-write operations)	915	35,085	110
	5003-16		Uniservo VIIIC Control (controls 1 to 16 VIIIC Tape units)	1,550	62,430	120
	*5008-17		Uniservo VIIIC Control (required with 5003-16 for simultaneous operations)	1,550	62,430	120
		F0627-04	Translate Option (for 5008-16)	110	4,410	5
		*F0627-03	Translate Option (for 5008-17)	110	4,410	5
		F0704-00	VIC Control Option (allows intermixing of VIC and VIIIC Tape units on a VIIIC control)	85	3,385	5
			Punched Card			
	*0706-99		Card Reader (900 cards/min)	415	12,985	115
	0600-00		Card Punch (300 cards/min)	715	21,560	230
	5010-01		Card Control (controls one Reader and one Punch)	920	28,620	265
			Printer			
	*0751-00		Printer (700 lines/min)	870	25,970	275
	*8120-00		Printer Control (controls one 0751-00 Printer)	810	27,440	180
COMMUNICATIONS		F0900-05	Communication Terminal Module Controller (CTMC) Communications Terminal Modules (CTM):	705	24,700	135
		F0901-04	Communication Terminal Module (Low-Speed)	65	2,255	15
		F0902-02	Communication Terminal Module (Medium Speed)	85	2,895	15
		F0903-02	Communication Terminal Module (High Speed)	100	3,630	15
		F0905-00	Automatic Dialing	20	635	5
		F0904-00	Parallel Output	40	1,315	10
		F0904-01	Parallel Input	40	1,315	10
		F0906-05	Spare CTM Controller	260	9,020	50
			Word Terminal Synchronous (WTS):			
	8552-01		Basic Cabinet	270	8,380	80
		F0614-00	Power Supply	110	3,335	30
		F0614-01	Power Supply	110	3,335	30
		F0771-01	WTS Module	485	14,210	160
		F0772-00	Voice Band Interface	5	225	-
		F0772-01	Unattended Answering	5	225	-
		F0772-02	Automatic Dialing	55	1,670	15
		F0772-03	Broad Band	5	225	-
		*F0764-00	I/O Channel Expansion (for expansion of 491 Processor from 8 to 14 I/O channels)	1,830	70,000	130

NOTES:

* No longer in Production

UNIVAC 494

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3012-99		494 Processor (includes 12 I/O channels; Display Console required)	9,835	373,600	1,310
	4009-97		Display Console	1,000	32,625	250
		F0774-00	Auxiliary Console (for mounting 2 to 4 communication control panels; left or right addition to Display Console)	165	6,600	10
		F0774-01	Auxiliary Console (same as F0774-00 but located in center of Dual Console)	165	6,600	10
		*F1088-00	494 Console Indicator	-	43,000	15
			Main Storage			
	7005-77		Storage (65K words)	11,925	488,000	785
	7005-76		Storage (131K words)	21,680	888,400	1,405
	7005-62		Storage Expansion (65K words; for field expansion of 65K memory to 131K words)	9,755	400,400	620
	*7005-95		Core Memory (131K words)	21,680	888,400	1,405
	*7005-96		Core Memory (98K words)	16,820	688,200	1,110
	*7005-97		Core Memory (65K words)	11,925	488,000	785
	*7005-98		Core Memory (32K words)	7,055	284,300	565
ATTACHMENTS, ADAPTERS, AND CHANNELS		F0745-00	I/O Channel Expansion (4 additional 250KC I/O channels; maximum of 24 channels total)	275	10,350	35
		F0745-01	I/O Channel Expansion (4 additional 549KC channels; maximum of 24 channels total)	595	23,140	70
		F0745-02	I/O Channel Speedup (converts 4 250KC channels to 549KC channels)	1,000	32,625	250
		F0597-02	1004 Control	205	7,840	20
		F0893-01	Transfer Switch (manual electronic)	168	6,540	18
	2508-00		Switch Cabinet (accommodates 5 Transfer Switches; integral operator panel)	405	12,740	60
	2508-01		Switch Cabinet (accommodates 5 Transfer Switches; remote operator panel)	405	12,740	60
	2508-02		Switch Cabinet (accommodates 4 Transfer Switches; integral operator panel; auxiliary power supply)	598	20,000	88
	2508-03		Switch Cabinet (accommodates 4 Transfer Switches; remote operator panel; auxiliary power supply)	598	20,000	88
MASS STORAGE			Drum Storage			
	7304-01		FH 880 Drum (786K words)	2,150	85,165	190
	8103-03		FH 880 Control (controls 1 to 8 drums)	1,550	58,800	190
	6016-00		FH 432 Drum (262K words)	1,070	42,435	100
	6015-00		FH 1782 Drum (2 million words)	2,940	117,210	260
	5012-02		FH 432/PH 1782 Control (controls 1 to 8 FH 432 or FH 1782 Drums in any combination)	2,145	82,515	260

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
MASS STORAGE (Contd.)			Drum Storage (Contd.)			
		F0786-01	Dual Channel (provides dual channel access to FH 432 Drum; required on each Drum)	70	2,255	15
		F0767-00	Dual Channel (provides dual channel access to FH 1782 Drum; required on each Drum)	70	2,255	15
		F0929-00	Write Lock Out	30	1,040	5
	6010-00		Fastrand II (25 million words)	4,050	164,640	300
		F0686-01	Fastbands	215	8,235	25
		F0688-01	Write Lockout	30	1,040	5
	5009-12		Fastrand Control (unbuffered control for 1 to 8 Fastrand II units)	1,280	51,060	115
	5009-13		Fastrand Control (buffered control for 1 to 8 Fastrand units; required for dual-channel operation)	2,560	102,120	230
	5009-97		Fastrand Dual Control (buffered dual-access control; contains dual access adapter for first two channels)	3,050	122,330	240
		F0763-00	Control Buffer (for converting an unbuffered control to a buffered control)	55	2,350	-
		F0959-99	Dual Access Drum Adapter (provides dual access to drums from one of two controls; one required for all subsequent drums except fifth)	50	1,830	10
		F0959-98	Dual Access Drum Adapter (same as F0959-90 but for fifth drum)	50	1,830	10
	6010-10		Fastrand III Drum	4,965	200,800	350
	5009-87		Fastrand III Control	1,565	62,220	135
	5009-83		Fastrand III Dual Control	3,650	147,010	270
	5009-79		Fastrand III Control (for field upgrade from single to dual access)	2,085	84,790	135
		F0763-01	Control Buffer	55	2,350	-
		F0686-01	Fastband	205	8,235	25
		F0688-01	Write Lockout	30	1,040	5
		F0959-97	Fastrand III Dual Access Drum Adapter (drum 2, 3, 4, 6, 7, 8)	50	1,830	10
		F0959-96	Fastrand III Dual Access Drum Adapter (drum 5)	50	1,830	10
INPUT-OUTPUT			Magnetic Tape			
			Uniservo VIC:			
	0858-00		Uniservo VIC Master (7-track; 8,540/23,741/34,160 char/sec; handles up to 3 slaves; nonsimultaneous)	515	17,350	115
	0858-08		Uniservo VIC Master (same as 0858-00 but allows read-read/read-write simultaneity)	570	19,800	115
	0858-01		Uniservo VIC Slave (7-track)	310	10,470	70
	0858-10		Uniservo VIC Master (9-track; 800 bpi. 34,160 bytes/sec; handles up to 3 Slaves; nonsimultaneous)	515	17,350	115
	0858-12		Uniservo VIC Master (same as 0858-10 but allows read-read/read-write simultaneity)	570	19,800	115
	0858-14		Uniservo VIC Slave (9-track)	310	10,470	70
	5008-04		Uniservo VIC Control (controls up to 4 non-simultaneous 7-track VIC Master units)	745	31,070	35
	5008-96		Uniservo VIC Control (controls up to 4 simultaneous, 7-track VIC Master units)	1,490	62,140	70
		F1021-00	7 to 9 Track Conversion (converts 7-track VIC Tape unit to 9-track)	-	-	-
		F1072-00	Simultaneous Capability (converts non-simultaneous 7-track VIC Master for simultaneous operation)	55	2,450	-

CLASS	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			Magnetic Tape (Contd.)			
INPUT-OUTPUT (Contd.)		F1072-01	Simultaneous Capability (converts non-simultaneous, 9-track VIC Master for simultaneous operation)	55	2,450	-
		F0627-04	Translate Option (for 5008-04)	110	4,410	5
		F0627-99	Translate Option (for 5008-96)	220	8,820	10
			Uniservo VIIIC:			
	0859-00		Uniservo VIIIC Tape Unit (7-track; 24,000/66,720/96,000 char/sec); non-simultaneous)	860	32,735	110
	0859-02		Uniservo VIIIC Tape Unit (same as 0859-00 but allows simultaneous read-read/read-write operation)	915	35,085	110
	0859-04		Uniservo VIIIC Tape Unit (9-track; 860 bpi; 96,000 bytes/sec; non-simultaneous)	875	33,390	110
	0859-08		Uniservo VIIIC Tape Unit (same as 0859-00 except allows dual access operation with read-read/read-write/write-read/write-write simultaneity)	890	34,045	110
	0859-10		Uniservo VIIIC Tape Unit (same as 0859-04 except allows dual access operation with read-read/read-write/write-read/write-write simultaneity)	905	34,700	110
	5008-16		Uniservo VIIIC Control (controls 1 to 16 7-track 0859-00 units)	1,550	62,430	120
	5008-88		Uniservo VIIIC Control (controls 1 to 16 7-track 0859-02 units)	3,100	124,860	240
	5008-81		Control Expansion (expands 5008-16 non-simultaneous control to simultaneous 5008-88 control)	1,550	62,430	120
		F0706-00	Control Adapter (adapts 7-track controls to 9-track format required on 9-track controls)	50	1,960	5
		F0627-04	Translate Option (for 5008-16)	110	4,410	5
		F0704-00	VIC Control Option (permits intermixing 7-track VIC and VIIIC Tape Units on 5008-16 control)	85	3,385	5
		F0999-00	7 to 9 Track Conversion (converts 7-track 0859-00 to 9-track 0859-04)	15	655	-
		F0999-04	7 to 9 Track Conversion (converts 7-track 0859-08 to 9-track 0859-10)	15	655	-
			Punched Card			
	0706-97		Card Reader	480	15,385	125
	*0706-99		Card Reader (900 cards/min)	415	12,985	115
		F1022-00	Check Read	65	2,400	10
	0600-00		Card Punch (300 cards/min)	715	21,560	230
	5010-01		Card Control (controls one 0600 punch and are 0706 header)	920	28,620	265
			Printer			
	0758-00		Printer (1200/1600 lines min)	1,250	43,500	305
	*0755-00		Printer (700/900 lines/min)	870	25,970	275
	5011-04		Printer Control (controls multiple 0758 Printers)	885	30,015	200
	*8120-02		Printer Control (controls one 0755 Printer)	810	27,440	180
		F0965-00	Printer Control Capability (permits control of 0758 Printer)	75	2,575	20
	*8120-03		Printer Control (controls second 0755 Printer)	810	27,440	180
COMMUNI-CATIONS		F0900-06	Communications Terminal Module Controller (CTMC)	705	24,700	135
		F0901-04	CTM-LS	65	2,255	15
		F0902-02	CTM-MS	85	2,895	15
		F0903-02	CTM-HS	100	3,630	15
		F0905-00	Automatic Dialing	300	635	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
			Printer (Contd.)			
COMMUNI-CATIONS (Contd.)		F0904-00	Parallel Output	40	1,315	10
		F0904-01	Parallel Input	40	1,315	10
		F0906-06	Spare CTM Controller	260	9,020	50
		F1027-00	CTM IV Low Speed	80	3,050	10
		F0148-00	CTM VI Low Speed	95	3,480	15
		F0991-00	CTM VI High Speed	125	4,570	20
		F0988-00	CTM VII High Speed	80	3,050	10
		F0988-01	CTM VII High Speed (includes block parity checking)	95	3,480	15
		F0989-00	CTM VII Medium Speed	60	2,175	10
		F0989-01	CTM VII Medium Speed (includes character parity checking)	70	2,610	10
		F0989-02	CTM VII Medium Speed (includes character and block parity checking)	80	3,050	10
		F1018-02	HS Interface Module (for 6 full-duplex lines)	60	2,175	10
		F1018-03	HS Interface Module (for 4 full-duplex lines)	40	1,525	5
		F1018-05	Expansion Kit (expands F1018-03 to 6 lines)	20	650	5
		F1019-01	HS Interface Module (8 full-duplex lines)	80	3,050	10
		F1019-03	HS Interface Module (4 full-duplex lines)	40	1,525	5
		F1019-05	Expansion Kit (expands F1019-03 to 8 lines)	40	1,525	5

NOTES:

(1) UNIVAC will extend rental agreements to a five-year term for systems in current production at a monthly rental of 85 per cent of the figure shown in this column.

*No longer in production.

PRICE DATA: UNIVAC 490

UNIVAC 490 computer systems are no longer being actively marketed; the following prices were those in effect while the system was in production. For price data on the UNIVAC 491, 492, and 494 systems, please turn to Page 800:221.101.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
CENTRAL PROCESSOR		UNIVAC 490 Central Processor (Including Control Console, Motor Alternator, and Power Control Cabinet)			
		With 16,384 Core Memory locations & 6 I/O Channels	9,500	1,300*	427,500
		With 16,384 Core Memory locations & 14 I/O Channels	10,000	1,365*	450,000
		With 32,768 Core Memory locations & 6 I/O Channels	13,500	1,340*	580,000
		With 32,768 Core Memory locations & 14 I/O Channels	14,000	1,390*	602,000
		4.8-Microsecond Accelerator Package			
		For 16,384 Core Memory locations	250	—	10,000
		For 32,768 Core Memory locations	500	—	20,000
INTERNAL STORAGE		Core Memory See Central Processor, above			
		FH-880 Magnetic Drum Subsystem			
	8112	FH-880 Drum	2,000	165	92,000
	8122	FH-880 Control & Synchronizer	1,420	165	71,000
		Fastrand Mass Storage Subsystem			
	8206	Fastrand Storage Unit	3,300	†	160,000
	8205	Fastrand Synchronizer	2,750	100	135,000
INPUT-OUTPUT		Uniservo IIA Subsystem			
	8143	Uniservo IIA Magnetic Tape Handler	450	95	20,000
	8113	Uniservo IIA Control & Synchronizer	1,530	130	76,500
	8142	Uniservo IIA Power Supply	550	40	25,300
		Uniservo IIIA Subsystem			
	8011	Uniservo IIIA Magnetic Tape Handler	750	155	36,500
	8003-1	Uniservo IIIA Control & Synchronizer (Single Channel)	3,700	170	177,600
	8003-3, 8003-5	Uniservo IIIA Control & Synchronizer (Dual Channel)	4,800	260	230,400
	8142	Uniservo IIIA Power Supply	550	40	25,300

† $250 for first unit; $120 for each additional unit.

* Applicable only when Central Processor is used for batch processing applications; maintenance charges for real-time applications available upon request.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
INPUT-OUTPUT (Contd.)		<u>Uniservo IIIC Subsystem</u>			
	8220	Uniservo IIIC Magnetic Tape Handler	800	62	38,400
	8208	Uniservo IIIC Tape Adapter Cabinet	1,000	50	48,000
	8209	Uniservo IIIC Control & Synchronizer	2,250	173	108,000
	8142	Uniservo IIIC Power Supply	550	40	25,300
		<u>Punched Card Subsystem</u>			
	8114	Card Reader (600 CPM)	350	75	17,500
	8124	Card Punch (150 CPM)	500	180	25,000
	8104	Card Control & Synchronizer	1,600	230	80,000
		<u>Paper Tape Subsystem</u>			
	8136	(Paper tape reader, punch and control unit)	645	110	32,250
		<u>High-Speed Printer Subsystem</u>			
	8121	Printer (700-922 LPM)	800	240	36,000
	8120-00	Printer Control & Synchronizer (700-922 LPM)	1,750	160	80,000
		<u>Communication Line Terminals</u>			
	CLT-50L	Low speed output (5 level)	25	#	1,125
	CLT-51L	Low speed input (5 level)	20		900
	CLT-80L	Low speed output (6, 7, 8 level)	30		1,350
	CLT-81L	Low speed input (6, 7, 8 level)	25		1,125
	CLT-80M	Medium speed output	35		1,575
	CLT-81M	Medium speed input	25		1,125
	CLT-80H	High speed output	45		2,025
	CLT-81H	High speed input	45		2,025
	CLT-80P	Parallel output	35		1,575
	CLT-81P	Parallel input	35		1,575
	CLT-Dialing	Automatic Dialing Unit	20		900
		<u>Communication Multiplexers</u>			
	C/M-4	For up to 4 CLTs	675	#	30,375
	C/M-8	For up to 8 CLTs	725		32,625
	C/M-16	For up to 16 CLTs	800		36,000
	C/M-32	For up to 32 CLTs	1,000		45,000
	C/M-64	For up to 64 CLTs	1,300		58,500
		<u>Communication Scanner/Selectors</u>			
	8150	4 Channels	800	#	36,000
	8151	8 Channels	1,000		45,000
	8152	12 Channels	1,250		56,250
	8153	16 Channels	1,500		67,500

Monthly maintenance charges will be quoted by the manufacturer upon request.

REPORT UPDATE

On February 24, 1969 UNIVAC announced new members of the 9000 Series. The new models, designated the 9200-II and the 9300-II, greatly extend the range of applications that can be accommodated by the smaller members of the 9000 Series. The principal extensions are in the size of main memory available and the type of peripheral devices that can be attached. These extensions bring to the smaller 9000 Series computers hardware and techniques that better take advantage of the high degree of processing power available. The lower 9000 Series computers now hold a far different position in the market than previously.

Hardware

The 9200 II will use essentially the same central processing unit as does the 9200; the principal differences are the availability of additional main storage and a change in the I/O structure.

The maximum storage size available with the 9200 II is 32,768 bytes. The multiplexor channel, optional on the 9200, is standard equipment on the 9200 II. Available as an option, is a selector channel with a peak transfer rate of 350,000 bytes per second. This feature is intended primarily to handle the 8411 Direct Access Subsystem.

Similarly, the 9300 II central processing unit is the same as the 9300, but with both the multiplexor channel and the 350,000-byte-per-second selector channel standard.

UNIVAC has not announced any new peripherals for the 9200 II and the 9300 II; instead peripheral devices for the 9400 will be made available for both models. In addition, peripherals available on the 9300 will be made available on the 9200 II.

The multiplexor and selector channels can accommodate up to eight device controllers each. Essentially, the 9200 II and the 9300 II can accommodate any peripheral device announced for the 9400 except Uniservo 12/16 magnetic tape units and the 16-line data communications controller. All options for the 9200 and 9300 are available for the 9200 II and 9300 II. The maximum number of tape units supported for the 9300 II is 16 and for the 9200 II is 8.

For further information on the peripheral devices released for the 9200 II and the 9300 II, the following pages in AUERBACH Standard EDP Reports may be consulted:

- Universo VIC: 810:091.100
- 0711-02 Card Reader (600 cards/min): 810:071.100
- 0604 Row Card Punch (200 cards/min): 810.074.100
- 0768 Line Printers (900/1100 or 1200/1600 lines/min): 814:011.315
- 8411 Disc File Subsystem 814:011.315

Software

All software for 9200/9300 Card, Tape, Disc, and Communications Systems can be used for the 9200 II and the 9300 II. In addition, UNIVAC has promised to develop several new packages to make effective use of the high speed 0768 printers and the 8411 disc units. The 0768 Printer will be considered strictly a data printer; any communications with the operator, such as diagnostic printouts from the language processors, will use the integral bar printer. Three levels of file processing, using the 8411, will be supported:

- Sequential loading and accessing of files;
- Random access to sequentially loaded files (Indexed Sequential); and
- Creation and access to randomly sequenced files.

Language processors to be available for 8411-oriented systems include:

- Assembler/Linker,
- Report Generator, and
- COBOL.

Each of these processors operate with a minimum of 24K bytes of main storage.

In addition to the major packages, software for the 8411 will include a modular sort/merge, library services, a disc-to-print symbiont, and miscellaneous testing aids.

Deliveries of tape-oriented 9200 II and 9300 II systems are scheduled to begin in six months. Deliveries of disc systems are planned for March 1970.

Pricing

Name	Monthly Rental, $*		Purchase, $	Monthly Maintenance, $
	1-year	5-year		
9200 II Processor	400	355	14,270	70
Selector Channel	100	80	4,320	10
Storage (24K)	1,185	1,020	47,630	90
Storage (32K)	1,565	1,350	62,860	120
Storage Expansion (16K to 24K)	400	340	15,890	30
Storage Expansion (24K to 32K)	380	330	15,230	30
Storage Expansion (16K to 32K)	780	670	31,120	60
9300 II Processor	910	795	32,890	165

*UNIVAC does not include maintenance prices in their published price lists; for ease of comparison, maintenance prices have been included in this column.

REPORT UPDATE

▶ UNIVAC INTRODUCES PAPER-TAPE SUBSYSTEM FOR 9000 SERIES

The UNIVAC Series 9000 acquired paper-tape input/output capabilities with the announcement of the Type 0920-00 Paper Tape Subsystem on September 30, 1968. This will not only allow users of UNIVAC's newest systems to enter new areas of application but it will also make transition to the 9000 easier for users of older, paper-tape oriented systems.

Consisting of the Paper Tape Control, Paper Tape Reader, Reader Spooler, Paper Tape Punch and Punch Spooler, this subsystem is housed in a free standing cabinet connected via a multiplexor channel. The system is completely modular so that any combination, one of each, of the components can be connected to the Paper Tape Control.

The 0920 reads at 300 cps and punches at 110 cps, handling any 5, 6, 7 or 8 level tape codes! It can also read or punch binary tapes. The selection of codes is accomplished through the use of a patch panel, called a program connection, mounted in the paper tape cabinet. UNIVAC states that all conventional perforated tape with a light transmissivity of 40% or less can be read by the tape reader.

IOCS routines will be provided for this subsystem.

First deliveries to customers are scheduled for the second quarter of 1969.

Pricing of the 0920-00 Paper Tape subsystems will be:

	Purchase Price	Monthly Rental Short Term	Monthly Rental 5 yr. lease	Monthly Maintenance
Paper Tape Control 0920-00	$ 7,180	$190	$165	$25
Paper Tape Reader F 1033-02	1,525	50	45	15
Reader Spooler F 1034-00	1,525	40	35	5
Paper Tape Punch F 1032-02	5,220	140	120	20
Punch Spooler F 1035	655	20	18	5
Totals:	$16,105	$440	$383	$70

Note: The above rental prices include the monthly maintenance charges.

REPORT UPDATE

UNIVAC ANNOUNCES 16K COBOL FOR THE 9300

In January 1968, UNIVAC announced a reduction in the memory requirement for use of a COBOL compiler with UNIVAC 9300 systems. The new 16K version of UNIVAC 9300 COBOL does not replace the existing 32K version; both will be made available. The 16K COBOL differs from the 32K version in that it requires more compilation time and uses a different method of indicating diagnostics. Instead of the message form of diagnostic output provided by the earlier compiler, the new 16K program provides numeric keys that refer to a diagnostic catalog.

All COBOL language facilities provided in the 32K version are incorporated in the new and smaller system, which therefore meets the USASI minimum requirements.

The minimum equipment configuration now required to compile a COBOL program includes a 9300 Processor with 16, 384 bytes of plated-wire memory, a card reader, a printer, and four tape units (9-track, or 7-track with the data conversion feature).

Customer availability of both the original 32K and the new 16K versions of 9300 COBOL is scheduled for September 1968.

UNIVAC ANNOUNCES DATA COMMUNICATIONS SUBSYSTEM-4

In February 1968, UNIVAC announced the addition of the DCS-4 to the existing communications facilities of the 9000 Series. The DCS-4 provides all the capabilities of the DCS-1 (see Report Update of 11/67) plus multi-line communication between the 9000 Series central processor and up to four remote systems. Each DCS-4 accommodates a maximum of four full-duplex or eight simplex positions. A maximum of two DCS-4s can be incorporated into any 9200/9300 System. The DCS-4 can control a wide range of speeds and services. Each Communication Subsystem can service four input and/or four output lines, permitting communication via: (1) telegraph lines at up to 150 bits per second; (2) public telephone networks at up to 2, 400 bits per second; or (3) leased broad-band lines at rates up to 230, 400 bits per second (Telpac † C). Both synchronous and asynchronous line terminals are available, as well as communication interfaces connecting line terminals with common carrier lines. Depending on DCS-4 line terminal choice, a UNIVAC 9200/9300 can communicate with teletypes, remote terminals, CRT Displays, computer systems, and any device using switched network facilities.

A UNIVAC 9000 Series computer equipped with a DCS-4 can communicate with the following UNIVAC systems: 418, 494, 1107, 1108, DCT 2000, 1004, 1005, and Uniscope 300.

A feature of the DCS-4 is that processor functions, including magnetic tape reading and writing, can be overlapped with communication at voice-grade and telegraph rates.

Like the DCS-1, the DCS-4 can be connected to the optional I/O Multiplexer Channel of a 9200 or 9300. The DCS-4 is compatible with IBM's new Binary Synchronous Communications (BCS) data transmission technique, as explained in the UNIVAC 9000 Series Report Update of 11/67. The software commitment is essentially the same for the DCS-4 as with the DCS-1, with necessary additions and modifications for greater flexibility. Line terminal character size can be from 4- to 10-level, depending on transmission speed.

Deliveries of the DCS-4 are scheduled to begin in the fall of 1968. The price of a DCS-4 configuration serving four telegraph lines is $522 per month or $19, 155 purchase; for a configuration serving one wide-band line, one voice-grade line, and two telegraph lines, the rental is $566 per month or $20, 750 purchase.

† Trademark of A. T. & T. Co.

REPORT UPDATE

UNIVAC UNVEILS THE 9400 SYSTEM

January 15, 1968, marked the debut of the UNIVAC 9400, third member of the 9000 Series family of compatible computers. Larger and more powerful than the 9200 and 9300 systems, the 9400 features both real-time and multiprogramming capabilities. Continued use of UNIVAC's fast plated-wire memory and monolithic integrated circuitry, blended with the 9400's dual-byte memory access, 32 general-purpose registers, and strong communications capabilities, promises impressive processing power within the 9400's competitive price class.

Primary marketing efforts will be directed toward upgrading present users of smaller UNIVAC 9000 series and IBM System/360 Model 20 systems. In this respect, the UNIVAC 9400 offers approximately three to four times the internal processing speed of the IBM 360/30 at roughly comparable system prices. Since the 9400 instruction set is a compatible subset of the IBM 360/30, present 360/20 programming staffs should experience little difficulty in converting to a UNIVAC 9400 system.

In gaining the 9400's cost/performance advantage, certain concessions had to be made:

- The 9400 implements only 68 of the 360/30's 142 instructions.
- Floating-point, binary multiplication, and binary division hardware facilities have not been implemented.

Plated-wire memory, available in capacities of 24,576, 32,768, 49,152, 65,536, 98,304, and 131,072 bytes, has a cycle time of 600 nanoseconds per 2-byte access. Processor operating efficiencies are further enhanced by the use of two sets of general registers — 16 for user programs and 16 that service the operating system. In addition, the UNIVAC 9400 provides separate control registers for each Selector Channel and Multiplexor Channel, allowing direct access to every channel when servicing I/O requests. An interval timer is a standard feature; storage protection is available as an option.

The standard Multiplexor Channel has a gross data capacity of 85,000 bytes per second. One or two optional Selector Channels, each having a 333KB/second capacity, can be added. Peripherals offered include:

- Three series of magnetic tape units, with transfer rates ranging from 34KB to 192KB.
- Two types of high-speed line printers — 1100 or 1600 alphanumeric lines per minute.
- Three communications subsystems that can accommodate up to 64 full-duplex lines.
- Up to 58 million bytes of on-line disc storage, with a data transfer rate of 156KB/second.
- A 600-cpm card reader.
- A 250-cpm card punch.

A UNIVAC 1004 or 1005 Processor can be used either on- or off-line with the 9400 system, in addition to, or in place of, the standard printer, reader, or punch.

Software will include multiprogramming provisions for five main programs, a Data Management System, Job Control Stream operation, a Basic Assembler, a 32K COBOL-65 compiler, a Report Program Generator, a 32K USASI FORTRAN compiler, a Systems Service Library, and a Utility Library.

Monthly rental for a basic 9400 system including a 24K memory, 4 magnetic tape units, 1100-lpm printer, 600-cpm card reader, and 250-cpm card punch is $5,880. Customer deliveries are scheduled to begin during the second quarter of 1969. Basic system software will be delivered concurrently; advanced software will follow at a later date.

UNIVAC ANNOUNCES THE 8410 DISC STORAGE SYSTEM

The 8410 Disc Storage System, announced on December 6, 1967, represents a considerable enhancement to the UNIVAC 9000 Series product line by providing random or sequential access to a moderate amount of on-line storage. The recording medium is a nickel-cobalt-coated disc in an interchangeable cartridge. Each single-disc cartridge can store up to 3.2 million bytes, but only 1.6 million bytes of each cartridge can be accessed "on-line". By physically removing each disc cartridge, turning it over, and replacing it on the drive, the remaining 1.6 million bytes of data become accessible.

Two independently operating disc handlers are housed in a single cabinet, and each handler services a single disc cartridge. Up to four dual-disc units are allowed in a maximum 9000 Series system configuration, providing a total on-line data capacity of 12.8 million bytes.

A seek function on one disc handler can be overlapped with seek, read, or write functions on another. Once the desired sector address has been determined, the average time required to position the head mechanism for randomly placed data is 110 milliseconds. The rotational speed is 1,200 revolutions per minute, which corresponds to 50 milliseconds per revolution (latency time). Thus, the average access time for randomly placed data, including 25-millisecond average latency time, is 135 milliseconds, an acceptable access time for use in many random processing applications.

The fastband search technique, which may be employed at the user's discretion, provides the address of the desired sector through use of a key (sector location data) contained in a special 50-sector track or "fastband" on each disc surface.

Although the 8410 Disc Storage System is capable of transferring data at the rate of 136,000 bytes per second, the effective speed, as limited by the data transfer capacity of the Multiplexor channel, is 100,000 bytes per second. Buffering logic located in the disc drive cabinet provides intermediate storage of up to 256 bytes. A maximum of 160 bytes can be transferred to or from the disc unit with a single disc read/write command.

Accuracy control during read/write operations includes a longitudinal parity check by sector. Control instructions include Write Check, Seek Track, and Sector Search commands.

Deliveries of the 8410 Disc Storage System will begin in approximately 12 months. The 8410 system's software support, scheduled for completion during the third quarter of 1968, will include a disc-oriented Input-Output Control System (IOCS), a Disc Report Program Generator, Library Services, and a Disc Sort Program. A completely tape-independent Disc Assembler will also be provided.

UNIVAC states that disc-oriented FORTRAN and COBOL compilers are not currently planned.

PRICES

SYSTEM	IDENTITY OF UNIT		PRICES			
	No.	Name	Monthly Rental (1) $ 1-Year Lease	Monthly Rental (1) $ 5-Year Lease	Monthly Maintenance $	Purchase $
8410 DISC STORAGE SYSTEM	8410-00	Dual Disc File – Master (2)	295	255	125	12,835
	8410-92	Dual Disc File – Slave	295	255	125	12,835
	8410-02	Single Disc File – Slave	180	155	80	7,830
	F 1023-00	Disc Drive Control (3) (for use without 1001 Control)	195	170	35	8,485
	F 1023-01	Disc Drive Control(3) (for use with 1001 Control)	195	170	35	8,485
	F 1016-00	Disc Drive	115	100	45	5,005
		Optional Features				
	F 1015-00	Buffer and Fastband Search (2)	155	135	25	6,745
	F 1102-00	Cartridge	–	–	–	380

(1) Monthly rental does not include maintenance cost.
(2) Required for minimum configuration.
(3) Choice of one is required for minimum configuration.

CONFIGURATION PRICES

Number of Drives	On-Line capacity, millions of bytes	PRICES* 1-Year $	5-Year $	Purchase $
2	3.2	830	745	28,065
3	4.8	1,090	980	35,895
4	6.4	1,250	1,125	40,900
5	8.0	1,510	1,360	48,730
6	9.6	1,670	1,505	53,735
7	11.2	1,930	1,740	61,565
8	12.8	2,090	1,885	66,570

* Rental prices include maintenance charges, Fastband Search option, and required Disc File Control.

REPORT UPDATE

▶ UNIVAC ANNOUNCES DATA COMMUNICATION SUBSYSTEM I

In October 1967, UNIVAC announced the addition of a modest data communications facility to its 9000 Series product line, thereby considerably broadening the applications areas for these low-priced computer systems.

One or two of the new DCS I systems can be connected to the optional I/O Multiplexor Channel of a 9200 or 9300 Processor, with each DCS I subsystem occupying one multiplexor subchannel. Each DCS I has a single-line capability, can service one input and/or one output line, and permits communications via: (1) the public telephone networks at speeds up to 2,000 bps; (2) leased voice-band lines at rates up to 2,400 bps; or (3) leased broad-band lines at rates up to 50,000 bps.

DCS I is physically housed within the existing computer cabinetry and is available with a wide selection of options to provide compatibility with most UNIVAC equipment, including the 418, 494, 1004, 1107, and 1108 computer systems, the DCT 2000 Data Communications Terminal, and other 9000 Series computers. In addition, DCS I is compatible with IBM's new Binary Synchronous Communications (BSC) data transmission technique, allowing communication with an IBM System/360 computer that is equipped with a Model 2701 Data Adapter Unit or 2703 Transmission Control Unit and the appropriate transmission adapter. Communication with a System/360, however, is restricted to the non-transparent USASCII mode.

Each DCS I contains a communications interface that connects to a single line for synchronous data communication at rates of up to 2000 or 2400 bps using voice-band lines, or up to 50,000 bps using broad-band lines. Message length can be varied from a single character up to the available memory capacity.

A choice of 5-, 6-, 7-, or 8-level (plus parity) transmission codes is available, including user-selected synchronizing, idling, start-of-message, and end-of-message characters. Odd or even parity is generated for transmitted characters and checked for received characters.

Incoming calls on the public telephone network can be automatically answered under program control.

CONFIGURATION

A DCS I Data Communications Subsystem includes a Line Terminal Controller which connects to the I/O Multiplexor Channel in the processor. The Controller coordinates the performance of its associated Line Terminals, which may be an input terminal, an output terminal, or both. Line Terminals, available in either Synchronous or Interprocessor models, perform parallel-to-serial and serial-to-parallel data conversions and provide control-character insertion into outgoing messages and corresponding control-character checks on incoming messages.

Line Terminals are connected, via a Communication Interface Unit, to an appropriate data set as follows:

Bell System Data Set	Facility	Speed, bps	UNIVAC Communication Interface
201A	Public telephone network	2,000	F 1002-04
201B	Leased voice-band	2,400	F 1002-03
201B/303C	Leased broad-band	50,000	F 1002-05

SOFTWARE

UNIVAC is currently developing software support for the DCS I, including a Communication Control Routine (CCR) supplement to the 9200/9300 Supervisor and several support packages for specific communication with 1107, 1108, 494, or DCT 2000 systems. Software to support communication with systems other than those specified above must be supplied by the user to handle interrupt processing, issuance of I/O requests, and the performance of clocking functions.

In addition to the CCR, UNIVAC is also extending its IOCS routines to include communications-oriented subroutines.

Initial deliveries of the DCS I are expected in June 1968. Initial software support will be delivered concurrently.

PRICES

Type or Feature No.	Product Name	Purchase Price	Monthly Maint.	Monthly Rental (1-Year Rental Agreement; Excludes Maintenance)
F1000-00	Line Terminal Controller	$4,350	$15	$100
	Communications Interface —			
F1002-03	Private Line	565	2	13
F1002-04	Data Phone	565	2	13
F1002-05	Broad-band	870	5	20
	Line Terminals, Synchronous —			
F1005-02	Output	1,130	5	26
F1005-03	Input	1,130	5	26
	Line Terminals, Interprocessor —			
F1005-04	Output	1,130	5	26
F1005-05	Input	1,305	5	30
F1008-99	Block Parity Feature	740	3	17

SUMMARY

.1 GENERAL

The 9200, announced on June 21, 1966, is a small-scale, card-oriented system that offers the new user an easy transition from tabulating machines to computers. It offers the advantages of familiarity of recording medium with the chance to use third-generation technology, all at a very attractive price. A user having a Univac 1004 installation, can see in the 9200, a painless way to upgrade his hardware.

The user of a small IBM 360 who is concerned with the complexities of the instruction repertoire of that machine, would be attracted by the simplified set of 35 instructions of the 9200 (multiply, divide, and edit are optional) that promise to do everything that he would need to do, with fewer stumbling blocks and in a manner that would keep conversion pains to a minimum.

On the negative side of the ledger are the very limited and relatively slow i/o devices announced with the 9200. A 250-lpm printer, a 400-cpm reader, and a 75-200 cpm punch do not seem to be capable of using the 1.2-microsecond cycle-time, plated-wire memory to its full capacity.

More recent expansions of the 9200 have added several other devices to increase 9200 capability. These include the 8410 Disc Storage Subsystem, the Paper Tape Subsystem, Data Communications Subsystems capable of handling up to eight lines, an on-line 1001 Card Controller and the ability to use an on-line UNIVAC 1004.

The larger 9300, also announced on June 21, 1966, is faster, larger and more versatile. The UNISERVO VIC tape drive announced as available with this system made the 9300 attractive to the users of small, tape-oriented, second-generation systems; e.g., the IBM 1401 and the RCA 301. As with the 9200, a strong effort was made to have the 9300 system appeal to the IBM 360 user by offering him simplified coding by using 35 instructions and data formats compatible with the 360. The peripheral equipment originally announced, however, was relatively slow in view of the potential shown by the 600-nanosecond per byte plated-wire memory.

Devices such as a 600-lpm printer, 600 cpm reader, 200 cpm card punch, and the 34 KBS UNISERVO VIC tape unit indicate throughput rates closer to the second generation level than to the third. In all fairness, most other manufacturers also do not provide high-speed magnetic tape units for their small-scale business-oriented computers.

Significant expansion in the capabilities of the 9300 System have been achieved by the addition of several new devices and systems. These include Data Communications Subsystems capable of handling up to eight lines, a Paper Tape Subsystem, the 8410 Disc Storage Subsystem, an on-line 1001 Card Controller, and the ability to use a UNIVAC 1004 on-line.

The prices that were announced for the 9200 and 9300 are among its chief competitive advantages. A basic 9200 system, containing 8192 bytes of plated-wire memory, printer, card reader and card punch can be rented for $1085 per month or purchased for approximately $40,000. The 9300 system rentals range from about $1740 to $9300 per month, and purchase prices range from about $63,000 to $350,000. A tape-oriented system with sort/merge capability (three tape units) can be rented for about $3000 per month.

The 9400 was announced on January 15, 1968. Larger and more powerful than its predecessors, it brings to the 9000 series true medium-scale power together with realtime and multiprogramming capabilities. The use of the plated-wire memory and monolithic circuitry combined with the 9400's dual-byte memory access, 32 general purpose registers, and strong communications capabilities provide processing power that is quite impressive in comparison with other computers in its price class.

Throughput rates on the 9400 are more in keeping with internal processing power. The standard Multiplexor Channel, optional on the 9200 and 9300, has a gross data capacity of 85,000 bytes per second. One or two optional Selector channels, each having a 333-kilobyte per second capacity, can be added.

A Univac 1004 or 1005 Processor can be used, if available, either on line or off line with the 9400 system, in addition to, or in place of, the standard printer, reader, and punch. Monthly rental for a basic 9400 system including a 24K memory, four magnetic tape units, 1100-lpm printer, 600-cpm reader, and 250-cpm card punch is $5880.

The latest announcement in the 9000 series is the 9200 II and 9300 II models. These additions are basically the same processors as the 9200 and 9300, but offer substantial increases in capability and versatility over the earlier models. This has been done by extending the line of available peripherals to include some of the devices previously available only on the 9400.

.1 GENERAL (Contd.)

The 9200 II, for example, can now be equipped with the UNISERVO VIC tape unit. Paper tape devices can also be attached, and both high-speed printers from the 9400 can be used. The Univac 8411 Direct Access Subsystem, which is IBM 2311 compatible, extends the capabilities of the lower end of the 9000 series to random-access processing. A 600-cpm card reader and 200-cpm and 250-cpm card punches also aid in increasing the throughput rate.

Maximum memory capacity of the 9200 II is 32,768 bytes compared to 16,384 in the 9200. The Multiplexor Channel, optional on the 9200, is standard equipment on the 9200 II. A 350-kilobyte-per-second Selector Channel, capable of controlling up to eight subsystems, is available as an option. All features currently available for the 9200 are available for the 9200 II.

Price increases over the 9200 have been modest. A basic 9200 II magnetic tape system with 24K of memory, 600-cpm card reader, 200-cpm card punch, 1100/900-lpm printer in addition to the integrated 250-lpm printer, and three UNISERVO VIC magnetic tape units, will rent for $4565 per month, including maintenance, on a one-year rental. A Selector Channel can be added for an additional $100 per month. The purchase price of the system would be $159,935, with monthly maintenance charges of $820; purchase of the Selector Channel would increase the cost by $4320 and the maintenance charges by $10 per month.

Changes in equipment for the 9300 II are not as extensive. The Multiplexor Channel, optional on the 9300, is standard equipment on the 9300 II. The Selector Channel is standard equipment on the 9300 II. This is not available on the 9300. Both the 1100/900-lpm and the 1600/1200-lpm high-speed printers are available in addition to the 600-lpm integrated printer. As on the 9200 II, the 8411 Direct Access Subsystem can be used to extend the capabilities of the system to random-access processing. All items available on the 9300 are available for the 9300 II.

A typical 9300 II magnetic tape system with 32K of memory, 600-cpm card reader, 200-cpm card punch, 1100/900-lpm printer, and three UNISERVO VIC magnetic tape units, will rent for $5775 per month, including maintenance, on a one-year rental. The purchase price would be $208,205, with monthly maintenance charges of $1015.

All software of 9200/9300 Card, Tape, Disk and Communications Systems is available for the 9200 II and 9300 II. In addition, several new packages are being developed to provide effective use of the newly added 0768 Printer and 8411 Disk. The 0768 will be supported as a data printer only by an IOCS incorporated in the output of the RPG, the COBOL, and FORTRAN compilers, and the Assembler. The Buffered Printing Module of the Concurrent Operating System will be modified so that report tapes can be optionally produced in the 0768 format. These tapes can then be processed by an 0768 version of the Tape-to-Print Symbiont.

Supervisors of 8411 (Direct Access Storage Subsystem) oriented configurations will operate in three environments. For machines with 16K and two 8411's, the Minimum Operating System or the Non-current Operating System will be provided. A user with 24K or 32K or storage will be able to run concurrent programs by using the Concurrent Operating System.

The 8411 IOCS will provide for three levels of file processing: sequential, indexed sequential, and random or direct access. These will be incorporated in the new, 8411-oriented Assembler Linker. RPG will be able to process Sequential or Indexed Sequential Files. COBOL will be implemented in a disk version that will conform to the United States of America Standards Institute minimum requirements. All existing card and tape language processors will be upgraded to optionally include Sequential and Indexed Sequential 8411 Processors. COBOL and FORTRAN will also include the Random Processor.

Deliveries of the Univac 9200 II and 9300 II Tape Systems are scheduled to begin in August 1969. Disk system deliveries are planned for March of 1970.

.2 DATA STRUCTURE

The UNIVAC 9200 and 9300 provide facilities for convenient handling of variable-length fields composed of either 8-bit bytes or 4-bit digits. The minimum addressable unit in memory, however, is one byte. Operand lengths can range from 1 to 256 bytes or digits, but in many instructions are limited to 16 bytes in length.

Data represented in the 4-bit format can be either signed (with a 4-bit sign digit preceding the least significant numeric digit of the field) or unsigned. Data in the 8-bit format is always unsigned, and is treated (as in the IBM System/360) as a byte consisting of eight data bits and a parity bit. The eight data bits in a byte can represent one alphanumeric character, two packed decimal digits, or a portion of a binary field. Like the System/360, digits must be placed in packed decimal format prior to performing decimal arithmetic operations.

Bytes can be handled individually or grouped together into fields. A "halfword" is a group of two consecutive bytes, or 16 bits. Binary numbers in the UNIVAC 9200 and 9300 are represented by signed halfwords (sign plus 15 data bits). No floating-point arithmetic operations can be performed by hardware. Fixed point decimal operands can be up to 16 bytes (31 digits and sign) in length. Machine instructions are either four or six bytes (38 or 42 bits) in length.

.2 DATA STRUCTURE (Contd.)

As in the System/360, data can be represented internally in either of two codes, EBCDIC or ASCII, depending upon the setting of a program-controlled mode flip-flop in the processor. Also, Translate instruction uses a table in main memory to accomplish efficient translations between any 8-bit codes.

A hardware translator provides automatic translations between external codes and a special UNIVAC internal compressed code which must be program-translated into EBCDIC or ASCII before the data can be processed.

.3 HARDWARE

.31 System Configuration

The basic UNIVAC 9200 system includes a 9200 Processor with a built-in 250-lpm printer; 8K-, 12K-, or 16K-bytes of plated-wire memory; a 400-cpm card reader; and a column card punch rated at 75 to 200 cpm. Only one of each of the basic I/O devices (i.e., one card reader, one printer, etc.) can be connected. Optional features available for the processor and I/O devices are described in the appropriate sections of this Introduction.

The optional Multiplexor I/O channel permits connection of a large variety of devices to the central processor. These include the following: 1001 Card Controller, 8410 Disc Storage Subsystem, Paper Tape Subsystem, on-line UNIVAC 1004, and two Data Communications Subsystems handling a maximum of eight lines. The Multiplexor can accommodate up to eight control units. The 1001 is connected to one control-unit position via a 1001 Control.

The 9200 II differs from the 9200 principally in that the Multiplexor Channel above is standard equipment. UNISERVO VIC tape units are available for attachment to this channel. Either of two card readers, the 0711-00 (400 cpm) or the 0711-02 (600 cpm) and two card punches, the 0603-04 (75-200 cpm) or the 0604-00 (200 cpm), can be attached directly to the processor using built-in control units. Also available are the 0768-00 and the 0768-99 high-speed printers. A 350 KB Selector channel, optionally available, permits the attachment of an 8411 Disc Storage Subsystem. Additionally, all peripheral equipment available with the 9200 are available with the 9200 II as well.

The basic UNIVAC 9300 system includes a 9300 Processor with a built-in 600-lpm printer; 8K-, 12K-, 16K-, or 32K-bytes of plated-wire memory; a 600-cpm card reader, and a column card punch rated at 75 to 200 cpm. Only one of each of the basic I/O devices can be connected.

The optional Multiplexor I/O Channel permits connection of a 100 Card Controller, a 200-cpm Row Punch, an 8410 Disk Storage System, Uniservo VIC magnetic tape units, and a data communications system. The Multiplexor Channel can accommodate up to eight control units. The 1001 Card Controller can be connected to one control-unit position of the Multiplexor via a 1001 Control. Each Uniservo VIC Control unit occupies one control-unit position and can control up to eight tape units. See Paragraph .355 for Uniservo configuration details. The 0768-00 and 0768-99 high-speed printers are also available for attachment via the Multiplexor Channel.

The 9300 II includes the Multiplexor channel as well as the 35 KB Selector channel as standard equipment. These permit the attachment of all peripheral devices available to the 9200 II as well as those offered with the 9300.

The basic UNIVAC 9400 system includes a 9400 Processor with a built-in console and keyboard/printer; 24,576, 32,768, 49,152, 65,536, 98,304, or 131,072 bytes of plated-wire memory; a standard 85KB Multiplexor Channel; a standard Interval Timer; and peripheral devices as required.

One or two 333KB Selector Channels are optionally available for the 9400 system; each channel can handle up to eight control units, on a one-device-at-a-time basis. Each Selector Channel can operate independently of normal processing operations, the other Selector Channel, and/or the Multiplexor Channel.

The standard Multiplexor Channel has eight shared subchannels, seven of which can be connected to peripheral device controllers. (One subchannel services the console Keyboard/Printer.) The Multiplexor Channel can transfer data between devices on all eight subchannels simultaneously as long as the total data rate does not exceed 85,000 bytes per second. 128 non-shared subchannels can be added with a communications adapter option, which must be used in order to operate communication subsystems on the Multiplexor Channel. In general, the Multiplexor Channel is used to handle relatively low-speed I/O devices, including printers, card readers, card punches, communications terminals, display devices, and the low-speed Uniservo VIC Magnetic Tape Handlers. The non-shared multiplexor subchannels permit data chaining operations.

.32 Central Processors

The overall architecture of the UNIVAC 9200 and 9300 Processors is similar to that of the IBM System/360 processors. The UNIVAC 9200 and 9300 Processors are functionally identical to each other; they differ only in internal speeds (the 9300 is twice as fast), in the complement of I/O devices that can be connected, and in the fact that the Multiply, Divide, and Edit facilities are extra-cost options in the 9200 and standard features in the 9300. Table I summarizes the basic characteristics and capabilities of the two systems.

TABLE I: CHARACTERISTICS OF THE UNIVAC 9200 AND 9300

SYSTEM	9200	9300
Memory cycle time, microseconds	1.2	0.6
Bytes accessed per cycle	1	1
Memory capacity, bytes	8K, 12K, or 16K	8K, 12K, 16K, or 32K
General registers	8	8
I/O control registers	8	8
Multiply, Divide, Edit instructions	Optional	Standard
Processor speeds, microseconds (signed 5-digit operands) —		
c = a + b	187.2	93.6
b = a + b	103.2	51.6
c = a x b	2,020.0	1,010.0
c = a/b	4,420.0	2,210.0
Move a to b	84.0	42.0
Compare a to b	103.2	51.6
Multiplexor I/O Channel rate, bytes/second	85,000	85,000
Card reading speed, cpm —		
Basic reader	400	600
1001 Card Controller	1000/2000	1000/2000
Card punching speed, cpm	75-200	75-200 or 200
Alphanumeric printing speed, lpm	250	600
Magnetic tape speed, bytes/second	Not available	34,160

The architecture of the UNIVAC 9400 Processor is similar to that of the smaller UNIVAC 9200 and 9300 Processors. The effective basic memory cycle rate is double that of the 9300 and four times that of the 9200. The first 512 bytes of main storage are reserved for use by the software and hardware for the handling of interrupts, indexing, I/O, and other control functions. Two sets of 32-bit general-purpose registers are also implemented in this low-order block memory. Features of the 9400 which are not found in the two smaller UNIVAC 9000 Series models include:

- Write storage protection (optional).
- Two sets of 16 general registers.
- Separate interrupt control registers for each I/O channel.
- An interval timer.
- Seven levels of processor interrupts.
- Direct access to interrupt condition data.
- Tabling of hardware status for communications interrupts.

Table II summarizes the basic characteristics of the UNIVAC 9400 Processor, including typical instruction execution times.

TABLE II. BASIC CHARACTERISTICS OF THE UNIVAC 9400

Memory cycle time, microseconds	0.6
Bytes accessed per cycle	2
Memory capacity, bytes	24K, 32K, 49K, 65K, 98K, or 131K
General registers, control	16
General registers, user	16
I/O control registers	4
Processor speeds, microseconds (signed 5-digit operands):	
c=a+b	46.8
b=a+b	23.4
c=axb	125.3
c=a/b	280.8
Move a to b	23.4
Compare a to b	23.4
Multiplexor I/O Channel rate, bytes/second	85,000
Selector I/O Channel rate, bytes/second	333,000
Card reading speed, cpm	600
Card punching speeds, cpm	250
Alphanumeric printing speeds, lpm	1100 or 1600
Magnetic tape speeds, bytes/second	8540 to 192,000
Disc storage peak transfer rate, bytes/second	156,000

.321 Instruction Formats

9200 - 9300

There are three types of instructions: I/O instructions, privileged or state control instructions. Both I/O and privileged instructions use the SI (Storage and Immediate Operand) instruction format, as found also in the IBM System/360. Processor instructions use either the SI, SS (Storage to Storage), or RX (Register to Indexed Storage) formats, which are identical to their System/360 counterparts. The RR (Register to Register) instruction format, however, is not implemented in either the 9200 or 9300 processors. Instruction types RX and SI are four bytes in length, while type SS instructions are six bytes long.

The first two 4-bit digits of a processor instruction designate the operation code, which is stated in hexadecimal notation. The remaining digits vary in their intent and purpose, depending upon the format type, as illustrated.

Operands in plated-wire memory can be addressed either directly or by means of the base-plus-displacement technique used in the System/360. If there is a 0 in the most significant bit position of an instruction halfword containing a memory address, the remaining 15 bits of the halfword are interpreted as a direct address. If the most significant bit is a 1, the "base address" contained in the general register specified by the next three bits is added to the "displacement" contained in the last 12 bits of the halfword to form the required memory address.

9400

The six types of UNIVAC 9400 instructions are two, four, or six bytes in length and are structured identically to their System/360 counterparts.

A two-byte instruction causes no reference to main storage, while a six-byte instruction causes two storage references. The six basic instruction formats are:

Type RR — Register to Register (2 bytes)

Op	R_1	R_2

Type RX — Register to Indexed Storage (4 bytes)

Op	R_1	X_2	B_2	D_2

Type RS — Register to Storage (4 bytes)

Op	R_1	R_3	B_2	D_2

Type SI — Storage and Immediate Operand (4 bytes)

Op	I_2	B_1	D_1

Type SS1 — Storage to Storage (6 bytes)

Op	L	B_1	D_1	B_2	D_2

.321 Instruction Formats (Contd)

Type SS2 — Storage to Storage (6 bytes)

Op	L_1	L_2	B_1	D_1	B_2	D_2

where B = 4-bit base register specification
D = 12-bit displacement
I = 8-bit literal operand
L = 8-bit operand length specification
Op = 8-bit operation code
R = 4-bit operand register specification
X = 4-bit index register specification

The first two 4-bit digits of a processor instruction designate the operation code, which is stated in hexadecimal notation. The remaining digits vary in their intent and purpose, depending upon the format type, as illustrated.

Operands in plated-wire memory are addressed by means of the base-plus-displacement technique used in the System/360; i.e., the "base address" contained in the general register specified by the instruction is added to the "displacement" contained in the last 12 bits of the instruction halfword to form the required memory address.

.322 Processing Facilities

The UNIVAC 9200/9300 instruction repertoire emphasizes decimal arithmetic operations upon variable-length fields, although it does provide facilities for adding and subtracting fixed-length binary fields. Efficient data movement, comparison, and editing facilities are provided, as are a number of logical commands to allow masking operations. Logical AND and OR commands can be performed on both decimal and binary data.

Fixed point decimal multiplication (15 by 15 digits maximum) and division instructions are standard with the 9300 and optional with the 9200; in like manner, the Edit instruction is standard with the 9300 and optional with the 9200. No floating-point hardware is available with either machine. A Translate instruction effects translations to or from any 8-bit code through the use of a lookup table in the plated-wire memory. The Edit instruction unpacks up to 31 digits plus sign from a field, either inserting "fill" characters where specified or zero-suppressing the edited data. Zero suppression and character insertion operations can be made in a single editing operation through the use of three different indicator bytes.

The UNIVAC 9200/9300 instruction repetoire is similar to, though not identical with, that of IBM's small-scale System/360 Model 20, and is far smaller and less comprehensive than the instruction set used in the IBM 360/30. Nonetheless, the limited set of 35 instructions chosen for implementation by UNIVAC should be entirely adequate for small scale business applications — and the smaller number of instructions should make programming easier and less prone to error.

The philosophy adopted for the UNIVAC 9400 system has been: (1) to implement an instruction set that provides representation in each of the major classes, (2) to assure upward compatibility from the 9200/9300 systems, and (3) to enable efficient programming — but to achieve economies through exclusion of non-essential instructions. Many of the 142 instructions implemented in the IBM System/360 Model 30, for example, were found to be of limited value and rarely used; these instructions have been omitted from the repertoire of the 9400. Far from useless, but nevertheless also omitted, were all arithmetic floating-point hardware features. UNIVAC feels, however, that since the primary market for the 9400 is in the business data processing environment, the lack of floating-point hardware is not a serious drawback.

