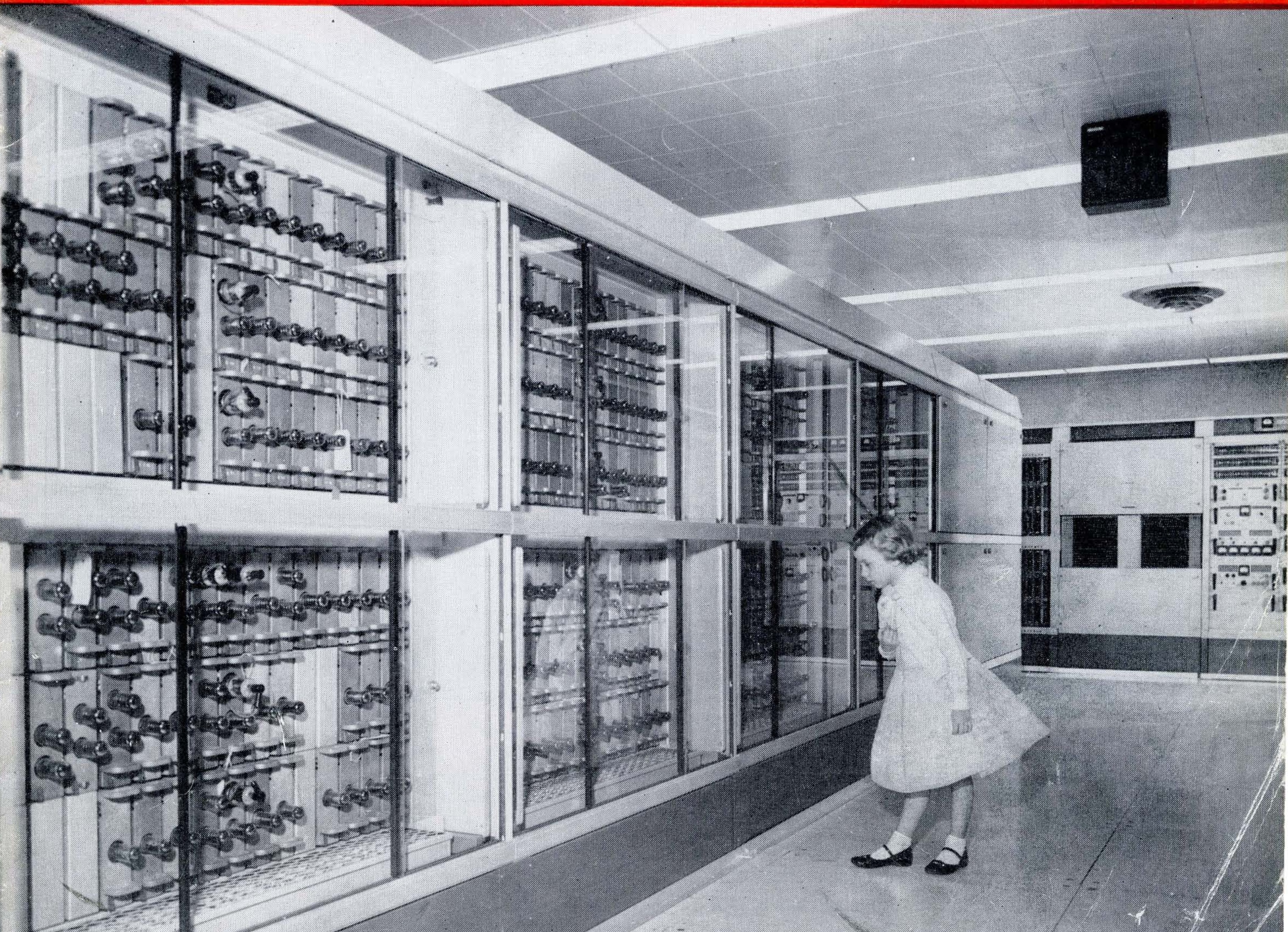
COMPUTERS
and AUTOMATION

DATA PROCESSING • CYBERNETICS • ROBOTS



APRIL
1958

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