computers and automation

THE ABC'S OF COMPUTERS

Comments on War Safety Control

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What is an Automatic Computer?

Neil Macdonald
Assistant Editor
Computers and Automation

1. What Is Computing?

Suppose you sit down with pencil and paper and center your attention on a problem that needs an answer, such as adding a set of figures on an income tax form with the figures all listed in front of you. You proceed to add them, adding first all the digits in the right-hand column, then all the digits in the next column (remembering any carry), then all the digits in the next column (again remembering any carry), and so on—until you finally arrive at the answer (or an answer, if you are not positive that your figuring is correct). When you do all this, you are *computing*.

When you stop at a street corner, looking first to the left for any oncoming traffic, then to the right, then estimating whether you can cross the street without any approaching car coming uncomfortably close to you, and finally decide to cross or to wait on the sidewalk—then you are computing.

When you are walking uphill along a poorly marked trail in the woods, wondering if you are really on the trail or have lost it, looking everywhere for trail blazes or cairns or any signs that other people have often passed that way before,—then you are computing.

Whenever you are taking in information or data, performing reasonable operations (both mathematical and logical operations) on the data, and are producing one or more conclusions or answers,—then you are computing.

A machine can also do this. It can take in information or data, perform a sequence of reasonable operations on the information it has received, and put out answers. When it does this, it is computing.

A very simple example of a computing machine is the ordinary business *adding machine,* which prints on paper tape the number entered into its keyboard, and also prints a total when the total key is pressed. A complex example of a computing machine is a modern *automatic digital computer,* which in each second can perform more than 10,000 additions, subtractions, multiplications, or divisions, on numbers of a dozen or more decimal digits, all according to a long sequence of instructions given to the machine.

A computing machine is able to take in and store information because within the machine there is equipment which can be positioned to express that information. For example, an adding machine often has ten keys for each column of digits to be added; those keys are marked with the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The machine *takes in* the digit whose key is pressed. For example, when, at the start of a problem, the 6 key is pressed, a little counter wheel inside the machine turns from 0 forward 6 steps (1, 2, 3, 4, 5, 6) and its setting is changed to 6, and so it is *positioned* to express the digit 6. There the counter wheel will stay until it is subsequently changed. So the machine records or remembers, or *stores* information by the arranging or positioning of some of the equipment inside the machine.

A computing machine is able to *calculate,* perform reasonable operations upon information, because the hardware inside the machine expresses arithmetical or logical relations, such as adding or subtracting, comparing or selecting. For example, suppose the small counter wheel inside the adding machine is now set at 6. Suppose next we set 8 on the keyboard in that same column of digits, pressing the 8 key down. Then this action causes that counter wheel to turn forward 8 steps 7, 8, 9, 0, 1, 2, 3, 4, so that it is now set at 4 (the right hand digit of 14 equal to 6 plus 8). Furthermore, there is a small extra side-tooth on that counter wheel between 9 and 0, so that when the counter wheel passes from 9 to 0, it nudges the next counter wheel on its left, and causes it to turn one step, thus "carrying" 1 into the setting of the counter wheel that expresses the next digit at the left.

A computing machine is also able to *put out* information, display the answers when it obtains them. For example, the adding machine contains a paper tape, and associated with each counter wheel position is a type wheel bearing the digits 0, 1, 2, and so on up to 9; then whenever the total key is pressed, the paper tape, an inked ribbon, and the type wheel are struck together, and the impressions of the type are transferred to the paper tape.

2. What Is an Automatic Computer?

But you may say, "That may be all very well, but this adding machine is not really a computer—it is just doing what some human being tells it to do at every single step. Whereas when I, a human being, work on one of my problems, I perform a long chain of steps. Frequently, in fact, I may stop and think just which step I am going to perform next. For example, if that badly marked trail baffles me enough, I may sit down somewhere for a while and think carefully just what I had best do next. But this adding machine that you have been talking about—it can't consider any problem like that!"

Yes, you would have been entirely right, until the year 1944. But in that year the first of a new breed of computing machines, the first automatic general-purpose computer, came into actual existence and began to operate. It was the Harvard IBM Automatic Sequence-Controlled Calculator, which that year started to do useful work in a laboratory in Cambridge, Mass., the result of a joint development project by Professor Howard Aiken of Harvard University, and International Business Machines Corporation.

This automatic computer had a truly important additional facility. It had a long loop of punched paper tape that stored a long sequence of instructions, in fact a set of instructions with no specified limit—for adding or substracting, multiplying or dividing, comparing or selecting, etc.—depending on the step it had reached. Calculations were organized into repeating cycles of steps, round after round. The machine was able to call for and pick up the numbers it needed at each step, perform the specified operation, store the result, and then go on to the next step. This property in a computing machine was new, and marked a very important break with the past.

But one more step remained to be taken and was taken in 1946 and 1947. This was to remove the long sequence of instructions from outside the machine and instead place them inside the machine, in the machine's internal storage warehouse of information. Then the machine itself could select, as might be needed or called for, the numbers or instructions required at each step, and in this way solve the problem.

And so, an automatic computer is a machine which is able to take in and store information (problems, numbers, instructions, . . .), perform reasonable operations on the information as may be required in the course of solving a problem, and put out answers.

3. What Is Information?

The definitions we have given above depend on the meaning of two important ideas, "information" and "reasonable operations." Let us try to clarify these ideas.

Information, from our own point of view as a human being, is likely to be thought of as one or more statements of facts, such as "The population of the world became more than 2.9 billion people during 1959." In other words, information is certainly what you find in a dictionary, telephone book, or textbook—but hardly at all what you find in a novel, story, or fairy tale.

Information, from the point of view of a computing machine, is not the same. Instead, it is a set of marks or signs that have meaning. These consist of letters or numbers, digits or characters, typewriter signs, other kinds of signs, and so forth. A computing machine reacts differently to different digits or characters, and reacts to them as units that have meaning. For example, if the computer is instructed "Add 365 the number of times stated in register R," and if register R stores the code for the number 3, then the computer will perform that operation 3 times. There exist other machines that deal with information but pay no attention to the meaning: this is true of a television pick-up camera, a printing press, a facsimile copier. But a computing machine groups together a set of say 10 to 20 digits or characters that belong together, treats them as a unit (which is regularly called a *machine word*), and is so constructed that the number 587.66 stored as marks in one register is treated as exactly equivalent to and interchangeable with the number 587.66 stored as similar marks in any other register.

Physically, the set of marks is a set of arrangements of some physical equipment. One of the characteristic ways of storing information in a computer is as a set of small magnetically polarized spots on a magnetic surface. An arrangement of spots "south-north, south-north, north-south, north-south, north-south, south-north" could stand for a code made up of ones and zeros as follows: 1 1 0 0 0 1. And this code might stand for, say, the letter M. The same code 1 1 0 0 0 1 occurring anywhere in the storage registers of the machine would also stand for the letter M.

The aspect of meaning that a computer can be said to "understand" is the aspect of logical or mathematical consistency among the information, instructions, and operations that the computer deals with. The computing machine has, of course, no knowledge of the "meaning" of an M or a 3 or of other information as it may occur in many sorts of situations in human society.

4. What Are Reasonable Operations?

The other idea that needs to be clarified in order to understand an automatic computer is "reasonable operations" upon information. These are mathematical and logical operations. *Mathematical operations* include addition, subtraction, multiplication, division, taking a square foot, etc., and also more advanced mathematical operations, such as the operation of algebra called "raising to a power" and the operations of calculus called "differentiating" and "integrating." These are operations on information which is in the form of numbers or of mathematical expressions much like numbers.

Logical operations include comparing, selecting, sorting, matching, merging (which is the placing of two separate sequences into a single sequence, as might be done with playing cards), etc. These are operations which may be performed either on numbers or on expressions made out of letters such as ordinary words. By skillfully assembling these operations in various ways, quite complicated reasonable operations may be arrived at, such as those that occur in translating from one language to another. For example, automatic computers have successfully translated from Russian to English, although so far restricted to moderately large vocabularies.

A particularly important logical operation performed by a computer is determining, at some time in a calculation, which of two operations called for in the instructions is to be performed next; the computer makes the decision by applying a rule (given to it) to a calculated result which is accessible in storage (becomes "known") only when that time in the calculation has arrived. This is called a *branching operation.*

5. Some Properties of Reasonable Operations

Now "reasonable operations" on information have some interesting and remarkable properties:

—they do not question the objective meaning of the starting data or facts;

—they do not question the objective truth of the starting statements or conditions;

—but they do find out (or *calculate* or *compute)* the consequences or implications contained in the starting data and statements.

For example, let us take the following statements:

1. The earth is still, and the sun goes around the earth, in a path that is nearly a circle.
2. The sun is still, and the earth goes around the sun, in a path that is nearly a circle.

3. Mars, Venus, and the other planets go around the earth in very complicated paths (called epicycles).
4. Mars, Venus, and other planets go around the sun in simple paths (called ellipses) which are nearly circles.

Let us also take a context in which we know what we mean by such words as "sun," "earth," "path," "circle"; and in which we have other statements and understandings such as "The sun apparently goes around an observer on the earth, passing from east to west during the day." Then if we start with statement 1, statement 3 can be computed to be true; and if we start with statement 2, statement 4 can be computed to be true.

A computer (human or machine) specializes in deriving conclusions (logical or mathematical) without regard to the objective truth of the starting data.

Another property of reasonable operations is important for us. This is the fact that since they do not depend on objective meaning or objective truth, a great deal of time is saved in calculation. For instance to add 222 and 555 and obtain 777 for the answer, neither the person computing nor the computing machine has to remember or in some way "conceive of" the meaning of these numbers. When we have a satisfactory kind of language—either of symbols on paper or arrangements of hardware in a machine—then the reasonable operations can be carried out with the symbols or the arrangements only.

And finally, if the premises correspond with the real world, and if the reasonable operations are correctly carried out, then so do the conclusions correspond with the real world.

From the point of view of a philosopher, it is curious that the patterns of marks or signs or symbols can imitate, can correspond with, patterns of objects in the real world—in much the same way as an architect's drawing can correspond with a building. The patterns of symbols picture the structure of portions of the real world. And instead of manipulating the reality with difficulty, we can manipulate the symbols with ease.

To take a very simple example, suppose a farmer has a flock of 222 sheep and a second flock of 555 sheep, and we want to know the total. We put down the six marks "2, 2, 2, 5, 5, 5" on paper, combine them by rules that are certainly mechanical since they do not require us to "think" of their meaning, and we come out with an answer "a total of 777 sheep." And this is a true statement about the real world, determined without doing anything at all with the sheep.

Billing 4 million customers of a public utility according to their actual use of gas or electricity and billing them each month by the operations of an automatic computer is a much bigger and far more important example. But the situation does not differ in quality, in essence—only in degree.

6. How Is a Computer Organized?

Now you may say, "Well, I can see many of the possibilities that you are describing. But specifically just how can a machine be arranged or constructed to do all the different kinds of reasonable operations that may be needed to work out the solution to a problem? And how does it perform them, all in the proper sequence, with the utmost tidiness—completely and accurately?"

This is an important question, but the answer is a little long.

First, the machine must have a way of taking in information. The part of the computer that takes in information is called the *input unit.* For the machine to accept it, information cannot yet be in the form most customary to human beings, spoken language; that presents very great difficulties to these machines. Instead, information for a *digital computer* has to be in the form of digits 0, 1, 2, 3, 4, . . . 9 or characters A, B, C, . . . &, ¢, . . . Even these marks have to be translated, usually by human beings —typists and clerks—into specially prepared symbols that the machine can accept; one example is punched holes in a card of standard size, which is the form of many payroll checks nowadays; another example is punched holes in continuous paper tape, which may be used in a telegraph office to send a telegram. Information for an *analog computer* has to be in the form of distances, or rotations, or voltages, or amounts of other physical variables.

Second, the machine must have a way of putting out information. The part of the computer that puts out information is called the *output unit.* The computer can easily put out information in a form acceptable to human beings. For example, the computer may give impulses to an electric typewriter, so that the keys are energized in the proper sequence to type out a message in ordinary typed characters which a human being can read. Or the computer may show a graph on a phosphorescent screen, such as the face of an oscilloscope. But in some cases, as in giving signals to an airplane pilot coming into an airfield for a landing, the computer may release the sound recordings of appropriate statements so that the pilot is told in spoken words over his radio just what he needs to know.

Third, the machine must have a way of storing information. The part of a digital computer which stores information is called *storage* or *memory.* Information that is stored inside a computer is stored in locations or *registers,* units of hardware in which the positioning of physical objects stores information. Each one ordinarily holds one "machine word," consisting usually of 10 to 20 decimal digits or characters, or their equivalent. The number of separate registers which the computer can "consult" or "look into" whenever desirable or necessary is usually somewhere between 1,000 and 15,000. The time required for referring to a specified register and copying out the information contained there is called the *access time;* it usually amounts to a few millionths of a second or less in modern fast computers. A characteristic way in which information is stored inside a computer is in the form of the polarization north-south or south-north of small magnetic cores, about 8 hundredths of an inch in diameter, each core storing one "yes" or "no," one bit of information.

In an analog computer, information is stored in as the amount of a physical variable held by a device—for example, the amount of rotation of a shaft, or the amount of voltage in a condenser, etc.

Fourth, the machine must have a way of performing reasonable operation on information. The part of a digital computer that does this is called the *calculating unit* or *arithmetical unit.* This unit of the machine has only a small memory or storage, usually for not more than 5 machine words, more customarily 3. But this unit is capable of performing automatically addition, subtraction, multiplication, division, comparing, selecting, and other mathematical and logical operations, such as may be called for by the instructions given to the machine. The number of different kinds of operations which the arithmetic unit can perform on request is usually between 10 and 50. More complicated operations are achieved by combining simpler operations according to a sequence of instructions.

In an analog computer there is no single arithmetical unit as such. Instead, incremental quantities of motion, electricity, etc., pass into the devices holding physical variables, and the quantities which they hold change according to the flow. For example, think of two rotating shafts geared together in such a way that one shaft B has to turn three times as much as the other shaft A; then, whenever shaft A has reached x turns, shaft B has reached $3x$ turns. The operations of addition, multiplication by a constant, mathematical integration, etc., are all provided for by the nature of physical devices connected together. Thus, the size of an analog computer may be reported by saying that it contains 30 adders, 60 integrators, etc.

Fifth, the machine must have one or more ways of allowing information to flow through it.

In a digital computer, there is a single channel along which all information flows, and it is usually called the *buss;* it consists of wires or coaxial cable running between all the registers, input, output, storage, and calculating unit. The buss is organized like a railroad with a main trunk line running through the whole computer, and a large number of sidings, allowing freight cars of information to enter or leave numerous stations or platforms all through the computer. The memory inside the computer needs to be very well equipped with sidings—if we are to succeed in selecting any one of 15,000 numbers in a few millionths of a second. But some of the selection is often achieved by calling at just the right instant of time for a number when it is available. For example, if the memory is expressed as polarized spots on a magnetic drum rotating at high speed, we control to the millionth of a second just when we call for the number that we want, and at the time the call becomes effective, the number is whisked off the surface of the drum because when it is called, it is just exactly at the reading point.

A machine word of ten characters in length may be moved through the machine on ten separate wires, the whole ten wires constituting the buss. Or, there may be a timing arrangement so that at ten successive times the ten characters in the number make use of a buss of a single wire, each character using it at a separate time. This is like the principle of the telephone where one wire is sufficient to carry all the information which you wish to send through the system.

In an analog computer, there are many channels for flow of information: there is a channel from each output of an adder, multiplier, integrator, etc., to each input of an adder, multiplier, integrator, etc. All channels are in use all the time, and the problem is solved by incremental changes travelling along all the channels simultaneously.

Sixth, and finally, the machine must have a *control section.*

In a digital computer, this section of the machine connects sidings, registers, into the buss, and disconnects them. The control unit regularly takes care of carrying out the instructions given to the machine, of executing the sequence or program of instructions.

In all digital computers, the control section takes in commands which are essentially of just exactly the same form in each step:

> Take the machine word from register . . .; put it in register . . .; and pick up the next order from register . . .

It is truly amazing that all the vast variety of operations performed by automatic computers can be organized as repetitions of this single general form of instruction or its equivalent. There are minor variations from one computer to another but we do not need to go into these variations here. The control register in the control unit contains the current instructions for the machine at each cycle or step, saying what register to take information out of, what register to put information into, and what register contains the next instruction to be executed.

Once an automatic digital computer is organized in this way, it is a completely general-purpose machine. It can carry out any sequence of instruction, any *program* which can be expressed exactly and translated into its command code.

In an analog computer, if it is electric or electronic, the control section may take the form of a plugboard with numerous terminals. The plugwires then establish the connection of the inputs and the outputs of the various adders, multipliers, integrators, etc. There is always a definite sequence in time as to which input or output is driving and which is driven; and there is always one independent (originating or initiating) terminal or plugwire hub, which corresponds to the independent variable, uniformly increasing time.

7. What Is Programming?

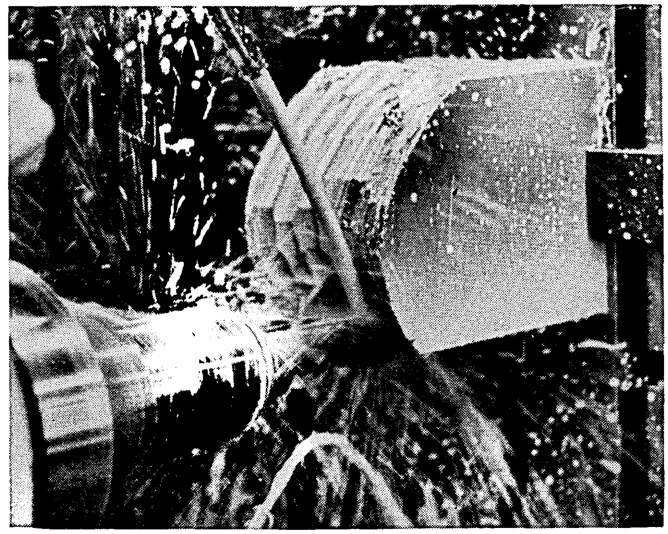
The word *program* has come into use to refer to the sequence of instructions which a computer carries out. It is more useful than the word "routine" or "schedule" or "sequence" and enables more linguistic compounds to be made, such as the verbal form "programming" and the noun "programmer." A *program* for a computer is an exact sequence of instructions that it uses to solve a problem.

Many programs for digital computers are composed in such a way that portions of them, called subprograms or subroutines, can be selected and copied by the computer from a library of computer programs (probably on punched paper tape or mag-

IBM asks basic questions in computer software

How much work can computers do?

These IBM *programmers are describing a machine part in* AUTOPROMT, *a programming language developed in cooperation with the United Aircraft Corporation.*



Following orders generated by an IBM *computer from an* AUTOPROMT *program, this numerically controlled milling machine is shaping a section of a hyperbolic paraboloid.*

Men use words to symbolize ideas. Computers use a vastly different kind of language. Present computer logic requires instruction in language so rudimentary that each year millions of words of programming are devoted to basically repetitive procedures. Unless ways are found to economize on this instruction, the usefulness of computers may be limited by the shortage of trained personnel to put them to work.

IBM programmers are simplifying communication with computers. Through careful selection and ordering of references to machine structure, they have developed programming systems that transfer a large part of the repetitive work in programming to the computer itself. These systems permit programmers to express their instructions in language resembling English. They also make different machines "look alike" so that programmers can state their problems with as little difficulty as possible. In addition, IBM programmers are experimenting with systems which use the computer's own capacity to construct new programming systems, such as assemblers or compilers.

Programming systems can extend beyond the level of handling machine references automatically to include applications. AUTOPROMT, IBM's system for numerical control of machine tools, is a codification of machine shop language and practice which enables a computer to determine machining instructions from a description of the part's surfaces. The computer generates the sequence of machine tool paths required to produce the part. IBM has also developed information retrieval systems which reduce the burden of indexing, abstracting or disseminating technical information. One experimental system reduces an article to an abstract by statistically determining the most significant sentences in the article.

Eventually, programming systems may grow beyond boundaries of individual disciplines to include general information on the nature of the physical world. Such systems would be supported by information retrieval systems and inference systems capable of seeing logical consequences of retrieved information. They would allow men who direct computers to focus their attention on creative aspects of future problems. By making systems like these possible, IBM programmers and mathematicians are playing a leading role in applying the computer to ever-widening areas of human knowledge.