A total of 68 instructions have been implemented in the 9400 Processor, including powerful provisions for handling decimal arithmetic operations upon variable-length fields and for adding and subtracting fixed-length binary fields. Binary multiplication and division hardware facilities, as in the 9200/9300, have not been implemented. Efficient data movement, comparison, and editing facilities are provided, as are a number of logical commands to allow masking operations. Logical AND and OR commands can be performed on both decimal and binary data.

A Translate instruction effects translations to or from any 8-bit code through the use of a lookup table in plated-wire memory. The Edit instruction unpacks up to 511 digits plus sign from a field, either inserting "fill" characters where specified or zero-suppressing the edited data. Zero suppression and character insertion operations can be made in a single editing instruction through the use of different indicator bytes.

.323 Operational States

The central processor always operates in one of two states: the Program State, in which user programs are executed and the I/O or Control State, during which control is given to the Supervisor program. Privileged instructions (Load State, Store State, and Supervisor Request Call) control the program state by setting and clearing control registers and flip-flops. This dual state processing capability is unique in small scale systems and is not provided by the IBM 360/20, for example.

An interrupt system causes the processor to enter the Control State and branch to the Supervisor whenever any of the following conditions occurs: completion of an I/O operation, memory parity error, memory address error, execution of a Supervisor Request Call, and invalid instruction.

Each of the two processing states, Program and I/O, are assigned eight registers, which are used solely within their respective states; one group of eight is used for internal processing functions, while the other group is reserved for input-output control functions. The processing group is used whenever the processor is operating in the normal program mode, called Processor Program State Control mode (PPSC). Whenever an I/O interrupt occurs, the processor switches automatically to the I/O Program State Control mode (I/OPSC) and uses the input-output group of registers. This system improves processing efficiency by eliminating the need to store and then reload the contents of the general registers whenever an I/O interrupt occurs. Conversely, programming flexibility will be somewhat restricted by the fact that only 8 of the 16 registers are available for general use by the programmer.

Program interrupts occur upon completion of input-output operations and upon detection of input-output or processor errors, as described in the preceding paragraph. A status byte is made available to the supervisor which examines this byte, determines the cause of the interrupt, and initiates the appropriate program action.

There are two functional processor states within the 9400: Supervisor and Standard. The Supervisor state is used primarily by the software operating system. In this state, all instructions (Supervisor and Standard) are valid and can be executed. The 16 privileged general registers are selected and low-order storage can be addressed. Instructions in the Supervisor set cannot be executed in a problem program.

The Standard (nonprivileged) state handles problem programs. In this state, the Supervisor (privileged) instructions are invalid, the problem set of general registers is selected, and low-order storage cannot be selected.

The dual-state general-register complement contributes substantially to the efficiency of the operating systems, since it eliminates the requirement for storing the contents of the user registers prior to performing any supervisor functions — as is the case in the IBM 360/30, for example.

.324 Interrupt System

The interrupt hardware in the UNIVAC 9400 Processor allows the processing unit to respond to a variety of service-demanding conditions that arise within the processor and/or the peripheral units. A key element in the interrupt system is the "Program Status Word" (PSW), a double (64-bit) word that indicates the operational status of the processor. When an interrupt occurs, it causes the current PSW to be transferred automatically to old PSW storage for that class of interrupt and the corresponding new PSW to be loaded from storage. The detailed status of the processor is thus saved for subsequent examination, and the new state of the processor is established. The 64-bit PSW holds enough information about a running program to enable program interrupt and restart without risk of data or sequence loss.

The 9400 interrupt hardware can handle seven possible interrupt conditions, which include the following (listed on a decreasing priority basis):

Supervisor call
Program exception
Interval timer
Selector channel 1
Selector channel 2
Multiplexor channel (shared subchannels)
Multiplexor channel (non-shared subchannels)

Each interrupt level has its unique interrupt status register, enabling the operating system to recognize the source of the interrupt immediately, without recourse to test routines. Both selector channels and the multiplexor channel (in both shared and non-shared modes) have separate interrupt status registers; each shared and non-shared multiplexor channel has indirect access to its own status register. When an I/O interrupt occurs, its source can be directly detected by the UNIVAC 9400 Supervisor.

.33 INTERNAL STORAGE

.331 Plated-Wire Memory

Probably the most significant technical innovation in the UNIVAC 9000 Series is the use of plated-wire memory for the main working storage. The plated-wire memory operates in a nondestructive readout (NDRO) mode, eliminating the need for the regenerative cycle which is required after every read operation in conventional magnetic core memories. Furthermore, most of the plated-wire manufacturing and testing operations can be carried out in continuous, automated processes. For these reasons, UNIVAC claims that its plated-wire memories can be offered with higher speeds and at lower costs than the core memories which are used in nearly all current computer systems.

The plated-wire memory is a magnetic storage device of the thin-film type. The substrate is a beryllium copper wire, 0.005 inch in diameter. The manufacturing process consists of electroplating an iron nickel alloy over an initial plating of copper. Plating is performed while the wire is in the presence of a circumferential magnetic field that is created by the passage of current through the wire itself. The wire that provides a base for the thin-film material also becomes an integral part of the read/write circuitry: it serves as the sense line during read operations and carries write current during write operations.

The UNIVAC 9200 has a memory cycle time of 1.2 microseconds per one-byte access, and memory capacities of 8,192, 12,288, and 16,384 bytes are available. The UNIVAC 9300's memory cycle time is 600 nanoseconds (0.6 microsecond) per one-byte access, and the available capacities are 8,192, 12,288, 16,384, and 32,768 bytes. Memory sizes can be increased at any time by field-installing additional modules. Every byte read from memory is checked for proper (odd) parity.

The 9400 main storage has a cycle time of 600 nanoseconds per half-word (two bytes), producing an effective memory cycle of 300 nanoseconds per byte accessed. Memory is available in capacities of 24,576, 32,768, 49,152, 65,536, 98,304, and 131,072 bytes, and can be expanded in the field by adding modules. Every byte read from memory is checked for proper (odd) parity.

The low-order 512 bytes of storage are reserved for use by the hardware and software for handling interrupt control, indexing, I/O control, and certain internal control functions. The two sets of general-purpose registers are also implemented within this low-order memory block.

In order to provide a data communications capability, four additional bytes of low-order main storage are required for each communications line in the subsystem. Since the 9400 can have 128 communications lines, a maximum configuration requires use of the first 512 bytes of main storage. Unauthorized access to this area of memory causes a processor interrupt.

.34 Disc File Storage

.341 8410 Disc Storage Subsystem

The 8410 Disc Storage System, announced on December 6, 1967, represents a considerable enhancement to the UNIVAC 9000 Series product line by providing random or sequential access to a moderate amount of on-line storage. The recording medium is a nickel-cobalt-coated disc in an interchangeable cartridge. Each single-disc cartridge can store up to 3.2 million bytes, but only 1.6 million bytes of each cartridge can be accessed "on-line". By physically removing each disc cartridge, turning it over, and replacing it on the drive, the remaining 1.6 million bytes of data become accessible.

Two independently operating disc handlers are housed in a single cabinet, and each handler services a single disc cartridge. Up to four dual-disc units are allowed in a maximum 9000 Series system configuration, providing a total on-line data capacity of 12.8 million bytes.

A seek function on one disc handler can be overlapped with seek, read, or write functions on another. Once the desired sector address has been determined, the average time required to position the head mechanism for randomly placed data is 110 milliseconds. The rotational speed is 1,200 revolutions per minute, which corresponds to 50 milliseconds per revolution (latency time). Thus, the average access time for randomly placed data, including 25-millisecond average latency time, is 135 milliseconds, an acceptable access time for use in many random processing applications.

The fastband search technique, which may be employed at the user's discretion, provides the address of the desired sector through use of a key (sector location data) contained in a special 50-sector track or "fastband" on each disc surface.

Although the 8410 Disc Storage System is capable of transferring data at the rate of 136,000 bytes per second, the effective speed, as limited by the data transfer capacity of the Multiplexor channel, is 100,000 bytes per second. Buffering logic located in the disc drive cabinet provides

(Contd.)

.341 8410 Disc File Subsystem (Contd.)

intermediate storage of up to 256 bytes. A maximum of 160 bytes can be transferred to or from the disc unit with a single disc read/write command.

Accuracy control during read/write operations includes a longitudinal parity check by sector. Control instructions include Write Check, Seek Track, and Sector Search commands.

.342 8411 Disc Storage Subsystem

Among the more significant items of equipment that were originally offered with the 9400 and now extended to the 9200 II and 9300 II is the UNIVAC 8411 Direct Access Storage Subsystem. This unit must be attached to the central processor through the Selector Channel, which is optional on the 9200 II and 9400 and is standard on the 9300 II. Up to eight drives may be installed. Each disc pack contains six discs with the data recorded on the ten inside surfaces.

The 8411 provides the 9000 Series with storage for variable length records. The maximum capacity is 7,250,000 bytes per disc pack with a total system storage capacity of 58,000,000 bytes.

Minimum arm positioning time is 25 milliseconds and the maximum time is 135 milliseconds, giving an average positioning time of 75 milliseconds. The minimum and maximum latency times are 0 and 25 milliseconds respectively. Maximum access time is 160 milliseconds, with the average access time being 87.5 milliseconds. The rotational speed of the disc drive is 2,400 rpm. The peak data transfer rate is 156,000 bytes per second. This unit is compatible with the IBM 2311 Model 1 Disk Storage Drive, minimizing conversion problems.

.35 Input-Output Equipment

UNIVAC offers two card readers, two card punches, two line printers, two high speed printers, one high-speed printer, one magnetic tape unit, one paper tape subsystem, two disc storage subsystems, and a high-speed multi-purpose card machine for use with 9200 and 9300 systems. The UNIVAC 9400 peripheral line currently includes one card reader, one card punch, two high-speed line printers, three magnetic tape subsystems, one disc storage subsystem, one paper tape subsystem on-line 1005, 9200, or 9300 Processors, and three data communication subsystems with a variety of terminal devices, including the recently-announced Uniscope 300 and UNIVAC's smaller-scale processors, the 1004, 1005, 9200, and 9300. In addition to the 9000 Series system peripherals listed above and detailed in the following paragraphs, UNIVAC offers as "RPQ" items several interface adapters capable of blending other manufacturers' devices into 9000 Series systems. Some of these devices are listed in Paragraph .357 below.

.351 Card Readers

The 400-cpm 0711-00 Card Reader is the basic input unit for the UNIVAC 9200 system. It reads standard 80-column cards photoelectrically, in column-by-column fashion, at a peak speed of 400 cards per minute. Optional features permit short cards of either 51 or 66 colums to be fed. The input hopper holds 1200 cards and the single output stacker holds 1500 cards. Checks are made for the following conditions: hopper empty, stacker full, misfeed, card jam, improper registration, photocell malfunction, and improper parity in data transmitted to the reader. Photocell malfunctions are detected by a light/dark check at the beginning of each card cycle. Control of card reader operations occupies the 9200 Processor for less than 1 percent of each 150-millisecond card cycle.

The 600-cpm 0711-02 Card Reader is the basic input unit for the UNIVAC 9300 system. Except for its higher peak speed of 600 cards per minute, its characteristics are similar to those of the 400-cpm reader described above. Control of card reader operations occupies the 9300 Processor for only 1 millisecond of each 100-millisecond card cycle.

The 600-cpm 0711-05 Card Reader and Control is the only card reader currently offered for use with the 9400 system. It reads standard 80-column cards photoelectrically, in column-by-column fashion, at a peak speed of 600 cards per minute. Data can be read either in 80-column EBCDIC or in an image mode having 160 6-bit characters per card. Optional features permit short stub cards of either 51 or 66 columns to be fed. The input hopper holds 1200 cards and the single output stacker holds 1500 cards. Checks are made for the following conditions: hopper empty, stacker full, misfeed, card jam, improper registration, photocell malfunction, and improper parity in data transmitted to the reader. Photocell malfunctions are detected by a light/dark check at the beginning of each card cycle. Multiple strobe checking is also employed.

The card reader includes a self-contained control unit and synchronizer that regulates data and control signal flow to and from the reader mechanism. The control unit is attached to the 9400 Processor via one non-shared subchannel of the multiplexor channel. Control of card reader operations occupies the 9400 Processor for less than 1% of each 100-millisecond card cycle.

.352 Card Punches

UNIVAC's new 0603-04 Column Card Punch is the basic card output device for both the UNIVAC 9200 and 9300 systems. It punches standard 80-column cards in column-by-column fashion. Cards are fed from a 1200-card input hopper past an optional pre-punch read station, a wait station, and a punch station, and then into one of two 850-card stackers. Program selection of either the normal output stacker or the reject stacker is an optional feature.

Rated punching speeds range from a maximum of 200 cards per minute when only the first 14 columns of each card are punched to a minimum of 75 cards per minute when all 80 columns are punched. In all cases, control of card punch operations occupies the central processor for a maximum of 1 millisecond per card. Checks are made for the following conditions: hopper empty, stacker full, chip box full, card jam, misfeed, improper punch motion (echo check), and improper parity.

The 0604-00 Row Punch can be connected to a UNIVAC 9300 or a 9400 system via the option Multiplexor I/O Channel. Because it punches cards in row-by-row fashion, it can maintain its rated speed of 200 cards per minute regardless of the number of columns punched per card. Standard 80-column cards are fed from a 1000-card input hopper past an optional pre-punch read station, a wait station, a punch station, and a post-punch read station used for hole-count checking purposes, and then into one of two 1000-card stackers. Program selection of either stacker is a standard capability, and error cards are automatically directed into the error stacker. Control of Row Punch operations occupies the 9300 Processor for only 2 milliseconds of each 300-millisecond card cycle.

.353 Punched Tape Subsystem

A Paper Tape Subsystem, model 920, was added to the UNIVAC 9000 series in September 1968. It consists of a Paper-Tape Control, Paper Tape Reader, Reader Spooler, Paper Tape Punch, and Punch Spooler. The 920 reads at 300 cps and punches at 110 cps, handling any 5, 6, 7, or 8 level tape codes.

.354 1001 Card Controller

The 1001 Card Controller, announced in May 1965, is a high-speed alphanumeric collator that can be connected to a UNIVAC 9200 or 9300 system via the optional Multiplexor I/O Channel and a 1001 Control. The 1001 has two card feeds and seven stackers. Each of the two card feeds can operate independently at up to 1000 cards per minute, and a column-by-column photoelectric read station is associated with each card feed. Thus, a UNIVAC 9200 or 9300 equipped with a 1001 (in addition to the basic 400-cpm or 600-cpm card reader) can simultaneously handle three separate card input files and can perform merging and selection operations while processing.

The 1001 also contains 256 six-bit character positions of core memory and processing capabilities such as addition, subtraction, comparison, and editing. It is externally programmed by means of a plugboard. These facilities permit the 1001 to be disconnected from the computer system and used for off-line collating, editing, sorting, or proving operations.

.355 Bar Printers

The 250-lpm printer is an integral part of the UNIVAC 9200 Processor and is the only printer currently offered for use in 9200 systems; its relatively low speed is likely to be the limiting factor on system throughput in many applications. The printer uses a horizontally oscillating type-bar — the first time UNIVAC has employed this printing technique. The advantages of this technique are its simplicity, low cost, elimination of vertical misalignment, and ability to use interchangeable type-bars.

The basic model has 96 print positions and a peak speed of 250 single-spaced or double-spaced lines per minute using the standard 63-character set. Vertical spacing is 6 lines per inch, and skipping speed is 25 inches per second. Control of printer operations occupies the 9200 Processor for about 31 milliseconds of each 240-millisecond print cycle.

Optional features permit the number of print positions to be expanded from 96 to either 120 or 132. Another option — Variable Speed Printing — provides a special type-bar that enables the printer, under program control, to print lines requiring only a 16-character numeric font at 500 lines per minute and lines requiring a 48-character alphanumeric font at 250 lines per minute.

The 600-lpm printer is integrated into the 9300 Processor cabinet. It, too, uses a removable, horizontally oscillating type-bar, but its peak speed, using the standard 63-character set, is 600 single- or double-spaced lines per minute. The optional Numeric Print feature provides an interchangeable 16-character type-bar that permits lines containing only the 10 numeric digits plus 6 special symbols to be printed at the rate of 1200 lines per minute. Skipping speed is 25 inches per second, and the basic 120 print positions can be expanded to a maximum of 132. Control of printing operations occupies the 9300 Processor for 31 milliseconds per line when the standard 63-character set is used, and for only 8 milliseconds per line when the optional 16-character numeric type-bar is in use.

(Contd.)

.356 High-Speed Printers

UNIVAC offers two versions of its new 0768 Printer for use in 9200 II, 9300, 9300 II and 9400 systems. The two units are identical except for rated speeds, and the slower, more economical model can be field-modified into the faster version.

The standard 0768 Printer operates at an average speed of 900 to 1100 printed lines per minute. The maximum rate of 1100 lpm is attained if the characters within a print line are included within any 49 contiguous characters of the 63-character set (and if single line spacing is being used). As an option, the print speed can be increased to 1600 lines per minute; the 1600-lpm speed is reached when a contiguous field of 43 characters is used. Skipping speed is 33 inches per second when printing at 6 lines per inch, and 22 inches per second at 8 lines per inch.

The controlling and synchronizing circuitry, including the 132-character print buffer and the print mechanism, are housed within a single free-standing cabinet. This complete printer subsystem is connected to the 9400 Processor by means of one of the eight non-shared subchannels of the standard Multiplexor Channel.

A forms container at the base of the unit houses the supply of forms being fed into the printer. Forms can vary from 4 to 22 inches in width and from 1 to 22 inches in length.

Controls are provided to allow manual adjustment of paper tension, form thickness, paper alignment, vertical print positioning, horizontal print positioning, and form advancement. The forms handling mechanism is designed to eliminate buildup of static electricity.

.357 Magnetic Tape Units

The Uniservo VIC Magnetic Tape Handlers, which have been used with most of UNIVAC's second-generation computers, are the only tape units announced to date for the UNIVAC 9200 II, 9300, and 9300 II systems. The standard models use 9-track tape with a recording density of 800 bytes per inch; thus, they are compatible with the 2400 Series magnetic tape units used with the IBM System/360. The tape speed of 42.7 inches per second provides a data transfer rate of 34,160 bytes per second, and tape can be read either forward or backward. Nominal start-stop times are 16.7 milliseconds when reading and 21.7 milliseconds when writing. Rewind time is 180 seconds or less per 2400-foot reel.

Tape reading and writing is overlapped with computing, and full read/write/compute simultaneity is possible in systems that include two tape control units. Control of magnetic tape operations occupies the 9300 Processor for approximately 10 microseconds per byte, or about 33% of the total data transfer time.

The basic Uniservo VIC Magnetic Tape Subsystem consists of one 9-track control unit, one master tape handler, and one slave tape handler. Each master tape handler can control up to three slave handlers, and one control unit can accommodate a maximum of eight tape handlers (two masters and six slaves). Each control unit occupies one of the eight positions on the 9300 Processor's optional Multiplexor I/O Channel. Two control units with a total of 16 handlers represent the maximum configuration that will be supported by the 9300 software.

The Uniservo VIC subsystem is also available in a 7-track version that provides compatibility with IBM 729 tape units and with many of the older Uniservo models. Recording densities of 200, 556, or 800 characters per inch result in data transfer rates of 8,540, 23,741, or 34,160 characters per second, respectively. The optional Data Conversion feature provides automatic two-way format conversions between the 6-bit characters on tape and the 8-bit bytes in memory. A 7-track tape subsystem consists of a 7-track control unit and up to eight 7-track handlers, arranged in the same way as the 9-track subsystem described above. Alternatively, 7-track slave handlers can be connected to a 9-track master handler and used in a 9-track subsystem if the optional 7-track feature is added.

Two types of magnetic tape subsystems are available for use with the UNIVAC 9400: the Uniservo 12/16 Subsystem (having two types of handlers) and the Uniservo VIC Subsystem. The Uniservo 12/16 Subsystem can be connected to the central processor through one or two optional Selector Channels, while the slower-speed Uniservo VIC Subsystem must be attached through the Multiplexor Channel. The recording modes employed in all NRZI-type units are IBM-compatible, thereby ensuring interchangeability of data tapes with tape units of most other computers.

The Uniservo 12/16 Magnetic Tape Subsystem consists of a synchronizer and any combination of Uniservo 12 and/or 16 tape units up to a maximum of 16 tape units. The magnetic tape units and special devices available in the Uniservo 12/16 Subsystem include features to provide: two recording modes, two levels of recording, several pulse densities, two read/write speeds, and various other features for simultaneity. Both the Uniservo 12 and 16 Magnetic Tape Units are available in 7- and 9-track models.

.357 Magnetic Tape Units (Contd.)

In 9-track operation, data is phase-encoded in 9-bit frames across the tape width, at a recording density of 1600 bpi. Each frame contains eight data bits plus one parity bit (one byte). The coding scheme for 9-track tapes is EBCDIC, which is the internal processor code. An optional dual-density feature for the 9-track units enables each unit to read and record data in the Non-Return-To-Zero (NRZI) mode at a density of 800 bpi. When this feature is included, the recording mode and density are controlled through the program instructions.

In the 7-track mode, data is recorded in 7-bit frames (NRZI mode only) across the tape width. In this case, each frame contains six data bits plus one parity bit. The synchonizer automatically converts the internal code of the central processor (EBCDIC) to or from 6-bit (BCD) code when 7-track units are used. A special data conversion feature is required to record and read three 8-bit bytes of information into four 6-bit frames, if EBCDIC to BCD translation is not desired. Data conversion is selected by program control.

Reading can take place with either forward or reverse tape motion; writing can be done only in the forward direction. The record blocking factor is established by operating system directives. Block size can be from 18 to 4096 bytes.

An optional feature can provide simultaneous read/read and read/write operations. This simultaneous feature must be added to the control, to the Uniservo 12 Master Tape Units, and to each Uniservo 16 Magnetic Tape Unit which is to operate in a simultaneous mode.

.358 Data Communications

Communications-oriented data processing is a strong feature of the UNIVAC 9000, which has the capability to serve from one to four Data Communication Subsystems (DCS) by means of a Communications Adapter. Although it is physically possible to connect eight DCS's to the channel, practical considerations limit the number of DCS's that can be connected. In the case of the UNIVAC 9200/9300 central processor, no more than two DCS's can be connected thereby limiting the number of duplex channels to eight (two DCS-4's). For the UNIVAC 9400, no more than four DCS's can be connected which impose a limit of 64 duplex channels (four DCS-16's). Each subsystem must be connected to one of the eight multiplexor subchannels. Circuitry is included in the DCS to control data transmission between the central processor and the line terminals. The DCS establishes the priority for individual lines when simultaneous service requests are made. Also, the DCS signals the operating system when a data transfer between the DCS and the central processor has been lost.

The subsystem can take a variety of forms, depending upon the needs of the particular installation. The modular elements comprising the subsystem are described in the following paragraphs. A block diagram (Figure 2) shows interconnections between the UNIVAC 9400 Processor, Data Communication Subsystems, and the remote devices.

The Line Terminal Controller provides logic to control the various Line Terminals and the automatic dialing adapter.

Pairs of Line Terminals can be connected to create a half duplex (send or receive) or full duplex (send and receive) communication link. Several types of Line Terminals provide varying speeds or a choice between synchronous and asynchronous operation. Four- to eight-level codes can be handled by selecting the proper model and mode of Line Terminals, as shown in Table V.

The Communication Interface Unit connects the Line Terminals to the common-carrier facilities. Each input/output line pair requires one Communication Interface Unit.

The Asynchronous Timing Assembly provides a clock source for asynchronous line terminals. A single unit provides one transmission rate for an entire Data Communication Subsystem. Asynchronous Timing Assemblies are available for transmission speeds of up to 1800 bps. Each Asynchronous Line Terminal of a different speed requires an Asynchronous Timing Assembly. The maximum number of ATA's are four and eight, in the case of the DCS-4 and DCS-16, respectively.

The Synchronous Timing Assembly (STA) provides a clock for synchronous operation. Clock signals are supplied for transmission at rates ranging from 1200 to 40,800 bps. These assemblies are needed only in a synchronous mode of operation where an asynchronous modem is used or where there is no external synchronized clock.

.359 Non-Standard "RPQ" Features

UNIVAC has either implemented or decided the feasibility of implementing certain "Request for Product Quotation" (RPQ) features to allow use of the following devices with the 9200/9300 Processors:

- MRC 1501 Mark Sense Card Scanner.
- UNIVAC III Processor.

.359 Non-Standard "RPQ" Features (Contd.)

- UNIVAC 0758 1200 lpm Printer.
- NCR 420 Optical Journal Tape Reader.
- Kimball KR 1200 Tag Reader.
- NCR 407 MICR Document Reader.
- IBM 1404 Bill Feed Printer.
- IBM 1231 Mark Sense Page Reader.
- Calcomp or Benson-Lehner Incremental Plotter.
- Farrington Optical Document Reader.

.36 SIMULTANEOUS OPERATIONS

Control circuits for the basic printer, card reader, and card punch are built into the 9200 and 9300 Processors; these three basic I/O devices, as well as devices connected via the optional Multiplexor Channel, can operate simultaneously with one another and with internal processing by interleaving their demands upon the plated-wire main memory. The Multiplexor Channel's maximum data rate, when operating in the multiplex mode, is 85,000 bytes per second — fast enough to permit read/write tape simultaneity in systems that include two Uniservo VIC control units. In the 9200 II and 9300 II, the availability of the 350KB Selector Channel allows the addition of the 8411 Disc Storage Subsystem to these processors.

All peripheral devices are connected to the 9400 through either the standard Multiplexor Channel, which lacks a "burst" mode, or the optional Selector Channel. Through the use of these channels, the 9400 can concurrently execute up to eight concurrent low speed input-output operations taking place on the standard I/O Multiplexor Channel and one concurrent high-speed data transfer per optional Selector Channel while executing one machine instruction.

.4 SOFTWARE

UNIVAC presently offers 9000 users a choice of three levels of software: card, disc, or tape-oriented. One of the distinctive features of the 9000 Series is that total upward program compatibility exists, with no rewriting of programs necessary when systems are upgraded.

.41 Basic Card Support

The basic card support package is designed for use with 9200/9300 card-oriented systems, which have an integrated printer, card reader, and card punch. All card programs will function either with the standard card reader or with the 1001 Card Controller without requiring special programming for each device. A principal component of the basic package is a 256-byte resident Supervisor. Also included are an assembler, report generator, gang-punch-reproduce program, and card IOCS routines. All of the basic card-oriented software has been delivered.

.411 Basic Card Executive (Supervisor)

This is a 256-byte (minimum) supervisor which aids the user in running successive card programs, although manual setups between jobs are still required. The Card Executive provides restart communication and recovery routines for I/O or processor errors.

.412 Basic Assembler

The Basic Assembler is a straightforward, card-oriented assembly system that allows the programmer to utilize all the hardware facilities of a card-oriented 9200 or 9300 system.

The assembly process is essentially a one-for-one translation in which symbolic instructions, coded in a fixed format, are converted into machine language instructions. A pre-assembly macro pass is provided which causes generalized library macro routines to be particularized in accordance with parameters specified by the programmer in a deck of macro instructions. These routines are then punched in source code for subsequent assembly. In addition, user macros can be incorporated into the library.

The assembler is a two-pass system, with a printed listing supplied as an output along with a relocatable object deck. A Card Linker is provided to link the object decks produced by several assemblies.

Input-output operations — such as reading, punching, and file checking — are coded by means of card IOCS macro instructions that generate linkages to the appropriate routines. A group of pseudo-instructions is provided to control the assembly process itself.

.413 Problem Oriented Facilities

The card-oriented Report Program Generator (RPG) accepts problem-oriented specifications and generates programs in Machine language to produce the specified reports. Input to the object programs is from punched cards; output can be in printed and punched-card form. The UNIVAC RPG uses essentially the same coding forms and specifications as the IBM System/360 RPG; its principal purpose is to ease the transition from punched card tabulating with unit record equipment to stored-program computing.

The Gangpunch-Reproduce Program Generator permits functions normally associated with tabulating equipment to be described in problem-oriented terms, and generates a program to perform the following specific functions: straight reproducing; master card, interspersed master card, and offset gangpunching; sequence checking; and consecutive punching.

A group of standard subroutines is provided to perform functions such as simulation of the hardware multiply/divide and edit instructions, dumping of specified memory areas, floating-point arithmetic, and evaluation of the common mathematical functions (using UNIVAC's "Mathpac" routines).

.42 Tape Oriented Software

This advanced package is designed for tape oriented 9300 systems. Plated-wire memory requirements vary for the different elements and therefore are separately listed for each program or software system.

There are three levels of tape-oriented software: a Minimum Operating System (MOS) which operates at the 8K- to 12K-byte machine level (and is accordingly restricted in its scope); a Non-Concurrent Operating System (NCOS), which operates in a 16K-byte environment; and a 24K to 32K-byte Concurrent Operating System (COS).

.421 Minimum Operating System

The 8K-byte MOS support includes a 256-byte Supervisor similar in nature and scope to the 8K-byte Card Executive, and provides semi-continuous supervision of all language and problem programs during their execution.

The minimum machine configuration required to use the Tape MOS includes three Uniservo VIC magnetic tape units, a card reader, a card punch, an I/O Multiplexor Channel, and 8,192 bytes of plated-wire memory.

At the 8K-byte MOS level, the Tape Assembler cannot be used, but a mixed set of Card-Tape IOCS routines are made available to the user.

The primary control programs are the 1,500-byte memory-resident Supervisor and Tape Dispatcher, the Job Control Program (JCP), the Tape IOCS, and the Initial Program Loader. No integrated loader is provided at the basic 8K-byte level, and as a result, continuous job stream (i.e., stacked job processing) cannot be handled.

.422 Non-Concurrent Operating System (NCOS)

The 4-tape or disc 16K-byte Non-Concurrent Operating System provides a small but complete operating environment for the sequential execution of user programs.

At the 16K-byte NCOS level, a Tape Assembler, FORTRAN compiler, COBOL compiler, Tape Report Program Generator, and magnetic tape utilities are provided. Control programs include an extended Supervisor and a Job Control Program. NCOS provides automatic services to:

- Locate programs and overlays on magnetic tape.
- Allocate facilities (memory space, magnetic tape unit assignments, and peripheral units) to a program.
- Terminate the program either upon completion of a job or earlier because some data errors must be corrected before normal processing can continue.
- Release the facilities of a terminated program for use by other programs.
- Process I/O interrupts and transfer control to the appropriate subroutine for interrupt analysis, possible error recovery, and subsequent control transfer to the peripheral unit.
- Coordinate operation-computer communication by handling output messages and both solicited and unsolicited information from the operator.
- Provide checkpoint/restart facilities.

.423 Concurrent Operating System (COS)

The 32K-byte Concurrent Operating System is essentially the same as NCOS, except that a limited multiprogramming capability is added. UNIVAC calls this feature concurrency, or the ability to perform one main user program concurrently with up to five data transcription routines, such as card-to-tape and tape-to-print. Each of these symbionts is a peripheral

.423 Current Operating System (COS) (Contd.)

program which, at the time of an interrupt, can take over the processor until its particular function is initiated or completed, at which time control is returned to the main program. COS requires use of a minimum of five magnetic tape units.

.424 Tape Assembler

The 34K-byte Tape Assembler is similar to the Card Assembler, but contains a built-in macro facility and uses magnetic tape to minimize card handling. The Tape Assembler requires use of at least four tape units and 16,384 bytes of memory.

.425 Compilers

COBOL and FORTRAN compilers are provided for use with any 9200 II or 9300 system that has a minimum of 16K bytes of main storage. The COBOL language includes all the facilities of the proposed minimum USA Standard COBOL language. The FORTRAN language facilities will include all of the Basic FORTRAN as specified by the USA Standards Institute, plus many of the features of the full USASI FORTRAN language. UNIVAC has also included some language extensions beyond those specified by the USA Standards Institute X3.4.3 FORTRAN Working Group. It is possible to link into a single program routines written in COBOL, FORTRAN, and Assembly languages.

.43 Disc Oriented Software

The 9200/9300 8410 Disc Storage Subsystem is supported by a somewhat limited disc software package. The package comprises the following components.

- Disc Dispatcher. The basic ingredient of the disc software, the dispatcher issues I/O commands, queues requests, handles error recoveries and performs the other functions of an I/O routine. The dispatcher is an integral part of the supervision.
- IOCS. This routine gives the user the capability of handling disc files in either sequential or random order. It provides for OPEN and CLOSE of files and the ability to GET or PUT records.
- RPG. The card RPG is enhanced by the inclusion of the 8410 functions necessary to give the user complete disc file control in object programs generated with RPG.
- Sort. Disc file sorting can be done on the minimum 9200/8410 configuration.
- Disc Assembler. A disc-oriented assembler using disc during assembly is provided.
- Disc Operating System. A modular disc oriented Operating System is provided incorporating such features as program locate and load from an 8410 System Disc and control stream buffering using disc.
- Library Services such as a System File Loader, loading object programs onto a disc system file, a Disc Loader, loading programs into memory from a system file, and an Indexed Sequential File Operation which searches for and presents desired records in a sequential file to the user program.
- Utility Routines available include Disc Prep, Disc Print, and Disc Dump and restore.

.44 9400 Operating System

Software for the UNIVAC 9400 will be delivered in two phases. The first release, a basic software package consisting of a tape operating system and associated language processors, will be available for initial customer installations during the second quarter of 1969. Design level of the basic 9400 Supervisor is 8-12K bytes of storage.

The five-level multiprogramming system, a complete 32K USA FORTRAN compiler, and a 65K USA COBOL compiler, will be available at a later date. The design level of the multiprogramming system will require somewhat more resident storage than the 8-12K bytes required for the basic system.

Supervisor

The 9400 Supervisor is an operating environment of unusual design and impressive scope for a medium-scale computer system. Borrowing on some of the more successful concepts proved in the large-scale 1108, UNIVAC has incorporated many features into the 9400 not normally found in a system this size. In addition to five-level multiprogramming, a system of variable time-slicing has been combined with a job-stream priority system to more fully utilize the available computer time.

.441 Priority Scheduling

Five program priorities are provided by the Supervisor Control Program, two of which are used by the operating system, and three by problem programs. The three types of problem programs and associated prior levels are:

- Communication programs — the highest priority level available to the user.
- Batch programs with high input-output utilization.
- Batch programs with low input-output utilization.

The user can designate priority levels in the job control stream by specifying priority level 1, 2, or 3, according to the known requirements of the problem program.

.442 Interval Timer and Time Allocation

A number of Supervisor services make use of the standard Interval Timer Feature, including:

- Allocation of processing time between various programs at each priority level, as specified by the user at system generation time.
- Establishment of job time limits to prevent unauthorized domination of the system by a single program.
- Simulation of a Day Clock that is accessible to the programmer.
- Notification of time-interval expiration.

The division of processing time among the jobs at a given program priority level is controlled through time allocation. Processing time is allocated to individual programs in intervals ranging from one millisecond to four seconds. If a program refuses to yield control of the central processor before its allocated time interval expires, an interrupt is set and the Supervisor intervenes to evaluate the utilization of the computer system. An accumulated control log of processing time is maintained and compared against an estimated maximum time requirement prior to each issuance of processing time. If a program exceeds its maximum estimated time requirement, the operator is notified to either initiate abort procedures or to allocate more time. As an optical feature, the Supervisor can automatically initiate abort procedures.

The lengths of the allocated intervals at each priority level are selected by the user at system generation time; the estimated maximum time requirement is selected for each program at the time it is loaded.

.443 Control and Linkage

Routines can be shared by problem programs in the multiprogramming environment. Control and linkage are functions of the Supervisor, and are handled in one of two ways. Requests for serially reusable routines are queued and then executed in sequence of job priority. Re-entrant coding allows concurrent execution of routines by two or more requesting jobs, but is limited to the data management portions of the Supervisor.

.444 Operator Communication Facilities

Facilities for communication between the operator and the Supervisor or problem program can include automatically time-stamped console messages to the operator. These full-text messages can state whether operator intervention is required before processing can resume, or whether an entry is required in the system's chronological log. Operator messages to the Supervisor are either replies to previous messages issued by the Supervisor or commands directing the Supervisor in its operations. The format and content of the reply depend upon the requirements of the Supervisor message being answered.

The problem program may have two-way communications with the operator, in which the console is treated as a peripheral device shared among problem programs. An index is maintained in auxiliary storage of all transient routines stored in the library. The more frequently-used transient routines are indexed in main storage. The transient storage scheduling routine, a part of the resident portion of the Supervisor, maintains these indices and coordinates all activity between calling routines and transient routines.

Transient routines are considered as logical extensions of the calling programs and are executed at the same priority level as their respective calling programs. All such routines are designed to operate within the space provided by one transient area. When a transient routine exceeds this boundary, it loads in program overlays using the LOAD and FETCH macro instructions; therefore, the effective size of transient routines is virtually unlimited.

.445 Interrupt Handling

The decoding and processing of all machine interrupts are handled automatically by the interrupt-handling function of the resident Supervisor. The programmer need not concern

.445 Interrupt Handling (Contd.)

himself with them when writing a problem program. There are seven types of interrupts, with the following priority order:

- Supervisor call.
- Program exception, which can be an illegal operation code, a privileged operation attempted in the problem state, a limits register check, a low-order storage check, a binary arithmetic overflow, or a decimal arithmetic overflow.
- Interval timer.
- Selector Channel 1.
- Selector Channel 2.
- Shared multiplexor subchannel.
- Nonshared multiplexor subchannel.

.446 Input-Output Control System (IOCS)

All activity between the central processor and its peripheral devices is controlled by a group of routines called the Channel Scheduler, which provides I/O queuing, dispatching, posting, and error-detecting services.

The programmer can communicate directly with the Channel Scheduler by using physical IOCS macro instructions. Whenever these macros are used, the programmer must supply the channel command words and provide any logical functions required by the problem program, such as blocking and unblocking records, checking for wrong record lengths, swapping buffer areas, and detecting and bypassing checkpoint records if they are interspersed with data records.

.447 Data Management

The UNIVAC 9400 Data Management Services provide an interface between problem programs and the hardware-oriented I/O portions of the Supervisor. The data management facilities provide record blocking and unblocking, buffering, data validation, and label processing.

The facilities consist of common-code subprograms. At systems generation time, the user selects those subprograms specifically needed to process his files. The result is a saving in storage space by having only one file processor program for all the files rather than several basically repetitive file processors tailored to each individual file. An additional increase in efficiency is gained through use of specialized linkages between the user's file table generated by the DEFINE THE FILE macros and the subprograms of common coding. These linkages are generated in sequences peculiar to the DEFINE THE FILE call, thus eliminating large areas of slow interpretive coding.

The initiation and termination procedures for file processing (OPEN and CLOSE) exist as system transient routines. The space used by the OPEN transient coding is used once and then overlaid with other Supervisor control coding; this coding is in turn overlaid with the CLOSE transient coding to terminate the file.

The user can access a file via either random or sequential access methods. File declaration macros are supplied for each access method and appropriate I/O device. A variety of processing macros for handling the data are also provided. Random processing can be either direct or indexed sequential.

.448 Job Control Program (JCP)

The Job Control Program (JCP) in the Supervisor controls the execution of work tasks in the job control stream, including task initiation, transition between programs, restarts, and job termination.

As the job control streams are submitted to the Supervisor, they are stored in direct-access storage files for subsequent selection and execution. The operator selects jobs to be evaluated for available facilities. If facilities are sufficient and available, the job is queued ready for processing time.

Transition from the normal termination of one job control stream to another is automatic, with messages to the operator for mounting tapes, setting up the printer, and performing other physical system adjustments. Checkpoint/restart is also provided. In addition to normal job termination, job suspension and cancellation are available through operator or program intervention.

.449 Message Control Program (MCP)

The Message Control Program is a generated I/O program that provides a logical input-output control system (IOCS) for communications processing. A problem program can use the MCP to control the input-output from communication lines.

.449 Message Control Program (MCP) (Contd.)

In addition to the normal GET and PUT type macros, macros are provided to construct a complete message control program that controls the flow of messages to and from a variety of commonly used remote terminals and the user's processing program. Messages of fixed or variable length flow from the remote terminals to be queued in main storage. From main storage, messages are then accessed by the problem program. If direct-access storage is used, the flow of messages from remote terminals to direct-access storage can be queued in an order specified by the user.

Since the MCP is generated by using macros, the user can specify the communication equipment configuration and the number and size of buffer areas to be used in both main and direct-access storage. The user can also specify functions such as message code translation, routing, time stamping, sequencing of messages, and error checking.

.450 Language Processors

UNIVAC is offering several language processors for use with 9400 systems, including an improved version of the 9200/9300 Basic Assembler, and disc-oriented COBOL compilers, tape- and disc-oriented FORTRAN compilers, and an IBM System/360 Model 20-compatible Report Program Generator.

.451 Assembler

The UNIVAC 9400 Assembly language features extensions to the original 9200/9300 Assemblers which allow the fabrication of desired memory address fields based on information generated at assembly time.

Assembler directives are provided to generate data, data words, values, addresses, and storage areas. Facilities are also provided to modify assembly control based on specific values at assembly time. A macro facility helps to reduce coding errors by calling pre-coded and pretested subroutines.

Output from the assembler run consists of a listing of the symbolic coding, object coding, diagnostic messages, and error indicators. A relocatable object module can be linked to other modules prior to loading for execution. The output object module can be produced in punched cards, written to tape, or recorded on the disc file.

The symbolic format for writing the Assembler instructions consists of three basic symbolic fields: label, operation, and operand. Combining names, grouping marks, arithmetic operators, and constants into operand expressions permits the solution of more sophisticated coding problems. Operand expressions can include location counter references and literals. Binary, hexadecimal, decimal, and character terms can be used to specify absolute values in the source code.

.452 COBOL compilers

The UNIVAC 9400 System will initially include a modified version of the 32K 9300 COBOL compiler. The second software release will contain a larger 9400 COBOL compiler. One is intended for tape configurations; the other, an enhanced version, is intended for direct-access storage configurations. Both compilers will conform to the specifications defined by CODASYL (COBOL Committee of the Conference on Data System Languages) publications. In addition, the features provided are in accordance with the proposed USASI Standard COBOL.

The tape compiler will include those features of COBOL required by USASI Low Level elements of the following Functional Processing Modules: Nucleus, Sequential Access, Segmentation, and Table Handling. In some cases, the features provided are above the required Low Level.

The 65K-byte direct-access storage compiler will include all of the features of the tape version, plus additional features required at the Medium Level of the proposed USASI Nucleus and Table Handling Functional Processing Modules; and the optional Low Level Random Access and Sort Functional Processing Modules.

Both COBOL compilers, in conjunction with the 9400 Supervisor, will provide:

- Sequence checking of source images.
- The ability to combine compilation output with output from other language processors.
- Compilation listings with diagnostic information.
- Maintenance of source-program libraries.

.453 FORTRAN Compilers

UNIVAC plans to offer two FORTRAN compilers for use with the 9400 system — a tape version and a direct-access version. The tape version will conform to USASI Basic FORTRAN, while the disc-oriented version will include all language features defined in

(Contd.)

.453 FORTRAN Compilers (Contd.)

USASI FORTRAN. Both versions will offer a number of useful extensions to the USASI standard languages.

Every statement acceptable to the tape-oriented compiler will also be acceptable to the direct-access compiler. Moreover, the output from each version will have the same form and can be used as input to the Linkage Editor.

The UNIVAC 9400 FORTRAN compilers are designed to compile quickly and efficiently. Programs written in IBM's 262K-byte design level H FORTRAN, for example, can be compiled in 32K on a UNIVAC 9400. Execution of the programs, however, will be comparatively slow as a result of the use of floating-point subroutines in lieu of floating-point hardware facilities.

.455 Report Program Generator

The UNIVAC 9400 Report Program Generator can accept 9200/9300 RPG source programs for program generation and execution on the 9400 Processor. In addition, IBM System/360 Model 20 RPG statements can be recompiled on a 9400 with little reprogramming.

The 9400 RPG system can produce an object program on punched cards, on disc, or on tape, or the program can be executed immediately after generation. The object program of the RPG is relocatable and can be linked as a subprogram to other assembled or generated programs.

.456 Service and Utility Programs

UNIVAC 9400 software support includes service and utility routines to perform common functions, including: sort/merge, magnetic tape and/or disc file maintenance, and the linking of output modules of language processors into a single executable program.

.457 Sort/Merge

The Sort/Merge program sequences files containing any volume of records on either ascending or descending keys. Input records to a sort can be direct from a problem program or from an input or output file, in any format permitted by the Supervisor. Record size depends upon the hardware facilities available, rather than upon the Sort/Merge program logic. Records may be of fixed or variable length.

In larger configurations, the UNIVAC 9400 Sort/Merge automatically utilizes all available memory space. This expansion of sort work areas permits significantly faster operation of the Sort program when the facilities are not shared with other programs.

The Sort/Merge program can transfer control to user-supplied coding when equality of specified key fields is detected. Thus, the user can, if he chooses, consolidate the contents of like records to reduce the overall quantity of data to be processed.

The Sort/Merge is a fixed program which reacts to parameters at run time. However, the parameter elements may be generated by the Assembler and filed in the library for repeated use. A restart procedure is available to reproduce, if necessary, any ordered subfile. Merging can be scheduled separately from the initial stages of sorting.

.458 Library Services

The UNIVAC 9400 operating environment requires the definition of a system library, which is a group of files described to the system at the time of systems generation. Input to the language processors, such as the Assembler, FORTRAN, COBOL, etc., may exist as part of the library. Output from the processors, in turn, can be entered into the library. Specification of the libraries to be used is accomplished in the job control stream.

UNIVAC 9400 software will include service routines to establish, compress, display, and alter the contents of the libraries, as well as routines necessary for interfacing between the processors and the library.

Provision exists for dumping selected portions of the specified library onto tape or cards and to re-enter the dumped elements directly into the file at a later time.

.459 Linkage Editor

The Linkage Editor connects object output modules into a single load module that can be loaded and executed by the Supervisor control program. In addition, the Linkage Editor searches the appropriate library and incorporates modules other than those in its primary input, either automatically or upon request. Program modifications are accomplished by deleting, rearranging, and replacing control sections as directed by Linkage Editor control statements. The Linkage Editor provides an overlay scheme for loading by the Supervisor, and reserves storage automatically for the common control sections generated by the Assembler. Diagnostic messages are logged via the Linkage Editor.

.460 Utility Programs

In this category are data transcription and file processing routines for creating, changing, and deleting files to suit the user's requirements. The control information required by

.460 Utility Programs (Contd.)

the Utility Program is furnished by parameters via the job control stream, and, in some cases, by the problem program.

The UNIVAC 9400 software includes two program testing aids: a dynamic memory snapshot dump, and a terminal (postmortem) dump. The snapshot dump can be user-specified to provide a listing of register contents, control information, or the contents of any range of addresses in the user program. It permits the program to continue after the specified dump has occurred. The postmortem dump provides complete error or abort condition listings that include all aspects of the user program. In this case, the program must be reloaded before a restart is attempted.

.5 COMPATIBILITY

.51 Intrafamily Compatibility

When the 9000 Series family was originally announced, UNIVAC promised to maintain upward compatibility with the larger, yet-unannounced models, so that source-language programs written for the smaller systems would be usable on the larger systems without reprogramming. The 9400 Processor fulfills this promise and should permit users of the two smaller systems to upgrade smoothly to the considerably enhanced power and flexibility of the 9400. Programs written in COBOL, FORTRAN, and RPG languages for the 9200/9300 can be recompiled and executed directly on the 9400 (assuming equivalent configurations), with little or no changes to the original source-language programs. Since the UNIVAC 9400 includes a number of advanced hardware features not available with 9200 and 9300 systems, downward compatibility will not always be possible.

Source programs written in 9200/9300 assembly languages, however, can require slight modifications prior to reassembling them for execution on the 9400 system. The two 9200/9300 assemblers (Card and Tape) are basically compatible languages, but they differ in their method of handling macro instructions and file definitions.

.52 IBM System/360 Compatibility

UNIVAC has, to a great extent, maintained both hardware and software compatibility with the IBM System/360 Models 20 and 30. All source programs written in the Model 20's RPG language and in the COBOL, FORTRAN, and RPG languages for the Model 30 can be recompiled and executed directly on UNIVAC 9400 systems that have similar configurations with little or no change to source-language statements. System/360 assembly-language programs, however, can require modifications prior to reassembly on UNIVAC 9400 systems, since the System/360 Model 30 Processor can use an instruction set that is larger than the 9400 set, and since all three systems (IBM System 360/20, 360/30, and UNIVAC 9400) handle certain macro instructions in different ways.

Data structure, data codes, and input-output media are compatible. Direct program compatibility at the machine level is precluded by differences in privileged instructions (i.e., those instructions reserved for operating system use).

UNIVAC 9200

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3030-00		9200 Processor (includes a 96-print-position, 250-line/min, 63-character type bar printer)	345	12,200	65
	3030-94		9200 II Processor (includes a 96-print-position, position, 250-line/min, 63-character type bar printer, and Multiplexor channel for up to 8 additional control units)	400	14,270	70
		F0882-00	Multiply, Divide, Edit	80	3,220	5
		F0866-00	120 Print Positions	125	4,830	15
		F0868-01	132 Print Positions	190	7,360	20
		F0868-00	Print Position Expansion (for field expansion from 120 to 132 print positions)	65	2,530	5
		F0865-00	Variable Speed Printing (includes 48-character, interchange-able type bar; permits 500-line/min, numeric printing and 250-line/min alphanumeric printer lines/inch	80	2,760	15
		F0969-00	8 Print Spacing	5	220	-
			Main Storage			
			9200:			
	7007-00		Memory (8K bytes)	395	15,870	30
	7007-10		Memory (12K bytes)	655	26,680	45
	7007-12		Memory (16K bytes)	785	31,740	60
		F0821-00	Memory Expansion-4K (for field expansion of 8K memory to 12K bytes)	260	10,810	15
		F0890-01	Memory Expansion-4K (for field expansion of 12K memory to 16K bytes)	130	5,060	15
			9200II:			
	7007-87		Memory (24K bytes)	1,185	47,630	90
	7007-85		Memory (32K bytes)	1,565	62,860	120
		F0890-95	Memory Expansion-8K (for field expansion of 16K memory to 24K bytes)	400	15,890	30
		F0890-93	Memory Expansion-8K (for field expansion of 24K memory to 32K bytes)	380	15,230	30
		F0890-94	Memory Expansion-16K (for field expansion of 16K memory to 32K bytes)	780	31,120	60
ATTACHMENTS, ADAPTERS, AND CHANNELS		F0869-00	Multiplexer I/O Channel (accommodates up to 8 control units)	55	2,070	5
		F0822-00	1001 Control	45	1,610	5
		F1104-99	Selector Channel (9200 II only)	100	4,320	10
MASS STORAGE			Disc Storage (9200 II only)			
	5024-00		Disc File Control	540	20,010	80
	8411-00		8411 Disc Drive	590	21,750	90
		F1211-00	Disc Pack	15	490	--
		F1043-00	Dual Channel	·100	3,700	15
		F1098-00	Record Overflow	10	435	--
		F1099-00	File Scan	36	1,525	--

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Magnetic Tape (9200 II only)			
	0858-99		UNISERVO VIC Subsystem (includes 9-track Master Handler and first slave unit; maximum of 8 handlers per sub-system)	895	30,655	195
	0858-10		UNISERVO VIC Master (9-track; 800 bpi; 34,000 bytes/sec; maximum of 3 Slaves per master)	515	17,350	115
	0858-14		UNISERVO VIC Slave (9-track)	310	10,470	70
	0858-98		UNISERVO VIC Subsystem (includes 7-track Master Handler and first Slave unit; maximum of 3 Slaves per master)	895	30,655	195
	0858-00		UNISERVO VIC Master (7-track; 200/556/800 bpi, 8,450/23,741/34,160 char/sec; maximum of 3 slaves per master)	515	17,350	115
	0858-01		UNISERVO VIC Slave (7-track)	310	10,470	70
			Features for UNISERVO VIC Subsystems:			
		F0828-00	7 Track Feature	55	2,030	5
		F0827-00	Data Conversion	55	2,030	5
		F1021-00	7 to 9 Track Conversion	--	--	--
			Punched Card			
	0711-00		Card Reader (400 cards/min)	140	4,735	30
		F0872-00	Short Card-51 Column	45	1,355	10
		F0872-01	Short Card-66 Column	45	1,355	10
	0711-02		Card Reader (9200 II only; 600 cards/min)	205	6,315	60
	0603-04		Card Punch (75 to 200 cards/min)	205	6,315	60
		F0870-00	Read/Punch Feature (pre-punch read station)	80	2,705	15
		F0871-00	Selective Stacker	11	410	-
		F1054-01	90 Column Read	20	410	-
	0604-00		Card Punch (9200 II only; 200 cards/min)	320	9,920	90
		F0875-00	Read/Punch Feature	155	4,735	45
		F0945-00	250 CPM Rate-(increases feed rate to 250 cards/min)	130	5,740	--
	0604-99		Card Punch-9200 II only; (250 cards/min)	450	15,660	90
		F0875-00	Read/Punch Feature	155	4,735	45
			Printer (8200 II only)			
	0768-00		Printer and Control (1100 lines/min with 49 char set; 900 lines/min with 63 char set)	1,250	40,675	315
		F1071-00	1,600/1,200 LPM Rate (converts 0768-00 to 0768-99)	300	9,790	75
	0768-99		Printer and Control (1,600 lines/min. with 48 char. set; 1,200 lines/min with 63 char. set)	1,550	50,465	390
COMMUNI-CATIONS	F1000-00		Line Terminal Controller (controls one input and/or one output Line Terminal)	115	4,350	15
		F1008-99	Redundance Check (provides block parity checking and generation)	20	740	3
			Communications Interface (provides interface between Line Terminal and data set):			
		F1002-03	2400-bit/sec line	15	565	2
		F1002-04	2000-bit/sec line	15	565	2
		F1002-05	Broad-band line	15	565	2
			Line Terminal Sync:			
		F1005-02	Output; 5-, 6-, 7-, or 8-level characters; up to 230,400 bits/sec	25	870	5
		F1005-03	Input; 5-, 6-, 7-, or 8-level characters; up to 230,400 bits/sec	31	1,130	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $
COMMUNI-CATIONS (Condt.)		F1005-04	Output; 10-level characters; for communication with remote 9000 series computers	31	1,130	5
		F1005-05	Input; 10-level characters; for communication with remote 9000 series computer	35	1,305	5

NOTES:

(1) UNIVAC will extend rental agreements to a five-year term for systems in current production at a monthly rental of 85 percent of the figure shown in this column.

UNIVAC 9300

UNIVAC does not include monthly maintenance charges in their published prices; these charges have been included in the Monthly Rental column in this Digest to permit convenient comparison with other systems.