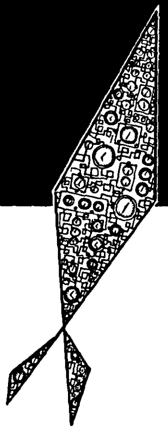
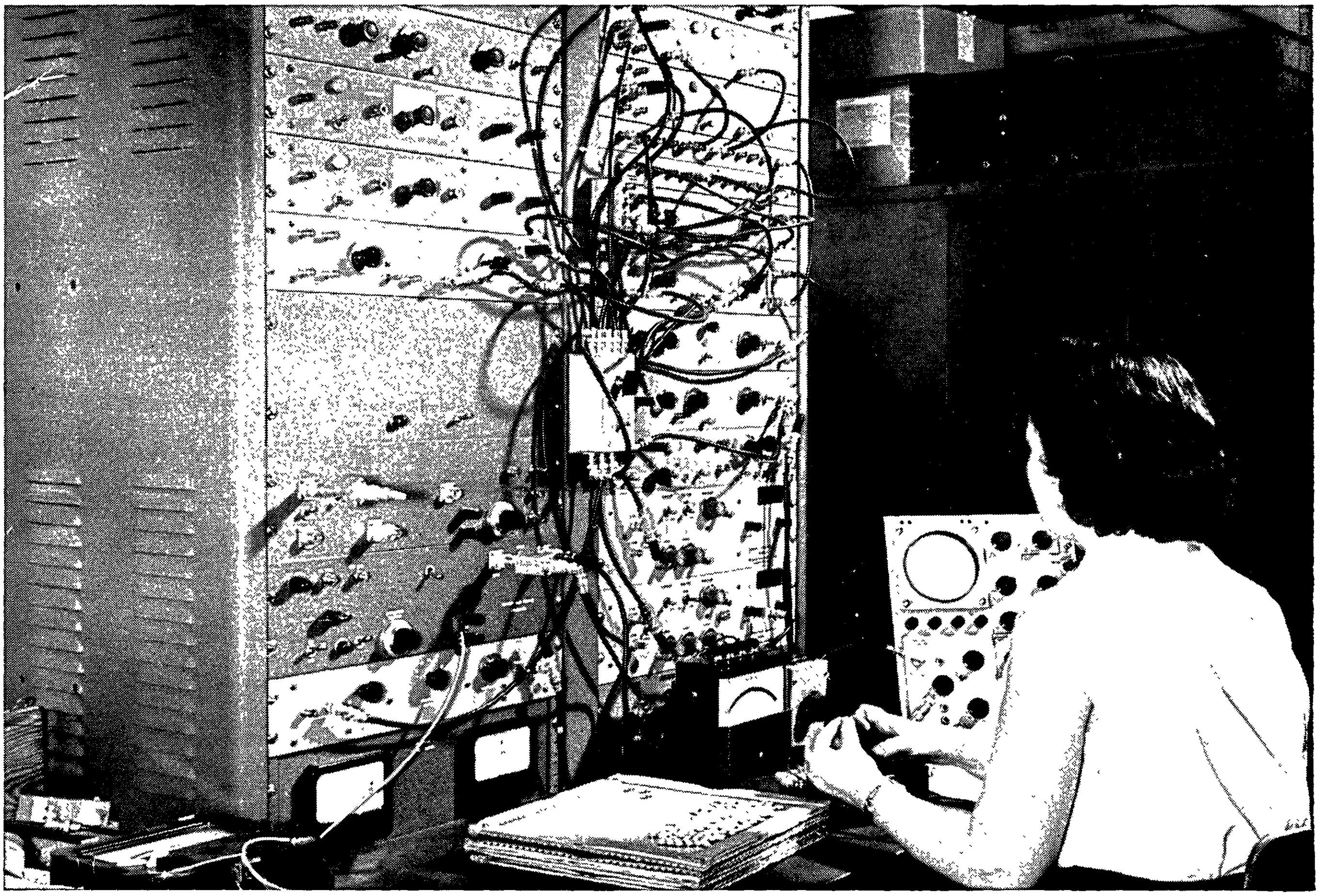
Miniature Complex Cams: A Computer Case History