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netic tape). This reuse saves the human labor of looking up the previous subprogram and copying it by hand or typewriter. An example is the program for finding the square root of a number; clearly the most efficient sequence of computer commands to find square root needs to be determined only once.

Programming for automatic computers requires a good deal of knowledge, common sense, and training. Specifically, programming requires: (1) understanding the operations of a business or the steps of a scientific calculation; (2) understanding the best ways for having a computer carry out these operations and steps; (3) arriving at a good sequence of commands for the computer to solve the problem; and (4) adequately translating these commands into computer language.

Since programming has proved a serious bottleneck in many applications of computers, a good deal of effort among computer manufacturers has gone into methods of automatic programming. This has taken several forms.

One form is the construction of *compiling programs* or compilers—which use the computer to take subprograms out of a library and hitch them together appropriately so as to solve a new problem. A second form is the construction of programs called *interpreters,* which accept instructions in certain standard words and translate these words into machine language, so that the machine "knows" what the words "mean." A third form is the development of common languages for automatic programming for problems, so that any problem when expressed in such a language can be given to any automatic computer, and the computer will translate the common language into its own instruction code, and then solve the problem. Two of the important common languages are ALGOL, for algebraic and mathematical problems, and COBOL, for business problems.

Computer manufacturers have encouraged the formation of groups of users of their machines, resulting in an exchange of programs among users. This has been an important factor in the development of automatic programming and a common language for giving programs to computers.

8. Can You "Educate" a Computer?

An automatic computer with a library of programs and a general language in which we can instruct the computer to solve a vast variety of problems is rather different from an automatic computer with just the same hardware but with no programs, and all the programming to be done from scratch. It is natural to call the first kind of computer an "educated" computer, and it is easy to see that the "education" of computers will increase with no specified or assignable limits.

Eventually more and more problems of mathematics and business, industry and government, society and science, will become programmed for computers. More and more tapes of programs will be available for placing on any computer. The amount of knowledge which a computer will have access to will begin to tower above the amount of knowledge which a human being has access to. If we are willing to use the word "educated," a computer with its storehouse of programs will be more "educated" than a human being, in a great many different areas.

After all, what is the education of a human being? It means putting into his control the keys to the storehouse of knowledge which the human race has compiled over 5,000 years of recorded history and more thousands of years of unrecorded history. In the training of a human being, to be able to *read* is probably the first and most important ability; for this is the ability which enables the human being to turn the key in the lock to the treasury of recorded knowledge. So also for computers, the capacity to interpret a program, the capacity to take in information, is a key to using a library of programs.

Just as the education of a single human being depends on the information, knowledge, and wisdom collected by great numbers of human beings preceding him, so the education of computers depends on a social enterprise also. Only the processes are different. The computer is fast in learning, the human being slow. The programmed computer remembers exactly everything it is told until its memory is wiped out by a new program; the human being can remember only a part of all that he is told, but that is not voluntarily erasable.

How Did Computers Happen?

Moses B. Berlin
Assistant Editor
Computers and Automation

Although the first modern automatic computer began to work as recently as 1944, the story of the development of ideas, devices, and machines entering into that automatic computer goes back a long time into the past. Problems of calculating with numbers, and recording numbers, have pressed upon human beings for more than five thousand years. An interesting example consists of baked clay tablets from ancient Babylon which record the use of numbers and computation in business transactions. Many of these tablets relate to agreements before 2000 B.C. between farmers and priests about the rent of land from the temple in return for a stated share of the produce grown.

Out of this long experience, little by little, the ideas that enter into the dream and eventually the construction of a complete automatic computer appear, and the ideas becoming incorporated into devices for computing that finally evolve into the automatic computer.

1. The Idea of Objects to Count With

Probably the first of the ideas used to deal with numbers is the idea of using small objects, such as pebbles, seeds, or shells, to count with, to supplement the fingers. For then you can refer to a number as "the number of pieces in a certain bag" or other container, even if you have no conventional name for the number.

2. The Idea of "Ten Of"

People, however, find it troublesome to count only in units—it takes too much time and effort. So very early a second idea appears: the idea of composing a new unit equal to ten of the old unit. The source of this idea is clearly the fact that a man has ten fingers; with this idea you could designate 87 by referring to all the fingers of 8 men, and then 7 more fingers on one more man.

3. The Idea of Specialized Places for Counting

In order to deal with numbers in their physical form of counted objects, a third idea appears; a specialized, convenient place upon which to lay out the counted objects. Such a place may be a smooth piece of ground, slab of stone, or a board.

It becomes convenient to mark off areas on the slab according to the size of unit you are dealing with—you have one area for ordinary units, one area for tens, one area for hundreds, and so on.

These developments gave birth to the *abacus,* the first computing machine. This device consisted of a slab divided into areas, and a supply of small stones for use as counters or objects to keep track of numbers. The Greek word for slab was *abax,* and the Latin word for the small stones was *calculi;* and so the first computing machine, the *abacus,* was invented, consisting originally of a slab and counting stones, and later on, a frame of rods strung with beads, for keeping track of numbers while calculating.

The system of numbering and the abacus go hand in hand together. The abacus is still the most widely used computing machine in the world.

Growing out of the abacus and the system of numeration, and their mutual effect upon each other, came the ideas of further specialized places or positions, culminating in the Arabic positional notation for numerals which reached Western Europe in the 1200's. Just as the small counting stones or *calculi* could be used in any area on the slab, so the digits 1, 2, 3, 4, 5, 6, 7, 8, 9 could be used in any position of a numeral. Just as the position on the slab answered the question as to whether units, tens, hundred, etc., were being counted, so the place or column or position of the digit (as in 4786 with its four places) answered the question as to what kinds of units were there being counted. And—this was the final key idea—just as a place on the slab could be empty, so the digit 0 could mark "none" in a place or column of a number.

That idea, by the way, required centuries to develop. The Romans did not have a numeral for zero; but about 300 B.C. in Babylon a symbol for zero was used. Then the Hindus developed the numerical notation that we call Arabic. The Arabs used the word "sifr" meaning "vacant" about 800 A.D. for "zero." About 1200 A.D. the Arabic word was transliterated into Latin giving rise subsequently to the two English words "cipher" and "zero."

4. The First Adding and Multiplying Machines

The first machine which would add numbers mechanically was invented by the French mathematician and philosopher Blaise Pascal in 1643. It contained geared counter wheels which could be set at any one of ten positions 0 to 9. Each gear had a little tooth for nudging the next counter wheel when it passed from 9 to 0 so as to carry 1 into the next column. The machine also had small latches which could be positioned to insert a number into a counter wheel.

Some 30 years later, in 1671, another mathematician, G. W. Leibnitz, invented a device which would control automatically the amount of adding to be performed by a given digit, and in this way he invented the first multiplying machine.

These machines and their improved successors began to be commercially made and sold in the 1800's. They have given rise to electric-powered but hand-operated adding machines and desk calculating machines which are found throughout offices in the United States today.

5. The Idea of the First Automatic Computer

The idea of an automatic machine which would not only add, subtract, multiply, and divide but perform a sequence of steps automatically, was probably first conceived in 1812 by Charles Babbage, a professor of mathematics at Cambridge University, England. He set out to build an automatic computer which he called a *difference engine* because he intended to use the machine to compute mathematical tables by adding differences. A great number of mathematical tables that mathematicians and scientists are interested in can be carried forward by adding differences or by performing rather simple arithmetic on differences. Hence Babbage's idea of a difference engine made a good deal of sense.

Babbage intended that his machine should compute the values of the tabulated mathematical functions and print out the results. No attention would be needed from the human operator, once the starting data and the method of computation had been set into the machine.

He gained the attention and interest of the British government, and construction was begun with aid from the government. For 20 years however little progress was achieved, and in 1833 government aid was withdrawn and the construction project was dropped. Babbage, however, was incurably obstinate and optimistic, and he at once laid plans for a much more ambitious computing machine, which he called an *analytical engine.* This was to consist of three parts: (1) the "store," where numbers were to be stored or remembered; (2) the "mill" where arithmetical operations were to be performed on numbers taken from the store; and (3) the "sequence mechanisms," which would select the proper numbers from the store and instruct the mill to perform the proper operation.

But neither of these machines were completely constructed although small parts of them were. Both Babbage and his son, who also tried to carry out his father's ideas, died without seeing the fruition of their ideas. The failure to construct either of the machines was due mainly to the lack of sufficiently accurate machine tools and of mechanical and electrical devices that finally became available around 1900-1910. It was not due to the inadequacy of the concepts, for they were perfect—complete and accurate.

6. The Idea of Machine Language Read Electrically

Another of the historical developments which has led towards the modern automatic computer began about 1886, when a statistician and inventor, Dr. Herman Hollerith, was working on the 1880 census in the United States. The census, six years after it had been taken, was still not entirely summarized and tabulated. Hollerith decided to experiment with cards with punched holes and with electrical devices to detect the holes and count them. He made use of an idea that had been used for at least 80 years in weaving cloth—cards with punched holes to control the weaving pattern used in the Jacquard loom. He realized that cards bearing human language were not readable by the machine; but that cards could be prepared using *machine language,* a language of punched holes, that ought to be readable by a machine.

Hollerwith's experiments and machines were successful, and have led to a great development of machines using punched cards for business, accounting, and statistical purposes. These machines, punched card calculating machines, have become a backbone of business calculations and reports all over the world.

7. The First Automatic Sequence-Controlled Calculator

The first automatic digital computer that worked was a machine called the Complex Computer, constructed at Bell Telephone Laboratories in New York in 1939. Dr. George R. Stibitz, an engineer there, noticed around him a lot of troublesome arithmetic multiplying and dividing *complex numbers,* numbers which electrical engineers find necessary for analyzing alternating electrical circuits. Every multiplication of two complex numbers requires four multiplications and two additions of ordinary numbers. Every division of one complex number by another requires six multiplications, two additions, one subtraction, and two divisions of ordinary numbers. The pattern or sequence of the operations with the ordinary numbers is always monotonously the same.

Stibitz decided that ordinary telephone relays could be wired together to do this annoying task. So he represented each decimal digit by a code of 1's and 0's, so that four relays by their patterns of being energized or not energized could express the code and designate each digit. The sequence of calculation was built into Stibitz's machine; it was completed in 1940, and demonstrated. While the computing panels remained in New York, some mathematicians at Dartmouth College, Hanover, New Hampshire, gave problems to the machine via teletype, and received the answers back via teletype in Hanover. The complex computer continued to do useful work at Bell Telephone Laboratories for some years until it was replaced by more powerful computing equipment.

8. The First Two General Purpose Automatic Digital Computers

The first general-purpose automatic digital computer was the Harvard IBM automatic sequence-controlled calculator, which started work in April 1944. It was constructed as a result of a joint enterprise by Professor Howard Aiken of Harvard University, who was stirred by Babbage's ideas, and International Business Machines Corporation, maker of a great quantity of punched card calculating machines of various kinds. This relay computer, when it was finished in 1944, ran 24 hours a day, seven days a week, and continued to operate for many years (with only a small amount of down-time due to malfunctioning) solving urgent problems in military computation.

This machine handled numbers of 23 decimal digits, storing them in any one of 72 storage registers. It performed additions in about ⅓ of a second, and multiplications in about 6 seconds. This machine was the first working realization of Charles Babbage's analytical engine. And it quickly led to more automatic digital computers with numerous improvements.

About the same time, from 1942 to 1946, another group of engineers at the Moore School of Electrical Engineering at the University of Pennsylvania in Philadelphia, headed by Dr. John W. Mauchly, a physicist, worked on the design and construction of an automatic electronic digital computer. This machine used instead of relays standard radio tubes and parts, and aimed for high speed. In 1946 the Eniac ("Electronic Numerica Integrator and Calculator") was completed at the Moore School. It contained 20 registers where numbers of 10 decimal digits could be stored or accumulated. It could add numbers at the rate of 5,000 additions per second. It also contained a multiplier which would carry out from 360 to 500 multiplications per second, a "divider-square-rooter," and other units.

The years 1944-1952 were years of eager interest and experiment by universities, government departments and small businesses. Then major business machine, and electric and electronics manufacturers became convinced that machines which would compute and process data automatically were important, and they entered the field on a big scale.

9. Recent Developments

From 1952 on there has been a prodigious development. The addition speed of computers has gone to more than 100,000 additions per second. The multiplication speed has risen to more than 10,000 per second. The amount of storage capacity, or memory, accessible to the computing unit of a computer has changed from the 72 storage registers of the Harvard IBM Automatic Sequence Controlled Calculator to literally millions of registers. Some of these registers are accessible to the calculating unit in less than a millionth of a second. Others are stored on magnetic tape, and are fed into the computer in streams at very high speed, so that the computer can refer to that information also with very small delays.

Not only speed and capacity but reliability of automatic computers has been multiplied by a factor of tens of thousands. The reliability has increased to the point where a billion and ten billion operations take place between errors. Besides, automatic checking has been built into computers so that no wrong results are allowed out.

By 1960, there were at least 20 major suppliers of automatic digital computers and data processors. Over 700 organizations and probably over 30,000 persons were engaged in one part or another in the field of computers and data processors. The market for such machines has been estimated to be upwards of 3/4 of a billion dollars per year.

10. Other Streams of Development

At the same time that this main stream of automatic digital computing has been developing and expanding, other streams of automatic handling of information have also developed and expanded.

One of these other streams is analog computers. An *analog computer* computes by using physical analogs of numerical measurements; for example, a distance, or the amount of turning of a shaft, or the amount of voltage in a circuit element, is used to represent a number in a problem. One of the simplest analog computers is the *slide rule,* where marks and distances represent numbers. Up to 4 or 5 significant figures of accuracy can be represented as a voltage inside an analog computer. An analog computer may have more than 100 or 200 circuit elements to expressing numerical magnitudes. Inside the computer the connections between these circuit elements mirror or simulate the relationships of the numerical variables in the problem. In this way a very powerful computer can be constructed which can solve intricate mathematical problems in engineering, in physics, in chemistry, in nucleonics, and in other branches of knowledge, at very high speed and with sufficient accuracy to answer a great many of the questions of engineers.

Hybrid machines, which use analog computers in one part of the system and digital computers in other parts of the system, are also being developed and applied.

Other kinds of elaborate automatic information-handling systems are also of course being developed. For example, the automatic dial telephone system is ramifying, and stretching out over very great distances. From many exchanges in the country, at the present time, it is possible to dial a telephone almost anywhere in the United States; the resulting call is automatically recorded as to length, automatically computed as to cost, and charged to the subscriber's record for automatic billing at the end of the month.

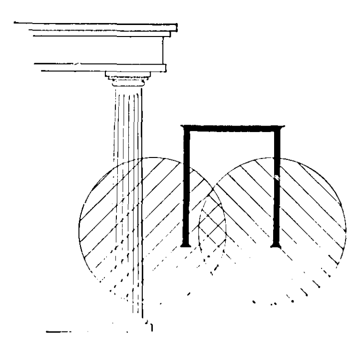
11. Causes

But this description of the history of invention and construction of computers and data processors is only part of the story. What caused this development?

There have been two main trends in the causes for this development. One is the growth of scientific and engineering knowledge, together with the increasing realization that the mathematics which expressed a great many relations could not be easily handled in the ordinary symbolic mathematical ways. Instead, the symbols had to be translated into numbers, and the numbers had to be handled arithmetically, elaborately and in detail and in a great many different cases. Take for example astronomy. Isaac Newton and Albert Einstein expressed general laws for the behavior of heavenly bodies. But the actual calculations for knowing where to look in the sky to see any particular heavenly body at any particular time have to be carried out numerically. Furthermore, the laws were general and in simple form, ignoring many complexities; the actual calculations for particular heavenly bodies were specific and had to take into account many uncomfortable details. Take for example calculating the orbit of the moon: the bulge of the earth at the equator, where the earth is wider than it is at the poles, has an effect on the orbit of the moon, and this has to be calculated in order to predict to the minute and second where the moon will be at any particular time. Such calculations are laborious. Similar laborious calculations occur in electrical engineering, in physics, in chemistry, in nucleonics, and elsewhere. Particularly, the effort to calculate tables for the trajectories for artillery shells was the reason for the support by the United States government of the Harvard and Moore School projects 1941-1945.

The other main trend is from the world of business. Here enormous quantities of records and calculations are required, in order that businesses may function. Take for example the life insurance business. Big insurance companies issue millions of policies under which insureds pay premiums and companies take on liabilities for losses. All kinds of various contingencies can happen to the persons insured under those policies, and extensive records are necessary. In one life insurance company, for example, formerly 11 basic records for a given policy had to be maintained in different departments of the company; to be handled by clerks; this was before the advent of automatic computers. The automatic electronic data processor of the current vintage enables all these records to be consolidated into a single record on magnetic tape, and a duplicate record on another magnetic tape, in case of accidental destruction.

The growth of a great civilization which is complex engineering-wise and technologically on the one hand, and complex business-wise and industrially on the other, has produced an enormous growth in the information to be handled and operated with. This provides the push, the energy, the urgency behind the great development of the automatic handling of information, expressed in computing and data processing systems.



A TRAFFIC COP AT EVERY CORNER

Source languages and their associated processors facilitate the job of coding an application for computer processing. They also reduce the number of clerical coding errors and, in most cases, they signal errors made in the use of source language. Beyond this, however, it is desirable to have additional aids to automate the diagnostic, operating, and maintenance functions associated with programs and their use. The package of programmed operating aids which Honeywell supplies to its equipment users is called "COP" (Computer Optimization Package). COP includes all software components other than source languages and their associated processors. The main function of COP is to exact the highest possible level of efficiency from the computer, and it does this in the following ways:

1. Program-tape maintenance and updating routines provide a high speed and efficient means of adding new programs to an existing file, processing corrections to existing programs, deleting programs which are no longer in use, and rearranging, if necessary, the sequence of programs on a program tape. These updating programs batch-process input data which may consist of any mixture of new programs, or requests for the deletion and rearranging of existing programs.

2. Program diagnostic routines assist the programmer in checking his work by providing for the automatic dumping of information from core storage and from tape. One of the most powerful features of Honeywell's approach to program diagnosis and checkout, a unique "Derail Technique" provides dynamic dumps at any point in a program without requiring the program to be changed from its final or production form. This way, any desired areas of core memory or magnetic records can be dumped automatically at programmer-specified points in the execution of the program. Parameters which pinpoint the requested information are entered independently of the program being tested.

The diagnostic information is printed in any of these programmer-designated formats: octal, decimal, alpha-numeric, or assembly language instruction format.

In the Derail Technique, the type, number, and extent of dumps are under the exclusive control of the programmer without affecting in any way the integrity of the program. Thus, the Derail Technique is a powerful tool in the minimization, location, and correction of program errors.

3. Test data routines aid in the handling and distribution of test data according to programmer-supplied parameters and permit the test data to be combined with the program being tested. This eliminates the need for a separate, or operator-controlled setup of test data for programs in the debugging state.

4. Monitor routines add to the efficient use of Honeywell systems by providing the following functions: **a.** Automatic loading of object programs either from a tape file or a card file. **b.** Automatic error correction using pre-coded orthocorrection routines which are also used with the object programs for correction of read errors that occur in the processing of tape data. **c.** Restart provisions which facilitate the setting of restart points within each program so that processing can be repeated without having to go back to the beginning of the program. **d.** Operator-machine communication to keep the operator informed of the progress of the run and permit his control instruction to be entered and acted upon with a minimum of delay and re-working. **e.** Coordination of the simultaneous running of independent programs. This relates to Parallel Processing in the Honeywell 800 and Simultaneous Peripheral Processing in the Honeywell 400.

LIBRARY OF STANDARD ROUTINES GROWS AS YOU GROW

The Honeywell library of standard routines, though part of COP, warrants special mention. It is available to all users of Honeywell EDP systems and provides for the following kinds of recurring data processing functions:

1. Sort/Merge Generators for Honeywell computers use the Honeywell-developed Cascade (N-1) and polyphase sorting techniques. The superior performance of these techniques over conventional sort methods is well established through extensive field use.

2. Automatic library facilities include an extensive collection of scientific subroutines. Additions are being made regularly to further extend the usefulness of this programming aid.

3. Tape and card input/output package relieves the programmer of the need for coding those portions of computer runs which deal with the manipulation of punched cards or magnetic tape data files.

4. Report generators supply Honeywell system users with routines for the arrangement of reports according to parameters supplied by the programmer.

5. Utility and service programs provide for the manipulation of data tapes, including the following functions: comparing, positioning, locating, sampling, correcting, copying, or editing.

