COMPUTERS and AUTOMATION

COMPUTERS AND DATA PROCESSORS, AND THEIR CONSTRUCTION, APPLICATIONS, AND IMPLICATIONS, INCLUDING AUTOMATION

Computer Simulation of Human Thinking and Problem Solving

The Role of the Digital Computer in the University

Management and the Computer of the Future

APRIL
1961
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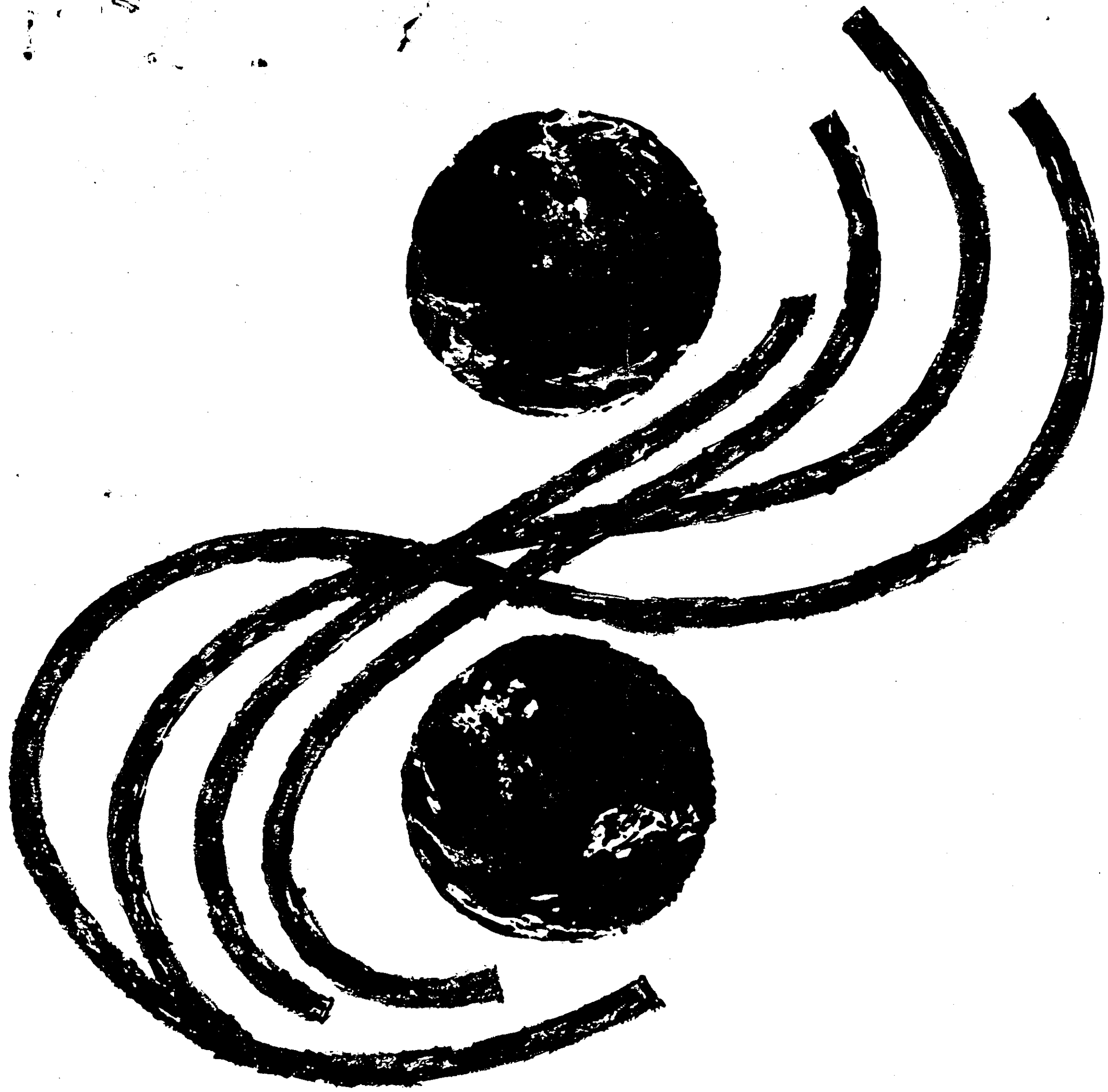
VOL. 10 - NO. 4 & 4B



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COMPUTERS *and* AUTOMATION

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Volume 10
Number 4 & 4B

APRIL, 1961

Established
September 1951

Vol. 10, No. 4B

News of Computers and Data Processors: ACROSS THE EDITOR'S DESK

. . . . inserted between pages 8 and 9 and between pages 24 and 25

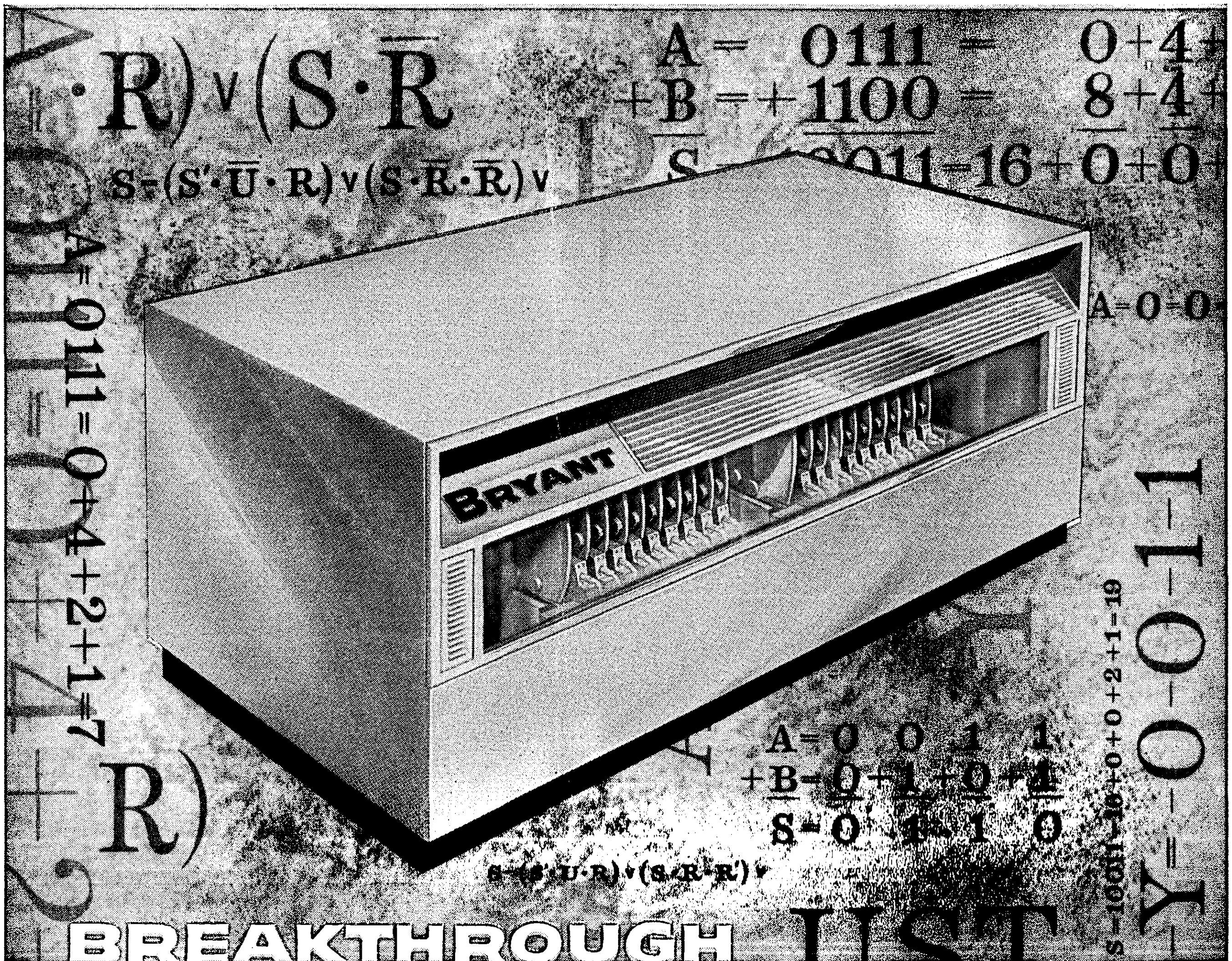
COMPUTERS and AUTOMATION is published 13 times a year (monthly except two issues in June) at 815 Washington St., Newtonville 60, Mass., by Berkeley Enterprises, Inc. Printed in U.S.A.

SUBSCRIPTION RATES: United States, $15.00 for 1 year, $29.50 for 2 years, including the Directory issue, or $7.50 for 1 year, $14.50 for two years, not including the Directory issue; Canada, add 50c a year for postage; foreign, add $1.00 a year for postage. Address all Editorial and Subscription Mail to Berkeley Enterprises, Inc., 815 Washington St., Newtonville 60, Mass.

ENTERED AS SECOND CLASS MATTER at the Post Office at Boston, Mass.

POSTMASTER: Please send all Forms 3579 to Berkeley Enterprises, Inc., 815 Washington St., Newtonville 60, Mass.

CHANGE OF ADDRESS: If your address changes, please send us both your new address and your old address (as it appears on the magazine address imprint), and allow three weeks for the change to be made.


BRYANT

Readers' and Editor's Forum

FRONT COVER: MAGNETIC TAPE RECORDING SYSTEM AT 1500 BITS PER INCH

A new high-density recording system, capable of recording magnetically on a reel of one-inch tape approximately 11 times the amount of digital data that can be recorded by conventional computer tape systems, has been developed by Potter Instrument Co., Plainview, L. I., N. Y.

As many as 190 300-page volumes of information can be recorded by the new system on a single 10½-inch reel of tape (see the front cover), as against 17 volumes recordable on one reel by the most popular techniques. This is a very substantial increase in tape storage capacity; it reduces tape handling requirements; and it leads to a greater return on the investment in computer installations.

This increase is made possible by a unique self-clocking technique by which clock signals are derived from the recorded information itself, and most of the problems of parallel coincidence-type recording are eliminated. Since the displacement of data on adjacent channels is made insignificant, the recording density along the tape can be greatly increased.

Data transfer rates are as high as 360,000 alphanumeric characters per second, via 16 parallel recording channels on one-inch tape, and at packing densities up to 1500 bits per inch. Yet the new system provides even higher reliability than is expected of standard recording methods.

The system can eliminate restrictions formerly imposed on some computers by limitations of the usual peripheral tape-handling equipment. In this way, many of the new generation of computer systems can operate closer to, or at, their proper speeds.

In a recent test of 40 hours continuous operation, less than 2 seconds of re-read time were required to recover data lost through transient error. During this test no pemanent loss of information occurred. More than 20,000 passes over any portion of the tape can be made without losing information, or significantly increasing the dropout rate.

The system is designated officially as the Potter Contiguous, Double-Transition High-Density Recording System; the equipment is largely the result of research and engineering work done by Dr. Andrew Gabor, senior engineer, and George Comstock, III, chief engineer.

The first application of the Potter High-Density Recording System is in high-speed tape transports for use with a Bendix Corporation G-20 Computer System destined for installation at Carnegie Institute of Technology, Pittsburgh, Pa. The Bendix G-20 Computer will serve there as the core of a Doctoral Program curriculum in "Systems and Communication Sciences," concerned with theories of programming, simulation of human cognitive processes, artificial intelligence, adaptive control, the science of administration, and the application of these techniques to management sciences.

"AUTOMATION—A NATIONAL RESOURCE, NOT A CAUSE FOR FEAR"—COMMENTS

I. Victor Paschkis

Professor of Mechanical Engineering
Heat and Mass Flow Analyzer Laboratory
Columbia University
New York, N. Y.

I have read with great interest John Diebold's "Automation—A National Resource, Not A Cause For Fear," in the February issue of **Computers and Automation.**

The author lists six main factors which may induce business to introduce automation (I quote):

> "The overriding factors dictating a decision to automate are (1) to cut production costs, (2) to reduce labor requirements, (3) to do existing tasks faster, (4) to do tasks not possible before, (5) to increase productivity, and (6) to aid decision-making, by providing faster and fuller information. Unfortunately, the worst reason, to save labor costs, is the most common one. The economics of the situation show that while automation does reduce costs, the reduction is seldom as much as expected. . . ."

Of his six items, items 1, 2, 3, and 5, it seems to me, are, for all practical purposes, identical: to reduce the cost by reducing required production time (labor costs).

The author's reason No. 4 is, in my opinion, not correct. Automation can provide processes which were not practical before, but not such which were not possible before; thus No. 4 is also reduced to economy and to a cut of production costs.

This leaves only the author's reason No. 6 (aid in decision-making); this would, in the writer's opinion, apply more to computation than to automation, two terms which are not identical.

Thus automation in the true sense always deals with saving labor costs, which the author terms "the worst reason." The author's proposed study does not seem to come to grips with the problem underlying the "worst reason," which, based on the above elimination, seems to be the only reason why automation is introduced.

In other words, automation will be and is introduced only if it means the production of a certain item with less expenditure of human time. If this be the case and if we are to avoid permanent large scale unemployment due to automation, only two courses

seem possible, either of which alone or taken jointly would influence the picture.

The first way is that of increasing production.

The second is that of reducing working time without reducing the take-home pay.

Ultimately increased production means giving to people within an economic system more goods or services. In the light of the disparity of the standard of living in this country and other parts of the world, increase of material goods here without thought given to other parts of the world will lead to increasing difficulties. Thus, from the viewpoint of increased productivity, automation is acceptable only in the long range view, if the wealth so created is shared with other parts of the world.

This leaves the second of the two ways to be considered: a reduction of working time. Western man today hardly knows what to do with his leisure time. This does not refer to some or possibly many of the professional people, but to the broad group of the population which went to high school or possibly did not even complete high school and then went to work. Our whole mechanized civilization, as well as our education stifle creativity from the very start. Children watch television, instead of acting out dramas or playing instruments themselves. People drive to beautiful spots in nature, but only ten minutes from the parking lot, nature is deserted, because no one will walk that far.

Thus, the problems due to automation and requiring study are a way to share the increased productivity with the world and a way to re-introduce in education the stimulation to creativity, not as a means to higher income, but as an enrichment of the personal life.

II. From John Diebold

John Diebold and Associates, Inc.
New York 5, N. Y.

I share Professor Paschkis' concern for the social and economic consequences of increased material abundance provided by automation. Certainly the question of how to use one's leisure time will be raised with increasing frequency as the number of hours in the standard work week decreases. This is a national issue. The fundamental cause of the problem is not the advent of automation but it is our failure as a nation to raise educational levels so that leisure time is not wasted but can be used to enrich our lives.

Spreading the fruits of higher productivity to countries not as highly endowed as the United States certainly should be a major aim of *foreign* policy in this decade.

A study of how to share with the world increased productivity due to automation would be welcome, but could hardly be an effective substitute for an assessment of its impact on our own economy. There is still much to learn: What is the best way to use this technology effectively? How will it affect the manpower requirements of the nation? How will it affect the make-up of business, finance and industry?

The particular statements to which Professor Paschkis refers were made by me before the Subcommittee on Energy Resources of the Joint Economic Committee of Congress, a group particularly interested in automation as an industry, its utilization and impact on employment, production and investment. Consequently, comments in my congressional testimony were specifically directed to these areas.

Merely lumping together the many reasons why organizations employ automation under the heading of "lowering labor costs" does not help others to understanding the true value of this technology. Any technological advance that has ever been made is a "labor cost reducer." Any increase in productivity—or output per man-hour—reduces the per unit labor needs and, of course, labor cost itself. But this does not properly emphasize such various motives for automating as increasing the quality and uniformity of a product, decreasing the floor space requirements of a factory operation, faster preparation of data for management decisions, forecasting sales more accurately, cutting the manufacturing cycle time for a product, preparing long-range weather forecasts, or diagnosing heart disease in a human being before any seizure occurs.

These are automation activities that cannot just be called labor costs reductions. What makes automation so important to the nation, especially at this time, is not that it displaces labor but that it materially increases the capability of our capital resources. Capital resources here are not only factories but hospitals and schools as well.