Information Storage Devices: A Component Case History

Automatic Quality Control Computers

Languages, Logic, Learning, and Computers





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COMPUTERS
and AUTOMATION

DATA PROCESSING • CYBERNETICS • ROBOTS

Volume 7
Volume 4

APRIL, 1958

Established
September 1951

FRONT COVER

ARTICLES

READERS' AND EDITOR'S FORUM

INDUSTRY NEWS NOTES

REFERENCE INFORMATION

INDEX OF NOTICES

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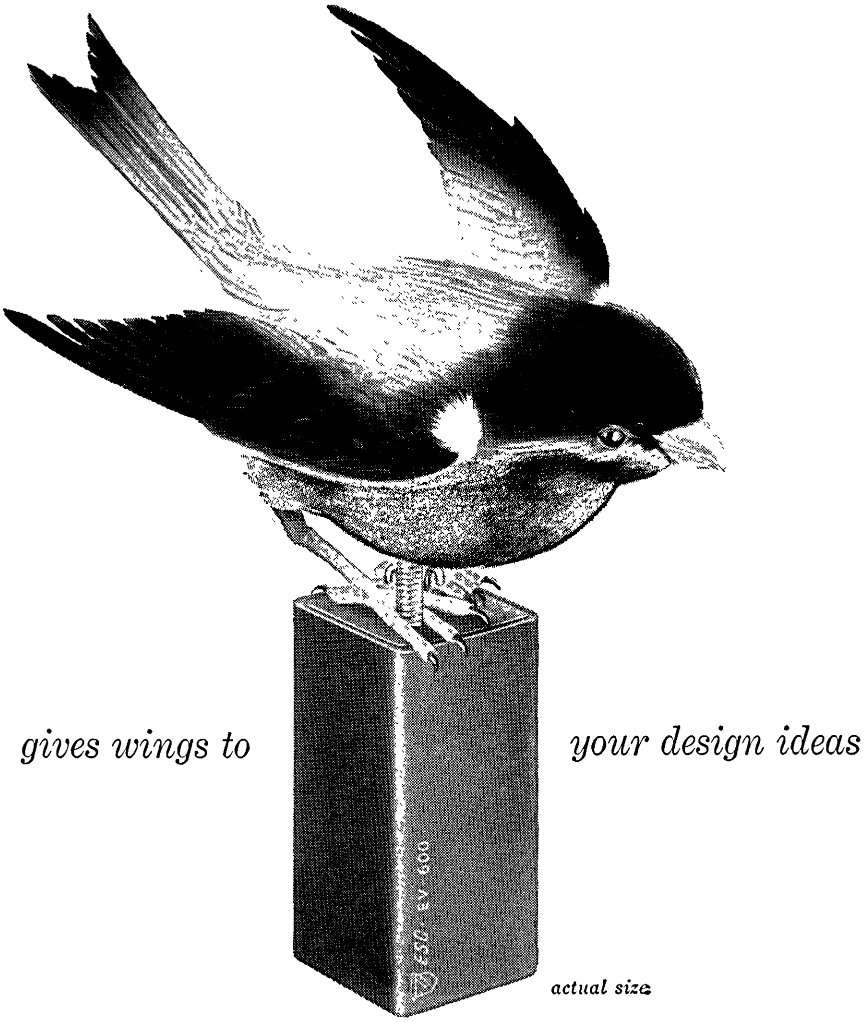
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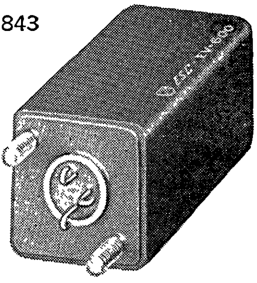