BATCH PROCESSING: A BUSINESS-LIKE APPROACH TO SOFTWARE

Batch Processing is a concept which relates to the mode in which programs are processed in a given compilation, assembly, checkout, or production run. Operationally, programs are handled in batches in the same way that data is grouped in a typical business operation, such as sales analysis or a payroll run. Because the processing of programs is automatic and sequential, manual or console-operator-controlled setup time between programs is reduced to a minimum. Batch Processing also provides facilities for proceeding from one program to the next program in the file with negligible operator intervention in the event of any kind of interruption in processing such as a programming hang-up during checkout.

The gains in efficiency due to the Batch Processing concept increase rapidly as the number of programs being batched rises. With as few as 10 programs batched in one checkout operation, efficiency gains of 5 to 1 are easily realized.

GOOD SOFTWARE MAKES GOOD HARDWARE BETTER — AND VICE VERSA

Honeywell software is designed to capitalize on, and complement the advanced capabilities of Honeywell hardware. Each extends the power of the other. The resulting gain in efficiency means far more productive processing per shift, and therefore more computing per dollar.

For more information on Honeywell software, including COP, contact your nearby Honeywell EDP office or write to Honeywell EDP, Wellesley Hills 81, Mass. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

Honeywell

H Electronic Data Processing

HOW MUCH POWER DO COMPUTERS PROVIDE?

Edmund C. Berkeley
Editor
Computers and Automation

A modern automatic computer embodies power, a great new power. It is the power to obtain answers to very many questions, and especially questions which until recently were beyond answering. But this power is not unlimited; questions can still be asked which no computer can yet answer.

We are interested in marking out the present-day limits of the powers of computers. We are interested in knowing how much power man has grasped, in the field of answering questions by means of computers.

For this purpose we shall make a close inspection of some very powerful computers of the present day, for they have strange and marvelous properties.

1. A Sample Question

For a base of comparison, however, let us begin with the powers of a human being and a desk calculator to answer questions. Suppose we start by asking these two computers what is 927538921 multiplied by itself, in other words, the square of this number.

I tried this myself. It took me five minutes to multiply it out the first time; and I made (without then noticing) three errors, putting a wrong digit in place of the correct one. Then I tried to verify the multiplication; that took 11 and 3/4 more minutes before I had caught the three errors and was satisfied that there were no more.

Next I made use of a Friden desk calculating machine with automatic multiplication. I set 927538921 on the keyboard, and 927538921 in the multiplier register, and pressed the "multiply" button, and after 8 seconds obtained in the answer dials the product: 860328449969844241 which agreed with my answer. This is a gain by a factor of 100, from about 1,005 seconds to about 8 seconds—rather a good gain.

Now, how long would it take to perform this multiplication on one of the fastest of modern computers, for example the Univac Larc? Once the numbers have been put inside the computer for operating upon, the first 10 decimal digits of the product can be obtained in 8 microseconds, and the entire product of 18 decimal digits can be obtained in 36 microseconds. Taking the 36 microsecond time as the comparable time in this case, we see that going from 8 seconds to 36 microseconds we have a gain by a factor of about 200,000. This is an enormous jump.

2. Other Features to be Compared

We have just compared a human being, a desk calculator and the Larc computer in regard to multiplying two nine-digit numbers. But of course there are many more facets to be compared than just this one:

(1) Input: the extent to which information can be taken into the computer or human being;

(2) Output: the extent to which information can be put out;

(3) Storage or memory: the extent to which information can be stored in the computer or made easily accessible to the computer;

(4) Computing and reasoning capacity: the variety of instructions which can be fulfilled;

(5) Control capacity: the extent to which instructions can be executed one after another;

(6) Reliability: the extent to which errors may occur and are detected and corrected;

(7) Tirelessness: the extent to which the computer or human being requires maintenance;

(8) Hardware: flesh and blood for the human being, wires and gadgets for the computer;

(9) Energy required: to make the computer or the human being operate;

(10) Cost.

Let us take a look at these facets one by one.

3. Input

The most powerful present-day computers can take in information, remember it within the machine exactly and with no forgetting, at the rate of about 100,000 characters per second. A *character* is either a letter of the alphabet, or a decimal digit, or some other single mark such as those on the keyboard of a typewriter. These characters are regularly expressed for the computer's purposes as a pattern of six or seven 1's and 0's, as for example, in the following scheme using six 1's, and 0's:

0 00 0000	A 010000	Q 100000	$ 110000
1 00 0001	B 010001	R 100001	. 110001
2 00 0010	C 010010	S 100010	, 110010
3 00 0011	D 010011	T 100011	; 110011
4 00 0100	E 010100	U 100100	: 110100
....	....	....	....

The 1's and 0's may be expressed for the computer: as punched holes (1) and blanks (0) in a card or a paper tape; as the presence (1) or absence (0) of an electrical pulse; or as polarized spots on a magnetic surface, south-north being a 1, north-south being a 0, or vice versa; etc.

The characters are handled by the computer usually in standard groups, called *machine words,* or just *words.* A common and convenient length of word is 12 characters; a machine word may consist of decimal digits only or letters only or some of both. Regularly, an instruction to the machine is expressed as a word; and so the same set of characters may have meaning sometimes as a number, sometimes as an instruction. A speed of 96,000 characters per second is the same as a speed of 8,000 words per second.

No human prodigy is conceivable who could take in 8,000 12-digit numbers in one second. In fact, most human beings could not take in even one 12-digit number in one second. If we should try to put into a human being's mind as few as 20 twelve-digit numbers in a minute, he would be completely unable to remember more than a small part of them unless he could write them down on paper.

A human being can take in a telephone number such as MI 8-1016 in about a second, and remember it long enough to dial it. Also, if we turn to a more congenial task, a fast reader can read about 500 words a minute, understanding the meaning of what he is reading even if he cannot reproduce the words literally.

Although the ability of the two contenders is qualitatively different, it might be fair to say that the computer has an advantage over the human being by a factor of 10,000 to one.

4. Output

The output of a computer varies according to the capacity of the auxiliary equipment receiving the information. A computer can record on magnetic tape, once it is ready and moving, at the rate of 100,000 characters per second. The computer can also control: a *paper tape punch,* which will punch paper tape at the rate of 100 characters per second; or a *card punch,* which will punch per second about 30 standard punch cards each of 80 columns; or a *high-speed line-printer* which will print in each second 17 lines, each of 80 to 120 characters.

All this *peripheral equipment* is obviously slow as compared with the computer. Consequently, for efficient use of the computer's tremendous calculating speed, devices called *buffers* may be used. A *buffer* is a storage device which is able to take in information at very high speed from the computer and then release the information at the proper speed for the peripheral equipment.

A human being can write by hand at the rate of about 30 words per minute, or type at the rate of about 60 words a minute, or talk at the rate of 200 or 250 words per minute. The ratio between a computer speed of about 8,000 words per second, and the top output speed of a human being of about 4 words per second, gives a factor of advantage to the computer of about 2,000 to 1.

5. Storage or Memory

The biggest present-day computer can have a *rapid memory,* storage or memory with very rapid access (like the scratch paper on which a man makes preliminary calculation) of 100,000 registers. In each one of these registers a machine word (say, 12 decimal digits or 60 binary digits) may be stored, available on call in about 2 microseconds.

In addition a very powerful computer may have access at one time to about 100 reels of magnetic tape. Each reel may contain 1 to 10 million machine words. These words are available on call from the central processor of the computer, but the access time to them may be more than a second, depending on the position of the information on the tape on the tape reel.

Besides these two kinds of memory, a computer may have an *intermediate memory* consisting of *magnetic drums.* These are large cylinders turning at high speed and coated with a magnetic surface on which information can be stored as multiple polarized spots. There may be 5 million registers of magnetic drum storage; the information in any register may be available in not more than a few thousandths of a second.

Here again, a man by himself is hardly comparable. The amount of information contained in the memory of a well-informed man, and able to be recalled whenever he chooses, might be the equivalent to 1,000 to 10,000 books or 2 million to 20 million words. Of course, it is almost impossible to disentangle pure memory or storage of a human being from the capacity of a human being to reason and to assemble words together in new ways. Besides there are other ways which human beings have for remembering—as, for example, the capacity to remember sights, sounds, smells, tastes, etc., and many of these memories cannot be successfully expressed in words—how can you say in words the way to recognize a person?

However, comparable to the computer's library of magnetic tape, a man can have access to a large library, and because he can read, he can gain access to great quantities of information. The Library of Congress, the largest library in the world, holds perhaps 10^{13} words, to which a man without too much trouble can have access.

For comparison, the computer has quick access to about 2 times 10^{9} words; the human being, to about 2 times 10^{7} words; factor of advantage for the computer, 100. Taking into account the libraries, however, the computer may have access perhaps to 10^{10} words; the human being, to 10^{13}. So for the first time, man beats the computer by a factor of 1,000.

This however is probably only a temporary advantage, lasting for another dozen or two dozen years. For gradually all books in libraries will be scanned by automatic optical reading devices and their information converted into records on magnetic tape to produce accessibility via computers.

6. Calculating and Reasoning Capacity

Most computers have 30 to 100 instructions built into their hardware, such as ADD or SELECT. In addition, a powerful computer has the capacity to perform a *pseudo-instruction,* a command which has the same appearance as an ordinary instruction but which the programmer has assembled from simpler instructions, and which can be called for by a single instruction word. This might be the case for SQUARE ROOT. Second, the manufacturer usually provides a library of programs, including for example a program for computing payroll. Third, there are simplified languages for instructing computers, so that persons who have not learned how to program a problem in terms of simple elementary instructions, corresponding with the hardware of the computer, can be given easier words to use, and using these easier words can instruct the computer. For example, there is a program called SOAP for the computer IBM 650; the word is an abbreviation for "symbolic optimum assembly programming." Techniques are developing steadily towards easier and easier programming of computers, including such ideas as compilers (for compiling several programs into larger programs), and special programming languages such as COBOL (common business-oriented language), so that the load of programming is largely transferred from the human being to the computer itself.

A well-trained human being can hold his own in computing and reasoning as compared with a com-

(Please turn to Page 22)

ACROSS THE EDITOR'S DESK

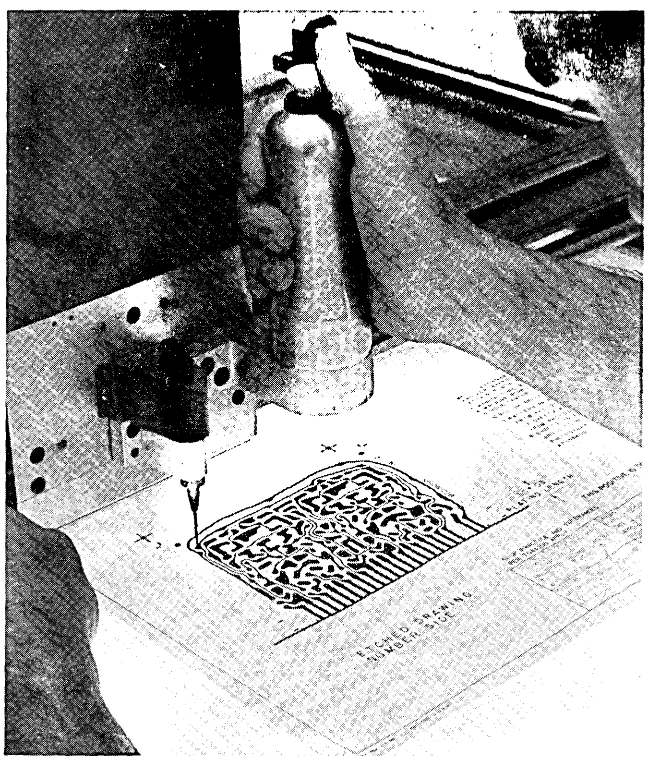
News of Computers and Data Processors

NEW PRODUCTS

AUTOMATIC EQUIPMENT FOR DRILLING PRINTED CIRCUIT BOARDS

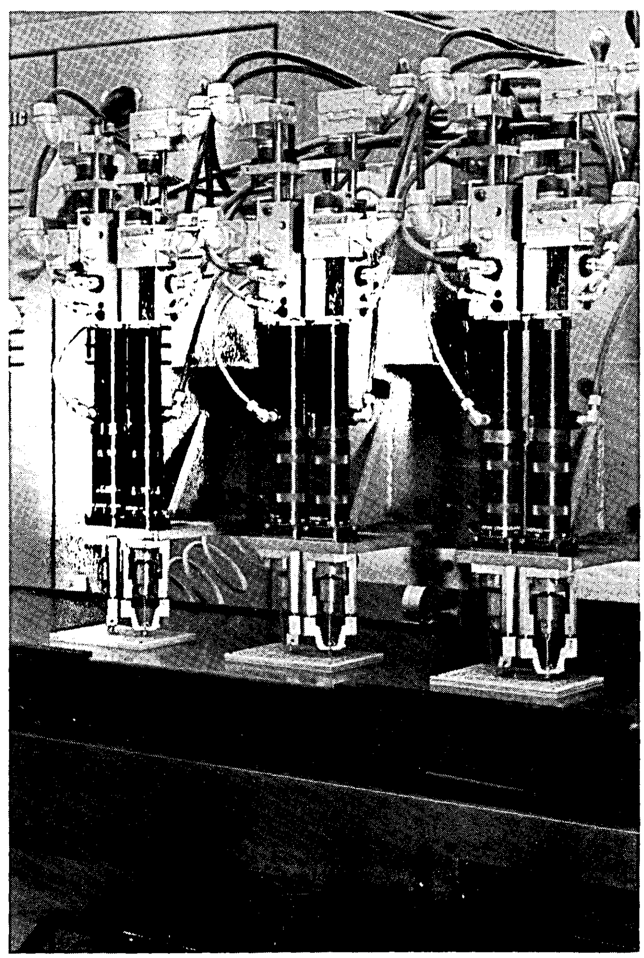
General Electric Company
Heavy Military Electronics Department
Syracuse, N. Y.

New equipment for automatically locating and drilling the component mounting holes required in printed wiring boards -- average board contains 200 holes -- has been developed by this company.



The new automatic equipment consists of two units, each of which can be operated independently. The first device is a drawing-to-tape converter which generates a completely programmed one-inch-wide eight-channel punched tape directly from a dimensionless drawing outlined on a 1/10 inch grid pattern. The second machine is a sixteen-spindle, tape-controlled drill press capable of reading the punched tape and automatically drilling 12 printed wiring boards simultaneously, without costly manual tooling and lengthy set-up time. While the drilling machine is being used to drill printed circuit boards, the programmer can be used for preparing tapes. Punched tapes are stored and filed by drawing number for repeated use.

This new combination Drawing-to-Tape Converter and Tape-Programmed Drilling Machine needs approximately ten minutes from the production drawing to the completed board as compared with the approximately 40 minutes of machine set-up time and several hours of planning and programming required by comparable manual machines.

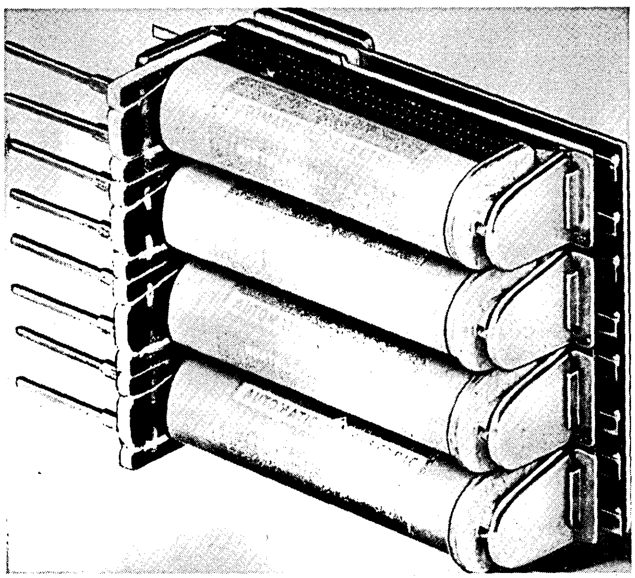


FOUR BINARY UNIT MEMORY RELAY

Automatic Electric
Subsidiary of General Telephone & Electronics
Northlake, Illinois

The Codel, a memory relay for multi-element code systems, has been developed by this company. It consists of four relays mounted on a common heelpiece; each of the four coils is equipped with a separate armature that operates on bifurcated Form A contact spring.

This relay will find application in computing devices for storing any binary number from 0000 to 1111. It may be used in both large and small systems for translating, storing, and sending digital or binary information.



AUTOMATIC LOADING OF MAGNETIC TAPE CARTRIDGES

International Business Machines Corp.
Data Processing Division
White Plains, N.Y.

An automatic loader for tape cartridges for computers for the IBM 7340 tape drive system has been developed by this company. The device allows automatic loading and unloading of magnetic tape. It holds a tape cartridge in reserve and automatically moves the reserve cartridge into position for use by the computer as soon as processing of the first cartridge is completed.

The cartridge loader attaches to the top of the 7340 drive mechanism. The operator knows when the second reel is being processed by a "change cartridge" light on the system's control panel.

AUTOMATIC ERROR CORRECTION WHEN PUNCHING PUNCH CARDS

International Business Machines Corp.
Data Processing Division
112 East Post Rd.
White Plains, N.Y.

Card punch operators can correct most punching errors with increased speed and confidence using a new feature developed by this company. A "correction" key is installed between the present "zero" and "release" keys on both alphabetic and numeric keyboards. Using this key, punch operators can -- in one operation -- eject an erroneously punched card and reproduce the next card to the exact point where the error occured.

RELAY WITH MAGNETIC MEMORY

Automatic Electric Company
Subsidiary of General Telephone & Electronics
Northlake, Ill.

A magnetic latching relay, the Series ERM, has been developed by this company. This small, bi-stable relay is held operated after the cessation of the initial pulse by the residual magnetism of the coil core, after the coil is de-energized. A second (reverse) pulse demagnetizes the core, and releases the armature. Two concentric windings do the trick.

The ERM relays may be used in computer and automatic tool controls for memory storage or "pulse stretching". They will also find use in pre-programming, where a time delay is needed between preparation and operation.

ELECTRONIC COMPONENTS: 500,000 IN 1 CU.FT.

P. R. Mallory & Co. Inc.
Indianapolis 6, Ind.

This company has developed resistors and capacitors the size of tiny pellets. A half million of them will fit into a cubic foot of space.

These very small components have application in miniaturization, as in vest-pocket electronic computers and data transmission systems the size of an attache case.

The components are assembled into a complete micro-circuit by dropping them into place in a mounting plate no bigger than a match cover. For maintenance, one entire circuit is replaced with another. This Mallory concept of electronic design is called Unitized Component Assembly.

COMPUTER "TRANSLATOR" FOR ATLANTIC MISSILE RANGE

Ortronix, Inc.
Orlando, Fla.

A solid-state device called a digital-data format converter has been developed for the Air Force by this company. It has been installed at the Technical Laboratory at Patrick Air Force Base for use by the Data Support Group.

The translator is a complete system made from standard printed circuit cards. The converter saves computer time by accepting information from various telemetry data receivers and converting it to computer "language" -- the standard IBM 7-level code, which is then recorded on a seven-track magnetic-tape handler. The tape is recorded in real time, but it is usually held until it is convenient to feed it to the computer.

The system is basically divided into two distinct sections: the electronics converter and the recorder section. It can accept up to eight thirty-six bit words once every 50 milliseconds. It stores this information in shift registers, and sends the data out on a continuous six-level code. Each word is presented on thirty-six parallel lines in a synchronized pulse.

NANOSECOND COMPUTER

Minneapolis-Honeywell Regulator Co.
Electronic Data Processing Division
Wellesley, Mass.

New equipment, called the Honeywell 1800 Series, has been developed for very large business and scientific applications by this company. It consists of a powerful central processor and a very fast arithmetic (floating-point) unit.

The new central processor (Model 1801) has an internal operating speed of more than 120,000 three-address operations per second for typical arithmetic instructions, such as additions and subtractions. The memory cycle speed is 2 microseconds.