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3030-02		9300 Processor (includes 120-print-position, 600-line/min, 63-character print bar printer)	755	26,500	150
	3030-96		9300 II Processor (includes 120-print-position, 600-line/min, 63-character print bar printer; Multiplexor channel for up to 8 additional control units; Selector channel (350 kbs))	910	32,890	165
		F0864-00	Print Position Expansion (from 120 to 132 print positions)	80	2,990	10
		F0867-00	High Speed Numeric Print (includes one interchangeable 16-character print bar; permits 1200-line/min numeric printing)	55	1,610	15
		F0969-00	8 Line/Inch Print Spacing	5	220	-
			Main Storage			
	7007-08		Memory - (8K bytes)	575	23,230	45
	7007-10		Memory - (12K bytes)	890	36,340	60
	7007-12		Memory - (16K bytes)	1,050	42,550	75
	7007-14		Memory - (32K bytes)	1,885	77,280	120
		F0821-99	Memory Expansion - 4K (field expansion of memory from 8 to 12K bytes)	315	13,110	15
		F0890-00	Memory Expansion - 4K (field expansion of memory from 12 to 16K bytes)	160	6,210	15
		F0890-01	Memory Expansion - 16K (field expansion of memory from 16 to 32K bytes)	835	34,730	45
	*7007-99		Memory (8K bytes)	575	23,230	45
	*7007-98		Memory (12K bytes)	890	36,340	60
	*7007-97		Memory (16K bytes)	1,050	42,550	75
		*F0890-99	Memory Expansion - 4K (field expansion from 12 to 16K bytes)	160	6,210	15
		*F0890-02	Memory Expansion - 16K (field expansion from 16 to 32K bytes)	835	34,730	45
ATTACH-MENTS, ADAPTERS AND CHANNELS		F0869-99	Multiplexer I/0 Channel	80	3,200	5
		F0822-99	1001 Control	55	2,070	5
MASS STORAGE			Disc Storage (9300 II)			
	5024-00		Disc File Control	540	20,010	80
	8411-00		8411 Disc Drive	590	21,750	90
		F1211-00	Disc Pack	15	490	--
		F1043-00	Dual Channel	100	3,700	15
		F1098-00	Record Overflow	10	435	--
		F1099-00	File Scan	36	1,525	--

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT			Magnetic Tape			
	0858-99		Uniservo VIC Subsystem (includes 9-track Master Handler and first Slave unit; maximum of 8 handlers per subsystem)	895	30,655	195
		F0828-00	7 Track Feature	55	2,030	5
		F0827-00	Data Conversion	55	2,030	5
	0858-14		Uniservo VIC Slave (9-track; 800 bpi; 34,000 bytes/sec; Maximum of 3 Slaves per Master)	310	10,470	70
	0858-10		Uniservo VIC Master (includes 9-track tape handler and control electronics)	515	17,350	115
	0858-98		Uniservo VIC Subsystem (includes 7-track Master Handler and first slave unit; maximum of 8 handlers per subsystem)	895	30,655	195
	0858-01		Uniservo VIC Slave (7-track; 200/556/800 bpi; 8540/23,741/, 34,160 char/sec; maximum of 3 Slaves per Master)	310	10,470	70
	0858-00		Uniservo VIC Master (includes 7-track tape handler and control electronics)	515	17,350	115
			Punched Card			
	0711-02		Card Reader (600 cards/min)	205	6,315	60
		F0872-00	Short Card-51 Column	45	1,355	10
		F0872-01	Short Card-66 Column	45	1,355	10
	0603-04		Card Punch (75 to 200 cards/min)	205	6,315	60
		F0870-00	Read/Punch Feature (Pre-punch read station)	80	2,705	15
		F0871-00	Selective Stacker	10	410	-
	0604-00		Card Punch (200 cards/min)	320	9,920	90
		F0875-00	Read/Punch Feature (Pre-punch read station)	155	4,735	45
		F1054-01	90 Column Read	20	410	-
			Printer (9300 II)			
	0768-00		Printer and Control (1,100 lines/min with 48 char. set; 900 lines/min with 63 char. set)	1,250	40,675	315
		F1071-00	1,600/1,200 LPM Rate (converts 0768-00 to 0768-99)	300	9,790	75
	0768-99		Printer and Control (1,600 lines/min with 48 char. set; 1,200 lines/min with 63 char. set)	1,550	50,465	390
COMMUNI-CATIONS	F1000-00		Line Terminal Controller (controls one input and/or one output Line Terminal)	115	4,350	15
		F1008-99	Redundance Check (provides block parity checking and generation)	20	740	3
			Communications Interface (provides interface between Line Terminal and data set):			
		F1002-03	2400-bit/sec line	15	565	2
		F1002-04	2000-bit/sec line	15	565	2
		F1002-05	Broad-band line	15	565	2
			Line Terminal Sync:			
		F1005-02	Output; 5-, 6-, 7-, or 8-level characters; up to 230,400 bits/sec	25	870	5
		F1005-03	Input; 5-, 6-, 7-, or 8-level characters; up to 230,400 bits/sec	31	1,130	5
		F1005-04	Output; 10-level characters; for communication with remote 9000 series computers	31	1,130	5
		F1005-05	Input; 10-level characters; for communication with remote 9000 series computer	35	1,305	5

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental $	Purchase $	Monthly Maint. $

NOTES:
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UNIVAC 9400

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CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
PROCESSOR			Processing Unit			
	3019-00		9400 Processor (includes keyboard/printer and Multiplexor channel for up to 7 additional control units)	900	33,280	135
		F1091-00	Storage Protection	120	4,350	20
			Main Storage			
	7010-94		Storage (24K bytes)	1,500	55,465	225
	7010-95		Storage (32K bytes)	2,150	79,390	325
	7010-96		Storage (49K bytes)	2,900	107,230	435
	7010-97		Storage (65K bytes)	3,350	123,760	505
	7010-98		Storage (98K bytes)	4,250	157,035	640
	7010-99		Storage (131K bytes)	4,950	182,920	745
		F1110-01	Storage Expansion-8K (field expansion from 24 to 32K bytes)	650	23,925	100
		F1110-02	Storage Expansion-16K (field expansion from 33 to 49K bytes)	750	27,840	110
		F1110-03	Storage Expansion-16K (field expansion from 49 to 65K bytes)	450	16,530	70
	7010-02		Storage Expansion-32K (field expansion from 66 to 98K bytes, includes additional cabinet)	900	33,275	135
		F1110-04	Storage Expansion-32K (field expansion from 98 to 131K bytes)	700	25,885	105
ATTACHMENTS, ADAPTERS, AND CHANNELS		F1092-00	Selector Channel 1	210	7,830	30
		F1092-01	Selector Channel 2	210	7,830	30
		F1093-00	Communications Adapter (provides 128 subchannels for data communication subsystem)	50	1,960	5
		F1001-00	Channel Adapter 9200/9300	100	3,700	15
		F0943-00	Channel Adapter 1004/1005	100	3,700	15
MASS STORAGE			Disc Storage			
	5024-00		Disc File Control	540	20,010	80
	8411-00		8411 Disc Drive	590	21,750	90
		F1211-00	Disc Pack	15	490	-
		F1043-00	Dual Channel	100	3,700	15
		F1098-00	Record Overflow	10	435	-
		F1099-00	File Scan	36	1,525	-
INPUT-OUTPUT			Magnetic Tape			
	0858-99		Uniservo VIC Subsystem (includes 9-track Master Handler and first slave unit; maximum of 8 handlers per subsystem)	895	30,655	195
	0858-10		Uniservo VIC Master (9-track; 800 bpi; 34,000 bytes/sec; maximum of 3 Slaves per Master)	515	17,350	115

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)	0858-14		Uniservo VIC Slave (9-track)	310	10,470	70
	0858-98		UniservoVIC Subsystem (includes 7-track Master Handler and first slave unit; maximum of 8 handlers per subsystem	895	30,655	195
	0858-00		Uniservo VIC Master (7-track; 200/556/800 bpi; 8,540/23,741/34,160 char/sec; maximum of 3 Slaves per Master)	515	17,350	115
	0858-01		Uniservo VIC Slave (7-track)	310	10,470	70
			Features for Uniservo VIC Subsystem:			
		F0828-00	7 Track Feature	55	2,030	5
		F0827-00	Data Conversion	55	2,030	5
		F1021-00	7 to 9 Track Conversion	-	-	-
	5017-99		Uniservo 12 Control (controls up to 16 Uniservo 12 handlers)	600	22,185	90
	5017-00		Uniservo 12/16 Control (controls up to 16 Uniservo 12 and/or Uniservo 16 handlers)	650	23,925	100
			Features for Uniservo 12 and 12/16 Controls:			
		F1131-99	Uniservo 16 Capability (for Uniservo 12 control)	50	1,740	10
		F1029-99	Simultaneous Operation	385	14,140	60
		F1029-00	Simultaneous Operation	435	15,880	70
		F0823-99	7 Track NRZI	125	4,785	15
		F0826-00	9 Track NRZI	125	4,785	15
	0861-00		Uniservo 12 Master (9-track; 1,600 bpi; 68,320 bytes/sec; maximum of three Slaves per Master)	560	20,015	100
	0861-01		Uniservo 12 Slave (9-track)	340	11,745	70
	0861-04		Uniservo 12 Master (7-track; 200/556/800 bpi; 8,540/23,741/34,160 char/sec-maximum of three Slaves per Master)	515	18,055	100
	0861-05		Uniservo 12 Slave (7-track)	310	10,440	70
			Features for Uniservo 12 Units:			
		F0934-99	Simultaneous Feature	90	3,265	15
		F0934-01	Simultaneous Feature	100	3,700	15
		F0934-98	Simultaneous Feature	90	3,265	15
		F0935-00	Dual Density	60	2,175	10
		F1041-00	7 to 9 Track Conversion	45	1,960	-
		F1041-01	7 to 9 Track Conversion	45	1,960	-
		F1042-00	7 to 9 Track Conversion	30	1,305	-
	0862-00		Uniservo 16 Unit (9-track; 1600 bpi; 192,000 bytes (sec).	830	31,755	110
	0862-02		Uniservo 16 Unit (7-track; 200/556/800 bpi; 24,000/66,720/96,000 char/sec)	830	31,775	110
			Features for Uniservo 16 Units:			
		F0936-99	Simultaneous Feature	20	870	-
		F0937-00	Dual Density	50	2,175	-
		F1040-00	7 to 9 Track Conversion	-	-	-
		F1040-01	7 to 9 Track Conversion	-	-	-
			Punched Card			
	0711-05		Card Reader and Control (600 cards/min)	265	8,265	75
		F0872-00	Short Card-51 Column	45	1,355	10
		F0872-01	Short Card-66 Column	45	1,355	10
	0604-99		Card Punch and Control (250 cards/min)	450	15,660	90
		F0875-00	Read/Punch Feature (pre-punch read station)	155	4,735	45
			Printer			
	0768-00		Printer and Control (1,100 lines/min with 48 char. set; 900 lines/min with 63 char. set)	1,250	40,675	315
		F1071-00	Speed up Capability (converts 0768-00 to 0768-99)	300	9,790	75

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $ (1)	Purchase $	Monthly Maint. $
INPUT-OUTPUT (Contd.)	0768-99		Printer and Control (1,600 lines/min with 48 char. set; 1,200 lines/min with 63 char. set)	1,550	50,465	390
COMMUNI-CATIONS		F-1000-00	Line Terminal Control-1 (controls 1 full-duplex line, requires F1094-00	115	4,350	15
		F1008-99	LRC (block-parity checking and generation)	20	740	3
	8575-00		Line Terminal Control-4 (controls up to 4 full-duplex lines; requires F1094-00; free standing)	270	10,000	40
		F1094-00	Line Terminal Control-4A (controls up to 4 full-duplex lines; requires F1094-00; housed in processor)	270	10,000	40
	8575-01		Line Terminal Control-16	600	22,185	90
		F1008-00	LRC (block parity checking and generation; for line Terminal Control -4, -4A and -16)	45	1,650	7
		F1012-00	Dual Channel (for Line Terminal Control -16)	100	3,700	15
		F1007-99	Auto Dialing Adapter (for Line Terminal Controls -4, -4A, and -16)	53	1,960	8
			Line Terminals (provides control of particular character format and communications facility):			
		F1003-99	Telegraph Non-Check	45	1,655	7
		F1003-98	LT Telegraph Checking	50	1,830	8
		F1003-97	LT Telex	67	2,440	11
		F1003-96	LT TWX	72	2,055	11
		F1004-99	LT Medium Speed Non-Check	54	2,000	8
		F1004-98	LT Medium Speed Checking	64	2,350	10
		F1005-99	LT Synchronous Non-Check	54	2,000	8
		F1005-98	LT Synchronous Checking	62	2,260	10
		F1005-97	LT Remote Computer	66	2,435	10
		F1006-99	LT Parallel	41	1,525	6
			Communications Interface (provides interface with data set or line):			
		F1002-01	C1 Telegraph (50-75 ma)	10	350	2
		F1002-02	C1 Telegraph (20-40 ma)	10	350	2
		F1002-03	C1 Private Line	15	565	2
		F1002-04	C1 Data Phone	15	565	2
		F1002-05	C1 Wideband	25	870	5
		F1002-08	C1 Mil Std 188B	15	565	2
			Timing Assemblies (provides clocking source):			
		F1010-99	ATA (asynchronous; 15 different speeds up to 2000 bits/sec)	12	435	2
		F1011-04	STA 600 (Synchronous; 600 bits/sec)	41	1,525	6
		F1011-00	STA 1200 (Synchronous; 1,200 bits/sec)	41	1,525	6
		F1011-05	STA 1800 (Synchronous; 1,800 bits/sec)	41	1,525	6

NOTES

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SUMMARY REPORT: A/S REGNECENTRALEN RC 4000

.1 BACKGROUND

The RC 4000 is a general-purpose digital computer, designed and manufactured by A/S Regnecentralen of Copenhagen, Denmark. The basic model is a medium-size computer oriented toward real-time computation in industrial control applications. The RC 4000 includes floating-point arithmetic for scientific computations and high-speed input-output devices for commercial data processing.

In Denmark interest in the computer had its first concrete manisfestation in 1955 when "Regnecentralen" (The Computing Center) was established as an independent, non-profit institution under the Academy of the Technical Sciences.

In 1956-58 Regnecentralen built DASK, the first Danish computer, which was based on electronic tube technology. In 1959-61 Regnecentralen developed GIER, a transistorized computer. The RC 4000, Regnecentralen's third generation computer, was developed in the years 1965 through 1967.

Regnecentralen today carries on large-scale public education and training programs in computer science, runs an international chain of service centers, and develops hardware and software for its computer systems. In the software area Regnecentralen has developed programming systems for computers of Swedish, German, and American manufacturers. Regnecentralen's standard programming systems cover such areas as payrolls, banking, housing administration, sales analysis, auditing, network planning, information retrieval, road building, surveying, and mathematical statistics.

.2 HARDWARE

.21 Data Structure

The RC 4000 is a single address, digital computer with typical instruction execution times of 3 to 4 microseconds (add 3 microseconds, multiply 15.5 microseconds, add floating 11 microseconds) and instruction length of 24 bits (plus 3 protection bits and 1 parity bit).

Integer arithmetic with operands of 12, 24, and 48 bits are standard. Floating point arithmetic with 48-bit operands (36-bit mantissa and 12-bit exponent), with short and long precision are standard.

The repertoire of 58 instructions includes manipulation of 12-bit bytes, word comparison, setting and testing of single bits, and inter-register operations.

.22 System Configuration

The basic RC 4000 configuration contains the RC 4005 Central Processor with a storage capacity of 4,096 words, the RC 315 Input-Output Typewriter, the RC 150 Paper Tape Punch, and the RC 2000 Paper Tape Reader.

The minimum system configuration needed to operate the RC 4000 Time-Sharing Package includes the RC 4005 Central Processor with a storage capacity of 16,384 words, the RC 315 Input-Output Typewriter, the RC 150 Paper Tape Punch, the RC 2000 Paper Tape Reader, the RC 4320 Magnetic Drum with a maximum storage capacity of 524,288 words and/or the RC 433 Magnetic Disc with a minimum storage capacity of 2,048,000 words, and the RC 4060 Input-Output Controller. In addition to these devices, the RC 4000 Time-Sharing Monitor can presently control RC 405 Punched Card Readers, RC 610 Line Printers, and RC 707 Magnetic Tape Units.

.23 Central Processor

The RC 4000 is a single-address, binary computer with a basic core storage of 16,384 words, expandable in modules of 16,384 words each, to a maximum storage capacity of 131,072 words. A small version of the machine with a main memory capacity of 4096 words is also available. The cycle time is 1.5 microseconds. The 24-bit data word on the RC 4000 is augmented by a standard 3-bit protection code plus one parity bit.

.23 Central Processor (Contd.)

The 58 instructions available for the RC 4000 include facilities for address handling, register transfers, integer byte and integer word arithmetic, logical operations, monitor control, arithmetic conversion, and floating-point arithmetic.

The RC 4000 has four accumulators, three of which also function as index registers. The registers are addressable as the first four words of internal storage, which makes inter-register operations possible.

The RC 4000 instruction format is divided into an operation field of 12 bits and an address field of 12 bits. The operation field specifies: one of 58 basic instructions; a result register W; an addressing mode, M; and an index register, X. The address field specifies a displacement, D, of from -2048 to 2047 bytes within the program.

For direct addressing of the entire storage, and effective address of 24 bits, the effective address A is generated as follows (where M indicates addressing mode, X index register, D displacement, and IC instruction counter):

- M = 00 - A = X + D direct addressing;
- M = 01 - A = contents of word (X + D) indirect addressing;
- M = 10 - A = X + IC + D relative addressing; and
- M = 11 - A = contents of word (X + IC + D) relative-indirect addressing.

The basic arithmetic operand is a 24-bit word. The RC 4000 also includes standard double-length operands of 48 bits for both integer and floating-point arithmetic. Direct addressing of 12-bit bytes in both integer and floating-point operations provide a means of manipulating character strings encountered in maintenance activities and program translation.

The RC 4000 includes optional backing storage consisting of the RC 4320 Magnetic Drum with a basic storage capacity of 65,536 words expandable in 65,536 word modules up to 524,288 words, and/or RC 433 Magnetic Disc Stores with exchangeable packs from 2,048,000 words to 12,288,000 words.

Slow, character-oriented devices like input-output typewriters, paper tape punches, and paper tape readers are connected to a single low-speed data channel, which communicates directly with the internal working registers. Each device has a separate buffer register of 24 bits, which transmits or receives one character at a time to or from the external data medium.

The data channel consists of a control unit and an input-output bus, with 24 bits for transfer of data to or from device buffers and 6 bits for channel control information.

Transfers of data between working registers and device buffers take place one at a time under program control. Transfers between buffer registers and external data media, however, are controlled independently by the devices, so that several such transfers can occur simultaneously.

Input-output devices such as magnetic drum storage, magnetic disc storage, and magnetic tape units, which transmit large volumes of data at high speeds, are connected to a single high-speed data channel. This channel provides input-output directly to or from the internal storage on a cycle-stealing basis. Program execution and input-output operations occur simultaneously.

Block transfers can take place on several devices at once. A multiplexor switches rapidly among the devices, connecting them whenever they are ready to transfer a complete data word to or from the internal storage. All input-output operations are handled by a single instruction.

.24 Card Equipment

The high-speed reader for the RC 4000 has peak speeds of 1200 80-column and 1620 51-column cards a minute.

The card reader utilizes asynchronous, pneumatic card feed, photo electric sensing, and column read. To ensure accuracy, the read station employs a dual read comparison check. In addition, a light/dark pre-read check is performed on each data channel before the card is read.

Both the input and output hopper have card capacities of 4000 cards while the select stacker has a capacity of 240 cards.

(Contd.)

.25 Line Printer

The line printer for the RC 4000 is suitable for both on-line and off-line use. The standard model has a speed of 1000 lines per minute with 132 print positions and a print density of 10 characters per inch horizontally and 6 or 8 lines per inch vertically. Other models are available.

The characters on the print barrel are arranged in order of greatest frequency; the buffer is released on the average in less than half a revolution, so that the paper can be advanced and the printing of the next line begun before the next revolution.

The line printer has a character set of 64 or 96 characters consisting of the decimal digits, the alphabet and certain special symbols. Other character sets are available.

Paper is skipped at a speed of 37.5 inches a second.

.26 Paper Tape Equipment

The RC 2000 Paper Tape Reader reads at 2000 characters per second. This high-speed device can be used on-line for input of data and programs or employed as a general purpose input device in conjunction with magnetic tape units and/or other peripherals. Besides being a fully transistorized, photo-electric reader, the RC 2000 incorporates the Servo Input Buffer System, whereby the number of unprocessed characters in a 256-word core store regulates the reading speed. By employing this core store as a buffer between the RC 2000 and the central processor or other processing device, it is possible to allow the type to be driven by a simple servo motor, thus eliminating abrupt starting and stopping and the resulting risk of tape breakage.

Normally RC 2000 accepts perforated paper tapes of the types shown in Table I, punched in any suitable opaque medium.

TABLE I: PAPER TAPE

Type	Number of Tracks	Nominal Width
One Inch	8 maximum	25.4 mm
Seven-Eigths Inch	7 maximum	22.2 mm
Olivetti (rectangular holes)	6 maximum	20.5 mm
Eleven-Sixteenths Inch	5 maximum	17.5 mm

The Paper Tape Punch, which is mounted on the console, is used as an output device for results of limited volume, error reports, program tapes, etc.

The punch perforates data onto 5-, 6-, 7-, and 8- track paper tapes at a speed of 150 characters per second. The tape is available in 300 meter rolls, the equivalent of 120,000 characters.

.27 Magnetic Tape Equipment

The magnetic tape unit is connected to the central processors via a buffer store to which four tape units may be connected.

The magnetic tape unit incorporates microgrammed searching for sensing of load-point and end-of-file marks. The combined read-write head permits read-after-write checking for parity.

The magnetic tape used has seven tracks, is one-half inch wide, and is internationally compatible. Table II summarizes the characteristics of the magnetic tape unit.

TABLE II: MAGNETIC TAPE STATION FOR THE RC 4000

Transfer Times	9,000 char/sec at 200 bits per inch
	25,000 char/sec at 556 bits per inch
	36,000 char/sec at 800 bits per inch
Tape Speed	45 inches per second
Interblock Gap	3/4 inch
Rewind Speed	180 inches per second
Start Time	9 milliseconds from start of tape movement to start of data transfer.

.28 Data Logging System

The RC data logging system enables off-line and on-line collection of analog and digital data. Analog input voltages are converted to digital numbers and recorded along with digital input data and time records from a digital clock. The analog inputs are divided into fast-scan group channels and slow-scan group channels.

The system accepts a maximum of 1024 analog input channels. A scan program may consist of several or all channels from one, two, or all three of the following groups: fast scan, slow-scan, or digital scan.

The system has the following built-in, automatic checking facilities: high temperature, power drop out, parity, over-range of input signal, and errors in analog to digital conversion.

.29 Other Peripheral Devices

The RC 4195 Graphic Display Terminal enables real-time graphic communication with the RC 4000 computer. Output is generated on a cathode ray tube, whereas a light pen is used for input. The display terminal has its own refresh memory, so that the RC 4000 is only engaged during generation of display file and processing of light pen interrupts. As the display terminal is a point display, all lines and curves must be composed of successive dots.

The display terminal, a self-contained unit with its own power supply, is connected to the low-speed data channel of the RC 4000. The graphic display terminal is operated by the standard input-output instruction for reading and writing in the refresh memory and setting a picture mask. The read-write address for the refresh memory can be preset by a control command and is automatically incremented following each read-write operation.

The display terminal is operated in a conventional XYZ coordinate system with Z representing intensity.

Refresh memory is 4,096 16-bit words, expandable to 8,192 16-bit words with a cycle time of less than three microseconds.

The RC 3000 Converter System operates a variety of peripheral devices independently of the RC 4000 Computer System, converting all input and output data to and from magnetic tape.

The converter itself, which is available in two models, the one for 7-track and the other for 9-track standard magnetic tape, consists of a paper tape reader (RC 2000), a control unit with a buffer storage for 1024 8-bit characters, and a magnetic tape unit (RC 707 or RC 709). The reader can be equipped with an automatic tape winder. The following peripheral devices can be connected to the control unit: paper tape reader, punched card reader, optical character reader, line printer, paper tape punch, and an incremental plotter.

The RC 1600 Graphic Converter, developed by Regnecentralen in collaboration with the Laboratory for Pulse and Digital Techniques at the Technical University of Denmark, operates drafting and graphic display devices, automatically generating symbols and vectors on the basis of digital input from 8-track paper tape or 8-bit characters from the low-speed data channel of the RC 4000.

.3 SOFTWARE

The RC 4000 software is built around Regnecentralen's operating system called Monitor I. This particular monitor was developed for the extended RC 4000 time-sharing system. The monitor controls the parallel execution of programs in core and the initiation of all input-output.

After initial system loading, the core storage contains the monitor and a basic operating system, which allows the operator to load and start programs from the backing storage.

The running programs, including the basic operating system, are executed in a time-sharing scheme, in which each program in turn is allotted a maximum of 20 milliseconds of computing time.

The monitor controls the following functions:

- initiation, execution, and termination of parallel programs;
- interprogram communication;
- console communication;
- reservation and initiation of sequential input-output; and
- creation, updating, and removal of common data areas on the backing storage.

Programs can be written in any of the available programming languages (Slang, ALGOL, FORTRAN). The storage protection system guarantees non-interference among 7 parallel user programs, but it is possible to start up to 22 programs provided they are error free. A running program occupies a contiguous storage area with a unique protection key.

Programs and peripheral devices are identified by symbolic names. All communication between parallel processes is handled uniformly by four monitor procedures called send message, wait answer, wait message, and send answer. Each process has a queue within the monitor, in which it can receive messages simultaneously from other processes.

Using these procedures it is possible to transfer parameters from one running program to another. It is also possible for any program to open a conversation with any typewriter console and vice versa. Finally, programs can send messages to sequential input-output devices, which initiate data transfers to and from core.

Users can retain programs and data in a semi-permanent manner on the backing storage, which is organized as a collection of named data areas. A fixed part of the backing storage is set aside for a catalog describing the names and locations of data areas. Each entry in the catalog is supplied with a protection key, which protects the corresponding data area against unauthorized updating.

The time-sharing monitor has no built-in assumptions about program scheduling and resource allocation; it allows any program to initiate other programs in a hierarchical manner. The system thus provides a general framework for different scheduling strategies, such as batch processing, multiple console conversation, and real-time scheduling.

.31 ALGOL 5

The Regnecentralen ALGOL 5 was developed for the extended RC 4000 computer system with drum and/or disc as backing storage. The compiler and the object programs can only be executed under the control of the time-sharing system Monitor I.

The source language is ALGOL 60 with the exception of integer labels, value lables, value arrays, and own arrays. The language is extended with facilities for handling peripheral devices of all kinds and for manipulating text strings and bit patterns.

The ALGOL program text can be input to the compiler from typewriter, paper tape, punched cards, magnetic tape, drum, disc, or a combination of these.

The object program is stored on drum or disc as a sequence of relocatable segments of 256 words each.

The compiler requires a core storage area of 4,096 words and a working area on the backing storage of sufficient size to hold the object program. If the backing storage is a disc, a core storage area of 8,192 words is recommended in order to obtain maximum compilation speed.

.32 FORTRAN

The source language FORTRAN for the RC 4000 computer is the ISO FORTRAN of the first level as described in "Draft ISO Recommendation No. 1539," ISO/TC 97 (CS-99) 153 JE, with the exception of DATA initialization of local variables and logical unit numbers. These numbers are replaced by names, which facilitates the use of peripheral devices of all kinds.

Generalizations and extensions of the language include: mixing of types in arithmetic expressions; general expressions, as subscripts and in DO statements, which makes it possible to count backwards; long integers, text constants, and bit patterns; mask operations; DATA initialization of COMMON variables anywhere; multiple entries in procedures; and optional inclusion of test program lines.

The FORTRAN program text can be input to the compiler from typewriter, paper tape, punched cards, magnetic tape, drum, disc, or a combination of these.

The object program is stored on drum or disc as a sequence of relocatable segments of 256 words each.

The compiler requires a core storage area of 4,096 words and a working area on the backing storage of sufficient size to hold the object program. If the backing storage is a disc, a core area of 8,192 words is recommended in order to obtain maximum compilation speed.

.33 SLANG 3

Slang 3 is the assembler language that has been developed for the RC 4000. The Slang 2 assembler, developed for the small RC 4000 computer without backing storage, is not described here as it is essentially the same as Slang 3.

Storage locations can be assembled as bytes, words, and double words. A byte is either an operation part or an arithmetic expression. An expression can include parentheses and the operators add, subtract, multiply, divide, logical AND, logical OR, and logical shift. The operands can be numbers with radix 2 to 9, integers, or symbolic addresses called identifiers.

A word is either a full instruction (an operation part followed by an expression) or an expression. A double word is a real number in the ALGOL 60 sense.

Programs that exceed storage capacity during assembly can be divided into segments, a segment being a block for which binary output is produced immediately at the end of the block. The assembly of a block can be conditioned by the value of an expression. The Slang program text can be input to the assembler from typewriter, paper tape, punched cards, magnetic tape, drum, or disc.

The assembler occupies about 2,000 words of core storage.

.34 UTILITY 3

Utility 3 contains essentially three routines; an editor program, a debug program and a loader program.

The editor program produces an edited text string from an original text string and a sequence of editing commands.

The editor can be operated either in conversational mode from a typewriter or in a batch processing mode, in which editing commands are input from paper tape, punched cards, magnetic tape, drum, or disc.

The editor program requires a core storage area of 4,000 words.

The debug program lets the operator insert breakpoints in a program at run time in order to display and change the contents of registers and storage locations on a typewriter.

The debug program occupies about 700 words of core storage.

The loader program loads a binary segment from paper tape. The binary segment is loaded with a start address and a protection key determined by the operator. After loading, the operator can specify a jump to an address within the program.

.35 MATHEMATICAL PROCEDURE LIBRARY

The initial numerical-mathematical library, written in Algol 5, contains the following procedures:

- solution of simultaneous linear equations with an arbitrary, symmetric, or band matrix of coefficients,
- calculation of eigenvalues and eigenvectors for a symmetric or arbitrary matrix,
- solution of simultaneous ordinary differential equations,
- calculation of definite integrals,
- calculation of all zeros for a polynomial or a zero for a given function,
- calculation of Fourier coefficients, and calculation of a Fourier sum,
- calculation of the Bessel functions and the modified functions of the first and second kind,
- extremum calculation for a function of several variables,
- multiple linear regression analysis and least squares polynomial approximation, and
- analysis of variance.

.36 OTHER SOFTWARE

Regnecentralen maintains a host of programs for process control including a flow integration and pulse count program, logging program, alarm scanning program, trend logging program, self-check programs for hardware, and an off-line process description assembler.

Regnecentralen has under development software in such areas as data transmission systems, multi-computer systems, and graphic input-output systems using drafting and display devices.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental	Purchase d Krona	Monthly Maint.
CENTRAL PROCESSOR	4005		Central Processor internal core storage of 16,384 words floating-point arithmetic digital clock 24-level interrupt unit operator's console device controllers for: RC 315 input output typewriter, RC 150 paper tape punch, and RC 2000 paper tape reader		758,000	
		4081	Core Storage Module — 16,384 words		260,000	
		4082	Storage Expansion Frame Applicable for core storage between 65,536 words and 131,072 words		90,000	
MASS STORAGE DEVICES	4320		Magnetic Drum storage, 65,536 words capacity, including controller		182,000	
		4321	Drum Storage Expansion Modules Head bar modules of 65,536 words of storage-up to a maximum of 524,388 words of storage		32,000	
	433		Magnetic Disc Storage 2 million words capacity excluding controller, including 1 disc pack		220,000	
			Disc Pack		7,164	
	4314		Magnetic Disc Controller Controls a maximum of 6 RC 433 magnetic disc storage units		108,000	
INPUT-OUTPUT DEVICES	315		Input-Output Typewriter		19,000	
	150		Paper Tape Punch		16,315	
	2000		Paper Tape Reader		45,525	
	707		Magnetic Tape Unit 7 tracks, including RC 4311 controller		132,000	
	709		Magnetic Tape Unit 9 tracks, including RC 4310 controller		153,000	
	610		Line Printer 64 character set, including controller		283,000	
			Alphabet Extension 96 character set		32,000	
	450		Strip Printer		6,500	
		4152	Strip Printer Controller		23,800	
	405		Punched Card Reader		218,000	

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental	Purchase d Krona	Monthly Maint.
			Input-Output Device Controller			
	4060		Input-Output Controller Cabinet Controls from four to fifteen devices		119,000	
	4061		Input-Output Controller Cabinet Controls from eight to twenty-three devices		143,000	
	4191		Incremental Plotter Controller Controls Calcomp Series 500 and 600 digital plotters		27,000	
	4121		Device Controller Controls RC 3115 input-output typewriter		30,000	
	4171		Device Controller Controls RC 150 Paper Tape Punch		24,400	
	4161		Device Controller Controls RC 2000 Paper Tape Reader		12,000	
OTHER I/O DEVICES	4195		Graphic Display Terminal		36,000	
			Storage Scope		14,700	
	4193		Device Controller Controls the Kingmatic 1215 Analog Drafting Machine and the Storage Scope		6,667	

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SUMMARY REPORT: BULL-GENERAL ELECTRIC GAMMA 10

.1 BACKGROUND

The Bull General Electric Gamma 10 is a compact stored-program, card-oriented processor intended essentially for small business applications. A basic Gamma 10 consists of a central processor, a card reader-punch, and a printer.

First deliveries of the Gamma 10 were made in June 1963; by January 1968, 1,500 were installed throughout the world. The rental price for the basic system ranges from $1,600 per month to $2,200 per month, depending on the capacity of the core storage.

Since the Gamma 10 first made its appearance, new peripherals have been introduced: a paper tape reader, a document reader for CMC 7 magnetic characters and/or optical recognition marks, and a low cost, newly designed magnetic tape unit.

The Gamma 10 is designed to replace conventional punched card equipment based on the tabulator by providing the advantages of stored programs. A user who is familiar with plugboard equipment will find the Gamma 10 easy to program. Program instructions are of the two address type. Core storage usage is minimized because symbolic addresses represent the data fields on the punched card and yield three character instructions.

Peripherals operate at maximum speeds through simultaneity provided by buffers at all input and output stations.

Some notable operational features are:

- During processing, the Card Reader/Punch automatically updates card files — a feature usually associated with larger systems.
- The programmer is relieved of the burden of deriving addresses. The same addressing system is used for both program and data.
- Program segmentation simplifies the modification and testing of programs and allows the user to take advantage of standard subroutines and programs.

The versatility of the GAMMA 10 is demonstrated by the variety of applications to which it has been applied: payroll, stock control and invoicing, aerodynamic stress calculations and the analysis of networks by the Critical Path Method.

.2 HARDWARE

.21 System Configuration

A Gamma 10 system includes a central processor that contains a core memory (High Speed Store), input/output buffer stores, an arithmetic unit and a control unit. The central processor also has an auxiliary unit known as a condition plugboard. The Gamma 10 system also includes an on-line card reader punch.

The standard peripherals of the GAMMA 10 are an on-line printer, a paper tape reader and a document reader. A set of two tape units is an optional feature.

.22 Data Structure

Each main memory location in the GAMMA 10 consists of six information bits plus an odd parity bit and contains one character or one decimal digit. Data transmitted from or to a peripheral is stored in variable length core areas. Each area is numbered and marked by a flag. A table is compiled which relates the area number to its core address.

.23 Central Processor

The central processor of the Gamma 10 has core storage capacities ranging from 1,024 to 4,096 characters. The processor and the reader-punch are located in the same cabinet. The system is complemented by a printer of which there are several types available; a paper tape reader, a document reader, and two magnetic tape units can be added optionally.

.23 Central Processor (Contd.)

The central core storage is made of ferrite cores and is character oriented. The core storage cycle time is seven microseconds.

The instruction set consists of between fifty-two and fifty-eight 3-character instructions depending on which peripherals are connected. The instructions are of the two address type. The two address instructions indicate the type of operation (1 character) and the area number (1 character each) of each operand. Core storage is therefore of the indirect address type, where the address is looked up in the area number table. The user is in no way concerned with the actual storage address.

Multiplication and division in the Gamma 10 are wired subroutines. Execution times for the central processor are shown in Table I.

Data being transferred from the central processor to the output units is stored in a 201 character output buffer. This capacity proves adequate for simultaneous printing and punching, since 120 or 144 locations are used for storing alphanumeric data for transmission to the printer and 80 locations are used for storing alphanumeric data and non-standard codes for transmission to the punch.

TABLE I: EXECUTION TIMES ON THE GAMMA 10

Operation	Time, milliseconds
Addition (6 digit numbers)	0.22
Subtraction (6 digit numbers)	0.22
Multiplication (6 digit numbers)	5.6
Division (12 digit number by a 6 digit number)	8.4
Comparison (6 digit number)	0.22

Data being transferred from cards to the central processor is temporarily stored in the 112 character input buffer. Eighty locations are used for storing the quantitive data that is to be processed and 32 locations are used for storing the qualitative data which is used to control processing sequences.

.24 Working Storage

During the operation of the Gamma 10, all data transfers between the various peripherals of the system must pass through core storage. To facilitate these data exchanges, core storage is divided into two areas, "High Speed Store" and buffer stores.

The High Speed Store is a character store with a cycle time of seven microseconds and a capacity of 1,024, 2,048 or 4,096 locations. The store locations are divided into areas whose lengths are fixed by the programmer according to the requirements of the data to be stored.

Each area can contain up to 64 characters and a maximum of 225 areas are available. Areas are arranged in groups of sixty-four areas each. The real addresses of the areas are stored automatically in Area Address Registers at load time. To address an item of stored data, the programmer need only know the number of the group and the number of the area within that group.

The buffer stores act as intermediaries in data transfers between the High Speed Store and the input-output units. These buffers consist of magnetic cores, with the same cycle time (seven microseconds) as the High Speed Store. The buffer stores permit simultaneity of processing and input-output operations. There are four different buffer stores in the GAMMA 10. The input buffer has 80 locations corresponding to the 80 columns of a punched card. As data is loaded it is automatically decoded and parity is checked. The condition buffer, a 32 location buffer, has a specialized function in that it enables up to 32 items on a card to be delineated for further reference in High Speed Store. The 80 location punch buffer stores data extracted from the High Speed Store to be punched while the print buffer has 120 or 144 locations corresponding to the 120 or 144 print positions on the printer and holds data extracted from the High Speed Store to be printed.

.25 Input-Output Devices

The Gamma 10 Card Reader/Punch is included in the basic processor. A special feature allows selected columns of a card to be punched while the card is being read. Both reading and punching is checked at a verifying station. Cards can be selected into one of three different reception pockets according to card code or results of calculations.

Reading and punching take place at a speed of 300 cards per minute. The Reader/Punch contains a primary track which holds the input cards to be processed and a secondary track located before the punch station for the introduction of blank cards in case updating is needed. The feed hoppers of the primary track and the secondary track have capacities of 3000 and 800 cards, respectively. There are three reception pockets for selecting cards as required with capacities of 300, 850 and 750 cards.

Each card station has a specific function:

- Card Station 1 is an eighty column reading station, referred to as RS1, and used to detect change of control cards.
- Card Station 2 is an eighty column reading station, referred to as RS2, which reads index codes and the data to be processed. This information is sent to input buffer.
- Card Station 3 is a blank station providing a calculation time of 200 ms. Without this station the time available between the end of the reading cycle and the beginning of the punching cycle (approximately 40 milliseconds) could be insufficient for certain calculations. It would then be necessary to stop the card during calculations, thus decreasing the overall speed of processing.
- Card Station 4 is a row by row punch with 80 punching dies.
- Card Station 5 is the third eighty column reading station, referred to as RS5, which provides a check on earlier readings at RS1 and RS2 as well as on any punching carried out at card Station 4.
- Card Station 6 is a 3-way card deflector which allows selection into one of the three reception pockets.

Card movement is controlled by three special commands: Primary track card feed, secondary track blank card insertion and card punching and card selection.

The Gamma 10 Printer operates on-line at 300 lines per minute. The 120 or 144 position print drum has 59 characters engraved in its circumference at each of the print positions. The characters are spaced at 8 or 10 to the inch in a printed line and printed lines are spaced at 6 to the inch.

The print drum rotates continuously at 300 rev/min and thus each character passes in front of its print head at this frequency. When a row of characters is in the printing position the print buffer is scanned to determine in which positions those characters are to be printed. The scan consists of 120 or 144 comparisons of the characters stored in the print buffers with the characters generated by an optical character generator rotating in synchronism with the print drum. When there is a match, the print hammer for that position is selected and the corresponding position in the print buffer is cleared.

The character generator provides a check on the operations of the print buffer. A spuriously coded character cannot be cleared from the buffer. If, when the data for the next line of print is to be transferred, the buffer is not completely cleared, the computer stops.

The 59 characters are arranged in a sector of the print drum such that the 18 symbols appear first, followed by the alphabet, 5 special symbols and the numerals 0 to 9.

The standard printer has one paper feed; a second paper feed can be fitted to enable two forms of the same or different widths to be printed side by side. Lateral and vertical adjustments are controlled by the operator.

The optional Paper Tape Reader can read 5, 7, or 8 track paper tape. Five and seven track tapes can be read at a speed of 500 characters per second. Eight track tapes can be read at a speed of 300 characters per second. The minimum available processing time for each character read is 2.2 milliseconds.

The optional LDI Document Reader operates at speeds varying from 150 to 300 documents per minute and can read documents of various formats. It can read:

- One line printed in CMC 7 magnetic characters;

.25 Input-Output Devices (Contd.)

- Two lines printed in CMC 7 magnetic characters; or
- One line printed in CMC 7 magnetic characters and a grid where the position of marks are detected optically.

The document reader processes documents with a maximum size of 8.25 inches by 4.52 inches and a minimum size of 1.935 inches by 2.85 inches.

The Gamma 10 can print turn-around documents in CMC 7 magnetic characters; in this case, the printer drum is equipped with CMC 7 numerical characters in addition to the usual typographical characters.

The optional MFU 35 Magnetic Tape Unit includes two tape handlers and uses 35-millimeter magnetic tape. Reading is done laterally by means of a rotary magnetic head. The blocks are of fixed length and contain 48 alphanumeric characters or 96 numeric characters. The operating speed is 1200 or 2400 characters per second.

.26 Control Console

The control console on the Gamma 10 has a set of indicator lights that gives details of the instruction at which a program has stopped. They can display data areas, character by character and display a program segment, instruction by instruction. Three switches are available whereby programs can be operated in a step by step mode, stepping segment by segment, card by card or instruction by instruction. Instructions can be altered or inserted from the console, and indexes can also be changed.

.3 SOFTWARE

A number of programs and routines are available which can be grouped into three types:

- Standard programs;
- Subroutines; and
- Service routines.

Each of the standard programs corresponds to a processing phase. They can be adapted to the users' requirements by means of punched card parameters. The key program is the "report generator" program which sub-divides groups, duplicates and distributes fields and calculates sub-totals, grand totals, balances and punches summary cards. Other programs perform card duplication, file reproduction and reproduction of constants.

The following subroutines are available:

- CIN — Calculates the check letter of a numeric reference number;
- Coin Analysis — analyzes an amount into banknotes and coins;
- Stamp Duty — calculates the stamp duty; and
- Alphanumeric Sort.

The service routines are used for program testing. A major program here is the "acceptability" routine. This program checks the order of the cards, verifies the operation codes of the instructions, compares program size to memory size and prints a listing of the program along with any error conditions.

The Assembly Preparation routine modifies the area, marker and segment numbers used by a subroutine if they are incompatible with the addresses allocated by the main program.

The Program Test Print routine inserts flags and requests for print-outs within a program at points selected by the user.

The Areas Print routine prints the contents of High Speed Store areas.

The Program Modification routine performs any program modifications which are necessary to debug a program and prints the modified program.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental, F	Purchase, F	Maint.*, F
PROCESSOR			Processing Unit			
			Bull General Electric Gamma 10: Central Processor, Card Read/Punch and 1024 characters of main memory	5,047	196,000	2,524
			Central Processor, Card Read/Punch and 2048 characters of main memory	6,283	244,000	3,142
			Central Processor, Card Read/Punch and 4096 characters of main memory	7,725	300,000	3,683
INPUT-OUTPUT			Magnetic Tape			
	MFU 35		Magnetic Tape Unit	2,410	96,000	1,236
			Printer			
	I 50		Printer: (120 print positions)	2,472	96,000	1,236
	I 51		Printer: (120 print positions)	2,596	101,500	1,293
	I 51		Printer: (144 print positions)	2,951	117,160	1,452
	CMC 7		Printer (includes CMC 7 characters)	2,745	108,000	1,360
			Document Reader			
	LD1		Document reader	1,617	71,400	736
	LD1		Document reader	2,344	100,200	1,116

* The maintenance charges given are those for a period of three months.

SUMMARY REPORT: GENERAL ELECTRIC GE-55

.1 BACKGROUND

The GE-55 is a small scale data processing system manufactured by BULL GE. The first announcement of the GE-55 was in Belgium in early 1966; the first customer delivery was also in Belgium during the last quarter of 1966. Since then about 450 GE-55's have been delivered world wide, and about 650 are now on order in Europe alone. The first delivery in the North American continent was in Mexico. GE recently initiated marketing of the GE-55 in the United States of America with a restricted configuration; first delivery in the U.S.A. is expected shortly. Initially, only selected subsets of the full GE-55 component line will be available in the U.S.A., and marketing will be restricted to Philadelphia, Pennsylvania and Detroit, Michigan.

Monthly rental can range from about $1000 per month to about $4000 per month. Current delivery time in Europe is about three months; slightly longer delivery time can be expected in the U.S.A.

The information in this report pertains to the GE-55 as marketed outside the U.S.A. unless otherwise specified.

.2 HARDWARE

.21 System Configuration

A GE-55 system includes a central processor that contains core memory, control logic, and read-only memory. The peripherals communicate with the central processor through channels. The GE-55 is equipped with two types of channels; standard speed channels for low speed devices such as keyboards and high-speed channels for fast devices such as the PRT 051 printer. Table I shows the I/O channels and standard peripheral assignments; in general, connection of peripheral devices is restricted to these assignments.

TABLE I: GE-55 INPUT-OUTPUT CHANNELS AND PERIPHERAL ASSIGNMENTS

Channel		Availability	Peripheral Connection
Type	Number		
Standard Speed	1	Standard	L617 Card Reader, Numeric Keyboard with Display Screen, and Alphanumeric Keyboard
	2	Standard	PS40 Card Punch or PTR055 Paper Tape Reader
	3	Standard	PRT050/057 Serial Printer or PTR055 Paper Tape Punch
High Speed	0	Optional	Magnetic drum
	1	Optional	Magnetic drum
	2	Optional	Reserved for expansion
	3	Standard	PRT051/052 or PRT055/056 Printer

.22 Data Structure

The basic addressable unit of the GE-55 is the octet, which consists of eight information bits and one parity bit and corresponds to the 8-bit byte terminology currently in use in the U.S.A. The eight information bits can represent either an alphanumeric character

.22 Data Structure (Contd.)

or two decimal digits. Octets can be handled individually or grouped together into variable length fields. Instructions are of zero, one or two address forms and are performed sequentially. The length of the instruction ranges between one and eight octets. GE states that the average instruction length is just over 4 octets.

Alphanumeric characters in storage are represented in ISO (International Standard Organization) internal code (shown in Table III). Punched card devices employ an intermediate 8-bit code shown in Table IV.

There are two possible formats for numeric data: unpacked format and packed format. A number in unpacked format is entered into core storage as an alphanumeric character in ISO internal code and expressed as an absolute value. A number in packed format may be expressed in absolute value or algebraic value (with sign). A number to be used in arithmetic operations is packed and expressed in algebraic value with the sign in the leftmost half of the most significant octet.

.23 Central Processor

All instructions are completely defined by the read-only memory unit. This unit is changeable, but the manufacturer states that there is no official provision for implementing special instruction sets. As presently implemented, the GE-55 appears as a multiple-register, decimal-arithmetic processor, with register-to-register arithmetic logic. A total of 500 core locations (octets) are reserved for arithmetic registers. Duplicate instructions are provided for single-length and double-length arithmetic, logical, and comparison operations. Single-length registers consist of 5 octets (9 digits plus sign); double-length registers consist of 10 octets (19 digits plus sign). Thus, a maximum of 100 single-length or 50-double-length registers or any combination are available to the programmer. Register length is determined by the instruction used. All arithmetic operations and most logical and compare operations take place between two registers. Additional instructions are provided for literal-to-memory logical and compare operations. Most instructions that reference memory, including the literal operations, jumps, and data movement, use one of the first 10 numeric registers as a base register. The base registers to be used are specified in the instructions along with a displacement of up to three decimal digits. In effect this provides 10 index registers for use by the programmer.

The overall instruction repertoire of the GE-55 can be classified into four general categories: input-output, data handling, arithmetic, and decision and control. The instruction repertoire is enhanced by inclusion of the following specialized instructions:

- Logical instructions that permit Inclusive OR, AND, and Exclusive OR operations.
- Translate instructions that provide automatic translation between intermediary card and internal code.
- Data handling instructions that permit moving, register exchange, and character insertion.
- Control instructions that permit multiprogramming.
- Instructions for handling variable length alphanumeric items.

The inclusion of specific facilities for multiprogramming is unusual in a machine the size of the GE-55. In the GE-55, up to five programs can be held in core storage simultaneously and be in various states of progress. In general the technique employed is to transfer control to another program whenever an I/O operation is initiated in the current program. Special instructions are provided to stop the program in progress and to start one of five programs. The programs are numbered in the sequence they are loaded into core. A special I/O connection code is used to allow the transfer to a new program while the I/O operation is being completed. The base address of each program's register area is maintained in the specialized register area of core storage. The user program is responsible for storing intermediate results prior to switching. This technique requires the programmer to establish the timing sequences of the program's processing and peripheral activities. Conditional blocking of one program is possible through two unique instructions: PRO and FREE. Each of these instructions references a program by its number. When two PRO instructions are encountered that reference one program, that program is blocked from execution. A FREE instruction releases one block established by a PRO instruction and frees the program for execution when called.

.23 Central Processor (Contd.)

Because the effect of only one PRO instruction is released by a FREE instruction, the next PRO instruction referencing the program will cause it to be blocked. Proper use of these two instructions allows the programmer a great deal of flexibility in making the execution of one program conditional upon occurrences in other programs.

Multiprogramming on the GE-55 differs with conventional practice because of the limitation on the number of peripheral devices and because of the way in which the programs are numbered.

Because the programmer controls the sequencing of processing and I/O operations, careful planning is required to take advantage of these features. In effect, these techniques allow the programmer to obtain maximum overlap between processing and I/O operations. It also adds significantly to the flexibility in carrying out various applications tasks.

A program interrupt can be generated by the operator by means of a pushbutton. This might be done in order to substitute a special error routine during a program's execution. Substitution takes place in the same way as a program jump:

- The contents of the program address register (which contains the current address of the interrupted routine) is stored in the interrupt return address register, and
- The contents of the interrupt address register (starting address of the service routine) is stored in the program address register.

The Arithmetic unit has a suitable speed for general data processing but is slow for mathematical work. Division and floating-point operations are available only as subroutines.

.24 Working Storage

Working storage is implemented by magnetic cores. Three sizes are available: 2,500, 5,000, and 10,000 octets. The core cycle time is 7.9 microseconds per access of one 8-bit octet.

During the operation of the GE-55, all data transfers between the various peripherals of the system must pass through core storage. To facilitate these data exchanges, core storage is divided into four different areas, each reserved for a distinct function.

The Communications Area is used by the control logic to supervise program linkage and is not accessible by application programs. Program linkage is required to perform simultaneous peripheral operations and multiprogramming. The communications area occupies 85 octets.

The Specialized Register Area is reserved for the use of the control logic both for storing immediate results and for supervising programs during execution; it is accessible to application programs. Specialized registers occupy 11 octets and are broken down into two categories: test registers and address registers. The test registers are the sign register, the comparison register and the overflow register.

The address registers monitor the execution of programmed instructions. These registers are the program address register, the program return address register, the interrupt address register and the interrupt return address register.

The Numeric Register Area occupies 500 octets. A numeric register covers five octets. Numeric registers use packed algebraic formats and may therefore contain 9 digits and a sign, or two adjacent registers may form a double register of 19 digits and one sign.

The Non-Specialized Area occupies the remainder of core storage and contains:

- Programs to be executed,
- I/O areas containing data to be transferred between the peripherals and core storage, and
- Miscellaneous data such as tables and intermediate results.

The core cycle time is 7.9 microseconds per access of one 8-bit octet.

.25 Auxiliary Storage

One or two magnetic drums can be connected to a GE-55 System. Each drum provides 89,600 octets (bytes) of storage organized in 128 tracks of 700 octets each. The drum rotates at 6000 revolutions per second providing an average access time of five milliseconds. The peak transfer rate is 70,000 octets per second.

.26 Input-Output Devices

Input-output devices available for the GE-55 include a punched card reader and punch, a paper tape reader and punch, keyboard with display screen, and several printers.

One card reader and one card punch can be included in a GE-55 system. The PS40 Card Punch has an input feed hopper and an output stacker with a capacity of 500 cards. It can process up to 60 cards per minute and must be stopped for loading or emptying. The L617 Card Reader has an input hopper and an output stacker with a capacity of 500 cards. It can process up to 150 cards per minute.

Both devices require programmed code translation. An intermediate 8-bit code is used as shown in Table IV. The zone punch is stored in the high order four bits, and the binary value of the punches in rows one through nine are stored in the lower four bits.

The Keyboard equipment includes an alphanumeric keyboard and a numeric keyboard with buffer and display screen. Both are under program control and the operational speed of both varies with the competency of the operator.

The numeric keyboard has 12 keys corresponding to the digits 0 to 9 and the two special characters ";" and ":". The buffer and display screen service as a double link between the central processor and the operator in that information is transferrable in either direction. The keyboard is locked until a program requests information and no information is transferred without operator validation. The alphanumeric keyboard consists of 45 keys corresponding to the 64 characters of the printer set.

The PTR055 Paper Tape Reader can read 11/16-inch (5-channel), 7/8-inch (6- or 7-channel), or 1-inch (8-channel) paper tape photoelectrically at up to 125 characters per second. The PTP055 Paper Tape Punch uses a slightly-oiled tape and can punch 11/16-inch (5-channel) or 1-inch (7- or 8-channel) tape at up to 105 characters per second. Reader and punch are available together on a single chassis as the PTS055 Paper Tape Reader/Punch.

A console common to both Reader and Punch is provided that contains a control desk, connection components, and "trans-coding" components.

Both the Reader and Punch operate on round holes and can accept ISO, H, or CCITT Telex 2 codes with hardware conversion to internal codes. Other codes can be accommodated through the trans-coding components in the console, which facilitate software code conversion. Either direct or software code translation is performed as tape is read and does not normally affect the reading speed. Direct translation when punching does not affect the punching speed, but software conversion typically slows the punching speed to about 100 characters per second.

A total of six printers are available for the GE-55; these are different versions of two basic designs. The two printer groups are

- PRT 051, PRT 052, PRT 055, and PRT 056;
- PRT 050 and PRT 057.

The PRT 051 prints 96 characters per line at 10 characters per inch. The peak printing rate is 100 or 200 lines per minute depending on whether the full character set (64 symbols) or a reduced character set (48 symbols) is used. The 16 additional characters in the 64-character set include various punctuation marks and special symbols.

The printing mechanism of the PRT 051 consists of 24 type-wheels. Engraved on each type wheel is the complete character set (64 symbols), and each wheel is used to print 4 character positions. When using the 48-character set, a total of four revolutions of the type-wheels are required to print one line, and an additional revolution is required to reposition the type-wheels at the beginning position. Forms positioning can be performed during the fifth revolution. When the full character set is used, there are actually two print operations.

.26 Input-Output Devices (Contd.)

The first operation prints symbols in the reduced 48-character set. A translation is then performed and the remaining 16 symbols in the 64-character set are printed in the second operation. Thus two complete cycles are required to print the full set and the peak speed is halved. The programmer controls the use of the two character sets. Because the PRT 051 Printer locks out the processor during printing, the effective speed of the printer will be below the peak speed in anything but a straight listing operation. GE states that speeds of 140 lines per minute can be attained in typical applications.

The PRT 051 Printer can accommodate forms from 4 to 16 inches wide and can print multi-part forms containing up to five carbons. The vertical spacing is either six or eight lines per inch.

Vertical forms control is by programmed skipping of one, two, or three lines and by a punched-tape control loop containing three channels. The programmer can specify skips to the next punch in either of two channels; the third channel is for detecting page overflow.

The PRT 052 is similar to the PRT 051 except it has 32 print wheels and can print 128 positions.

The PRT 055 is a slowed down version of the PRT 051. The peak speed of the PRT 055 is 83 lines per minute with the restricted 48-character set and 58 lines per minute with the full 64-character set. The PRT 056 is similar to the PRT 055 but can print 128 positions.

The PRT 050 Serial Printer prints the full 64-character set serially at a peak rate of 50 characters per second. Including the time for return of the printing mechanism to the first position, an average rate of about 40 characters per second can be attained.

The PRT 050 Printer contains one print cylinder with the characters engraved in eight groups of eight characters each. Character codes received from the processor cause the print cylinder to be mechanically positioned and rotated to the proper character.

The PRT 050 can print up to 128 character positions at a horizontal pitch of 10 characters per inch. The vertical spacing is six lines per inch. Carriage control on the PRT 050 is exercised via control codes in the data stream and permits carriage return, skip one line, and skip to the next hole punched in the vertical format loop (synchronized with paper). The PRT 050 can accommodate forms from 3 to 16 inches wide and can print up to 5-part sets.

The effective printing speed of the PRT 050 is dependent on the number of characters printed per line. Typical speeds are about 200 lines per minute at 10 characters per line and 20 lines per minute for a full 128 characters per line. The skipping speed is equivalent to 25 lines per second.