Readers' and Editor's Forum

FRONT COVER: INSPECTION OF GIANT COMPUTER BY HOSPITAL PLAN SUBSCRIBER

The front cover shows a young hospital plan subscriber, Shari Weber, age 4, looking at one of the 24 sections of a giant automatic computer, which commenced operating February 18 in Detroit. The machine is the Datamatic 1000, made by the Datamatic Division of Minneapolis Honeywell, Newton Highlands, Mass. Each reel of magnetic tape in this machine is 2700 feet long, and the magnetic tape is 3 inches wide. The reel can store all the data for 180,000 members of the Detroit Blue Cross Blue Shield Plan. In one second the Datamatic system "reads" and "writes" at the rate of 60,000 decimal digits, while simultaneously doing 1000 multiplications or 4000 additions, or some combination of them and other operations, depending on the programming.

THE SOCIAL RESPONSIBILITY OF COMPUTER SCIENTISTS

I. From the Editor

In the January issue of "Computers and Automation," we began to discuss the subject whether computers and automation were a "curse or blessing." We raised the question, "What should a magazine do about arguing these subjects, accepting a social responsibility about them, taking an editorial stand on them?" We asked for votes from readers on this issue, "YES, let's discuss and argue the social responsibility of computer scientists, or NO, let's stick to the technical side, and leave the controversial subject of the social effects of computing devices to other people."

We are glad to have received the following eight votes up to February 14, and we are grateful to those who sent them.

II. From Readers:

R. E. Cordray, Chico, Calif.

Yes. Do discuss social responsibility. (But in separate articles or features).

Russell Chauvenet, Silver Spring, Md.:

YES. — I vote for more discussion of social responsibility of computer scientists. It is not a truly scientific attitude to disclaim responsibility for or interest in the consequences of our work.

A. W. Trorey, La Habra, Calif.:

Re your January 1958 editorial, speaking for myself, YES.

Robert J. Huhn, Newark, Del.:

In regard to your editorial in your January 1958 issue concerning the social responsibility of computer scientists, I feel definitely YES, you should discuss the subject. You should however confine yourself to the subject of computers and their impact on society, leaving other technical fields in which computers are used, such as rockets, missiles, H-bombs, to those whose primary responsibility or field of interest these things are. Of course, when computers make possible large changes in these fields, one gets involved; however I suggest that your editorial policy should avoid such involvement except when absolutely necessary. There is plenty to be done in just the impact of computers themselves on people and their institutions.

Walter B. Morton, Jr., Anaheim, Calif.:

By all means, discuss! We and our professional societies are lopsided and unintegrated members of the body politic. To mix a simile, we resemble Achilles sulking in Plato's cave.

Frederick B. Wood, San Jose, Calif.:

I say YES, let's discuss the social responsibility of computer scientists in "Computers and Automation."

Norman E. Polster, Southampton, Pa.:

I have just polled a few of my associates in the Research and Development Department on the question raised in "Readers' and Editor's Forum." "Should we discuss and argue the social responsibility of computer scientists?" Each said emphatically "Yes!" One said there should be good reason before an editor should refrain from expressing his ideas and those of his readers.

Mahatma Gandhi once illustrated the importance of choosing the right issue: it is best not to argue about segregation in bar rooms if you are fundamentally opposed to bar rooms themselves. Our technical organizations do just this when they sidestep the issues of personal social responsibility of the scientist regarding the uses for his work, by discussing instead integrity in any work.