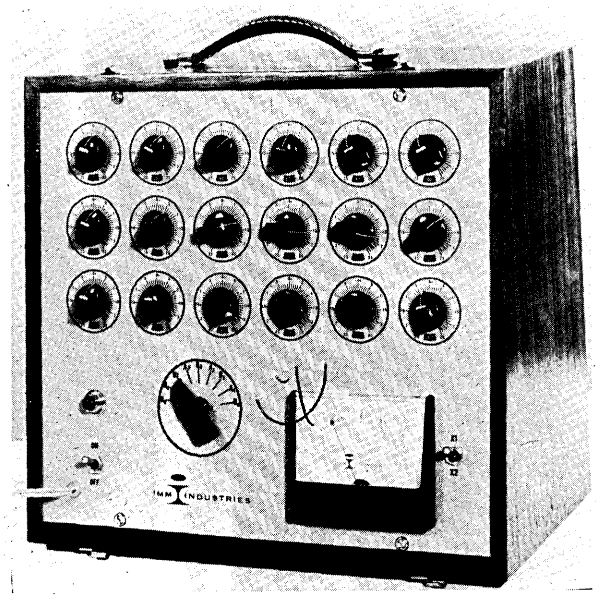
The new floating-point unit (Model 1801B) will operate at nanosecond (billionth of a second) speeds when used in conjunction with the new 1801 central processor.

The 1800 Series equipment is compatible with Honeywell 800 peripheral devices and automatic programming aids.

FOURIER ANALYSIS COMPUTER

IMM Industries
12160 Victory Blvd.
North Hollywood, Calif.

A compact analog computer which performs a Fourier analysis in three minutes is being manufactured by this company. It is designed for desk-top operation and is completely portable. The computer weighs 19 lbs. Its power requirements are 50 watts, dc to one kc.



Inputs are the 18 dials, each representing an abscissa of any waveform that can be plotted. Output is the DC offset and the magnitude of the 1st, 2nd, 3rd, and 4th harmonics, read on the meter.

PORTABLE DIGITAL COMPUTER FOR BIOLOGICAL STUDIES

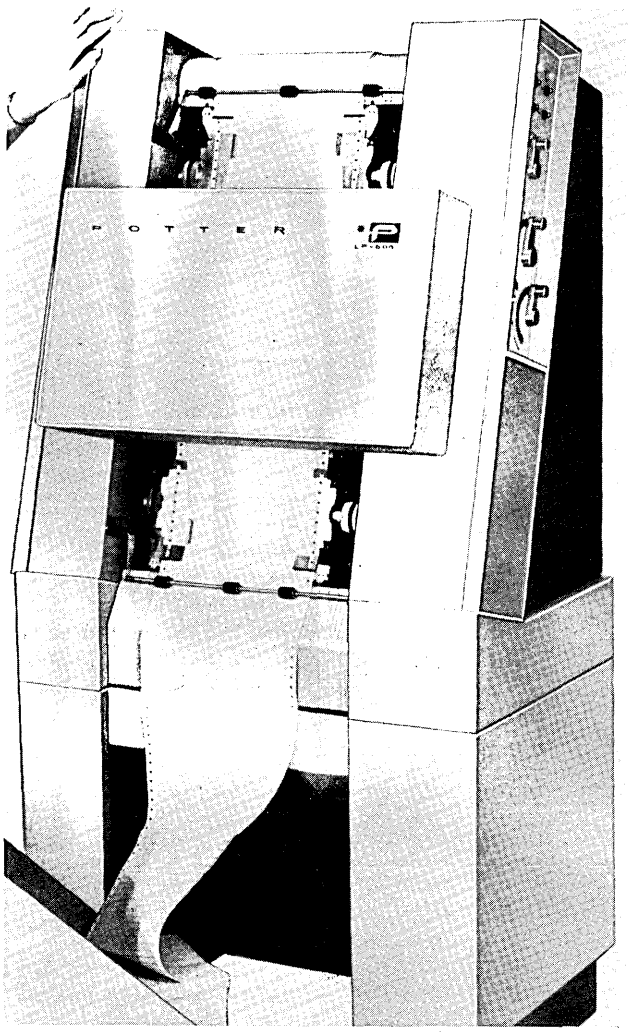
Mnemotron Corporation
45 S. Main Street
Pearl River, N.Y.

CAT 400 (Computer of Average Transients), made by this company, is a portable, multi-purpose digital computer for the study of biological and other variables. The CAT 400 computer averages four different variables simultaneously. It serves a whole range of computing functions, such as: analog-to-digital conversion; recording fast wave forms; automatic plotting of digital data; statistical distribution of events; and function generation.

POTTER LP-600 HIGH-SPEED PRINTER

Potter Instrument Co., Inc.
Plainview, N.Y.

The LP-600 high-speed printer, produced by this company, is rated at 10 consecutive lines of printing per second. Long-life hammers mounted on rubber torsion bearings give controlled type penetration and even type wear. The printer operates easily by a swing-down printing drum, a roll-out paper supply



carriage, and a static-electricity paper discharger at the output end of the printer. The paper-feed system eliminates form skewing. Modular solid-state electronics are used throughout the printer. At the Eastern Joint Computer Conference in Washington in December, it operated continuously throughout the show without down-time or adjustment.

NEW INSTALLATIONS

IBM 7080 FOR BAYWAY REFINERY

The Bayway Refinery of Humble Oil & Refining Company in Linden, N.J., has replaced its 705 computer with a new IBM 7080 model.

The 7080 is completely transistorized and was installed in the same space that the 705 formerly occupied. It can handle input and output of data at least three times faster than the old equipment. New computer programs are being designed specifically for the 7080.

SOLID-STATE SYSTEM FOR NATURAL GAS CONTROL

A new, solid-state supervisory control and data-logging system made by Control Data Corporation, Minneapolis, Minn., has been installed to control the flow of natural gas in one of the major pipeline complexes of the United States. The system is a Control Data 8000 Series Digital Control System. It consists of a dispatch station and three remote satellite stations.

The Control Data 8000 Series integrates digital supervisory control and data logging standard equipment, and is directly compatible with digital computers. The 8000 system hardware is based on standardized modules and design techniques.

Applications for the Control Data 8000 Series Digital Control Systems also include economical load dispatching of electrical power systems, and control of water supply systems.

HYBRID COMPUTER "TRICE" TO SPEED SPACE PROGRAM

Packard Bell Computer Corp., 1905 Armacost Ave., Los Angeles 25, Calif., is constructing hybrid general-purpose/digital-differential-analyzer computing systems to be placed in operation this year in two installations of the National Aeronautics and Space Administration. The two systems, called TRICE, are expected to speed work in the Apollo lunar landing program. TRICE will be used to solve space and other advanced scientific problems involving differential equations in real time.

The gh/dda combination permits computation to be carried out while events under study are actually occurring. It provides the real time speed capabilities of an analog computer with the accuracy and repeatability of a digital computer.

INSURANCE GROUP INSTALLS DATASPEED SYSTEM

A commercial Dataspeed communications system has been installed by Hardward Mutuals - Sentry Life Insurance Group, Stevens Point, Wisc. Dataspeed transmission equipment is a product of the Bell System.

Dataspeed sending units are operating in 10 branch offices across the nation. Daily transactions, recorded on punched cards, are automatically converted to paper tape. This is transmitted to the home office in Stevens Point. From the receiver, it is converted to magnetic tape which is checked against a master tape containing records of every policy the company has in force. Each policy is brought up to date every 24 hours.

Messages are transmitted at a rate of 1050 words per minute. Daily transmission formerly took from 1½ to 5 hours per branch. The same amount of information now is sent in 9 to 30 minutes per branch.

IBM 7090 AT M.I.T. COMPUTATION CENTER

An IBM 7090 data processing system has been installed at the Mass. Inst. of Technology's Computation Center, Cambridge, Mass., by the International Business Machines Corp. It is available at no charge for the educational and research use of M.I.T. and 39 participating New England colleges.

The 7090 is up to six times faster than the center's previous machine, an IBM 709, yet occupies about half as much space. The new computer has 19 magnetic tape units, as against 13 with the former machine. Some processing speeds of the 7090 are: additions or subtractions at an average rate of 229,000 per second; multiplications at 39,500 per second; and divisions at 32,700 per second. Input and output of data will be facilitated with two smaller, auxiliary IBM 1401 computer systems.

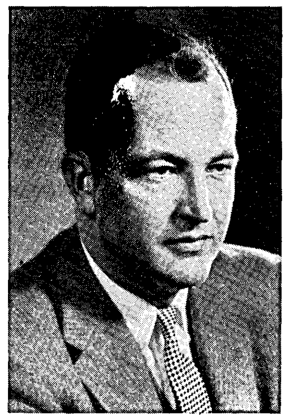
AUTOMATIC SERVICING OF MORTGAGE LOANS

Kissell Company, Springfield, Ohio, a mortgage banking firm, has installed an IBM 1401 computer. The new equipment will be used to provide automatic servicing of nearly 42,000 mortgage loans.

About one-half of the computer's time will be spent processing the mortgage loan file; the balance, in general accounting work, preparing reports for management, and investment analysis. The 1401 will review the entire loan file each day, selecting those on which transactions have occurred and posting all new information. The computer can process ten mortgage loans a second. The entire daily review will take less than three hours instead of the present method, which requires working three shifts.

PEOPLE OF NOTE

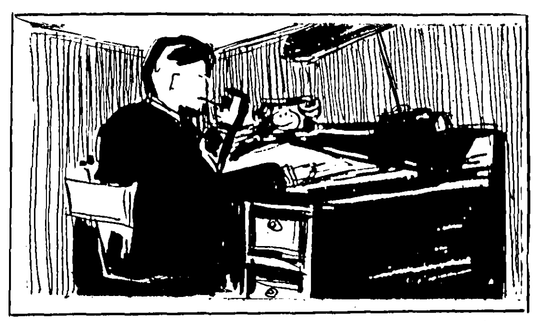
DIVISION OF I.B.M. APPOINTS PRESIDENT



Donald T. Spaulding has been appointed president of the Federal Systems Division of International Business Machines Corporation. The division, headquartered at Rockville, Md., is responsible for IBM service to the federal government. Mr. Spaulding joined IBM in 1949 and was group director of product line prior to his new appointment.

ITT FEDERAL LABORATORIES PRESIDENT ELECTED

Dr. William M. Duke has been elected as president of ITT Federal Laboratories. He joins ITT from Space Technology Laboratories, Inc., where he was senior vice president. In his new position, Dr. Duke will be in charge of operations at ITT Federal Laboratories' headquarters in Nutley, N. J., as well as branch locations at Clifton and Belleville, N. J.; Palo Alto and San Fernando, Calif.; and Fort Wayne, Ind.



NEW CONTRACTS

RAILROAD FREIGHT CAR UTILIZATION:
'MILLION-DOLLAR STUDY AT BATTELLE INSTITUTE

Seven major railroads are supporting a study at Battelle Memorial Institute, Columbus 1, Ohio, to develop advanced decision-making tools for America's railroad industry. The study will apply the so-called "systems analysis technique" to complex freight transport operations.

In 1958, 17.2 billion loaded car miles were recorded by Class I railroads. At the same time, 10.2 billion empty car miles were generated. Based upon a low cost estimate of 6 cents a mile, the cost of empty car movement to the railroads was $612,000,000. The 10.2 billion empty car miles have another implication: a 5-1/2 billion-dollar investment in rolling stock was unavailable for use each day. If the analysis brings even a small improvement in car distribution operations, it can mean a significant savings for the railroads.

Using a high-speed digital computer, systems engineers are now "building" an elaborate mathematical model of a railroad freight traffic system. This model will then be used as a management tool to evaluate, in advance, the consequence of specific management decisions directed toward cost reduction and improved service.

The seven railroads underwriting the cost of the new research program are the Canadian National Railways, the Chesapeake and Ohio Railway Company, Missouri Pacific Railroad Company, New York Central System, Norfolk and Western Railway, Southern Railway System, and St. Louis-San Francisco Railway Company. It is expected that others may also participate in the three-year program.

DIGITAL MAGNETIC TAPE RECORDERS:
$1,000,000 CONTRACT FOR
CONSOLIDATED ELECTRODYNAMICS CORP.

Orders totaling more than $1 million have been received by Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co., from Sylvania Electric Systems, a subsidiary of General Telephone & Electronics Corp., for digital magnetic-tape recorders. These will be used in military installations throughout the world.

AERONUTRONIC RECEIVES $10 MILLION INCREASE
FOR OPERATIONS CENTRAL

Ford Motor Company's Aeronutronic Division, Newport Beach, Calif., has received a $10,496,476 contract increase for continued development and fabrication of a model of an electronic operations center for the "Army of the Future". Known as Operations Central AN/MSQ-19, the concept combines the judgment and skill of the field commander and his staff with the speed and information capabilities of computing, data processing, and display equipment. Combat intelligence, and reports and orders from other headquarters are received, electronically processed, and transmitted visually to the commander and his staff in a matter of seconds, in the form of projected maps, overlays, and tote boards.

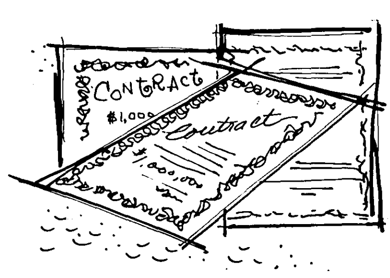
The Operations Central is being developed for the U. S. Army under the management direction of the U. S. Army Combat Surveillance Agency.

INTEGRATED INFORMATION SYSTEMS
FOR DIVISION OF U.S. STEEL CORP.

Computers combined with production control and communications systems at National Tube Division, U.S. Steel Corp., will provide greater efficiency for quoting customer inquiries.

A contract has been signed with General Electric Computer Department, Deer Valley Park, Phoenix, Ariz., for leasing the computer systems. The computers will be combined with a system for accumulating and transmitting system associated with a teletype network connecting National Tube's 13 district sales offices throughout the nation.

Basically, the computer systems are made up of the GE-225 general-purpose transistorized computer, high-capacity random access memory, and a specially-designed inquiry system. Additional equipment includes dual magnetic tape handlers, card reader, card punch, paper tape reader and punch, and a 900-line per minute printer. All programming will be done in COBOL and translated into machine instructions by G. E.'s General Compiler, known as GECOM.



TRW COMPUTER CONTROL SYSTEM FOR NEW TVA POWER UNIT

The Tennessee Valley Authority will use a digital computer as a main part of the control system for its new Widows Creek Steam Plant Unit 8 near Bridgeport, Ala. The computer, a TRW-330, will be supplied by TRW Computers Company, a division of Thompson Ramo Wooldridge Inc., 8433 Fallbrook Ave., Canoga Park, Calif. The computer will be used in conjunction with combustion control equipment.

The computer system will automatically perform sensor scanning and alarm monitoring, data logging, trend recording, and performance calculations. The system can be expanded later to control the boiler-turbine generators, and to perform cold startup, hot restart, normal shutdown, and emergency shutdown.

The contract for the control system, awarded by TVA in competitive bidding, marks the twelfth purchase of a TRW computer system by the electric power industry.

LOS ANGELES CITY SCHOOL SYSTEM ORDERS BURROUGHS B5000 DATA PROCESSOR

A large-scale Burroughs Corporation B5000 Information Processing System has been ordered by the Los Angeles City School system.

The school system, with some 46,000 employees, must deal with 54 different types of payroll. In addition to speeding payroll preparation, the B5000 will permit increased personnel statistical analysis, additional educational administrative work, and expansion of general accounting and budgetary control applications.

The Los Angeles City Schools' B5000 will include one processor (including a 32,768-word memory drum), one 4,096-word magnetic core memory module, one input-output channel, four high-speed magnetic tape units, a card reader, punch, and line printer.

DRESSER/SIE SUPERVISORY CONTROL SYSTEM ORDERED BY INTERPROVINCIAL PIPE LINE

Dresser Electronics, SIE Division, Houston, Texas, has received a contract from Interprovincial Pipe Line for a supervisory control system in excess of $100,000. The system will be used for operation of Interprovincial's new Westover-Buffalo extension to their 20" crude oil pipe line. Equipment being supplied will be standardized and solid-state.

DISNEY STUDIOS TO INSTALL EDP SYSTEMS

Animation and advanced automation will be teamed when Walt Disney Productions takes delivery this fall of an RCA 301 electronic data processing system. A lease agreement has been signed with the Radio Corporation of America.

The computer will be used to help control and record motion picture and television costs; information on TV, theater bookings, and revenues; payroll, inventory and general accounting.

The computer system will include a six-tape magnetic memory unit, a 20,000 character core memory, and a high-speed printer.

TERRAIN-AVOIDANCE COMPUTER CONTRACTS FOR ABOUT $16.9 MILLION

General Motors AC Spark Plug division has awarded Autonetics, a division of North American Aviation, Inc., Downey, Calif., contracts totaling approximately $16.9 million for radar terrain-avoidance computers and accessories. The computers are the heart of terrain-avoidance systems designed to give low-level flight skills to Strategic Air Force Boeing B-52 bombers.

The computers are developed and manufactured by Autonetics Armament and Flight Control Products in Anaheim, Calif.

ITT CORP. -- NIPPON ELECTRIC CO., LTD.

International Telephone and Telegraph Corp. and Nippon Electric Co., Ltd., Tokyo have signed a five year manufacturing and sales agreement.

Under the agreement ITT Kellogg, Chicago, communications division of ITT, will have exclusive distribution in the United States and in Canada of NEC-manufactured transmission products. ITT will also have the right to manufacture such NEC-designed products.

$50,000,000 CONTRACT EXTENSION FOR ARGONNE NATIONAL LABORATORY

The U. S. Atomic Energy Commission has extended its contract with the University of Chicago for the operation of the Argonne National Laboratory until September 30, 1966.

Argonne, one of the world's leading "atoms for peace" research centers is located 25 miles southwest of downtown Chicago near Lemont, Ill. Annual cost of the work for fiscal year 1962 is estimated at about $50,000,000.

AUTOMATION

TWO CONSOLE PANELS EQUAL 12 MEN IN THE ENGINE ROOM FOR AUTOMATED SHIP

On the bridge of the 9,800-ton Kinkasan Maru, a small console controls the engine room four decks below. In a noise-proof, air-conditioned room, next to the engine room, a seaman sits at a console-topped desk and scans meters, registers, and multi-colored lights that tell whether any of the equipment in the engine room is in need of attention. No one is in the engine room.

The installation on the 493-foot cargo ship marks the first remote-control operation of a transoceanic vessel. Capt. Nobu Takebayashi said, "It is as simple as driving an automobile".

On a trial run from Yokahama to New York, the ship carried a crew of 43 men instead of the normal 50, but 38 men is expected to be the need for the future. One man at the control panel on the bridge brought the ship to dockside in Brooklyn more quickly than the conventional method, which requires relays of signals to and from the engine room. The captain said that greater maneuverability was the best feature of the new installation.

The remote-control installation was built by the Tokyo Keiki Company for the Mitsui Line, the builder-owner of the Kinkasan Maru. A sister ship will be built this year. Eventually the 36-ship fleet of Mitsui will all be remote-control vessels.

AUTOMATIC PRODUCTION OF AUTOMOBILE FENDERS

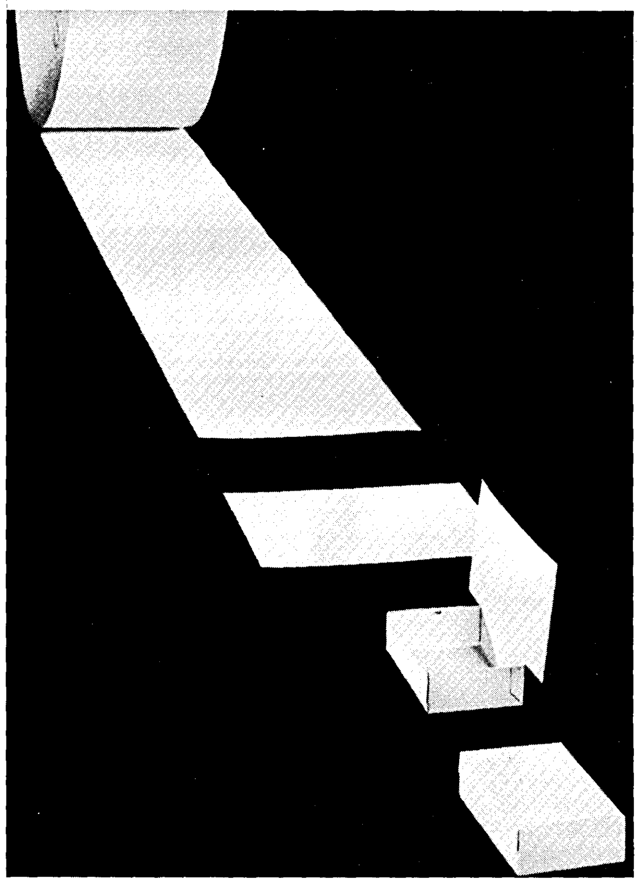
The Clearing Division of U. S. Industries, Inc. has developed a fully integrated, automated press line for the production of automobile fenders at Nissan Motor Co., Ltd., Tokyo, Japan.