The PRT 057 Serial Printer is similar to the PRT 050 but prints at 40 characters per second and has a skip speed equivalent to 20 lines per second.

Other peripheral devices are being developed. Already shown in Paris, the Datanet 51 permits data communications at up to 2400 bits per second. This particular development will pave the way for use of the GE-55 as a sophisticated remote terminal for GE-600 series or other large computer systems.

.3 SOFTWARE

For the U.S.A. card-oriented GE-55, two software systems are provided: Basic Operating System/Card (BOS/C) and Extended Operating System/Card (EOS/C).

The key program in BOS/C is the "acceptability" program. This program accepts source code written in a basic symbolic language, checks for format errors, and outputs a condensed object program in machine language. All machine functions are available in the symbolic language. It provides symbolic operation codes and allows symbolic addressing.

A number of programs and routines are available in BOS/C and can be grouped into three types:

- Service software functions,
- Utility software functions,
- Mathematical routines.

.3 SOFTWARE (Contd.)

Service software functions facilitate program preparation, debugging, and task operation. These include such operations as program loading, memory dumps, program supervision, and error detection and recovery. The acceptability program is included in this category.

Utility software functions perform fundamental and frequently-used conversions and calculations, such as data listings, duplicating card decks, and monetary conversions. In addition there is a PERT System which performs PERT time and PERT calendar calculations.

The mathematical routines perform floating-point conversions during both input and output and include a special floating-point package for such operations as addition, subtraction, multiplication, division and comparison. Floating point subroutines are available for square root, sine, cosine, arctangent, exponentiation, hyperbolic tangents and logarithms. Statistical routines provide standard analyses such as averages, variances, etc., as well as measures of regression and correlation.

The Extended Operating System/Card (EOS/C) has just been released and provides a significant increase in the tools available to the programmer.

There are two key programs under EOS/C: the GESAL assembler and the Supervisor. The assembler permits assembly of source programs written in General Electric Symbolic Assembly Language (GESAL). GESAL is a full-fledged assembly language and provides:

- Capability to insert comments for program annotation;
- Convenient address indexing for stepping through tables;
- Macro-instructions for floating-point arithmetic operations;
- Object program relocatability;
- Unlimited subroutine calls within a program and two-level nesting of subroutines within another subroutine;
- Debugging facilities such as non-destructive, variable-length core dumps; and
- Control statements for multiprogramming of multiple tasks.

The GESAL assembler is a three-phase program. In the first phase the source statements are decoded, a program listing and diagnostic statements are printed, and a deck is punched in an intermediate language designed to facilitate debugging. In the second phase the logical order if the cards are checked and the assembly process completed. The final program is then executed under control of the Supervisor to check internal programming consistency. The third phase produces a condensed object deck.

The EOS/C Supervisor is a core resident routine that provides the interface between GE-55 hardware and user programs. It manages subroutine calls and provides additional non-destructive memory dumps.

The basic software provided for the European configurations is essentially the same as BOS/C. In addition, a version is available for operation with magnetic drum storage. With magnetic drums, provisions are included for segmentation of programs and automatic call and retrieval from the drum of various segments. When the drum is included in the system a compiler is available for compiling programs written in a subset of USASI Basic FORTRAN called MINIFORTRAN. MINIFORTRAN has all facilities of the United States of America Standards Institute (USASI) Basic FORTRAN with the exception of functions and Equivalence, Common, and Computed Go To statements.

.4 PRICE DATA

A basic GE-55 card configuration corresponds to the AUERBACH Standard Configuration I and consists of:

- Central Processor with 10,000 octets of core storage,
- L617 Card Reader,
- PS40 Card Punch,

.4 PRICE DATA (Contd.)

- PRT 051 Printer, and
- Alphanumeric and numeric keyboards,

In Europe the prices are as follows in U.S.A. dollars:

Component	Monthly Rental, $	Purchase, $	Monthly Maintenance, $
Configuration as above	1384	66,430	208
Configuration as above but with PRT 050 Serial Printer replacing PRT 051 Printer	1234	59,230	178
Magnetic Drum	418	20,060	39
High Speed Channel Extension (3 channels)	50	24,000	4

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SUMMARY REPORT: ELBIT 100

.1 BACKGROUND

Elbit Computers, one of the ELRON Electronic Industries, Ltd., group in Haifa, is Israel's only commercial computer manufacturer. Besides the Elbit 100, Elbit has produced a series of desk calculators—the Elbit 200, 1200, and K200; a series of digital differential analyzers; and an educational analog computer, the Elbit EAC-15. The Elbit 100 was introduced in late 1967 and first delivered in January 1968. About 200 Elbit computers have been sold in Israel and Western Europe.

Elron Inc., a subsidiary of the ELRON Electronic Industries, Ltd., based in Skokie, Illinois, is marketing the Elbit 100 in North America.

A 12-bit, single address, fixed word length computer with a typical add time of 7.2 microseconds, the Elbit 100 is capable of operating up to 256 channels of input/output equipment via its I/O bus. The Elbit 100 features a two-level memory system, one a standard read-write core storage with from 1024 to 4096 12-bit words of 2-microsecond cycle time and the other a 256-word fixed microprogrammable Read Only Store with a 400-nanosecond cycle time.

Typical applications for the Elbit 100 are data terminal or concentrator, process controller, data converter, production tester, data verifier, and numerical controller of machine tools.

The basic Elbit 100 sells for $6400 and the largest model costs $7600. These prices are FOB Skokie, Illinois, and include power fail protection, an interface to the Teletype ASR 33, manuals, and standard software. The Teletype ASR 33 and other peripheral devices are not included in the base price.

The Elbit 100 comes with a software package that includes an assembler, maintenance routines, and an on-line debugging program. Other program tapes are available at a nominal charge of $5 each.

.2 HARDWARE

.21 System Configuration

The base price of $6400 for an Elbit 100 includes a 1024-word 12-bit core storage, a 256-word read-only storage, all power supplies, power fail protection, 256 input/output channels, microprogrammed priority interrupt, and an interface for a Teletype 33 ASR.

An additional 1,024 words of 12-bit core storage add $600 to the base price and an additional 3,072 words of 12-bit core storage add $1200 to the base price. Most peripherals can be operated without modification and can be purchased directly from the manufacturer.

.22 Data Structure

The basic addressable unit on the Elbit 100 is the 12-bit word. A word can contain an instruction or an operand.

Fixed and floating point software are standard with the Elbit 100. In the floating point library, the number occupies two memory words in the case of the double precision library and three words in the case of the triple precision library. The most significant bit of the first word is called the sign of the number. The number is positive when this bit is zero and negative when this bit is one; the value zero may have either sign. The next three most significant bits of the word may have either sign. The following three most significant bits of the first word form the exponent, which may have a value between 0 and 7. The remaining bits of the number, 20 for double word or 32 for triple word, divided into four-bit digits (5 or 8 digits), form the mantissa of the number.

.23 Central Processor and Working Storage

The basic central processor of the Elbit 100 includes 1024 12-bit words of core storage and provisions for connecting a Teletype 33 ASR and up to 256 input/output channels.

Core storage can be expanded to 1024 words and 4096 words. Two 4096-word Elbit 100 systems can be connected through an interface to provide 8192 words of core storage.

Each 12-bit location of core storage consists of a 12-bit instruction or operand. The core storage cycle time per access of one word is 2 microseconds.

The Elbit 100 is a single-address, fixed word length, binary processor. One one-word accumulator is provided. This is a 12-bit register made up of three 4-bit registers. One of its functions is to accumulate the results of all arithmetic operations. Its value is displayed on the front panel and can be altered by means of the illuminated pushbuttons. It also serves as the input/output register and, as such, is connected to the I/O bus. The three 4-bit portions of the accumulator can be manipulated independently.

The read-write memory of the Elbit 100 consists of an array of "3D" type cores arranged in pages of 256 12-bit words. The memory is addressed via a 12-bit Memory Address Register (MAR) consisting of three 4-bit registers (W, V, U) with W holding the page number and V, U holding the address within the page. Thus 16 pages of 256 words or a total of 4,096 words can be directly addressed. The V, U portion of this register is also used in an input/output operation to define the channel number of the device to be interfaced.

The Elbit 100 central processor is designed around a Read-Only Store (ROS), which is a hard-wired plug-in module that can be readily changed on site. The fundamental data-manipulation functions of the machine are engineered as microinstructions. The wiring of the ROS determines the sequence of microinstructions to be executed, and hence the instruction set of the machine. Elbit can wire special ROS's with microprograms written to customer specifications. In this way, a customer may, if he wishes, provide a completely nonstandard instruction set for his machine, but a more usual use is in specifying special-purpose extensions to the instruction set supplied. The ROS consists of 256 input lines.

The extra versatility provided by the ROS is particularly valuable in the kinds of computer application for which the Elbit 100 is intended; fast specialized interrupt handling facilities or interfacing with nonstandard devices can often be aided by the suitable use of special-purpose microprograms. These features make microprogrammed computers attractive for use as device controllers or multiplexors in real-time applications where a fast response time is required. However, the penalty for this flexibility is increased execution times for the standard instruction and interrupt sequences compared to hard-wired machines in the same price range.

The Elbit 100 standard basic instruction set provides single-address instructions consisting of binary add and subtract arithmetic operations, transfer conditionally or shift unconditionally, and input/output operations. Decimal arithmetic, logical, and floating point operations are performed by standard subroutines. There are no hardware provisions for indexing or for multiply and divide operations. One level of indirect addressing is allowed.

.24 Interrupt

The basic Elbit 100 has the ability to recognize a single level of interrupt. Receipt of an interrupt signal triggers an interrupt flip-flop associated with the ROS. Upon termination of each instruction, the ROS interrupt flip-flop is checked. If it has been set to one, the microprogram transfers control to the microroutine which disarms the interrupt, resets the interrupt flip-flop, stores the program counter, and transfers control to the ROS supervisory routine.

The software system consists of the Interrupt Supervisor and device service routines. The Interrupt Supervisor stores the condition of the program at the time of the interrupt and scans for the device that requested the interrupt. The device service routines are of two types, first and second order. A first-order device service routine is always completely executed and cannot be overridden by any other device. A second-order device routine may itself be interrupted by a call from any other device. Although there is no external priority logic, the order in which the devices are scanned decides which device will be served first when two devices call for an interrupt simultaneously.

The power fail service is always accepted before any other interrupt signal. Should a device service routine, of the first order, take more than 1 millisecond to complete, it has to check whether the power fail has been generated in the interim.

With the addition of the Real-Time Interrupt Adapter (RTA) option to the main frame, the Elbit 100 has the ability to distinguish among four interrupt levels of different priorities. The four

(Contd.)

levels can be independently enabled or disabled. The RTA is supported by the standard software.

.25 Mass Storage

Bryant Computer Products, a division of Ex-Cell-O Corp., supplies the CLC-1 Magnetic Drum Unit for use with the Elbit 100. The CLC-1 has a 1.2-million bit storage capacity on 32 data tracks with a maximum track capacity of 37,700 bits. Data is recorded at 1200 bits per inch. The average access time at 3600 rpm is 8.5 milliseconds and at 3000 rpm the average access time is 10 milliseconds. An optional CLC-1 system is available with 16 data tracks and a 600,000-bit storage capacity.

.26 Input/Output Interface

The Elbit 100 can be used to its best advantage as a system component or a portion of a control loop because of the ease with which it can be interfaced with the outside world. Since the system of interface used is a "bus" type, no logic changes are required when additional channels up to a total of 256 are to be added to the standard machine in the field. Another important feature of the Elbit design philosophy for its interface system is that it is peripheral independent.

.27 Input/Output Devices

The least expensive input/output device available for use with the Elbit 100 is the Teletype Model ASR 33/620. This device combines a typewriter, punched paper tape reader, and paper tape punch which operate at 10 characters per second and provide an ASCII character set. The ASR 33 Teletype interfaces directly with the central processor of the Elbit 100. A hardware loader is a standard feature.

For more rapid entry of punched tape programs and data, the Elbit 100 offers a Digitronics Model 2500. The Model 2500 is a photoelectric tape reader which can handle 5-, 6-, 7-, or 8-level tapes interchangeably.

The Tally P120 Paper Tape Punch can be used with an Elbit 100. The P120 punches, 5-, 6-, 7- or 8-level code at a rate of 120 characters per second and features built-in parity checking.

The Elbit 100 can record data in IBM compatible tape format on the Kennedy Model 1400/360 Incremental Recorder. Data is recorded at a density of 800 bits per inch (bpi) on 9-track, 1/2-inch magnetic tape at a maximum speed of 500 bytes per second.

The Elbit 100 can record on and read from 7- or 9-channel magnetic tape with a Peripheral Equipment Model 5820 Magnetic Tape Unit. The Model 5820 records at 800 bpi at a rate of 25 inches per second. Parity checking is provided with the interfaces to both the Kennedy and the Peripheral Equipment tape units.

The Shepard 880 Digital Printer is a small label printer that can be interfaced to the Elbit 100 computer. The Shepard 880 has an ASCII 64-character set and prints 80 characters per line at 600 lines per minute. The Shepard 880 sells for $9850.

.3 SOFTWARE

The programming system for the Elbit 100 is designed for ease of use. All programs are written in Elbit Symbolic Language (ESL) for which there is an assembler. ESL instructions are written in mnemonic code and decimal form.

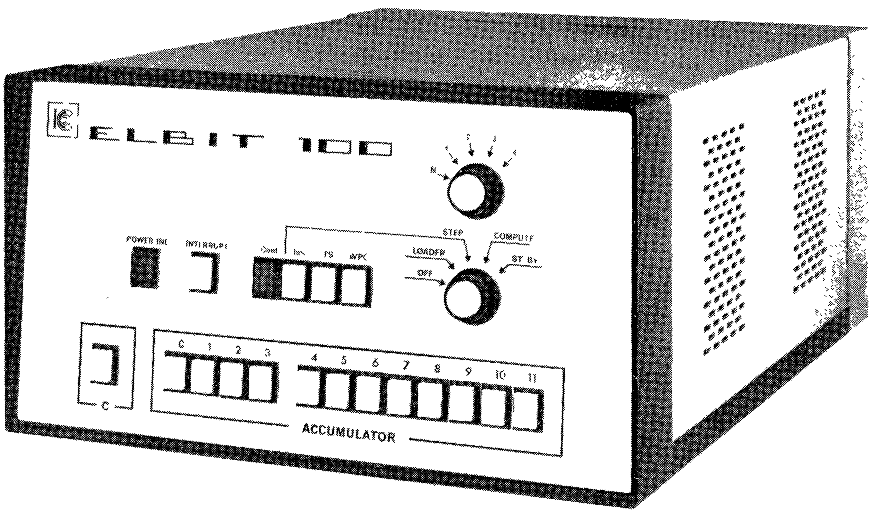
The Elbit Assembly Program (EAP) accepts source programs written in ESL and converts them into the machine code equivalent. This conversion is accomplished in two passes. The first pass is for display of the labels with assigned associated addresses while the second pass provides the complete listing of the program with the error messages and the self-loading object tape. The EAP operates with a minimum configuration of 2048 words of core memory and an on-line Teletype ASR 33/620.

Elbug is an on-line debugging program. Eight powerful operations provide monitoring of the executed program, tracing of a selected location, altering, printing, and punching of parts of core memory. Communication with Elbug is via Teletype, and a self-protection feature does not allow an operator to destroy the Elbug program. Elbug occupies 512 words of core storage.

The Elbit 100 is supported by a fairly wide range of software punched on paper tape. Subroutines are provided to simulate logical AND, OR, and Exclusive OR. The Arithmetic

Library includes subroutines for fixed point binary operations (both single and double word) and decimal and floating point calculations. The utility routines provide for BCD-to-binary and binary-to-BCD conversion. Also available are decimal, hexadecimal, bit-by-bit, and alphanumeric print routines and a provision for table look-up.

The Elbit 100 is supplied with special-purpose programs for such applications as data concentration, incremental digital plotting, display control, and multichannel integration.



PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature Number	Name	Monthly Rental $	Purchase $	Monthly Maint. $
CENTRAL PROCESSOR	100		Central Processor (4096 words)		7600	
	100		Central Processor (2048 words)		7000	
	100		Central Processor (1024 words)		6400	
			Main Frame Options			
			Real-Time Adapter (recognizes 4 levels of Priority Interrupt signals)		500	
			Real-Time Clock		300	
			Desk-Top Cabinet		100	
INTERFACE SYSTEMS*			ASR 33 Interface		825	
			Benson Plotter Interface		1100	
			Digitronics 2500 Interface		770	
			Kennedy 1600 Interface		1100	
			Magnetic Drum Interface		4400	
			PEC Incremental Tape Interface		2200	
			Sheppard 880 Line Printer Interface		1425	
			Tally P120 Interface		990	

*Elbit offers a family of standard interface cards and mounting hardware to facilitate user-designed interface systems. These cards range in price from $110 to $550.

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SUMMARY REPORT: FUJITSU FACOM 270 SERIES

.1 BACKGROUND

Fujitsu Limited of Tokyo, Japan, the only independent computer manufacturer in that country, announced its FACOM 270 Series in 1963. The 270 Series consists of three models, namely, 270-10, 270-20 and 270-30. Models 270-20 and 270-30 have both upward and downward compatibility.

Memory capacities for this series of binary processors range from 1,024 words on the smallest 270-10 to 65,536 words on the largest 270-30.

The purchase price for the FACOM-270-10 ranges from ¥5,400,000 (about $19,500), to ¥10,000,000, while the FACOM 270-20 sells for from ¥18,000,000 to ¥100,000,000. The largest model in the series, FACOM 270-30 has a purchase price ranging from ¥30,000,000 to ¥240,000,000. All prices are as of June, 1969.

The 270-10 was first delivered in February, 1963, the 270-20 in July, 1966 and the 270-30 in March, 1968.

Fujitsu, a world-renowned manufacturer of communications and electronics equipment, should not be dismissed lightly in their independent venture into the computer market. This is especially true since they more recently announced the FACOM 230 Series which shares compatible peripherals with the 270 Series; the FACOM 230 Series is discussed in Summary Report 1541.

.2 HARDWARE

.21 System Configuration

The largest FACOM 270-10 system can contain a central processor, an IBM Input-Output Typewriter, a magnetic drum, a paper tape reader, a paper tape punch, a real-time controller with display systems and other real-time equipment.

The largest FACOM 270-20 system can include a central processor with a built-in magnetic drum unit, a direct channel to which can be connected a FACOM WRITER, a paper tape reader and punch, a line printer, a plotting device, a card reader and a magazine file. Also included in the configuration are two data channels, 6 magnetic tape units and up to eight of the other available peripherals. Data communication equipment and real-time I-0 devices can also be added.

The largest FACOM 270-30 system can handle all the peripherals handled by the 270-20 and additionally can have up to seven data channels, allowing a greater number of peripherals and data communications devices to be connected.

.22 Data Structure

The basic addressable unit of the 270 Series is the word, which consists of sixteen binary bits and one parity bit. The sixteen binary bits can represent two characters or four decimal digits. The 8-bit character corresponds to the 8-bit byte terminology currently in use in the U.S.A. Instructions are of one address form and instruction lengths range from one to two words.

FACOM 270-20 and 270-30 represent a floating point number as a fraction having 24 or 56 bits and an exponent of 7 bits.

.23 Central Processor

As presently implemented the FACOM 270 Series appears as fixed word length, binary processors with one address per instruction.

FACOM 270-10 provides no floating point facilities and allows fixed point multiplication and division only through the use of subroutines.

.23 Central Processor (Contd.)

Parity checking is provided along with three index registers and one level of program interrupt.

As an auxiliary storage, a 32,768 word magnetic drum unit can be connected to the system. It has an average access time of 17 milli-seconds.

FACOM 270-20 and FACOM 270-30 are designed specifically for scientific, engineering, and process control applications. The two systems differ in the capacity of their central processors, and auxiliary storage, their internal speeds and the number of peripheral devices that can be attached. The Series 270 central processors are compared in Table I. Two instructions are provided on both systems for floating point arithmetic to handle operations of two words and four words in length.

TABLE I. FACOM 270 SERIES CENTRAL PROCESSOR CHARACTERISTICS

Model No.	Minimum Storage Capacity (words)	Maximum Storage Capacity (words)	Cycle time, μsec	Checking	Storage Protection	Program Interrupt, Levels	Numbers of Index Registers
270-10	1,048	4,096	2/word	Parity	None	1	3
270-20	4,096	32,768	2.4/word	Parity	Write only	12	3
270-30	8,192	65,536	.9/word	Parity	Write only	12	3

The FACOM 270 Series accomplishes editing through subroutines in all models. Model 10 has no indirect addressing and none of the models have table look-up capabilities. Otherwise, the instruction repertoire (34 in all models) of the series includes instructions to load and store information, to perform boolean operations (Model 10 has no inclusive OR instruction), for shifting, both logical and arithmetic, indexing operations and the four basic arithmetic operations as well as double-length addition and subtraction.

.24 Auxiliary Storage

The FACOM 270 Series is provided with four models of magnetic drum, three models of magmetic disc, and one model of magnetic disc pack drive.

Table II lists the characteristics of the available auxiliary storage devices.

TABLE II. CHARACTERISTICS OF FACOM 270 SERIES AUXILIARY STORAGE DEVICES

Type of Unit	F622D Drum	F623A Drum	F624B Drum	F627A Drum	F631A Disc	F631B Disc	F631K Disc	F461K Disc Pack Drive
Maximum Number of Units On Line	8 per channel	8 per channel	8 per channel	8 per channel	8 per channel	8 per channel	4 per channel	8 per channel
Maximum Number of Words Per Unit	131,000 bytes	262,000 bytes	2,096,000 bytes	524,000 bytes	33.5M bytes	67.1M bytes	90M bytes	7.25M bytes
Waiting Time, msec -								
Minimum	0	0	0	0	0	0	0	0
Average (Random)	10	20	17	8.4	150	130	130	87.5
Maximum	20	40	34	17	290	270	270	160
Effective Transfer Rate, Char/Sec	25,000 bytes	27,000 bytes	120,000 bytes	150,000 bytes	56,000 bytes	107,500 bytes	130,000 bytes	156,000 bytes
Data Checking	Parity	Parity	Check bytes	Check bytes	Check bytes	Check bytes	Check bytes	Check bytes

.25 Magnetic Tape Units

The FACOM 270 Series includes eight models of magnetic tape units. Any one model or any mixture of models can be attached to any of the 270 Series central processors. All models except one (F401A) have lateral and longitudinal parity checking on reading and read-after-write checking on writing; model F401A has track parity checking when reading and double write when writing. See Table III for data transfer rates and other characteristics of all available models.

TABLE III. CHARACTERISTICS OF FACOM 270 SERIES MAGNETIC TAPE UNITS

Model No.	Tape Speed inches per second	Recording Density bytes per inch	Number of Tracks	Peak Speed, bytes per second	Interlock Gap Lengths, inches	Transfer Rate Kilo-Char/sec.		Rewind Time, Minutes	IBM Compatibility	
						1000-char blocks	100-char blocks		729	2400
F606A	4	333 556	7	15,000 25,000		11.00 15.60	3.26 3.57	5.5	X X	X X
F603B	75	200 556	7	15,000 41,700	.75	12.90 28.90	5.77 7.67	2.0	X X	X X
F603C	120	200 556	7	24,000 66,700	.75	20.70 46.40	9.33 12.40	1.5	X X	X X
F603D	75	556 800	7	41,700 60,000	.75	28.90 36.70	7.67 8.12	2.0	X X	X X
F603E	120	556 800	7	66,700 96,000	.75	46.40 59.00	12.40 13.20	1.5	X X	X X
F603F	5	800	9	60,000	.58	39.50	9.70	2.0		X
F603G	120	800	9	96,000	.58	63.70	15.80	1.5		X
F401A	30	333	4	1,670		1.10	.32	1.5		

.26 Peripheral Equipment

The FACOM 270 Series is provided with one card reader model and one card punch model (Table IV). Eight card readers per channel and eight card punches per channel can be connected to any of the central processors and two additional on-line readers or punches can be connected via direct channel. The card reader features dual-read data checking and code translation while the card punch features code translation and read-after-punch data checking.

Six models of paper tape input-output equipment are available (Table IV). All models can be connected to any central processor in the 270 Series eight per channel plus two by direct channel. The paper tape readers have no code translation but feature dual read data checking and read 6 or 8 level codes. The paper tape punches feature feed checking and punches 6 or 8 level codes.

Table V lists the five models of typewriters which are available with the 270 Series. A wide range of speeds and character set sizes have been provided.

.3 DATA COMMUNICATIONS

The FACOM 270 Series is designed to handle data communications. The system is used to gather data sets from remote locations, to process them and to output the processed data or send the appropriate command information back to the remote locations.

To accomplish this, additional equipment such as data transmitters and terminal equipment have been developed. Data transmitters use 6 or 8 level paper tape at transmission speeds of 50, 200 or 1200 bits per second. A longitudinal redundancy check is performed on all data.

The FACOM 1510 Terminal handles data transceiving on 6 or 8 level paper tape, keyboards and printers. Data Transmission speeds are 50 to 100 bits per second with a longitudinal-vertical check on all data.

The FACOM 1530 Terminal is designed exclusively for banking and financial institutions. It consists of a terminal controller and terminal writers. The input-output mode is by keyboard and printer at data speeds of 200 and 1200 bits per second. Up to three terminal writers can be controlled by each terminal controller. The printing speed is 15.5 characters per second.

.4 SOFTWARE

The software of the 270 Series is designed with emphasis on compatibility among all the models of the series. The FACOM 270 COBOL compiler language and FACOM 270 FASP assembly language are typical business oriented languages. COBOL is a full COBOL equivalent to COBOL '61 Extended, incorporating the SORT verb. FASP is a real time assembler incorporating pseudo instructions and macro instructions based on symbolic instructions which have one to one correspondence with machine language.

TABLE IV. PERIPHERAL EQUIPMENT FOR THE FACOM 270 SERIES

Type of Unit	Model Number	Rated Speed
Card Reader	F664A	800 Cards per minute
Card Punch	F683A	250
Paper Tape Reader	F749A	400 or 200 char/sec, 6 or 8-level codes
Paper Tape Reader	F749E	1200 or 600 char/sec, 6 or 8-level codes
Paper Tape Reader	F750A	240 char/sec
Paper Tape Reader	F748A	1000 char/sec
Paper Tape Punch	F766A	200 char/sec
Paper Tape Punch	F767A	100 char/sec
Printer	F642A	1000 to 1500 lines/min, 64 or 128 character set
Printer	F643A	240 to 480 lines/min, 50 or 100 character set
Printer	F643C	240 to 480 lines/min, 50 or 100 character set
Electronic Printer	---	10,000 lines/min
XY Plotter	F6201B	400 steps/sec
Optical Character Reader	(Document Scanner)	440 sheets per minute
Optical Character Reader	(Page Scanner)	360 lines per minute
Optical Character Reader Reader	(Journal Scanner)	440 lines per minute

.4 SOFTWARE (Contd.)

FACOM 270 ALGOL and FACOM 270 FORTRAN are typical scientific compilers. The 270 FORTRAN is equivalent to FORTRAN IV.

A PL/1 compiler is also available. For the language specifications, an importance is placed on International Standards and Japanese Industrial compatibility as much as possible with compiler languages for other types of computers.

A variety of subroutines and utility programs are available in the form of sorts, merges, file handling routines and input-output control programs.

Application programs for operation research and linear programming are available, as well as, PERT/TIME and PERT/MANSCHEDULE.

Simulation Programs such as SOL (Simulation Oriented Language), DYNAMO (DYNAmic Models) and KEMPF (Kaigin Econometric Method Program by Fujitsu) are available.

Approximately 100 library routines are available for scientific and engineering applications.

TABLE V. FACOM 270 SERIES TYPEWRITER CHARACTERISTICS.

	FACOM 788A	FACOM 789A	FACOM 790A	FACOM 791A	FACOM 801A
Rated speed, char/sec	10	15.5	9.8	15	15
Size of character set	88	88	86	128	88
Number of columns	100	156	130	120	130
Character spacing, char/inch	10	12	10	10	10

PRICE DATA

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
CENTRAL PROCESSOR			FACOM 270-20 System		
		F7200A	Central Processing Unit (Including Drum)	265,000	11,925,000
		F7220A	Main Storage --- 4 k - 16 bits-Words	70,000	3,150,000
		—	(Up to 32 k Words)		
			FACOM 270-30 System		
		F7300A	Central Processing Unit (Including a Drum)	490,000	22,050,000
		F7320A	Main Storage --- 8 k - 16 bits-Words	190,000	8,550,000
		F7310A	Main Storage --- 16 k 16 bits-Words	350,000	15,750,000
			Features for 270-20 Systems		
		F7210A	Memory Protection	20,000	900,000
		F7211A	Floating Point Arithmetic	65,000	2,925,000
		F7233A	Line Printer Adapter	10,000	450,000
			Features for 270-30 System		
		F7310A	Memory Protection	30,000	1,350,000
		F7311A	Floating Point Arithmetic	100,000	4,500,000
		F7312A	TIMER	25,000	1,125,000
		F7333A	Line-Printer Adapter	10,000	450,000
			Channels		
			For 270-20 System		
		$F7232A_1$	Data Channel (Single)	105,000	4,725,000
		$F7232A_2$	Data Channel (Dual)	180,000	8,100,000
		$F7232B_1$	Data Channel (Single) (A magnetic tape controller)	130,000	5,850,000
		$F7232B_2$	Data Channel (Dual) (Dual magnetic tape controller)	220,000	9,900,000
		F7232C	Data Channel (A data channel and a magnetic tape controller)	190,000	8,550,000
			For 270-30 System		
		F7331A	Data Channel (Single)	60,000	2,700,000
		F7332A	Data Channel (Single) (A magnetic tape controller)	110,000	4,950,000
INPUT-OUTPUT			Punched Card and Printer		
		F567K	Card Reader (100 cards/min)	45,000	2,025,000
		F664K	Card Reader (800 cards/min)	180,000	8,100,000
		F683K	Card Punch (250 cards/min)	260,000	11,700,000

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
INPUT-OUTPUT (Contd)		F687K	Card Punch (Require F 1620 A/B)	65,000	2,925,000
		F643A	Line-printer (240 lines/min 80 position)	110,000	4,950,000
		F643C	Line-printer (240 lines/min 136 position)	135,000	6,075,000
		F642K	Line-printer (1,000 lines/min 136 position)	330,000	14,850,000
			Paper Tape Adapter		
		F1021A	Input-output adapter (For up to 4 paper tape units)	96,000	4,320,000
		F1006	Paper tape adapter	60,000	2,700,000
		F1406	Paper tape adapter	93,000	4,185,000
		F1620A	Paper Tape Adapter (Up to 4 paper tape units)	100,000	4,500,000
		F1620B	Paper Tape Adapter (Up to 8 paper tape units)	160,000	7,200,000
			Magnetic Tape		
		F1211A	Magnetic Tape Controller (Single channel) for F603 B/C	112,000	5,000,000
		F1212A	Magnetic Tape Controller (Dual channel) for F603 B/C	198,000	8,910,000
		F1205A	Magnetic Tape Controller (Single channel) for F606A only	105,000	4,725,000
			Disk and Drum Storage		
		F1213A	Magnetic DISK Controller (For a single disk)	130,000	5,850,000
		F1214A	Magnetic DISK Controller (For one or two disks)	220,000	9,900,000
		F631A	Magnetic DISK Unit (33.5 MB)	750,000	33,750,000
		F631B	Magnetic DISK Unit (67.1 MB)	1,000,000	45,000,000
		F631K	Magnetic DISK Unit (90MB)	900,000	40,500,000
		F1223A	DISK PACK Controller (Up to 4 Devices)	130,000	5,850,000
		F461B	DISK PACK Unit (5.12 MBytes)	185,000	8,325,000
		F1718A	File Control Unit	330,000	14,850,000
		F462K	DISK PACK Unit --- 7.25 M Bytes (Requires F1718A)	180,000	8,100,000

(Contd.)

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
INPUT-OUTPUT (Contd)		F622D	Magnetic Drum Unit (131^{KB})	195,000	8,775,000
		F623A	Magnetic Drum Unit (262^{KB})	300,000	13,500,000
		F627K	Magnetic Drum Unit (622^{KB})	210,000	9,450,000
		F624B	Magnetic Drum Unit (2,097^{KB})	450,000	20,250,000
			Paper Tape Unit		
		F749A	Paper Tape Reader (200/400 char/sec)	39,000	1,305,000
		F750A	Paper Tape Reader (240 char/sec)	38,000	1,710,000
		F749E	Paper Tape Reader (600/1200 char/sec)	45,000	2,025,000
		F748A	Paper Tape Reader (1,000 char/sec)	85,000	3,825,000
		F748E	Paper Tape Reader (600 char/sec)	65,000	2,835,000
		F766A	Paper Tape Punch (200 char/sec)	60,000	2,700,000
		F767A	Paper Tape Punch (100 char/sec)	43,000	1,935,000
			On-Line Type Writer		
		F801D	FACOM-WRITER	40,000	1,800,000
		F801D-1	Subpaper Tape Reader	3,800	171,000
		F801D-3	Verify Option	7,600	342,000
		F790A	Typewriter	70,000	3,150,000
		F791A	Typewriter	55,000	2,475,000
		F788A	Typewriter	48,000	2,160,000
		F789	Typewriter	60,000	2,700,000
			Display		
		F-6221A	Character Display Unit	165,000	7,425,000
		F6201B	X-Y Plotter	55,000	2,475,000

SUMMARY REPORT: FUJITSU FACOM 230 SERIES

.1 BACKGROUND

The FACOM 230 Series is manufactured by Fujitsu Limited of Tokyo, Japan. Originally the 230 Series consisted of five models that were classified into three categories, small-size Model 10, small-to-medium-size Models 20 and 30, and large-size Models 50 and 60. Upward data and program compatibility is maintained within each category of the Series. More recently Fujitsu has announced three new models— Models 25, 35 and 45. Conceived as real-time systems, these models take full advantage of Fujitsu's complement of real-time equipment.

FACOM 230-10 rents for ¥270,000 (about $970) per month. The system was first delivered in December, 1965. The 230-20 was announced in October, 1965 and has monthly rentals of ¥1,200,000 to ¥4,300,000. FACOM 230-30 was announced in June, 1964 and rents for ¥2,000,000 to ¥8,000,000. First delivered in March, 1966, the FACOM 230-50 rents for ¥2,900,000 to ¥15,000,000. FACOM 230-60 was announced in mid-1967 and has a monthly rental ranging from ¥10,000,000 to ¥72,000,000. All prices quoted were as of June, 1969.

.2 HARDWARE

.21 System Configuration

A 230 Series system can span tremendous ranges in size, processing power and areas of applicability. The smallest and most basic system, FACOM 230-10, consists of central processing unit, 4,096 byte main memory, 65,536 byte internal magnetic drum, typewriter, paper tape reader, and paper tape punch.

At the other end of the scale, the FACOM 230-60 can have a multiprocessor configuration consisting of a maximum of 2 central processors and extended core to a maximum of eight units of 262,144 words each, eight selector channel units, three multiplexor channel units, four magnetic drum units, two disc units, eight magnetic tape units, 2048 communication lines, three card readers, a card punch, two line printers, a paper tape punch and reader and up to 512 typewriters.

Models 230-25, 35 and 45 represent Fujitsu's entry into the real-time market. The configurations are formed much the same as their scientific and business counterparts, Models 20, 30 and 50. However, special consideration has been given to their usefulness in the real-time environment. These models all come equipped with the terminal facilities that are available with the 230 Series (shown in Paragraph .3).

.22 Data Structure

The word length on the 230-10 is 8 binary bits plus a word mark and a parity bit. On the 230-20 and 230-30 a word is 4 bits long with an associated word mark and parity bit. The 230-50 and 230-60 have 36 bits per word for data plus 4 flag bits and 2 parity bits.

On Models 230-10, 230-20 and 230-30 characters are eight bits in length and on Models 230-50 and 230-60 characters are represented by six bits.

Model 230-10 has variable length operands, up to six bytes per instruction and a binary or decimal arithmetic representation.

Models 230-20 and 230-30 have variable operands, 4, 8 or 12 digits per instruction and a decimal or hexadecimal arithmetic radix. Models 230-50 and 230-60 have fixed length operands, one word per instruction and perform binary arithmetic.

The three smaller models have variable size fraction, up to 20 digits on Model 10 and up to 128 digits on Models 20 and 30. All three models have two digit exponents. Models 50 and 60 have 27 or 62 bits fraction and 9 digit exponents.

.23 Central Processor

The 230 Series range of applicability is reflected in the varying span of its instruction sets.

Model 10 has an instruction repertoire of 30 instructions which is considerably less than the other models of the 230 Series; Models 20 and 30 have 70 instructions each and Model 50 has 257 instructions while Model 60 has 235 instructions. Models 25, 35 and 45 have 84, 84 and 94 instructions respectively.

The basic arithmetic add and subtract operations are included in all the FACOM 230 Series models. The other arithmetic operations are not included in the Model 10 although they are included in the other models; subroutines are provided on the Model 10 to simulate the missing operations. Model 10 also differs from the other models of the Series in having no address indexing capabilities.

The instruction repertoires of all models include flexible facilities for character manipulation, program control, shifting, logical, and test and transfer operations. In addition, Models 50 and 60 have an extensive repertoire of table look-up and translate instructions.

FACOM 230-10 is the smallest model of the 230 Series. Model 10 appears as a binary-decimal arithmetic processor with one to six bytes per instruction and having 0, 1, or 2 addresses per instruction.

FACOM 230-20 was announced as a small-to-medium-size computer for business applications. Models 20 and 30 have similar processor features (Table I). Both models have hardware facilities for floating point arithmetic as well as indirect addressing, editing and boolean operations. Instruction lengths are 4, 8 or 12 digits, with variable operands and 0, 1 or 2 addresses. The arithmetic radix can be either decimal or hexadecimal.

TABLE I. FACOM 230 CENTRAL PROCESSOR CHARACTERISTICS

	230-10	230-20	230-30	230-50	230-60	230-25	230-35	230-45
Storage Capacity								
Minimum	4,096	4,096	4,096	16,384	32,768	8,192	32,768	65,536
Maximum	8,192	32,768	32,768	65,536	262,144	65,536	131,072	1,048,000
Cycle Time, μsec	2.0	1.8	2.2	2.2	0.92	1.5	.5	.5
Memory Protection	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Index Register	—	2	2	8	8	8	8	8
Number of Instructions	30	70	70	257	235	84	84	94

FACOM 230-30 is a medium-size, general purpose, variable word length system with a main memory cycle time of 2.2 microseconds per two digits. Main memory is available in sizes ranging from 8,192 to 65,536 core locations. Up to four selector channels, one of which can be replaced by a multiplexor channel, can be connected to the system. As an option, memory protection is available in units of 128 bytes. Both decimal and binary arithmetic can be performed. Instructions are 4, 8 or 12 digits in length. Two index registers are provided and indirect addressing and boolean operations are possible.

FACOM 230-50 is a large scale, fixed word length, binary, general purpose system. Each word consists of 42 bits: 36 data bits, 4 flag bits and 2 parity bits. Thirty-six bits of binary data corresponds to approximately 10,5 decimal digits. Main memory capacities range from 16,384 words to 65,536 words with a cycle time of 2.2 microseconds per word. Both fixed and floating-point operations can be performed and double precision is available for floating-point operations. Up to seven selector channels and/or multiplexor channels can be connected to the system. Eight index registers are available and indirect addressing and boolean operations can be performed.

The FACOM 230-60 general purpose system is the largest model among the FACOM Series 230. Model 60 is downward compatible with Model 50 in both program and data.

(Contd.)

.23 Central Processor (Contd.)

FACOM 230-60 is a binary machine having an instruction length of one word and one address per instruction. Five levels of interrupt are provided on the 230-60. These include overflow conditions, Input-Output control and operator intervention. Eight index registers are provided. There are facilities for indirect addressing, editing of formats, table look-up and boolean opertions. Multiprocessing is achieved by connecting up to two central processors and up to three channel controllers. Each channel controller can control up to six multiplexor channels and/ or selector channels.

Main memory is configured as a multi-bank system. The memory is expandible in units of 32,768 words from a minimum memory capacity of 32,768 words to a maximum capacity of 262,144 words. Each unit of 32,768 is further divided into two banks, so that the minimum capacity of main memory has two banks, and the largest has 16 banks. Each bank operates independently with a cycle time of 0.92 microseconds.

Optionally, an even larger memory unit can be added to the system. An additional 786,432 words in units of 262,144 words can be added to the previous maximum capacity of 262,144 words. Each extended 262,144 word unit is divided into two banks, each operating independently at cycle rates of 6 microseconds. The console has facilities that partition the system, i.e., by setting manual switches individual units can be made unavailable for use by other units.

Main memory accessing is 2-way, 4-way or 8-way interleaved. Each central processor can access three words of data at a time and each channel control unit can access two words of data at a time, all units operating simultaneously.

The FACOM 230-60 has six base registers that are used for dynamic relocation of programs within core memory making it suitable for time-sharing operations, on-line real time processing and multiprogramming.

FACOM 230-60 can easily function as a data communications processor since each selector channel can handle up to 256 input-output devices and each multiplexor channel, having 1024 subchannels, can be connected to communications lines.

.24 Auxiliary Storage

The FACOM 230 Series is provided with four models of magnetic drum, three models of magnetic disc, and one model of magnetic disc pack drive. Three units of additional core memory consisting of 262,144 words each are available for Model 230-60. This additional core memory has an average access time of 6 microseconds and an effective transfer rate of 6 million bytes per second. Parity checking is provided.

Table II lists the characteristics of the remaining auxiliary storage devices.

TABLE II. CHARACTERISTICS OF FACOM 230 SERIES AUXILIARY STORAGE DEVICES

Type of Unit	F622D Drum	F623A Drum	F624B Drum	F627A Drum	F631A Disc	F631B Disc	F631K Drum	F461K Disc Pack Drive
Maximum Number of Units on-line	8/channel	8/channel	8/channel	8/channel	8/channel	8/channel	4/channel	8/channel
*Maximum Number of words/unit	131,000 bytes	262,000 bytes	2,096,000 bytes	524,000 bytes	33.5M bytes	65.1M bytes	90M bytes	7.25M bytes
Waiting time, msec -								
Minimum	0	0	0	0.0	0	0	0	0.0
Average (Random)	10	20	17	8.4	150	150	130	87.5
Maximum	20	40	34	17.0	290	290	270	160.0
Effective Transfer Rate Char sec	25,000 bytes	27,000 bytes	120,000 bytes	150,000 bytes	56,000 bytes	107,500 bytes	130,000 bytes	156,000 bytes
Data Checking	Parity	Parity	Check bytes	Check bytes	Check bytes	Check bytes	Check bytes	Check bytes

.25 Magnetic Tape Units

The FACOM 230 Series is provided eight models of magnetic tape units. Any one model or any mixture of models can be attached to any of the 230 Series central processors. All models except one (F401A) have lateral and longitudinal parity checking on reading and read-after-write parity checking on writing.

Model F401A has track parity checking when reading and double write when writing. See Table III for data transfer rates and other characteristics of all available models.

TABLE III. CHARACTERISTICS OF FACOM 230 SERIES MAGNETIC TAPE UNITS

Model No.	Tape Speed inches per second	Recording Density bytes per inch	Number of Tracks	Peak Speed, bytes per second	Interlock Gap Lengths, inches	Transfer Rate Kilo-Char/sec.		Rewind Time, Minutes	IBM Compatibility	
						1000-char blocks	100-char blocks		729	2400
F606A	4	333 556	7	15,000 25,000		11.00 15.60	3.26 3.57	5.5	X X	X X
F603B	75	200 556	7	15,000 41,700	.75	12.90 28.90	5.77 7.67	2.0	X X	X X
F603C	120	200 556	7	24,000 66,700	.75	20.70 46.40	9.33 12.40	1.5	X X	X X
F603D	75	556 800	7	41,700 60,000	.75	28.90 36.70	7.67 8.12	2.0	X X	X X
F603E	120	556 800	7	66,700 96,000	.75	46.40 59.00	12.40 13.20	1.5	X X	X X
F603F	5	800	9	60,000	.58	39.50	9.70	2.0		X
F603G	120	800	9	96,000	.58	63.70	15.80	1.5		X
F401A	30	333	4	1,670		1.18	.32	1.5		

.26 Peripheral Equipment

The FACOM 230 Series is provided with one card reader model and one card punch model (Table IV). Eight card readers per channel and eight card punches per channel can be connected to any of the central processors and two additional on-line readers or punches can be connected via direct channel. The card reader features dual-read data checking and code translation while the card punch features code translation and read-after-punch data checking.

Six models of paper tape input-output equipment are available (Table IV). All models can be connected to any central processor in the 230 Series eight per channel plus two by direct channel. The paper tape readers have no code translation but feature dual read data checking and read 6 or 8 level codes. The paper tape punches feature feed checking and punches 6 or 8 level codes but have no code translation.

TABLE IV. PERIPHERAL EQUIPMENT FOR THE FACOM 230 SERIES

Type of Unit	Model Number	Peak Speed
Card Reader	F664A	800 Cards per minute
Card Punch	F683A	250
Paper Tape Reader	F749A	400/200 char/sec, 6/8 level codes
Paper Tape Reader	F749E	1200/600 char/sec, 6/8 level codes
Paper Tape Reader	F750A	240 char/sec
Paper Tape Reader	F748A	1000 char/sec
Paper Tape Punch	F766A	200 char/sec
Paper Tape Punch	F767A	100 char/sec
Printer	F642A	1,500/1,000 lines/min, 64/128 character set
Printer	F643A	480/240 lines/min, 50/100 character set
Printer	F643C	480/240 lines/min, 50/100 character set
Electronic Printer	—	10,000 lines/min
XY Plotter	F6201B	400 Steps/sec
Optical Character Reader	(Document Scanner)	440 sheets per minute
Optical Character Reader	(Page Scanner)	360 lines per minute
Optical Character Reader	(Journal Scanner)	440 lines per minute

.26 Peripheral Equipment (Contd.)

Table V lists the five models of typewriters which are available with the 230 Series. A wide range of speeds and character set sizes have been provided.

.3 DATA COMMUNICATIONS

The FACOM 230-20 On-Line System is designed specifically for data communications. The system is used to gather data from remote locations, to process them and to output the processed data or send the appropriate command information back to the remote locations.

To accomplish this, additional equipment such as data transmitters and terminal equipment have been developed. Data transmitters use 6 or 8 level paper tape at transmission speeds of 50, 200 or 1200 bauds. A longitudinal redundancy check is performed on all data.

The FACOM 1510 Terminal handles data transceiving on 6 or 8 level paper tape, keyboards and printers. Data Transmission speeds are 50 and 100 bauds with a longitudinal-vertical check on all data.

The FACOM 1530 Terminal is designed exclusively for banking and financial institutions. It consists of terminal controller and terminal writers. The input-output mode is by keyboard and printer at data speeds of 200 and 1200 bauds. Up to three terminal writers can be controlled by each terminal controller. The printing speed is 15.5 characters per second.

.4 SOFTWARE

The software of the 230 Series is designed with emphasis on compatibility among all the models of the series. The Master Control Program for the series can control concurrently up to four jobs. The FACOM 230 COBOL compiler language and FACOM 230 FASP assembly language are typical business oriented languages. COBOL is a full COBOL equivalent to COBOL '61 Extended, incorporating the SORT Verb.

FACOM 230 ALGOL and FACOM 230 FORTRAN are typical scientific compilers. The 230 ALGOL is full ALGOL based on Revised Report ALGOL 60. The 230 FORTRAN is equivalent to FORTRAN IV.

A PL/I compiler is also available. As to the language specifications, an importance is placed on International Standards and Japanese Industrial Standards (JIS) and, at the same time, consideration is given to obtaining as much compatibility as possible with compiler languages for other types of computers.

A variety of subroutines and utility programs are available in the form of sorts, merges, file handling routines and input-output control programs.

Application programs for operation research and linear programming are available, as well as, PERT/TIME and PERT/MANSCHEDULE.

Simulation Programs such as SOL (Simulation Oriented Language), DYNAMO (DYNAmic Models) and KEMPF (Kaigin Econometric Method Program by Fujitsu) are available.

Approximately 100 library routines are available for scientific and engineering applications.

TABLE V. FACOM 230 SERIES TYPEWRITER CHARACTERISTICS

	FACOM 788A	FACOM 789A	FACOM 790A	FACOM 791A	FACOM 801A
Rated speed, char/sec	10	15.5	9.8	15	15
Size of character set	88	88.0	86.0	128	88
Number of columns	100	156.0	130.0	120	130
Character spacing, char/inch	10	12.0	10.0	10	10

PRICE DATA

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
CENTRAL PROCESSOR			FACOM 230-10 System		
		F2100A	Central Processing Unit (Including 4 k Bytes and a Drum)	230,000	10,350,000
		F2120A	Main Storage --- 4 k Bytes (Up to 8 k bytes)	58,000	2,610,000
			FACOM 230-20 System		
		F2200A	Central Processing Unit	260,000	11,700,000
		F2220A	Main Storage --- 4 k Bytes (4 k to 8 k Bytes)	70,000	3,150,000
		F2221A	Main Storage --- 8 k Bytes (16 k to 32 k Bytes)	130,000	5,850,000
			FACOM 230-30 System		
		F2311A	Central Processing Unit	410,000	18,450,000
		F2321A-I	Main Storage --- 4 k Bytes	238,000	10,710,000
		F2321A-II	Main Storage --- 8 k Bytes	292,000	13,140,000
		F2321A-III	Main Storage --- 16 k Bytes	400,000	18,000,000
		F2321A-IV	Main Storage --- 32 k Bytes	616,000	27,720,000
		F2341A-I	Console	79,000	3,555,000
		F2331A-I	Index and Floating Arithmetic	184,000	8,280,000
		F2331A-II	Index Option	133,000	5,985,000
			FACOM 230-50 System		
		F2500B	Central Processing Unit (Including 8 k 36-bit words)	1,640,000	73,800,000
		F2520B	Main Storage --- 8 k - 36-bit words	380,000	17,100,000
		F2540C	Console (Including 100 card/min card reader)	129,000	5,805,000
		F2541C	Console (Including 400 char/sec paper tape reader)	129,000	5,805,000
		F2545C	Console	100,000	4,500,000
			FACOM 230-60 System		
		F2600A	Central Processing Unit	2,450,000	110,000,000
		F2620A	Main Storage --- 32 k - 36-bit words (Up to 262 k - 36-bit words)	1,800,000	81,000,000

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
CENTRAL PROCESSOR (Contd)		F2632A	High Speed Transfer Unit	160,000	7,200,000
		F2612A	Main Storage Adapter	70,000	3,150,000
		F2640A	Operating Console	30,000	1,350,000
		F2642A	Configuration Console	40,000	1,800,000
		F2610A	Multi-Processor Adapter	150,000	6,750,000
			Bulk Core Memory		
		F2621A	Bulk Core Memory --- 131 k 36-bit words (Only FACOM 230-60)	2,000,000	90,000,000
		F2622A	Bulk Core Memory --- 262 k - 36-bit words (Only FACOM 230-60)	3,200,000	144,000,000
			Processor Options		
			For 230-10 System		
		F2130A	Input-Output Controller	36,000	1,620,000
		$F2130A_1$	Input-Output Controller I	12,000	540,000
		$F2130A_2$	Input-Output Controller II	12,000	540,000
		$F2131A_1$	Line Printer Adapter	10,000	450,000
			For 230-20 System		
		F2210A	Memory Protection	20,000	900,000
			Channels		
			For 230-20 System		
		F2230A	Data channel (Single)	50,000	2,250,000
		F2231A	Data channel (Single)	70,000	3,150,000
			For 230-30 System		
		$F2332B_1$	Data channel (Single)	162,000	7,290,000
		$F2332B_2$	Data channel (Dual)	269,000	12,105,000
			For 230-50 System		
		F2531B	Data channel (Single)	197,000	8,910,000
			For 230-60 System		
		F2639A	Data Channel Controller (Up to 6 channels)	1,320,000	49,400,000

(Contd.)

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase, ¥
CENTRAL PROCESSORS (Contd)					
		F2638A	Channel Adapter	100,000	4,500,000
		F2613A	Channel Power Supply Units	60,000	2,700,000
		F2631A	Data Channel (Single)	320,000	14,400,000
			For 230-20 System		
		F2233A	Multiplexor Channel (256 Sub-channels)	150,000	6,750,000
		F2233B	Multiplexor Channel (512 Sub-channels)	170,000	7,650,000
			For 230-30 System		
		F2335A	Multiplexor Channel (256 Sub-channels)	150,000	6,750,000
		F2335B	Multiplexor Channel (512 Sub-channels)	170,000	7,650,000
			For 230-50 System		
		F2533B	Multiplexor Channel (512 Sub-channels)	230,000	10,350,000
		F2533C	Multiplexor Channel (1024 Sub-channels)	250,000	11,250,000
			For 230-60 System		
		F2633A	Multiplexor Channel (1024 Sub-channels)	380,000	17,100,000
INPUT-OUTPUT					
			Punched Card and Printer		
		F567K	Card Reader (100 C/M)	45,000	2,025,000
		F664K	Card Reader (800C/M)	180,000	8,100,000
		F683K	Card Punch (250 C/M)	260,000	11,700,000
		F687K	Card Punch (Require F 1620 A/B)	65,000	2,925,000
		F643A	Line-printer (240 L/M --- 80 position)	110,000	4,950,000
		F643C	Line-printer (240 L/M --- 136 position)	135,000	6,075,000
		F642K	Line-printer (1,000 L/M --- 136 position)	330,000	14,850,000
			Paper Tape Adapter		
		F1021A	Input-output adapter (Up to 4 paper tape units)	96,000	4,320,000

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase ¥
INPUT-OUTPUT (Contd)		F1006	Paper tape adapter	60,000	2,700,000
		F1406	Paper tape adapter	93,000	4,185,000
		F1620A	Paper tape adapter (Up to 4 paper tape units)	100,000	4,500,000
		F1620B	Paper Tape Adapter (Up to 8 paper tape units)	160,000	7,200,000
			Magnetic Tape		
		F1211A	Magnetic Tape Controller (Single channel) for F603 B/C	112,000	5,000,000
		F1212A	Magnetic Tape Controller (Dual channel) for F603 B/C	198,000	8,910,000
	FACOM 230-20	F1205A	Magnetic Tape Controller (Single channel) for F606A only	105,000	4,725,000
		F1206A	Magnetic Tape Controller (Dual channel) for F606A only	160,000	7,200,000
		F1216A	Magnetic Tape Controller (Single channel) for F603 F/D	140,000	6,300,000
	FACOM 230-30	F1217A	Magnetic Tape Controller (Dual channel) for F603 F/D	235,000	10,575,000
		F1216B	Magnetic Tape Controller (Single channel) for F603 G/E	140,000	6,300,000
		F1217B	Magnetic Tape Controller (Dual channel) for F603 G/E	235,000	10,575,000
		$F1002A_1$	Magnetic Tape Controller (Single channel) for F603 B/C/D/E	112,000	5,040,000
		$F1002A_2$	Magnetic Tape Controller (Dual channel) for F603 B/C/D/E	198,000	8,910,000
		F1201A	Magnetic Tape Controller (Single channel) for F603 B/C/D/E	123,000	5,535,000
	FACOM 230-50	F1202A	Magnetic Tape Controller (Dual channel) for F603 B/C/D/E	218,000	9,810,000
		F1716A	Magnetic Tape Controller (Single channel) for F603 D/F	165,000	7,425,000
		F1716A-11	Cross-Call Option (for F1716A)	10,000	450,000
		F1716B	Magnetic Tape Controller (Single channel) for F603 E/G	165,000	7,425,000

Class	Identity			Prices	
	Model Number	Feature Number	Name	Monthly Rental, ¥	Purchase ¥
INPUT-OUTPUT (Contd)	FACOM 230-60	F1716B - 11	Cross Call Option (for F 1716B)	10,000	450,000
		F1717A	Magnetic Tape Controller (Dual channel) for F603 D/F	275,000	12,375,000
		F1717A-11	Cross Call Option (for F1717A)	20,000	900,000
		F1717B	Magnetic Tape Controller (Dual channel) for F603 E/G	275,000	12,375,000
		F1717B-11	Cross Call Option (for F1717B)	20,000	900,000
		F603B	Magnetic Tape Unit (41.7^{KC})	123,000	5,535,000
		F603C	Magnetic Tape Unit (66.7^{KC})	184,000	8,280,000
		F603D	Magnetic Tape Unit (60^{KC})	145,000	6,525,000
		F603E	Magnetic Tape Unit (96^{KC})	185,000	8,325,000
		F603F	Magnetic Tape Unit (60^{KB})	170,000	7,650,000
		F603G	Magnetic Tape Unit (96^{KB})	220,000	9,900,000
			Disk and Drum Storage		
		F1213A	Magnetic DISK Controller (Only one)	130,000	5,850,000
		F1214A	Magnetic DISK Controller (Up to two Devices)	220,000	9,900,000
		F631A	Magnetic DISK Unit (33.5^{MB})	750,000	33,750,000
		F631B	Magnetic DISK Unit (67.1^{MB})	1,000,000	45,000,000
		F631K	Magnetic DISK Unit (90^{MB})	900,000	40,500,000
		F1223A	DISK PACK Controller (Up to 4 Devices)	130,000	5,850,000
		F461B	DISK PACK Unit (5.12^{MBytes})	185,000	8,325,000
		F1718A	File Control Unit	330,000	14,850,000
		F462K	DISK PACK Unit --- 7.25 M Bytes (Requires F1718A)	180,000	8,100,000
		F622D	Magnetic Drum Unit (131^{KB})	195,000	8,775,000
		F623A	Magnetic Drum Unit (262^{KB})	300,000	13,500,000
		F627K	Magnetic Drum Unit (622^{KB})	210,000	9,450,000
		F624B	Magnetic Drum Unit (2,097^{KB})	450,000	20,250,000
			Paper Tape		
		F749A	Paper Tape Reader (200/400 char/sec)	39,000	1,305,000
		F750A	Paper Tape Reader (240 char/sec)	38,000	1,710,000
		F749E	Paper Tape Reader (600/1200 char/sec)	45,000	2,025,000
		F748A	Paper Tape Reader (1,000 char/sec)	85,000	3,825,000
		F748E	Paper Tape Reader (600 char/sec)	65,000	2,835,000
		F766A	Paper Tape Punch (200 char/sec)	60,000	2,700,000
		F767A	Paper Tape Punch (100 char/sec)	43,000	1,935,000

Class	Identity			Prices	
	Model Number	Feature	Name	Monthly Rental, ¥	Purchase, ¥
INPUT-OUTPUT (Contd)			On-Line Type Writer		
		F801D	FACOM-WRITER	40,000	1,800,000
		F801D-1	Subpaper Tape Reader	3,800	171,000
		F801D-3	Verify Option	7,600	342,000
		F790A	Typewriter	70,000	3,150,000
		F791A	Typewriter	55,000	2,475,000
		F788A	Typewriter	48,000	2,160,000
		F789A	Typewriter	60,000	2,700,000
			Display		
		F-6221A	Character Display Unit	165,000	7,425,000
		F6201B	X-Y Plotter	55,000	2,475,000

SUMMARY REPORT: HITACHI HITAC 3010

.1 BACKGROUND

The HITAC 3010 is a small-to-medium-scale data processing system manufactured by Hitachi, Ltd., of Tokyo, Japan. Manufactured under license from the Radio Corporation of America, the solid-state HITAC 3010 is similar in most respects to the second-generation RCA 301, a popular U.S. data processing system that has performed reliably in several hundred installations.