We are not spending *enough* for machines. Our reinvestment rate for plant and equipment—the percentage of our national product invested in capital stock—is one of the lowest of any of the industrial nations of the world. Added to this, much of the production facility of the country is technologically obsolete; the average age of manufacturing equipment in this country is well above that of both Western Europe and the Soviet Union. Our difficulties in competing in the world market are multiplying rapidly. Automation, then, becomes important not only to save labor costs but more significantly to *save capital resources*—to use them more economically.

Any significant technological change in work processes has an effect on employment rolls. But I think it misleading to attribute our unemployment problem to automation itself. If our economy would be expanding at a faster rate sufficient to make better use of available labor, the "Automation" issue would be minimized.

Obviously, the nation's present economic difficulties are not going to disappear without direct action on the part of all sectors of the economy. This means streamlining industry to compete effectively in world markets by introducing more efficient means of production, eliminating featherbedding practices and spurring more research and development in manufacturing; this means more attention paid to education of our youth and re-education of adults with obsolete skills; and this means more cooperation on the part of labor and management with all levels of government to facilitate the re-distribution of the labor force among industries with attractive employment opportunities.

NEWS of Computers and Data Processors

"ACROSS THE EDITOR'S DESK"

COMPUTERS AND AUTOMATION

Volume 10
Number 4B

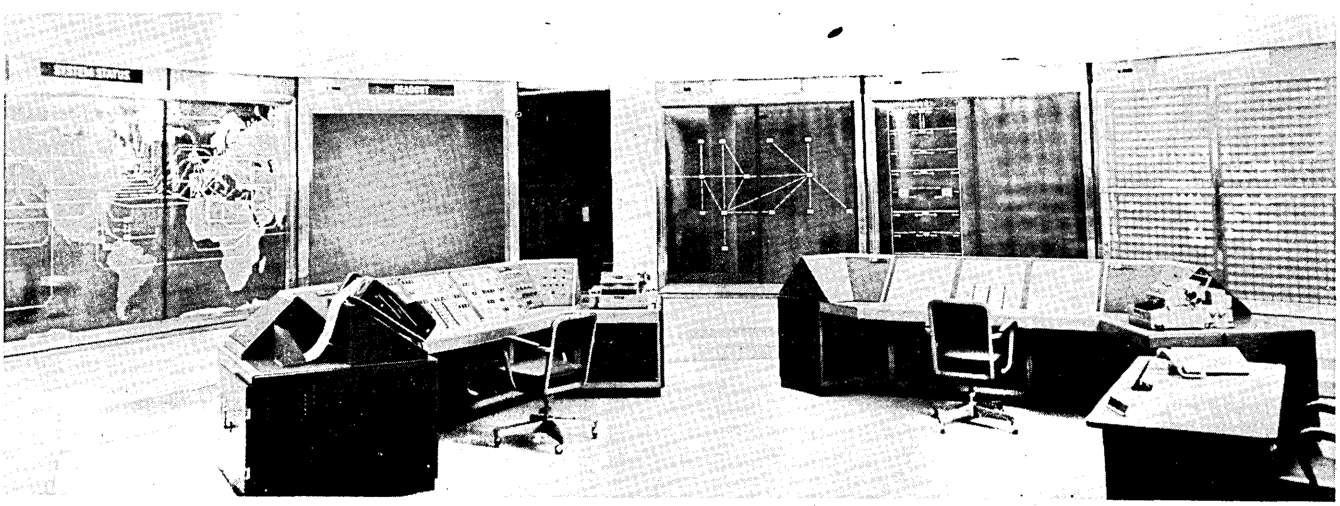
APRIL 2, 1961

Established
September 1951

Published by Berkeley Enterprises, Inc., 815 Washington St., Newtonville 60, Mass.

DEFENSE NATIONAL COMMUNICATIONS CONTROL CENTER DEDICATED

Philco Corp.
Philadelphia 34, Pa.



The picture shows an overall view of the Defense National Communications Control Center, the "heart" of the Defense Communications Control Complex under the direction of the Defense Communications Agency. It was officially dedicated on March 6 in Arlington, Va. The center monitors and controls the long-haul, non-tactical communications facilities of the Army, Navy and Air Force. It was completed in 22 weeks by Philco Corporation, prime contractor. On the left are the console and status panels (a third panel Traffic Status, to the left of the System Status panel, is not shown). To the right are the network panels and control center. Adjacent to the control room area is a Philco 2000 electronic data processing system which is the electronic brain that drives the status and network boards, and provides information and answers to queries on communications status throughout the world to System Supervisors who operate the consoles.

COMPUTER ON THE SPOT: "OVER THE WEEKEND" FROM NEED TO SALE

R. L. Mullins, President
Alwac Computer Div.
El-Tronics, Inc.
Hawthorne, Calif.

A unique approach to marketing an electronic digital computer was taken recently by this company.

Alwac officials reported that Phil Smith, Western Regional Sales Manager, learned indirectly on a Friday evening that National Missile & Electronics, Inc. of Los Angeles required early delivery of a computer.

On the following Monday morning a moving van with a $78,000, 3000-pound Alwac III-E computer aboard, parked at the Century Boulevard office of National Missile & Electronics, Inc. With no previous contact and no appointment, Smith entered the offices and asked to see Mr. Hal Rose, President of National Missile. Smith introduced himself and his company, explained that he had learned on Friday evening of their computer requirement, and asked where "their" computer should be installed.

Within two hours the installation was complete and the Alwac Computer was operating.

> Mr. Rose of National Missile stated: "The confidence displayed by the Alwac Computer Division merited our serious consideration of their computer. Smith was accompanied on his 'canvass call' by their Installation and Service Chief, Chief Engineer, Programming Supervisor, and a member of their engineering staff. This kind of service by Alwac has allowed National Missile to 'get a jump' on some programs which are of vital concern to our national security."

"COMPUTERS -- KEY TO TOTAL SYSTEMS CONTROL" IS THEME OF EASTERN JOINT COMPUTER CONFERENCE, DEC. 1961

1961 Eastern Joint Computer Conference Committee
Zeke Seligsohn, Public Relations Chairman
1111 Connecticut Avenue, N.W.
Washington 6, D.C.

The 1961 Eastern Joint Computer Conference, to be held December 12-14 at the Sheraton-Park Hotel in Washington, D.C., has announced its theme, "Computers -- Key to Total Systems Control".

Bruce G. Oldfield, Program Chairman, stated that this theme reflected one of the most significant trends in modern computer technology: "Until quite recently, computers were considered to be data processing ends in themselves. Now they are more and more being treated as merely one element -- although the most vital one -- in total systems for operations in government, defense, industry, and business management. Other important elements in the closed loop of the 'total system' are data acquisition, digital data communications, display, and actual control or guidance."

The 1961 EJCC will follow this total systems approach by presenting the latest advances in equipment and concepts leading toward computer control of present and future systems. Papers are invited in such representative areas as:

- Business Management Control
- Military and Space Command Control Systems
- Industrial Process Control
- Real Time Systems
- Network Control
- Man-Machine Systems
- Self Organizing Systems
- High Speed Digital Data Communications

Each person wishing to contribute a paper to the program should submit two copies of both a 100-word abstract and a two-page summary to:

Bruce G. Oldfield
IBM Federal Systems Division
326 E. Montgomery Avenue
Rockville, Maryland

The deadline for submission of abstracts and summaries is June 20, 1961. Authors whose papers are chosen for presentation will be promptly notified.

Inasmuch as papers will be published prior to the Conference and made available to the attendees, the full text of papers chosen for presentation must be submitted to the Program Chairman by September 1, 1961.

COMPUTER CORRELATES DATA FROM BIOLOGICAL TESTS FOR SCREENING CHEMICALS

Bendix Computer Division
The Bendix Corporation
Los Angeles, Calif.

The Research Center of the American Can Company is using a Bendix G-15 computer to correlate data gathered in 90-day animal feed tests.

The purpose of the test is to determine the possible toxic nature in food additives and package components. Data that formerly required all day to hand-calculate, is now processed in one-half hour.

Under the requirements of the Food Amendment to the Food, Drug, and Cosmetic Act, all chemicals used in the preservation of food and in food packages must undergo a two-year test before distribution to the public.

As a preventive to possible failure after two years of testing, American Can conducts preliminary 90-day tests, which make it possible to eliminate highly toxic food additives from consideration. If no toxicity appears during the 90-day period, tests are continued for the required two years. This method provides American Can with a substantial decrease in time and development costs for new products.

In the feed tests, chemicals -- extracted from test products -- are administered in feed to a highly specialized strain of laboratory rats. The animals are weighed weekly and their food intake and eating habits carefully noted. At the end of the period, exacting tests are also performed to disclose any abnormalities in blood and tissue.

A highly reliable test of animal health is gained through the measurement of body and organ weight. By use of the Bendix G-15, it is feasible to determine various correlation coefficients for body and organ weight as determined by food intake and for the ratio of body to organ weight.

The information is used to determine the over-all effects of chemicals on test animals and whether or not to continue with full-scale tests.

The computer also handles paper work from the research laboratory, as well as technical data furnished by other divisions and subsidiaries. Additional work for the computer includes: evaluation of taste panel tests, design and improvement of containers, packaging research, and quality control.

TWO SUMMER COURSES IN COMPUTER CONTROL

Case Institute of Technology
Cleveland, Ohio

A two-week summer course in Digital Control Systems Engineering will be held from June 19-30, 1961. It is designed to meet the needs of military and industrial engineers engaged in, or wishing to enter, advanced technology in the following areas:

1. Military guidance, control, and data systems.
2. Industrial numerical process control systems.
3. Manufacturing processing with numerically controlled machines.

The course will include 20 lectures given by the staff of Case's Numerical Control Laboratory and will be supplemented with certain guest lectures. Lectures include:

Boolean algebra fundamentals and minimization techniques.
Number systems, codes and code conversions.
Logical elements and memory elements.
Boolean matrices and diode matrices.
Analog-digital and digital-analog conversion methods.
Error detection, correction codes, and logical implementation.
Introduction to sampled data analysis.
Dynamic behavior of physical systems with discontinuous inputs.
Digital interpolation and comparison.
Storage techniques.

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Also, a one-week specialized, intensive seminar-type course will be held June 19-23, 1961, for engineers in industry and government interested in the problems of automatic control of systems for optimum performance.

The purpose of this course is to present a background of theory and techniques for computer control of complex systems. Certain applications in the process industries, power distribution, steel processing, and space guidance will be discussed. The lectures will include:

Mathematical Techniques for Optimization: calculus of variations, dynamic programming, gradient methods.
Direct Methods of Optimizing Control.
Model Methods of Optimizing Control.
Model Generation and Adaptation.
Adaptive and Self-organizing Control Concepts.

PRINTED CIRCUITS USING METAL BOARDS FOR GREATER FLEXIBILITY

Farrington Mfg. Co.
Needham Heights 94, Mass.

Electronic circuits printed on metal, instead of the conventional plastic laminates, have been developed by this company.

The new circuit boards are capable of withstanding temperatures in excess of 900°F, nearly twice the temperature of ordinary printed plastic panels.

The new printed circuit boards are not limited in size and are not subject to warping or breakage. Bond strength of the new circuits is more than 10 times that of existing circuits.

The trade name "Dielox" for these new boards is derived from the techniques used in the manufacture of substrate, a process involving the building up or depositing of dielectric oxides on prefabricated metals, such as aluminum oxide on aluminum or magnesium oxide on steel.

The circuit boards combine the temperature, mechanical, structural and fabrication characteristics of metal with the insulating, thermal conductivity, dielectric, and hardness characteristics of the ceramic-like oxides.

Among other properties, the material does not smash, crack, scratch, craze or fracture in any size or thickness. With its superior thermo-dimensional stability, exacting fabricating dimensions can be maintained, even when formed for three-dimensional circuitry. The base can be color-coded for identification.

MAGNETIC STORAGE DRUM USES READ/WRITE HEADS A FEW MILLIONTHS OF AN INCH DISTANT

Litton Systems, Inc.
Division of Litton Industries
5500 Canoga Ave.
Woodland Hills, Calif.

A magnetic storage drum that employs contact read/write heads to achieve large capacity, nonambiguous storage of digital data is being produced by this company, and is available.

The drums are the data storage medium in a variety of military computers for ground, aircraft and missile use. Results indicate that many years of life can be expected under severe environments.

Heads directly contact the drum until the drum reaches its operating turning speed, at which time surface air movement causes the heads to rise a few millionths of an inch from the surface. This provides wear characteristics comparable to fixed non-contact heads, but the close proximity of the heads to the drum surface gives much more efficient electro-magnetic coupling than do fixed heads.

Write-currents are reduced by a factor of four to only 3.5 to 5 ampere turns at 300 millivolts, compared with 15 ampere turns required with fixed heads. Read signals are also high, with a one-volt signal obtainable.

Greatly improved packing densities of bits are made possible by the head-to-drum configuration. The close electromagnetic coupling allows the heads to be operated as close together as physically possible without objectionable crosstalk. Less than one per cent noise is apparent from all sources.

The drum, end bells, and shrouds are cast from magnesium for light weight, strength, and reduced thermal expansion. The drum periphery is plated with a nickel-cobalt alloy, which provides the magnetic storage medium. The thickness of this magnetizable coating is held to 4 to 10 millionths of an inch. The final drum surface is given a mirror-like finish.

Read/write heads were developed from the special alloys to withstand friction, severe shock, vibration and temperature. Each head is suspended from its mounting bracket by a fine spring that provides appropriate head pressure.

CONNECTICUT'S MOTOR REGISTRATION SYSTEM NOW COMPLETELY COMPUTERIZED

C-E-I-R Inc.
1200 Jefferson Davis Highway
Arlington 2, Va.

The task of automating on a computer the motor vehicle registration system of the state of Connecticut has been completed.

For the past ten months, the Hartford office of this company has worked out with the state of Connecticut a system whereby the 1,200,000 motor registrations for Connecticut are processed automatically on a computer system. (Under Connecticut's "staggered" system, registrants do not receive certificates in the same month; the distribution is spaced evenly over the entire year.)

Under this automatic system it is possible within the space of a few hours or even within minutes to identify the ownership of any Connecticut-owned vehicle for any administrative or police purpose. The system can even locate a car or owner on the basis of quite fragmentary information.

As an example, suppose a hit-and-run driver has struck and injured someone on the streets of New Haven at 10 A.M. One witness has seen that it was a green sedan and is of the opinion it was of a certain low cost make. Through the use of the automatic system, in this case an RCA 501 computer, it will be possible to run through the data on all of the cars of that make and type and color in New Haven or in adjoining areas, in a matter of moments. Police work can be speeded up greatly and the Motor Vehicle Department can render greater service in the public interest.

The computer will make possible quick and economical studies, sometimes in minutes, of the relationships between motor accidents and different age groups in different kinds of communities, under different driving conditions.

Connecticut is the first state to set up such a completely automatic motor registration. Five million alpha-numeric characters are manipulated daily in this processing. The state of Connecticut has contracted with this company for these services and pays a rental fee only for the actual time the computer is in use. Thus, the state is not burdened disproportionately with the investment or manpower requirements of the facility.

The new system has an error rate under one-half of one percent of the volume, which is far below the old human error rate.

One of the advantages to a state of computerizing its system is that the state is ready for an incredible amount of expansion without a proportionate increase in cost. When the system can process 1,200,000 registrations, it can handle 2,000,000 with almost the same speed and without anywhere near the increase in clerical help which would be required for expansion under the clerical system.

COMPUTER-BASED TEACHING MACHINE SUBJECT OF GOVERNMENT GRANT

System Development Corp.
2500 Colorado Avenue
Santa Monica, Calif.

This company has received an $88,283 grant from the United States Office of Education for research on the use of a computer-based teaching machine to select and organize educational material for high school students.

The new grant was awarded for an eighteen month study, proposed by the Automated Teaching Project at SDC, headed by Dr. John Coulson of SDC's Research Directorate. The research program specifies the development and evaluation of self-instructional materials appropriate to students taking courses in high school mathematics. The educational material will be developed in SDC's automated teaching laboratory which uses a digital computer as the control and basic decision-making element of a teaching machine. The resulting materials will be evaluated during several weeks of use in several Los Angeles area high schools.