The fender production line consists of six presses, connected by automatic transfer mechanisms, and weighs a total of 700 tons. Only two operators are required for the entire automated line, which has an hourly production rate of 1200 units.

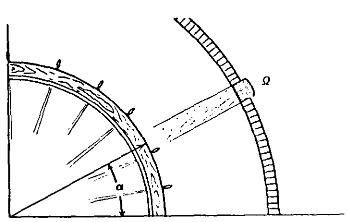
AUTOMATED ON-THE-SPOT PACKAGING SYSTEM

An automated packaging system has been developed by Midwest Foil & Packaging Co. of St. Paul, Minn., in cooperation with Packaging Corporation of America's Research and Development Division in Grand Rapids, Mich. It includes automatic manufacture of cartons right on the assembly line.

The new packaging system, called Web Form, will handle all package sizes used by the frozen food industry. Custom-built Web Form machines, feed the paper board reel, cut out blanks, score, crease, form, and heat-seal the package. The whole process takes only a fraction of a second. The new system operates at speeds up to 3 cartons per second.



The first food-processor to order a custom-designed Web Form system is the Chun King Frozen Foods Corporation. Its machinery will be in operation in May of this year.



SOFTWARE NEWS

AUTOMATIC DRAFTING

Thompson Ramo Wooldridge, 455 Sheridan Ave., Michigan City, Ind., has designed and is building four all-transistorized numerical control systems for Universal Drafting Machine Company's new "Orthomat" drafting machine. The combination of the TRW 3000 contour control with the drafting equipment will allow digital information from computers to be graphically portrayed on paper or similar material in a matter of minutes. Orthomat will handle any drawing up to 5' x 12' and at drawing speeds up to 200 inches per minute.

As an example of its use, engineers cite the need of the aircraft and auto industries for translating complex mathematical formulae into structural and part drawings. The new drafting machine will be able to automatically convert the computer information on tape to exact scale drawings in a fraction of the time that it now takes draftsmen.

Another application will be in verifying program tapes for automatically controlled machine tools.

Boeing-Seattle has purchased three systems to perform lofting of airframe structures and verification of computer-designed numerical control milling machine tapes. North American Aviation, Rocketdyne Division, has purchased a system to draw structural parts of advanced missile designs.

SELF-ADJUSTING AUTOMATIC PILOT FOR PLANES

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., has a new automatic pilot which can adapt itself to flight conditions without having to be preset.

The guidance system is called the H-14. It adjusts itself to conditions as they develop in flight rather than being preset electronically to meet specific conditions. A computer is the heart of the H-14. It automatically compensates for varying flight conditions such as speed, altitude, weight and wind gusts. The computer gives the device the ability to sense conditions affecting the plane it is controlling. The H-14 will be marketed by Beech Aircraft Corp.

MAN-COMPUTER OVERCOMING LANGUAGE BARRIER

A skilled programmer will often spend days reducing a problem to computer code, but Itek Corp., Lexington, Mass., has developed a device that can communicate with a computer in speedier and simpler language -- pictures.

The device, called the EDM, is the draftman's pencil hitched to a computer. With a photoelectric light pen, the operator of an EDM can draw designs for engineering problems graphically on a cathode ray tube screen. The designs pass through into an inexpensive computer, which translates the designs and stores the answers in its memory banks in digits and also on microfilm. The engineer may engage in a "conversation" with an EDM, recall any of his earlier drawings to the screen in a millisecond, and alter lines and curves by simply pressing buttons and sketching with the light pen.

Itek expects to deliver the machine within twelve months. The letters EDM have been translated by Itek variously as Electronic Drafting Machine, Engineering Design Machine, or Engineering Drafting Machine.

CLEAR -- HONEYWELL 290 PROGRAMMING SYSTEM

Minneapolis-Honeywell's Special Systems Division has developed a new technique, known as CLEAR (Compiler, Loaders, Executive program, Assembler, Routines), for the Honeywell 290 digital process computer. The system includes a compiler and an improved assembler.

The compiler, called FAST (Formula and Statement Translator), is a computer language similar to Fortran and includes a translating program including process-control routines. It accepts most Fortran-written programs without conversion. The compiler program is stored on perforated or magnetic tape. It is transferred into the drum memory of the Honeywell 290 control computer by one of the loading routines whenever programs are to be compiled for later translation into assembler input language and finally into basic machine language.

The CLEAR assembler accepts a mixture of computer languages and merges these into one main program. A perforated tape is produced in basic machine language that can be entered into the H290 computer using the loading routines. The assembler checks incoming programs, routines and subroutines for errors, producing diagnostic information concerning them so that corrections, if any are needed, can be made.

NEW APPLICATIONS

FRENCH HOUSEWIVES SHOP WITH PUNCHED CARDS

A new discount supermarket in Nice, France, is giving French housewives experience with electronics. With each item they put in their basket, "Superdis" shoppers take a punched card from the display shelf. The punch card shows the discount price, standard price, and description of merchandise. At the checkout point, an IBM tabulating machine receives the punched cards and prints an itemized invoice.

CLASSIFIED ADVERTISING PUBLISHING BY COMPUTER

A General Electric computer is being used in Phoenix, Arizona to prepare the classified section of a daily newspaper, the Arizona Journal.

Ads are typed on a Justowriter, producing typed copy and punched tape. Data-phone automatically transmits the tape information to GE's Information Processing Center, where it enters the computer, and is transferred to magnetic tape.

The computer sorts the ads, alphabetically and by classification; the master tape of the previous day's edition is run with the new tape, killing the expired ads and inserting the new ads in their proper position. This produces a new master tape, which is sent back in punched tape form to the Journal's photo-compositor.

A by-product of the operation is the preparation of bills for expired ads, ready to drop in the mail. An entire page of classified advertising can be put on tape in about 30 minutes.

AUTOMATIC BUYING VIA TELEPHONE DATA TRANSMISSION

A factory and an industrial distributor have streamlined purchasing and order-processing of small tools and industrial supplies through a telephone hook-up with electronic data handlers at each end. The plant is the Atomics International Div. of North American Aviation, Canoga, Calif.; the distributor is Ducommun Metals & Supply Co., Los Angeles. Much purchasing paperwork has been eliminated through the use of this system. Also, the need for large inventories has also been greatly reduced.

DIGITAL COMPUTER TO CONTROL LOS ANGELES TRAFFIC

Los Angeles, Calif., will use a digital computer system to help control vehicular traffic this spring. The computer system will monitor four miles of Sunset Boulevard west from downtown Los Angeles and regulate traffic signals in response to vehicular flow. The control center will be in City Hall.

A Thompson Ramo Wooldridge RW-300 is being used to analyze and direct traffic patterns and will react at once to changing traffic conditions on the boulevard. The computer will receive traffic volume and movement information, transmitted by telephone lines, from automatic detectors located within and at the borders of the controlled section of Sunset Boulevard. By using this data and an analysis program stored in its memory, the RW-300 will continuously decide on the best settings of the traffic signals. These decisions, transmitted back to the intersections, will control the signals to provide the most effective flow of traffic.

This pilot system will be gradually expanded to control more and more of the critical intersections in congested areas of Los Angeles.

BUSINESS NEWS

C-E-I-R ANNOUNCES RECORD SALES

C-E-I-R, Inc., a world-wide corporation for economic, industrial and operations research, announced record sales of $10,940,358 for its eighth fiscal year ended September 30, 1961. Including sales of those companies merged during fiscal 1961, this represents an increase of $5,170,478, or 90 per cent over sales of C-E-I-R in the preceding year. It completes an eight-fold expansion of the company in the last three years.

Dr. Herbert W. Robinson, president and chairman of the board, pointed out that in the past two years the company's expansion program has changed it from a local Washington operation to a large international corporation. During the last fiscal year the company's data processing equipment in place was increased more than three times.

However, heavy intangible investment in expansion amounting to $1,175,000 during fiscal 1961 contributed to a deficit of $874,018 for the year's operations. Dr. Robinson indicated, however, that a satisfactory profit for 1962 was forecast by the company on the basis of its projected volume of about $20 million.

Approximately half of the corporation's income is derived from the professional services it renders in the fields of operations research, economics, logistical planning and computer programming. The rest of its income is derived from the sale of electronic computer services. The proportion of commercial business of the firm increased from 56 per cent the previous year to 79 per cent.

During 1961 new operations were started up or existing operations were expanded into full-size C-E-I-R Centers at Boston, Hartford, New York, Houston, Los Angeles, San Francisco, London, Paris, and Mexico City. In all, C-E-I-R now operates 20 service centers and field offices in North America and Europe.

The corporation's expansion program includes mergers with compatible companies in its field. C-E-I-R has merged with the American Research Bureau, the television audience measurement organization, and with ARB Surveys and Facts Consolidated, leading market research firms.

The principal computer in use at most major C-E-I-R Centers is the IBM 7090/1401 system. A significant factor in the corporation's investment program has been the development of proprietary programs for the 7090. These include CEIRCODER, a program to generate automatically programs for business data processing; OPAL, a program to automate the analysis of market research surveys and analyses; and RAMPS, an automated method of project planning and control, like PERT but including cost.

During the past year C-E-I-R announced plans to install its second giant 7030 IBM STRETCH computer. This machine will be installed in a new building now under construction in Cambridge adjacent to the Massachusetts Institute of Technology campus. This building is the first of a group of five structures that will make up Technology Square. Previous announcements have disclosed C-E-I-R's plan to establish a STRETCH Center in Los Angeles. The two computers are scheduled to start operation in fiscal 1963.

Dr. Robinson said that the corporation's immediate objective would be to consolidate its recent heavy investments and fulfill their purpose by turning them into profitable operations.

ELLIOTT BROTHERS ANNOUNCES COMPUTER SALES

Below is a table of the order and deliveries of National-Elliott digital computers manufactured by Elliott Brothers (London) Ltd., England.

	Delivered	On Order
Type 401	1	
Type 402	10	
Type 403	1	
Type 405	33	1
Type 802	7	
Type 803	54	29
Type 502		2
Special Purpose Computers	7	
Totals	113	32

The company also is manufacturing the NCR 315 computer at Borehamwood for the National Cash Register Company Limited.

NCR ANNOUNCES SALES FIGURES

The consolidated sales of The National Cash Register Company, a leading computer builder, totaled $518,884,000 for 1961. This represents an increase of 13% over consolidated sales for 1960. The net income for 1961 was $21,708,000, an increase of 8% over 1960.

New Computing Centers

EASTERN AIRLINES' ELECTRONIC COMPUTER CENTER

Eastern Air Lines has opened an electronic computer center at Charlotte, N.C. to provide its customers with instantaneous reservation and flight information. Up-to-the-second seat inventories of all EAL flights for a 365-day period are maintained by the new system, which coordinates reservation activity in 42 cities.

The center has two Univac 490 real-time computers manufactured for Eastern by the Remington Rand Univac Division of the Sperry Rand Corp. Access to the computers is provided by remotely-located input-output devices. Information is sent throughout the 42-city system by means of long distance telephone lines and conventional teletype circuits. In addition to the two computers, two additional subsystems are operating at the center: 5 flying-head drums with associated channel synchronizers and drum control units; and magnetic tape subsystem control equipment.

Eastern's computers are able to handle a minimum of 46 different types of operations; complete at least 500 transactions per minute with a potential for expansion to 1500; take in and retain data on all 1500 of Eastern's daily flights for the next 365 days; and send this data on request by "agent sets" to all of the 876 agent desks at the airport or downtown offices in 42 of the airline's principal cities.

USC DEDICATES COMPUTER SCIENCES LABORATORY

The University of Southern California has dedicated its $2-million Computer Sciences Laboratory for education and research.

Two of the nation's leading manufacturers of electronic data processing equipment joined in equipping the laboratory. Both a UNIVAC solid state 80 and a Honeywell 800 occupy much of the 13,000 square-foot area of the building at 1010 West Jefferson Blvd., Los Angeles, Calif. The co-operating corporations are able to train their own personnel at the Computer Sciences Laboratory on their own equipment while USC itself has use of all of the equipment on a one-shift-per-day basis for its own educational and research purposes.

BATTELLE EXPANDS COMPUTING CENTER

An expanded computing center with a new Bendix G-20 Computing System is operating at Battelle Memorial Institute in Columbus, Ohio.

The center has special communication lines so that the computer can be controlled from remote points. The system can be programmed to handle several distinct problems according to priority. The computer can make up to 83,000 calculations a second, and will print 1000 lines a minute; its magnetic tapes will read or write up to 240,000 decimal digits a second.

A special simulator, developed by Bendix for Battelle, made it possible for Battelle scientists to transfer computing problems from other equipment to the new equipment in a day's time -- a changeover that might otherwise have required months of effort.

MISSILE SYSTEMS CORP. COMPUTER CENTER

A new computer center is being operated by Missile Systems' DataMation division in Los Angeles, Calif. The new center is equipped with IBM data processing facilities, together with allied data programming and reduction equipment.

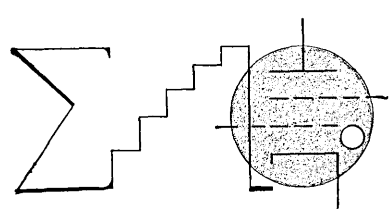
The center, together with other installations of the DataMation division in Los Angeles and Denver, supports major missile and space programs with technical documentation. It also provides preparation and publication skills for instructional maintenance material.

LITTON INDUSTRIES COMPUTER CENTER

A Computer Center has been installed at the Guidance and Control Systems Division of Litton Systems, Woodland Hills, Calif.

The center is equipped with an IBM 704 computer and related on-line and off-line data processing equipment. The equipment includes magnetic tape units, magnetic core storage, card readers, printer and punch, and all necessary peripheral equipment.

The Computer Center, facilities and personnel, are available on an hourly rental basis to other firms.



New Firms, Divisions, and Mergers

MARQUARDT AND CEIR, INC. ENTER SALES AGREEMENT

The Marquardt Corporation, Van Nuys, Calif, and CEIR, Inc., Los Angeles, Calif., have entered a sales agreement for marketing of IBM 704 computer time and services. The joint computer service bureau program is aimed at accommodating industrial requirements for scientific data computations, PERT reporting systems, reliability reporting programs, and general computer programming.

According to the agreement, CEIR serves as exclusive sales agent for the marketing of IBM 704 time to outside customers. Marquardt schedules and performs the work and will use the equipment to process its own scientific, engineering, and administrative computing requirements.

TECH/OPS ESTABLISHES "CORPORATE FELLOWSHIPS"

The position of "Corporate Fellow" has been established by Technical Operations, Inc. of Burlington, Mass. Patterned after the university fellow, the Corporate Fellow will be chosen from Tech/Ops' scientific staff. He will be freed from administrative responsibilities. His goals, interests and activities will be largely self-determined.

Tech/Ops seeks through its Fellows: consideration of long-term corporate technical goals; intellectual stimulation of the professional staff; and continued contact with the most advanced thinking and thinkers in technical fields.

INDUSTRIAL CONTROL EQUIPMENT AGREEMENT BETWEEN FOXBORO COMPANY AND RCA

Radio Corporation of America has made an agreement with The Foxboro Company to provide on a non-exclusive basis RCA-developed computers and electronic equipment for industrial control systems. The principal electronic units involved in the RCA-Foxboro agreement are the RCA 110 industrial process control computer, the RCA 100 control computer, and the RCA 130 industrial data transmission link.

BECKMAN-TOSHIBA, LTD. AGREEMENT

Beckman Instruments, Inc. has formed a jointly-owned company with Tokyo Shibaura Electric Company (Toshiba) to manufacture and distribute Beckman products in Japan. The new firm, Beckman-Toshiba, Ltd., will be centered in Tokyo and be staffed by Japanese personnel.

The firm will produce precision potentiometers; components for electronic instruments and systems; gas chromatographs; and analytical instruments for scientific and industrial applications.

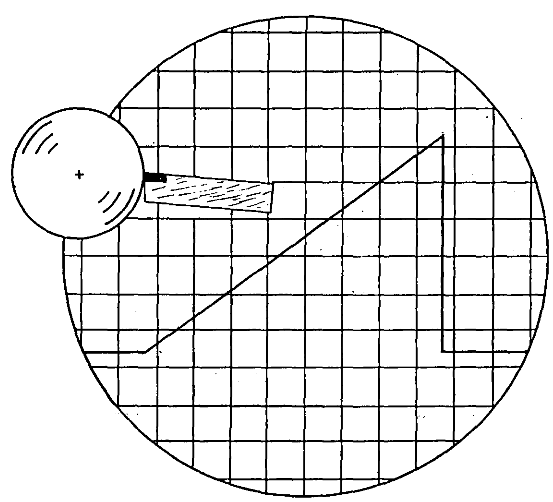
BENSON-LEHNER FORMS NEW DIVISION

Benson-Lehner Corp., Santa Monica, Calif., has formed a Data Services Division to help meet growing data processing requirements of government agencies and industry. The Division is located at 1860 Franklin St., Santa Monica.

The Data Services Division is using Benson-Lehner data processing equipment such as the Electroplotter J, as well as an IBM 1620 computer supported by a complete IBM card tabulating department.

FOXBORO ADDS NEW AUTOMATION GROUP

The Foxboro Company, Foxboro, Mass. has formed a new digital systems division. This new division will design and manufacture automation systems for control of industrial processes. Foxboro will now have "in house" means for engineering and manufacturing integrated digital and analog systems of measurement and control.



DIGITAL COMPUTER CENSUS

(Figures and information reprinted with permission from "Automatic Data Processing Service News Letter", for January 22, 1962, published by The Diebold Group, Inc., 430 Park Ave., New York 22, N.Y.)

The following figures show over 14,000 installations of digital computers, both general purpose and more limited. The figures apply as of the end of 1961, to computers made by United States manufacturers.

CLASS I. GENERAL PURPOSE DIGITAL COMPUTER SYSTEMS

Vacuum-tube circuitry -- See definition of Class I.

Manufacturer	Computer	Delivered	On Order	Notes
Large-Scale:				
Burroughs	Burroughs 220	53	6	-
International Bus. Mach. Corp.	IBM 701	4	0	N
	IBM 702	5	0	N
	IBM 704	90	3	-
	IBM 705 & 705 III	165	7	-
	IBM 709	30	2	-
Minneapolis-Honeywell	Datamatic 1000	7	0	N
Radio Corp. of America	Bizmac I	1	0	N
	Bizmac II	4	0	N
Remington Rand	Univac Scientific 1100 Series except Univac 1107	41	0	-
	Univac I & II	59	0	N
Medium-Scale:				
Alwac	Alwac III-E with tapes	5	0	-
Bendix	G-15 with tapes	158	-	-
Burroughs	Burroughs 205 with tapes	83	5	-
International Bus. Mach. Corp.	IBM 650 with tapes and/or Ramac	250	4	-
Remington Rand	Univac File Computer	101	2	-
Underwood	Elecom Series	4	0	-
Small-Scale:				
Alwac	Alwac II & III	8	0	N
	Alwac III-E	32	0	-
Bendix	G-15 (no tapes)	194	-	-
Burroughs	Burroughs 205 (no tapes)	19	1	-
Idaho-Maryland	Readix	7	0	N
International Bus. Mach. Corp.	IBM 650 (card)	725	10	-
	IBM 305 Ramac	1,050	50	-
National Cash Register	NCR 102	30	0	N
Royal-McBee	LGP-30	445	20	-
TOTAL CLASS I COMPUTERS		3,570		

N No longer in production.

CLASS II. GENERAL PURPOSE DIGITAL COMPUTER SYSTEMS

Transistorized circuitry -- See definition of Class II.