The scientist has a special moral responsibility to society in our modern world because of the widespread devastation that his inventions can produce. It is not sufficient to continue to work at a job that you feel is morally wrong, and then say I will do all in my power as a citizen of a democracy to change the result of the work. It is necessary to be active as a citizen, to be sure, but it is more important for one's own moral strength to continue to examine the use to which one's work is put and then make a moral judgment. It is as simple as saying "For me this is right, or for me this is wrong." Until scientists measure up to the tremendous social responsibility that is placed on their shoulders, our world will continue to be a precarious mixture of "curse or blessing."

Robert Tscudin, Sappington, Mo.:

Re your note in the January issue of "Computers and Automation" — Let's not be quiet! By all means, raise hell! A little more noise is needed at this point in our history.

III. From the Editor

Among the readers who have written to us there is unanimity: YES, discuss. Perhaps 8 votes for and no

[Please turn to page 9]

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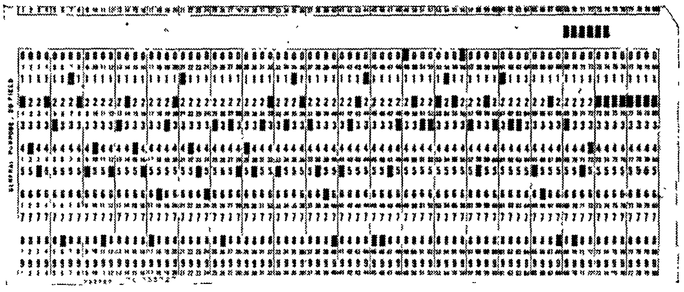

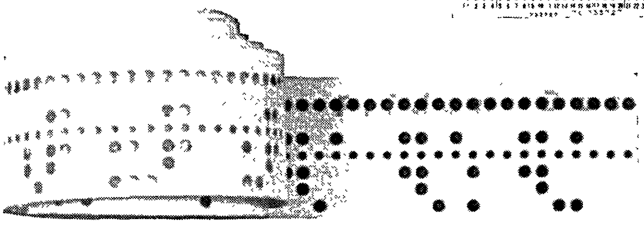

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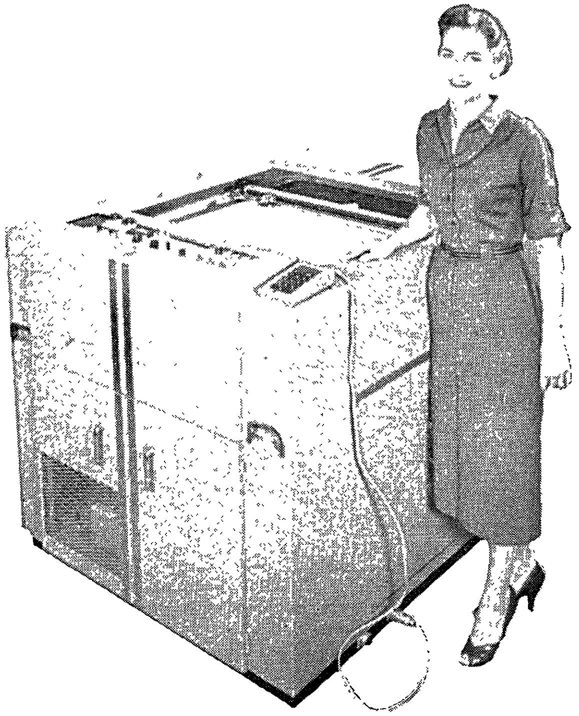

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How to speed up a digital computer

New Ampex Digital Tape System quickens input and output

Ampex's new digital tape equipment is to computers as a super-super highway would be to 1958's new 300 horsepower automobiles. Computer arithmetic can move at electron speeds — but previous input/output rates have been like bumper-to-bumper traffic. Now the jam is broken.

60,000 six-bit characters per second is one of several transfer rates available on the new Ampex Digital Tape System. Depending on how you can accept the data, some Ampex rates are even faster, others are somewhat slower.