Experimental evidence will be obtained as to whether automated teaching devices and materials will facilitate learning in the rote and conceptual aspects of high school mathematics, and whether such techniques are effective for students who have not been performing at a level considered appropriate to their basic aptitudes. These underachievers will be compared with normal and overachieving students to see if the automated instructional materials have benefited them relatively.

SDC's experimental teaching machine is presently being used to teach a course in symbolic logic, a largely conceptual subject matter. Each student sees a sequence of educational material best suited to his educational needs by a technique known as "branching" in which the student is skipped over certain portions of topics if he demonstrates his proficiency in this material, and is given additional remedial material on those topics needing further amplification. The machine has been used since January, 1960, for several research studies in the field of automated teaching.

U.S. DEFENSE DEPARTMENT'S COMPUTER IS AN AUTOMATED CATALOG OF THE WORLD'S BIGGEST SHOPPING LIST

International Business Machines Corp.
Federal Systems Division
326 E. Montgomery Avenue
Rockville, Maryland

The U.S. Department of Defense is keeping up-to-the-minute records of the Federal government's three and a half million supply items in a new computer information system. In effect, the system is an electronic catalog of the world's biggest shopping list.

-- On the 60 reels of computer magnetic tape above, the U.S. Defense Department has electronically cataloged the three and a half million Federal supply items it manages. --

A big IBM 705 III computer, the hub of a national network, can process 16 million characters of inventory information a day for government buyers, NATO and other allied nations.

In its main job, as clearing house for supply data, the 705 III and its peripheral equipment will sharply reduce the time needed to update, maintain and cross reference the vast files of active Federal stock item numbers and corresponding manufacturers' identification numbers. Any inquirer, from vendor to supply sergeant, can refer to this single, correlated source, always up-to-date, that tells immediately whether items are already in the Federal catalog.

Also, if a purchasing agency plans to buy an item already cataloged, the system supplies a complete list of present users and the location and amount of available excess inventories. Duplicate purchases may thereby be prevented, and the Federal stockpile can be tapped at a speed never before possible.

The new equipment can handle 100,000 individual actions by supply management in a day, twice the capacity of the previous method. For this service, the Armed Forces Supply Support Center has filed a billion characters of supply item information on 218 reels of computer magnetic tape.

By July next year, three intermediate scale IBM 1401 data processing systems will be correcting, editing, and compressing the great flood of incoming raw data into forms for more efficient processing by the more powerful 705 III.

The AFSSC system will be working on the massive, continuous cataloging job about fifty per cent of the time. It will produce facts to support AFSSC's two other missions: (1) providing data for the management of standardization activities and (2) promoting inter-agency utilization of supply items by rapidly furnishing accurate data on common usage and inventory availability. The balance of the computer's time will be applied in these areas and in fulfilling other management requirements.

Pre-Provisioning Identification

One of the biggest current jobs needing the power of the IBM 705 III will be what is called "pre-provisioning identification".

With many new kinds of items going into the supply storehouse every day, a central point is needed to prevent duplications before orders are placed. For example, before purchase, a new missile with 30,000 parts can be completely stock numbered and cataloged on the computer. Then the whole supply system can be searched in minutes to find out if any of the 30,000 items are already in available excess assets.

The first pre-provisioning identification runs on the Center's new system indicated that up to 30 per cent of new item parts already exist in inventories. The Center is forecasting much greater savings as the preliminary screening technique is broadened.

Management and the Computer of the Future

Massachusetts Institute of Technology
Cambridge 39, Mass.

In celebration of the Centennial Year of Massachusetts Institute of Technology, the School of Industrial Management has arranged a series of lectures on the theme, "Management and the Computer of the Future."

Eight distinguished speakers have been asked to consider the potentialities and limitations of the computer in activities related to management.

The Centennial Lecture Series was facilitated by a grant from the International Business Machines Corporation.

The program is given below. The first of these lectures is reported in this issue of **Computers and Automation.** The entire series of lectures and the discussion will be published in full by Massachusetts Institute of Technology.

March 9: "Computers in the Educational Process." Speaker: Professor Alan J. Perlis, Director of the Computation Center, Carnegie Institute of Technology. Presiding: Professor Donald G. Marquis, School of Industrial Management, M.I.T. Discussants: Professor Peter Elias, Department of Electrical Engineering, M.I.T. Dr. Joseph C. R. Licklider, Bolt, Beranek and Newman, Inc.

March 13: "Managerial Decision Making as a Feedback System." Speaker: Professor Jay W. Forrester, School of Industrial Management, M.I.T. Presiding: Robert C. Sprague, Chairman, Sprague Electric Company. Discussants: Professor Charles Holt, Graduate School of Industrial Administration, Carnegie Institute of Technology. Professor Ronald A. Howard, Department of Electrical Engineering, M.I.T.

March 22: "Computer Simulation of Human Thinking and Problem Solving." Speaker: Professor Herbert A. Simon, Associate Dean, Graduate School of Industrial Administration, Carnegie Institute of Technology. Presiding: Professor Sidney S. Alexander, School of Industrial Management, M.I.T. Discussants: Professor George A. Miller, Department of Psychology, Harvard University. Professor Marvin L. Minsky, Department of Mathematics, M.I.T.

March 27: "A Library for 2000 A.D. Speaker: Professor John G. Kemeny, Chairman, Department of Mathematics and Astronomy, Dartmouth College. Presiding: Professor William N. Locke, Director of Libraries, M.I.T. Discussants: Professor Robert M. Fano, Department of Electrical Engineering, M.I.T. Dr. Gilbert W. King, Director of Research, International Business Machines Corporation.

May 5: "Scientists and Decision Making." Speaker: Sir Charles Percy Snow, author and critic. Presiding: Dean Howard W. Johnson, School of Industrial Management, M.I.T. Discussants: Professor Elting E. Morison, School of Industrial Management, M.I.T. Professor Norbert Wiener, Department of Mathematics, M.I.T.

May 8: "The Changing Structure of Computer Programs for Describing Complex Processes." Speaker: Professor George W. Brown, Director the Western Data Processing Center, University of California, Los Angeles. Presiding: Professor Philip M. Morse, Director of the Computation Center, M.I.T. Discussants: Professor Michael P. Barnett, Department of Physics, M.I.T. Dr. Grace M. Hopper, Chief Engineer —Research Programming, Sperry-Rand Corporation.

May 16: "Trends in Computer Design." Speaker: Professor Nicholas C. Metropolis, Director, Institute of Computer Research, University of Chicago. Presiding: Dr. Emanuel R. Piore, Vice President—Research and Engineering, International Business Machines Corporation. Discussants: Dr. Gene M. Amdahl, Staff, Director of Research, International Business Machines Corporation. Professor John McCarthy, Department of Electrical Engineering, M.I.T.

May 22: "What Computers Can Do Better." Speaker: Dr. John R. Pierce, Director of Research—Communications Principles, Bell Telephone Laboratories. Presiding: Dr. Vannevar Bush, Honorary Chairman of the Corporation, M.I.T. Discussants: Professor Walter A. Rosenblith, Department of Electrical Engineering, M.I.T. Professor Claude E. Shannon, Donner Professor of Science, M.I.T.

THE COMPUTER DIRECTORY AND BUYERS' GUIDE FOR 1961, 7TH ANNUAL EDITION

The Computer Directory and Buyers' Guide for 1961, the 7th annual edition, will be published this year in July on a new basis.

We shall seek to make it a complete and inclusive directory and guide for the greatly expanding field of computers and data processors.

It will contain at least the following reference information:

1. **Roster of Organizations**
2. **Roster of Products and Services: The Buyers' Guide**
3. **Roster of Computing Services**
4. **Roster of Consulting Services**
5. **Descriptions of General Purpose Digital Computing Systems**
6. **Descriptions of Analog Computers**
7. **Descriptions of Special Purpose Computers and other reference information**

For subscriptions received March 1 and later, the "Computer Directory" will no longer be automatically included in every subscription to "Computers and Automation." The price of the directory will be $12 before publication, $15 after publication. Any purchaser of the directory will receive the monthly issues of "Computers and Automation" at no additional cost. If the directory is not included in a subscription, the price of the monthly issues of "Computers and Automation" will remain at $7.50 per year (in the United States).

The Role of the Digital Computer In the University

Alan J. Perlis
Director of the Computation Center
Carnegie Inst. of Technology
Pittsburgh, Pa.

(Based on a talk at Massachusetts Institute of Technology, Cambridge, Mass., on March 9, 1961)

Computers in Universities

Currently more than 100 computers are installed in American universities. An additional two dozen or so will be added this year; yet in 1955 the number was less than 25. Of course, the number of computers employed in industry has increased by more than this factor of 5; and the number in government has increased at even a greater rate. Nevertheless, considering the costs involved in obtaining, maintaining, and expanding these machines, the universities have done well in acquiring hardware, especially considering the financial hardships under which they suffer. Actually, much of the credit for the scope of the computer collection in universities is due to intelligent planning by International Business Machines Corp. and to the stubborn efforts of some Washington patriots at the National Science Foundation who, taking advantage of a period of national dismay, arranged for funds so that universities could not only have computers, but could have good ones, i.e., ones having large storage and high processing speed.[1] Of course, the NSF and IBM decisions were not made in internal vacuo. They had before them considerable evidence of the intelligent and farsighted use some universities could put computers to. Certainly M.I.T. has provided, starting with the Bush analyzer, and, through Whirlwind, to the present computer-rich environment, evidence for anyone who cared to examine, that universities could indeed do wonders with these machines.

Now that computers are generally available at universities it is time to assess their purpose there.

Purposes of Computers at Universities

Firstly, the present basic purpose is to make computations arising out of the university research program. Some of this research makes marginal use of the computer—for computation arising during the performance of the research. Some uses require the computer's full-time participation, e.g., simulation studies and some numerical analysis research. Some research, started in the former category, ends in the latter. Less often encountered is the reverse trend. Sad to state, some uses occur merely because the computer is present, and seem to have no higher purpose than that.

Some of this research is quite important. Some uses invent computation techniques which will probably have a more profound effect than the stated end of the research itself. Testifying to the increasing use of computers in graduate research, an increasingly large percentage of M.S. and Ph.D theses in the psychological and physical sciences, and engineering, contain reference to tables, and approximate equation solutions produced by a computer.

Most university computation centers produce annual reports documenting the diversity of applications in the physical, biological, and economic sciences successfully carried out or in progress on university computers during one year. The list and some of the results are quite impressive. They testify to the value of the role of the computer in the university. It is quite likely that this "convenience" in, but a few years, will have settled immutably into our thought as an absolutely essential part of any university research program in the physical, psychological, and economic sciences.

Numerical Analysis

As a consequence of prolonged contact of research students with the computer, their interest in numerical analysis has increased and courses are now available in this subject in all universities possessing computers.

Most of these courses are on classical numerical analysis. Few require or encourage continual contact with the computer. Partly this is because the time required to teach programming to the students would seriously reduce the contact hours available to numerical analysis; and partly because the machine time is just not available—either in length of period or frequency.

This is a serious deficiency, not because numerical analysis cannot be taught, appreciated, or learned without a computer; but because if a student is programming continuously, it is possible to reduce the programming composition effort to that required of any mode of communication in which we are expected to be fluent (for example, writing in English). Also, it is possible to reveal, through real problems in which the students are personally concerned and which illustrate as no blackboard or textbook example can, the important developments of a subject.

At Carnegie the two-term senior numerical analysis course requires each student to program and run about twenty numerical solutions of diverse problems. But even this number is not nearly as many as would be desired.

Computer Programming

Whereas numerical analysis has fitted naturally into the educational program of the engineer and scientist, computer programming per se has not. Generally, programming has meant either dilute numerical analysis, or code learning, or logical design of computers; and sometimes fantastic mixtures of all three. In many schools its intellectual content is considered so devoid of university material that only from necessity is it taught, and then only in after-hours short courses given without credit, or inspiration, or even perspective. Such courses are often summed up with a triumphant exercise in coding, e.g., use of Simpson's rule to obtain approximations for pi. These courses are taught as if a computer were merely another shop tool.

In the past three or four years, however, some economics departments have begun the systematic exploitation of the computer as part of their research and educational programs. Some of these research projects are primarily analysis of data; others utilize the computer to simulate organizations, their actions, and policies; others study mathematical models of economic practice. The models are often combinatoric. It is amazing to see students who have great difficulty with calculus manipulate scheduling models represented as graphs—and glibly program clever algorithms which compute values of graph properties.

Management Games

One of the most important applications to economic education is the development of the management game as an educational tool. The injection of the game into the educational process has stimulated the student's appreciation of the decision-making problems in management.

There are, of course, many kinds of management games and diverse opinions about its role in education. A faculty whose members are fluent in programming—because it has been made simple for them to learn and to practice—will see more clearly and more basically the ramifications of a complex game upon economics education. If the computer is available as a matter of course to the students, they will see in it a really powerful educational tool.

The Carnegie management game[2] is becoming, not a marginal laboratory exercise, but a pivot for management education. The authors of the game believe that it will develop through actual practice the following skills:

1. An ability to abstract, organize, and use information from a complex and diffuse environment.
2. An ability to forecast and to plan.
3. An ability to combine the role of generalist and specialist.
4. An ability to work effectively with other people.

The game involves a good deal of information transfer and sharpens the ability of the player to analyze information. In time, he will be able to program mathematical models into which he can feed the data he gathers from the game-dominated situation.

Having available a functioning "doll's house," the faculty can, without fear of by-passing practical examples, donate their wisdom to matters of important theory and relationships which, coupled with student drill, give the proper balance to an education.

The preceding catalogue of uses has several common features. Except for many economics applications these uses are characterized by extensions of previously used methods to computers; and they are accomplished by people already well along in training in their field of specialty and having already received most of this training without computer contact.

Existing Education in the Use of the Computer

It is, however, the thesis of this paper that the programming and using of computers deserves an early appearance in the university curriculum of the educated man. Indeed, not only should such training appear early, but also often during one's university attendance.

How are users educated today to use the computer? The methods include:

(i) Teaching at the point of application. When an application arises, train the student, through the example, to recognize the computer application and utilize the computer for it. Clearly extensions of method will occur to the student but major thematic reorganizations of theory and material, motivated by a computer viewpoint, are not likely to originate from the student.

(ii) Teaching at the time of his mathematical maturity. This permits his absorption of a catalogue of numerical techniques which are of general utility in computer application. This is the standard approach of the numerical analysis course.

(iii) Teaching one's self. Self-education occurs when the student thinks he cannot do his assignments without the computer.

I remark that:

Method (i) suffers from a dependence on instructors who, for the most part even at this time, are neophytes on computers; and on the deficiencies of any piecemeal education on how to use any machine. The importance the Ford Foundation places on computer education of engineers is evidenced by the healthy programs they support at Michigan[3] and M.I.T. Much of this support is directed towards the computer education of engineering faculties—still largely deficient in computer education.

Method (ii) suffers from identifying the domain of computer application too closely with the standard techniques of numerical analysis.

Method (iii) suffers from the peril of possibly illustrating that universities and their carefully nurtured degree programs are not in any case necessary to our society.

Some universities have used a fourth method. A credit course involving the use of some automatic programming language is provided. Fluency in "conversation" with this language and clear understanding of the language's grammar are the intents of such a course. Here, too, the approach suffers from limited pedagogic objectives; and the output is a student, well conversant in, say, ALGOL 60, but quite uneducated as to what computation is all about.

Desirable Education in the Use of the Computer

These approaches all fall far short of what is urgently needed because whatever appreciation they call forth about computers comes too late in the education program and is too parochial. It is thus important to state clearly when the computer and the student should first meet and what should be the nature of their acquaintance.

The product of a university education must have received training directed to the development of sensitivity, rationality and an intelligent table look-up procedure.