Manufacturer	Computer	Delivered	On Order
Class IIA (Desk):			
Autonetics	Recomp II	125	0
	Recomp III	24	0
Control Data	CDC 160 & 160A (*1)	120	50
International Bus. Mach. Corp.	IBM 1620	410	500
Monroe	Monrobot XI	70	125
National Cash Register	NCR 390	60	200
	NCR 310	15	20
Packard Bell	PB 250	51	38
Royal McBee	RPC 4000	39	18
Class IIB (Small):			
Burroughs	B250, B260, B270, B280	6	120
General Electric	GE 210	45	25
	GE 225	38	69
International Bus. Mach. Corp.	IBM 1401	1,750	5,200
Minneapolis Honeywell	Honeywell 400	8	-
National Cash Register	NCR 315	0	70
Radio Corp. of America	RCA 301	47	60
Remington Rand	Univac Solid State 80 & 90	430	174
Royal McBee	RPC 9000	2	10
Class IIC (Medium):			
Bendix	Bendix G-20	10	-
Burroughs	B5000	0	8
Minneapolis Honeywell	Honeywell 800	33	-
International Bus.Mach. Corp.	IBM 7070, 7072, & 7074	190	250
	IBM 1410	3	475
National Cash Register	NCR 304	21	9
Radio Corp. of America	RCA 501	68	17
Class IID (Large):			
Control Data	CDC 1604	27	12
International Bus. Mach. Corp.	IBM 7080	0	50
	IBM 7090	125	100
Philco	Philco 2000 (models 210 & 211)	17	23
	Philco 2000 (model 212)	0	5
Radio Corp. of America	RCA 601	0	6
Remington Rand	Univac 1107	0	4
	Univac III	0	42
	Univac 490	2	12
Sylvania	Sylvania 9400	2(*2)	0
Class IIE (Extra Large):			
International Bus. Mach. Corp.	Stretch	2	5
Remington Rand	Larc	2	0
TOTAL CLASS II COMPUTERS		3,742	

*1 Machines are being supplied National Cash as a component of the NCR 310 system
*2 For in-company installations

MISCELLANEOUS DIGITAL COMPUTERS

Manufacturer	Computer	Delivered	On Order	Notes
Burroughs	E-101 & E-103	140	35	-
Clary	DE 60	48	10	-
International Bus. Mach. Corp.	IBM 604	4,800	350	-
	IBM 607	450	-	N
	IBM 608	50	-	N
	IBM 609 & 609B-1	250	210	-
	IBM 610	225	25	-
Monroe	Monrobot IX	124	23	-
Remington Rand	Univac 40, 60 & 120	1,050	30	-
Underwood	100	4	-	N
TOTAL MISCELLANEOUS COMPUTERS		7,141		

N No longer in production

Definitions

Class I consists of systems with vacuum tube circuitry and which can be classified into large-scale, medium-scale, and small-scale, based on the computer and its associated peripheral equipment as defined below. There is no implied evaluation of machine capabilities in terms of large, medium and small. Mimimum requirements for each group follow: Large-scale: The system uses magnetic tapes and the computer operates at microsecond arithmetic speeds. Price in general is in the order of magnitude of one million dollars or more. Medium-scale: The system uses magnetic tapes and the computer operates at millisecond arithmetic speeds. In general, the price range is from $500,000 to $1,000,000. Small-scale: The system does not use magnetic tapes but the computer is internally programmed.

Class II consists of systems with transistorized circuitry, generally known as "second generation" computers. Many of these systems are characterized by expandability or modular design. The criteria used for subdividing Class II are shown below:

	Monthly Rental	Number of Magnetic Tapes	Average Storage (in bits)	Overlap of Reading, Writing, Computing	Notes
A. Desk (does not refer to physical size)	Under $2,000	None	20,000	None	Input-output normally paper tape or keyboard. No high speed printer.
B. Small	Under $12,000	0-6	100,000	None	All input-output on line.
C. Medium	$12-25,000	6-12	500,000	Yes	Magnetic tape oriented.
D. Large	$25-75,000	More than 12	1,000,000	Yes	Magnetic tape oriented.
E. Extra Large	Over $75,000	More than 12	Over 1,000,000	Yes	Speeds and capacities outside range of normal business data processing

For most Class II systems, expansion to the next higher level is possible without serious imbalance.

Miscellaneous computers are card calculators and other machines which do not fall into one of the above systems classifications.

(Continued from Page 19)

puter, except in the department of speed. The speed of execution of calculating and reasoning in a computer, once it has been correctly programmed and the information is within the computer, has an advantage of about 1,000,000 to one. But there are instances where a human being is still a respectable competitor: in playing a good game of chess, in recognizing a handwritten address on an envelope, in distinguishing which light at a street intersection is a traffic light, and so on.

7. Control Capacity

What a computer does from one operation to the next is determined by the *control unit.* The control unit consists at rock bottom of a register which contains an instruction, the current instruction which sets the switches throughout the machine for the next transfer of information. Then as soon as the switches are completely set, the information is transferred in a flash throughout the machine. Then the control register takes in the next instruction, which in turn establishes what will happen next throughout the machine. The flow of instructions into the control register is regularly produced by the program. The most powerful present-day computer can handle 2 million instructions per second.

But recently some new and fruitful system ideas have been applied to the control unit. In early computers, the central processor of information would "sit around" idle while waiting for some piece of peripheral equipment to put in or take out information. For example, if it was a card punch which could punch 2,400 characters a second, while the computer could produce 80,000 characters a second, the computer might be idle waiting for the card punch for 40 seconds, and the computer would be working one out of every 40 seconds. This very serious waste of expensive capacity had to be eliminated.

A succession of useful ideas has been applied to this problem. First, there was the *on-line buffer* mentioned above, whereby an auxiliary buffer memory would take the 2,400 characters from the computer at the computer's speed and then deliver them to the card punch at the card punch's speed. Second came the *off-line buffer* or tape-to-card converter: the computer would load up a magnetic tape reel with information for the card punch, and then the card punch governed by the converter would work away for a long time punching cards. Third came the idea of *multiple trunks,* lines running to many buffers for many pieces of peripheral equipment, each buffer calling the central processor when it needed loading. Then came the idea of *multi-program and traffic control*—shared guided control of the central processor for different equipment and different programs. Also, *program-interrupt* features provided top priority for urgent business. In this way, the idea was pursued that the computer itself should be responsible for working on many programs and many calls from equipment, in each case attending to instructions in such a way as to maximize the amount of work done and minimize the waiting of any program or peripheral device. So the central processor became no longer the analog of a single human computer, but the analog of a section head in charge of a number of human computers.

Let us compare this marvellous control capacity of a computer with the control capacity of a human being. In the first place, he cannot always keep his attention on even a single program of things to be done: his mind wanders; he has a coffee break; he stops to chat with the clerk sitting next to him in the office; then he concentrates again filling another sheet of calculations; and so on. Perhaps a good speed of a human being in thinking is 2 or 3 elementary reasoning operations per second. In the multiplication of 927538921 by itself, there were about 600 or 700 elementary reasoning operations. In "9 times 9 is 81, and 2 carried is 83, write 3, and carry 8," we would count 4 elementary reasoning operations. And this gives a speed of approximately 2 per second. Of course a good deal of the time a human being will just wonder about the way to go at a problem. If in geometry I wish to show that the sum of the angles of any triangle is 180°, I may not know how to start at first, and I may have to guess, experiment, and explore.

So the factor of advantage for the computer is on the order of a million to one.

8. Reliability

The first automatic computers of the 1940's were not very reliable. The equipment of which they were made had not been engineered to be exceedingly accurate and reliable. The programmer for the problem usually had to program the checks that he wanted used, by doing the same operation in another way. For example, in multiplication A times B would use equipment differently from B times A, and so both operations might be programmed, and then the computer would be given an instruction to compare the results. If the difference in the results exceeded a certain tolerance, then the machine would stop; and the operator in charge of the computer, and the mathematician in charge of the program, and the maintenance man in charge of keeping the machine going would consult on how to get rid of the error!

Those days have long since gone. Now computers can operate with extraordinary reliability, with as many as a billion or ten billion operations between errors. Automatic checking of various kinds is built into the machine. Machine faults are divided into two kinds: intermittent and constant. An intermittent fault may be due for example to a speck of dust momentarily between a magnetic reading head and the magnetic tape, so that a 1 is read as a 0. A constant fault may be due to a component going below par so that electric pulses do not pass through it properly any more. For both these causes of fault there are diagnostic programs so that the point where the computer made the mistake can be located. To avoid loss of desired information, checking digits are carried along by the machine with the information. For example, if the numer of 1's in a character is even, the checking digit is an additional 1. If the number of ones in the character is odd, the checking digit is 0. The machine can automatically count digits in a character at numerous points throughout a calculation, and can always at once tell whether a character is wrong, (has an even number of 1's, in the example), and can automatically rerun from a preceding point.

But even better than this is automatic recalculation of missing information and automatic correction of errors. This power is a feature of the Honeywell 800 computer, made by Minneapolis-Honeywell, in a patented scheme called Orthotronic control. With this system, the machine itself is able to recompute correct information automatically and without pausing, by making use of checking digits not only in rows but also in columns.

In comparison with these amazing realities, the unreliable, error-prone human being feels like shrinking into a corner. The standard procedure in the 1930's and 1940's in the life insurance business for calculation by clerks with desk calculators was to have the calculation done once by one clerk, then a second time by another clerk independently, and then inspected by the section head. This caught most but not all errors.

If we measure reliability by the average number of operations between errors, then we should say perhaps for the computer 10 billion and for the human being at best 1,000, and so the factor of advantage is 10 million.

9. Tirelessness

The computer of course is little different from any other machine when it is a matter of tirelessness or to use a less human expression, *operating ratio.* This is the quotient of the amount of time that the computer operates correctly divided by the amount of time that the computer ought to be available for operating. The numerator does not exclude time when the program did not run because the human programmer made a mistake. The denominator does include the time when the computer is idle for *preventive maintenance,* when the technicians go over it with a fine-toothed comb seeking to locate components that are about to fail, to be pulled out and replaced with new ones so that the maximum operation may be achieved.

The operating ratio in many computer installations is 97 and 98 per cent, even when there are multiple shifts up to 168 hours per week.

A human being does get fatigued. He does need sleep (though his heart does not, for it keeps pumping while he sleeps having mastered the trick of never getting tired). He has to stop to eat and behave in other ways like the animal and biochemical system that he is.

The highest operating ratio of a human being is perhaps around 84 hours a week out of the 168 hours available, or about 50%. The usual work week of course of 35 hours represents 21 per cent operating ratio.

The factor of advantage for the computer is about 4 to 1.

10. Hardware

The most advanced computers of the present day are called *solid-state* computers, because they make extensive use of solid-state electronic devices such as transistors, germanium diodes, and magnetic shift registers,—not electronic tubes. This increases speed, cuts down electric power consumption, reduces heat, and saves space.

One of the important solid-state devices used in computers is the "magnetic core." This is a small doughnut-shaped bead of a magnetic ceramic, called *ferrite,* which is arranged with other cores in flat planes and strung with insulated wires. When a current is passed through a wire going through one of these cores, the polarization of the core can be changed from one direction to the other direction. This enables the core to be changed, from storing a zero to storing a one, or by running current in the reverse direction, from storing a one to storing a zero. These magnetic cores are the heart of the rapid memory, that part of storage of information which can be most rapidly consulted in the powerful computers. Their polarization can be switched at best in about half a microsecond. Access to a magnetic core memory in a powerful computer can be a microsecond.

Even faster memory devices are on the way, such as spots of magnetic film deposited on thin glass plates. Their polarization can be switched in a few hundredths of a microsecond.

It seems likely that the size of computers will become smaller and smaller at the same time as they increase in power and capacity. Eventually the powerful computer, in hardware may be a rival of the human brain in size also.

11. Manufacture and Costs

At the present time more than 20 manufacturers in the United States make automatic digital computers of various kinds. Outside of the United States there are at least 15 more manufacturers of commercial automatic computers, but none of the machines they are making are as powerful as the most powerful machines being made in the United States.

The number of types of commercial computers currently in the United States is about 45 or 50. Their price ranges from over $10 million to about $25,000; the monthly rental ranges from about $300,000 to about $700.

The most powerful computers which recently were being contracted for are the IBM 7030 Stretch computer, being marketed by International Business Machines Corp., and the Univac Larc, being made by the Remington Rand Univac Division of Sperry Rand. A non-commercial Larc was delivered in 1960 to the Livermore Atomic Research Center in California. The commercial forms of Larc and Stretch have not yet been delivered at present writing.

One of the really important factors in the cost of a computer is the unit cost per calculating operation. As the price of a computer goes up, the cost per calculating operation goes down. For the most expensive computers, the cost is least.

For example, take the Stretch computer, rental about $300,000 monthly, and assume 500,000 calculating operations per second. In a month then, it will do about 1.2 times 10^{12} calculating operations. This is at the rate of 100,000 calculating operations for 2½ cents. Even if this figure does not allow for many factors that should be considered—particularly, the cost of programming—still it shows a profoundly new power existing in society for answering questions.

COMPUTERS AND WORLD PEACE

COMPUTERS AND WORLD PEACE — ANNOUNCEMENT

Edmund C. Berkeley
Editor, Computers and Automation

Beginning with this issue, **Computers and Automation** will have a new department, which will be published from time to time, "Computers and World Peace."

The final impulse in a long sequence of impulses in this direction has come from one of the announcements of the 1962 Spring Joint Computer Conference in San Francisco, May 1 to May 3.

> "One session, entitled 'Peace and the Role of Computers' will describe the part computers may be expected to take in man's search for world peace. Dr. Louis Fein, Palo Alto, Calif., consultant, will serve as chairman for this symposium."

If any reader of **Computers and Automation** is unable to express his remarks at that symposium—or subsequent to that symposium has remarks to express—he is invited to send them to us so that we may consider them for publication in the pages of this magazine.

President John F. Kennedy has said that man must abolish war, or war will abolish man. The territory of this magazine is not the whole giant problem and all its proposed solutions, but those sections of the problem and its solutions which are particularly related to the science and technology of handling information, symbolized in the fantastic powers of the modern automatic computer.

A major part of the current attention of this department will be directed towards the concept of War Safety Control, explained in a group of reports in the January 1962 issue of **Computers and Automation**. See the box on this page.

FIRST RESEARCH CONTRACT OF U. S. ARMS CONTROL AND DISARMAMENT AGENCY TO BENDIX CORPORATION

The United States Arms Control and Disarmament Agency announced in February the award of the first of a series of studies to be undertaken by the agency. These studies are part of its long range program of program research covering various areas and problems related to arms control and disarmament. The contract, totaling $150,000, deals with a study of techniques for monitoring the production of strategic delivery vehicles. It was awarded to the Systems Division of the Bendix Corporation, Ann Arbor, Mich.

It is thought that the contract will result in a helpful contribution to disarmament planning and negotiations. The study will include consideration of the production of strategic delivery systems such as long-range missiles and bombers capable of delivering nuclear weapons. It will include identifying and evaluating techniques both on the site and remote from the site of the delivery systems.

WAR SAFETY CONTROL — COMMENTS

I. From James J. Wadsworth

President, The Peace Research Inst.
Washington 6, D. C.

To the Editor:

I read with great interest the 14-page report on "Computers and War Safety Control" which you sent me and wish to thank you for calling it to my attention. This is unquestionably a serious and significant proposal which should be given the most careful consideration.

Since, as you know, the Peace Research Institute is focusing its attention on the contributions which science can make to the cause of peace, we will of course give this proposal the attention and consideration which it deserves.

You may have noticed in our brochure that one of our major activities is the analysis of such proposals by holding "working conferences." These conferences serve both to promote the broadest possible con-

WAR SAFETY CONTROL

For the benefit of those readers who did not see the January issue, "War Safety Control" is a proposed system which is analogous to Air Traffic Control, and which was proposed in 1961 by Howard G. Kurtz, a former airline pilot and manager, and a member of the U. S. Army Reserve, 1929-46.

Essentially, War Safety Control is the idea of a multi-national technological control system (making use of computers, other devices, and people) to secure safety from war on behalf of all nations jointly and *regardless* of the government that they have.

Single reprints of the 14-page January report are available from **Computers and Automation** on request; reprints in quantity, at cost.

sideration of worthwhile suggestions for peace initiatives, and to submit these suggestions to the kind of critical evaluation which will be most valuable in further clarifying and developing them.

Once again, my thanks for bringing this report to my attention.

II. From Lyndon B. Johnson

The Vice President
Washington, D. C.

To Howard Kurtz:

Your studies in War Safety Control are very interesting and provocative. I am happy that you thought to bring this to my attention.

I have been in touch with the State Department and they were very interested in your proposal. They also informed me that you were very highly thought of by many people in the Disarmament Administration.

Please keep me informed on your further development of this plan.

III. From William C. Foster

Director, U. S. Arms Control and Disarmament Agency
Washington 25, D. C.

To Howard Kurtz:

. . . While I cannot agree with your comments regarding past and present United States policy and strategy, I find your idea of war safety controls a challenging concept. In the field of arms control and disarmament, one of the more serious problems is that of verification and enforcement of the disarmament obligations which nations may assume. Inspection of military and economic activity, detection of possible violations of disarmament agreements, and action to insure compliance with such agreements are all facets of this problem. If automatic systems of detection and surveillance, including electronic systems, could be made operationally feasible and acceptable to the nations involved as one of the bases for enforcement action, the solution of the problem of verification would be considerably advanced.

In the studies of verification and control which this Agency is undertaking, the concept of such automatic systems will of course be given appropriate consideration.

IV. From Senator John Stennis

Chairman, Preparedness Investigating Subcommittee
United States Senate
Washington 25, D. C.

To Howard Kurtz:

This is in further reference to your WAR SAFETY CONTROL concept. . . .

We have received a number of replies to the letter which we wrote some time ago to the persons on the list supplied by you. As one might expect, the comments made have an extreme range of variety and no definite pattern is established by them.

All of the persons replying acknowledged that you were a person of dedication and zeal and that you are patriotically inspired. *Also, there was general agreement that your concept is technologically feasible.* Beyond these areas the variance in the comments became apparent.

The comments upon your concept ranged all the way from genuine and unreserved enthusiasm to the opinion that, while technically sound, it presented nothing really new. Intermediate views included the thought that it was in such general terms that it presented nothing for precise study and the comment that it alone was not the entire answer but only a part of it. Some persons expressed doubt of its political and sociological feasibility.

You can understand, then, my inability to reach a categorical and final conclusion at this time. It occurs to me that *the matter needs further definition, study and specification.* Among the questions which have been raised are:

(a) Is the activation of the concept feasible from a political viewpoint;

(b) Just what would be involved in the system from the standpoint of hardware;

(c) How would the system actually operate technically;

(d) Assuming that there was clear detection of preparations for aggression by any nation, just how would we react; in other words, how could the detected aggression be prevented or negated; and

(e) What specifically is the plan of action.

Please be assured of my continuing interest in this subject. . . .

V. From Mrs. Eleanor Roosevelt

New York 21, N. Y.

To Howard Kurtz:

I am sending your material with a little covering note to the President because I think it is worth reading. With my good wishes. . . .

THE ETHIC OF SECRECY

Prof. John L. Kennedy
Chairman, Dept. of Psychology
Princeton Univ.
Princeton, N. J.

I would look to the establishment of something like a War Safety Control organization to find ways of mutual information exchange between competitors so that the checks and balances necessary to prevent a major world catastrophe may be developed.

I am particularly concerned with the ethic of secrecy as it affects the problem of mutual estimation of intent between adversaries. It seems to me that we will never be able to abolish competition (nor would it be desirable to do so) as a fundamental motivation for adaptation to change. The rules under which we compete, however, appear to be inadequate and archaic. I believe that the world community of nations can no longer afford the ethic of secrecy.

It is possible to conceive of a world in which the spotlight of publicity is routinely focused on the planning and decision-making bodies of the major competitors by modern electronic methods. This is the obverse of the world described by Orwell in "1984," where the spotlight is directed at the individual.

My own version of a War Safety Control organization would require, as a first step, only the information processing and dissemination function, not a police function. My expectation would be that such freely available information would provide many of the checks and balances that would lead to a slowing of the arms race.

The community of scientists has already taken giant steps toward the development of an anti-secrecy ethic, which not only permits but demands rapid exchange of basic research ideas and data. Many people attribute the rapid development of science in the service of mankind to the mutual unwritten agreement requiring free publication of scientific information.

I am in charge of a laboratory here at Princeton in which we have been studying competition between 3-man planning and decision-making groups for the past three years. Through the use of closed-circuit television and sound, we have been able to give our groups complete access to the plans and actions of three other groups out of the total of ten competing groups. Although it takes some time to adjust to this unusual environment, the result has not been a collapse of competition or a "stalemate" but rather a very rapid development of new ways of competing and adjusting. We hope to be able to study the complete exchange of information condition next year.

CALENDAR OF COMING EVENTS

April 2-5, 1962: Annual Meeting of POOL (LGP-30, RPC-4000, and RPC-9000 Electronic Computer Users Group), Penn-Sheraton Hotel, Philadelphia, Pa.; contact Dr. Henry J. Bowlden, Union Carbide Corp., P. O. Box 6116, Cleveland 1, Ohio

April 4-6, 1962: Univac Users Association and Univac Scientific Exchange Organization, Leamington Hotel, Minneapolis, Minn.; contact David D. Johnson, Sec'y, Univac Users Association, Ethyl Corp., P. O. Box 341, Baton Rouge, La.