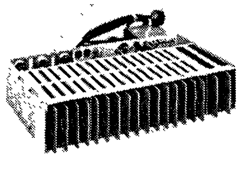
FR-300 Digital Tape Handler

To achieve a livelier pace . . . a SYSTEM of new equipment

In a complete digital computer, the Ampex equipment provides two neatly packaged functions: input source and output receiver. By treating these as systems unto themselves, Ampex achieves optimum performance and reliability. In them, four interdependent items have been matched: tape handler, heads, amplifiers and magnetic tape. For the total result, the four are inseparable.

The Ampex FR-300 tape handler operates at 150 inches per second. With this new speed plus other format improvements contributed by the other Ampex components, transfer rates can be increased up to six fold over previous standards. Search times too can be reduced to one sixth.

The FR-300 starts or stops in 1.5 milliseconds. These times can be depended upon indefinitely. Hence they drastically reduce the buffer storage requirements of the computer system. Also, inter-record distances are accurate and are shortened by half.



Complete Electronic Assembly

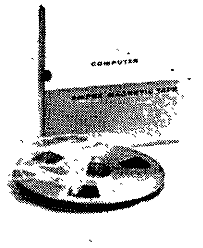
Despite its racehorse gait, the FR-300 is a workhorse machine thoroughly tested and perfected in a year-long component shakedown. Its dependability and low maintenance requirements are aimed at increasing the computer's available working hours per day.

Two other Ampex tape handlers, the FR-400 and FR-200A operate at lower speeds, serving smaller computers and auxiliary digital equipment such as converters, printers, etc.

Read/write heads and amplifiers work together to achieve higher bit-packing densities. On the Ampex system, the 200-bit-per-second standard is conservative. Ampex's new heads can resolve pulses much closer than this. And the amplifiers easily handle the tremendous transfer rates achieved when closer bit packing and high tape speeds are combined. All-transistor design of the amplifiers achieves extreme reliability and compactness.

Ampex computer tape, a new specially formulated type, plays a key part in system reliability. To reduce *significant* dropouts and spurious noise to zero, the tape is manufactured in a completely air-conditioned plant. Employees wear lintless "surgical" clothing. And each reel is individually tested and packaged within two hermetically sealed wraps.

A tough new oxide binder on Ampex Computer Tape withstands many times the use of any previous "long wear" tapes. Virtually no oxide rubs off; heads need much less frequent cleaning. Precision reels, available as an option, protect the tape edges from damage and improve tape handling and guidance.



A newly published brochure is available describing all components of the Ampex Digital Tape System and explaining performance specifications. May we send you a copy?

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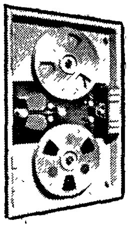
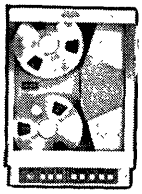
MAGNETIC TAPE APPLICATIONS BY AMPEX

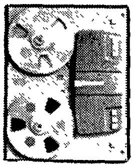
11 ONE OF A SERIES



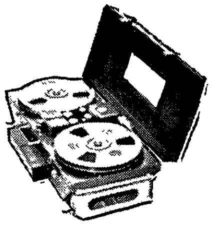
Series FR-100



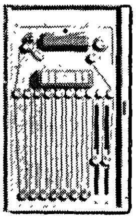
Model FR-400 Digital



Model FR-200A Digital



Series 800 Mobile and Airborne



Series FL-100 Loop Recorders

Model MR-100 Missile Recorder

Readers' and Editor's Forum

[Continued from page 6]

votes against indicate that there is a significant majority of our readers who are in favor of "discussion and argument" over the social responsibility of computer scientists. So we shall act accordingly, until we find contrary evidence.

"Computers and Automation" invites discussion and argument over the social responsibility of computer scientists — in all fields where computers are apparently an essential ingredient in the success of devices in that field. Let's consider some examples of these fields, where computer scientists have a social responsibility:

1. The application of computers in the social and economic planning of a society: it could be reasonably argued that the really successful social and economic planning of a society requires the use of automatic computers so that good solutions to the enormous problems can be found.