The first, as the poet Macleish has so aptly said, is for the development of a feeling for the meaning or relevance of facts. The second is for: the development of fluency in the definition and manipulation of convenient structures; experience and ability in choosing representations for the study of models; and self-assurance in the ability to work with large systems. The third, of course, is the catalogue of facts and problems which give meaning and physical reference to each man's role in society.

While the computer may conceivably play a small role in the development of human sensitivity, it is quite critical to the other developments. Indeed, no other mechanical instrument combines so well the theoretical and practical balance necessary to these developments.

Consequently I feel that the first contact of a student with the computer should be in his freshman year. This contact should be technical and not purely descriptive. Each student during this first course should program and run or have run for him a large number of problems on the computer. At least for engineering and science freshmen, this course should share with Mathematics and English the responsibility of developing literacy, while Physics and Chemistry develop the background toward which this literacy is to be applied.

In a liberal arts program the course could be delayed until the sophomore year. Nevertheless it certainly deserves inclusion for sophomores in liberal arts programs because of the universal relevance of the computer to the problems of our time.

A First Course in Computers

One must admit that for this first course the best content is not yet known. Few such courses have been offered. Consequently, what is said here is based only on admittedly limited experience at Carnegie Institute of Technology.

The course was offered to 46 students last term, and they are continuing through a second term. In addition, 200 freshmen are taking the course this spring. It was considered essential that each student do about 20 problems on the computer in a term. Of course, grading 5,000 programs in a 16-week period is a task well beyond the endurance limits of most instructors. Consequently, the computer was programmed to accomplish the grading, and naturally to keep the grades of the students.

During the first term the students wrote programs in a symbolic machine code, the Carnegie TASS system; and during the current term they are writing their codes in GATE, the Carnegie Algebraic Language system.

Coding in machine language, they were taught mechanical algorithms of code analysis that enabled them to do manually what the GATE translator does automatically. In particular they became adept in decoding complex logical relations to produce branching codes and in manual decoding of complex formula evaluations by mechanical processes. The intent is to reveal, through these examples, how analysis of some intuitively performed human tasks leads to mechanical algorithms accomplishable by a machine.

The processes are given at two levels: a first description using "informal" bookkeeping methods and a quite precise one using completely formal rules and representations described in a formal programming language.

In the course of analyzing these complex formulae the students are given processes, represented by flow charts, as the **definitions** of functions. The functions included are: the square root (Newton's method), the logarithm, and the exponential. In the latter two the computations are not those commonly used as subroutines on machines but have the advantage that their definitions use only arithmetic operations and square root. It is analytically proved that each of these processes actually is the function claimed. To do this the student is given some elementary theorems on limits of sequences and the Weierstrass development of real numbers from nested sets of decreasing intervals. These concepts are illustrated through computation exercises.

The purpose is to reveal one of the important principles of programming: The definition of complex processes by a rational construction from processes already given.

Teaching Programming

What should the student be taught about programming?

The following list although admittedly incomplete represents some fundamentals that the student should acquire.

1. Parametrization. Every program contains at least one parameter and binding it is necessary before the program can be run on a machine. Furthermore, within limits, the more parameters present, the more powerful the program, i.e., the more tasks it can accomplish by the binding of a few parameters. There are numerous examples which can be used: n*th* root instead of square root; ordering n numbers instead of 100 numbers; the number of ways of making an amount of money from coins of stated denominations. However, the empty computer is the most flexible program possible but requires a great deal of parameter binding prior to each run to give new programs.

2. Iteration. Most programs contain cycles of operation so that the same instructions can be utilized on varying data. Teaching the student to think in terms of cycles or repetitive processes is most important.

3. Recursion. Instruction sequences may utilize themselves as sub-functions of their own operation. Recursion permits many processes to be programmed from the outside in. Many processes are most naturally thought of in this way, e.g., differentiation, statement scanning, game playing, etc. These examples illustrate the indeterminate delay which may arise in execution of a chain of operations.

4. Definitions. The development and cataloging of highly useful code sequences. These may then be

substituted into code for an occurrence of their name. Variations among substitution instances may be induced by controlling parameters. These code sequences may, of course, contain definitions of other code sequences so that complex schemata may be generated.

5. *A priori* attention to eventualities regardless of likelihood. The development of a mechanical attitude towards mechanical processing requires that processing of very unlikely cases be provided for. The programming of the solution of a quadratic equation or the analysis of the general second degree equation in two variables to determine the nature of conic sections are good examples where many students fail to provide for all the eventualities. The willingness to program through a tedious collection of tests on special cases must be fostered.

6. Representation. The data organization in each problem, may have a "natural" representation for one phase of a computation and a different "natural" representation for another. Transformations between representations must always balance the ease of processing versus the work involved in transformation.

7. Mechanical language. Each process, before it is run on a machine, must be described in some specific computer language. The nature of such languages is best illustrated by cataloging their properties since they simplify the coding of certain types of problems. Here the student becomes acquainted with the inherent limitations of mechanical syntax.

The student learns that often the instinctive way he chooses to describe a process is not satisfactory. But he also learns that there **are** ways by which he can produce descriptions that are acceptable to a computer, that are not really strange.

8. Simulation. The rather important realization that a process—possibly not even associated with and operating external to a computer—may, to varying degrees of approximation, be imitated on a computer, e.g., some simple game playing, some simple learning.

9. Proof. The student should, through examples, construct proofs that certain algorithms he constructs actually do the task for which they are designed. Unfortunately he can only be guided by example and by appeal to a catalogue of useful proof devices; no universal proof method exists.

In a course such as the one described it is important that the student be quickly graded on his progress and guided past his mistakes. The computer can grade his progress in a generally satisfactory way. However the identification of mistakes in programming and the isolation of the source of a student's misunderstanding in the course material is a task which is incredibly complex and no good automatic solution is available.

A program, behaving like a teaching machine, is currently being designed to teach to students and faculty at Carnegie the syntax of a programming language composed of ALGOL 60, machine assembly code, and list processing.

Since, in this first course the concepts of computer programming are new, it is these that must be taught, and emphasis on the programming languages employed must be subordinated. Indeed the language is learned as a convenient set of signs for describing these processes. In the course of learning the techniques the student is taught the syntax by the highly mechanical routine of the teaching machine, but it is the problem he programs that really regulates his fluency with the machine.

The first, and most critical, stage of the computer's role in the university, it seems, is clear. It is to train entering students in the theory of computation through the development of the concepts of programming. To do this the computer plays a partner's role with the teacher in sequencing the student through a set of problems and language definitions, representative of computation principles.

Results of Computer Course

At the completion of this first course, the student should be able, for example, to recast his learning of, say, calculus so as to be able to devise mechanical methods for a computer to differentiate elementary expressions. He should also be able to naturally make the separation between the introduction and consequence of definitions and the mechanical manipulation in calculus. The **concept** of the teaching program for calculus should not only appear natural but so should the planning procedure for accomplishing it.

I would also expect such students, later in their education, in a course in complex variables to give serious thought to the properties of an algorithm that would perform on a computer the formal evaluation of certain definite integrals by contour integration using the calculus of residues.

The student's algorithm, would of necessity, be only a partial one. Parametrized it will be a proof that certain **classes** of integrals can be so treated. His limited success with the algorithm will not cause him to lose interest in such use of a computer but rather prepare him for the ultimate role of the machine.

Technician for Mechanical Analysis

Thus, I would certainly expect such students to attack with interest the problem of creating within the computer a technician for doing mechanical analysis. The role of technician matches the role of teaching assistant to serve as an aid in mathematical manipulation, and in obtaining proofs. The computer educated as a technician would be quite valuable, to do the dirty work in helping a student to perform the tiresome manipulations required by many of the problems in, say, Whittaker and Watson.

Development of Programming Languages

I see it as a fundamental task of the university computing center to develop the programming languages in whose terms such a technician may be programmed. Such a programming language will require more flexible notational abilities than any now extant. But it is the university laboratory which should develop it.

Salient Features of a University Computer

It goes without saying that the university computer or computers on which this education program is to be accomplished must possess certain salient features: high speed; multi-programming ability; multiple input-output facilities—low in price and cheap in number; high-speed printers; and large random access storage units.

The computer should also be economical to possess, so that the burden of its upkeep will not prejudice its use as an educational instrument rather than only for contract research computing.

Remote in/out consoles are critically important for the success of this program. Past use has emphasized automatic computing—that is, **a priori** directed machine control of the computing process. Naturally as computing power increases there is an accompanying tendency to increase the automation of problem-solving both in scope and in depth in a given situation; for example, automatic error analysis in the solution of ordinary differential equations. One reason for this is that the expense of computer operation does not usually make it feasible for the problem solver to be "in the computer loop."

But in the educational program it is essential that the student be able to function in the computer loop without at the same time causing an exorbitant increase in computer cost. Indeed, we may regard this as one of the prime intentions of the educational computer system being described. However, though the student is in the loop we specify that he must not control the loop, i.e., he enters when permitted and leaves when told. Thus it is reasonable to consider that the computing load consists of a pattern of running codes some of which are monitored from an array of consoles. The rate at which characters enter from the console is absurdly low, being about 2 characters a second. Consequently input from the console will be by a code organized to maximize information transmitted per character. The computer will require about 150 micro-seconds per character at transmit time. Thus, in a message, about 300 micro-seconds every second will be devoted to maintaining records about input data. The input information will naturally be processed as a group only after a terminal signal is received.

The ultimate university computer must possess this satellite facility so that many students may have simultaneous access to the computer.

Given then the appropriate computer, the capability of developing programming systems, the proper freshman course and possibly follow-up courses, the computer will achieve its ultimate role as handmaiden to scholarly university activities.

Bibliography

1. Report on a Conference of University Computing Center Directors, Communications of the ACM, October 1960.
2. The Carnegie Tech Management Game, Graduate School of Industrial Administration, Carnegie Institute of Technology, 1960.
3. Conference Report on the Use of Computers in Engineering Classroom Instruction, Communications of the ACM, October 1960.

CALENDAR OF COMING EVENTS

April, 1961: Joint Automatic Techniques Conference, Cincinnati, Ohio; contact J. E. Eiselein, RCA Victor Div., Bldg. 10-7, Camden 2, N. J.

Apr. 13-14, 1961: UNIVAC Users Association Spring Conference, Statler-Hilton Hotel, Los Angeles, Calif.; contact Donald Houghton, Secretary, UNIVAC Users Assoc., Westinghouse Electric Corp., 3 Gateway Center 15-West, Pittsburgh 22, Pa.

Apr. 19-21, 1961: S. W. IRE Reg. Conf. and Elec. Show, Dallas, Tex.; contact R. W. Olson, Texas Instruments Co., 6000 Lemmon Ave., Dallas 9, Tex.

May 2-4, 1961: Electronic Components Conference, Jack Tar Hotel, San Francisco, Calif.

May 7-8, 1961: 5th Midwest Symposium on Circuit Theory, Univ. of Ill., Urbana, Ill.; contact Prof. M. E. Van Valkenburg, Dept. EE, Univ. of Illinois, Urbana, Ill.

May 8-10, 1961: 13th Annual National Aerospace Electronics Conference, Biltmore and Miami Hotels, Dayton, Ohio; contact Ronald G. Stimmel, Chairman, Papers Committee, Institute of Radio Engineers, 1 East 79 St., New York 21, N. Y.

May 9-11, 1961: Western Joint Computer Conference, Ambassador Hotel, Los Angeles, Calif.; contact Dr. W. F. Bauer, Ramo-Wooldridge Co., 8433 Fallbrook Ave., Canoga Park, Calif.

May 22-24, 1961: 10th National Telemetering Conference, Sheraton-Towers Hotel, Chicago, Ill.

May 22-24, 1961: Fifth National Symposium on Global Communications (GLOBECOM V), Hotel Sherman, Chicago, Ill.; contact Donald C. Campbell, Tech. Program Comm., I.T.T.—Kellogg, 5959 S. Harlem Ave., Chicago 38, Ill.

May 23-25, 1961: Symposium on Large Capacity Memory Techniques for Computing Systems, Dept. of Interior Auditorium, C St., Washington, D. C.; contact Miss Josephine Leno, Code 430A, Office of Naval Research, Washington 25, D. C.

June 6-8, 1961: ISA Summer Instrument-Automation Conference & Exhibit, Royal York Hotel and Queen Elizabeth Hall, Toronto, Ontario, Can.; contact William H. Kushnick, Exec. Dir., ISA, 313 6th Ave., Pittsburgh 22, Pa.

June 28-30, 1961: Joint Automatic Control Conference, Univ. of Colorado, Boulder, Colo.; contact Dr. Robert Kramer, Elec. Sys. Lab., M.I.T., Cambridge 39, Mass.

June 28-30, 1961: 1961 National Conference and Exhibit, National Machine Accountants Association, Royal York Hotel, Toronto, Canada; contact R. C. Elliott, NMAA, 1750 W. Central Rd., Mt. Prospect, Ill.

July 9-14, 1961: 4th International Conference on Bio-Medical Electronics & 14th Conference on Elec. Tech. in Med. & Bio., Waldorf Hotel, New York, N. Y.; contact Herman Schwan, Univ. of Pa., School of EE, Philadelphia, Pa.

July 16-21, 1961: 4th International Conf. on Medical Electronics & 14th Conf. on Elec. Tech. in Med. & Bio., Waldorf Astoria Hotel, New York, N. Y.; contact Dr. Herman P. Schwan, Univ. of Pa., Moore School of Electrical Eng., Philadelphia 4, Pa.

July 21-22, 1961: 1961 Northwest Computing Association Annual Conference, Univ. of British Columbia, Vancouver, British Columbia, Can.; contact Conference Information, Northwest Computing Assoc., Box 836, Seahurst, Wash.

BURROUGHS CORPORATION ANNOUNCES

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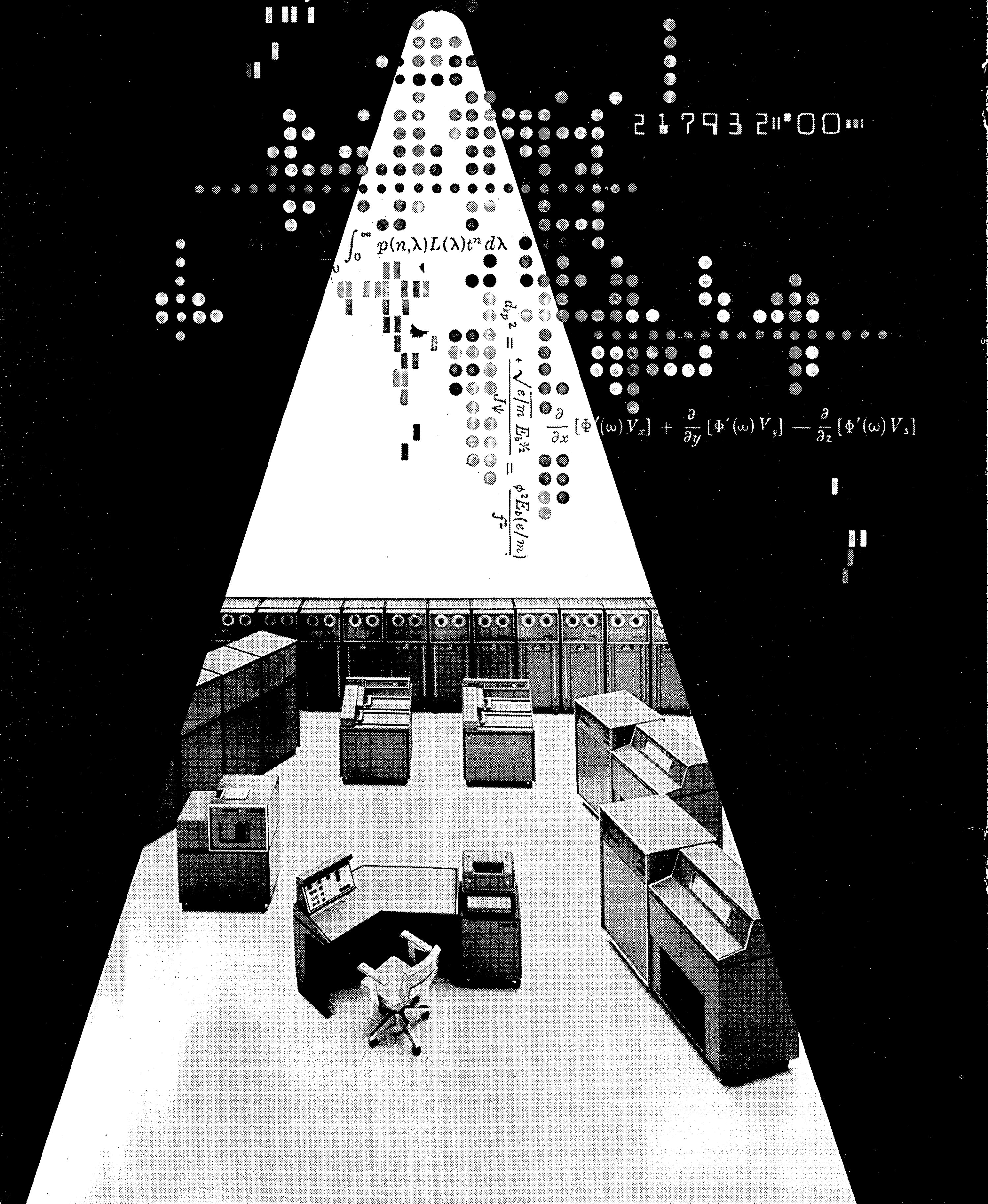

Computer Simulation of Human Thinking and Problem Solving

Herbert A. Simon
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Allen Newell
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Santa Monica, Calif.