The HITAC 3010 was announced in 1961, and initial customer deliveries were made in May 1962. Approximately 80 systems have been delivered to date. Hitachi is currently marketing the HITAC 3010 system in Japan.

Monthly rentals for typical HITAC 3010 configurations range from about $5,000 for a system with 10,000 characters of core memory, 4 magnetic tape units, a line printer, and card equipment to about $22,000 for a system with a 40,000-character memory, 12 high-speed magnetic tape units, a line printer, high-speed card equipment, and an interrogating typewriter. The 3010 system uses a data structure based upon six-bit alphanumeric characters, and its internal operations are more suitable for general business data processing than for scientific applications. Memory cycle time is either 3.5 or 7 microseconds per 2-character access.

The HITAC 3010 system features a high degree of compatibility with the RCA 301 and with the larger HITAC 4010 Realcom system, Hitachi's version of the RCA 3301 Realcom system. In addition, the third generation HITAC 8000 Series computers can be equipped with an Emulator that enables them to execute programs written for a HITAC 3010 system.

.2 DATA STRUCTURE

The basic unit of the HITAC 3010's data structure is the "character", which consists of six information bits and a parity bit. The six information bits in a character can represent either an alphanumeric character or a portion of a binary field.

Characters can be handled individually or grouped together into variable-length fields. Instructions, however, have a fixed length of 10 characters. The instructions are of a two-address form and are performed sequentially.

.3 HARDWARE

.31 Central Processors and Core Memories

A HITAC 3010 system can be built around any of four types of central processors: Small, Standard, High-Speed, or Scientific. The Small and Standard systems use central processors which are functionally the same, but the Small system is physically more compact. The Standard system is fully compatible with the central processors of the Small and High-Speed systems. The High-Speed system performs internal operations at twice the speed of the other systems. The Scientific Processor includes a high-speed arithmetic unit that performs fixed- and floating-point arithmetic and address indexing.

Table I summarizes the principal characteristics of all the HITAC 3010 processor models.

There are 41 instructions in the standard HITAC 3010 repertoire. They can be classified into four general categories: input-output, data handling, arithmetic, and decision and control.

TABLE I. HITAC 3010 PROCESSOR CHARACTERISTICS

System	Model	Memory Capacity, characters	Cycle Time, microseconds per 2 characters	Number of Instructions
Small	H-303Y H-304Y	10,000 20,000	7 7	41 41
Standard	H-303 H-304 H-305	10,000 20,000 40,000	7 7 7	41 41 41
High-Speed	H-304S H-305S	20,000 40,000	3.5 3.5	41 41
Scientific	H-355	40,000	7	51

.31 Central Processors and Core Memories (Contd.)

The instruction repertoire is enhanced by inclusion of the following specialized instructions:

- A Translate by Table instruction that permits efficient internal processing of various code structures.
- A Local Symbol instruction that permits an internal search, within core memory, for any character designated.
- Transfer instructions that permit transfer of data to the left or right within core memory.
- A Repeat instruction that permits the next repeatable instructions to be repeated a specified number of times.

There is no integrated editing facility, but edit routines are rapid and straightforward, and there is a good variety of instructions for handling variable-length alphanumeric items, including a convenient code translation operation and Boolean operations. Indirect addressing is a standard feature, but indexing is provided only in the H-355 Scientific processor. No program interrupt facility is available.

The arithmetic unit has a suitable speed for general data processing but is slow for mathematical work. Except in the Scientific system, multiplication, division, and floating-point operations are available only as subroutines.

.32 Punched Card Equipment

One card reader and one card punch can be included in a 3010 system. Table II summarizes the characteristics of the available punched card equipment. All four devices employ automatic code translation, and all but the H-334 Punch can accommodate binary data (160 6-bit characters per card).

.33 Paper Tape Equipment

One paper tape reader/punch or one paper tape reader and one paper tape punch can be included in a 3010 system. All devices employ automatic code translation.

The H-321 Reader/Punch operates at 100 characters per second. Seven-channel tape is standard, and an optional feature is available to accommodate 5- and 6-channel tape.

The H-322 Reader reads up to 1,000 characters per second from 5-, 6-, or 7-channel tape.

The H-331 Punch punches 100 5- or 7-channel characters per second.

.34 Optical Character Reader

One H-5820 Optical Character Reader can be included in a 3010 system. This unit reads, on demand, at a rate of approximately 1,500 documents per minute. A mark reading feature is available for the H-5820.

.35 Magnetic Tape Equipment

Six different models of Hitachi magnetic tape units are available for the 3010 system. In addition, one or two IBM 729 II tape stations can be included. Table III summarizes the characteristics of the Hitachi units. All Hitachi units provide forward and reverse reading capability.

TABLE II: PUNCHED CARD EQUIPMENT

Device	Model	Peak Speed, cards per minute	Feed Type
Reader	H-323	600	continuous, by row
Reader	H-329	1470	demand, by column
Punch	H-334	100	demand, by row
Punch	H-336	200	continuous, by row

TABLE III: MAGNETIC TAPE EQUIPMENT

Model	Peak Speed, characters per second	Density, characters per inch	Number of Tracks	Tape Width, inches	Reel Length, feet	Rewind Speed, inches per second	Maximum Number of Drives
H-381	10,000	333	7	1/2	1200	19	12
H-382	30,000	500	7	1/2	1200	120	12
H-581	33,333	333	16	3/4	2400	150	14
H-197	55,000	550	16	3/4	2400	150	14
H-582	66,667	667	16	3/4	2400	150	14
H-3485	83,000 or 120,000*	200/556/800	7	1/2	2400	300	14

*With High-Speed systems only.

The 16-track units provide a dual recording capability that helps to ensure accuracy. The 16 tracks accommodate two sets of 6 data bits, each set having a parity bit and a timing bit. All models except the H-381 and H-581 provide read-after-write checking and automatic rollback on reads. The H-381 and H-382 units include 3, 4, or 6 tape drives per unit.

.36 Typewriter Equipment

The typewriter equipment includes the H-338 Monitor Printer and the H-328 Interrogating Typewriter, either or both of which can be included in a 3010 system.

The Monitor Printer prints at a rate of up to 10 characters per second. The Interrogating Typewriter allows inquiry or control messages to be entered into the system via a keyboard, and prints data from the computer at a rate of up to 10 characters per second.

.37 Line Printers

A maximum of two line printers can be included in a 3010 system. Two different models are available. The H-333 has 120 print positions and prints at a peak speed of 1,000 lines per minute. The H-335 has 160 print positions and prints at a peak speed of 1,070 lines per minute. Both printers offer a print font of 64 characters.

.38 Auxiliary Storage

The H-366 Disc File is available in four models with data storage capacities of 22, 44, 66, and 88 million characters. A maximum of two disc files can be used in a HITAC 3010 system. Average random access time is 105 milliseconds, and peak data transfer rate is 32,000 characters per second.

.39 Simultaneous Operations

Without the optional Simultaneous Mode Control, the HITAC 3010's capability to perform simultaneous operations is limited to rewinding magnetic tapes, advancing forms on the printer, and seeking disc records. The central processor is fully occupied in controlling all I/O data transfer except during short periods at the end of each transfer load.

When the Simultaneous Mode Control is added, any one input or output operation can be overlapped with internal processing. Alternatively, two peripheral units can interleave transfers of data into or out of core memory while processing is suspended.

.4 SOFTWARE

Software for the HITAC 3010 is available in three different versions, for installations in which the program library is held on cards, paper tape, or magnetic tape. In addition to standard subroutines, assembly routines, and diagnostic routines, there is an elementary operating system appropriate for this class of computer, and an integrated program testing procedure.

Software available to facilitate programming, program testing, and operation of the HITAC 3010 system includes the following systems and routines.

.41 Language Translators

- COBOL (based on the COBOL-61 language).
- FORTRAN (based on the FORTRAN II language).
- Assembly System with File Control Processor.
- Report Program Generator.

.42 Service Routines

- Sort program.
- Merge program.
- File maintenance program.
- Program transcriber.
- Consolidata.
- Debugging routines.
- Peripheral routines.

.43 Application Programs

- PERT/TIME.
- Linear programming system.
- Libraries for scientific and technical computations.

.5 PRICE DATA

Price information was unavailable at press time; price data will be included in future issues.

SUMMARY REPORT: HITACHI HITAC 8000 SERIES

.1 BACKGROUND

The HITAC 8000 Series is the third-generation family of central processors, peripheral devices, and supporting software manufactured by Hitachi, Ltd., of Tokyo, Japan. Manufactured under license from the Radio Corporation of America, the HITAC 8000 Series hardware and software is similar in many respects to the RCA Spectra 70 line.

Noteworthy characteristics of the HITAC 8000 Series include:

- The high degree of program compatibility, both upward and downward, among three of the five processor models. Compatibility is also achieved with the IBM System/360 and RCA Spectra 70 processors through similar hardware design and compatible source languages.
- The wide range of input-output and storage devices.
- The numerous arithmetic modes and data forms, and the resulting complexity of machine-language coding.
- The emphasis upon software support through several levels of integrated operating systems.
- Two disc-oriented operating systems for both small-scale and medium-to-large-scale system use.
- The use of true monolithic integrated circuits in the 8210, 8300, 8400, and 8500 processors.
- The availability of optional features that enable certain HITAC 8000 Series processor models to emulate a number of second-generation IBM computers and the Hitachi HITAC 3010 system.

The HITAC 8000 Series was announced in September 1965, and initial customer deliveries were made in March 1966. Approximately 300 of the 8000 Series systems have been delivered to date. Hitachi is currently marketing the HITAC 8000 Series in Japan.

.2 DATA STRUCTURE

The HITAC 8000 Series data structure is identical in all respects with that of the IBM System/360 and the RCA Spectra 70. The basic unit of data storage is the "byte," which consists of eight data bits plus (in most system components) one parity bit. The eight data bits in a byte can represent one alphanumeric character, two decimal digits, or a portion of a binary field.

Bytes can be handled individually or grouped together into fields. A "halfword" is defined as a group of 2 consecutive bytes, or 16 bits. A "word" in the HITAC 8000 Series is a group of 4 consecutive bytes, or 32 bits. A "double word" consists of 2 consecutive words, or 64 bits. The location of any field or group of bytes is specified by the address of its leftmost byte.

Every fixed-length field (halfword, word, or double word) must be located in main storage on an "integral boundary;" i.e., the storage address of the field must be a multiple of the length of the field in bytes.

This restriction is particularly important for efficient operation of the HITAC 8500 processor, which accesses up to four bytes in parallel, and the same restriction has been applied to the smaller processors in order to maintain compatibility. Variable-length (decimal) fields are processed serially by byte in all models, so they may start at any byte location.

At the low end of the HITAC 8000 line of processors, the 8210 and 8200 processors can perform arithmetic operations on two basic types of operands: fixed-point binary and

.2 DATA STRUCTURE (Contd.)

variable-length decimal. The larger HITAC 8000 Series processor models can perform arithmetic operations on four basic types of operands. In addition to fixed-point binary and variable-length decimal, these models can also perform arithmetic operations on two sizes of floating-point binary operands. The basic arithmetic operand size is the 32-bit fixed-point binary word. Most fixed-point instructions can alternatively specify the use of 16-bit halfword operands.

Floating-point numbers can be represented in either a "short" (32-bit) or "long" (64-bit) format. The fractional part occupies 24 bits in the short format and 56 bits in the long format. The hexadecimal character occupies 7 bits in both formats and permits representation of numbers ranging from 10^{-78} to 10^{75}.

Decimal arithmetic is performed upon 4-bit BCD digits packed two to a byte, with a sign in the rightmost four bits of the low-order byte. Decimal operands can be up to 16 bytes (31 digits and sign) in length.

The 8-bit byte structure has certain basic advantages over the 6-bit data format: decimal digits can be packed more conveniently, the standard 7-bit ISO code and the Extended BCD Interchange Code can be used, and today's familiar character sets can be conveniently expanded.

.3 HARDWARE

.31 System Configuration

The HITAC 8000 Series peripheral devices and their controllers are connected to the central processors through input-output channels of various types and capacities. A single multiplexor channel is provided as standard equipment for the 8210, 8300, 8400 and 8500 systems. Selector channels are provided as standard equipment for the 8200 and 8210, and as optional equipment for the larger systems. A selector channel provides direct control of one high-speed input-output operation at a time.

Table I shows the various combinations and capacities of multiplexor and selector channels possible for all HITAC 8000 systems, together with the maximum number of simultaneous I/O operations per system.

.32 Internal Storage

.321 Main core storage

The range of core storage sizes and speeds available with the various HITAC 8000 Series processors is shown in Table II.

The optional storage protection feature can protect the contents of specified 2,048-byte blocks of core storage from being altered as a result of program errors or misguided input data. This feature prevents overwriting by unauthorized programs, but it does not guarantee privacy since any program can still read the contents of any desired portion of core storage.

.322 Auxiliary Storage

Six different models of auxiliary storage devices are available in the form of magnetic drums, discs, and cards. All except the H-8566 Drum Memory Unit use interchangeable cartridges. The storage capacities of these devices range from 400,000 bytes for a small-capacity disc drive to over 530 million bytes for the magnetic-card mass storage unit. Similarly, average access times range from 8.6 milliseconds to 488 milliseconds.

Table III lists the various HITAC 8000 Series auxiliary storage devices with their principal functional characteristics. The H-8564, H-8568, H-8566, and H-8577 can be used with the HITAC 8300, 8400, and 8500 processors; the single controller used for all these storage devices allows an installation to tailor its complement of storage devices to satisfy its specific capacity and access-time requirements. The H-8564-21, H-8564-12, and H-8564-11 Disc Storage Units can be used only with the HITAC 8210 processor. No auxiliary storage devices can be used with the HITAC 8200 processor.

.33 Central Processors

Five processor models currently form the nucleus of the HITAC 8000 Series. Three of the processor models — the 8300, 8400, and 8500 — are program-compatible and suitable for a broad range of business and scientific applications. The 8200, with its restricted

TABLE I: HITAC 8000 SERIES INPUT-OUTPUT CHANNEL COMBINATIONS

Standard Channel Complement	Processor Model				
	8200	8210	8300	8400	8500
Selector Channels —	1	1	0	0	0
Trunks per channel	6	2	-	-	-
Number of simultaneous data transfer operations	2	1	-	-	-
Multiplexor Channels —	0	1	1	1	1
Trunks per channel	-	6	8	9	9
Number of simultaneous data transfer operations	-	20	192	256	256
Fully Expanded Channel Complement	**Processor Model**				
	8200	8210	8300	8400	8500
Selector Channels —	1	1	2	3	6
Trunks per channel	6	2	2	2	4
Number of simultaneous data transfer operations	2	1	2	3	6
Multiplexor Channels —	0	1	1	1	1
Trunks per channel	-	6	8	9	15
Number of simultaneous data transfer operations	-	20	192	256	1024
Combined total of possible simultaneous data transfer operations	2	21	194	259	1030

TABLE II: HITAC 8000 SERIES MAIN CORE STORAGE CHARACTERISTICS

Core Storage Capacity, Bytes	8200	8210	8300	8400	8500
4,096	8200-4	—	—	—	—
8,192	8200-8	8210-8	—	—	—
16,384	8200-16	8210-16	8300-16	—	—
24,576	—	8210-24	--	—	—
32,768	—	8210-32	8300-32	—	—
65,536	—	—	8300-65	8400-65	8500-65
131,072	—	—	—	8400-131	8500-131
196,608	—	—	—	8400-196	—
262,1444	—	—	—	8400-262	8500-262
393,216	—	—	—	—	8500-393
524,288	—	—	—	—	8500-524
Cycle Time, μsec	2.0	1.4	1.44	1.44	0.84
Bytes Accessed per Cycle	1	1	2	2	4
Effective Cycle Time per Byte, μsec	2.0	1.4	0.72	0.72	0.21

.33 Central Processors (Contd.)

instruction repertoire, is best suited for use as a satellite system for the larger HITAC 8000 Series processors. The 8210 also has a limited instruction repertoire, but its expanded throughput capability for disc-oriented applications makes it suitable for certain single-processor installations.

Comparative arithmetic execution times for the various HITAC 8000 processors are illustrated in Table IV.

.33 Central Processors (Contd.)

The remainder of this discussion of central processors concerns itself exclusively with the HITAC 8300, 8400, and 8500 models. These processors are designed to be compatible with the IBM System/360 computer. They offer the full System/360 instruction repertoire except for the "Test and Set" and "Privileged" instructions, which are normally reserved for operating system use and are not used in users' programs. Thus, HITACHI expects to achieve two-way System/360 program compatibility — to a limited extent at the machine-language level and to a much greater extent at the assembly, COBOL, and FORTRAN language levels.

The HITAC 8000 Series processors contain facilities for addressing main storage, for fetching and storing information, for executing stored-program instructions in the desired order, for arithmetic and logical processing of data, and for initiating all communication between main storage and peripheral devices. Each program uses sixteen 32-bit general registers and four 64-bit floating-point accumulators or as index registers. These registers are contained in a 128-word scratchpad memory in the HITAC 8400 and 8500 processors. In lieu of scratchpad memory, the HITAC 8300 processor provides 128 words of additional core storage for use equivalent to that of scratch-pad memory. Different parts of these memory units are used as the operational registers, depending upon which processor state is being used.

Instructions can be two, four, or six bytes in length. Main storage addresses are formed by adding a 12-bit "displacement" contained in the instruction to a 24-bit "base address" contained in one of the 16 general registers. The addresses in many instructions (including most binary arithmetic and logical instructions) can be further modified by adding a 24-bit "index" contained in another general register; this effectively provides a double indexing capability. The base-register technique of address formation facilitates program relocation and segmentation, at the expense of increased programming complexity.

TABLE III: HITAC 8000 SERIES AUXILIARY STORAGE UNITS

Device	Capacity Range, (millions of bytes per control unit)	Average Access Time, msec	Data Transfer Rate bytes/sec
H-8566 Drum Memory Unit	1.6 to 6.4	8.6	210,000
H-8577 Mass Storage Unit	233.4	87.5	312,000
H-8564 Disc Storage Unit	7.25 to 58.0	87.5	156,000
H-8568 Mass Storage Unit	536.9 to 4,295	488	70,000
H-8564-12 Disc Storage Unit*	2.56 to 5.12	72.5	156,000
H-8564-11 Disc Storage Unit*	5.12 to 10.24	87.5	156,000
H-8564-21 Disc Storage Unit*	5.12	87.5	156,000

*Usable only with the HITAC 8210 processor.

The basic arithmetic mode of the HITAC 8300, 8400, and 8500 processors is fixed-point binary, using 32-bit operands and two's complement notation. Most instructions can alternatively specify the use of 16-bit "halfword" operands to improve storage utilization. Most products and all dividends are 64 bits long. Fixed-point arithmetic and comparison instructions specify one operand in a general register and a second operand in either main storage or a general register; these instructions are four bytes long when they specify an operand address in main storage and two bytes long when both operands are in registers.

The System/360-compatible instruction set includes instructions which perform fixed-point arithmetic, comparison, branching, moving, loading, storing, shifting, radix

.33 Central Processors (Contd.)

conversion, code translation, packing, unpacking, and Boolean operations. The radix conversion operations perform automatic conversions between signed, packed decimal fields up to 15 digits in length and 32-bit signed binary integers. The code translation instruction uses a table to translate any 8-bit data code to any other 8-bit code. The packing and unpacking instructions convert numeric BCD data between the one-character-per-byte format used in most input-output devices and the two-digits-per-byte format used for decimal arithmetic.

The decimal arithmetic facility provides additional instructions for addition, subtraction, multiplication, division, comparison, and editing of decimal numbers. Decimal arithmetic is performed upon 4-bit BCD digits packed two to a byte, with a sign in the rightmost four bits of the low-order byte. Decimal operands may be up to 16 bytes (31 digits and sign) in length. The length of each decimal field is specified in the instruction referencing it. Two-address (6-byte) instructions of the storage-to-storage type are used for all decimal operations; the general and floating-point registers are not utilized.

The floating-point arithmetic facility provides additional instructions for addition, subtraction, multiplication, division, loading, storing, and comparison of both "short" (32-bit) and "long" (64-bit) floating-point numbers. Floating-point instructions specify one operand in a floating-point register and a second operand in either main storage or a floating-point register.

Following are the five basic instruction formats:

- Type RR — Register to Register (2 bytes)

Op	R_1	R_2

- Type RX — Register to Indexed Storage (4 bytes)

Op	R_1	X_2	B_2	D_2

- Type RS — Register to Storage (4 bytes)

Op	R_1	R_3	B_2	D_2

- Type SI — Storage and Immediate Operand (4 bytes)

Op	I	B_1	D_1

- Type SS — Storage to Storage (6 bytes)

Op	L_1	L_2	B_1	D_1	B_2	D_2

B = 4-bit base register specification
D = 12-bit displacement
I = 8-bit literal operand
L = 8-bit operand length specification
Op = 8-bit operation code
R = 4-bit operand register specification
X = 4-bit index register specification

.34 Input-Output Equipment

A fairly wide range of conventional input-output units is available for the HITAC 8000 Series computer family. These units and their capabilities are summarized in Table V.

.35 Data Communications Equipment

The Communications Controller Multichannel (CCM), usable with the 8300, 8400, and 8500 processors, terminates from 1 to 48 communications lines serving a wide variety of remote terminals. Each of the 1 to 48 scan positions requires a communications buffer, and in some cases a data set, to interface with the communications line. The CCM is connected to a HITAC 8300, 8400, or 8500 computer by one trunk of the multiplexor channel. Each scan position of a CCM uses one multiplexor subchannel.

TABLE IV: ARITHMETIC EXECUTION TIMES FOR THE HITAC 8000 SERIES PROCESSORS

Task	Processor Model				
	8200	8210	8300	8400	8500
Fixed Point Binary					
c = a + b	88	65.88	51.36	25.20	4.48
c = ab	#	#	140.64	81.96	9.41
c = a/b	#	#	232.44	111.21	14.18
Fixed Point Decimal					
c = a + b	88	63.51	63.12	35.28	15.64
c = ab	#	415.6	340.15	119.9	31.32
c = a/b	#	647.8	731.16	203.03	45.93
Floating Point — Short					
c = a + b	#	#	79.17	37.44	7.10
c = ab	#	#	182.08	67.66	11.62
c = a/b	#	#	391.52	101.24	15.02
Floating Point — Long					
c = a + b	#	#	116.87	52.65	9.69
c = ab	#	#	465.09	211.51	24.49
c = a/b	#	#	1218.21	305.23	40.85

NOTE: All times are expressed in microseconds. The fixed-point decimal times are based on 5-digit (3-byte) decimal operands. The floating-point times are based on both the short-form (32 bits) and the long-form (64 bits) binary operands. The 8200 and 8210 do not require programmer-initiated operand movement to a fixed accumulator register. The symbol "#" indicates that the facility is not available.

TABLE V: HITAC 8000 SERIES INPUT-OUTPUT UNITS

Unit	Peak Speed	Processor Models to Which Unit Can be Connected	Comments
H-8239-11 Card Reader/Punch	400/91 cpm	8200 through 8500	
H-8239-21 Card Reader	400 cpm	8200 through 8500	
H-8239-31 Card Punch	91 cpm	8200 through 8500	
H-8233 Card Reader	750 cpm	8200 through 8500	
H-8238 Card Reader	1,470 cpm	8200 through 8500	
H-8234 Card Punch	100 cpm	8200 through 8500	
H-8235 Card Punch	250 cpm	8200 through 8500	
H-8226-1 Paper Tape Reader	500 cps	8210 only	
H-8227-1 Paper Tape Punch	110 cps	8210 only	
H-8229-22 Paper Tape Reader/Punch	200/100 cps	8210 only	
H-8221 Paper Tape Reader/Punch	200/100 cps	8200 through 8500	
H-8222 Paper Tape Reader/Punch	1,000/100 cps	8200 through 8500	
H-8244 Printer	300 lpm	8210 only	63 or 110 character print drum
H-8245 Printer	600 lpm	8200 through 8500	63 or 110 character print drum
H-8246 Printer	1,250 lpm	8200 through 8500	63 or 110 character print drum
9-track Magnetic Tape Units (H-8432/8442/8445)-800 bpi density	30,000, 60,000 120,000 byte/sec.	8200 through 8500	7-track adapters available
9-track Magnetic Tape Units (H-8451/8453)-1600 bpi density	60,000, 120,000 byte/sec.	8200 through 8500	800 bpi adapters available

.36 Simultaneous Operations

A HITAC 8000 Series central processor (except for models 8200 and 8210) can concurrently execute:

- One machine instruction;
- Up to eight high-speed input-output operations (one per selector channel); and
- Multiple slower input-output operations via a multiplexor channel.

(Contd.)

.36 Simultaneous Operations (Contd.)

Table I shows the mix possibilities and simultaneous operations capabilities of the various HITAC 8000 Series input-output channels.

In general, the relationships between HITAC 8000 Series peripheral devices and input-output data channels are determined at installation time and cannot be altered under program control except by the inclusion of special optional features. Since it is not normally possible to assign by program any free channel to any available peripheral device, the number of input-output operations that can actually occur simultaneously may in many cases be considerably fewer than the theoretical maximum. However, special features are available to switch a limited number of devices to free data channels under program control.

.4 SOFTWARE

Seven levels of programming systems and operating systems are supplied by Hitachi for the HITAC 8000 Series: 8200 Programming System, 8210 Disc-Oriented Programming System (DOPS), Primary Operating System (POS), Tape Operating System (TOS), Tape/Disc Operating System (TDOS), Disc Operating System (DOS), and Extended Disc Operating System (EDOS). The 8200 programming system, DOPS, TOS, TDOS, and DOS are already in use, and EDOS is scheduled to be released during 1970. Since the original announcement of the HITAC 8000 Series, Hitachi has greatly improved its standard software by adding "third-generation" software facilities such as disc-oriented control systems, disc file language facilities, automatic on-line file management techniques, and comprehensive data communications control routines.

POS, TOS, TDOS, DOS and EDOS are applicable to HITAC 8300, 8400 and 8500 systems. POS requires a minimum of 32,768 bytes of core memory; and TOS, TDOS, DOS and EDOS require at least 65,536 bytes of core memory. Multiprogramming control for up to six jobs is provided for HITAC 8000 Series systems that have at least 65,536 bytes of core memory. DOS-II is an enhanced version of DOS that provides improved throughput capabilities especially for large-scale, on-line real-time use.

.41 Programming System

The 8200 programming system provides an assembler, RPG, COBOL, FORTRAN, tape sort/merge and a set of service routines. This software system makes the 8200 suitable for magnetic-tape-oriented data processing applications and for use as a satellite with larger HITAC 8000 Series systems.

.42 Disc-Oriented Programming System (DOPS)

The 8210 Disc-Oriented Programming System provides an assembler, RPG, COBOL, FORTRAN, POPS, tape sort/merge, disc sort/merge, control programs, and a set of service routines. Control programs consist of master control, program loader, physical IOCS and logical IOCS. A minimum of 8192 bytes of core memory and one disc drive are required for use of DOPS. Multiprogramming control for up to two jobs is provided for HITAC 8210 system and this requires at least 24,576 bytes of core memory.

POPS (Problem Oriented Programming System) is characterized by its capability for on-line updating of multiple files based on simulations data input from several local typewriters. A batch program and a real-time program are executed simultaneously by a roll-in/roll-out controller included in the POPS control.

.43 Primary Operating System (POS)

The Primary Operating System, for use with the HITAC 8300, 8400, and 8500 systems, is a magnetic-tape-oriented software system that provides basic supervisory control for the sequential execution of programs, interrupt control, and input-output control, as well as a COBOL compiler, FORTRAN compiler, assembler, report program generator, and standard utility routines.

POS COBOL is a subset language of full COBOL 65, and POS FORTRAN is a subset of FORTRAN IV. Both require 32,768 bytes of core storage and four magnetic tape units. No routines are supplied for the automatic control of these devices. They can be programmed in assembly language. The only forms of multiprogramming supported by POS and the HITACHI-provided Peripheral Control Routine, which permits concurrent operation of up to three data transcription routines.

.44 Tape Operating System (TOS)

The second major level of HITAC 8000 Series software support for the 8300, 8400, and 8500 systems is designated the Tape Operating System (TOS). TOS is a magnetic-tape-oriented integrated software package that provides supervisory control programs, language processors, and utility programs for installations that have a minimum hardware configuration of 65,536 bytes of core storage, five magnetic tape units, console typewriter, card reader, and line printer. The facility to control multiprogrammed operation of up to six programs concurrently is the primary feature of TOS software.

The basic TOS executive program requires a minimum of 16KB of core storage. The Monitor program that coordinates the operations of stacked-job processing requires an additional 4KB, and the File Control Processor for input-output device and file control requires another 4KB to 8KB of core storage.

Although the theoretical maximum number of problem and control programs that can be processed concurrently is six, the actual limit will frequently be fewer than six, limited by the amount of available core storage and the number of available peripheral devices. As many as five magnetic tape units can be dedicated to system control and library functions when processing in a stacked-job multiprogramming environment.

In addition to a comprehensive assembly system, TOS offers a COBOL language similar to IBM's Operating System/360 COBOL F, as well as full-scale FORTRAN IV language that includes all Operating System/360 FORTRAN IV facilities.

.45 Tape/Disc Operating System (TDOS)

Hitachi's Tape/Disc Operating System (TDOS) is an improved and extended version of its Tape Operating System (TOS). In addition to all TOS software facilities, TDOS offers options that permit system control routines, problem programs, and library subroutines to reside on either the H-8564 disc or H-8566 drum unit in order to improve the system throughput capabilities. As a result, TDOS offers more efficient multiprogrammed operations than does the tape-oriented Tape Operating System. Also, with TDOS the number of Job Control Language statements required to prepare and compile object programs is reduced, increasing the efficiency of program preparation.

Another significant addition to the TDOS software package is a comprehensive set of input-output routines for control of data communication devices. This communications package, called the Multichannel Communication Program (MCP) offers most of the same facilities as the IBM System/360 Queued Telecommunications control. The MCP system can accept remote messages either as they are entered or as polled, in contrast to the polled-only acceptance technique of QTAM.

The minimum HITAC 8000 Series core storage requirements for use of TDOS remains at 65KB, of which 17KB is permanently reserved for the Executive. Both the Executive Monitor and the optional data communications package require 4KB of storage. The Monitor, however, is a transient routine and does not require permanent residence in core; the data communications control routines are permanently resident.

.46 Disc Operating System (DOS)

The Disc Operating System (DOS) is an improved and extended version of the Tape/Disc Operating System (TDOS). In addition to providing all TDOS software facilities, DOS is a disc-oriented operating system designed mainly to:

- Improve throughput capabilities in on-line,
- Reduce operator intervention in handling magnetic tape; and
- Reduce the system use of magnetic tape units.

DOS includes several functional additions to TDOS: catalogued procedures, roll-in/roll-out, disc seek prefetch function, device interchangeability between low-speed I/O or magnetic tape units and disc drives, and a disc sort/merge generator. A catalogued procedure permits the cataloguing and retrieval of a job stream or a set of run-time control parameters from a disc file. Roll-in/roll-out permits temporary storage of lower-priority programs in a disc area. For stacked-job processing controlled by the Monitor, the device interchangeability function can be extended to higher-level languages such as COBOL and FORTRAN. The minimum core storage requirement for use of DOS remains at 65KB, of which 19KB are permanently reserved for the Executive.

.46 Disc Operating System (DOS) (Contd.)

Throughput in on-line, real-time applications can be improved by using DOS-II, which can control up to 15 users' tasks. The multitask control function is designed to enable a specific user program to process a maximum quantity of input data per unit time interval. DOS-II is an improved version of the DOS Executive and FCP, and it uses the same lan- language processors, utility routines, library maintenance routines, and initializers as DOS. FCP is a re-enterable routine, permitting simultaneous use of one copy of the program by a number of tasks. Although DOS-II is designed for use with as little as 65KB of core storage, more storage is recommended for efficient use of the multitask control feature.

.47 Extended Disc Operating System (EDOS)

The Extended Disc Operating System is an enhanced and extended version of the Disc Operating System (DOS). In addition to all the DOS software facilities, EDOS offers the following:

- Multi Job Stream

  Three batch programs or two batch programs and one on-line program can be operated under multiprogramming with all the batch programs executed under job stream.

- Input Job Stack

  Multiprogramming can be carried out effectively as all jobs are executed after being stacked in discs or drums.

- Output Job Stack

  Results of three multi job streams are temporarily stored in discs or drums and then output to line printer or card equipment according to priority.

- Job schedule

  Jobs can be executed according to a sequential job schedule and also according to a priority job schedule.

- Job accounting

  Logging facilities of job accounting, such as processor time of a job, input-output device usage time, and the like are provided.

The basic control program of EDOS requires 10,240 bytes of memory. EDOS is compatible with TOS, TDOS and DOS and fully compatible with the latter two on an object level.

.5 COMPATIBILITY

.51 Program Compatibility Within the HITAC 8000 Line

There is a high degree of program compatibility, in both the upward and downward directions, among the HITAC 8300, 8400, and 8500 models. Among these three models, any valid program that runs on configuration A will run on configuration B and produce the same results if:

- Configuration B includes the required amount of main storage, the same or compatible input-output devices, and all required special features; and

- The program is independent of the relationships between instruction execution times and input-output rates.

These limitations indicate that there will be a high degree of effective upward compatibility, making it easy to expand an installation, but that the concept of downward compatibility will be useful mainly in making possible the common use of subroutines and software, rather than in making it feasible to "shrink" an installation as its workload decreases or to back up a large computer with a smaller one.

Although the HITAC 8200/8210 instruction repertoire is a subset of that for the larger processors (except for input-output instructions and address modification instructions), the different software system designs restrict the compatibility of the 8200 and 8210 with the larger 8000 Series systems. Some program conversion is required before an assembly-language source program written for an 8200 or 8210 can be run on an 8300, 8400, or 8500 System.

.52 Program Compatibility with the IBM System/360

Hitachi provides, through its HITAC 8000 Series source languages, program compatibility with the IBM System/360. The HITAC 8000 COBOL and FORTRAN languages are in many cases identical with their System/360 counterparts. Furthermore, since the instruction repertoire of the large HITAC 8000 Series processors is virtually identical with that of the corresponding IBM processors, Hitachi has been able to develop System/360 program compatibility at the assembly-language level as well. The differences in the "privileged" instructions, however, make it impossible to run machine-language System/360 on a HITAC 8000 system, program recompilation or reassembly is always required. In many cases, the System/360 operational control cards can be retained and used directly in the HITAC 8000 program input stream.

When the HITAC 8000 software was first delivered during 1966, the lack of source-language-level support of random-access storage devices was a significant limitation in comparison to IBM System/360 software. Hitachi has since developed COBOL and RPG software with capabilities for directly controlling random-access devices. A FORTRAN compiler with similar capabilities is presently under development.

.53 Program Compatibility with the HITAC 3010 System

The optional 3010 Emulator feature offers a high degree of compatibility between the HITAC 8000 Series and Hitachi's second-generation HITAC 3010 system.

.54 Program Compatibility with Second-Generation IBM Computers

HITACHI offers a series of Emulator features that enable certain models of the HITAC 8000 Series to run object programs written for certain second-generation IBM computer systems. The IBM computers whose programs can be run by the various HITAC 8000 systems (when properly equipped) are as follows:

HITAC 8000 System	Systems Emulated	Release Dates
HITAC 8300	IBM 1401/1460	now in use
HITAC 8400	IBM 1401/1460	now in use
	IBM 1410/7010	now in use

Emulation, in general, requires a HITAC 8000 system with an equivalent array of peripheral equipment, more processing power, and more core storage than the second-generation system to be emulated. The functions of most of the common peripheral devices (e.g., card readers, card punches, printers, magnetic tape units, and console typewriters) can be emulated, but the less common devices (e.g., optical and magnetic character readers, paper tape units, data communications devices, and random-access storage devices) cannot be emulated. Time-dependent programs and programs not written in accordance with IBM programming manuals, when emulated, may yield results which differ from those obtained in the original system; the handling of many console operations and error conditions will differ; and a variety of specific program restrictions and limitations apply to each Emulator feature. Nevertheless, most users of second-generation IBM computers will be able to run most of their programs on a HITAC 8000 system with little or no need for immediate reprogramming.

The principal value of the Emulator features is that they enable users of second-generation IBM computers to spread the task of reprogramming for the HITAC 8000 system over an extended period of time. In nearly every case, the emulation mode involves additional equipment costs and falls short of fully utilizing the performance capabilities of the HITAC 8000 system. Therefore, for maximum efficiency, most users will want to recode all of their principal applications for the HITAC 8000 system as soon as possible. The cost of the additional core storage and of the optional features required for emulation must be borne until all of the user's programs have been recorded.

.6 PRICE DATA

Pricing information was unavailable at press time; price data will be included in future issues.

SUMMARY REPORT: NIPPON ELECTRIC NEAC-SERIES 2200

.1 BACKGROUND

The Nippon Electric Company (NEC) was originally founded as a Japanese manufacturer of telephone equipment, and has since extended its interests to cover a wide range of communications and other electronic equipment. Nippon first entered the computer field in 1957, and currently claims to have the largest share of the Japanese domestic computer market of any single manufacturer. Few Nippon computers are sold outside Japan.

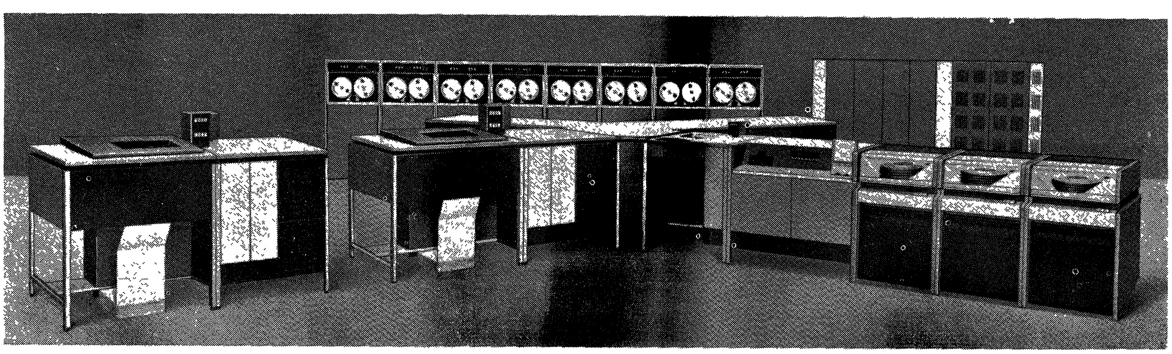
Nippon has a licensing agreement with Honeywell EDP in the United States. Software development by the two companies tends to be a joint effort, while the hardware developments of the two companies are complementary, with each company benefitting from the work of the other.

The NEAC-Series 2200 is similar to the Honeywell Series 200. The NEAC-Series 2200/50 was developed by Nippon and is similar to the Honeywell 110, the smallest member of the Honeywell Series 200 — since it has different peripherals from the other machines in the family, it is discussed separately in Report I576. The NEAC-Series 2200 models discussed here are the Models 100, 200, 300, 400 and 500, of which the Models 100 through 400 correspond to the Honeywell 120 through 2200. The NEAC-Series 2200/500 has roughly the same capabilities as the Honeywell 3200. Recently, Nippon announced the NEAC-Series 2200/700, which will be discussed in a future Report.

Nippon tends to act as a supplier of complete systems, with a heavy emphasis on communications. At their Tokyo data center, Nippon has NEAC-Series 2200/50, /100, /400 and /500 — a NEAC-Series 2200/500 is being used for time-sharing at Osaka University.

Noteworthy characteristics of the NEAC-Series 2200 include:

- The high degree of program compatibility, both upward and downward, among all processor models. NEAC-Series 2200 processors are designed according to the "Liberator" concept, which allows the users of various competitive systems, e.g., the IBM 1400 series, to use automated, one time translation of programs for execution ot higher-performance NEAC-Series 2200 systems.
- The wide range of input-output and storage devices.
- The emphasis upon software support through several levels of integrated operating systems.
- The use of true monolithic equipment with a "storage protect" capability which shields the contents of one or more designated memory areas against accidental alteration by unrelated programs.



NEAC-Series 2200/500 Installation.

.1 BACKGROUND (Contd.)

Information is stored in main memory locations either in pure binary form as 6-bit alphanumeric characters, or as signed decimal quantities. Parity checking in each character position is automatic. Any number of consecutive locations can be grouped to form fields; groups of consecutive fields can be delineated as items. Fields and items are defined, respectively, by word marks which resemble those used in the IBM 1400 Series.

There are no reserved input/output areas in main memory — this allows both a high degree of programming flexibility and economical usage of main memory.

NEAC-Series 2200 processors have available a repertoire of instructions which, with tremendous flexibility and power derived from the use of variant characters, can handle arithmetic, logical, control, editing, and input/output functions necessary for business data processing. Also included in all processors are instructions for handling peripheral and communication interrupts and for manipulating data in codes of up to 12 levels.

The NEAC-Series 2200 is based upon an improved version of the original NEAC-2200 system which was first delivered in 1964. The NEAC-Series 2200 was first announced in May 1965. The 400 processor was delivered in October 1966 and the 100 and 500 in November 1966. Delivery of the first 300 system was in 1967.

NEAC-Series 2200 processors contain high speed memories, modular memory capacities, powerful instructions, efficient addressing methods and suitable input/output facilities to afford simultaneity of operations, as well as high level computing power. All processors are equipped with:

- Direct, indexed, and indirect addressing
- 2 to 4 character address interpretation
- Program assignable read/write channels
- Automatic program interrupt
- Multi-level code handling facility

NEAC-Series 2200 systems rentals range from approximately $800 to $55,500 per month.

.2 HARDWARE

.21 Central Processors

Five central processors currently form the nucleus of the NEAC-Series 2200. It is considered that these processors Models 100, 200, 300, 400, and 500 span a range equivalent to that spanned by the IBM System/360, Models 20 through 60. Table I summarizes the basic characteristics and capabilities of the NEAC-Series 2200. Comparative arithmetic times for the various Series 2200 processors are illustrated in Table II.

Instructions are variable in length. The basic instruction format consists of an operation code which specifies the type of operation to be performed, two operand fields which specify the binary addresses of fields to be used in the operation and a variant character. The variants are used to expand the meaning of the operation code or to specify literally a piece of data to be used in the operation.

Multiply and divide operations are standard in all processors except Model 100. Models 300 and 400 can be equipped with a floating point arithmetic facility for use in scientific applications; floating point operations are standard on the Model 500.

.22 Working Storage

Main memory cycle times range from 2 microseconds to 188 nanoseconds per 6 bit character and control memory cycle times from 500 nanoseconds to 188 nanoseconds.

The speeds of NEAC-Series 2200 memories are complemented by the wide range of storage capacities available at each speed level. Memory size in the Model 100 processor ranges from 2,048 to 32,768 six bit characters. At the other end of the scale, the Model 500 processor is available with 65,536 to 524,288 character memories. The modularity of the NEAC system is exemplified by the relatively small increments in which main memory can be expanded.

.22 Working Storage (Contd.)

All NEAC-Series 2200 main memory locations are directly addressable. Three additional features facilitate advanced programming and addressing of large memories — indexed and indirect addressing and variable-length address interpretation.

Six main memory index registers are provided in configurations having 32,768 or fewer storage locations; larger memories are equipped with 30 index registers. Indirect addressing enables the user to reference stored information via one or more intermediary addresses. Variable length address interpretation allows instructions of either two-character, three-character or four-character addresses.

.23 Input-Output

NEAC-Series 2200 processors possess several features which enable them to provide simultaneity which is powerful but easy to use; program assignable read/write channels, multiple input/output trunks, and an interrupt processing facility.

The use of program-assignable read/write channels enables NEAC-Series 2200 processors to compute while concurrently servicing from 3 (Model 100) up to 16 (Model 500) input/output operations. In addition, Series 2200 processors provide facilities for interfacing with a large number of peripheral controls, ranging from a possible 11, in the case of the Model 100, up to 64 in the Model 500. The high internal speeds of these processors insure that when simultaneity is fully exploited, the demands to service peripheral devices will still be satisfied. That this capability does not depend upon complex software or expanded system configurations is more significant.

The basic Model 100 processor is equipped with integrated controls for a 500 line per minute printer, a 400 card per minute card reader, a punch which processes cards at rates from 100 to 400 per minute, a 300 frame per second paper tape reader, and a paper tape punch which punches at the rate of 60 frames per second. The card devices can be separate or combined as a reader-punch. Up to four non-simultaneous magnetic tape units with a tape speed of 24 inches per second can be connected to the basic Model 100 processor. All other peripheral controls are connected to NEAC-Series processors via input/output trunks. The number of such trunks available in a processor ranges from 11 in the Model 100 to 64 in the Model 500. A control unit which handles both reading and writing (for example, a magnetic tape control) connects to a pair of trunks. The number of peripheral controls possible in a system depends on the number of input/output trunks available.

TABLE I: PRINCIPAL CHARACTERISTICS OF NEAC-SERIES 2200 PROCESSORS

Processor Model	Main Memory Speed (Cycle Time)	Memory Capacity (Thousands of Characters)	Number of Input/Output Trunks	Number of I/O Operations Simultaneous With Computing	Advanced Programming Instructions	Financial Edit Instruction	Multiply and Divide Instructions	Scientific Processing Instructions	Memory Protect Facility
100	2 μsecs. per character	2 to 32	5 to 11	2 or 3	Optional	Optional	*	*	*
200	2 μsecs. per character	4 to 65	8 to 16	3 or 4	Optional	Optional	Standard	*	*
300	1.5 μsecs. per character	16 to 131	16	4	Standard	Standard	Standard	Optional	Optional
400	1 μsec. per character	16 to 262	16 to 32	4 to 8	Standard	Standard	Standard	Optional	Optional
500	1.5 μsecs per 8 characters	65 to 524	32 to 64	8 to 16	Standard	Standard	Standard	Standard	Optional

*Feature not available on this model

Data is transferred between main memory and a trunk (and thus a peripheral device) via a read/write channel assigned by the instruction which initiates the transfer. A read/write channel is a data path across an interface between memory and a peripheral device. Whenever an input-output operation is to be performed, a program-assigned read/write channel completes the path between the required peripheral device and the main memory.

The degree of peripheral simultaneity achievable by any NEAC-Series 2200 processor depends upon the number of read/write channels with which it is equipped. Standard equipment of the Model 100 processor includes three read/write channels, of which any two can be active at one time. The simultaneous use of the third channel is available with feature N1016, an auxiliary read/write channel.

.23 Input-Output (Contd.)

Sixteen read/write channels are available in the Model 500, allowing up to sixteen input and output operations, in any combination, to go on at the same time as internal processing. In order to appreciate the power of the read/write channel concept, consider the following statistics: In one minute, a NEAC-Series 2200 system equipped with a Model 200 processor having four read/write channels can:

- Read 800 cards;
- Punch 10 columns of data into 400 cards;
- Print 950 lines of 120 characters each; and
- Read or write 4,360 tape records of 500 characters;

(or perform any combination of four I/O operations) and, in the same minute, execute 1.25 million instructions.

The NEAC-Series 2200 automatic program interrupt facility provides supervision of processing involving combinations of input-output operations and computing. This facility allows automatic branching between a main program and service routines for all I/O devices. The automatic hardware interrupt has important applications in the field of data communications and other real time areas.

The NEAC-Series 2200 interrupt processing facility consists of a hardware program interrupt, which signals a condition in an input-output control unit, and a set of instructions used in processing interrupts. An interrupt occurs whenever a peripheral device has completed an input-output operation. Interrupts from particular peripheral controls can be inhibited by a program as necessary.

A program interrupt is accompanied by:

- Automatic storing of main indicator values, control register contents, and an indication of interrupt source; and
- Automatic branching to a routine whose address was previously loaded into a special control memory register.

Only a single instruction is necessary to resume the main program at its point of interruption and to restore all main program indicators and control registers to their previous values.

A major feature of the structural design of NEAC-Series 2200 processors is the use of integrated system modules. Each module contains all the circuitry required for a particular system's functions; for example, one module contains all the printer control circuitry. This modularity simplifies the expansion of a system; in many cases, expansion involves little more than plugging in additional modules. Reliability within each module is enhanced by the use of silicon semiconductors as well as the latest advances in monolithic integrated circuits.

.3 CONSOLE EQUIPMENT

The Model N220-3 console is a control and communication center for the central processor of the NEAC-Series 2200 System. It can be located up to ten feet away from the central processor and is connected by two input-output trunks.

The console is a free-standing cabinet in which are housed a console typewriter, a basic control panel, and a logic area. The control panel contains the main power switches, check condition indicator lights and certain basic operator controls; it also contains 4 to 8 sense switches which allow the operator to change program flow. The console typewriter transmits and records instructions and data between the operator and the computer and is used to perform most of the system control operations.

The console typewriter can perform peripheral input/output operations, control operations and logging operations. As a peripheral device, the typewriter can type messages from a program, or, under program control, enter parameters into memory from the keyboard. As a logging device, the keyboard is used as a standard typewriter without affecting the contents of memory or systems operation.

Two programmed peripheral data transfer instructions are required to enter a parameter into memory — an output instruction requesting a parameter and an input instruction which specifies to the console logic the data input area to be used. The second instruction activates the TYPE light on the console allowing as many characters to be typed as are needed to fill the input area.

(Contd.)

.3 CONSOLE EQUIPMENT (Contd.)

Carriage return, vertical movement of the paper, and single line spacing are controlled by the CARRIAGE RETURN key or a parameter in the first instruction given. Vertical spacing is three or six lines per inch; horizontal spacing is ten characters to the inch.

The console can be used for manual intervention in the system's operation. Certain keys (0-7, A, B, L, P, R, S) and the space bar perform the following control functions:

- Loading and interrogation of main and control memory;
- Bootstrapping;
- Register dumping;
- Central clearing;
- Logging;
- Stepping one instruction; and
- Initialization.

.4 PERIPHERAL EQUIPMENT

.41 Card Equipment

NEAC offers an array of punched card equipment for use on 2200 systems. These units incorporate such features as endfeed card processing, demand feeding, automatic translation between the 12-bit Hollerith card code and NEAC central processor code, and transcription mode reading and punching.

Two devices are offered for use in Series 2200 systems to optically read 80 or 51 column punched cards; a 400 card per minute reader, Model N123, available only with Model 100 and an 800 card per minute reader, Model N223.

NEAC provides three models of card punches: the N214-1 operates at 400 cards per minute, the N224A-1 at 100 cards per minute, and the N224A-2 at 250 cards per minute.

TABLE II: ARITHMETIC EXECUTION TIMES FOR THE NEAC-SERIES 2200 PROCESSORS

TASK	Execution Time In Microseconds for Processor Model				
	100	200	300	400	500
Fixed Point					
c = a + b	123	84	61.5	43	12
c = ab	3100(s)	500	363	216.5	96.2
c = a/b	3700(s)	1134	850.5	612.5	196.5
Floating Point					
c = a + b	n/a	n/a	34.5*	26*	6
c = ab	n/a	n/a	46.5*	32*	12
c = a/b	n/a	n/a	51 *	45*	21

* With optional equipment.
(s) Using subroutine.
n/a not available.

There is also available a card reader/punch, the N214-2 with speeds up to 400 cards per minute. This dual-purpose device has three operational modes; it reads, punches or reads a card and punches additional information into the card on the same pass.

Table III contains a summary of the characteristics of all card processing equipment available.

TABLE III. SUMMARY OF NEAC-SERIES 2200 CARD EQUIPMENT CHARACTERISTICS

	Card Reader		Card Punch			Card Reader/Punch
	N123	N223	N214-1	N224A-1	N224A-2	N214-2
Speed, cards/min.	400	800	100 to 400	100	250	100 to 400
Simultaneity	The central processor, regardless of model, is free to perform other data transfers or computing during at least 99% of a card device's transfer interval.					
Programmed Operations	Read data and transfer to specified memory area on error card, offset-stack cards or go busy.		Punch data from specified memory area			Punch data from specified memory area, read data and transfer to specified memory area, read/punch same card
Data Transfer Mode*	Automatic translation between Hollerith card and 6-bit central processor code is standard. Additional transcription mode reading and punching capacity also available.					
Data Protection	Illegal punch check cycle check	Illegal punch check cycle check	Punch check	Hole-count check		Illegal punch check on Reading punch check on punching
Input Hopper/Output Stacker capacity, cards	3000/2500	3000/2500	1200/1300	1000/1500		1200/1300

*Transcription mode reading and punching not available in MODEL 100 processor's integrated card equipment control.

.42 Printers

As indicated in Table IV, printing speeds offered range from 420 to 950 single-spaced lines per minute; 120 or 132 print positions per line are available.

Peripheral data transfer instructions are used to operate the printer, while error and busy status is sensed through a peripheral control and branch instruction. A print roll on which characters are embossed moves pass print hammers during the printing cycle. A cyclic check is made for accuracy.

.43 Magnetic Tape Equipment

Two complete families of magnetic tape units are available for use in NEAC-Series 2200 systems:

- Units which process 1/2 inch tape provide the standard means for storing 6-bit data and IBM compatibility, including end-of-file mark recognition and the ability to translate from card images in IBM even-parity tape code to NEAC Series 2200 processor code. These units read forward, write forward, backspace one record, space forward one record, rewind, rewind and release and erase; backward read is also available.