April 9-11, 1962: Meeting of the 304 Association (Users of NCR 304 Data Processor), Minute Maid Co., Orlando, Florida; contact L. J. Rushbrook, The 304 Association, National Cash Register Co., Main & K Streets, Dayton 9, Ohio.

April 9-13, 1962: Business Equipment Exposition, McCormick Place, Chicago, Ill.; contact G. H. Gutekunst, Jr., Mgr., Press Information, Business Equipment Manufacturers Exhibits, Inc., 235 E. 42 St., New York 17, N. Y.

April 11-13, 1962: SWIRECO (S. W. IRE Conference and Electronics Show), Rice Hotel, Houston, Tex.; contact Prof. Martin Graham, Rice Univ. Computer Project, Houston 1, Tex.

April 16-18, 1962: Symposium in Applied Mathematics on "Interactions Between Mathematical Research and High-Speed Computing," at American Mathematical Society and Association for Computing Machinery Symposium, Atlantic City, N. J.; contact Mrs. Robert Drew-Bear, Head Special Projects Dept., American Mathematical Society, 190 Hope St., Providence 8, R. I.

April 18-20, 1962: Conference on Information Retrieval in Action, Cleveland, Ohio; contact Center for Documentation and Communication Research Conference, Western Reserve Univ., 10831 Magnolia Dr., Cleveland 6, Ohio

April 24-26, 1962: 12th Annual International Polytechnic Symposium, devoted to "The Mathematical Theory of Automata," United Engineering Center, 345 E. 47 St., New York, N. Y.; contact Symposium Committee, Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N. Y.

April 25-27, 1962: National Microfilm Association Convention, Mayflower Hotel, Washington, D. C.; contact Vernon D. Tate, Exec. Secretary, National Microfilm Association, P. O. Box 386, Annapolis, Md.

April 30-June 8, 1962: Seminar in Search Strategy, Graduate School of Library Science, Drexel Institute of Tech., Phila. 4, Pa.; contact Seminar in Search Strategy, Graduate School of Library Science, Drexel Inst. of Tech., Phila. 4, Pa., Att: Mrs. M. H. Davis

May 1-3, 1962: Spring Joint Computer Conference, Fairmont Hotel, San Francisco, Calif.; contact Richard I. Tanaka, Lockheed Missile & Space Div., Dept. 58-51, Palo Alto, Calif.

May 7-8, 1962: Fifth Annual Conference of the Association of Records Executives and Administrators, Waldorf-Astoria Hotel, New York City; contact Miss Judith Gordon, AREA Conference publicity chairman, Metal & Thermit Corp., Rahway, N. J.

May 8-10, 1962: Electronic Components Conference, Marriott Twin Bridges Hotel, Washington, D. C.; contact Henry A. Stone, Bell Tel. Lab., Murray Hill, N. J.

May 9-11, 1962: Operations Research Society of America, Tenth Anniversary Meeting, Shoreham Hotel, Washington, D. C.; contact Harold O. Davidson, Operations Research Inc., 8605 Cameron St., Silver Spring, Md.

May 14-16, 1962: National Aerospace Electronics Conference, Biltmore Hotel, Dayton, Ohio; contact George A. Langston, 4725 Rean Meadow Dr., Dayton, Ohio

May 21-25, 1962: Institute on Electronic Information Display Systems, The American University, Washington, D. C.; contact Dr. Lowell H. Hattery, Director, Center for Technology and Administration, The American University, 1901 F St., N.W., Washington 6, D. C.

May 22-24, 1962: Conference on Self-Organizing Systems, Museum of Science and Industry, Chicago, Ill.; contact Mr. George T. Jacobi, COSOS Conference Sec'y, Armour Research Foundation, 10 W. 35 St., Chicago 16, Ill.

May 28-June 1, 1962: Colloquium on Modern Computation Techniques in Industrial Automatic Control, Paris, France; contact French Association of Automatic Control (AFRA), 19, Rue Blance, Paris 9, France.

June 4-14, 1962: Mathematical Techniques of Optimization (10-Day Short Course on Operations Research), Purdue University, Lafayette, Ind.; contact Div. of Adult Education, Purdue University, Lafayette, Ind.

June 11-July 20, 1962: Summer Institute on Advanced Topics in the Computer Sciences, Computation Center, University of North Carolina, Chapel Hill, N. C.; contact Dr. John W. Carr, III, Computation Center, University of North Carolina, P. O. Box 929, Chapel Hill, N. C.

June 18-Sept. 14, 1962: Engineering Summer Conference Courses, Univ. of Mich., Ann Arbor, Mich.; contact Raymond E. Carroll, Univ. of Mich., 126 West Engineering Bldg., Ann Arbor, Mich.

June 19-21, 1962: Fourth Joint Automatic Control Conference, Univ. of Texas, Austin, Tex.; contact Prof. Otis L. Updike, Dept. of Chemical Engineering, Univ. of Va., Charlottesville, Va.

June 19-21, 1962: Second Annual San Diego BioMedical Engineering Symposium and Exhibit, Stardust Motor Hotel, San Diego, Calif.; contact The Program Committee, Inter-Science, Inc., 8484 La Jolla Shores Dr., La Jolla, Calif.

June 19-22, 1962: National Machine Accountants Association International Conference, Hotel Statler, New York, N. Y.; contact R. Calvin Elliott, Exec. Dir., NMAA, 524 Busse Highway, Park Ridge, Ill.

June 27-28, 1962: 9th Annual Symposium on Computers and Data Processing, Elkhorn Lodge, Estes Park, Colo.; contact W. H. Eichelberger, Denver Research Inst., Univ. of Denver, Denver 10, Colo.

June 27-29, 1962: Joint Automatic Control Conference, New York Univ., New York, N. Y.; contact Dr. H. J. Hornfeck, Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

July 17-18, 1962: Rochester Conference on Data Acquisition and Processing in Medicine and Biology, University of Rochester Medical Center, Rochester, N. Y.; contact Mr. Kurt Enslein, University of Rochester, Rochester 20, N. Y.

July 18-19, 1962: Data Acquisition & Processing in Medicine & Biology, Whipple Auditorium, Strong Memorial Hospital, Rochester, N. Y.; contact Kurt Enslein, Brooks, Inc., 499 W. Comm. St., P. O. Box 271, E. Rochester, N. Y.

August 9-11, 1962: Northwest Computing Association Annual Conference, Seattle, Wash.; contact Robert Smith, Conference Director, Box 836, Seahurst, Wash.

Aug. 21-24, 1962: 1962 Western Electronic Show and Convention, California Memorial Sports Arena and Statler-Hilton Hotel, Los Angeles, Calif.; contact Wescon Business Office, c/o Technical Program Chairman, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Aug. 27-Sept. 1, 1962: 2nd International Conference on Information Processing, Munich, Germany; contact Mr. Charles W. Adams, Charles W. Adams Associates, Inc., 142 the Great Road, Bedford, Mass.

Sept. 3-7, 1962: International Symp. on Information Theory, Brussels, Belgium; contact Bruce B. Barrow, Postbus 174, Den Haag, Netherlands

Sept. 3-8, 1962: First International Congress on Chemical Machinery, Chemical Engineering and Automation, Brno, Czechoslovakia; contact Organizing Committee for the First International Congress on Chemical Machinery, Engineering and Automation, Vystaviste 1, Brno, Czechoslovakia.

Sept. 19-20, 1962: 11th Annual Industrial Electronics Symposium, Chicago, Ill.; contact Ed. A. Roberts, Comptometer Corp., 5600 Jarvis Ave., Chicago 48, Ill.

Oct. 2-4, 1962: National Symposium on Space Elec. & Telemetry, Fountainbleu Hotel, Miami Beach, Fla.; contact Dr. Arthur Rudolph, Army Ballistic Missile Agency, R & D Op. Bldg. 4488, Redstone Arsenal, Ala.

Oct. 8-10, 1962: National Electronics Conference, Exposition Hall, Chicago, Ill.; contact National Elec. Conf., 228 N. LaSalle, Chicago, Ill.

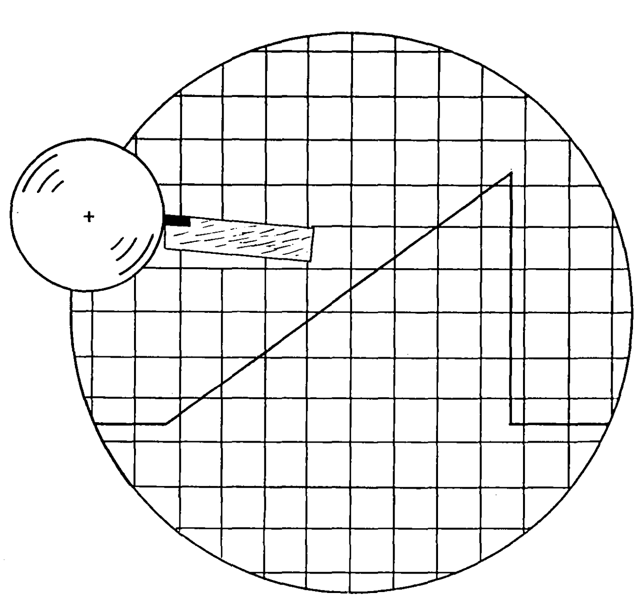
October 15-18, 1962: Conference on Signal Recording on Moving Magnetic Media, The Hungarian Society for Optics, Acoustics and Cinetechnics, Budapest, Hungary; contact Optikai, Akusztikai, es Filmtechnikai Egyesulet, Szabadsag ter 17, Budapest V, Hungary

Oct. 30-31, 1962: Conference on Eng. Tech. in Missile & Spaceborne Computers, Disneyland Hotel, Anaheim, Calif.; contact William Gunning, EPSCO-West, 240 E. Palais Rd., Anaheim, Calif.

Nov. 5-7, 1962: 15th Annual Conf. on Elec. Tech. in Medicine and Biology, Conrad Hilton Hotel, Chicago, Ill.; contact Dr. J. E. Jacobs, 624 Lincoln Ave., Evanston, Ill.

Nov. 13-15, 1962: NEREM (Northeast Res. & Engineering Meeting), Boston, Mass.; contact NEREM-IRE Boston Office, 313 Washington St., Newton, Mass.

Dec. 4-5, 1962: Eastern Joint Computer Conference, Bellevue-Stratford Hotel, Philadelphia, Pa.



Readers' and Editor's Forum

FRONT COVER: PHOTOGRAPHIC INPUT CELL BY CELL TO A COMPUTER

The front cover shows an aerial photograph, in which the upper portion has been sampled, quantized, stored on magnetic tape, and retrieved from a computer; the lower portion shows the original photograph. The picture is of seaplanes in San Diego Bay near Lindberg Field, California. The photographic input device, which analyzes photographs for computer purposes, was developed by Cornell Aeronautical Laboratory, Buffalo, N. Y., and is associated with its IBM 704 computer. The photo input facility will be used to aid automatic photointerpretation, character recognition, etc.

Details of a photograph can be inserted into the computer on a cell-by-cell basis. The photographic data is thereby converted to a form allowing the digital computer to perform complex operations to recognize significant photographic features.

The photo input facility consists of: a facsimile transmitter of slightly less than 100 lines per inch resolution; an analog-digital sampler and converter; and some special isolating and control circuitry. Ninety seconds are required for the insertion of an entire five-inch by five-inch photograph. A five-inch by five-inch picture is broken into approximately 250,000 individual elements, each having 16 possible levels of intensity.

An output display can show graphically the photographic information actually contained within the computer. Combinations of type in the computer's printer are used to represent 4 different levels in the picture although the photographic information actually in the computer is in 16 levels of gray.

THE CUMULATIVE "WHO'S WHO IN THE COMPUTER FIELD"

Up to present writing, we have mailed over 20,000 inquiries to people in the computer field for their Who's Who entries. We have received somewhere between 1,500 and 2,000 entries, instead of the necessary minimum of 12 or 15 thousand.

Accordingly, we are moving the closing date for the 1962 Cumulative "Who's Who in the Computer Field" from the end of February to the end of June.

We ask all our readers and all their friends and associates in the computer field to please complete their Who's Who entry forms, and send them to us. There is no cost or charge for being listed. See the entry form on page 34.

AN ELECTRONIC DATA PROCESSING GLOSSARY FOR THE SPACE AGE

T. Tancer
Worcester, Mass.

The vocabulary used in the data processing industry is continually changing. New words are frequently introduced, and the meanings of old words shift with time. The following brief glossary is intended to provide the reader with succinct, but accurate, definitions of some new terms and the new meanings of some old ones.

System: Anything with one or more components.

Sophisticated system: A system with at least two components.

Very sophisticated system: We built it.

Extremely sophisticated system: You built it and we are trying to sell you something.

Algorithm: A general term used to denote things which were formerly called "programs," "routines," and "subroutines."

Program: Something you get at the theater.

Programmer: Coder.

Senior programmer: One who writes algorithms.

Proposal: A series of half truths told by a boy to a prospective wife or by a bidder to a prospective customer.

Unsolicited proposal: A proposal made to an honest woman or to one's uncle in the Defense Department.

High speed electronic data processing system: Our computer.

Computer: Your computer.

Growth company: Company losing money and therefore forced to issue stock in order to support its management in the style to which it is accustomed.

Non-profit company: A growth company that does not issue stock.

Software: A set of tapes provided by computer manufacturers to encourage sales and distinguishable from trading stamps by the lack of perforations.

Programming system: Software which makes it unnecessary for the algorithmer to understand the relatively simple language of the machine and makes it necessary for him to understand the language of a far more complex programmer's manual.

Programmer's manual: A rather thick booklet occasionally useful for propping open doors.

Automation: A technique for replacing a small number of unskilled laborers by a large number of unskilled programmers.

Operator: A person who removes your program when he thinks it is looped, or one who removes your girl-friend when he thinks you are.

Flip-flop: A computer component more likely to do the latter than the former.

National convention: A meeting of minds for the transfer of bodies.

Wise: A suffix much used by the un-.

Work: In physics, a term used to denote the transfer of energy. Also (slang) a term used in the data processing industry to denote an activity occasionally allowed to interrupt coffee breaks.

RADIATION-RESISTANT COMPUTER

Federal Systems Division, Space Guidance Center
International Business Machines Corp.
Owego, N. Y.

An aerospace computer that can operate in an intense radioactive environment is being developed by scientists at this laboratory. It will be able to operate next to nuclear propulsion systems in future atmospheric and space vehicles and in the natural radioactive fields that may exist in space.

Circuits have been exposed without breaking down to heavy radiation pulses from the Atomic Energy Commission's Godiva Reactor at Los Alamos, N. M., and also to intense and continuous radiation from the Battelle Memorial Institute's Research Reactor at Columbus, Ohio.

The computer uses tunnel diode circuits, and is micro-miniaturized. Including input/output equipment, it occupies 2 cubic feet, will weigh about 100 pounds, and will run on 150 watts of power, the amount needed for a reading lamp.

It is a general-purpose machine. Its memory stores more than 12,000 words of instructions and data. In one second, it can carry out 70,000 computing operations.

SESSIONS OF THE SPRING JOINT COMPUTER CONFERENCE, SAN FRANCISCO, MAY 1-3, 1962

A program offering 37 papers in 11 sessions has been set for the 1962 Spring Joint Computer Conference at the Fairmont Hotel, San Francisco, May 1-3. The sponsor of the conference is the American Federation of Information Processing Societies.

Dr. Richard I. Tanaka, manager of Computer Systems-Logical Design for Lockheed Missiles and Space Co., Palo Alto, is technical program chairman.

The professional presentations will place focus on new developments, indicate trends, and try to identify the major contributions computer technology is expected to make in the future.

Accordingly, one session entitled "Peace and the Role of Computers" will describe the part computers may be expected to take in man's search for world peace. Dr. Louis Fein, Palo Alto, Calif., consultant, will be chairman for this symposium.

In addition to this symposium, the sessions will be as follows:

Computer Systems; Circuits and Memory Devices; Information Retrieval; Man-Machine Cooperation; Theoretical Problems in Artificial Intelligence; Data Analysis and Model Construction in the Study of the Nervous System; Programming and Coding; Study of Business Systems; DDA and Hybrid Computation; and Analog Applications and Techniques.

SPACEBORNE COMPUTER CONFERENCE — CALL FOR PAPERS

R. A. Kudlich
A. C. Spark Plug Div.
General Motors Corp.
El Segundo, Calif.

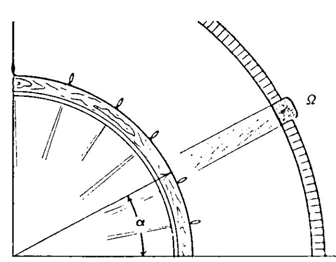
The Professional Group on Electronic Computers of the Institute for Radio Engineers is sponsoring a national conference on engineering technology in missile and spaceborne computers. The conference will be held at the Disneyland Hotel, Anaheim, Calif., October 30-31. Papers presented at the conference will be concerned with all engineering aspects of computers and digital information processing systems which are an integral part of the airborne equipment for missile and space systems.

Primary emphasis for the conference will be on working equipment and techniques, but papers describing significant new approaches and future trends are also wanted. The program will include both invited and contributed papers. The Conference Proceedings, with reprints of all conference papers, will be available for distribution at registration.

Authors desiring to present papers at this conference should submit four copies of a 1,000-word summary by June 15. The summary should accurately describe the author's work in order to assist the program committee in selecting papers. Final choice of papers will be completed by July 15; authors will be notified immediately.

Final copies of papers to be presented will be required by September 28 to allow time for printing in the Conference Proceedings. Company and Government clearance, where necessary, should be obtained by the author prior to submission of the summary.

All summaries and papers should be sent to: Dr. R. A. Kudlich, Program Chairman, AC Spark Plug Division, General Motors Corporation, 950 North Sepulveda Blvd., El Segundo, California.



COMMON FALLACIES IN THINKING

Munson B. Hinman, Jr.
San Jose, Calif.

To the Editor:

Which of the following fallacies can computers commit?

1. *Over-generalizing.* Jumping to conclusions from one or two cases.
2. *"Thin entering wedge."* A special type of over-generalizing involving prediction. If this thing is done, then that thing—usually dire—will follow.
3. *Getting personal.* Forsaking the issue to attack the character of its defender.
4. *"You're another."* My point may be bad, but yours is just as bad, so that makes us quits.
5. *Cause and effect.* If event B comes after event A, then it is argued to be the result of A.
6. *False analogies.* This situation, it is argued, is exactly like that situation—but it isn't.
7. *Wise men can be wrong.* Clinching an argument by an appeal to authority.
8. *"Figures prove."* A subclass of the above, especially popular in America today.
9. *Appeal to the crowd.* Distorting an issue with mass prejudices.
10. *Arguing in circles.* Using a conclusion to prove itself.
11. *"Self-evident truths."* Trying to win an argument by saying "everybody knows" it must be true.
12. *Black or white.* Forcing an issue with many aspects into just two sides, and so neglecting important shades of gray.
13. *All gray.* Forcing an issue that has two sides, into many shades of gray, and arguing that there are no substantial differences between the shades of gray.
14. *Guilt by association.* Making a spurious identification between two dissimilar persons or events.
15. *Appeal to pity.*
16. *Appeal to fear.*
17. *Appeal to ignorance.*

Essential Special Terms in Computers and Data Processing

The special terms of any subject are the key to understanding it; the special terms of the field of computers and data processing are accordingly, the key to the understanding of this field.

Among the many special terms in any field of knowledge, there are two kinds: those that are essential, that convey the key ideas of the subject to a person interested in understanding it; and those that are helpful but not essential. An example of the first kind of term in the computer field is "binary notation"; it would be very hard to understand much of the field of computers without knowing the meaning of "binary notation." An example of the second kind of term is "minimum latency programming"; for many purposes it is not necessary to know exactly what this term means, especially since one can guess (correctly) that it means programming which has a certain minimum property.

The following short glossary contains a selection of the essential special terms for the field of computers and data processing.