(Based on a portion of a talk at Massachusetts Institute of Technology, Cambridge, Mass., March 22, 1961)

It is no longer necessary to argue that computers can be used to simulate human thinking, or to explain in general terms how such simulation can be carried out. A dozen or more computer programs have been written and tested that perform some of the interesting symbol-manipulating, problem-solving tasks that human beings can perform, and that do so in a manner which simulates, at least in some general respects, the way in which humans do these tasks. Computer programs now play chess and checkers, find proofs for theorems in geometry and logic, compose music, balance assembly lines, design electric motors and generators, memorize nonsense syllables, form concepts, and learn to read.[1]

With the proof of possibility accomplished, we can turn to more substantive questions. We can ask what we have learned about human thinking and problem solving through computer simulation: to what extent we now have theories for these phenomena, and what the content of these theories is. Since I want to talk about these substantive matters, I shall simply make the following assertions, which are validated by existing computer programs.

1. Computers are quite general symbol-manipulating devices that can be programmed to perform non-numerical as well as numerical symbol manipulation.
2. Computer programs can be written that use non-numerical symbol manipulating processes to perform tasks which, in humans, require thinking and learning.
3. These programs can be regarded as theories, in a completely literal sense, of the corresponding human processes. These theories are testable in a number of ways: among them, by comparing the symbolic behavior of a computer so programmed with the symbolic behavior of a human subject when both are performing the same problem-solving or thinking tasks.

The General Problem Solver

The theory I shall have most to say about is a computer program called the General Problem Solver. It is not "general" in the sense that it will solve, or even try to solve, all problems—it obviously won't. It is called "general" because it will accept as tasks all problems that can be put in a specified, but fairly general, form, and because the methods it employs make no specific reference to the subject matter of the particular problem it is solving. The General Problem Solver is a system of methods—believed to be those commonly possessed by intelligent college students—that turn out to be helpful in many situations where a person confronts problems for which he does not possess special methods of attack.

Before general methods can be applied to any particular class of problems, of course, the problem solver must also learn, or be taught, the rules that apply to that particular problem domain. The General Problem Solver will not prove theorems unless instructed in the rules of proof in the particular branch of mathematics to which the theorems belong. Thus, in any particular problem domain, the resources available to the General Problem Solver include information about the task environment as well as its own repertory of methods.

Missionaries and Cannibals

Let me introduce the General Problem Solver (which I shall call GPS) by means of a simple example. Many of you are familiar with the puzzle of the Missionaries and Cannibals, and some of you saw a young lady solving the puzzle in a recent CBS television program celebrating MIT's centenary. There are three missionaries and three cannibals on the bank of a wide river, wanting to cross. There is a boat on the bank, which will hold no more than two persons, and all six members of the party know how to paddle it. The only real difficulty is that the cannibals are partial to a diet of missionaries. If, even for a moment, one or more missionaries are left alone with a larger number of cannibals, the missionaries will be eaten. The problem is to find a sequence of boat trips that will get the entire party safely across the river—without the loss of any missionaries.

Suppose, now, that we encountered this puzzle for the first time. We are endowned by nature and nurture with certain abilities that enable us to tackle the problem. We might or might not solve it, but we could at least *think* about it. In what would this thinking consist? In particular, how could we bring to bear our general problem-solving skills, which make no reference to missionaries and cannibals, on this particular situation?

Clearly, we have to form some kind of abstraction of the problem that will match the abstractness of our general methods: We have some people and a boat on *this* side of the river and we want them on *that* side of the river. Stated abstractly, we have a certain state of affairs, and we want a different state of affairs. Moreover, we can describe both states and we can also describe what the differences are between them—between what we have and what we want.

In this case, the differences between the given and the desired are differences in physical location. Our men are on one side of the river; we want them on the other. But we have had vast experience with differences in location, and that experience (stored somehow in memory) tells us that boats are useful devices for reducing differences of location on water. So we begin to consider the possible sequences of boatloads that will get our party across the river without casualties.

It is clear from this formulation of the problem what part is played in its solution by our general problem-solving techniques and what part by our knowledge and experience of the particular problem domain in question. A general solution technique is to characterize the given and desired situations, to find the differences between them, and to search for means—implements or operators—that are relevant to removing differences of these kinds. Our knowledge of the task and our experience tell us what the given and desired situations are, and what kinds of operators may be relevant for getting from here to there.

Structure of the General Problem Solver (GPS)

We can now characterize the program of the General Problem Solver more formally.[2] The program deals with symbolic *objects* that describe or characterize situations—the given situation, the desired situation, various intermediate possible situations. The program also deals with symbols representing *differences* between pairs of objects, and with symbols representing *operators* that are capable of inducing changes in the objects to which they are applied.

Goal Types. The processes of GPS are organized around *goals* of three types:

1. *Transformation* goals: to transform object a into object b.
2. *Difference Reduction* goals: to eliminate or reduce difference d between objects a and b.
3. *Operator Application* goals: to apply operator q to object a.

Methods. With each type of goal in GPS there is associated one or more methods, or processes, that may contribute to the attainment of the goal. The principal methods in the present version of GPS are three in number, one for each type of goal:

1. Method of transformation goals: to transform a into b,
   a. Notice a difference, d, between a and b;
   b. Establish the goal of reducing d between a and b;
   c. Try to attain this new goal;
   d. If successful, find a new difference and repeat.
2. Method for difference reduction goals: to reduce d between a and b,
   a. Recall an operator, q, that is relevant to differences of the type of d;
   b. Establish the goal of applying q to a;
   c. Try to attain this new goal;
   d. If successful, return to the previous transform goal.
3. Method for operator application goals: to apply operator q to a,
   a. Compare conditions for application of q with object a;
   b. If these are not satisfied, establish and try to attain the goal of transforming a into an object a' that meets these conditions;
   c. When the conditions are satisfied, apply q to a', and return to the previous difference reduction goal with the modified object, a', and the original object a.

This is a rather simplified description of what goes on in GPS, but it gives the broad outline of the program. GPS, to put it simply, is a program that reasons about ends and means. It is capable of defining ends, seeking means to attain them, and, in the process of so doing, defining new subsidiary ends, or subgoals, to the original end.

As a theory of human problem solving, GPS asserts that college students solve problems—at least problems of the sorts for which the program has been tested—by carrying out this kind of organized ends-means analysis. It does not assert that the process is carried out consciously—it is easy to show that many steps in the problem-solving process do not reach conscious awareness. Nor does the theory assert that the process will appear particularly orderly to an observer who does not know the program detail or, for that matter, to the problem solver himself. It does assert that if we compare that part of the human subject's problem-solving behavior which we can observe—the steps he takes, his verbalizations—with the processes carried out by the computer, they will be substantially the same.

Abstracting and Planning Processes. Before we leave this description of GPS, I should like to mention one other kind of process that we are incorporating in the program, and that certainly must be included if we are to explain and predict the behavior of our subjects—particularly the brighter ones. We call these additional methods *abstracting* and *planning* processes. Briefly, abstracting consists in replacing the objects, the differences, and the operators, with new symbolic expressions that describe the situation in much more general terms, omitting the detail.[3] For example, we might ask GPS to prove a trigonometric identity:

$$\cos^2 x + \sin^2 x = \tan x \cot x.$$

Here, GPS might take as a the expression, "$\cos^2 x + \sin^2 x$," and as b the expression, "$\tan x \cot x$." In using the planning method, these might be abstracted to: *(a')* "an expression containing cos and sin" and *(b')* "an expression containing tan and cot," respectively. Then, the methods of GPS could be applied to transforming the abstracted given object, a', into the abstracted desired object, b'. If this goal were attained, the steps employed for this transformation would generally provide a *plan* for transforming the original, detailed given object, a, into the original desired object, b. In the particular case illustrated, the plan might be something like: "First eliminate cos and sin from the expression, and then introduce tan and cot."

The Generality of Ends-Means Analysis

The processes incorporated in GPS have actually been observed in the behavior of our human subjects solving problems in the laboratory. By analysing the tape-recorded protocols of their problem-solving efforts, we can identify the occurrences of the three

goal types and the four methods. Moreover, the augmented GPS, containing the planning method, incorporates a substantially adequate set of processes to explain our subjects' behavior in some of these simple theorem-proving, puzzle-solving situations.[4] By the adequacy of GPS, we mean two things:

1. We do not find in the subjects' protocols evidences of processes quite different from those postulated in GPS. This may mean only that we don't know how to look for them; but,

2. When we have compared the trace of the GPS computer (or hand simulations of the computer program) with the protocols of a subject solving the same problem, we have found that the two often follow the same path—noticing the same things about the problem expressions, establishing the same subgoals, applying the same operators, running down the same blind alleys—over periods of time ranging up to several minutes. That is to say, the processes in GPS are sufficient to produce a stream of behavior in a given problem situation quite similar to that produced by the human subject.

These kinds of tests, even if broadened, would still not say much about the generality of GPS as a theory of human thinking and problem solving. It might turn out that if we examined tasks quite different from those used in developing the program, and made the same careful records of subjects' protocols, we would find many new processes exhibited that are not contained in GPS. However, extensions of GPS in fair detail to problem domains that were not considered when the program was developed indicate that its processes are adequate at least to these other domains. For example, Missionaries and Cannibals, which was first suggested as a possible task by Mr. Thomas Wolf of the Columbia Broadcasting System, has been solved by the current version of GPS—not without some reorganization of the program, but without addition of new goal types or methods. Similarly, the applications to algebraic and trigonometric identities and to certain learning tasks appear to require no enlargement of the basic repertory of methods. Less detailed analysis of a variety of other tasks shows GPS to be adequate for these also.

Still, these additional tests do not carry GPS beyond a fairly limited range of formal problem-solving situations. It would be of considerable interest to explore, even qualitatively, the powers and limitations of GPS when it is confronted with a thinking or learning task of quite a different kind from any of these. Let us carry out a reconnaissance along these lines. First, I should like to describe, on the basis of what is now known, the processes that humans use in a task that appears, superficially, to be quite different from problem solving. Then, I shall propose a framework which shows that these processes can be subsumed under those already incorporated in the General Problem Solver. The particular task I shall examine was chosen because quite a bit is known about it.

The Acquisition of Speech

There are many human activities to which we would apply the term "thinking" but not the term "problem solving." There are also many activities we would usually call "learning" rather than "thinking." We would ordinarily call a child's acquisition of speech, "learning." I propose to consider the acquisition of speech as an example of human cognitive activity that is at something of an opposite pole from the rather highly verbalized, somewhat conscious, practiced problem solving of an intelligent and educated adult. We can then judge whether the processes at these two poles are quite different or basically the same.

Speech acquisition has been about as well studied as any non-laboratory complex human activity, and from my review of the literature, I judge that there is general consensus about the particular facts I shall use.[5] If I am wrong in that assumption or in my interpretations of the facts, Professor Miller is one of the best-equipped men in the country to put me straight.

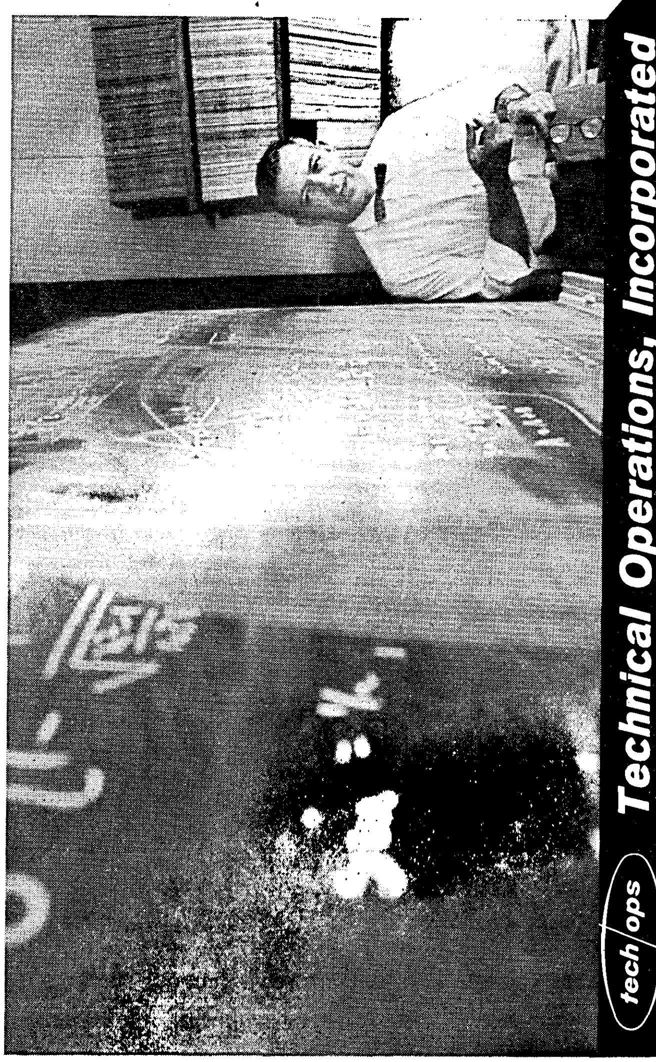
Central Representations

We consider an infant who has already learned the names of a few objects—as evidenced by the fact that he can point to them or fetch them when they are named by an adult—but who has not yet pronounced their names. From his behavior, we can infer that when the child perceives the spoken word "ball," his perception has some kind of internal representation in the brain that permits it to be associated, through previous experience, with some internal representation of a visually perceived ball.

To *say* the word "ball," the child must, in addition, store some kind of program capable of energizing, through motor (efferent) channels, the muscles involved in speech production—in the production of the specific phonemes of that word. Let us call the "whatever-it-is" in the central nervous system that represents internally a perceived sensory stimulus an *afferent* or *perceptual symbol*. Let us call the "whatever-it-is" that represents the program for initiating the motor signals an *efferent* or *motor symbol*.

Learning to speak, in this formulation, means acquiring the motor symbols that correspond to perceptual (auditory) symbols of words already known, and associating the former with the latter. Now the difficulty is that there is no way in which the corresponding perceptual and motor symbols can "resemble" each other—can symbolize the appropriateness of their association by resemblance. The correspondence is purely arbitrary. (We shall have occasion to qualify the adverb "purely" when we come to consider the factorization of words into phonemes and phoneme components.) The infant is faced (if he only knew it!) with the immense inductive task of discovering which motor symbols will cause speech production that, when he hears it, will produce, in turn, an appropriate auditory symbol to be perceived and recognized. And the task appears at first blush to have little structure that would permit it to be approached with some less arduous technique than trial-and-error search.