- Units which process 3/4 inch tape provide data compatibility with NEAC — 2400/3400/2800/3800 systems and, in addition, feature a unique Orthotronic control technique for data checking and regeneration. These units read forward, write forward, backspace one record, rewind and release, and regenerate tape channel.

As indicated in Table V, data transfer speeds range from 7,200 to 96,000 characters per second for units processing 1/2 inch tape, and from 32,000 to 88,000 characters per second for units processing 3/4 inch tape.

In the 1/2 inch tape units reading and writing can proceed simultaneously under the direction of a single tape control unit at the same time that computing is in progress (24 inch per second drives do not have this facility).

The vacuum technique has been incorporated in the design of all NEAC tape units. This technique controls the mounting, driving and stopping of tape. A write enable ring and a manual tape unit switch are used to guard against destructive unintentional write attempts.

All information written on 1/2 inch tape is immediately read and checked. During a write operation, a parity bit is generated for each frame and also each data channel. These bits are checked during reading. Failure of any of these checks causes a program accessible indicator to be set. The 3/4 inch tape equipment has the further ability to regenerate any tape channel on the basis of the parity established by the other channels and the frame parity bits.

Table V summarizes the characteristics of the available magnetic tape equipment.

TABLE IV: SUMMARY OF PRINTER CHARACTERISTICS

MODEL	N222-4	N206A-1	N122A-1
Print Speed, lines/min	950 (46 char. set); 750 (63 char. set)	500 (61 char. set); 420 (109 char. set)	500 (61 char. set); 420 (109 char. set)
Demand on Central Processor, %	Model 100: 19 Model 500: 3.6	Model 100: 18.4 Model 500: 3.5	18.1
Print positions per line	120 or 132		
Character Set	10 numeric, 26 alphabetic, and 27 special; or 48 Kana, and 5 special	10 numeric 26 alphabetic, 48 Kana, and 25 special	10 numeric, 26 alphabetic, 48 Kana, and 25 special
Skip speed inches/sec.	35	20	20
Vertical specing	6 or 8 lines per inch		

.44 Paper Tape Equipment

There are three models of paper tape readers, N109A-1, N209A-1 and N209A-2, which process 5 through 8 level tapes at the rate of 300, 300 and 1000 frames per second, respectively.

Four paper tape punches are available, N110A-1, N210A-1, N210A-3 and N110A-3. These punch the 5 through 8 levels of tape at the rate of 50, 60, 110 and 110 frames per second, respectively.

Frame parity is generated by programmed instruction during punching and checked in reading. The reader can be equipped to check each frame for even or odd parity.

Table VI summarizes the characteristics of the available paper tape equipment.

.5 AUXILIARY STORAGE

.51 Random Access Drum File and Control

The Model N271A drum file and control offers high speed access to large quantities of stored data. Up to 8 drum storage units (with a total capacity of 2.6 million characters) can be connected in a non-simultaneous manner to one drum control operating on-line with a NEAC-Series 2200 System.

The drum, the power supply and a read/write rack are housed in a single cabinet. The drum control is contained in one central processor logic drawer.

Multiple subsystems, each composed of a drum control which requires two input/output trunks and from one to eight drum units can be connected to a single computer.

TABLE V. CHARACTERISTICS OF NEAC-SERIES 2200 MAGNETIC TAPE UNITS

Model Number	N204B-1 N204B-2	N204B-3 N204B-4	N204B-5	N204B-7	N204B-8	N204B-9	N204B-11 N204B-12	N204A-1	N204A-2	N204A-3
Recording Density, bits inch	556,200	556,200	556,200	200,556,800	200,556,800	556,800	556,200	533	533	740
Peak Transfer Rate, kilo-char sec	20.0,7.2	64.0 16.0	66.7,24.0	7.2,20.0.28,8	16,0,44,4,64.0	66.7,96.0	13.3,4.8	32.0	64.0	88.0
Tape Speed, inches sec	36	80	120	36	80	120	24	60	120	120
Tape Rewind Speed, inches/sec	108	240	360	108	240	360	72	180	360	360
IBM 729 Compatible	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Nc
IBM 2400 Compatible	No	No	No	No	No	No	No	?	?	?
Features and Comments	N204B-1 is pre-requisite for N204B-2	N204B-3 is pre-requisite for N204B-4					N204B-11 is pre-requisite for N204B-12			

TABLE VI: SUMMARY OF PAPER TAPE EQUIPMENT CHARACTERISTICS

	N109A-1	N209A-1	N209A-2	N110A-1	N210A-1	N210A-3	N110A-3
Read Speed, frames/sec	300		1,000	–			
Punch Speed frames/sec	–			60		110	
Read Method	Photo-read			—			
Punch Method	—			Die-punch			
Tape Speed, inches/sec	30		100	6		11	
Data Format	Japan 6 level, International 8 level; International 6, 7 level, or International 5 level		Japan 6 level, and International 6,7,8 level, Japan 6 level, and International 5,6,7 level; or Japan 5 level and International 8 level	Japan 6 level and Japan 8 level		International 8 level, and Japan 6 level, International 6, 7 level and Japan 6 level; or International 5 level, and Japan 6 levels	
Demand on Processor, %	0.2		0.4	0.01			
Data Protection	Parity check and Re reading check			None			

.51 Random Access Drum File and Control (Contd.).

Data is stored at a density of approximately 406 bits per inch on the magnetic surface of a 9-inch diameter cylindrical drum which has a constant speed of 3600 rpm. The drum has 256 data tracks and read/write heads.

The standard data record contains 128 characters (one sector); one track can contain ten such records. However, records can be variable in length. A drum unit has the capacity for 2,560 standard records or 327,680 characters, making the total capacity of an eight drum subsystem 2,621,440 characters.

The average access time for any record on the drum is 8.3 milliseconds. The average transfer rate between the central processor and the drum is 103,000 characters per second or 1.67 milliseconds per standard record.

Recorded data is protected by a PERMIT/PROTECT switch on each drum which inhibits writing when in the PROTECT position. A parity bit is generated for each character during writing and automatic parity checking is performed when reading. Any check condition generates a program-accessible error indication.

Data transfer interrupts the central processor one character cycle per character transfer. The central processor is available for other operations during a search for a record area.

The instruction set for the drum is search and write, write, search and read, read, and read address register.

The Random Access Drum file, Model N271 has the same features as Model N271A with the following exceptions:

- The data capacity is 20,480 records of 128 six bit characters or 2,621,440 characters;
- The drum rotation speed is 1200 rpm;
- The record access time is 27.5 ms (average); and
- The transfer rate is 106,000 characters per second.

.52 Disc Equipment

The N261, N262 Random Access Disc File and Control is a rapid memory device which records and reads data from one to 36 (N261) and 72 (N262) magnetic discs. As many as eight N261 or four N262 disc files can be connected to a control unit. The storage capacity of each disc file is 134 million (N261) or 268 million (N262) 6-bit characters, which means that the storage capacity per control is expandable up to 10,000 million characters.

Discs rotate under 64 (N261), 128 (N262) movable read/write heads at 1167 rpm. The average access time is 78 milliseconds. The data transfer rate is 188,000 characters per second. Only one memory cycle is required to transfer one character from main memory.

The Disc Pack Unit, Model N259, is a high-speed random access filing device. It combines the characteristics of both magnetic discs and tape units in that data records can be variable in length and formatted under program control. It is connected to the N257 disc pack control which is connected to the input/output trunks of the central processor.

One disc pack unit has a storage capacity of 9.2×10^6 characters and has an average access time of 110 milliseconds. The data transfer rate is 208,000 characters per second.

.6 DATA COMMUNICATIONS

The NEAC-Series 2200 encompasses a broad-scale data communications capability, including:

- Multiple channel communication control unit to handle an exceptionally wide array of communication lines, speeds and terminal devices.
- Fast-access mass storage devices.
- Powerful processor communications features, including an automatic interrupt system, multi-level code handling capability, an interval timer and a programmable real time clock.
- An advanced, multi-purpose remote terminal device, the data station.
- A full line of software for interrupt processing and message handling.

.61 Processor Communications Features

Several features available in NEAC-Series 2200 processors make them especially well suited to handle communications applications. These features include simultaneity, an automatic interrupt facility, a multi-level code handling facility and timing devices for real-time operations.

Simultaneity is achieved through the use of program assignable read-write channels in allowing the processors to direct the data flow to and from several peripheral devices concurrent with internal processing. For example, the Model 100 processor is able to perform as many as four input/output operations along with internal processing. Projected to the Model 500 processor, as many as 16 data transfers may occur concurrent with computing.

The automatic interrupt facility enables efficient direction of processing involving concurrent real-time and business or other applications. Automatic branching between a main program and real time service routines allows servicing of communications controls which are ready to transmit or relay data.

The multi-level code handling facility enables processing of ASCII as well as other 8 bit codes. This feature includes the ability to translate automatically between character codes of up to 12 levels, and also to trap special code configurations of up to 12 levels.

Two types of timing devices are available in NEAC-Series 2200 processors to provide access to real time information. Each timer requires one input/output trunk. A Model N213-3 interval timer effects automatic program interrupt at intervals specified by a program.

Multiple channel communication controls are available on NEAC Series 2200 systems to receive and transmit data over toll and leased lines.

The multiple channel communication control (Models N284 and N292) can direct transmission and reception of messages over as many as 256 communication lines. A communication adapter unit (Model N285 and N293) is required as an interface between the control and each channel being used. Data can be transferred at rates up to 2400 bits per second in a single line. Polling is also available. When more than 256 communication lines are used, plural controls are added.

By using the communication switching unit (Model N215) up to 256 lines can be switched simultaneously to another multiple channel control. The N216 peripheral control switching unit enables a communicationcontrol facility to switch between different NEAC-Series 2200 systems. Many combinations of these two facilities can produce numerous ways of switching.

Three different validity checks are performed on the data being communicated:

- Parity and long checking are standard on all NEAC devices.
- A transmission lapse activates a program accessible indicator in the receiving processor.
- All transmissions and receptions are confirmed.

.62 Data Station

Nippon Electric makes available a Data Station, a multipurpose remote terminal device which can be used for a broad range of communications applications, as well as for off-line jobs, such as keyboard to paper tape.

The data station features a transmission speed of 1200 bits per second and a wide choice of input/output devices. The standard control unit can regulate up to seven of the standard peripheral devices. The data station transmits over a telephone grade line using a modulation and demodulation unit. Communications can be directed locally by the operator or remotely by the central computer. Parity and long checking validate the transmission. An automatic facility is available for initiation of automatic retransmission of data containing errors.

.63 Communications Software

To complement the capability of NEAC-Series 2200 communications hardware, there is a full line of software to aid in implementing a variety of applications ranging from sophisticated message switching to polling systems. Some of the functions performed by this software are:

- Interrupt processing — Determines servicing required by each line, establishes priority of high speed lines and optimizes distribution of processing time.
- Real Time Input Analysis — Converts communication code to processor code; interpret message headers; generates storage assignment requests; checks message formats for validity and generates output queue requests.
- Output Stacking and Interfacing — Generation of requests to processor for messages; reception of messages from output queues; transmission of messages; maintenance of queuing.
- Random Access Storage and Retrievel — Allocations of random access storage, reading and writing of records, and maintaining queues.
- Line Status — Determines line availability and overall utilization.

.7 SOFTWARE

NEAC-Series 2200 software is supplied in versions tailored to fit equipment configurations comprising many different memory capacities and input/output combinations.

The NEAC Software System is broadly classified as two systems — the NEAC-Series 2000 Programming System and the NEAC-Series 2200 Application System.

.71 Programming System

The NEAC-Series 2200 Programming System is composed of the Basic Programming System and Operating Systems, MOD 1, MOD 2 and MOD 3.

The Basic Programming System is used in the small scale NEAC-Series 2200 in the form of punched cards, paper tape or magnetic tape.

The routines which are always stored in the main memory (e.g., Resident monitor) have been designed to minimize space to conserve memory. For instance, if a program (a system program or a user's program) is read from a paper tape or cards, the loader occupies only 80 characters of memory. The minimum main memory equipment for the system is 4,096 characters.

.72 Language Processors

The primary language processors, available for the entire 2200 Series provided that certain memory requirements are met, are the Easycoder assembler, the Liberator Conversion programs, and the FORTRAN and COBOL compilers.

.73 Easycoder Assembler

Several Easycoder versions are provided to meet the needs of all system sizes and compositions. This flexibility includes provisions for all types of peripheral configurations and takes advantage of increased internal and input/output processing facilities where available. Easycoder includes facilities for macro instructions that generate calls to library subroutines at assembly time.

.74 COBOL Compiler

To complement the modularity of the Series 2200 hardware, the various COBOL compilers implement a set of language modules, expanding the features of COBOL as the machine capability is increased.

The Series 2200 COBOL compilers are syntax-directed; the smallest version can operate in a configuration consisting of three magnetic tape units, a card reader, an on-line printer and a processor containing an 8,192 character memory. Other compilers are available for memory sizes of 16K and larger.

All Series 2200 COBOL compilers are modularly expandable and self-adapting to memories larger than the minimum. They accept batched source programs and will operate in a batch-compile, load and go mode.

.75 FORTRAN Compiler

The smallest Series 2200 FORTRAN compiler requires 16,384 characters of memory, plus four magnetic tape units, a card reader, card punch, and printer. This version translates a major portion of FORTRAN IV, including logical statements and testing, data initialization, labeled COMMON areas, and type statement declarations. Larger versions exploit the added features and instructions of the scientific hardware option and process programs using up to 524,288 characters of main memory.

.76 Liberator Conversion Programs

The Liberator concept, an integral design feature of every Series 2200 processor, has many facets, including compatibility of programming languages, data formats, and peripheral input/output devices. Programs written for the IBM 1401, 1410, 1440, 1460, and 7010 systems can be converted to run on any of the NEAC-Series 2200 processors with the aid of simulators. This conversion can be achieved using any one of a series of available programs in the following categories:

- Easytran, which converts programs at the symbolic level, operating either on a NEAC system or on a 1400-series system.
- Bridge, which converts programs at the machine level, operating on NEAC equipment.

Easytran accepts as input symbolic source programs written in SPS (Symbolic Programming System) and/or Autocoder language. The principal output of Easytran is a symbolic program in the proper form for input to the Easycoder Assembler. Additional outputs include a parallel listing of the Autocoder and Easycoder Symbolic programs, a cross reference listing of all labels (tags) used in the input program, and an English language diagnostic listing.

Bridge translates 1400-series programs at the machine code level. The principal output of Bridge is an operable object program in either single card or condensed card load format, or in the form of card images on magnetic tape. The original and converted programs are listed side-by-side. The object time package improves the efficiency of the object program by overlapping input-output operations to take advantage of NEAC peripheral simultaneity.

.77 Operating System MOD 1

Operating System MOD 1 is a software system provided for enlarging the capability of the medium scale NEAC-Series 2200. It is designed as a magnetic tape system which allows the processing of programs written in different languages in the same Job Stack, e.g., assembler language and COBOL language.

The program maintenance routine can handle both the NEAC System program and a user developed program in the same way. It performs maintenance at both levels, source language and machine language.

MOD 1 is used in NEAC-Series 2200 systems having a memory of from 12,288 to 65,536 characters and 3 to 6 magnetic tapes. All the peripheral devices are supported.

The Operation Control Routine of operating System MOD 1 supplements the function of NEAC-Series 2200 hardware. One important function of this routine is program loading.

.78 Operating System MOD 2

Operating system MOD 2 is used on any model of the NEAC-Series 2200 having a memory of more than 49,152 characters. It is designed to make job scheduling easier by reducing human errors and by reducing an operators work.

Jobs are processed one after another under the control of the System Monitor. A job consists of several steps. For example, in a job compiling a subprogram written in FORTRAN, assembling a subprogram written in Easycoder and combining them into a program and executing it, the steps are:

- Compilation by FORTRAN compiler;
- Assembly by Easycoder assembler;
- Linking of sub-programs by Linkage loader; and
- Execute program.

In the System Monitor, there exists a section called Central I/O which provides central input-output control. Advantages of the Central I/O are:

- Simultaneous operation between peripheral devices and the central processor uses only the hardware interrupt facility;
- Input-output errors are automatically checked; and
- Input-output operations are generated by macro instructions.

.79 Operating System MOD 3

Operating system MOD 3, used principally by the Model 500 NEAC-Series 2200, includes multiprogramming control and priority scheduling of stacked jobs. The multiprogramming of jobs within the system is automatically scheduled, to ensure the fullest use of the available main memory and peripheral devices.

.8 APPLICATIONS SOFTWARE

Greatly diversified management application systems are provided for the NEAC-Series 2200, over a wide range of applications.

.81 FICS (Forecasting for Inventory Control System) consists of a single series program encompassing the following operations:

- Up-dating and maintenance of sales record demand files;
- Analysis of actual demand data and up-dating and formulation of parameters used in demand and stock level forecasting;
- Forecasting of demands (sales); and
- Computation and up-dating of parameters used in stock control and supply management operations.

In addition, ISIM (Inventory Simulation System) simulates stock control operations applying FICS.

.82 PERT (Program Evaluation and Review Technique) is used to forecase the time required for completion of projects within specified time periods and to evaluate progress and results. Three different PERT systems are provided for the NEAC-Series 2200. Their outstanding features are:

- Evaluation of complicated network computations quickly and accurately;
- Identifying those portions of the overall project which require greater control and supervision: and
- The production of a wide variety of reports.

.83 LP (Linear Programming) is a system used for solving problems utilizing linear programming techniques. The system is divided into several segments which are applied one after the other thus making corrections easily and quickly. A simple method is employed in the LP system in which statistical tabular data is maintained. Two types of LP systems are provided with the NEAC-Series 2200; revised simplex and composite simplex.

Other packages include a general purpose simulator, budget simulation, econometric analysis, investment analysis, management control, statistical computations, mathematical analyses, matrix calculations and plotting routines.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES	
	Model No.	Feature No.	Name	Monthly Rental ¥	Purchase Thousands ¥
CENTRAL PROCESSOR	E050		Central Processor (4,096 characters)	220,000	9,900
		E050M-1	Additional Memory (4,096 characters)	50,000	2,250
		E050M-2	Additional Memory (8,192 characters)	100,000	4,500
RANDOM ACCESS STORAGE	E270		Drum Controller	30,000	1,350
	E271		Drum Storage (81,900 characters)	60,000	2,700
	E260		Disc Pack Controller	40,000	1,800
	E261		Disc Pack Storage (819,000 characters)	90,000	4,050
INPUT-OUTPUT			Punched Card		
	E214		Card Reader/Punch	180,000	8,100
			Paper Tape		
	E211		Paper Tape Controller	25,000	1,125
	E209-A		Paper Tape Reader (Domestic 6 level)	10,000	450
	E209-B		Paper Tape Reader (International 8 level)	10,000	450
	E209-C		Paper Tape Reader (International 6, 7 level)	10,000	450
	E209-D		Paper Tape Reader (International 5 level)	10,000	450
	E210-A		Paper Tape Punch (International 8 level, Domestic 6 level)	30,000	1,350
	E210-B		Paper Tape Punch (International 6, 7 level, Domestic 6 level)	30,000	1,350
	E210-C		Paper Tape Punch (International 5 level, Domestic 6 level)	30,000	1,350
			Printer		
	E206		Hi-Speed Printer	180,000	8,100
		E1030	Extended Print Chain (132 characters)	20,000	900
		E1039	Alpha-Numeric High Speed Printing Feature	25,000	1,125
			Magnetic Tape		
	E203		Magnetic Tape Control Unit	40,000	1,800
	E204-1		Magnetic Tape Unit	50,000	2,250
	E204-3		Magnetic Tape Unit	40,000	1,800
	E204-2		Additional Tape Panel	30,000	1,350
			Other		
	E220-A		Input-Output Typewriter (Domestic 6 level)	40,000	1,800
	E220-B		Input-Output Typewriter (International 8 level)	40,000	1,800

CLASS	IDENTITY OF UNIT			PRICES	
	Model Number	Feature Number	Name	Monthly Rental in ¥	Purchase Price in Thousand ¥
INPUT-OUTPUT (Contd.)			Printers		
	N206A-1		Printer, Medium Speed	236,000	10,620
	N222-4		Printer, Hi-Speed	410,000	18,450
	N122A-1		Printer, Medium Speed	180,000	8,100
	N222S-4		Printer (attached Ortho Code)	520,000	23,400
		N031A-1	Extended Print Positions (N206A-1)	23,000	1,035
		N032	Extended Print Positions (N222-4)	23,000	1,035
		N1031A-1	Extended Print Positions (N122A-1)	23,000	1,035
		N032S	Extended Print Positions (N222S-4)	23,000	1,035
		N039A-1	KANA Code Translation (N222-4)	30,000	1,350
			Magnetic Tape		
	N103		Magnetic Tape Unit	150,000	6,750
	N204A-1		Magnetic Tape Unit	140,000	6,300
	N204A-2		Magnetic Tape Unit	225,000	10,125
	N204A-3		Magnetic Tape Unit	280,000	12,600
	N204B-1		Magnetic Tape Unit	110,000	4,950
	N204B-2		Magnetic Tape Unit	95,000	4,275
	N204B-3		Magnetic Tape Unit	155,000	6,975
	N204B-4		Magnetic Tape Unit	140,000	6,300
	N204B-5		Magnetic Tape Unit	210,000	9,450
	N204B-7		Magnetic Tape Unit	120,000	5,400
	N204B-8		Magnetic Tape Unit	170,000	7,650
	N204B-9		Magnetic Tape Unit	215,000	9,675
	N204B-11		Magnetic Tape Unit	95,000	4,275
	N204B-12		Magnetic Tape Unit	75,000	3,375
	N204C-13		Magnetic Tape Unit	145,000	6,925
	N204C-15		Magnetic Tape Unit	200,000	9,000
	N203A-1		Magnetic Tape Controller	99,000	4,455
	N203A-2		Magnetic Tape Controller	99,000	4,455
	N203A-3		Magnetic Tape Controller	144,000	6,480
	N203B-1		Magnetic Tape Controller	153,000	6,885
	N203B-2		Magnetic Tape Controller	153,000	6,885
	N203B-3		Magnetic Tape Controller	189,000	8,505
	N203B-4		Magnetic Tape Controller	153,000	6,885
	N203B-5		Magnetic Tape Controller	108,000	4,860
	N203B-6		Magnetic Tape Controller	153,000	6,885
	N203C-7		Magnetic Tape Controller	150,000	6,750
	N205-1		Magnetic Tape Switching Unit	54,000	2,430
	N205-2		Magnetic Tape Switching Unit	87,000	3,915
	N205-3		Magnetic Tape Switching Unit	119,000	5,355

SUMMARY REPORT: NEAC SERIES 2200/50

.1 BACKGROUND

The NEAC-Series 2200/50 is logically a member of the 2200 family (see Report I575); however, because it has its own peripherals, it is being treated in a separate report. Nippon Electric Co. of Tokyo, Japan offers this processor for the small scientific or commercial user, although the software which has been developed seems to indicate usefulness in the area of retail and inventory control and billing.

The Nippon Electric Company assesses that NEAC-Series 2200/50 is suitable as a satellite computer or as a batch processor.

The NEAC-Series 2200/50 shares full program compatibility with all other models of the 2200 Series and has the same instructions as the NEAC-Series 2200 Model 100.

.2 HARDWARE

.21 Central Processor

The basic capacity of the Model 50 is 4,096 characters; however, by adding the EO50M-1 and EO50M-2 additional memories, capacities of 8,192 and 16,384 are available The memory cycle time is 2 microseconds per 6-bit character.

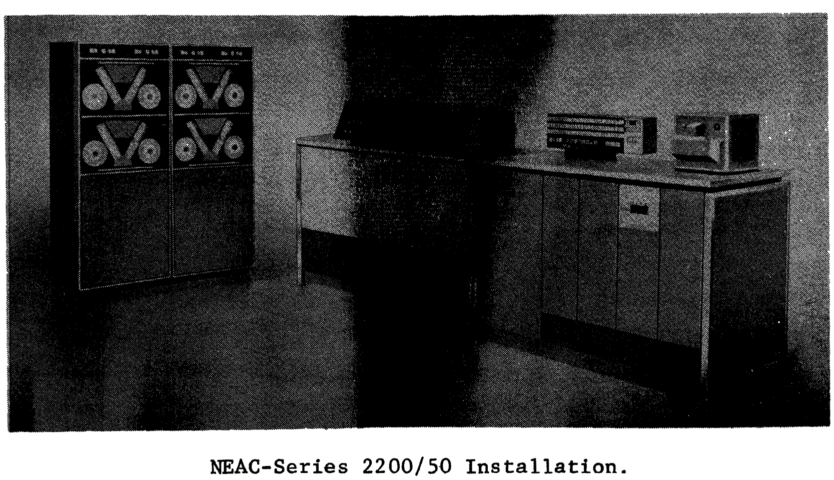
Information is stored in main memory locations as 6-bit alphanumeric characters. Any number of consecutive locations can be grouped to form fields; groups of consecutive fields are known as items. There are two programmed punctuation bits associated with each memory location which define fields and items and are known as word marks and item marks, respectively. There is a parity bit associated with each character position.

The Model 50 processor has six main memory index registers in actual locations 02-04, 06-10, 12-14, 16-20, 22-24 and 26-30. All memory locations are direct, indirect and indexed addressable.

There are 37 available instructions for the Model 50, two of which editing and 8-level code processing are optional.

The Model 50 has two standard and one optional read-write channels and connects up to eight input-output control units. All Model 50 peripheral controls are connected to the processor via input-output trunks. This means that the Model 50 can be connected to as many peripheral controls as the number of available input-output trunks.

Data is transferred between the main memory and a trunk via a read-write channel which is assigned by the instruction which initiated the transfer.



NEAC-Series 2200/50 Installation.

.21 Central Processor (Contd.)

The automatic program interrupt facility provides simple but efficient supervision of processing involving combinations of input-output operations and computing. This allows automatic branching between a main program and servicing routines for all input-output devices.

The Model 50 interrupt processing facility consists of a hardware program interrupt which signals a particular condition in an input-output control unit. An interrupt instruction subset is available for interrupt processing.

A program interrupt occurs at the completion of any input/output operation. All interrupts can be inhibited by program control. A single instruction is necessary to resume a main program and to reset all indicators and registers.

.22 Data Structure

The basic addressable unit of the Model 50 is a 6-bit character. Any number of consecutive locations can be grouped to form fields; a group of consecutive fields form items. Fields and items are defined by word marks and item marks.

Instructions are variable in length. The basic instruction format consists of an operation code, two operand fields which specify the binary addresses of fields to be used in the operation, and a variant character. The variant characters expand the meaning of the operation code or represent data to be used by the instruction. Both decimal and binary arithmetic can be performed.

.23 Card Equipment

The E214 Card Reader-Punch performs three operations: reading, punching and reading a card and punching additional information into the card on the same pass. The E214 has a reading speed of 400 cards per minute and a punching speed of from 100 to 400 cards per minute. Cards are end fed and optically read. The appeal of the unit is enhanced by the addition of a dual punching head for punching two columns simultaneously.

The E1064 Transcription Feature is optional. Table I gives the characteristics of the E 214.

TABLE I: CHARACTERISTICS OF NEAC-SERIES 2200/50 CARD EQUIPMENT

Reading Speed	400 cards per minute
Punching Speed	100 to 400 cards per minute
Data Protection	Validity check, cycle check on reading; punch check on punching
Hopper/Stacker Capacity	1200/1300 cards
Punch Feed Read	Standard
Direct Transcription	Optional
Maximum Number of Units in System	8

.24 Printer

The Model 50 is equipped with a chain printer, the E206 High-Speed Printer. The printer has a print speed of 333 lines per minute and has 60 characters available for printing. The standard printer has 120 print positions but the E1030 Extended Print Option permits the printing of a 132 character line.

The skipping rate is 100 lines per second and vertical spacing is 6 lines per inch. Control instructions for line and form spacing and editing instructions are available to the programmer.

The NEAC-Series 2200 Model 50 can accommodate a maximum of eight E206 Printers.

.25 Paper Tape Equipment

The E211 Paper Tape Controller connects both the E209 Paper Tape Reader and the E210 Paper Tape Punch to the central processor. Both units process 5, 6, 7 or 8 level tape. The E209 Reader processes at 300 characters per second while the E210 Punch operates at 110 characters per second. Both units come equipped with odd or even parity checks. Table II lists the characteristics of both units.

TABLE II: CHARACTERISTICS OF NEAC-SERIES 2200/50 PAPER TAPE EQUIPMENT

Characteristic	E209 Paper Tape Reader	E210 Paper Tape Punch
Speed	300 char/sec	110 char/sec
Read/Punch Mechanism	Photoelectric	Die Punch
Tape Transport Speed	30 inches/sec	11 inches/sec
Data Format	5, 6, 7, or 8 Level Code	
Data Protection	Program generated parity; Dual read check	

.26 Magnetic Tape Units

The E204 Magnetic Tape Units process 1/2 inch, 7-track tape. The E203 Tape Controller controls up to four tape units sharing a common input-output trunk. Write attempts can be guarded by a write-enable ring and a manual tape unit switch. All information which is written is read and checked. Parity is checked during reading and writing. Table III shows the principal characteristics of the E204 tape unit.

TABLE III: CHARACTERISTICS OF THE E204 MAGNETIC TAPE UNIT

Transfer Rate	8,900 char/sec
Tape Width	1/2 inch
Tape Length	450 feet per reel
Number of tracks	7
Read-Write Speed	16 inches/sec
Recording Density	556 char/inch
Inter-record Gap	0.45 inches or 0.75 inches
Rewind Speed	48 inches/sec
Maximum Number of Units in System	32

.27 Random Access Equipment

Mass storage for the NEAC-Series 2200 Model 50 system is provided by disc pack and drum storage units. The E261 Random Access Disc Pack Storage consists of removable disc pack storage cartridges. As many as four E261 storage modules can be connected to an E260 disc controller. Each module contains one disc pack which consists of five discs of which eight surfaces can be used to store data.

There are 64 tracks per surface which are further divided into 16 sectors. Each sector has a capacity of 100 characters giving a total disc capacity of 819,200 characters.

The head positioning time ranges from 126 to 500 milliseconds. Data is transferred at a rate of 83,333 characters per second. The 2200/50 system can contain up to 32 Disc Pack Storage units.

The E271 Random Access Drum rotates at 3600 rpm which provides an access time of 8.3 milliseconds. The E270 Drum Controller can handle as many as four such units. A read-write head is assigned to each of the 64 data tracks. A band consists of four tracks giving 16 bands per drum. Bands are further divided into 40 sections each of which can contain 128 characters giving one tenth the storage capacity of the disc pack of 81,920 characters. Data is transferred at 103,000 characters per second. The maximum number of drums which the 2200/50 can contain is 32.

.28 Input-Output Typewriter

The E220 Input-Output typewriter, or NEAC WRITER, consists of a typing mechanism, a keyboard and a paper tape input-output section. Up to four E220's can be connected to an E1025 Adapter which may be attached to the E211 Paper Tape Controller. Six- or eight-level paper tape can be processed. Table IV lists the peak speeds of the E220.

TABLE IV: CHARACTERISTICS OF NEAC-SERIES 2200/50

Printing Speed	560 char/min
Paper Tape Reading Speed	560 char/min
Paper Tape Punching Speed	900 char/min
Maximum Number of Units in System	32

.3 SOFTWARE

The software system of the NEAC Series 2200 Model 50 includes the following:

- Three E system
- Programming systems
- Application systems

The Model 50, being one model in the NEAC Series 2200 line, allows programs written for all other models of the Series to be run.

.31 Three E System

The Three E system is composed of EASY BILL, EASY PRO, and EASY COBOL. EASY BILL is an automated program package which includes functions of billing processes and can produce billing programs as directed by parameter cards. The minimum machine configuration to use EASY BILL is a 4,096 character central processor, 1 paper tape reader, 1 typewriter and an 819,200 character disc pack storage unit or a drum storage unit of 81,920 characters.

EASY PRO contains functions for sorting, collating, merging and reproducing. The minimum machine requirements are a central processor with 4,096 characters of memory, 1 paper tape reader, 1-4 magnetic tape units and 1 printer.

EASY COBOL is a Japanese language version of basic COBOL. The minimum configuration required is a 4,096 character central processor, 1 paper tape reader, 1 typewriter, and 4 magnetic tapes or 1 disc storage unit with a capacity of 819,200 characters.

.32 Programming Systems

The programming systems for the Model 50 consist of the following:

- Basic Programming System
- Operating System MOD I

The Basic Programming System is mainly for paper tape based users while the operating system is card based. The Basic Programming System includes an Easycoder assembler, a COBOL processor, a program for editing and updating files, control programs, data manipulation routines and scientific subroutines. The minimum machine configuration contains a central processor with a 4,096 character memory, 1 paper tape reader, 1 printer and one to four magnetic tape units.

Besides the contents of the Basic Programming System, the Operating System MOD 1 contains a FORTRAN compiler, two COBOL compilers (an English and Japanese version), and an interrupt control package.

The minimum machine configuration required for the Operating System MOD 1 is a main memory of 4,096 characters and an additional channel trunk, 1 card reader punch, 1 printer and 4 magnetic tapes.

.33 Applications Systems

The NEAC Series 2200 Model 50 is supplied with three basic application tools, the Forecasting for Inventory Control System (FICS), Program Evaluation and Review Technique (PERT), and Linear Programming Packages (LP).

FICS is used to forecast sales, processes files of sales demands and updated parameters used in stock control and supply management operations. FICS requires a machine configuration of 8,192 characters.

(Contd.)

.33 Applications Systems (Contd.)

PERT is used to forecast the time required for completion of projects within specified time periods and to evaluate progress and results. PERT is based on the premise that minor activities incorporated within larger projects exert a considerable influence upon the overall project schedule. PERT identifies those portions of the overall project which require greater control and supervision and produces a wide variety of reports. The minimum machine configuration required to run PERT is a memory size of 16,384 characters.

The LP system is used for solving problems which utilize linear programming techniques. The system is divided into several segments which perform given functions and overlays the next segment. A Simplex method is used in the system in which statistical tabular data is maintained on magnetic tape which makes it possible to handle numerous variables and limiting equations.

The minimum machine configuration required to use the LP system is a memory size of 16,384 characters.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES	
	Model Number	Feature Number	Name	Monthly Rental in ¥	Purchase Price in Thousand ¥
CENTRAL PROCES-SORS	N100		Processor (2,048 characters)	300,000	13,500
		N100M-1	Additional Memory (2,048 characters)	40,000	1,800
		N100M-2	Additional Memory (4,096 to 16,384 characters)	80,000	3,600
		N100M-3	Additional Memory (4,096 to 32,768 characters)	70,000	3,150
	N200		Processor (4,096 characters)	450,000	20,250
		N200M-1	Additional Memory (4,096 to 32,768 characters)	80,000	3,600
		N200M-2	Additional Memory (8,192 to 65,536 characters)	110,000	4,950
	N300		Processor (16,384 characters)	930,000	41,850
		N300M-1	Additional Memory (16,384 to 65,535 characters)	260,000	11,700
		N300M-2	Additional Memory (16,384 to 131,072 characters)	150,000	6,750
	N400		Processor (16,384 characters)	1,600,000	70,000
		N400M-1	Additional Memory (16,384 to 131,072 characters)	200,000	9,000
		N400M-2	Additional Memory (32,768 to 262,144 characters)	300,000	13,500
	N500		Processor (65,536 characters)	2,700,000	121,500
		N500M-1	Additional Memory (65,536 to 262,144 characters)	800,000	36,000
		N500M-2	Additional Memory (131,072 to 524,288 characters)	1,200,000	54,000
			Features for 2200/100 Processors		
		N1011	Advanced Programming	27,000	1,215
		N1013	Editing Instructions	18,000	810
		N1014	8-bit Code Handling	9,000	405
		N1015	Auxiliary Input/Output Trunk	54,000	2,430
		N1016	Auxiliary Read/Write Channel	108,000	4,860
			Features for 2200/200 Processors		
		N010	Advanced Programming	36,000	1,620
		N013	Editing Instructions	32,000	1,440
		N015	Auxiliary Input/Output Trunk	54,000	2,430
		N016	Auxiliary Read/Write Channel	18,000	810
			Features for 2200/300 Processors		
		N1100	Scientific Unit	108,000	4,860
		N1114	Storage Protect	18,000	810
		N0191	Optional Instruction Package	18,000	810
			Features for 2200/400 Processors		
		N1115	Auxiliary Read/Write Channel	36,000	1,620
		N1117	Storage Protect	18,000	810
		N1100	Scientific Unit	108,000	4,860
		N0191	Optional Instruction Package	18,000	810
		N1121	Extended Multi-programming Option	40,000	1,800
			Features for 2200/500 Processors		
		N1118A	Storage Protect	100,000	4,500
		N1116A	Auxiliary Read/Write Channel	100,000	4,500

CLASS	IDENTIFY OF UNIT			PRICES	
	Model Number	Feature Number	Name	Monthly Rental in ¥	Purchase Price in Thousand ¥
RANDOM ACCESS STORAGE	N270		Drum Storage Control (Controls up to 8 drum units)	103,000	4,635
	N271		Drum Storage	230,000	10,350
		N075	Track Protect	9,000	405
	N270A		Drum Storage Control (controls 8 drum units)	80,000	3,600
	N271A		Drum Storage	180,000	8,100
		N075A	Track Protect	5,000	225
	N257		Disc Pack Drive Control	200,000	9,000
	N257-1		Disc Pack Drive Control	230,000	10,350
	N259		Disc Pack Drive	185,000	8,325
	N260		Disc Control Unit	230,000	10,350
	N261		Disc File	1,450,000	65,250
	N262		Disc File	2,460,000	110,700
		N077	8-bit Transfer Feature	20,000	900
	N4005		Disc Pack	5,400	243
			Punched Card		
INPUT-OUTPUT	N207		Card Reader Control	86,000	3,870
	N208		Card Punch Control	76,000	3,420
	N227		Card Read/Punch	258,000	11,610
		N017	Stacker Select	9,000	405
		N040	Direct Transcription	18,000	810
		N060	Direct Transcription	18,000	810
		N061	Hole Count Checking	36,000	1,620
		N062	Punch-Feed Read	38,000	1,710
	N223		Card Reader	140,000	6,300
		N044	Direct Transcription	9,000	405
		N043	51 Column Adapter	15,000	675
	N208A-1		Card Punch Control	76,000	3,420
	N224A-1		Card Punch	78,200	3,519
		N061A-1	Hole Count Checking	36,000	1,620
		N060A-1	Direct Transcription	18,000	810
	N208A-2		Card Punch Control	76,000	3,420
	N224A-2		Card Punch	140,000	6,300
		N060A-2	Direct Transcription	18,000	810
		N061A-2	Hole Count Checking	36,000	1,620
	N207A-2		Card Read Control	86,000	3,870
		N062A-2	Punch Feed Read	38,000	1,710
		N064	Direct Transcription	20,000	900
	N208-1		Card Punch Control	54,000	2,430
		N064-1	Direct Transcription	36,000	1,620
	N214-1		Card Punch	108,000	4,860
	N208-2		Card Read/Punch Control	81,000	3,645
	N214-2		Card Read/Punch	126,000	5,670
		N066	High Speed Skip	9,000	405
	N123		Card Reader	72,000	3,240
			Paper Tape		
	N209		Paper Tape Input	99,000	4,455
	N209A-1		Paper Tape Input	35,000	1,575
	N209A-2		Paper Tape Input	105,000	4,725
	N109A-1		Paper Tape Input	12,000	540
	N210		Paper Tape Output	81,000	3,645
	N210A-1		Paper Tape Output	45,000	2,025
	N210A-2		Paper Tape Output	81,000	3,645
	N110A-1		Paper Tape Output	33,000	1,485
		N029A-1	Special Code Detection	10,000	450
		N029A-2	Special Code Detection	10,000	450
		N1029A-1	Special Code Detection	10,000	450
		N028A-1	ISO Code Processing	10,000	450
		N028A-2	ISO Code Processing	10,000	450

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SUMMARY REPORT: PHILIPS P1000 SERIES

.1 BACKGROUND

Philips Gloeilampenfabrieken, who prior to 1968 was active in core memories, peripherals and computers, has made a full-scale entry into the computer market with the announcement of its P1000 series, a line of three program-compatible computers which parallel the IBM System/360 Models 30, 40, and 50.

The P1000 Series has many advanced features, including a very broad size range for core memory from 16,384 to 517,288 octads of 1 μsec on the smallest computer to an extended core of over 14,680,064 octads of 2.5 μsec on the two larger models.

Other features of the P1000 Series are the compactness of the hardware, the extensive instruction set, and the special provisions for multiprogramming and dual system processing. The appeal of the P1000 Series is further enhanced by a balanced set of operating and applications software. An extensive range of equipment is available, which enables an installation to be extended if, and when, required. First deliveries are scheduled for 1969.

.2 DATA STRUCTURE

The basic unit of data in core storage is the octad, which consists of eight information bits and an associated parity bit. A word is four octads or 32 bits in length.

In the P1000 Series, data can appear in two forms: fixed length and variable length. Data of fixed length may have the following formats: the octad (eight bits), the half word (sixteen bits), the word (thirty-two bits), and the double word (sixty-four bits). Fixed length data can be grouped in the following way:

- Alphanumeric characters (1 character per octad) in the EBCDIC (Extended Binary Coded Decimal Interchange Code) or the USASCII (United States of America Standard Code for Information Interchange)
- Binary coded integers have half word and word formats
- Floating point numbers have word and double word formats
- Logical data may take any form up to the double word format or a combination of four double words.

Decimal numbers occupy 1 octad at minimum, 1 sign tetrad and 1 digit tetrad and at maximum 8 octads, 1 sign tetrad and 15 digit tetrads.

.3 HARDWARE

.31 Central Processors

There are three basic sizes of internal storage for each of the central processor models, as shown in Table I.

The processing units consist of a control section, registers, and provisions for arithmetic and logical operations. The control section contains the necessary equipment for converting logic addresses into store addresses, for storage protection, for address modification and indirect addressing, and for transferring data.

Programs may be written in relation to a relative address zero. The ultimate location in storage is determined by the control program monitor. A program base register (PBR) is filled by the control program with the starting address of the program from which, during processing, all addresses can be derived. This technique is called address conversion. Usage of the PBR makes dynamic relocation of a program possible even if that program is under execution. The length of a program is maintained in a program length register (PLR) and together with the PBR, this register prevents the program limits from being exceeded.

.31 Central Processors (Contd.)

Use can be made of the segmenting feature in the P1200 and P1400 to enable segments of programs to reside in different locations in storage or, temporarily, on another storage medium.

In the P1000 Series a distinction is made between direct, modified, and indirect addressing. In direct addressing the address portion of an instruction represents an explicit address in store. A maximum of 65,536 octads are accessible through direct addressing.

With modified addressing, use is made of the contents of one of the 14 index registers that are available. Two levels of indexing are permitted. With indirect addressing, the address portion of an instruction does not contain the relevant operand address, but the address of a storage location that does contain the operand address. Modification of indirect addressing permits addressing of up to 2^{24} locations.

Available on the P1000 Series are 2 arithmetic registers, (A and B), 14 index registers, 1 condition register and 1 point-location register.

Arithmetic operations include binary, decimal or floating point. Five number formats are available:

> Half-word integers that are integral binary numbers with a length of 16 bits, including the sign bit. Negative numbers are represented in two's complement notation.

TABLE I: CENTRAL PROCESSOR CAPACITIES

Central Processor	Core Storage		Additional Core Modules	
Model	Model	Octads	Model	Octads
P1100	P1100-001 P1100-002 P1100-003	16,384 32,768 65,536		
P1200	P1200-001 P1200-002 P1200-003	65,536 131,072 262,144	P1200-008	2,097,152
P1400	P1400-001 P1400-002 P1400-003	131,072 262,144 524,288	P1400-008	2,097,152

TABLE II: CHARACTERISTICS OF MAGNETIC TAPE UNITS

Type	Model	Recording Method	Number of Tracks	Features		
				Tape Speed, inches/second	Character Density, Char/inch	Peak Transfer Speed, char/second
P1061	001	NRZ	9	37.5	800	30,000
	002	NRZ	9	75	800	60,000
	003	NRZ	9	112.5	800	90,000
P1061 (with P1061-13 installed)	001	NRZ	7	37.5	200	7,500
					556	20,000
					800	30,000
	002	NRZ	7	75	200	15,000
					556	40,000
					800	60,000
	003	NRZ	7	112.5	200	22,500
					556	60,000
					800	90,000
P1064	001	PM	9	37.5	1600	60,000
	002	PM	9	75	1600	120,000
	003	PM	9	112.5	1600	180,000

(Contd.)

TABLE III: PUNCHED CARD EQUIPMENT

Feature	Card Reader			Card Punch	
	P1010	P1011	P1012	P1015	P1016
Reading Speed for 80-column cards, cards/min	400	800	1500	-	-
Reading Speed for 51-column cards, cards/min	500	1000	2000	-	-
Punching Speed for 80-column cards, cards/min	-	-	-	100	300
Punching Speed for 51-column cards, cards/min	-	-	-	-	400
Capacity of Hopper	1400	2500	2500	1000	2000
Capacity of Stacker	1000	2000	2000	1000	2000
Capacity of Selection Stacker	-	100	2000	-	-

TABLE IV: LINE PRINTERS

Feature	Model		
	P1030-001	P1030-002	P1030-003
Printing Speed, lines/min	360	600	1000
Skipping Speed, inches/sec	20	20	35
Maximum number of copies	5	5	5
Horizontal Spacing, characters/inch	10	10	10
Vertical Spacing, lines/inch	6	6	6

.31 Central Processors (Contd.)

- Word integers that are integral binary numbers with a length of 32 bits including the sign bit. Negative numbers are represented in two's complement notation.
- Decimals that are binary coded decimal numbers, consisting of an even number of tetrads (4 bits) with an algebraic sign and 15 decimal digits maximum.
- Word floating point numbers, consisting of a sign bit, a 7-bit exponent and a 24-bit fraction. Numbers in this notation range between 5.4×10^{-79} and 7.2×10^{75}.
- Double-word floating point numbers, which are similar to the word format but with a fraction of 56 bits. Numbers in this notation also range between 5.4×10^{-79} and 7.2×10^{75}.

Logical data can be of a fixed or variable length. When a logical item is used as an operand of fixed length it is processed in a register. The length of variable data can be up to 256 octads. Alphanumeric characters are expressed in EBCDI Code but it is possible to process data in the United States of America Standard Code for Information Interchange (USASCII).

The P1000 Series has instruction lengths of one and two words. Only the field instructions are of the double word format. Although all word instructions have the same format the meaning of the different portions can vary according to the type of the instruction.

Both types of instruction are always located at word addresses in storage; i.e., a multiple of 4 octads.

There are two types of channels in the P1000 Series: Character Allocated Transfer Channel (CATCH) and Block Allocated Transfer Channel (BATCH).

.31 Central Processors (Contd.)

CATCH executes the complete input-output procedure for the transfer of one character only. The advantage of this is that characters can be transferred to and from different input-output devices in succession.

CATCH has a lower data transfer rate than that of BATCH, and hence is used for low-speed devices. BATCH is concerned with one input-output device at a time and is blocked against any other transfer of data. BATCH is used on high-speed devices such as magnetic tape units and disc units.

.32 Magnetic Tape Equipment

The magnetic tape units are available in two nine-track, single-density types: the P1061 and the P1064. As an option, the P1061 can be provided with facilities for recording on seven tracks in one of three densities. Each type of tape unit is available in three models of different speeds. Details of the tape units are shown in Table II.

Data is recorded on the P1061 Model by means of a non-return-to-zero (NRZ) method and on Model P1064 by means of the phase modulation (PM) method. On the three-density version of Model P1061, the density is changed by means of a switch on the units. All models allow reading backwards.

The 8-bit EBCDIC Code is used for data representation along with a parity bit. The standard magnetic tape reel holds approximately 2400 feet of tape.

The P1060 and P1062 Tape Control Units may be used in conjunction with up to eight P1061 or P1064 Magnetic Tape Units, respectively. Both control units allow as many as eight tape rewinds simultaneously or one unit to be reading or writing and seven units rewinding. The seven-track, three-density feature on Model P1061 is provided through the installation of feature P1060-13.

The tape units controlled by the P1062 may be of type P1061 if the P1062-012 NRZ Feature is installed.

.33 Disc Equipment

The P1041 Disc Unit is provided with an interchangeable pack of six 14-inch diameter discs. Data is recorded on 10 of the 12 sides available by means of an access mechanism that has 10 read/write heads. Each side of a disc has 200 tracks for storing data; the storage capacity of a disc pack is 7,250,000 octads. The average access time to a block of data is approximately 90 milliseconds and the peak transfer speed is 156,000 octads per second.

The self-contained P1040 Disc Control Unit is used in conjunction with up to eight disc units and allows positioning of the access mechanisms to proceed simultaneously on each of up to eight disc units; data can only be written or read from one disc unit at a time. The P1040-012 Dual Entry Switch is designed for dual system operation and allows connected disc units to be accessed via two channels, one from each of the combined processors.

.34 Data Communication Equipment

The P1000 data communication equipment includes the P1086 Teleprinter, the 1085 Data Collection Device together with the necessary control units, the P1080 Data Communication Control Unit, and the P1080-010 and P1080-012 Line Control Units. The P1080 Data Communication Control Unit has a maximum of 16 line connections. Four of the 16 can be used by P1080-012 Line Control Units and the remaining 12 are used by P1080-010 Line Control Units.

A maximum of twenty P1085 Data Collection Devices can be connected to the P1080-012 Control Unit. Data collection devices permit data communication in one direction. Data can be input from the P1085 keyboard or from punched cards or from external sources by normal telephone lines.

The P1086 Teleprinter can be connected to the P1080-010 via a single line and permits data communication in two directions. Data can be input by manual operation of the P1086 keyboard or with punched tape. Output of data is accomplished by printing and/or punching tape. Here also use can be made of normal telephone lines.

.4 INPUT-OUTPUT DEVICES

.41 Punched Card Equipment

Three card reader models are available: P1010, P1011 and P1012. As shown in Table III they differ mainly in their speed of operation. Reading is carried out photoelectrically, column by column, and the hopper and stacker can be loaded and emptied during operation. The control units for the readers are built into the equipment. All cards being processed are checked in transport and any faults stop the reader.

Two card punch models are available: P1015 and P1016. These differ mainly in the speed of operation and the size of the cards which can be punched (Table III). Both card punch models check for faulty punches, and Model P1015 has an optional selection feature.

.42 Printing Equipment

The Model P1030 Line Printer is a family of three models: P1030-001, P1030-002, and P1030-003. These models differ mainly in their speed of operation (Table IV).

Paper sizes range from 4.5 to 19 inches wide. All three models of line printers have 64 character sets arranged on a printing drum, and characters may be printed in up to 132 positions per line depending on the paper size.

.43 Punched Tape Equipment

The P1020 Punched Tape Reader is very compact and reads paper, mylar or nylon tape at a speed of 1000 characters per second. Tapes punched in five, six, seven or eight channels are able to be read. Checking is provided by a second read head.

The punched tape reader is attached to a control unit which controls one tape reader.

The P1025 Tape Punch has a maximum speed of 150 characters per second. About 10 characters can be punched per inch of tape in either five, six, seven or eight channels. A tape punch control unit can control one tape punch.

.5 SOFTWARE

.51 Operating Systems

There are four operating systems provided for the P1000 Series: Support Package, Basic System, Extended System and Multiprogramming System.

The Support Package is intended for smaller P1000 installations dealing principally with punched card processing. It differs considerably from the other Operating Systems:

- maximum core storage used will not exceed 64K octads
- its operating programs are coded in Autocode S and are on punched cards which require translation before use and the user must add them to the source program
- each program must be run separately.

The system support routines for Support Package are Update S, Tape Sort S, Disc Sort S, Rug S, Autocoder S, and system utility routines.

The Basic System is available for users with an installation having a central processor with a minimum of 32,767 octads of main memory, at least one card reader, an operator's typewriter and one magnetic tape unit or one disc unit.

The following programs are available in the Basic System:

- ALGOL B, FORTRAN B, COBOL B;
- Autocoder B assembly program;
- RUG B - Report and Update Generator;
- Utilities, Linkage Editor B, Update B;
- Disc Sort B, Tape Sort B;
- Macro Processor;

.51 Operating Systems (Contd.)

- Data Management B; and
- Basic Monitor and Job Control B.

The Extended System requires a minimum central processor capacity of 65,536 octads, one card reader, an operator's typewriter, one line printer and one disc unit or five magnetic tape units. The greatest advantage of the Extended System is that the slow peripheral equipment does not retard the execution of the user programs.

The Extended System consists of the same programs as the Basic System except for the Extended Monitor and Job Control E.

The Multiprogramming System enables a maximum of 15 programs to be executed simultaneously. A priority system is used to determine the order of operations.

A Multiprogramming System requires the following minimum configurations: 131,072 octads of core storage, one card reader, one line printer, one operator's typewriter, three disc units and a segmenting feature.

The hardware Dual System Feature is supported by the Dual System Routines B, E and M, which are optional features of the Basic, Extended and Multiprogramming Monitors.

.52 Data Communications Routines

Data Communications modules B, E and M are developed to handle messages entering via data communications control units from remote terminals. When used in one of the operating systems, these routines always have the highest priority.

For the Basic Operating system, extended by the data communication module, the arrival of a message stops the execution of the current program which will be temporarily rolled out and the data communication routine B are loaded and executed.

Two priorities are recognized by data communication modules E and M. A high priority message is handled by stopping and rolling out the current Program.

The lower priority message is held in an external storage medium and the relevant data communication program is executed as soon as possible after the end of the current program. Within the Multiprogramming Operating System a message is handled by giving control to the relevant data communication program as soon as the message is completed.

PRICE DATA

Pricing information for the Philips P1000 Series was unavailable at press time. Price data will be included in future issues.

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SUMMARY REPORT: ICL SYSTEM 4

.1 BACKGROUND

International Computers Limited (ICL) of London, England was formed in 1968 and represents the culmination of a series of mergers among English computer manufacturers that effectively consolidates almost all of England's computer manufacturing into single corporate structure. ICL now manufactures three lines of computers of which the System 4, Models 30, 40, 50, 70 and 75, are compatible with IBM's System 360/25 through System 360/75.

The System 4 Series was designed for use in both the commercial and scientific data processing community and possesses the following general attributes:

- A broad range of real-time communications equipment;
- Compatibility within the series; and
- System expansion and product line expansion.

ICL now markets in about 70 countries throughout the world and maintains marketing support in the United States. ICL can offer leasing agreements of 3, 5 or 7 years. Maintenance contracts are usually for seven years. Table I highlights some of the features of the five processors. The Models 4-70 and 4-75 are, in fact, the same computer with the addition of a paging unit in the 4-75. This unit, based on an associative memory, is designed for use in time-sharing operations. The paging unit slows down the instruction execution rate of the machine when it is in use, since special action is needed on each access to main memory. It is possible to run a Model 4-75 without using the paging unit; in this mode, it has the same instruction execution rate as the Model 4-70.

Typical rentals range from £1,700 per month for a 4-30 to £12,000 per month for a 4-70. The first 4-50 was delivered in June 1967, followed by the first 4-30 in October 1967. Deliveries of 4-70 commenced in March 1968 and of 4-75 in September 1968.

The principal characteristics of System 4 include:

- All processors use monolithic micro-integrated circuits.
- A high degree of compatibility among the larger models and with IBM System/360 and RCA Spectra 70.

System 4 has the same non-privileged instruction set as the full IBM System/360 and RCA Spectra 70 Series instruction set, except for the 4-30, which uses the commercial subset of instructions. The data codes and formats are also the same for System 4 and System/360. Software is provided for various levels of operating system according to the type of configuration available and the user's needs.

ICL maintains a technical information exchange agreement with RCA, and System 4 and Spectra 70 share similar design concepts. Except for the 4-50, which closely corresponds to the Spectra 70/45, there is not a close correspondence between individual System 4 models and Spectra models.