I. General Concepts

computer—1. A machine which is able to calculate or compute, that is, which will perform sequences of reasonable operations with information, mainly arithmetical and logical operations. 2. More generally, any device which can accept information, apply definite reasonable processes to the information, and supply the results of these processes. 3. A human being who can perform these operations and processes.

analog computer—A computer which calculates by using physical analogs of the variables.—Note: Usually a one-to-one correspondence exists between (1) each numerical variable occurring in the problem and its solution and (2) a varying physical measurement such as voltage or rotation in the analog computer. In other words, an analog computer is a physical system in which the analysis or solution of the problem is mirrored by the varying behavior of the physical system.

digital computer—A computer in which information is represented in discrete form and which calculates using numbers expressed in digits and yeses and noes expressed usually in 1's and 0's, to represent all the variables that occur in a problem.

data processor—A machine for handling information in a sequence of reasonable operations.

cybernetics—1. The comparative study of the control and the internal communication of information-handling machines and the central nervous systems of animals and men, in order to understand better the functioning of brains and communication. 2. The study of the art of the pilot or steersman.

feedback—The returning of a fraction of the output of a machine, system, or process to the input, to which the fraction is added or substracted. If increase of input is associated with increase of output, subtracting the returned fraction (negative feedback) results in self-correction or control of the process, while adding it (positive feedback) results in a runaway or out of control process.

negative feedback—The returning of a fraction of the output of a machine, system, or process to the input from which the fraction is subtracted; if an increase of input is associated with an increase of output but the increase of output produces a decrease of input, this results in self-correction or control of the machine, system, or process. For example, if an increase of caterpillars is associated with an increase of parasites destroying them, then the caterpillar-parasite populations display negative feedback.

positive feedback—The returning of a fraction of the output of a machine, system, or process to the input, to which the fraction is added; if an increase of input is associated with an increase of output, and the increase of output produces a still further increase of input, this results in a runaway or out-of-control process. For example, if an increase of rabbits results in a still further increase of rabbits, the population of rabbits displays a runaway or out-of-control process.

automatic data processing (ADP) —The processing of information by: (1) obtaining input information in machine language as close to the point of origin as economically possible; (2) operating on the information by automatic computer and other machines, without human intervention, as far as economically justified; and (3) producing just the output information needed. For example, a department store would have attained automatic data processing if: (1) at the time of each sale the details were entered mechanically into the system by a salesperson's plate, a customer's plate, and a merchandise punched ticket; and (2) reports to management, bills to customers, reorders for low inventory, commissions to sales clerks, and other desired output reports were all computed and produced by the system without human intervention.

integrated data processing (IDP) —1. Data processing organized and carried out in a completely planned and systematic way, without bottlenecks. 2. A group of data-processing procedures built around a common machine language, such as punched paper tape, in which there is a minimum of operations by human clerks, such as typing data to go into the system.

language—1. A set or system of symbols used in a more or less uniform way by a number of people so that they may communicate with and understand one another.
2. Electronic Computers. A system consisting of a carefully defined set of characters, rules for combining them into larger units (words or expressions), and specifically assigned meanings, used for representing and communicating information or data among a group of people, machines, etc.

II. Digital Computers

input—Computers. 1. Information transferred from outside the computer, including secondary or external storage, into the internal storage of the computer. 2. The sections of the computer which accept information from outside the computer, for example, magnetic tape readers or punch card readers.

output—Computers. 1. Information transferred from the internal storage of a computer to secondary or external storage, or to any device outside of the computer. 2. The device or devices which bring information out of the computer.

memory—Computers. 1. The units which store information in the form of the arrangement of hardware or equipment in one way or another. Same as "storage." 2. Any device into which information can be introduced and then extracted at a later time.

arithmetic unit—Digital Computers. The section of the hardware of a computer where arithmetical and logical operations are performed on information.

control unit—Digital Computers. That portion of the hardware of an automatic digital computer which directs the sequence of operations, interprets the coded instructions, and initiates the proper signals to the computer circuits to execute the instructions.

address—Digital Computers. A label, name, number, or symbol identifying a register, a location, or a device where information is stored.

access time—Digital Computers. 1. The time interval between the instant at which the arithmetic unit requires information from the storage or memory unit and the instant at which the information is delivered from storage to the arithmetic unit. 2. The time interval between the instant at which the arithmetic unit starts to send information to the memory unit and the instant at which the storage of the

WHO'S WHO IN THE COMPUTER FIELD — CUMULATIVE EDITION, 1962

Computers and Automation will publish this summer a cumulative edition of "Who's Who in the Computer Field." The closing date for receiving entries is June 30, 1962. If you are interested in computers, please fill in the following Who's Who entry form (which may be copied on any piece of paper) and send it to us for your free listing. If you have friends in the computer field, please call their attention to sending us their Who's Who entries. The cumulative edition will include only the entries of persons who send us their Who's Who information.

Name? (please print) ....

Your Address? ....

Your Organization? ....

Its Address? ....

Your Title? ....

Your Main Computer Interests?
( ) Applications
( ) Business
( ) Construction
( ) Design
( ) Electronics
( ) Logic
( ) Mathematics
( ) Programming
( ) Sales
( ) Other (specify):

....

Year of birth? ....
College or last school? ....
Year entered the computer field? ....
Occupation? ....
Anything else? (publications, distinctions, etc.) ....

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When you have filled in this entry form please send it to: Who's Who Editor, **Computers and Automation**, 815 Washington Street, Newtonville 60, Mass.

information in the memory unit is completed.—In analog computers, the value at time *t* of each dependent variable represented in the problem is usually immediately accessible when the value of the independent variable is at time *t*, and otherwise not accessible.

random access—Computers. Access to the memory or storage under conditions where the next register from which information is to be obtained is chosen at random, in other words, does not depend on the location of the previous register. For example, access to names in the telephone book is "random access"; the next name that anyone is going to look up in the book may be almost anywhere in the book with roughly equal probability.

pulse—Circuits. In general, a sharp difference, usually over a relatively short period of time, between the normal level of some physical variable corresponding to the average level of a wave or waves and a high or low level of that physical variable corresponding to the crest or trough of the wave; often, a sharp voltage change. For example, if the voltage at a terminal changes from —10 to +20 volts and remains there for a period of 2 microseconds, one says that the terminal received a 30 volt 2 microsecond pulse. A positive pulse is characterized by a rise or increase from one value of the variable to a greater value, a finite duration of the greater value, and a decay or decrease from the greater value back to the original value. A negative pulse is the same except that the change is to a smaller value.

channel—1. Digital Computers. A path along which information, particularly a series of digits or characters or units of information, may flow or be stored. For example, in the machine known as a punch card reproducer, information (in the form of punch cards) may flow in either one of two card channels which do not physically connect. 2. Magnetic Tape or Magnetic Drums. A path parallel to the edge of the tape or drum along which information may be stored by means of the presence or absence of polarized spots, singly or in sets. 3. Delay Line Memory. A circular path forward through the delay line memory and back through electrical circuits along which a pattern of pulses representing information may be stored.

clock—Digital Computers. In a synchronous computer, the master circuit which provides pulses at equal times which schedule the operations of the computer.—In an asynchronous computer, there is no need for such a clock, since the closing or completion of one circuit initiates the operation of a subsequent circuit.

transducer—A device which converts energy from one form to another. For example, a slab of quartz crystal embedded in mercury can change electrical energy to sound energy (and vice versa), as is done in sonic delay lines in certain computer memory systems.

card—Computers. 1. A card of constant size and shape, adapted for being punched in a pattern which has meaning. The punched holes are sensed electrically by wire brushes, mechanically by metal fingers, or photo-electrically. Also called "punch card." One of the standard punch cards (made by International Business Machines Corporation) is 7 and ⅜ inches long by 3 and ¼ inches wide, by 0.007 inches thick, and contains 80 columns in each of which any of 12 positions may be punched. Another of the standard punch cards (made by Remington Rand Division of Sperry Rand) is of the same size, but contains 90 columns in each of which any one or more of 6 positions may be punched. 2. A thin board of plastic or similar material for mounting small circuit parts connected by printed circuits; a printed-circuit board.

magnetic tape—Tape made of paper, metal or plastic, coated or impregnated with magnetic material, on which polarized spots representing information may be stored.

III. Programming

information—1. A set of marks or an arrangement of hardware that has meaning or that designates one out of a finite number of alternatives. 2. Any facts or data. 3. Any marks, characters, or signals which are put in, processed by, or put out by a computer.

instruction—Computers. A machine word or a set of characters in machine language which specifies that the computer take a certain action. More precisely, a set of characters which defines an operation together with one or more addresses (or no address) and which, as a unit, causes the computer to operate accordingly on the indicated quantities. Note: The term "instruction" is preferred by many to the terms "command" and "order"; "command" may be reserved for electronic signals; "order" may be reserved for uses in the meaning "sequence," as in "the order of the characters."

code (noun)—Computers. A system of symbols for representing information in a computer and the rules for associating them.

program (noun)—Computers. 1. A precise sequence of coded instructions for a digital computer to solve a problem. 2. A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the effective use of the results.

transfer instruction—Digital Computer Programming. An instruction or signal which conditionally or unconditionally specifies the location of the next instruction and directs the computer to that instruction. See "jump."

pseudo-code—Digital Computer Programming. An arbitrary code, independent of the hardware of a computer, which has the same general form as actual computer code, but which must be translated into actual computer code if it is to direct the computer.

automatic programming—Digital Computer Programming. Any method or technique whereby the computer itself is used to transform or translate programming from a language or form that is easy for a human being to produce into a form that is efficient for the computer to carry out. Examples of automatic programming are compiling routines, interpretive routines, etc.

plugboard—A removable board holding many hundreds of electric terminals into which short connecting wire cords may be plugged in patterns varying for different programs for the machine. To change the program, one wired-up plugboard is removed and another wired-up plugboard is inserted. A plugboard is equivalent to a program tape which presents all instructions to the machine at one time. It relies on certain signals in the punch cards passing through the machine to cause different selections of instructions in different cases. 2. A similar board which may be used to guide or edit the handling of information in a computer or its output.

IV. Operation

check digit (s)—One or more digits carried along with a machine word (i.e., a unit item of information handled by the machine), which report information about the other digits in the word in such fashion that if a single error occurs (excluding two compensating errors), the check will fail and give rise to an error alarm signal. For example, the check digit may be 0 if the sum of other digits in the word is odd, and the check digit may be 1 if the sum of other digits in the word is even. It is possible to choose check digits for rows and columns in a block of characters recorded on magnetic tape, for example, in such a way that any single error of a 1 for a 0 or a 0 for a 1, can be located automatically by row and column, and eliminated automatically by the computer.

automatic checking—Computers. Provision, constructed in hardware, for automatically verifying the information, transmitted, manipulated or stored by any device or unit of the computer. Automatic checking is "complete" when every process in the machine is automatically checked; otherwise it is partial. The term "extent of automatic checking" means (1) the relative proportion of machine processes which are checked, or (2) the relative proportion of machine hardware devoted to checking.

computing efficiency—Computer Operation. The ratio obtained by dividing (1) the total number of hours of correct machine operation (including time when the program is incorrect through human mistakes) by (2) the total number of hours of scheduled computer operation including time when the machine is undergoing preventive maintenance.

V. Representation of Information

digit—1. One of the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, used in numbering in the scale of ten. 2. One of these symbols and sometimes also letters expressing integral values ranging from 0 to n-1 inclusive, used in a scale of numbering to the base n.

character—Digital Computers. 1. A decimal digit 0 to 9, or a letter A to Z, either capital or lower case, or a punctuation symbol, or any other single symbol (such as appear on the keys of a typewriter) which a machine may take in, store, or put out. 2. One of a set of basic or elementary unit symbols which, singly or in sequences of two or more, may express information and which a computer may accept. 3. A representation of such a symbol in a pattern of ones and zeros representing a pattern of positive and negative pulses or states.

notation (in the sense "scale of notation" or "positional notation" for numbers)—Arithmetic. A systematic method for stating quantities in which any number is represented by a sum of coefficients times multiples of the successive powers of a chosen base number n (sometimes more than one). If a quantity is written in the scale of notation n, then the successive positions of the digits report the powers of n. Thus 379 in the scale of 10 or decimal notation means 3 hundreds, 7 tens, and 9. The number 379 in the scale of 16 (used in some computers) means 3 times sixteen squared, plus 7 times sixteen, plus 9 (which in decimal notation would be 889). 1101 in the scale of two means 1 eight, 1 four, 0 twos, and 1 one (which in decimal notation would be 13). In writing numbers, the base may be indicated by a subscript (expressed always in decimal notation) when there may be doubt about what base is employed. For example, 11.101_2 means two, plus one, plus one half, plus one eighth, but 11.101_3 means three plus one, plus one third, plus one twenty-seventh. Names of scales of notation which have had some significant consideration are:

Base	Name
2	binary
3	ternary
4	quaternary, tetral
5	quinary
10	decimal
12	duodecimal
16	hexadecimal, sexidecimal
32	duotricenary
2,5	biquinary

The digits used for "ten" and "eleven" are ordinarily "t" and "e"; beyond eleven, uniformity of nomenclature has apparently not yet developed.

binary notation—The writing of numbers in the scale of two. Positional notation for numbers using the base 2. The first dozen numbers zero to eleven are written in binary notation as 0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011. The positions of the digits designate powers of two; thus 1010 means 1 times two cubed or eight, 0 times two squared or four, 1 times two to the first power or two, and 0 times two to the zero power or one; this is equal to one eight plus no fours plus one two plus no ones, which is ten.

coded decimal (adjective)—Computers. A form of notation by which each decimal digit separately is converted into a pattern of binary ones and zeros. For example, in the "8-4-2-1" coded decimal notation, the number twelve is represented as 0001 0010 (for 1, 2) whereas in pure binary notation it is represented as 1100. Other coded decimal notations are known as: "5-4-2-1," "excess three," "2-4-2-1," etc. Following are the codes for the decimal digits 0 to 9 in each of the mentioned systems:

Decimal	*8-4-2-1*	*5-4-2-1*	*Excess three*	*2-4-2-1*
0	0000	0000	0011	0000
1	0001	0001	0100	0001
2	0010	0010	0101	0010
3	0011	0011	0110	0011
4	0100	0100	0111	0100
5	0101	1000	1000	1011
6	0110	1001	1001	1100
7	0111	1010	1010	1101
8	1000	1011	1011	1110
9	1001	1100	1100	1111

biquinary notation—Numbers. A scale of notation in which the base is alternately 2 and 5. For example, the number 3671 in decimal notation is 03 11 12 01 in biquinary notation; the first of each pair of digits counts 0 or 1 units of five, and the second counts 0, 1, 2, 3, or 4 units. Roman numerals are essentially a biquinary notation, except that different letters are used in each place, V and I in the first place, X and L in the second place, C and D in the third, etc.; for example, the biquinary number 03 11 12 01 is in Roman numerals MMMDCLXXI. Biquinary notation expresses the representation of numbers by the ancient counting frame or *abacus,* and by the two hands and five fingers of man: and has been used in some automatic computers.

binary digit—A digit in the binary scale of notation. This digit may be only 0 (zero) or 1 (one). It is equivalent to an "on" condition or an "off" condition, a "yes" or a "no," etc.

bit—A binary digit; a smallest unit of information; a "yes" or a "no"; a single pulse in a group of pulses; a single magnetically polarized spot in a group of such spots; etc. This word is derived from the "b" in "binary" and the "it" in "digit."

machine language—Computers. 1. Information in the physical form which a computer can handle. For example, punched paper tape is machine language, while hand-written characters on paper are not machine language. 2. Numbers or instructions expressed in a form that a computer can process at once without conversion, translation, or programmed interpretation.

machine word—Digital Computers. A unit of information of a standard number of characters, which a machine regularly handles in each transfer. For example, a machine may regularly handle numbers or instructions in units of 36 binary digits: this is then the "machine word."

VI. Mathematics and Logic

fixed-point calculation—Computers. Calculation using or assuming a fixed or constant location of the decimal point or the binary point in each number.

floating-point calculation—Computers. Calculation taking into account varying location of the decimal point (if base 10) or binary point (if base 2), and consisting of writing each number by specifying separately its sign, its co-efficient, and its exponent affecting the base. For example, in floating-point calculation, the decimal number —638,020,000 might be reported as —6,3802, 8, since it is equal to $—6.3802 \times 10^8$.

complement—1. Arithmetic. A quantity which is derived from a given quantity, expressed in notation to the base *n,* by one of the following rules. (a) Complement on *n:* subtract each digit of the given quantity from *n*-1, add unity to the rightmost digit not zero, and perform all resultant carries. For example, the twos complement of binary 11010 is 00110; the twos complement of binary 0001 1010 is 1110 0110; the tens complement of decimal 679 is 321; the tens complement of decimal 000679 is 999321. (b) Complement on *n*-1: subtract each digit of the given quantity from *n*-1. For example, the ones complement of binary 11010 is 00101; the ones complement of binary 00011010 is 11100101; the nines complement of 679 is 320; the nines complement of decimal 000679 is 999320. The complement is frequently employed in computers to represent the negative of the given quantity. 2. Boolean Algebra. The element equal to the universe element except the stated element; the result of the operation NOT . . . or ALL EXCEPT. . . . The complement of a Boolean element *a* is NOT-*a*, written a′, or ∼*a*.

parameter—1. Mathematics. A constant or variable which enters fundamentally into a mathematical function and which has the property that its different values produce different functions. For example, the function $y = ax + b$ has two parameters, *a* and *b*; when *a* and *b* are constant, $y = ax + b$ represents a line, but the choice of values of *a* and *b* determines the angles and distances at which the line cuts the coordinate axes. 2. Digital Computer Programming. In a subprogram, a quantity which may be given different values when the subprogram is used in different parts of one main program, but which usually remains unchanged throughout any one such use. For example, a parameter may specify the number of characters in an item, the position of the decimal point, the number of columns in a field, the number of times a certain cycle of operations is to be repeated, etc. To use a subprogram routine successfully in many different programs requires that the subprogram be adaptable by changing its parameters.

Boolean algebra—An algebra like ordinary algebra but dealing instead with classes, propositions, on-off circuit elements, etc., associated by operators AND, OR NOT, EXCEPT, IF. . . . THEN, etc., and permitting computations and demonstration, as in any mathematical system, making use of symbols efficient in calculation. This algebra was named after George Boole, famous English mathematician (1815-1864), and is the first algebra met with in studying logic.

AND—1. Logic (and Boolean Algebra). A logical (or Boolean Algebra) operator which has the property that if *P* and *Q* are two statements, then the statement "*P* AND *Q*" is true or false precisely according to the following table of possible combinations:

P	*Q*	*P AND Q*
false	false	false
false	true	false
true	false	false
true	true	true

The AND operator is often represented by a centered dot (.), as in P.Q. (read "P dot Q"), only by no sign as in PQ (read "PQ"). 2. Circuits. A connection between two circuits A and B or two circuit elements A and B which passes a signal if and only if both A and B contain the signal.

inclusive OR—Logic (and Boolean Algebra). A logical operator which has the property that if *P* and *Q* are two statements, then statement *P* or *Q* is true if and only if *P* is true or if *Q* is true or if both *P* and *Q* are true. The inclusive *OR* operator is often represented by a Gothic v, as in *P* v *Q* (read "P vee Q").

NOT—Logic (and Boolean Algebra). A logical operator that has the property that if *P* is a statement, then the statement "NOT-*P*" ("it is not the case that P"), is true if the statement *P* is false, and false if the statement *P* is true. The NOT operator is often represented as follows: P′ (read "P prime"), $\overline{P}$ (read "P dash"), or ∼P (read "tilde P").

exclusive OR—Logic (and Boolean Algebra). A logical operator that has the property that if *P* and *Q* are two statements, then the statement *P* OR ELSE *Q* is true precisely according to the following table of possible combinations:

P	*Q*	*P OR ELSE Q*
false	false	false
false	true	true
true	false	true
true	true	false

The exclusive OR operator, the OR ELSE operator, has the property: *P* OR ELSE *Q* is equivalent to *P* AND NOT *Q*, OR *Q* AND NOT *P*, and accordingly may be written in symbols *P.Q′* v *P′.Q*.

ADVERTISING INDEX

Following is the index of advertisements. Each item contains: Name and address of the advertiser / page number where the advertisement appears / name of agency if any.

NOTICE: This April 1962 issue of **Computers and Automation** contains 60 pages: the regular section, pages 1 to 40; and the last-minute section (which closed March 20) pages 1B to 20B, inserted between pages 20 and 21.

ACHPHENOMENON

The mind focuses upon the center cube, each face having required a distinct cut. Until that realization, the problem of proving that a minimum of six cuts is necessary to make twenty seven cubes out of one appears insurmountable. Insight, perception, Achphenomenon at work.

In our work on guidance and control systems, computers and their components, we look to engineers with ingenuity. If you're looking for an atmosphere conducive to creative thinking and the chance to explore new directions, send a resume to Mr. Nick B.Pagan, Manager Professional and Scientific Staffing. Expect a prompt reply.

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