There is ample evidence that much trial-and-error search is indeed required before the infant acquires the skill of speaking. The child imitates the adults around him, and he imitates himself (echoic speech). Gradually, over many months, he acquires the motor symbols that enable him to produce sounds which he hears as the expected auditory symbols. In the early



stages, the child's acquisition of a speaking vocabulary appears to be paced by the task of developing the new motor symbols. At later stages, he is able to produce a word relatively easily once he has learned to recognize the corresponding auditory symbol.

Factorization

A little reflection will persuade us that something more than trial and error is involved. If that were all, the three hundreth word would be no easier to pronounce than the first. The child learns to learn. In what does this consist?

Although the motor symbol cannot be compared with the perceptual symbol, the *correct* perceptual symbol for a word can be compared, through imitation, with the perceptual symbol produced by the attempt to pronounce the word. If these are different, modification of the motor symbol can be attempted until an auditory symbol resembling the correct one is perceived.

Thus far we have been assuming that the units in terms of which these transactions take place are words. But there is no reason for this assumption—the child might well attend to particular syllables, phonemes, or even components of phonemes. The auditory symbols for words can be compound symbols or *expressions*—strings of phonemes, each phoneme itself encoded in terms of its component frequencies and other characteristics. It is even more plausible to suppose that the motor symbols would be constructed from smaller units, for each word involves a temporal succession of syllables, each syllable a temporal succession of phonemes, and each phoneme a whole set of signals to the several muscles involved in that part of the speech act. Thus, one of the many components of the motor symbol for the spoken word "dog" might be the signal that pushes the tongue against the palate in the initial "d" phoneme of this one-syllable word.

The Learning Process

There is considerable evidence today that this picture of the processes of word-recognition and word-production is correct, at least in broad outline. Many of the components involved in both auditory and motor symbols have been tentatively identified, and there is good experimental evidence for some of them.[6] But what does the picture, if true, contribute to our understanding of the child's acquisition of speech?

It means that the inductive learning need not be blind inductive learning—attempting to associate by pure trial and error each of a large number of words with an appropriate motor symbol chosen from the myriad of producible sequences of speech sounds. On the contrary, to the extent that specific factors in the auditory symbol vary with specific factors in the motor symbol (e.g., as one of the formant frequencies in vowel sounds varies with the size of the resonating mouth cavity), the search for the correct symbol can be very much restricted. Components can be corrected on a one-at-a-time basis. For example, the child trying to pronounce "dog" can at one time attend to the correctness of the vowel, at another time to the correctness of the initial consonant, or even to the aspect of the initial consonant associated with tongue position.

Thus, the hypothesis of factorization is supported both by experimental evidence that it does take place, and by theoretical reasons why it "should" take place—why speech acquisition would be very much easier with it than without it. Trial-and-error acquisition of words without factorization would require a search, in each instance, for the correct motor symbol from among tens of thousands of possible symbols. Trial-and-error acquisition of phonemes would require a search from among only a few hundred phonemes (much fewer are actually used, of course, in any single dialect). Trial-and-error search among phoneme *components* would be even more restricted—there are, for example, probably only a half dozen distinguishable tongue positions. Thus, by factorization of the total space of possibilities, a very limited trial-and-error search of the factors can be substituted for an immense search of the product space. Moreover, once the child has acquired motor symbols corresponding to the common phonemes, acquisition of new words (new combinations of these same phonemes) could be very rapid.

Summary: the Child's Acquisition of Speech

Let us now summarize our description, partly factual, partly hypothetical, of the speech acquisition process. The child acquires perceptual auditory symbols corresponding to words he has heard and has associated with visual symbols. He tries, on a trial-and-error basis, to produce words, hears his productions, and compares these auditory symbols with those already stored. When he detects differences, he varies the motor symbol to try to remove them. As he learns, he detects that changes in certain components of the motor symbols alter only certain components of the auditory symbols. Thus he is able to factor the correction process and thereby accelerate it greatly.

Acquisition of Speech by GPS

Now it is very easy, with a few changes in vocabulary, to translate this whole description back in terms of GPS. When the translation has been made, we shall see that the processes just described are the methods of GPS.

Let us, in this translation, call the auditory symbols *objects*. We assume that there exist central processes that modify motor symbols—that change one or more of their components. We will call these processes *operators*. A change in a motor symbol will, in turn, change the auditory symbol that is perceived when that motor symbol produces a sound.

The child detects *differences* between the object he has produced (i.e., his perception of the sound) and the correct object (his perception of the sound when produced by adults). He applies operators to the motor symbol to modify the sounds he produces, hence the object perceived; and he compares the latter again with the correct object. This search process continues until he can reproduce the perceived object.

But this does not account for the factorization, which we have argued is so crucial to the efficiency of the learning process. How will GPS learn (1) which differences in objects are associated with which operators upon the motor symbols, and (2) how to factor objects and operators? Although the answers to these questions are far from certain, a scheme we

NEW DIGITAL COMPARATOR CONTROLS MACHINERY TO ONE 110,000TH OF AN INCH

Hycon Mfg. Company
1030 So. Arroyo Parkway
Pasadena, Calif.

A digital comparator for use in automatic control has been developed by this company. The new unit uses numerical rather than analog commands to control machinery to one 110,000th of an inch at rates as high as 30 inches per minute. Prime information is obtained from a punched tape program.

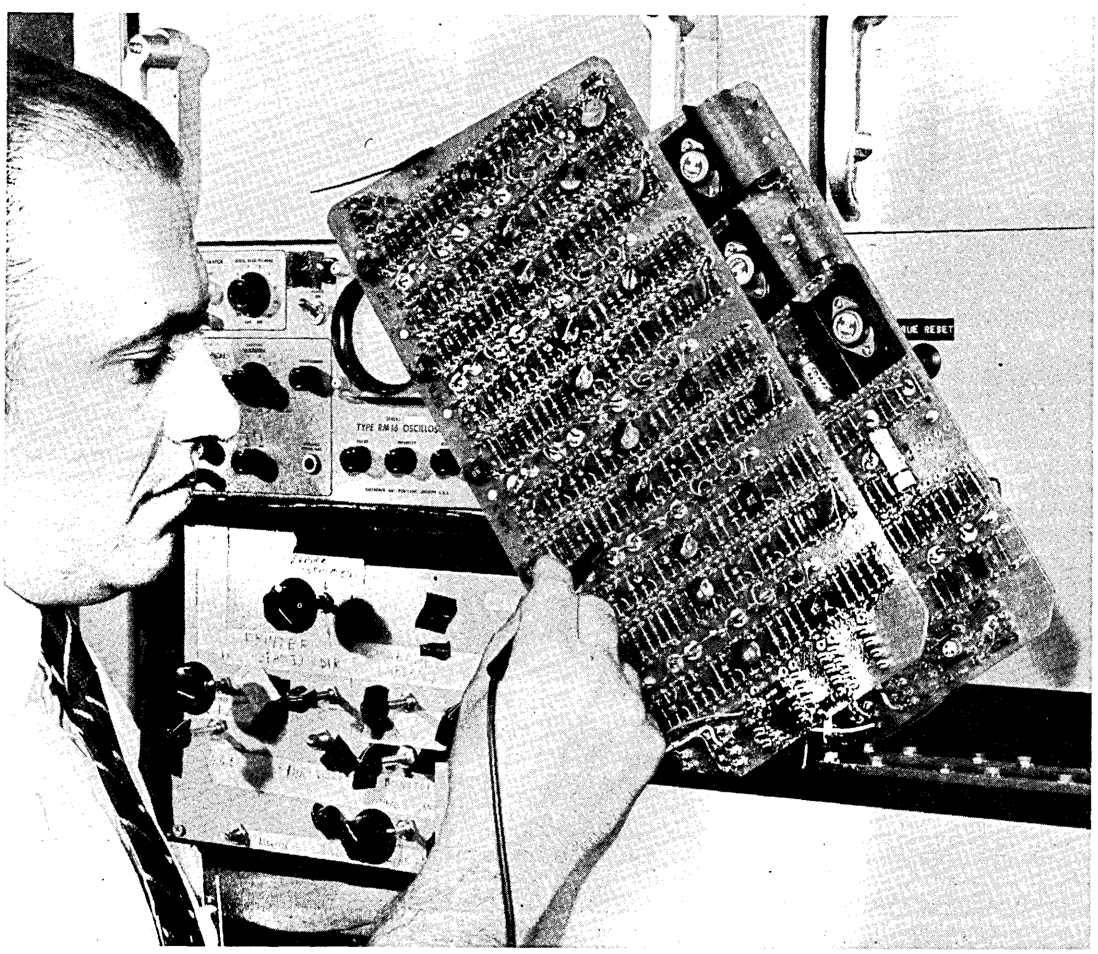
The new comparator is a proven section of the H-299 Photographic Rectifier developed recently by Hycon. It has many applications in the fields of process control and machine tools where precision is required with low-cost processing.

The comparator is composed of command and feedback displacement counters, a differential analog converter, and associated circuitry. Numerical positions are registered in each counter from absolute incremental position encoders. Counting can be bidirectional.

The converter section of the comparator produces an analog voltage for the least significant decades of the numerical difference. Logic circuitry is added to prevent complementary analog voltages from appearing and to provide maximum forward and reverse error voltage when the true numerical difference exceeds two decades.

In incremental operation, the position pulse frequencies, indicating a continuous displacement, are converted to the velocity-error voltage analog for use in precision control.

The unit features either binary or decimal coding, operates from absolute or incremental reference and feedback commands, has no adjustments, no critical voltage regulation and is constructed with fold-out transistorized circuit boards with many test points for ease of maintenance.



THE FIRST "PROGRAMMED DATA PROCESSOR" DELIVERED AND IN USE

Digital Equipment Corp.
Maynard, Mass.

A new low-to-medium-priced, solid-state, digital computer designed and manufactured by this company, which is capable of operating at twice the speed of most large computers in use today, has been formally accepted by Bolt, Beranek & Newman, Inc., Cambridge, Mass.

The computer, called the DEC Programmed Data Processor (PDP), will be used by BBN on many advanced research projects it conducts for government and for private industry. Several of these projects involve the use of the computer as an automatic teaching machine for instruction in such different subjects as foreign language vocabulary and Sonar sound recognition. The computer's high speed will enable it to teach different subjects simultaneously to different people, making use of time-sharing.

The computer will also be used to study: various types of control systems; the human nervous system, under a variety of conditions; speech analysis and simulation; pattern recognition; how to program a computer to identify letters of the alphabet, numbers, patterns, and other graphic representations.

The computer accomodates 16 different input-output devices without internal modification of the computer. One such device is a visual display unit, that looks like a television set, which enables the operator to view on its screen data stored in the computer memory.

The computer is a single address, single instruction, stored program machine with unusual programming features. The computer does not require special power, subflooring or air conditioning. Five-megacycle circuits, a five-microsecond magnetic core memory, and fully parallel processing make possible a computation rate of 100,000 additions per second.

Standard equipment on the DEC computer consists of a paper tape reader, a typewriter for on-line input and output operations, and a paper tape punch. Optional input-output equipment includes sequence break, cathode ray tube visual display, a "light pen" (which can write with light on the cathode ray tube visual display), card punch and card reader controls, tape units, and tape control units. Built-in multiply and divide orders are available as a central processor option. The random access core memory is expandable in modules of 4096 words of 18 binary digits. The price of a PDP with standard equipment and one memory bank is approximately $110,000. It operates in binary; programs are used to convert from decimal to binary and vice versa.

The computer has a word length of 18 binary digits. Instructions are carried out in multiples of the memory cycle time of five microseconds. Add, subtract, deposit, and load, for example, are two-cycle instructions requiring 10 microseconds. Multiplication by programmed subroutine requires 350 microseconds on the average, and division takes about 600.

Program features include single address instructions, multiple step indirect addressing and logical and arithmetical commands. Among the console features are flip-flop indicators grouped for convenient octal reading, six program flags for automatic setting and computer sensing, and six sense switches for manual setting and computer sensing.

SMALL COMPUTER AND BUSINESS-FORM-WRITING MACHINE INTRODUCED

Smith-Corona Marchant, Inc.
701 Washington St.
Syracuse 1, N.Y.

A small computer and business-form-writing machine have been developed by this company.

The writing machine, called the Typetronic 2215 prints out business forms automatically at more than 100 words a minute by means of an electric typewriter tied into electronic components. It is controlled by either punched tape or edge punched cards.

The other unit, the Typetronic 6615, contains transistor arithmetic circuits for performing calculations, and a magnetic disk memory with nine recording heads for storing information. It also employs an electric typewriter to feed data into the system or write out results.

The 2215 costs from $4,000 to $6,000, and the 6615 from $6,000 to $9,000, depending on the requirements of the particular installation. Smith-Corona plans to add one more feature soon, so that users will be able to convert a 2215 into a 6615, or vice versa.

NEW HYBRID ANALOG COMPUTER EMPLOYS DATA STORAGE AND TIME-SHARING COMPONENTS

Computer Systems, Inc.
Culver Road
Monmouth Junction, N.J.

A hybrid computer has been developed by this company, which puts together: (1) the analog computer's speed, lower cost, ease of programming, and improved output presentation; and (2) the digital computer's capacity for data storage and time-sharing of components.

It is called the 5800 DYSTAC® Analog Computer; it features high-speed repetitive operation and dynamic storage of analog data to an accuracy of ±0.01% and a time base accuracy of ±0.5 microseconds. The new computer can optimize any model at 100 cycles per second, in diverse fields such as operations research, chemical kinetics, aerodynamics, structures, astrophysics, and hydrodynamics, and regardless of whether the problems are static or dynamic, or whether they cover cost, design, or production control.

The system affords rapid and accurate solution for such former "trial and error" problems as: automatic optimization, automatic correlations, data fitting, probability distributions, Fourier analysis, convolution and superposition integrals, eigenvalues. Problems ranging from distillation column design to multidimensional heat transfer, from boundary value problems to transport delays can also be handled.

The operational amplifier used in the computer has universal capabilities as an electronic multiplier, divider, resolver, and function generator. Further, it deals with roots, powers, exponents -- including decimal fractions -- as easily as it deals with conventional addition and subtraction.

ELECTRICAL PROXIMITY READER OF DIGITAL CODES

Robert C. Montross
Square D Company
Milwaukee, Wis.

A new electrical device to speed handling of mail in mechanized post offices has been developed by this company. The device is a proximity reader of digital codes, designed to route trays of letters automatically to their proper destination within the post office.

The device is designed to detect and read the presence of coded information, digital in nature (in this case information on a coded card on the letter tray) without requiring actual physical contact with the information medium. The basic sensing mechanism is a small transducer which translates the coded information into an electrical signal which operates an electric control circuit.

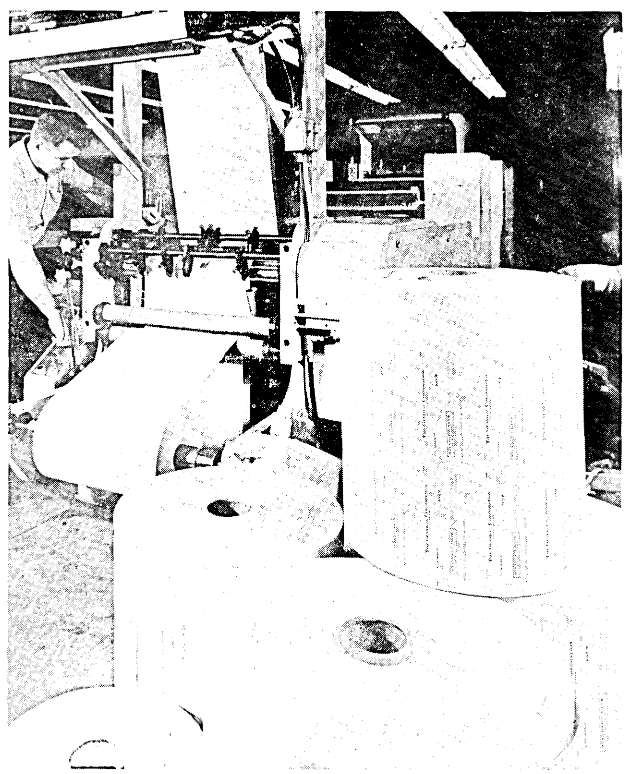
The flexibility of design permits reading a large number of different codes by simply changing wiring between standard components.