.21 Data Structure

The data structure used in System 4 is identical with that of the IBM System/360 and the RCA Spectra 70 Series. The basic unit is the 'byte', consisting of eight data bits and one parity bit. A byte can represent one alphanumeric character, two decimal digits or part of a binary field. Binary fields are either two consecutive bytes ('halfword'), four consecutive bytes ('word'), or eight consecutive bytes ('double word'). Halfwords, words and doublewords must be located in storage on an integral boundary, that is the address of the first byte must be a multiple of the number of bytes in the field. Decimal and alphanumeric fields may be of variable length in all processors.

Instructions are two, four or six bytes in length. Decimal operands, in all processors are from one to sixteen bytes long. They are made up of 4-bit BCD digits packed two to a byte,

.21 Data Structure (Contd.)

with a sign occupying the least significant half-byte. Fixed point arithmetic is performed on halfwords and words in the 4-40 upwards. The 4-30 performs decimal arithmetic and fixed point binary add and subtract only, using variable length operands from one to sixteen bytes, on words and halfwords. Floating point arithmetic can be simulated on the 4-30, but on the other processors floating-point instructions are implemented in hardware, using either 'long' or 'short' operands. 'Long' operands (using a doubleword for one number) consist of a 56-bit fraction and a 7-bit hexadecimal exponent; 'short' operands (single word) have a 24-bit fraction and 7-bit exponent.

.22 Central Processor

The 4-30 processor has instructions for performing decimal arithmetic, binary addition and subtraction, comparison, branching, moving, loading, storing, packing, unpacking, code translation, editing and Boolean operations. The 4-40, and higher numbered processors, also have facilities for radix conversion, binary multiply and divide, and floating point arithmetic. The full instruction set of the 4-40 upwards contains 144 instructions, while the 4-30 has 41 instructions. Instructions are two, four or six bytes in length. A 2-byte instruction has no reference to main storage; a 4-byte instruction refers once to main storage, and a 6-byte instruction refers twice to main storage.

Main storage addresses are formed by adding a 12-bit 'displacement' from the instruction to a 24-bit 'base address' kept in one of the 16 general registers. This allows program segmentation and relocation as well as one level of address modification. A second level of modification is provided in many instructions where a 24-bit 'index', held in a general register, is added to the base-plus-displacement address in instructions referring to one storage address and a register. System 4 has no indirect addressing.

On the 4-30, there are five types of interrupt. On the larger processors, there are up to 32 types of interrupt. Interrupts are caused by input-output, illegal arithmetic operands, overflow, illegal operation code, improper addressing, etc. The larger processors have four processor states to give fast interrupt servicing and each state has its own set of registers in the 'scratchpad store'. User programs run in the normal state until interrupted while the interrupt is analyzed and serviced in other states. The 4-30 has two processor states; interrupt servicing takes place in the normal state.

Storage protection and the interrupt system permit efficient multiprogramming of a maximum of 14 programs on the 4-40 upwards. Multiprogramming allowed on the 4-30 is of up to three media conversion routines with a main program.

In the 4-70 and 4-75, banks of store are interleaved, reducing the cycle time to 0.65 μsec. Store protection in all processors is against writing only, allowing a program to access another area but not to change it.

In the 4-40, 4-50, 4-70 and 4-75, scratch pad storage is provided to hold registers, etc. The 4-40 and 4-50 have 128 32-bit words, and the 4-70 and 4-75 have 72 32-bit words with a separate scratch pad for input-output operations in the Multi-channel Control Unit.

The cycle times for the scratchpad memories for the different processors are included in Table I. Table II gives some representative arithmetic times.

.23 Simultaneity

Peripheral devices and their controllers are attached to System 4 processors via various types of input-output channels. A selector channel controls one high-speed input-output operation at a time. A multiplexor channel can control many low speed devices operating concurrently.

The 4-30 has up to 8 concurrent selector channels, and a multiplexor channel to which up to 115 devices can be connected. The 4-40 can have 3 concurrent selectors and a multiplexor providing for 256 devices. The 4-50 has the same capabilities as the 4-40 with an additional feature for direct control of up to 5 other processors. The 4-70 and 4-75 can operate up to 16 selectors concurrently, can have up to 506 devices connected to the multiplexor and can have direct control of 5 other processors.

Each channel has one or more trunks. Each trunk is connected to one device control unit which controls one or more devices depending on the type of device. All types of processor can be linked to exchange data. Note that, for the purposes of applying the restrictions described in this Section, a communications network which is multiplexed through a control unit counts as a single concurrent device.

TABLE I: ICL SYSTEM 4 CENTRAL PROCESSOR CHARACTERISTICS

Characteristics	4-30	4-40	4-50	4-70/75
Storage Size, Bytes	16,384 to 65,536	65,536 to 131,072	65,536 to 262,144	65,536 to 1,048,576
Cycle Time, μsec	1.5	1.5	1.4	0.65
Bytes/Access	2	2	2	4
Reserved Storage, Bytes	None	2048	2048	512
Scratchpad	None	Yes	Yes	Yes
Scratchpad cycle time, μsec.	-	0.5	0.3	0.25
Number of Instructions	41	144	144	144
Levels of Multiprogramming	*	14	14	14
Data Transfer Rates (KB/Sec)	360	465	520	4,000
Interrupt Levels	2	4	4	4

* One user program plus up to three media conversion routines.

TABLE II: ARITHMETIC EXECUTION TIMES ON SYSTEM 4 PROCESSORS

Operation	Processor Execution Time, μsec				
	4-30	4-40	4-50	4-70	4-75
Fixed point binary 32-bit operands					
c = a + b	53.70	33.84	25.20	4.82	6.12
c = ab	673	119.40	81.96	9.17	10.52
c = a/b	691	162.09	111.21	14.10	15.45
Fixed Point Decimal*					
c = a + b	50.1	63.22	42.0	14.72	16.52
c = ab	672.8	194.29	129.86	67.45	69.49
c = a/b	694.3	319.93	213.99	93.50	95.54
Floating point-short 32-bit operands					
c = a + b	-	40.32	37.20	6.82	8.17
c = ab	-	70.54	67.66	9.90	11.25
c = a/b	-	104.12	101.24	13.68	15.03
Floating point-long 64-bit operands					
c = a + b	-	55.53	52.60	8.68	10.03
c = ab	-	214.39	211.50	16.36	17.71
c = a/b	-	308.11	305.24	23.64	24.99

* a and b are five-digit operands for all the decimal arithmetic operations except division, for which a has ten digits and b has five digits.

.24 Mass Storage

Mass storage for System 4 is provided by a range of random access devices which allow up to 700 million bytes per unit as shown in Table III. All the units have IBM-compatible track formats.

.24 Mass Storage (Contd.)

The Replaceable Disc Unit uses interchangeable stacks of six discs. The 4-30 processor can be outfitted with the fixed length field version of this unit but only Models 4-40, 4-50, 4-70 and 4-75 can use variable length fields. Different control units are required for the two versions.

Information is stored on the ten inner surfaces of the six discs in a stack with a read-write head for each surface which contains 200 operational tracks plus 3 alternate tracks.

Ten tracks can then be covered at any one time and constitute a "cylinder". All the discs rotate at 2,400 rpm with head movement between adjacent tracks in 23 milliseconds and across all tracks in 145 milliseconds. The average head positioning time is 90 milliseconds and the average latency is 12.5 milliseconds. Up to eight replaceable discs can be connected to a single control unit.

The Discfile contains four disc stacks operated as two independent pairs each with a capacity of 350 million bytes. The discs rotate at 1,500 rpm with head movement between adjacent tracks in 27 milliseconds and across all tracks in 140 milliseconds, giving an average head movement time of 80 milliseconds. The average latency is 20 milliseconds. With single-track recording the peak data transfer rate is 265,000 bytes per second - two-track, or parallel, recording gives a peak data transfer rate of 530,000 bytes per second. Up to eight 350 million byte discfiles can be connected to a single control unit.

A Magnetic Drum unit is also available for System 4. This has a capacity of two million bytes and is controlled by a drum control unit to which up to eight drum units can be connected. The access time for the drum unit is 10 milliseconds, and four tracks are read in parallel, giving a peak data transfer rate of 875,000 bytes per second. This high transfer rate limits the use of this device to System 4 Models 70 and 75.

Table III lists the capacities and transfer rates of all the System 4 Mass Storage units.

TABLE III. SYSTEM 4 MASS STORAGE UNITS.

Type of Storage	Model Number	Capacity, bytes	Peak Transfer Rate, bytes per second	Average access Time, milliseconds.
Replaceable disc storage	4425	7,250,000	156,000	102.5
Discfile	4440	350,000,000	265,000 or 530,000	100
	4443	700,000,000		100
Magnetic Drum	4430	2,200,000	875,000	10

.25 Magnetic Tape Equipment

Two types of magnetic tape recording are available for System 4 - the Non-Return-to-Zero (NRZ) mode at 800 bits per inch and Phase Encoding at 1600 bits per inch. For each of these recording modes, there are three different nine-track tape units with different transfer rates. There is also a seven-track magnetic tape unit, which uses the Non-Return-to-Zero method of recording and can be used at three different recording densities. The units provided for Phase Encoded recording can optionally record in the NRZ mode.

A device control unit links up to 8 magnetic tape devices to the processor, and can optionally be extended to handle 16 magnetic tape devices. Dual channel control can be provided on each magnetic tape unit.

Seven track tapes have two optional features. The pack/unpack facility converts three eight-bit bytes to four six-bit characters when writing and vice versa when reading. The translation facility provides for the conversion from eight-bit bytes in E B C D I C code to six-bit binary coded decimal characters. Pack/unpack and Translate can all be used for both odd or even parity and any available character density. Table V contains the various physical characteristics as well as the rated speeds of the various tape unit models. Reverse reading is provided on all models.

TABLE IV: SYSTEM 4 INPUT-OUTPUT EQUIPMENT

Unit	Rated Speed	Features and Comments
4580 Paper Tape Reader	1500 char/sec	includes controller.
4581 Paper Tape Reader	1500 char/sec	no controller; up to 3 4581 readers can be connected to a 4580 reader.
4585 Paper Tape Punch	150 char/sec	
4513 Medium Speed Card Reader	800 cards/min	reads 51- or 80-column cards.
4515 High Speed Card Reader	1435 cards/min	reads 51- or 80-column cards.
4520 Standard Speed Card Punch	100 cards/min	80-column cards only.
4521 High Speed Card Punch	300 cards/min	80-column cards only.
4522 High Speed Card Punch	300 cards/min	80-column cards only; includes binary image punching feature.
4554 High Speed Line Printer	1350 lines/min	160 print positions.
4555 High Speed Line Printer	1350 lines/min	132 print positions.
4560 Medium Speed Line Printer	750 lines/min	160 print positions.
4561 Medium Speed Line Printer	750 lines/min	132 print positions.

TABLE V: SYSTEM 4 MAGNETIC TAPE UNITS

Model	No. of Tracks	Recording Density, rows per inch	Speed inches per second	Rewind Speed inches per second	Peak Transfer Rate, bytes per second
4450	7	800	75	150	60,000
		556	75	150	41,700
		200	75	150	15,000
4452	9	800	75	150	60,000
4453	9	800	150	300	120,000
4454	9	800	37.5	100	30,000
4458	7	800	75	150	60,000
		556	75	150	41,700
		200	75	150	15,000
4460	9	1600	37.5	150	60,000
4461	9	1600	75	150	120,000
4462	9	1600	125	250	200,000

TABLE VI: SYSTEM 4 DIGITAL PLOTTERS

Model	Paper Width, inches	Step Length	Step Rate, steps per second
4710	31	.01 inches	200
4711	31	.005 inches	300
4712	12	.01 inches	300
4713	12	.005 inches	300
4714	31	.1 mm	300
4715	12	.1 mm	300

.26 Input-Output Devices

The characteristics of the principal input-output devices for System 4 are summarized in Table IV. Besides the devices listed, there is a range of digital plotters whose characteristics are given in Table VI. There is also a MICR (magnetic ink character) sorter/reader and a mark-sensing document reader, both of which can be used on-line to a System 4 computer. The data communications equipment available for System 4 is discussed in Paragraph .27.

Five, seven and eight track Paper Tape can be handled having width variations of 11/16 inch, 7/8 inch and 1 inch which can be adjusted under manual control. Spoolers are available as an optional feature but tape dispensers are supplied. The ISO code is the normal code used for paper tape equipment on the System 4, however program conversion is possible for other codes. The ISO code is automatically converted to the internal E B C D I C code.

Two models of Card Reader provide for the reading of 51 and 80 column cards at 800 and 1435 cards per minute. Automatic conversion between the System 4 extended Hollerith card code and the internal E B C D I C code is provided on both models. In addition, the readers can have the option to read in binary card images. The readers have two stackers with capacities of 2,000 cards each. Both stackers are program selectable. The hopper capacity is also 2,000 cards and loading and unloading is permitted during operation.

All Card Punches for System 4 have a read-after-punch feature for data checking. Two stackers with capacities of 850 cards each are provided on high speed punches and an input hopper with a capacity of 1,000 cards is available. The input hopper of the standard-speed punch has a capacity of 850 cards and the output stacker has a capacity of 850 cards.

All punches are row-oriented and Model 4521 and Model 4522 differ only in the addition of a punch binary feature on Model 4522.

The printers for the System 4 are barrel-type and print a 64 character subset of E B C D I C in the E C M A type B font. Paper for these printers varies in width between 4 and 20 inches.

The maximum print line is 160 characters in length. A printer acts independently of the central processor via its own control unit once a buffer has been loaded.

Printing can be spaced at six or eight lines to the inch under operator control. Normal multiple line feeding is 33 inches per second; however, when the high-speed paper motion option is employed, feeding at 75 inches per second is possible. A special printing barrel is available which gives increased printing speeds, for purely numeric data, of 1500 lines per minute on the medium-speed printers and 2700 lines per minute on the high-speed printers.

The characteristics of the various Digital Plotters available for System 4 are given in Table VI. Both continuous lines and individual points can be plotted on all models. The plotting paper can be translucent and can be plain or marked with a number of linear and non-linear scales. Annotation is possible on all models.

The System 4 MICR Reader/Sorter, Model 4601 processes documents marked with a single line of up to 84 magnetic ink characters at a rate of 1,500 documents per minute. When the reader/sorter is operated off-line, documents are sorted into the 13 available pockets according to the value of a specified digit. When the operation is on-line, characters are sent to core storage and the documents are sorted under program control. Any document between 2.5 and 4.25 inches high and 5.75 and 9.5 inches wide is acceptable.

A Model 4652 Lector 2 Mark Sensing Document Reader can be used on-line to a System 4 computer. Document can have up to 16 data columns and one control column, with up to 79 lines on the form. The line spacing can be up to five lines per inch. Marks can be entered by hand, by computer printer, or by using an address plate. The range of acceptable document sizes is from 4 by 5 inches to 10 by 16 inches. The documents are moved through the device at 30 inches per second, giving throughput rates ranging from 6,500 documents per hour for 6" documents to 3,000 documents per hour for 16" documents.

.27 Data Communications Equipment

A comprehensive range of data communications equipment is available for System 4. The devices available can be broadly classified into two types - limited distance control units and unlimited distance control units.

.27 Data Communications Equipment (Contd.)

The limited distance control units are those used where the data communications requirements are localized. Communications between two System 4 computers within 200 feet of each other is provided by the Data Exchange Controller, which allows two processors to be connected together via selector or multiplexor channels, the peak data transfer rate being governed by the speed of the slowest input-output channel involved in the transfer. Communication between a System 4 computer and up to 16 local terminals is provided by the Multi-Purpose Device Control Unit. The peripheral devices concerned can be up to 4000 feet from the controller, and the data transfer rate can be up to 800 bytes per second for each device on the controller. The devices available for use with the Multi-Purpose Device Control Unit include an output writer operating at 10 to 15 characters per second, an alphanumeric keyboard and a slow card reader, which reads standard, 80-column cards at an effective rate of 100 cards per minute.

The unlimited distance control units are designed for communications with remote devices over telegraph lines, or public, private or leased telephone lines. These devices include the Single Channel Communications Controller, which is used for communication in a conversational mode between two System 4 computers. Various models are available to suit different line speeds and using seven- or eight-bit character codes. Facilities for manual calling or automatic dialing are available with this device.

Communication between a System 4 computer and a number of remote terminal devices is provided by the Multi-channel Communications Control Unit. This is a special-purpose computer which is used for the control of up to 112 remote devices connected to the multiplexor channel of a System 4 computer. The total overall data transfer rate on all the lines handled by a single multi-channel communications control unit can not exceed 57,600 bits per second. The functions of the Multi-channel Communications Control Unit include the transmission of characters between main storage and remote devices and the detection of certain control characters and error conditions. The remote devices connected to a System 4 computer via a Multi-Channel Communications Control Unit are typically terminal devices, but they can include other System 4 computers connected either via a Single Channel Communications Control Unit or another Multi-channel Communications Control Unit.

Remote terminal devices available from ICL for use with System 4 computers include teletypewriters, video data terminals and various types of banking terminals. There is a range of Remote Data Terminals, each of which handles up to four local devices and communicates with the computer via a data link operating at up to 4800 bits per second. Devices available for use with the Remote Data Terminals include teletypewriters, paper tape reader, a card reader and a line printer. Besides these devices, a range of off-line paper tape transmission devices is available from ICL.

.4 SOFTWARE

The organizational structure of the software for the System 4 is similar to that of IBM for System/360, and RCA for Spectra 70. Software for a particular installation is selected on the basis of processor size and type and the available backing storage. All compilers, operating systems, utilities, assemblers and application packages are classified by regime. Each regime contains an automatic program trials system in which modules of user programs can be amended, compiled in relocatable form, linked together and run without operator intervention.

Multiprogramming of up to 14 programs is available in regimes which use a minimum configuration of 65,536 bytes of storage on Model 4-40 and above. A remote multi-access time sharing system is being developed for the 4-75.

Table VII shows the minimum configuration for each regime, and Table VIII shows the main features of the software for each regime. All the software described is currently available with the exception of the Multijob operating system, which is scheduled for release in the first quarter of 1970.

The tape operating systems, regimes 3D, 4E and 5E, include COBOL, FORTRAN and a Report Program Generator. Regimes 4E and 5E also include a compiler for CLEO - a commercial autocode originally developed for ICL's LEO computers. Multiprogramming of up to six programs is allowed in 4E and 5E, where the resident supervisor routines occupy 16,384 bytes of storage. In regime 3D the supervisor occupies 12,288 bytes of storage.

The disc-based operating system for large machines, regimes 4J, 5J and 7J, includes an ALGOL compiler and various application packages as well as the facilities of the tape-based systems. J regimes have a more sophisticated job control system than E regimes.

TABLE VII: MINIMUM EQUIPMENT REQUIREMENTS FOR SYSTEM 4 OPERATING SYSTEMS

Computer	4-30		4-40, 4-50, 4-70 or 4-75		
Regime	3D	3H	E-Level	J-Level	Multi-job
Minimum Main Memory, bytes	32,768	32,768	65,536	65,536	131,072
Input Device (Paper Tape Reader or Card Reader)	1	1	1	1	1
Line Printer	1	1	1	1	1
Magnetic Tape Units	5	0	6 (1)	0	0 (2)
Replaceable Disc Units	0	1	0	2	3 (2)

(1) Five of the units must be nine-track - the other can be either seven- or nine-track
(2) Two replaceable disc units and two magnetic tape units can be used instead of three replaceable disc units.

TABLE VIII: FACILITIES AVAILABLE IN SYSTEM 4 OPERATING SYSTEMS

Computer	4-30		4-40, 4-50, 4-70 or 4-75		
Regime	3D	3H	E level	J level	Multi job
Type of system	Tape based	Disc based	Tape based	Disc based	Remote job entry
COBOL	X	X	X	X	X
With Random Access		X	X	X	X
FORTRAN	X	X	X	X	X
ALGOL				X	X
CLEO			X	X	X
Report Program Generator	X	X	X	X	X
PERT	X	X		X	X
Linear Programming —					
Simplex	X	X		X	X
Transportation	X	X		X	X
Matrix Scheme				X	X
Statistics Package				X	X
APT IV				X	X
CSL (Simulation Language)				X	X

.4 SOFTWARE (Contd.)

Within each of the J level operating systems, there is multiprogramming of up to 14 user programs. This multiprogramming is based on a stream concept. The Supervisor allows up to six streams (A to F). Each stream consists of a fixed amount of core storage and a fixed number of each type of peripheral device; discs are excepted, since all programs in all streams can access the disc concurrently. Since stream sizes are tailored for each installation, it is presumed that programs would be developed to fit these streams.

Multiprogramming control is on a priority basis where each program is assigned a running priority, 1 to 14 (where 14 is the highest priority), when it is loaded. The best use of the

(Contd.)

.4 SOFTWARE (Contd.)

machine is achieved by peripheral-dominated programs being given the highest priorities and calculation-dominated programs the lowest.

Whenever a program is waiting for a peripheral transfer, Supervisor passes control to the highest priority program able to continue. Hardware checks are performed to inhibit the destruction of any one program by another.

Extensive software support is provided for communications equipment, particularly in the J regimes. The Communications Control Package, a software package available with the J regimes which is tailored to the needs of each installation, provides software support for the use of a variety of terminals and other remote devices. A number of different types of use are supported, and there are facilities to allow a number of separate, multi-programmed user programs to use communications devices at the same time. There are facilities for multiprogramming engineering test programs with other communications programs, so that some of the terminals on a system can be tested while other parts of the system are in use.

The Multijob operating system, scheduled for release in the first quarter of 1970, will provide facilities for remote job entry and remote program testing. Batch processing facilities will be available concurrently, and remote job entry will be performed on a roll-in/roll-out basis using a replaceable disc unit.

.5 PRICE DATA

ICL does not issue a general price list. Price data for specific configurations will be published in a future issue.

SUMMARY REPORT: ICL 1900 SERIES

.1 BACKGROUND

The ICL 1900 Series, manufactured by International Computers Limited of London, England, presently consists of 14 central processors and a wide range of peripheral equipment and supporting software. The 1900 Series systems are suitable for both business and scientific applications, and most models provide facilities for multiprogramming and real-time operations. Most of the peripheral units and all of the programming languages are fully compatible within the series. The 1900 Series was introduced by ICT (International Computers and Tabulators Limited) in September 1964. At that time the series consisted of the 1902, 1903, 1904, 1905, 1906, 1907 and 1909 processors. The small-scale 1901 processor was added in September 1965. The 1900 Series design was largely based upon the earlier FP 6000, a computer developed by Ferranti-Packard Limited in Canada to the specifications of the Ferranti Computer Department in England, which merged with ICT in September 1963.

In 1967 ICT announced the 1904E, 1905E, 1906E, and 1907E processors, which use 1.8-microsecond core memories, and the 1904F, 1905F, 1906F, and 1907F processors, which use 0.75-microsecond core memories. In October 1967, ICT introduced the large-scale 1906A processor, which uses integrated circuits. In January 1968 four more integrated-circuit processors were added to the line: the 1901A, 1902A, 1903A, and 1904A.

The A, E, and F series processors have effectively replaced the eight original 1900 Series processors. Table I summarizes the principal characteristics of the 14 processors that are currently being actively marketed.

In July 1968, ICT joined forces with English Electric Computers to form a new computer company — by far the largest in the United Kingdom — called International Computers Limited (ICL). The formation of ICL represented the culmination of a long series of moves aimed at the consolidation of the various United Kingdom computer manufacturers. ICL currently plans to continue marketing both the 1900 Series and the System 4, which was English Electric's third-generation computer line and is discussed in Summary Report I850.

The 1900 Series has enjoyed far greater market acceptance than any previous British-built computer line. To date, more than 1350 orders have been received and more than 900 systems have been installed. The availability of the faster "A" series processors and more advanced software has considerably enhanced the marketing prospects for this well-conceived product line.

ICL is the largest organization not controlled from the U. S. in the commercial and scientific computer business. It has marketing activities in over 70 countries around the world and it is estimated that it has some 45 to 50 per cent of the U.K. market. ICL's new super computer, the 1908A, projected for delivery in 1972, is said to be "one of the most powerful computers in the world."

.2 HARDWARE

.21 Central Processors

Any program written for a 1900 Series central processor can be run on any other central processor in the series; hardware features not included in a processor, such as floating-point, are simulated by software routines. A part of this general philosophy of compatibility is the ICL standard interface for attaching peripheral devices to the central processor. This interface insures that any peripheral can be connected to any processor in the range, subject only to the data transfer capacity of the channel concerned, and also that older peripheral devices supplied with the earlier 1900 Series computers can be used on the more recently announced members of the Series.

Certain processors can be paired with another central processor of the same type to form a dual-processor configuration. Programs in either processor have access to peripherals connected to either processor. The processors share a common core store. One executive and one operating system is shared by the two constituent processors, but program

.21 Central Processors (Contd.)

instructions are able to run in each of the processors simultaneously. Through store interleaving, up to eight words can be accessed at one time.

The first eight words of each program are used as accumulators for arithmetic, copying, testing, and logical functions. Three of the accumulators can also be used as modifying (index) registers. Additional hardware, to implement the accumulators as separate hardware registers, is available optionally.

There are two branch modes in the 1900 Series instruction set, normal branch mode (one word instruction) and extended branch mode (two-word instruction). The normal branch mode limits the address part of a branch instruction to 15 bits or 32,768 locations. The extended branch mode allows 22 bits for the address of the branch instruction, which theoretically allows the addressing of up to 4,194,304 locations.

The general word format of a program instruction is represented by four fields: an accumulator field, an operation field, a modifier field and an operand field.

The priority interrupt feature consists of a number of peripheral channels for attaching non-ICL peripherals to certain 1900 Series Central Processors. Peripherals connected by means of this feature will be serviced in Priority mode which has a higher priority than Executive mode.

The principal characteristics of the ICL 1900 Series processors currently being marketed are shown in Table I. These processors are divided into three principal groups: A series, E series, and F series. The A series are the latest to be added to the 1900 line and incorporate integrated circuits. The principal difference between corresponding models of the E and F series is the speed of the associated core storage. The four models within the E and F series are fundamentally the same machine; differences in the models are whether or not the basic machine is equipped with floating point arithmetic and whether it is a single or dual processor. The newly announced 1908A is the only model in the A series that can be equipped for dual processing. Multiprogramming is supported on all models except the 1901A. Special-purpose paging hardware, which divides the available memory into 1024-word pages, is available for the 1906A and 1908A.

TABLE I. PRINCIPAL CHARACTERISTICS OF THE ICL 1900 SERIES PROCESSORS

Processor Model	Cycle Time, Microseconds	Minimum Core Storage, 24-bit Words	Maximum Core Storage 24-bit Words	Input-Output Channels	Integrated Circuits	Dual Processors	Floating-Point Hardware
1901A	4.0	4,096	16,384	4 to 7	Yes	No	Optional
1902A	3.0	8,192	32,768	4 to 8	Yes	No	Optional
1903A	1.5	16,384	65,536	4 to 12	Yes	No	Optional
1904A	0.75	65,536	262,144	10 to 31	Yes	No	Optional
1906A	0.75	65,536	524,288	14 to 49	Yes	No	Optional
1908A	0.33	131,072	2,097,152	64 to 80	Yes	Optional	Standard
1904E	1.8	32,768	262,144	6 to 30	No	No	No
1905E	1.8	32,768	262,144	6 to 30	No	No	Standard
1906E	1.8	65,536	262,144	12 to 60	No	Yes	No
1907E	1.8	65,536	262,144	12 to 60	No	Yes	Standard
1904F	0.75	32,768	262,144	6 to 30	No	No	No
1905F	0.75	32,768	262,144	6 to 30	No	No	Standard
1906F	0.75	65,536	262,144	12 to 60	No	Yes	No
1907F	0.75	65,536	262,144	12 to 60	No	Yes	Standard

.22 Data Structure

The basic unit of storage on the 1900 Series Computers is called a word and consists of 24 consecutive bits plus parity.

A character of data is stored as six consecutive bits. Data in pure binary form is always interpreted as having a numerical value. Apart from counter modifier words, words holding pure binary data has the most significant bit reserved as a sign bit. Negative numbers are expressed as a complement.

Signed numbers may be fixed-point integers or fractions, mixed, or floating-point, and may be held in a single word or a double word.

A counter modifier (index) word can be used in two forms: as a word-counter modifier or as a character-counter modifier. The word-counter modifier uses 9 bits to hold a count of the number of times an operation is to be performed, up to a maximum of 511; 15 bits are used to hold the modifier. In the character-counter modifier word, the character modifier occupies two bits, the counter occupies 7 bits and can contain a maximum value of 127, and the modifier occupies the remaining 15 bits of the word.

For a single length integer the binary point is assumed to be right justified. Single length integers lie in the range -2^{23} to $+2^{23}$ inclusive. Negative integers are stored as their complements with respect to 2^{24}.

Fixed-point arithmetic operations are provided for single- or double-word operands for either integer or fraction formats.

For a mixed number the binary point can be assumed to lie between any two bits of the one or two words holding the number. However, the general 1900 Series convention is to use two words to store a mixed number; one word for the integer part and one word for the fraction part. In this case the number is referred to as a 'mid-point' number since the binary point is assumed to be between the two words.

Floating-point numbers can be held in single, double, or quadruple words; the double word form is standard and has a 37-bit fraction plus sign and an 8-bit exponent plus sign.

.23 Card Readers

The 1900 Series includes five different card readers. Models 2104, 2105 and 2106 read 600, 300 and 600 80-column cards per minute, respectively.

Also available are Model 2101 that reads 1,600 80-column cards per minute and Model 2103 that reads 600 40-column cards per minute.

Models 2106 and 2101 can be equipped with a binary image feature, which interprets each card column as two 6-bit characters. Any of five card codes, including the IBM 1401 code, can be switch-selected on the 2102. Several other card readers have been discontinued, but could be connected to a new processor because of the common interface.

.231 Card Punches

The 1920 card punch is a row punch, capable of punching 100 80-column cards per minute. The 1922 is a column punch capable of punching 33 cards per minute, while the 2151 is a row punch capable of punching 300 cards per minute.

.232 Line Printers

The 1900 Series includes five different line printers. All are drum-type printers using continuous-form paper. A 64-character print font, 10-character-per-inch horizontal spacing, and vertical and horizontal tabs are provided on all models. All can print six lines to the inch; in addition, Model 1933 can print eight lines per inch. Table II lists the various printers models available on the 1900 series processors along with their peak speeds and available print positions.

.233 Paper Tape Equipment

All ICL paper tape I/O devices normally employ the ICL 8-track (7 data-bit) code based upon the I.S.O. 7 data-bit code. The characteristics of the readers and punches are shown in Table III.

TABLE II. LINE PRINTERS

Model	Speed, Lines/min.	Number of Print Positions
1933	1100 or 1350*	120 or 160
2401	300	96 or 120
2402	600	96 or 120
2404**	300	96 or 120
2405**	600	96 or 120

* The lower speed is with the full 64-character set. The higher speed is using only a restricted 48-character portion of the full set.

** The 2404 or 2405 is integrated into the 1901A processor cabinet.

TABLE III. PAPER TAPE EQUIPMENT

Model	Name	Peak Speed, char/sec
1915	Reader	300
1916	Reader	1000
2601	Reader/Punch	250/110
2602	Reader/Punch	1000/110
1925	Punch	110

.234 Disc Storage

Both fixed- and removable-disc storage is available for the 1900 Series. Fixed-disc storage units have a capacity range of from 100.66 million to 741 million 6-bit characters. Up to 14 fixed-disc storage units may be included in a system, permitting a maximum of 10.4 billion characters of on-line storage. Exchangeable Disc Storage units have a capacity range of from 1.64 million to 8.19 million 6-bit characters. Up to 8 Exchangeable Disc Storage units can be connected to one controller.

The characteristics of the ICL disc units are summarized in Table IV.

TABLE IV: ICL 1900 SERIES DISC STORAGE UNITS.

Model	Type of unit	Number of discs	Storage capacity, char	Average access time, msec.	Average data transfer rate*, char/sec
2801	Exchangeable disc store	6	4.1 million	97.5	208,000
2802	Exchangeable disc store	6	8.19 million	97.5	208,000
2805/1	Fixed disc store	7	100.66 million	150	135,000
2805/2	Fixed disc store	14	218.10 million	150	135,000
2805/3	Fixed disc store	26	419.43 million	150	135,000
2806/2	Fixed disc store	7	218 million	150	135,000
2806/3	Fixed disc store	14	421 million	150	135,000
2806/4	Fixed disc store	28	741 million	150	135,000
2820	Twin exchangeable disc store	2	1.64 million	162.5	208,000
2821	Twin exchangeable disc store	2	3.28 million	162.5	208,000

*The average data transfer rate in the table represents the average peak data transfer rate for the unit concerned. In some cases a unit has different data transfer rates on different tracks of the disc.

.235 Magnetic Drums

Drum storage is available for the 1900 Series with average access times ranging from 6.5 to 21.5 milliseconds and storage capacities ranging from 32,768 to 4.19 million 24-bit words (131,056 to 16.8 million characters). The larger figures represent the capacity of a four-drum system.

The characteristics of the ICL drum units are summarized in Table V.

TABLE V. ICL 1900 SERIES DRUM STORAGE UNITS

Model	Description	Average Access Time, Milliseconds	Words Per Track	Average Data Transfer Rate, Characters/Second
1962	Magnetic Drum 32,768 words	11.5	256	50,000
1963	Magnetic Drum 131,072 words	11.5	512	100,000
1964	Magnetic Drum 524,288 words	21.5	1,024	100,000
2851	Magnetic Drum 524,288 words	6.3	1,024	800,000

.24 1004 Link

One ICL 1004/0 or 1004/2 Data Processor can be linked, via a standard interface, to any ICL 1900 Series central processor provided it is not operating in a multi-programming environment. The link enables those already using the plugboard-programmed, UNIVAC-designed 1004 to utilize the additional processing facilities and memory of a stored-program computer. The 1004 is effectively both a card reader and a line printer contained in one unit. It is no longer manufactured by ICL, but second-hand 1004 units are available.

For use as a 1900 Series peripheral, the 1004 must have a suitably plugged control panel. ICL has designed a 1004 input-output program to perform the following operations:

- Read an 80-column card.
- Transfer 80 characters from the 1004 to a 1900 Series Central Processor.
- Transfer 120 or 132 characters and one paper feed control character from a 1900 Series Central Processor to a 1004 for printing.
- Print a line of 120 or 132 characters.
- Transfer 8 characters from a 1900 series central processor to a 1004 for punching.
- Punch an 80-column card.
- Translate from 1004 internal code to 1900 internal code and vice versa.

Within the limits of the 1004 program capacity available after the input-output program is implemented, it is possible to include other routines. However, the successful incorporation of such routines is a user responsibility.

When not being used as a peripheral device for a 1900 series central processor, the 1004 can be used independently.

.25 Magnetic Tape Systems

The 1900 Series is available with eight different magnetic tape systems. All the systems are packaged in "clusters" containing from two to six tape drives. The 2501 cassette tape system discussed in this Report is no longer being sold by ICL but is still supported. All the tape systems except the 2501 record either 7 or 9 tracks on half-inch-wide magnetic tape in various sizes of reels containing up to 2400 feet of tape. The 2501, which

.25 Magnetic Tape Systems (Contd.)

is a cassette tape system, records 8 tracks on a loop of one-inch-wide magnetic tape with an average length of 240 feet. Except in the case of the 2501, one track is used for parity bits. With the 2501, a cyclic check code is used. Table VI summarizes the basic characteristics of the tape systems available for the ICL 1900 Series.

The 2404, 2405, 2406, and 2407 tape systems write in the forward direction only and can read in either the forward or reverse directions. All the other tape systems write and read in the forward direction only.

TABLE VI: ICL 1900 SERIES MAGNETIC TAPE SYSTEMS

Tape System No.	Drives per Cluster	Number of Tracks	Tape Speed, inches per sec	Recording Density, bits per inch	Peak Speed, 6-bit char/sec	Interblock Gaps, inches	Character Parity, odd or even	Full Rewind Time, minutes
1971	2/4/6	7	37.5	200/556	20,800	0.56/0.75	Either	4
1972	2/4/6	7	75	200/556	41,700	0.56/0.75	Either	2.5
1973	2/4/6	7	75	200/556/800	60,000	0.56/0.75	Either	2.5
2501	4	8	150	531	10,000	1.2	None	0.32*
2504	2/3/4	9	37.5	1600	80,000	0.6	Either	3
2505	2/3/4	9	75	1600	160,000	0.6	Either	3
2506	2/3/4	9	37.5	800	40,000	0.6	Either	3
2507	2/3/4	9	75	800	80,000	0.6	Either	3

*The 2501 does not actually rewind but passes tape in the forward direction only. The time shown is the maximum for initializing the tape and includes the time to move the tape to the beginning point.

The 9-track tape units record data in eight tracks, with the ninth bit for parity. The data may be in binary form (i.e., each 8-bit row represents a third of a word), or alphanumeric characters may be recorded as 6-bit characters. In the latter case, a row represents either one complete 6-bit character and two bits of the next, or two 4-bit subsets of two consecutive 6-bit characters.

Except for the 2501 Cassette system, tape block lengths in the 1900 Series are limited by standard software convention to a maximum of either 2,048 or 4,096 six-bit characters, depending upon the central processor model. The 2501 block length is similarly limited to 512 24-bit words.

.26 Optical and Magnetic Readers

The document sorter/reader reads hand-made or printed marks from forms of a wide variety of sizes. The positions of the marks to be read are detected by means of a sequence of pre-printed markings along one edge of each form which are used to control the reading action of the device. Under program control, the sorter/reader can also route documents to any of three output stackers. An additional feature is the reading of 80-column cards for which code translation is required. The document sorter/reader is plugboard-controlled and operates at two speeds, 150 and 300 documents per minute.

The Universal Document Transport can be equipped to read characters printed in the OCR'B' font and hand-made or printed marks from forms of a wide variety of sizes. The reading function is controlled by marks along the edge of each form. Under program control, the 8101 can also route documents to any one of three stackers; additional stackers may be included in modules of three. The 8101 can also be equipped to read standard 80-column punched cards, though it lacks automatic code translation facilities. The unit is plugboard-controlled and has a peak speed of 600 documents per minute. The 8500 MICR Sorter/Reader reads characters encoded in the OCR'A' font at a peak speed of 1,200 documents per minute. It has 18 stackers and can be used for off-line sorting.

.27 Digital Plotter

The 1934 Digital Incremental Plotter, available with the entire 1900 Series, plots one variable against another to produce, under program control, annotated graphs complete

.27 Digital Plotter (Contd.)

with scale markings, calibrations, legends, and curve identification symbols. This device is available in six models offering various incremental steps and plotting widths. Step sizes range from .1 millimeter to .01 inch. Plotting widths are 11 and 29.5 inches.

For all models, X- and Y-axis plotting speeds are 300 steps per second, and the 2-axis speed is 10 operations per second. Chart length is 120 feet, and the data transfer rate, through the standard interface, is 300 characters per second.

.3 COMMUNICATIONS EQUIPMENT

Communications equipment for the 1900 Series comprises remote or local terminals and their associated peripherals, able to connect with 1900 Series processors by telephone, telegraph, or local lines through computer and control equipment. Control equipment attached to a 1900 Series processor can operate through either single channel or multi-channel (multiplexor) connections.

.31 Teletypewriters

Four models of the 7071 Typewriter can be connected to a 1900 Series processor, locally or remotely over leased telegraph lines either through a single channel (7070) or a multi-channel connection. Each teletypewriter is a character by character printer with a four-row keyboard. Friction-feed and sprocket-feed platens can be fitted to the typewriters. Each teletypewriter operates at speeds of 6-2/3 or 10 characters a second.

.32 Alpha-numeric Display Units

Many display units are available for use with 1900 Series processors either locally or remotely. The ICL 7153 may act as an out-station, communicating with a central processor over leased telephone lines. These devices can display 13 lines of characters, with either 40 or 80 characters to a line, chosen from a 64-character font. Four function keys are provided for editing.

.33 Message Buffering Multiplexors.

The 7900 Series communications equipment includes three basic modules:

- Line termination units (7922-7923) which allow connections to telegraph lines;
- Line Scanners (7920/1, 7920/2) which sample each line, assemble received bits into characters, transmit characters as bits, and perform code translation; and
- Linking unit (7921) which connect line scanners to line control and message-buffering units (7901, 7902).

.34 Character Buffering Multiplexors

Two character buffering multiplexors, Model 7007/2 and a 7900 module, are available for 1900 Series processors.

The 7007/2 allows up to 62 half-duplex transmission lines to be connected to a 1900 Series processor. Transmission lines are linked to the 7007/2 via data terminals, chosen to suit the transmission characteristics of the line and data.

.4 SOFTWARE

ICL 1900 Series software includes Executive, which oversees the system operations; two operating systems, GEORGE and Automatic Operator; the PLAN assembler; compilers for NICOL, COBOL, ALGOL and FORTRAN; and a group of library routines and application packages.

.41 Executive

Executive is supplied with each 1900 Series central processor and resides in a protected area of core memory. Its general purpose is to take over, from both programmer and operator, the execution of routine error-prone tasks and to organize the running of user programs in the most efficient manner, including programs originally written for a less powerful configuration. To achieve this purpose, Executive has the following four main functions:

.41 Executive (Contd.)

- To sanction, initiate, and check all peripheral transfers.
- To execute all "extracode" functions. (These are routines contained in Executive that generally simulate hardware functions, such as floating-point arithmetic, which are not included in a particular 1900 Series configuration.)
- To control, execute, or initiate all communications with the operator via the console typewriter.
- To organize and control multiprogramming and dual-programming.

.42 Operating Systems

In addition to the various versions of the Executive, operating systems of varying degrees of complexity are provided for the 1900 Series, to insure increasingly automatic operation for the larger members of the 1900 Series. For the smaller processors of the range, an Automatic Operator is provided, which increases the operating efficiency of the Executive by providing for the input of control messages to the system on cards or paper tape.

Operating systems for the larger members of the Series are given the acronym GEORGE (GEneral ORGanizational Environment). Each of the versions of GEORGE provides for the processing of a stream of jobs interspersed with control messages. GEORGE 1 provides complete control of the running of a job stream, providing the operator with a log indicating peripheral devices which require operator attention. Background jobs can be multiprogrammed with the main job stream. GEORGE 2 provides additional facilities for the maintenance of input and output buffers on magnetic tape or discs.

GEORGE 3 provides full control of multiple job streams, while GEORGE 1 and 2 control single job streams with or without concurrent multi-programming. Integral with

GEORGE 3 is a multiple on-line programming module (MOP), which provides multi-access facilities to a virtually unlimited number of users, up to 60 of which can be serviced at one time. Facilities are included for the interactive line-by-line input of programs. Multi-access facilities on smaller 1900 Series installations are provided by Mini-MOP, a scaled-down version of MOP, which allows servicing of up to 16 enquiry typewriters with the concurrent running of background jobs. The initial version of Mini-MOP offered FORTRAN, ALGOL and JEAN, ICL's conversational language developed for the solution of technical calculations. The initial version catered for up to nine users operating simultaneously.

The GEORGE 4 operating system will provide an operating system for 1900 Series machines with hardware paging units.

.43 Language Processors

The primary language processors, available for the entire 1900 Series subject to their main memory requirements, are the PLAN Assembler and the NICOL, COBOL, FORTRAN and ALGOL compilers. These processors have exactly the same form regardless of the operating system under which they are run. Output from the PLAN assembler and from the FORTRAN, COBOL and ALGOL compilers is compatible in the sense that subprograms compiled from any of these different source languages can be linked into a single object program at load time.

.44 Assembler

The basic 1900 Series programming language is PLAN, which is available in several sizes, based on central processor memory capacity. The PLAN language enables the programmer to describe the work to be done by a program in an unambiguous and logical manner, using symbolic names rather than numbers. PLAN includes facilities for "pseudo-operations", which are single line statements that generate calls to ready-made subroutines at assembly time.

.45 NICOL Compiler

NICOL is a commercial programming language for the smaller 1900 Series computers. It is designed specifically for 4096-word computers without auxiliary storage, but it can also be used in larger installations. The features of this language closely resemble the facilities of a tabulator. NICOL is, therefore, particularly suitable for data processing installations changing over from tabulating equipment to a computer.

.46 Library Routines and Applications Packages

Several hundred programs and subroutines are available in the ICL program library for the 1900 Series computers. These include routines of general commercial, scientific, or mathematical interest and routines that facilitate peripheral device handling. Most commercial routines are oriented to the Sterling monetary system. ICL provides complete programs for many particular commercial and scientific needs. Among these are ICL PERT, PROMPT (for production control), SCAN (for inventory management), FIND (for information retrieval), NIC (for indexing and cataloging), PROP (for investment evaluation), and COMPAY (for company payrolls). Other packages cover such fields as civil engineering, traffic, engineering, linear programming, matrix calculations, and statistical analysis.

.47 FORTRAN Compilers

The first version of FORTRAN implemented on 1900 Series computers was developed before the publication of the American Standards Association (A. S. A.) draft. It is equivalent in general scope to A. S. A. Basic FORTRAN although it has some FORTRAN IV features.

Presently available on the 1900 Series computers are FORTRAN IV or 1900 FORTRAN and the original version developed for the series. However, 1900 FORTRAN does include some extensions, and also some slight restrictions to obtain what is basically a one-pass compiler.

1900 FORTRAN has a feature for multiple assignment statements which is not available in standard FORTRAN. A multiple assignment statement gives the same value to more than one variable or array element. It has the form

$$V_1, V_2, \ldots . V_n = e$$

where each V is a variable or array element and e is an expression.

1900 FORTRAN allows TYPE INTEGER expressions for m_1, m_2, m_3 in the statement DO λ i = m_1, m_2, m_3 provided they have previously been defined. Some input and output subroutines are provided in 1900 FORTRAN to facilitate multiprogramming operations in dynamically controlling which peripherals are currently available to a program. Also special forms of the I, D, E, F and G descriptions are provided to allow input records to have a free format.

.48 COBOL Compilers

There are two versions of 1900 COBOL, namely Compact COBOL and Full COBOL, for which there are seven compilers available. The Compact COBOL compilers require machine configurations having at least 8,192 storage locations while the Full COBOL compilers require at least 16,384 core storage locations. Common to all configurations on which these compilers are run is the following equipment: one central processor, one paper tape reader or one card reader, one line printer, one card or paper tape punch if the object program is required on cards or paper tape, and one console typewriter. Other peripherals such as discs and magnetic tapes are needed with their respective versions.

.49 Other Packages

1900 Algol is almost a full implementation of Algol 60 and includes as subsets ECMA ALGOL and SUBSET ALGOL 60 (IFIP).

Compilers are currently available on paper tape or magnetic tape using card or paper tape input.

1900 EMA (Extended Mercury Autocode) is a considerably more powerful language than Mercury Autocode, which it includes as a subset.

Simulation is a technique for obtaining information about the performance of a system without ever putting that system into operation. A model is constructed so that the results obtained by operating or modifying the model indicate the results to be expected when the corresponding real system is operated or modified. SIMON and CSL, simulation languages, have been developed to simplify such processes. SIMON uses ALGOL procedures and 1900 CSL uses FORTRAN procedures.

The IBM 1401 and ICL 1500 Simulators operate under the SPAN system. Both simulators operate on the 1903 or larger machines. The 1401 Simulator accepts even parity 1401 tapes (200, 556 or 800 bpi). A 1500/1900 file conversion program is available.

.49 Other Packages (Contd.)

Students taking City and Guilds computer courses at technical colleges throughout Britain, write programs in the City and Guilds language to be run on ICL's 1900 Series computers by using an ICL developed compiler.

ICL's Rapidwrite for the 1900 Series is a commercial autocode based on COBOL. COBOL being a rather wordy language sometimes seems cumbersome to the user not requiring the self-documenting feature of COBOL. Rapidwrite is designed to relieve such a user of that burden by enabling the user to write his source programs in an abbreviated short-hand form while retaining the full self-documenting features of COBOL via the Rapidwrite system.

.5 PRICE DATA

ICL does not issue a general price list. Price data for specific configurations will be published in a future issue.

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SUMMARY REPORT: SIEMENS SYSTEM 4004

.1 BACKGROUND

Siemens System 4004 is the third-generation family of central processors, peripheral devices, and supporting software marketed by Siemens AG, Munich, West Germany. Some noteworthy characteristics of the Siemens System 4004 are:

- The high degree of program compatibility, both upward and downward, among four of the six Siemens 4004 processor models. Compatibility also exists with certain IBM System/360 and RCA Spectra 70 processors through similar hardware design and compatible source languages.
- The numerous arithmetic modes and data forms.
- The wide range of input-output and storage devices.
- The availability of emulators on the 4004/35 and 4004/45.
- The use of monolithic integrated circuits.
- The extensive software support as evidenced by several levels of integrated operating systems.

The 4004/45 and 4004/55 processors were first delivered in the second half of 1966 and the 4004/35 was introduced in 1967. First deliveries of the 4004/16 and 40004/26 processors are scheduled for October 1969. Recently, Siemens announced the 4004/46 processor, which is a modified 4004/45 including a virtual memory for time-sharing use.

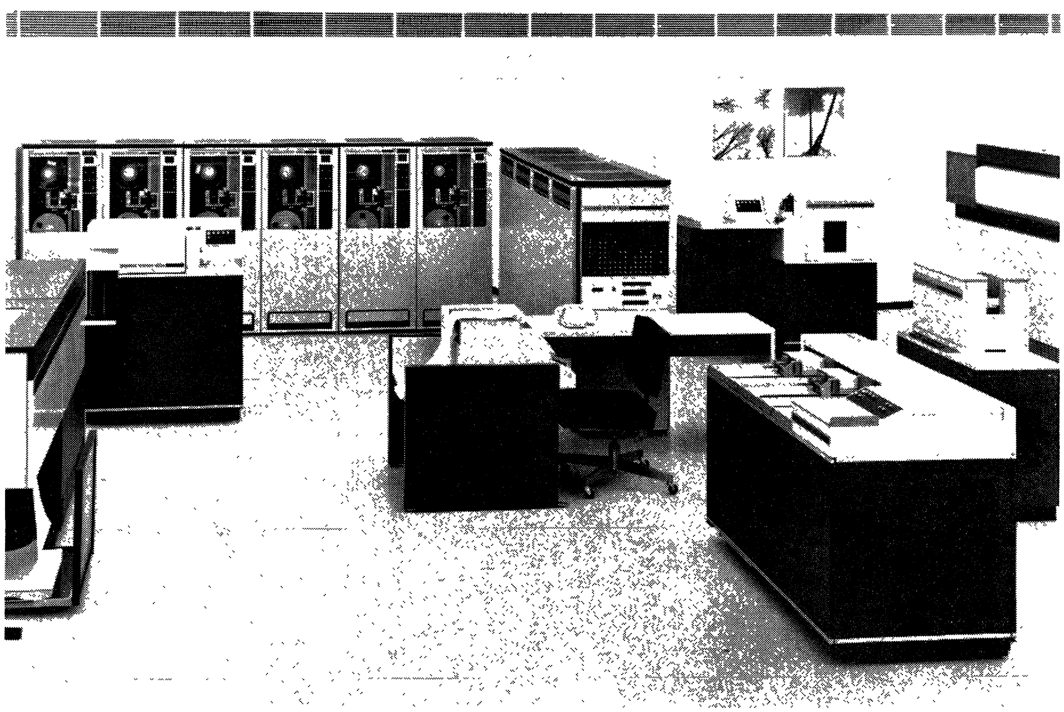

Figure 1. Siemens 4004/45 Computer System

.2 DATA STRUCTURE

The Siemens System 4004 data structure is based on the Extended Binary Coded Decimal Interchange Code (EBCDIC). The system is also capable of receiving, processing and sending information in the United States of America Standard Code for Information Interchange (USASCII).

Alphanumeric data is represented by 8-bit bytes; each byte can represent one alphanumeric character, two decimal digits, or eight binary digits (bits).

Fixed length data of 16, 32, 64 bits, or variable length data of up to 256 bytes can be processed. For purposes of data description, the terms "character" (one byte), "half-word" (two bytes), "word" (four bytes), and "double word" (eight bytes) are used. In the Siemens System 4004 a two-part system of memory addressing is used. According to this system, a machine address consists of a base address and a displacement address. The displacement address, specified in the instruction, consists of twelve bits and enables the programmer to address a region of up to 4096 bytes. The base address, stored in one of the General Purpose registers (32 bits), is used for extended addressing. The base address, in effect, subdivides memory into sections of 4096 bytes, and the displacement address specifies the individual byte within the 4096 byte section.

The Siemens System 4004 uses several instruction formats including two-, four- and six-byte forms. Each instruction contains an operation code (one byte) and a maximum of three operand addresses. Each main memory reference address can be indexed by one of the General Purpose registers in combination with the Base Address register. The Model 4004/16 and 26 processors contain instruction complements which are functional subsets of the larger 4004/35, 45 and 55 instruction complements. Floating point operations are standard on the 4004/35, 45, and 55 processors. All models are capable of decimal and binary arithmetic operations. Decimal operations are performed on variable- or fixed-length operands in "packed" format — two digits packed into one byte. The maximum field size permitted is 31 digits plus sign; the operations are performed from storage to storage.

Binary, fixed-point arithmetic operations use either storage or registers for computation depending on the processor model. In the Model 4004/16 and 26 Processors, a maximum field length of 127 bits plus sign bit is permissible. In the Model 4004/35, 45, and 55 Processors, field length is limited to 31 bits (plus sign), but arithmetic operations are performed in the registers and several can be coupled to increase precision.

Where floating-point arithmetic operations are provided, four additional double-length registers are supplied for computation and storage of results. Both short and long precision (four and eight bytes respectively), are provided. The absolute value of floating-point numbers can range from 2.4×10^{-78} to approximately 7.2×10^{75}.

.3 HARDWARE

.31 Central Processors and Main Memory

Presently, six processors are offered within the Siemens System 4004: 4004/16, 4004/26, 4004/35, 4004/45, 4004/46, and 4004/55. Four of the models are program-compatible and cover a broad range of business and scientific applications, 4004/35, 4004/45, 4004/46 and 4004/55, the 4004/46 is a 4004/45 modified for time-sharing. The 4004/16, with a restricted instruction repertoire, is probably best suited as a satellite of larger 4004 processors. The 4004/26 has a limited instruction repertoire. Memory cycle times range from 1.44 microseconds for the 4004/35 to 840 nanoseconds on the 4004/55. One to four bytes are fetched per memory cycle, depending on the processor model. Memory storage capacities range from 8,192 bytes to 524,288 bytes. The characteristics of the main memories of the processor models in the System 4004 are given in Table I.

Simultaneous operation of peripheral devices is possible through the use of input-output channels operating independently of each other. Depending on the processor model, one multiplexor channel and several selector channels are available. The multiplexor operates in a time-multiplex mode and thus provides for time-shared input-output operation.

.32 Scratchpad Memory

The Scratchpad Memory, a fast micro-magnetic storage device, contains the General-Purpose, Floating-Point and various other registers required for program and input-output control, and has a capacity of 128 four-byte words. The maximum cycle time is 300 nanoseconds for one word. Locations in scratchpad memory are uniquely addressed by the Load Scratchpad and Store Scratchpad instructions.

(Contd.)

TABLE I: SIEMENS SYSTEM 4004 MAIN CORE STORAGE CHARACTERISTICS

Core Storage Capacity, Bytes	16	26	35	45	46	55
8,192	•					
16,384	•	•				
32,768		•	•	•		
65,536		•	•	•		•
131,072				•		•
262,144				•	•	•
524,288						•
Cycle Time, μsec	0.88	0.88	1.44	1.44	1.44	0.84
Bytes Accessed per Cycle	1	1	2	2	2	4
Effective Cycle Time per Byte, μsec	0.88	0.88	0.72	0.72	0.72	0.21

.33 Console and Typewriters

The Model 4004/97 Console and Typewriter, available with Processors 35, 45, 46 and 55, is a free standing self-contained unit which provides for operator control and supervision of processing.

A set of pushbutton switches allows programs or data to be loaded into memory, allows program start and interrupt and also displays the current processor state. The typewriter also allows the operator to communicate with the operating system and vice versa.

A parity bit is generated for each character sent from the typewriter to the processor and a bit by bit echo check is performed on all characters coming from the processor to the typewriter.

The Model 4004/4217 interrogating typewriter is a peripheral device intended for use with processors 16 and 26. Data interchange with the processor is at a maximum of 20 characters per second. A line can contain 72 characters and one carbon can be prepared.

A parity bit is generated for each character sent to the processor and a bit by bit echo check is performed on all characters sent to the typewriter.