The device also offers a new approach to some long-known problems of counting, sorting, and monitoring the flow of conveyor-transported objects.

ENCODED PAPER CHECKS ROLL OFF PRESSES

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

Paper checks, imprinted with magnetic ink characters for automatic machine recognition, roll from a high-speed printing press at IBM's Supplies Division plant at Greencastle, Indiana. A new product for IBM, the paper checks are available in unit sets and continuous forms for automated check handling. IBM has produced punched card documents for more than 40 years and magnetic ink punched card checks for more than a year.



AIRLINE INFORMATION DATA SYSTEM TO BECOME COMPLETELY COMPUTER-BASED

Eastern Air Lines, Inc.
10 Rockefeller Plaza
New York 20, N.Y.

Immediate information on availability of seats, expected departure times and arrival times of planes, and other flight information of interest to Eastern Air Lines' customers is to become a reality in December, 1961, with the installation of a "real-time" computer-based reservations system.

An advanced solid-state electronic system consisting of two Remington Rand Univac 490 "Real-Time" computers and their associated auxiliary equipment will then go to work. The system will be used to keep the airline's seat reservation inventories and other flight information constantly up to date to the fraction of a second.

The New York City electronic reservations center will come under control of the new Univac system in December, 1961; the complete system, providing control of all Eastern flight reservations, will be installed by the first quarter of 1962.

The new system will complete automatic information-handling in 17 major areas, now booking 32,000 passengers daily, with the addition of Charlotte, Chicago, Cleveland, Detroit, Indianapolis, Jacksonville, Louisville and Tampa. These passengers will receive immediate answers to their reservations questions by means of a high-speed communications network carrying information to the Univac Real-Time Computers over 4,880 miles of high-speed telephone communications lines.

The new Univac system will immediately show when a reservation has been cancelled and will make it available for immediate resale. For example, if someone "no-showed" in Boston for a jet flight Boston-Chicago-Los Angeles, the system will be sufficiently fast to make this seat available to a customer requesting it in Chicago. Also, actual arrival and departure times and other flight information relating to operations will be furnished to reservations agents by the new system.

Included in the new system are some advanced electronic devices and techniques: computers that "talk" to each other; and clocks that automatically trigger messages notifying operators of action required.

DIGITAL COMPUTER FOR AUTOMATIC CONTROL OF PROGRAM CHANGES IN TELEVISION STATIONS

T R W Computers Company
Division of Thompson Ramo Wooldridge Inc.
202 North Canon Drive
Beverly Hills, Calif.

A digital computer system designed for automatic and error-free program switching in television broadcasting stations has been developed by this company.

With the new system, called TASCON -- for Television Automatic Sequence CONtrol -- and based on the RW-300 digital computer, switching orders for an entire day of television programs can be stored in the computer memory; these include orders for equipment warmup, or prestart. Then, with precision timing, the unit automatically turns on tape machines, projectors and other equipment so that sound and pictures go on the air at the scheduled time and in the correct sequence.

Switching instructions are regularly stored far in advance of busy station-break periods, but changes can be entered at any time -- hours ahead or within seconds of air-time. This degree of flexibility is possible because the operator can communicate directly with the digital computer.

The displays tell the operator what is currently on the air, when the next switching sequence will begin and where the sound and picture will originate. During entry of data, the displays can be used by the operator to verify each switching instruction before it is stored in memory.

Accuracy is assured in the new system by the extensive self-checking features of the digital computer. The unit offers the flexibility, speed and reliability of a digital computer, but is competitive in price with other automatic program switching systems.

Although the primary function of the system is automatic switching control, it also can be applied as an aid to program scheduling and operations, for maintenance checkout of video and audio systems and for record keeping to simplify accounting.

ADDITIONAL COMPUTER SYSTEMS FOR NAVAL TACTICAL DATA SYSTEMS

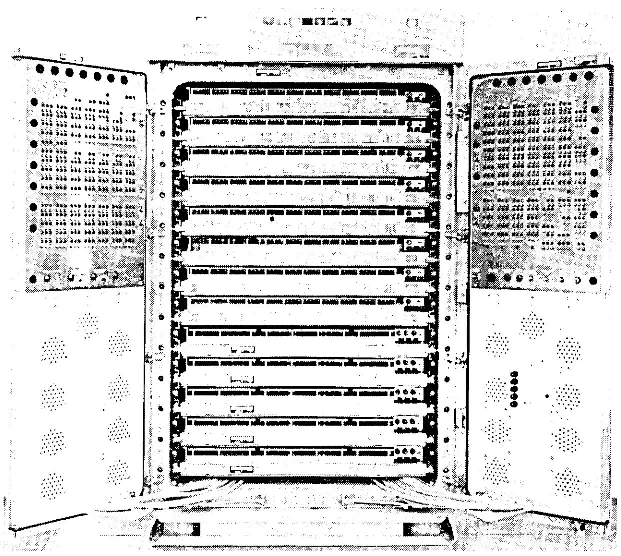
Remington Rand Univac Military Dept.
St. Paul, Minn.

The Navy announced on March 9 that it has awarded a $5,534,526 letter contract to this company for the production of additional computer systems for the recently announced Naval Tactical Data System (NTDS).

The Univac Advanced Navy Computer to be manufactured under this new contract are general-purpose, stored-program, high-speed devices which form the "heart" of the system.

The Naval Tactical Data System consists of computers which send information to a series of consoles that display schematic pictures showing targets, their types and movements, and the defensive and offensive postures of friendly ships and aircraft.

The Univac Advanced Navy Computer, a real-time machine designated AN/USQ-20V, collects, processes and evaluates naval tactical data in a combat situation and recommends courses of action. From a naval tactical standpoint, the use of computers for the collection, display, and dissemination of combat



information permits the automation of many routine tasks, which can be performed infinitely faster and more accurately, thus freeing the men to concentrate on decision-making.

Computers aboard the units of a widely-deployed task force exchange information which, added to that held internally in their memory sections, provides quite complete knowledge of the over-all tactical situation. After evaluation, the computers recommend and transmit at extremely high speeds, alternative courses of defensive action.

By enabling the ships to communicate continually with each other, the computers allow the task force to operate as though it were one huge ship.

The Univac AN/USQ-20V, containing 3,776 identically packaged electronic circuit modules, measures only 33" x 37" x 65" and is built to withstand the environmental hazards inherent in shipboard operations.

The memory section contains 1,000,000 bits of information. Thirty bits, comprising a single word, can be drawn from any location in the memory in 2.5 millionths of a second. In one second the machine can complete up to 70,000 instructions.

NEW ELECTRONIC SWITCH HAS 10^{-9} SECOND TRANSFER TIME

Raytheon Company
Semiconductor Division
200 First Avenue
Needham, Mass.

A super-speed, electronic switch that can more than double the output of today's computers has been demonstrated by this company.

The switch incorporates the Raytheon avalanche-mode silicon transistor in a microwave strip transmission line. The switch turns off or on in less than one thousandth of a microsecond (0.000 000 001 second), this being the fastest switch yet known to be in existence.

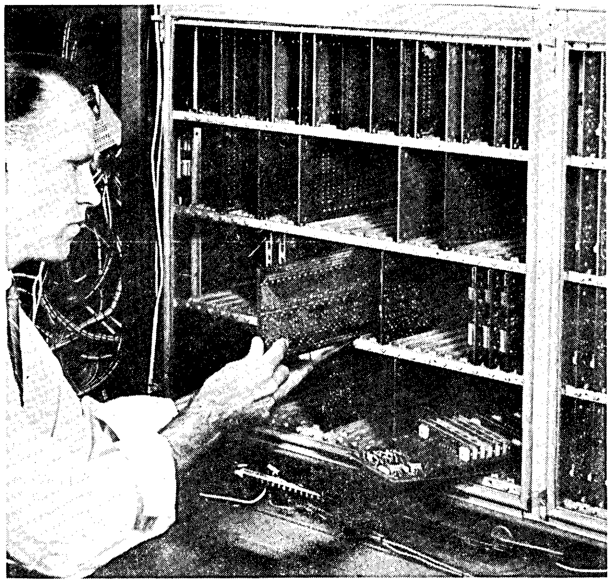
The switch produces a clean rectangular pulse, which has been long desired for many applications, utilizing a reflection technique. Immediate applications of such a device include pulse generators and other instrumentation circuitry.

This is apparently the first time a semiconductor has been combined in a switch circuit with a microwave strip transmission line. Until the advent of the avalanche mode transistor, no semiconductor of this type operated at frequencies high enough to use a microwave strip transmission line effectively.

SPECIAL "ARMORED" DRILL HELPS PREPARE COMPUTER PRINTED-CIRCUIT CARDS

Morse Twist Drill & Machine Co.
New Bedford, Mass.

Hundreds of small holes must be drilled or punched in modern printed circuit cards for modern computers to permit placing wires and transistors. Over 18,000 printed circuit cards are incorporated in Philco Corporation's new Philco-2000 electronic data processing system.



-- A Philco engineer installs one of over 18,000 printed circuit cards found in each Philco-2000 computer. The cards are threaded with wires and mount transistors and other components. --

Many of these cards are made of a highly abrasive compound, epoxy resin with glass fiber, too rugged for conventional drills. So new high-speed "electrolized" steel drills have been created for this purpose.

"Electrolizing" a drill -- a patented process -- increases a tool's life up to ten times, by coating its surface with a hard, dense alloy. This enables the tool to cut through punishing materials.

Before drilling, the circuit cards are imprinted with slight depressions to help the operator guide his cutting tool to the proper location. A pre-drilled brass master template controls the positioning of the drill. A pointer, attached to a movable surface of the drilling machine on which the card is secured, is guided to a hole in the template. This brings the card to a point where the drill is directly over a depression -- the exact location of the desired hole. The operator then lowers the drill head and makes the hole.

The drill head is so designed that, if the drill is not lowered exactly into the center of the depression on the circuit card, the machine will not operate. This prevents inaccurate placement of holes in the cards.

FERRITE CORE DEVELOPED TO OPERATE OVER A RANGE OF 155°C

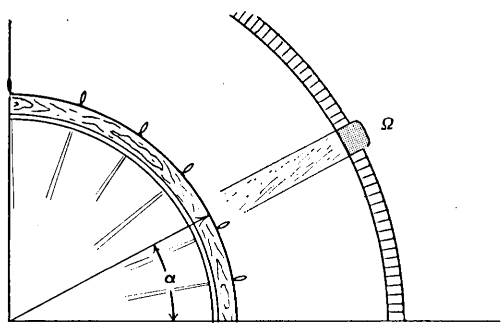
Ampex Computer Products Co.
P. O. Box 329
Culver City, Calif.

This company has developed a ferrite core that will operate in a coincident current mode over a temperature range of -55°C to +100°C without current or temperature compensation.

Using this core, an airborne memory is being developed that can be used for new space applications. This new memory is a random-access, coincident-current unit with a capacity of 1344 bits. The complete memory, including the sense amplifiers, operates using pulse techniques which keep the power consumption to a minimum. The only DC current flowing during quiescent periods is a fraction of a milliampere used for biasing flip flops. When the memory is operating at a 2 kc rate, the power consumption is only a fraction of a watt.

To minimize the number of semiconductors and to simultaneously increase the reliability, magnetic techniques were used wherever practical. All marker outputs and address outputs are driven directly from cores.

The 1344 bit unit occupies 34 cubic inches and weighs approximately sixteen ounces.



WHO'S WHO IN THE COMPUTER FIELD

From time to time we bring up to date our "Who's Who in the Computer Field." We are currently asking all computer people to fill in the following Who's Who Entry Form, and send it to us for their free listing in the Who's Who that we publish from time to time in **Computers and Automation.** We are often asked questions about computer people—and if we have up to date information in our file, we can answer those questions.

If you are interested in the computer field, please fill in and send us the following Who's Who Entry Form (to avoid tearing the magazine, the form may be copied on any piece of paper).

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.

have proposed elsewhere would enable GPS to handle these tasks also.[7] I will sketch it briefly:

1. Given a set of differences and a set of operators, GPS can, with modest amounts of trial and error, detect which operators are relevant to producing or eliminating which differences. To take a crude, but simple, example: it takes relatively little trial and error to discover what differences in the perceived sound are associated with changes in the rounding of the lips while producing a vowel. The factorization has already largely been carried out by nature, so to speak, because changes in only a few aspects of the motor signal will change only a few aspects of the perceptual symbol.

2. The GPS processes can themselves be employed to discover inductively a "good" factorization—a "good" set of differences. To do this, GPS must be supplied with some very general criteria as to what constitutes such a good set. The criteria would be of the following sorts:

   a. Only one or a few operators should be relevant to each difference (so that, given a difference, an appropriate operator can be found without too much search).
   b. Only one or a few differences should be associated with each operator (so that the sounds produced can be varied factor by factor).

and a few others of the same general kind.

With such a set of criteria provided, finding a good set of differences simply becomes another kind of problem to which GPS can apply its problem-solving methods. What are the objects, differences, and operators in terms of which this new kind of problem is formulated? To avoid unnecessary confusion, we will capitalize the terms OBJECTS, DIFFERENCES, and OPERATORS in speaking of the new problem context in order to distinguish them from the objects (perceptual symbols), differences, and operators (changes in motor symbols) involved in the original task of acquiring speech.

The OBJECTS for the new problem-solving task are the *sets of differences* in the original task environment. The new DIFFERENCES designate to what extent particular sets of differences meet the *criteria* we have just listed. OPERATORS are processes for altering the set of differences under consideration by deleting differences from the set, adding differences, or generating new differences for possible inclusion. GPS then tests in what respects particular OBJECTS (sets of differences) are DIFFERENT from the desired OBJECT (as indicated by the criteria). It seeks to remove these DIFFERENCES (modify the set of differences) by applying OPERATORS (by adding, subtracting, or modifying differences).

Since this scheme has not been realized on a computer, we cannot tell how effective GPS would be in handling it. All we can say is that it is a problem whose solution can be attempted with the means at the disposal of GPS.

A due respect for parsimony would suggest, then, that instead of postulating quite different processes for the acquisition of such skills as speaking from those postulated for adult problem solving, we embrace tentatively the hypothesis that the processes are in fact the same—that the General Problem Solver provides a description of both processes. This hypothesis would provide a sharp focus for empirical research into the early speech behavior of the child. . . . . .

NOTES

[1] For an excellent recent survey of heuristic programs, although with emphasis upon "artificial intelligence" rather than simulation of human thought, see Marvin Minsky, "Steps Toward Artificial Intelligence," *Proceedings of the Institute of Radio Engineers,* 49:8-30 (January 1961).

[2] For a fuller description, see A. Newell, J. C. Shaw, and H. A. Simon, "Report on a General Problem-solving Program," in *Information Processing,* Proceedings of the International Conference on Information Processing, UNESCO, Paris, 15-20 June 1959; pp. 256-264. (Paris: UNESCO, 1960).

[3] See *ibid.,* pp. 261-2, for a description of a specific planning method for GPS. In our subjects, abstracting often takes the form of simply ignoring some of the problem detail at certain stages of the solution process.

[4] See A. Newell and H. A. Simon, "The Simulation of Human Thought," in *Current Trends in Psychology, 1959* (Pittsburgh: U. of Pittsburgh Press, 1961).

[5] See, for example, C. E. Osgood, *Method and Theory in Experimental Psychology* (New York: Oxford U. Press, 1953) pp. 683-690; G. A. Miller, "Speech and Language," Chapter 21 in S. S. Stevens, ed., *Handbook of Experimental Psychology* (New York: Wiley, 1951); and G. A. Miller, *Language and Communication* (New York: McGraw-Hill, 1951), Chapter 7.

[6] For a general introduction to these topics, see G. A. Miller, *Language and Communication,* Chapter 2. An excellent recent survey is Richard Fatehchand, "Machine Recognition of Spoken Words," in F. L. Alt, ed., *Advances in Computers* (New York: Academic Press, 1960), pp. 193-321. See also J. W. and C. D. Forgie, "Results Obtained from a Vowel Recognition Computer Program," *The Journal of the Acoustical Society of America,* 31:1480-89 (1959), and A. M. Liberman, *et al.,* "Minimal Rules for Synthesizing Speech," *ibid.,* 31:1490-99 (1959). The last three references cited illustrate, incidentally, the large role that computers are playing today in linguistic and phonetic research.