.34 Auxiliary Storage

Up to 12 random access devices can be connected to one controller. The controller has a set of commands that are translated into specific commands for each of the different devices. Seeking and selecting specific data within a file is accomplished independently of the processor.

The Model 4004/564 Disc Storage Unit has a capacity of 7.25 million bytes of information held on an interchangeable disc pack. Up to 8 units can be attached to one 4004/551 Controller. The unit provides 200 data tracks plus three alternative tracks per read/write head and has ten such heads. The total disc pack capacity is 2,000 tracks, each having packing densities of 433 bits per centimeter (1100 bits per inch) for a total of 3,660 bytes. The peak data transfer rate between the processor and the disc storage unit is 156,000 bytes per second. The minimum seek time is 30 milliseconds; average seek time is 75 milliseconds and maximum seek time is 135 milliseconds. The disc rotates at 2400 revolutions per minute giving an average latency of 12.5 milliseconds.

The Models 4004/567-8 and -16 Drum Memory Units are used to provide virtual memory for the time-sharing 4004/46 processor. They have an effective transfer rate of 277,000 bytes per second and a rotational time of 20 milliseconds. The Model 567-8 has a capacity of 4,128,800 bytes per unit, while the 567-16 has a capacity of 8,257,600 bytes.

.34 Auxiliary Storage (Contd.)

The Model 4004/568-11 Mass Storage Unit comprises from one to eight removable magazines. All card magazines are served by a common read/write station. The Model 4004/551 Controller can accommodate up to four Mass Storage Units. The basic storage element of the unit is a 16 by 4 1/2 inch magnetic card, which records data on one side only. Each card has 128 separately addressable tracks containing 2,139 bytes each and each card magazine houses 256 cards.

The Models 4004/4570-1 and 4004-4570-2 Direct Access Storage Units are operated by their own control electronics. The Model 4570-1 provides random-access storage for 233.4 million bytes on 8 (plus one stand-by) interchangeable disc packs and the Model 4570-2 for 145.4 million bytes on 5 interchangeable disc packs. One disc pack provides 200 data tracks plus three alternative tracks; the total disc pack capacity is 29.17 million bytes, the track capacity 7,294 bytes. Data is transferred between the processor and the Direct Access Storage Unit at the peak transfer rate of 312,000 bytes per second. The average seek time is 60 ms. Since the disc rotates at 2,400 rpm there is an average latency of 12.5 ms. Read-read, read-write or write-write simultaneity is possible on any two disc packs serviced by the Model 4004/4572 Auxiliary Storage Control.

.35 Sequential Input-Output Units

The peripheral devices for the Siemens System 4004 are listed in Table II, together with their rated speeds.

The Model 4004/243 High Speed Printers are drum-type printers capable of printing up to 1,250 lines per minute. A line contains up to 160 print positions. A maximum of 64 different characters can be printed. The printers are buffered, which means that once they are loaded they act independently of the central processor.

Paper advance for the first line is 12 milliseconds; for lines 2 to 8 it is 6.67 milliseconds; for line 9 onwards it is 2.22 milliseconds. Fan-fold paper is used and its width can vary from 4 to 8 3/4 inches.

Data is checked during transmission from processor to buffer and buffer to printer. A low paper condition or an invalid character in the buffer causes an indication to be sent to the processor.

The Model 4004/4247 high speed printer is a drum type printer which operates at a maximum of 1,500 lpm for numeric print. Each line is 132 characters in length. There are 64 different characters in the print set.

Paper advance time for the first line is 16.5 milliseconds; each subsequent line requires 6.35 milliseconds. Fan-fold paper is used varying in lengths from 2 to 21 3/4 inches including margins. An optional feature is a second paper transport which enables the printer to print on two forms simultaneously and independently. The width of both forms cannot exceed 22 3/4 inches.

The Model 4004/4241 and /4242 Printers are buffered train printers capable of printing up to 910 lines per minute. A single line contains 80-, 136- or 160-print positions depending on the model.

Paper advance time for the first line is 18.85 ms, each subsequent line requiring 6.35 ms; high-speed paper advance time from line 6 onwards is 2.17 ms per line. The Model 4004/4242 has a second paper transport for printing on two forms simultaneously at a maximum of 143 print positions per line.

The Model 4004/4245 Printer is a buffered drum type printer which operates at a maximum of 285 lines per minute. Each line is 120 or 136 characters in length, the character set consisting of 48 or 64 different characters.

Paper advance time is 24 ms for the first line and 12 ms for each subsequent line. The line density is 6 or 8 lines per inch.

.35 Sequential Input-Output Units (Contd.)

The Models 4004/4250 to 4004/4250-5 are Videoscan Document Reader-Sorters capable of reading numerical characters in OCR-A, IBM-407-1, or OCR-B font at a maximum speed of 1600 documents per minute. The device has 16 sort-pockets.

The Model 4004/4251 Videoscan Document Reader reads OCR-A numerical characters at a rated speed of 1600 documents per minute in 3 sort-pockets.

The Model 4004/4252 Videoscan Document Reader reads OCR-A numerical characters at a rated speed of 750 documents per minute in 12 sort-pockets.

TABLE II: SIEMENS SYSTEM 4004 INPUT-OUTPUT UNITS

Device	Rated Speed
Card Punch 4004/234-10, -11	100 cpm
Card Punch 4004/236-10, -11	300 cpm
Card Reader 4004/237-10, -21	1,435 cpm
Card Reader 4004/4235	600 cpm
Card Punch 4004/4238	420 cpm
Card Reader 4004/4239-10, -20	1,000 cpm
Paper Tape Reader 4004/4223	1,200 char/sec
Paper Tape Punch 4004/4225, -s	100 char/sec
Paper Tape Reader 4004/4226	400 char/sec
Paper Tape Reader 4004/4227, -s	1,000 char/sec
Paper Tape Reader 4004/4227-0	850 char/sec
Paper Tape Punch 4004/4228, -s	150 char/sec
Edge-Punch Card Reader 4004/4280, /4281	120 char/sec
Edge-Punch Card Punch 4004/4282	28 char/sec
Printer 4004/243-30, -40	1,250 lpm
Printer 4004/4241-18, /4242-1B	910 lpm
Printer 4004/4241-1D, /4242-1D	765 lpm
Printer 4004/4241-2B, /4242-2B	465 lpm
Printer 4004/4241-2D, /4242-2D	390 lpm
Printer 4004/4245-1	285 lpm
Printer 4004/4245-2	200 lpm
Printer 4004/4247-1-B1, -B2, -B3, -B4	620 lpm
Printer 4004/4247-1-F1	750 lpm
Printer 4004/4247-2-B1, -B2, -B3, -B4	620 lpm
Printer 4004/4247-2-F1	750 lpm
Videoscan Document Reader-Sorter 4004/4250, -1, -2, -3, -4, -5	1600 documents/min
Videoscan Document Reader-Sorter 4004/4251	1600 documents/min
Videoscan Document Reader-Sorter 4004/4252	750 documents/min
Console and Typewriter 4004/97	10 cps
Console and Typewriter 4004/4217	20 cps

Siemens System 4004 magnetic tape devices are capable of processing 7 or 9 track tape and are available in several versions. All magnetic tape devices are capable of reading in the forward and reverse directions. The Siemens System 4004 magnetic tape devices are fully compatible with the IBM Series 2400 magnetic tape devices and tapes can be interchanged between the two systems as required. Table III summarizes the characteristics of the available devices, while Table IV summarizes the available tape controllers.

TABLE III: CHARACTERISTICS OF SIEMENS SYSTEM 4004
MAGNETIC TAPE TRANSPORTS

Model No.	Tape Speed, Inches Per Second	Recording Density, Characters Per Inch	Peak Speed, Char Per Second	Interblock Gap Size, Inches	Full Rewind Time, Seconds
432 (7 track)	37.5	200 556 800	7,500 20,850 30,000	0.75	254
432 (9 track)	37.5	800	30,000	0.6	254
441 (7 track)	50.0	333 500	16,600 25,000	0.6	96
442 (7 track)	75	200 556 800	15,000 42,000 60,000	0.75	195
442 (9 track)	75	800	60,000	0.6	195
4432 (7 track)	37.5	200 556 800	7,500 20,850 30,000	0.75	130
4432 (9 track)	37.5	800	30,000	0.6	130
4442 (7 track)	75	200 556 800	15,000 42,000 60,000	0.75	130
4442 (9 track)	75	800	60,000	0.6	130
4443 (7 track)	75	200 556 800	15,000 42,000 60,000	0.75	60
4443 (9 track)	75	800	60,000	0.6	60
4446 (7 track)	150	200 556 800	30,000 83,400 120,000	0.75	60
4446 (9 track)	150	800	120,000	0.6	60
4451 (9 track)	37.5	800 1600	30,000 60,000	0.6	130
4453 (9 track)	75	800 1600	60,000 120,000	0.6	130

TABLE IV: SIEMENS SYSTEM 4004 MAGNETIC TAPE CONTROLLERS

Tape Controller	Tape Devices Controlled	Version
Model 4004/463	432 441 442 4432 4442 4443 4446	9 or 7-Track
Model 4004/472	432 442 4432 4442 4443 4446	9-Track
Model 4004/473	432 442 4432 4442 4443 4446	9 or 7-Track
Model 4004/4472	432 442 4432 4442 4443 4446	9-Track
Model 4004/4475	432 442 4432 4442 4443 4446 4451 4453	9-Track
Model 4004/4476	4451 4453	9-Track

Each of the six tape controllers is available in four versions:

— 108 single-channel; max. 8 devices
— 116 single-channel; max. 16 devices
— 208 dual-channel; max. 8 devices
— 216 dual-channel; max. 16 devices

.36 Simultaneous Operations

The control of the transmission of data between the processor and an associated peripheral device is accomplished through channels and the Siemens Standard Interface. A channel may be considered as an independent unit controlling data flow to and from the processor and releasing control to the input or output device. This release allows the processor to function simultaneously with the input-output operation. Each channel utilizes its own set of commands to perform input-output operations. These commands, referred to as channel commands, control the device once a start command has been issued by the processor. Chaining of channel commands provides a means by which several operations, such as multiple reads, may be completed independent of processor operation.

The Siemens Standard Interface functions as a connector between the channel and a device control. The interface establishes an identical relationship with each input-output device in that any device may be connected to the interface regardless of type, size or speed. The number of channels connected varies with the processor model. System 4004 offers two types of channel: Selector Channels and Multiplexor Channels.

.36 Simultaneous Operations (Contd.)

The Selector Channels control the transfer of data to and from peripheral devices. A Selector Channel has from one to four trunks, depending upon the processor model. The type of controller connected to a trunk determines the number of devices that can be connected to that trunk. For example, a tape controller controls as many as 16 tape devices. Selector Channels can operate concurrently; however, each Selector Channel can operate only one device at a time.

The Multiplexor Channel can control up to nine input-output trunks, through which up to 256 devices can be addressed (on the 4004/35 and higher-numbered processors, one trunk is required to connect the operator's console). The Multiplexor has two modes of operation - Multiplex Mode and Burst Mode. The Multiplex Mode is used for the simultaneous operation of a number of low-speed devices on the Multiplexor, while the Burst Mode (which is not available for the Models 16 and 26) allows the operation of high-speed devices on the Multiplexor. Only one device at a time can be used on the Multiplexor when it is operating in Burst Mode.

.37 Memory Protect

The protection of memory segments from destruction by overlaying is provided in Model 4004/35, 45, 46, and 55 Processors through the optional Memory-Protect feature. This feature can protect up to 15 memory segments; the basic segment is 2,048 bytes and can be increased in multiples of 2,048 bytes.

The memory-protect feature consists of a set of registers that are constantly scanned during instruction execution to ascertain that the data field operated upon by an instruction resides within preset limits. An interrupt condition is set when a program attempts to modify data located in an area of memory not allocated to this program or program section.

This feature greatly enhances the multiprogramming capabilities of the Siemens System 4004.

.38 Elapsed-Time Clock

An elapsed-time clock for real-time processing applications is available in the Siemens System 4004. This feature is standard on the Model 4004/26 Processor and optional in the Model 4004/35, 45, 46, and 55 Processors. The clock is maintained on a power line frequency (50 cycles per second) rate providing an interrupt capability every 20 milliseconds. The clock can be reset at any time by programmed instruction.

.39 Data Communications Equipment:

The Data Exchange Control enables two, close-by Siemens System 4004 Processors to communicate with each other. Data can be transferred at high speed in either direction, but in only one direction at a time. The transmission rates depend upon the type of channel used and the number of simultaneously active devices that are attached to the transmitting and receiving processors.

The Data Exchange Control can be a powerful tool for multiprocessor applications. In a real-time system, for example, status information and queue tables can be continuously transferred from the operating processor and to the backup processor.

This permits the backup processor to assume immediate control and continue processing operations in case of a failure in the operating processor.

The Model 4004/668 Communications Controller (multichannel) operates on the processors /35, /45, /46, and /55 and terminates from 1 to 48 communications lines. The maximum data rate per line is 2,400 bits per second. The maximum throughput that one 4004/668 can handle is 6,000 character per second. The Model 4004/4666 Communications Controller (multichannel) operates on the /35, /45, and /55 processors and serves from 1 to 30 communications lines. The maximum data rate per communications line is 4,800 bits per second; the maximum total communications data rate of one 4004/668 is 8,000 characters per second.

Each of the scan positions requires a communications buffer, and in some cases a data set, to interface with the communications line. Each scan position uses one Multiplexor subchannel.

(Contd.)

.39 Data Communications Equipment (Contd.)

The Communications Control (single-channel) Model 4004/656 permits half-duplex communications between one System 4004 computer system and another System 4004 computer system that is equipped with the appropriate communications equipment. Different attachments permit communication over common-carrier leased voice-band or broadband line.

.4 SOFTWARE

Siemen's software systems for the System 4004 series, in general, parallel the structure and contents of the software supplied by RCA for its Spectra 70 series. Siemens provides "third-generation" software through such facilities as disc-oriented control systems, disc file language facilities, automatic on-line file management techniques, and comprehensive data communications control routines. Multiprogramming control for up to six jobs is provided for Siemens 4004 systems that have a minimum of 32K bytes of core storage.

The principal levels of Siemens 4004 software are designated Primary Operating System, Tape Operating System, Tape-Disc Operating System, Disc Operating System, and Time Sharing Operating System in order of increasing complexity and capability. Software for the small-scale Siemens 4004/16 system, however, is a specially-designed, card-oriented set of routines that provides assembly language, Report Program Generator, I/O control, and service routine facilities at the 4K-byte core storage levels and additionally includes a Sort/Merge Generator at the 8K-byte core storage level. The system can also be supplied in a magnetic tape-oriented version.

The Siemens 4004/26 operating system offers basically the same supervised facilities as the Primary Operating System (POS) for the larger Siemens 4004 systems and functions with a minimum hardware configuration of 16K bytes of core storage. The principal limitation of 4004/26 POS facilities in comparison with the POS facilities for 4004/35, 4004/45 and 4004/55 systems is the omission of a COBOL language processor.

A limited Disc Operating System (DOS) is available on the 4004/16 and 4004/26 systems only and is available in card and paper tape versions.

.41 Primary Operating System (POS)

The Primary Operating System for use with the Siemens 4004/35, 4004/45 and 4004/55 systems is a magnetic tape-oriented software system that provides basic supervisory control for sequential execution of programs, interrupt control, input-output control, as well as a COBOL compiler, assembler, report program generator, and standard utility routines. POS COBOL is a subset of full COBOL 65 and requires a minimum of 32K bytes of core storage for compilations. The POS Assembler also requires use of 32K bytes of core storage.

No FORTRAN processor is provided under POS, nor are any routines supplied for the automatic control of random-access devices, although the operation of these devices is programmable at the assembly-language level. Multiprogramming capabilities are provided through the Peripheral Control Routine, which permits concurrent operation of up to three data transcription routines.

.42 Tape Operating System (TOS)

The second major level of Siemens 4004 software support designed for use with the 4004/35, 4004/45, and 4004/55 systems is designated the Tape Operating System (TOS). TOS is a magnetic tape-oriented integrated software package that provides supervisory control programs, language processors, and utility programs for installations that have a minimum hardware configuration of 65K bytes of core storage. The facility to control multiprogrammed operation of up to six programs concurrently is the primary feature of TOS software. The basic TOS Executive program requires a minimum of 16K bytes of storage. The Monitor program that coordinates the operations of stacked-job processing requires an additional 4K bytes, and the File Control Processor for input-output devices and file control requires another 4K to 8K bytes of core storage.

In addition to a comprehensive assembly system, TOS offers a COBOL language and a full-scale FORTRAN IV language.

.43 Tape/Disc Operating System (TDOS)

Siemens' Tape Disc Operating System (TDOS) is an improved and extended version of its Tape Operating System (TOS). In addition to all TOS software facilities, TDOS offers options that permit system control routines, problem programs, and library subroutines to reside on discs or drums in order to improve the Siemens 4004's throughput capabilities.

As a result, more efficient multiprogrammed operations are possible than with the tape-oriented TOS. The efficiency of program preparation is increased due to a reduction in the number of Job Control Language statements required to prepare and compile object programs. The TDOS software package also includes a set of input-output routines for the control of data communications devices.

TDOS requires a minimum hardware configuration of 65,536 bytes of core storage, of which 16,384 bytes are permanently reserved for the Executive.

.44 Disc Operating System (DOS)

The Siemens 4004 Disc Operating System (DOS) provides a comprehensive disc-oriented multiprogramming control and operating environment for the 4004/35 and higher-numbered processors. It requires a minimum memory capacity of 32,768 bytes, and provides multiprogramming of up to six programs. Major features include a relocatable-loader, a non-resident monitor, the ability to control input jobstreams concurrently, and the sharing of random access file space by several programs. DOS is functionally composed of three component groupings: a system for controlling the entire system environment; language translators for compiling and/or assembling symbolic source programs into machine-coded programs ready to be placed in executable form by the linkage editor; and a utility system providing a variety of system service functions such as diagnostics, library maintenance, Sort/Merge, etc.

.45 Time Sharing Operating System (TSOS)

The newly announced Time Sharing Operating System (TSOS) is a specialized software system designed for control and support of the new Siemens 4004/46 time-sharing processor. The system is scheduled to provide advanced time-sharing capabilities, as well as improved facilities for handling batch processing in a multiprogramming mode.

Provided within the TSOS Executive program will be routines for handling task scheduling (capable of using a time-slicing algorithm), memory management, device allocation, physical-level input-output, and a combination command and job control language. Also provided as a TSOS system program will be a File Control Processor (FCP) with extensive automatic data management capabilities. In addition to all of the language processors and utility routines used with TOS and TDOS, TSOS will also provide a full conversational FORTRAN compiler, plus conversational text editor and desk calculator programs. Conversational syntax checking will also be provided for the FORTRAN, COBOL, and Assembler languages.

The minimum equipment required to use the Time Sharing Operating System includes a Siemens 4004/46 processor with at least 262K bytes of core storage, a 4004/567 Drum Memory Unit, two 4004/564 Disc Units, two 9-track magnetic-tape units, one card reader, and one printer. To support conversational users, the system must also include a 4004/668 Communications Controller - Multi-channel and from 1 to 48 remote terminal units.

.5 COMPATIBILITY

.51 Program Compatibility Within the Siemens 4004 Line

Siemens emphasizes the high degree of program compatibility, both upward and downward, among the following models of Siemens 4004: 4004/35, 4004/45 and 4004/55.

Among these three models, any valid program that runs on configuration A will run on configuration B and produce the same results if:

- Configuration B includes the required amount of main storage, the same or compatible input-output devices, and all required special features; and
- The program is independent of the relationships between instruction execution times and input-output rates.

(Contd.)

.52 Program Compatibility with the IBM System/360 and RCA Spectra 70 Series

Siemens provides program compatibility with both RCA Spectra 70 Series and IBM System/360 through the Siemens 4004 source language. The Siemens 4004 COBOL and FORTRAN languages are in many cases identical to their Spectra 70 and System/360 counterparts. Since the instruction repertoire of the large Siemens 4004 processors is virtually identical with those of the similar-sized IBM and RCA processors, Siemens is able to realize program compatibility with them at the assembly-language level as well.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
PROCESSOR			Processing Unit			
			Model 4004/16:			
	4004/16-B		Central Processor (8,192 Bytes)	3,395	135	165,000
	4004/16-C		Central Processor (16,384 Bytes)	5,870	230	286,000
			Model 4004/26:			
	4004/26-C		Central Processor (16,384 Bytes)	6,575	260	320,000
	4004/26-D		Central Processor (32,768 Bytes)	10,475	415	510,000
	4004/26-E		Central Processor (65,536 Bytes)	14,980	590	730,000
			Model 4004/35:			
	4004/35-D		Central Processor (32,768 Bytes)	13,163	518	641,250
	4004/35-E		Central Processor (65,536 Bytes)	18,428	730	897,750
		5001-35	Memory Protect	556	24	26,980
		5002-35	Elapsed Time Clock	224	10	10,735
		5003-35	Direct Control	878	38	42,750
		5005-35	301 Emulator	1,755	72	85,500
		5006-35	1401 Emulator	1,433	58	69,825
		5030	Selector Channel	702	29	34,200
		5031	Selector Channel	1,209	48	58,900
			Model 4004/45:			
	4004/45-D		Central Processor (32,768 Bytes)	18,428	730	897,750
	4004/45-E		Central Processor (65,536 Bytes)	23,693	936	1,154,250
	4004/45-F		Central Processor (131,012 Bytes)	30,713	1,210	1,496,250
	4004/45-G		Central Processor (262,144 Bytes)	47,385	1,867	2,308,500
		5001-45	Memory Protect	556	24	26,980
		5002-45	Elapsed Time Clock	224	10	10,735
		5003-45	Direct Control	878	38	42,750
		5005-45	First 301 Emulator	2,204	86	107,350
		5005-45	Second 301 Emulator	2,305	95	112,100
		5006-45	First 1401 Emulator	2,204	86	107,350
		5006-45	Second 1401 Emulator	2,305	95	112,100
		5015	Selector Channel	965	38	47,025
		5016	Selector Channel	1,658	67	80,750
		5026-45	First 1410 Emulator	2,418	96	117,800
		5026-45	Second 1410 Emulator	2,515	100	122,600
			Model 4004/46:			
	4004/46-G		Central Processor (262,144 Bytes)	58,385	2,300	2,844,300
		5001-46	Memory Protect	540	25	26,125
		5002-46	Elapsed Time Clock	215	10	10,450
		5003-46	Direct Control	855	35	41,515
		5019-46	Elapsed Time Clock	525	25	25,270
		5040	Selector Channel	3,920	160	191,000
		5041	Selector Channel	5,775	230	281,200
		5042	Selector Channel	7,450	295	362,900
			Model 4004/55:			
	4004/55-E		Central Processor (65,536 Bytes)	36,641	1,445	1,785,050
	4004/55-F		Central Processor (131,072 Bytes)	43,661	1,723	2,127,050
	4004/55-G		Central Processor (262,144 Bytes)	60,333	2,376	2,939,300
	4004/55-H		Central Processor (524,288 Bytes)	98,943	3,898	4,820,300
		5001-55	Memory Protect	663	29	32,110

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
PROCESSOR (Contd.)			Processing Unit (Contd.)			
		5002-55	Elapsed Time Clock	224	10	10,735
		5003-55	Direct Control	1,102	43	53,675
		5020	Selector Channel	1,970	82	95,950
		5022	Selector Channel	3,510	139	171,000
		5024	Selector Channel	5,051	202	246,050
MASS STORAGE			Disc			
	4004/564		Disc Storage (7.25 Million Bytes)	2,400	218	105,634
	4004/4570-1		Direct Access Storage (233.4 Million Bytes)	24,275	2,460	1,080,622
	4004/4570-2		Direct Access Storage (145.88 Million Bytes)	16,575	1,500	737,843
			Drum			
	4004/567-8		Drum Memory Unit (4,128,800 Bytes)	11,915	1,645	580,450
	4004/567-16		Drum Memory Unit (8,257,600 Bytes)	23,830	3,290	1,160,900
			Magnetic Card			
	4004/568-11		Mass Storage Unit (536,870,912 Bytes)	12,734	1,003	620,350
			Controller			
	4004/551		Random Access Controller	2,311	91	112,433
		5501-18	Input/Output Attachment Feature to use Model 4004/564	NC	NC	NC
		5502-14	Input/Output Attachment Feature to use Model 4004/568-11	775	34	37,620
		5508	Input/Output Attachment Feature to use Models 4004/567-8, -16	430	20	20,710
		5511	Off-Line Scan Feature	161	10	7,695
		5512	Record Overflow Feature	63	5	3,000
		5513	Multichannel Switch	488	19	23,750
	4004/4572		Auxiliary Storage Control forModels 4570-1, -2	11,061	166	510,906
		45572	Input/Output Attachment Feature for Model 4004/4572	NC	NC	NC
	4004/4573-1		Attachment to use 4570-1, -2	1,615	70	78,500
	4004/4573-2		Attachment to use 4570-1, -2	2,675	105	130,000
INPUT-OUTPUT			Punched Card			
	4004/234-10		Card Punch (100 cpm)	1,970	274	95,950
	4004/234-11		Card Punch (100 cpm)	2,486	346	120,650
		5213	Scored Card Feature for 234-10, -11	44	10	2,138
	4004/236-10		Card Punch (300 cpm)	3,296	456	160,550
	4004/236-11		Card Punch (300 cpm)	3,803	528	185,250
		5215	Scored Card Feature for 236-10, -11	44	10	2,138
	4004/236-10		Card Reader (1,435 cpm)	2,847	394	138,700
	4004/237-21		Card Reader (1,435 cpm)	3,627	504	176,700
		5202	51-Column Card Feature for 237-10, -21	44	10	2,138
		5204	Column Binary Feature for 237-10, -21	132	10	6,413
		5211	End-of-File Feature for 237-10, -21	NC	NC	NC
		5269	Column 81 Inhibit for 237-10, -21	10	5	247
	4004/4235		Card Reader (600 cpm)	930	130	45,000
		45201	End-of-File Feature	68	10	3,325

(Contd.)

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
INPUT-OUTPUT (Contd.)			Punched Card (Contd.)			
		45202	90-Column Card Feature	98	14	4,750
		45206	Column Binary Feature	49	10	2,375
	4004/4238		Card Punch (420 cpm)	1,600	220	78,000
		45212	Column Binary Feature	15	5	600
	4004/4239-10		Card Reader (1,000 cpm)	1,435	205	70,000
	4004/4239-20		Card Reader (1,000 cpm)	1,560	220	76,000
		45207	Column Binary Feature	34	5	1,520
		45208	Scored Card Feature	24	5	1,140
		45209	Mark Sensing Feature	200	30	9,800
		45210	90-Column Card Feature	30	5	1,370
		45211	End-of-File Feature	15	5	665
			Punched Tape			
	4004/4223		Paper Tape Reader (1,200 char/sec)			
	4004/4225		Paper Tape Punch (100 char/sec)	722	101	34,960
	4004/4225-S		Paper Tape Punch (100 char/sec)	722	101	34,960
	4004/4226		Paper Tape Reader (400 char/sec)	605	82	29,735
	4004/4227		Paper Tape Reader (1,000 char/sec)	956	134	46,550
	4004/4227-S		Paper Tape Reader (1,000 char/sec)	956	134	46,550
	4004/4227-O		Paper Tape Reader (850 char/sec)	956	134	46,550
	4004/4228		Paper Tape Punch (150 char/sec)	330	90	10,850
	4004/4228-S		Paper Tape Punch (150 char/sec)	330	90	10,850
	4004/4280		Edge-Punch Card Reader (120 char/sec)	105	30	3,500
	4004/4281		Edge-Punch Card Reader (120 char/sec)	105	30	3,500
	4004/4282		Edge-Punch Card Punch (28 char/sec)	260	70	8,655
	4004/4220		Paper Tape Controller to use Models 4004/4223, /4228, /4280, /4281, /4282	1,030	45	50,000
	4004/4221		Paper Tape Controllers to use Models 4004/4228, /4282	760	35	35,000
	4004/4222		Paper Tape Controllers to use Models 4004/4223, /4280, /4281	760	35	35,000
	4004/4224		Paper Tape Controller to use Models 4004/4225, /4226, /4227	707	96	34,295
		45224	Controller Attachment for second device	171	29	8,360
			Printer			
	4004/243-30		Printer (1,250 lpm)	4,840	670	236,000
	4004/243-40		Printer (1,250 lpm)	6,360	880	310,000
	4004/4241-1B		Printer (910 lpm)	4,950	690	241,000
	4004/4241-1D		Printer (765 lpm)	4,950	690	241,000
	4004/4241-2B		Printer (465 lpm)	4,000	555	195,000
	4004/4241-2D		Printer (390 lpm)	4,000	555	195,000

CLASS	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
	IDENTITY OF UNIT			PRICES		
INPUT-OUTPUT (Contd.)			Printer (Contd.)			
	4004/ 4242-1B		Printer (910 lpm)	5,460	755	266,000
	4004/ 4242-1D		Printer (765 lpm)	5,460	755	266,000
	4004/ 4242-2B		Printer (465 lpm)	4,525	625	220,000
	4004/ 4242-2D		Printer (390 lpm)	4,525	625	220,000
		45256	Hi-Speed Paper Advance } for 4004/4241, /4242	110	15	5,200
		45264	Train Cartridge } for 4004/4241, /4242	290	45	14,000
	4004/ 4245-1		Printer (285 lpm)	2,985	415	145,000
	4004/ 4245-2		Printer (200 lpm)	2,985	415	145,000
	4004/ 4247-1-B1		Printer (620 lpm)	3,803	528	185,250
	4004/ 4247-1-F1		Printer (750 lpm)	3,803	528	185,250
	4004/ 4247-1-B2		Printer (620 lpm)	3,803	528	185,250
	4004/ 4247-1-B3		Printer (620 lpm)	3,803	528	185,250
	4004/ 4247-1-B4		Printer (620 lpm)	3,803	528	185,250
	4004/ 4247-2-B1		Printer (620 lpm)	4,388	610	213,750
	4004/ 4247-2-F1		Printer (750 lpm)	4,388	610	213,750
	4004/ 4247-2-B2		Printer (620 lpm)	4,388	610	213,750
	4004/ 4247-2-B3		Printer (620 lpm)	4,388	610	213,750
	4004/ 4247-2-B4		Printer (620 lpm)	4,388	610	213,750
			OCR — Devices			
	4004/4250		Videoscan Document Reader-Sorter	10,695	1,500	497,200
	4004/ 4250-1		Videoscan Document Reader-Sorter	12,600	1,795	588,000
	4004/ 4250-2		Videoscan Document Reader-Sorter	15,735	2,205	730,000
	4004/ 4250-3		Videoscan Document Reader-Sorter	15,735	2,205	730,000

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
INPUT-OUTPUT (Contd.)			OCR — Devices (Contd.)			
	4004/ 4250-4		Videoscan Document Reader - Sorter	16,970	2,380	789,100
	4004/ 4250-5		Videoscan Document Reader - Sorter	19,230	2,695	894,200
	4004/4251		Videoscan Document Reader - Sorter	6,715	940	312,200
	4004/4252		Videoscan Document Reader - Sorter	5,465	760	255,000
			Console			
	4004/97		Console and Typewriter	1,458	62	70,918
	4004/4217		Console and Typewriter	455	70	22,000
	4004/4215		Control	360	15	17,500
		45215	Control Expansion	65	5	3,000
			Magnetic Tape			
	4004/ 463-108		Tape Controller (single channel)	3,725	149	181,450
	4004/ 463-116		Tape Controller (single channel)	6,143	245	299,250
		5414-1	382 Tape Mode Feature } for 463-108, -116	68	5	3,230
		5415-1	Pack/Unpack Feature } for 463-108, -116	224	10	10,735
	4004/ 463-208		Tape Controller (dual channel)	4,934	197	240,350
	4004/ 463-216		Tape Controller (dual channel)	8,015	317	390,450
		5414-2	382 Tape Mode Feature } for 463-208, -216	132	10	6,413
		5415-2	Pack/Unpack Feature } for 463-208, -216	380	14	18,430
	4004/ 472-108		Tape Controller (single channel)	3,081	125	150,100
	4004/ 472-116		Tape Controller (single channel)	5,928	235	288,800
	4004/ 472-208		Tape Controller (dual channel)	4,290	173	209,000
	4004/ 472-216		Tape Controller (dual channel)	7,683	302	374,300
	4004/ 473-108		Tape Controller (single channel)	3,305	134	160,835
	4004/ 473-116		Tape Controller (single channel)	6,152	245	299,535
		5402-1	Pack-Unpack Feature	224	10	10,735
	4004/ 473-208		Tape Controller (dual channel)	4,626	187	225,245
	4004/ 473-216		Tape Controller (dual channel)	8,019	317	390,545
		5402-2	Pack-Unpack Feature	380	14	18,430
	4004/ 4472-108		Tape Controller (single channel)	3,080	125	150,100
	4004/ 4472-116		Tape Controller (single channel)	5,930	235	288,800
	4004/ 4472-208		Tape Controller (dual channel)	4,290	175	209,000
	4004/ 4472-216		Tape Controller (dual channel)	7,685	305	374,300
	4004/ 4475-108		Tape Controller (single channel)	4,485	180	219,000

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
INPUT-OUTPUT (Contd.)			Magnetic Tape (Contd.)			
	4004/ 4475-116		Tape Controller (single channel)	6,770	270	330,000
	4004/ 4475-208		Tape Controller (dual channel)	6,065	240	295,000
	4004/ 4475-216		Tape Controller (dual channel)	10,300	410	502,000
	4004/ 4476-108		Tape Controller (single channel)	3,630	145	177,000
	4004/ 4476-116		Tape Controller (single channel)	6,240	250	304,000
	4004/ 4476-208		Tape Controller (dual channel)	4,720	190	230,000
	4004/ 4476-216		Tape Controller (dual channel)	8,210	330	400,000
	4004/ 432-1		Magnetic Tape Unit	2,637	365	120,650
	4004/ 432-2		Magnetic Tape Unit	2,637	365	120,650
	4004/ 441-1		Magnetic Tape Unit	3,101	432	151,050
	4004/ 441-2		Magnetic Tape Unit	3,101	432	151,050
	4004/ 442-1		Magnetic Tape Unit	3,949	547	180,500
	4004/ 442-2		Magnetic Tape Unit	3,949	547	180,500
	4004/ 4432-7		Magnetic Tape Unit	1,320	170	60,325
	4004/ 4432-9		Magnetic Tape Unit	1,320	170	60,325
	4004/ 4442-7		Magnetic Tape Unit	1,975	275	90,250
	4004/ 4442-9		Magnetic Tape Unit	1,975	275	90,250
	4004/ 4443-1		Magnetic Tape Unit	1,974	274	90,250
	4004/ 4443-2		Magnetic Tape Unit	1,974	274	90,250
	4004/ 4446-1		Magnetic Tape Unit	2,210	310	101,000
	4004/ 4446-2		Magnetic Tape Unit	2,210	310	101,000
	4004/ 4451		Magnetic Tape Unit	1,555	220	71,000
	4004/ 4453		Magnetic Tape Unit	2,210	310	101,000
			Communications			
	4004/ 627-10		Data Exchange Control	1,970	82	95,950
	4004/656		Communication Control (single channel)	1,820	75	88,500
	4004/ 668-11		Communication Control (multi-channel)	3,081	125	150,100

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Monthly Maint. DM	Purchase DM
INPUT-OUTPUT (Contd.)			Communications (Contd.)			
	4004/ 668-21		Communication Control (multi-channel)	3,959	158	192,850
	4004/ 668-31		Communication Control (multi-channel)	4,836	192	235,600
	4004/710		Telegraph Buffer	122	5	5,795
	4004/ 720-21		ADS Buffer (for 668-11, -21, -31)	185	10	8,978
	4004/ 720-22		ADS Buffer (for 668-11, -21, -31)	185	10	8,978
	4004/ 721		SDS Buffer (for 668-11, -21, -31)	185	10	8,978
	4004/780		Time Generator/Buffer (for 668-11, -21, -31)			
	4004/4666		Communication Control (multi-channel)	1,365	58	66,500
	4004/ 4713-1		Telegraph Buffer (for 4666)	141	10	6,840
	4004/ 4713-2		Telegraph Buffer (for 4666)	141	10	6,840
	4004/752		Video Data Terminal	741	29	36,100
SWITCHING DEVICES	4004/ 310-21		Standard Interface Switch	390	19	19,000
	4004/ 310-22		Standard Interface Switch	780	34	38,000
	4004/ 310-23		Standard Interface Switch	1,170	48	57,000
	4004/ 310-24		Standard Interface Switch	1,560	62	76,000
	4004/ 310-25		Standard Interface Switch	1,950	77	95,000
	4004/ 310-26		Standard Interface Switch	2,340	96	114,000
	4004/ 310-27		Standard Interface Switch	2,730	110	133,000
	4004/ 310-28		Standard Interface Switch	3,120	125	152,000
	4004/ K 310		Switch Expansion Kit	180	10	8,598
	4004/ 350-2		Switch Controller	2,087	86	101,650
	4004/ 350-3		Switch Controller	2,535	101	123,500
	4004/ 350-4		Switch Controller	2,965	120	144,400

SUMMARY REPORT: SIEMENS SYSTEM 300

.1 BACKGROUND

Siemens AG of Munich, West Germany announced the System 300 in the third quarter of 1965. The System 300 originally consisted of four models, namely, 302, 303, 304 and 305. More recently two additional models, 301 and 306, have been introduced to expand the range of the System 300's processing capability. Memory capacities for this series of binary processors range from 4, 096 24-bit words on the smallest 301 to 65, 536 words on the largest 306.

Models 301 and 306 represent Siemens' attempt to compete with the imports in those two ranges (small and large scale systems) from Western Europe and the U. S. A. The Siemens System 300, as originally introduced, was a second-generation range of computers; these two new processors extend the range to compete with third-generation equipment.

The purchase price for the System 300 ranges from 60, 000 DM (about US $15, 000) to 165, 000 DM for the Model 301 and from 410, 000 DM (about $103, 000) to 1, 090, 000 DM for the Model 306.

Siemens, a manufacturer of communications and electronics equipment, should not be dismissed lightly in its venture into the computer market. This is especially true since it more recently announced the 4004 Series, which is discussed in Summary Report 1950.

.2 HARDWARE

.21 System Configuration

A Siemens System 300 includes a central processor that contains core memory, an arithmetic unit and a control unit. The peripherals communicate with the central processor through channels. The System 300 is equipped with two types of channels; standard speed channels for low-speed devices such as teletypes, and high-speed channels for fast devices such as discs and magnetic core storage units.

A wide range of peripheral units is optionally provided for connection to the central processors. The available peripheral units are compatible on all models of the System 300.

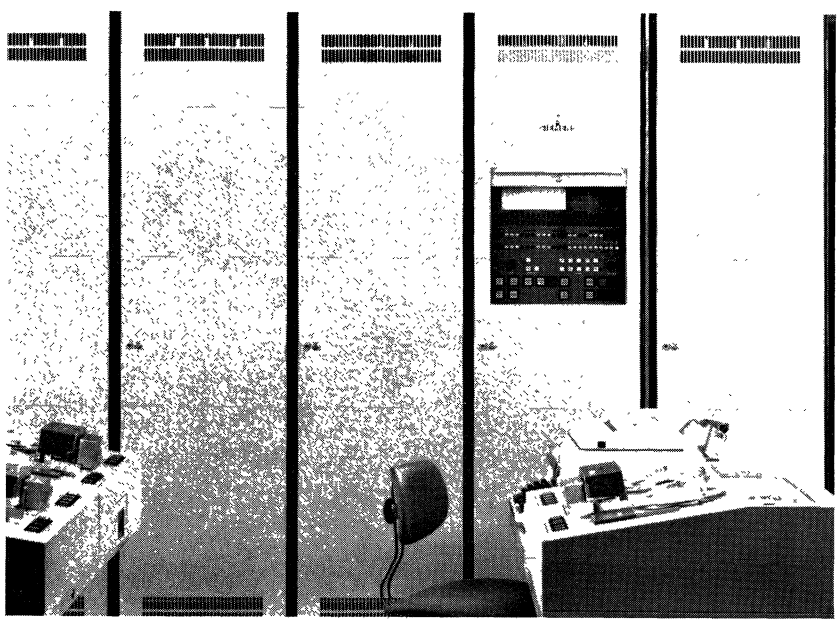

Figure 1. Siemens System 300 Computer

.22 Data Structure

The basic addressable unit of the System 300 is the 6-bit binary character. Four such characters constitute the 24-bit word. The 24 binary bits can represent four characters or four decimal digits. Models 305 and 306 represent a floating point number as a fraction having 24 or 34 bits and an exponent of 10 bits.

Instructions are one 24-bit word in length, with a 14-bit address, a 1-bit accumulator designator (right or left), a flag bit to interrogate the console interrupt flag, a bit to test for address modification, an interrupt bit and a 6-bit operation code. The interrupt bit can be set by the following conditions: an illegal operation has occurred in the instruction register, an interrupt has been issued by a peripheral unit or the operator has depressed the interrupt button on the console.

TABLE I: SIEMENS SYSTEM 300 CENTRAL PROCESSOR CHARACTERISTICS

Model No.	301	302	303	304	305	306
Minimum Storage Capacity (words)	4, 096	8, 192	4, 096	8, 192	8, 192	16, 384
Maximum Storage Capacity (words)	16, 384	16, 384	16, 384	16, 384	16, 384	65, 536
Main Memory Cycle Time, μsec	1. 6	1. 5	33*	1. 5	1. 5	0. 6
Checking	None	None	None	None	None	Parity
Storage Protection	None	None	Write only	Write only	Write only	Write only
Program Interrupt (levels)	2	Multiple	Multiple	Multiple	Multiple	Multiple
Number of Index Registers	None	None	None	None	None	16

* The System 300 Model 303, an early member of the range, was substantially slower than the other models. It was developed from the earlier Siemens 3003.

.23 Central Processor

As presently implemented, the System 300 processors appear as fixed word length, binary processors with one address per instruction. Models 301 and 302 have only one accumulator while the remaining processors each have two. There is only a limited downward compatibility of index registers because of the different instruction sets. Model 306 comes equipped with 16 index registers. Index registers are not simulated through software on the models without index registers. Parity checking is provided only on Model 306.

The basic instruction set is common to all models of the System 300. In successive models the basic instruction list is made more powerful through the use of address modification subsets to take advantage of the more powerful system. The instruction repertoire of all models of System 300 include a full complement of shift instructions, logical and transfer instructions, branching and arithmetic instructions and peripheral control instructions. Model 301 has 22 instructions, Model 302 has 23, Model 303 has 31, Model 304 has 40, Model 305 has 46 instructions and Model 306 has a full complement of 55 instructions. Models 301 through 304 provide no floating point facilities. Model 303 allows only fixed point addition, subtraction and multiplication and Models 301 and 302 permit fixed point addition and subtraction only.

Multilevel indirect addressing is available on all models of the System 300. Siemens refers to this as Address Substitution. Each instruction has an interrupt bit, bit 18, that is set by the programmer to enable the interrupt system. Interrupts can also be enabled from the console and from peripheral units that request servicing.

(Contd.)

.23 Central Processor (Contd.)

All models of the Siemens System 300 are capable of processing up to 23 independent programs on a multiprogramming basis. The individual programs are processed on 23 priority levels (program numbers) to ensure that the program with the highest priority is processed first, if necessary by interruption of a less important program.

The contents of essential registers in the processors are displayed through a number of optical indicators, and toggle and pushbutton switches that allow access to any location in main memory for manual input-output transfers.

The input-output channels are provided with standard interfaces for the connection of peripheral units. A distinction is made between standard interfaces which are provided in all processors of the System 3000 and high-speed channel interfaces which are optional and available on Models 304, 305, and 306 only.

The Siemens System 300 is fully upward compatible for programs written on the machine language level; this means that all programs written for a specific processor model of the system can be run without modifications on the larger models of the system.

A means for providing downward compatibility is offered on the assembly language level. On this level, all instructions not included in the instruction complements of the individual central processors are coded as macro instructions so that, when non-implemented instructions are found at assembly time, they are replaced by a subroutine which simulates the illegal instructions.

.24 Auxiliary Storage

Auxiliary storage for the System 300 is provided by the Model 2027 Magnetic Core Storage Unit, and by the drum and disc units whose characteristics are given in Table II. A storage controller is available for the connection of drum units — up to five drum controllers can be connected to Models 302 and 303, and up to ten can be connected to Models 304 and 305. From one to four drum units can be connected to a drum controller, but different drums connected to the same controller cannot be used simultaneously.

The Disc Storage Unit contains an exchangeable disc stack with six magnetic discs. Disc storage units are connected to the processor through a disc controller to the high-speed channel.

The Model 2027 Magnetic Core Storage Unit is connected to the processor via a high-speed channel and provides secondary storage of 16, 384 words.

TABLE II: CHARACTERISTICS OF SIEMENS SYSTEM 300
AUXILIARY STORAGE DEVICES

Type of Unit	2013 Drum	2014 Drum	2015 Drum	2027 Magnetic Core Storage Unit	2051 Disc
Maximum Number of Units On-Line	4/Trunk	4/Trunk	4/Trunk	1/Trunk	1/Trunk
Maximum Number of Words/Unit	65, 536	131, 072	262, 144	16, 384	1, 792, 000
Waiting Time (μsec)					
Minimum	0	0	0	—	0
Average (Random)	32	32	32	—	87.5
Maximum	64	64	64	—	16.0
Effective Transfer Rate, char/sec	72, 000	72, 000	72, 000	2, 668, 000	208, 000
Data Checking	Cyclic	Cyclic	Cyclic	Parity	Cyclic

.25 Peripheral Equipment

The peripheral units for System 300 are listed in Table III.

The Siemens System 300 provides three different types of peripheral units capable of processing punched cards.

Model 2009 is a column by column reader/punch; the cards can be printed under program control during punching.

Models 2010 and 2021 are a reader and a punch, respectively and feature automatic code translation and a column binary feature on reading and punching.

Presently two printers are available as shown in Table III. Model 2023 is available at option with 120 and 104 print positions per line; the Model 2022 has 120 print positions per line. Forty-eight different characters can be printed.

The Model 2022 Printer can print up to 1500 lines per minute if only numeric data is printed; the speed for Model 2023 is 1600 lines per minute for numeric print.

Five models of paper tape input-output equipment are available. Model 0001, a console paper tape reader, is used only with processor Model 303, while the Model 0016 Console Paper Tape Reader is available for Processor Models 302, 304, 305, 306.

The three remaining paper tape input-output units (Models 2006, 2007 and 2008) can be connected to any central processor in the System 300.

All models feature automatic code translation; Models 2006, 2007 and 2008 have parity checking while Models 0001 and 0016 contain a second read station for data checking.

TABLE III: PERIPHERAL EQUIPMENT FOR SIEMENS SYSTEM 300

Type of Unit	Model Number	Rated Speed	Data Checking
Card Reader/Punch	2009	53 cards/min	—
Card Reader	2010	660 cards/min	Validity
Card Punch	2021	420 cards/min	Echo
Paper Tape Reader	0001	30 char/sec	Second Read Station
Paper Tape Reader	0016	200 char/sec	Second Read Station
Paper Tape Reader	2006	400 char/sec	Parity
Paper Tape Reader	2008	400 char/sec	Parity
Paper Tape Punch	2007	150 char/sec	Parity
Printer	2022	1500 lines/min	Echo, Timing
Printer	2023	1600 lines/min	Timing
Console Typewriter	2017	10 char/sec	—

.26 Process Signal Input-Output Units

The System 300 provides a range of analog/digital and control devices. A special feature of the Siemens System 300 is the wide variety of devices for the automatic interchange of data between the processor and the process to be controlled. With the System 300, two types of process signal input-output units are provided, both of which connect to the processor via a standard interface.

The Model P1K Process Signal Input-Output Unit handles a maximum of 12 process signal input-output devices that are located in the immediate vicinity of the processor.

.26 Process Signal Input-Output Units (Contd.)

The Model P2K Process Signal Input-Output Unit handles process signal input-output devices as remote as 12.5 miles from the central processor and the maximum information transfer rate is 2400 bauds.

These process signal input-output units handle analog variables, binary signals, digital inputs, timing pulses, and alarm signals.

The Models P3 and P4E Process Signal Input-Output Units handle the input-output of digital data at a speed of 220,000 words per second for P3 and 30,000 words per second for the P4E in the immediate vicinity of the processor and remotely up to 3/4 mile.

.3 DATA COMMUNICATIONS

The System 300 is designed to handle data communications. To accomplish this, additional equipment such as data transmitters and terminal equipment has been developed.

The Model 2011 Telegraph Unit is one of the data communications units provided with the Siemens System 300. This unit provides for connection of teleprinters and paper tape equipment to any Siemens System 300 processor through private or public lines. It can also be used to connect System 300 processors with each other via telegraph lines. The maximum data transmission rate is 200 bits per second. Over short distances it is possible to transmit characters in parallel at a maximum rate of 500 characters per second.

Siemens has under development, equipment for higher-speed data transmission at a maximum rate of 1200 bits per second. This equipment will make it possible to connect Siemens System 300 processors and Siemens System 4004 processors via telephone channels.

The Data Exchange Control 2041 enables two adjacent Siemens System 300 processors to communicate with each other at a rated speed of 54,000 characters per second. The Data Exchange Control 2071 transfers data between one Siemens System 4004 processor and another Siemens System 300 processor; the transmission rate depends upon the type of channel used and the connected processors.

.4 SOFTWARE

Control Systems consisting of a supervisor (the Control System) and other system programs are used to extend the hardware capabilities of the Siemens System 300 processors. These systems control the overlapped operations of hardware elements and of programs. The required Control System functions are initiated by calls in the user programs which consist of an instruction sequence that is written as a macro instruction in the 300 assembler language.

The Control System of the System 300 provides for multiprogramming of up to 23 independent programs and one scheduling routine. The Control System allocates a software program counter to each of these programs which use the hardware program counter in alternation. The program with the highest priority is always processed first, if necessary, after the interruption of a lower priority program. When programs require input-output operations, they are held up until higher priority operations are completed.

Program priorities depend on the program numbers; program No. 1 has the highest priority. It may be interrupted only if it must wait for completion of input-output operations or if Control System operations are required. The Control System also controls the shared use of core memory areas (in a time-sharing environment) and of subprograms by concurrently operating programs and automatically assigns, and prepares a directory of, storage areas on external storage devices.

To prevent the blocking of program processing, the Control System maintains queue lists for the peripheral units by storing the necessary information from the program requesting the input-output operation and continuing the program.

Programs for the Siemens System 300 are generally written in the PROSA 300 Assembly Language. ALGOL 300 is a multiple-pass compiler and corresponds to the IFIP Subset of ALGOL 60.

FORTRAN IV-300 is a multiple-pass compiler and corresponds to the IBM 360 FORTRAN E level.

PRICE DATA

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Purchase DM	Monthly Maint. DM
CENTRAL PROCESSOR	301-4		Central Processor (4,096 words)	1,300	155	60,000
			301 Memory Expansion Options			
		4-8	from 4,096 to 8,192 words	760	90	35,000
		8-12	from 8,192 to 12,288 words	760	90	35,000
		12-16	from 12,288 to 16,834 words	760	90	35,000
	302-8		Central Processor (8,192 words)	3,045	355	140,000
	302-16		Central Processor (16,384 words)	4,425	518	204,250
	303-4		Central Processor (4,096 words)	2,575	302	118,750
	303-8		Central Processor (8,192 words)	3,650	427	768,340
	303-12		Central Processor (12,288 words)	4,575	538	211,090
	303-16		Central Processor (16,384 words)	5,750	672	265,430
	304-8		Central Processor (8,192 words)	4,650	542	214,700
	304-8 SK21		Central Processor (8,192 words) with one high speed channel for 1 external unit	4,835	566	223,250
	304-8 SK25		Central Processor (8,192 words) with one high speed channel for 5 external units	5,555	648	256,500
	304-16		Central Processor (16,384 words)	6,030	706	278,350
	304-16 SK21		Central Processor (16,384 words) with one high speed channel for 1 external unit	6,215	725	286,900
	304-16 SK25		Central Processor (16,384 words) with one high speed channel for 5 external units	6,935	811	320,150
	305-8		Central Processor (8,192 words)	5,370	629	247,950
	305-8 SK21		Central Processor (8,192 words) with one high speed channel for 1 external unit	5,555	648	256,500
	305-8 SK2-5		Central Processor (8,192 words) with one high speed channel for 5 external units	6,275	734	289,750
	305-16		Central Processor (16,384 words)	6,750	787	311,600
	305-16 SK21		Central Processor (16,384 words) with one high speed channel for 1 external unit	6,935	811	320,150
	305-16 SK25		Central Processor (16,384 words) with one high speed channel for 5 external units	7,655	893	353,400
	306		Central Processor (16,384 words)	8,860	1,040	410,000
			306 Memory Expansion Options			
		16-32	from 16,384 to 32,768 words	4,750	560	220,000
		32-49	from 32,768 to 49,152 words	5,185	610	240,000
		49-65	from 49,152 to 65,536 words	4,750	560	220,000
			Features			
		SK21	High speed channel for one external unit	185	19	8,550
		SK25	High speed channel for five external units	905	106	41,800
MASS STORAGE UNITS	2027		Magnetic Core Storage Unit (16,384 words)	3,395	398	156,750
			Drum			
	0011		Drum Storage (65,536 words)	1,654	192	76,000
	0012		Drum Storage (131,072 words)	2,265	264	104,500
	0013		Drum Storage (262,144 words)	2,880	336	133,000
			Controller			
	2013-1/-2		Drum Storage Controller with one Drum Storage 0011	3,085	360	142,500
	2014-1/-2		Drum Storage Controller with one Drum Storage 0012	3,705	432	171,000

CLASS	IDENTITY OF UNIT			PRICES		
	Model Number	Feature	Name	Monthly Rental DM	Purchase DM	Monthly Maint. DM
MASS STORAGE UNITS (Contd.)			Controller			
	2015-1/-2		Drum Storage Controller with one Drum Storage 0013	4,320	504	199,500
		0010	Drum Cabinet (for Drum Storage Expansion)	825	96	38,000
		0042	Drum Cabinet (for Drum Storage Expansion)	825	96	38,000
			Disc			
	2051		Disc Storage (1.792 Million words)	2,400	218	105,634
		0017	Disc Pack	55	-	1,800
			Controller			
	2050-1/-2		Disc Storage Controller	2,210	238	91,586
INPUT-OUTPUT DEVICES	0002		Channel Selector (Expansion only for Model 303)	65	10	2,850
	2092		Interface Attachment	620	72	28,500
			Punched Tape			
	0001		Paper Tape Reader Controller (30 char/sec)	110	14	4,845
	0016		Paper Tape Reader (200 char/sec)	310	38	14,250
	2006		Punched Tape Controller (400 char/sec)	610	72	28,025
	2007-1		Paper Tape Punch (100 char/sec)	725	86	33,440
	2007-2		Paper Tape Punch (100 char/sec)	725	86	33,440
	2007-3		Paper Tape Punch (150 char/sec)	750	91	34,440
	2007-4		Paper Tape Punch (150 char/sec)	750	91	34,440
	2008-1		Paper Tape Reader/Punch (400/100 char/sec)	1,045	125	48,165
	2008-2		Paper Tape Reader/Punch (400/100 char/sec)	1,045	125	48,165
	2008-3		Paper Tape Reader/Punch (400/150 char/sec)	1,070	130	49,165
	2008-4		Paper Tape Reader/Punch (400/150 char/sec)	1,070	130	49,165
			Punched Card			
	2009		Card Reader/Punch (13...53 cpm)	885	120	40,660
	2010		Card Reader (600 cpm)	1,360	158	62,700
	2021		Card Punch (104...420 cpm)	1,545	182	71,250
		0026	Column Binary (read)	55	10	2,375
		0027	Column Binary (punch)	15	5	600
			Printer			
	2022-A		Printer (1500 lpm)	3,715	437	171,475
	2023-1		Printer (1600 lpm)	3,520	412	162,450
	2023-2		Printer (1600 lpm)	3,335	388	153,900
	2023-3		Printer (1600 lpm)	2,340	278	107,825
		0018	Expansion from 104 to 120 print positions	105	14	4,750
		0019	Expansion from 120 to 136 print positions	105	14	4,750
			Data Exchange Controller			
	2041		Data Exchange Controller	980	115	45,000
	2071		Data Exchange Controller	1,245	160	57,000