[7] The full account of this learning scheme is given in A. Newell, J. C. Shaw, and H. A. Simon, "A Variety of Intelligent Behavior in a General Problem Solver," pp. 153-187 in M. C. Yovits and S. Cameron, eds., *Self-Organizing Systems* (New York: Pergamon Press, 1960).

AUTOMATED KITCHEN

"Welcome to our automated computerized kitchen. Put box on table. Here's your money."

BOOKS AND OTHER PUBLICATIONS

Moses M. Berlin
Allston, Mass.

We publish here citations and brief reviews of books and other publications which have a significant relation to computers, data processing, and automation, and which have come to our attention. We shall be glad to report other information in future lists if a review copy is sent to us. The plan of each entry is: author or editor / title / publisher or issuer / date, publication process, number of pages, price or its equivalent / comments. If you write to a publisher or issuer, we would appreciate your mentioning **Computers and Automation.**

Theory of Switching Circuits, Fifteenth Quarterly Progress Report / Univ. of Penna., The Moore School of Electrical Engineering, Philadelphia 4, Penna. / 1960, mimeographed, 75 pp, limited distribution.

This technical, research, report includes sections and chapters with titles such as "Counting by a Class of Growing Automata," "Gate Machine, Aggregate Machine, and Canonization," "Sums of Defining Functions," and "Irredundant Conjunctive Normal Formulas."

Ralston, Anthony, and Herbert S. Wilf, editors, and 22 other authors / Mathematical Methods for Digital Computers / John Wiley & Sons, Inc., 440 Park Ave., South, New York 16, N. Y. / 1960, printed, 293 pp, cost ?

The editors of this volume have assembled papers on various topics related to the application of computers to mathematical problems. Twenty-six papers are put into six categories: Generation of Elementary Functions, Matrices and Linear Equations, Ordinary Differential Equations, Partial Differential Equations, Statistics, and Miscellaneous Methods. Among the papers presented, are: The Numerical Solution of Polynominal Equations, The Solution of Linear Equations by the Gauss-Seidel Method, Generation of Elementary Functions, and Network Analysis. An index is included and each paper presented has references.

Current Research and Development in Scientific Documentation, No. 7 / Supt. of Documents, U. S. Govt. Printing Office. Washington 25, D. C. / November, 1960, printed, 153 pp, 65¢.

This report, compiled by the Office of Science Information Service, National Science Foundation, includes descriptions of, and statements about, progress in five areas of documentation: 1. Information Requirements and Uses; 2. Information Storage and Retrieval; 3. Mechanical Translation; 4. Equipment; 5. Potentially Related Research. 181 brief entries are published, describing progress of various locations; reference to them is facilitated by a complete subject index, an index of individuals and organizations, and an index of sponsoring agencies.

Some Applications of Statistical Sampling Methods to Outgoing Letter Mail Characteristics—NBS Technical Note #16, PB 151375 / Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. / 1959, printed, 142 pp, $2.75.

Distribution of Incoming Letter Mail at Baltimore, Maryland City Post Office—NBS Technical Note #33, PB 151392 / address above / 1959, printed, 120 pp, $2.50.

Distribution of Mail by Destination at the San Francisco, Los Angeles, and Baltimore Post Offices—NBS Technical Note #27, PB 151386 / address above / 1959, printed, 56 pp, $1.50.

These three publications report on statistical studies conducted by the National Bureau of Standards for the Post Office Department, to determine methods for the speeding of postal handling through automatic handling. In each of the reports, conclusions are listed in tables, and charts are given; the conclusions relate to the ability of a computer using punched card input to control postal processes by determining letter size and color characteristics, and separating various classes of mail.

Fifer, Stanley / Analogue Computation / McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y. / 1961, printed, 4 vols., 1331 pp, $39.50.

These four volumes explain the theory, techniques and applications of the analogue computer, analysis of problems for input, necessary mathematical knowledge, precision and accuracy considerations, and optimum operation. In Volume 1, the author, President of Dian Labs., Inc., covers a general introduction and The D-C Feedback Amplifier, the Linear Potentiometer, Multipliers, Resolvers, The Diode, and The Relay. Volume two includes: Recorders and Analogue-to-Digital Converters, Function Generators, Function Generation Techniques, Transfer Functions and Checking and Error Analysis, etc. Volume three includes: The Mechanical Differential Analyzer, Partial Differential Equations, The Polynomial Equation, The Potential Analogue, etc. The final volume includes: Fourier Analysis, Noise, Flutter, Advanced Techniques, and other topics. In all, there are thirty chapters. Subject and name indexes.

Adler, Irving / Thinking Machines: A Layman's Introduction to Logic, Boolean Algebra, and Computers / The John Day Co., 62 West 45 St., New York 36, N. Y. / 1961, printed, 189 pp, $4.00.

This book is aimed at the algebra-level person who is interested in learning about computers. The information is presented in the simplest possible manner, and as a result, only the most general information is given. Twelve chapters include such headings as: Hardware Brains, Algebra of Numbers, Calculating Machines, Electronic Computers and, Thinking Machines and the Brain. A short bibliography of introductory books, and an index are included.

Polydoroff, W. J. / High-Frequency Magnetic Materials, Their Characteristics and Principal Applications / John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. / 1960, printed, 220 pp, $9.00.

This book discusses the characteristics of ferromagnetic materials and their applications at high frequencies. The author, inventor of permeability tuning and the ferromagnetic loop antenna, holds over 50 patents. Numerous charts, illustrative examples and tables accompany the text, which contains fifteen chapters, including: Solid State Magnetic Materials, Ferrites, Permeability Tuning, Special Applications of Magnetic Materials, and Ferrites in Microwave Applications. Index.

Schure, Alexander / Semiconductors and Transistors / John F. Rider Publisher, Inc., 116 West 14 St., New York 11, N. Y. / 1961, printed, 144 pp, $2.90.

The physics of semiconductors and

transistors is presented in a clear, self-contained manner, and applications of transistors are discussed. The information is aimed at the reader somewhat familiar with circuitry and the nature of electronic devices. Five chapters include: Introduction to the Semiconductors, The P-N Junction Diode, Introduction to the Transistor, The Transistor as a Circuit Element, and Small Signal Analysis. Review questions and an index.

Davies, Gomer L. / Magnetic Tape Instrumentation / McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y. / 1961, printed, 263 pp, $8.50.

The techniques and instruments of magnetic tape data recording are explained and discussed, from basic principles to advanced applications. Eleven comprehensive chapters include information about: Fundamentals of Recording and Reproduction, Tape Motion Irregularities, Speed Control Systems, Head and Head Stacks, Magnetic Tape Systems, etc. Two appendices discuss tape-transport flutter and time displacement error. Index.

Davison, J. F. / Programming for Digital Computers: Putting Computers to Profitable Use / Business Publications Ltd., Mercury House, 109 Waterloo Rd., London, S.E. 1, England / 1961, printed, 175 pp, 35 shillings.

An introduction to the techniques of computer program writing is presented with information about the general nature of programs and some details of more advanced coding techniques. Eight chapters cover such topics as: Introduction to Computers, Details of Programming, More Sophisticated Programming Techniques, and Interpretive Schemes and Autocodes. An appendix which provides a summary of the Tridec order code is included.

Conway, B., J. Gibbons, and D. E. Watts / Business Experience With Electronic Computers / Controllers Institute Research Foundation, 2 Park Ave., New York 16, N. Y. / 1959, printed, $5.00

This book provides "a synthesis of what has been learned from electronic data processing installations." The authors have assembled information offered by seventeen "first users" of computers. The general principles set down will be of particular interest to those in the higher ranks of business management. The parts of the book include: Making the Decision; Preparing for and Introducing Electronic Equipment; Company Education and the Programming Group: Development of the Applications; Conversion from Prior Methods; Operating Electronic Equipment; etc.

Racker, Joseph / Technical Writing Techniques for Engineers / Prentice-Hall, Inc., Englewood Cliffs, N. J. / 1960, printed, 234 pp, $6.95 ($5.20 for classroom text).

Engineers and technicians will find in this valuable book a set of rules and general information on the proper ways to write technical reports, presented in handbook style. The author is vice president and chief engineer of U. S. Electronic Publications, Inc., and a member of the Society of Technical Writers. The five chapters are entitled: Introduction; Selecting and Writing at the Proper Level; The Right Word; Technical Illustrations; and Preparation of Technical Manuscripts. Glossaries are included of the following kinds of technical terms: air force; automation; computer; electrical and electronic; guided missile; radio and radar navigation; space technology; transistor.

NEW PATENTS

RAYMOND R. SKOLNICK
Reg. Patent Agent
Ford Inst. Co., Div. of Sperry Rand Corp., Long Island City 1, New York

The following is a compilation of patents pertaining to computer and associated equipment from the "Official Gazette of the U. S. Patent Office," dates of issue as indicated. Each entry consists of patent number / inventor(s) / assignee / invention. Printed copies of patents may be obtained from the U. S. Commissioner of Patents, Washington 25, D. C., at a cost of 25 cents each.

January 3, 1961

2,967,018 / Laurence E. Fogarty, Binghamton, New York / General Precision Inc., a corp. of Delaware / An analog computing apparatus for providing an output potential commensurate with the time integral of the product of two inent quantities which vary with time.

2,967,019 / John Turtora, Fairfax, Va. / U. S. A. as represented by the Sec. of the Navy / A frequency controlled integrator.

2,967,030 / Cary T. Isley, Jr., Los Angeles, Calif. / The Martin Co., a corp. of Maryland / An electrical computer.

2,967,250 / Harvey A. Druker, Lansdale, and Laurence R. Brown, Berwyn, Pa. / Briggs Associates, Inc., Morristown, Pa. / An electronic shift register.

2,967,296 / Kun Li Chien, Fullerton, Calif., and Charles H. Propster, Jr., Haddonfield, N. J. / R.C.A., a corp. of Del. / An information extracting system.

January 10, 1961

2,967,664 / Thomas I. Ress, Los Angeles. Calif. / I.B.M. Corp., New York, N. Y. / An electro-optical data processing system.

2,967,665 / Theodor Einsele and Karl Ganzhorn, Sindelfingen, Germany / I.B.M. Corp., New York, N. Y. / A magnetic core adding device.

2,967,954 / Gilbert L. Hobrough, Scarborough, Ontario, Canada / Hunting Survey Corp., Lim., Toronto, Ontario, Canada / A diode lattice multiplier with inherent limiting.

2,968,026 / Robert J. Froggatt, Norwood Green, Southall, Eng. / Electric and Musical Ind., Lim., Hayes, Eng. / A storage arrangement, especially for electrical data handling apparatus.

2,968,027 / James A. McDonnell, Binghamton, Joseph M. Terlato, Bronx, and Jack E. Greene, Vestal, N. Y. / I.B.M. Corp., New York, N. Y. / A data processing system memory control.

2,968,028 / Eiichi Goto and Hiroshi Yamada, Tokyo, Japan / Fuje Tsushinki Seizo Kabushiki Kaisha, Kawasaki, Japan / A multi-signal controlled selecting system.

2,968,029 / Herman K. Grosser, Hilversum, Netherlands / North American Philips Co., Inc., New York, N. Y. / A permanent memory storage comprising magnetically bistable cores arranged in rows of M—coils each.

2,968,030 / Hewitt D. Crane, Palo Alto, Calif. / Burroughs Corp., Detroit, Mich. / A magnetic core flip-flop circuit.

January 17, 1961

2,968,439 / Jan A. Rajchman, Princeton, N. J. and George W. Brown, Pacific Palisades, Calif. / R.C.A., a corp. of Del. / An electronic digital binary computer.

2,968,693 / Francis J. Gaffney, Westport, Charles A. Wesley, Ridgefield, and Charles P. Bukowski, Cos Cob, Conn. / The Teleregister Corp., Stamford, Conn. / A simultaneous-to-serial permutation code converter.

2,968,694 / George E. Schwender, Huntington, and Richard A. Vanderlippe, Bloomfield, N. J. / Bell Telephone Lab., Inc., New York, N. Y. / A code signal programmer.

2,968,791 / Ellsworth L. Johnson, Billerica, Mass., and Pasquale W. Rocco, Poughkeepsie, and Dan C. Ross, Wappingers Falls, N. Y. / I.B.M. Corp., New York, N. Y. / A buffer storage system.

2,968,792 / Francis V. Adams, Endicott, N. Y. / I.B.M. Corp., New York, N. Y. / A compacted word storage system.

2,968,793 / John C. Bellamy, Barrington, Ill. / Cook Electric Co., Chicago, Ill. / A system, method and apparatus for processing data or information.

2,968,795 / George R. Briggs, Princeton, and Arthur W. Lo, Fords, N. J. / R.C.A. Corp., a corp. of Del. / A magnetic shift register system.

2,968,796 / John H. Lane, Altadena, and Victor M. Walker, South Pasadena, Calif. / Burroughs Corp., Detroit, Mich. / A magnetic core transfer circuit.

2,968,797 / Eugene W. Sard, Flushing, N. Y., and Harvey Salz, Belleville, N. J. / U. S. A. as represented by the Sec. of the Army / a magnetic core binary counter system.

2,968,798 / Donald L. Drukey, Manhattan Beach, Calif. / Thompson Ramo Wooldridge, Inc., Cleveland, Ohio / A magnetic transducing method and system.

2,968,799 / James T. Smith, San Jose, Calif. / I.B.M. Corp., New York, N. Y. / A transducer for generating signals in response to magnetic fields emanating from a magnetic recording surface.

January 24, 1961

2,969,478 / John P. Eckert, Jr., and Herman Lukoff, Phila., Pa. / Sperry Rand Corp., a corp. of Del. / An information storage system.

2,969,522 / James S. Crosby, Jr., Rhinebeck, N. Y. / I.B.M. Corp., New York, N. Y. / A data transmission and storage system.

2,969,524 / David R. Bennion, Loma Mar, Calif. / Burroughs Corp., Detroit, Mich. / A bi-directional shift register.

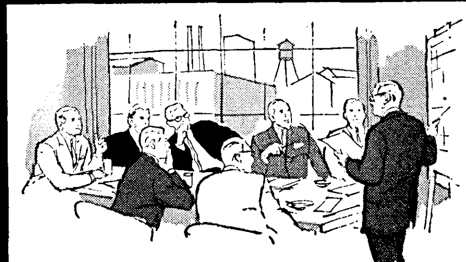
2,969,525 / John L. Hill, North St. Paul, Minn. / Sperry Rand Corp., a corp. of Del. / An apparatus for locating information recorded in a section of one of a plurality of information tracks.

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.

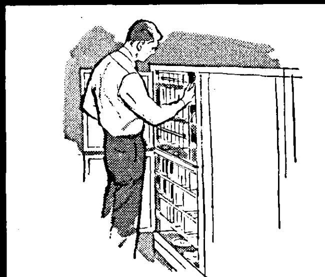
Customer Training

Programming



Management Seminars

Career Opportunities in Computer Marketing



Installation and Maintenance

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SALES REPRESENTATIVES who are experienced in the preparation of presentations to top management groups and who have established a record of success in data processing sales.

SYSTEMS ANALYSTS experienced in the study of customer's problems and individual data processing needs who can suggest economical and practical systems configurations for a particular application.

PROGRAMMERS experienced in scientific, business and commercial programming who can provide on-site assistance to customers.

EDUCATIONAL SPECIALISTS who can develop comprehensive courses to train personnel for the optimum performance of a data processing system.

INSTALLATION and MAINTENANCE ENGINEERS experienced in all phases of installation, start-up and continued maintenance of transistorized large scale data processing equipment.

PUBLICATIONS SPECIALISTS who can prepare technical sales bulletins, instruction manuals, reports and other material on the subject of electronic data processing.

CONTACT
Mr. John Felos
Professional Placement Mgr.
PHILCO/COMPUTER DIV.
Willow Grove, Pa.

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