2. The application of computers in military radar warning systems, automatic analysis of possible attacks, and automatic replies, like SAGE. It is evident that the success of these devices depends intimately on computers.

3. The application of computers to the guidance of rockets, missiles, supersonic aircraft, etc. It is evident that the success of these devices depends intimately on computers. A ballistic missile would be worthless without good automatic programming inside of it, and good automatic navigation of it.

In fact, if the computer art could be wiped out at this moment, all threat of intercontinental ballistic missiles with nuclear warheads would be eliminated, for there would be no way to direct them to a target.

How can computer scientists fulfill a social responsibility?

First, a computer scientist can think about what is right about computer applications, and what is wrong, and what his conscience tells him he ought to do. This kind of thinking will take time away from designing new circuits, inventing new materials, and working out new programs — but it may lead to more happiness for human beings generally, as a result of the invention and development of computers.

Second, a computer scientist can discuss with other people the subject of social responsibility. Certainly, in these days a good "organization man" is not expected to raise questions about right and wrong, and his own responsibility, but to accept without question the standards of right and wrong of the team and of the organization in which he happens to be working. But it is not right for a man to delegate his conscience to anyone else.

Third, a computer scientist can refuse to do what he thinks is wrong and accept the consequences of doing what he thinks is right, harsh though they may be.

Fourth, he can raise his voice, express his ideas on paper, write letters to Congressmen, and organize with other people — to help make computers lead to more happiness for human beings generally. Certainly, work on computing systems for spreading poison gas effectively will not lead to more happiness for human beings generally.

The ways in which computer scientists can help make computers a blessing for society and not a curse constitute a big subject. Yet it has not received the attention in books and papers which it deserves. "Computers and Automation" will welcome articles and papers which deal with this subject.

COMMENTS ON "ARE AUTOMATIC COMPUTER SPEEDS FASTER THAN BUSINESS NEEDS?"

I. From: Ned Chapin

Stanford Research Institute
Menlo Park, California

Mr. Thomas E. McDonnell, Jr., Operations Analyst at Stanford Research Institute, has pointed out a valuable improvement in Footnote No. 5 in my article "Are Automatic Computer Speeds Faster than Business Needs?", published in "Computers and Automation" October, 1957.

The present footnote, on page 17, is a technically accurate statement but can be made more significant by the following rewording:

> That is, if the processing speeds be measured in microseconds per unit, the ratio of the costs of the faster automatic computers to the costs of the slower automatic computers is less than the ratio of the speeds of the slower automatic computers to the speeds of the faster automatic computers."

Since the improvement is of general interest, may I suggest it for your Forum columns?

II. From: Harold Weiss

Phoenix, Arizona

I should like to offer some extensions and reservations to Mr. Ned Chapin's provocative article, "Are Automatic Computer Speeds Faster Than Business Needs?", which appeared in the October 1957 issue.

1. Mention of buffering is essential to a discussion of speed limitations on computer data handling. The buffer is a storage device which helps to match the slower information transfer rates of peripheral equipment to the relatively high internal processing speed of computers. In an unbuffered machine (some of which are still being developed) there is direct addition of the time required for input, output, and computation. In a buffered machine, significant overlaps of these operations may occur. Programming techniques exist which make valuable use of buffers. For example, multiple input subroutines allow the storage of input data in the internal memory before the information is required for processing. This may effectively do away with the input limited problem in many cases.

   In view of the above statements, it is not valid to classify every application under one of the three broad categories of limitation. This obviously does not apply to the unbuffered machine. Even on buffered machines, one encoun-

[Please turn to page 26]

A Computer Case History:

MINIATURE COMPLEX CAMS

Phyllis Huggins

Bendix Computer Division
Bendix Aviation Corp.
Los Angeles 45, Calif.

In a matter of minutes, today's aircraft and missiles pass through the earth's troposphere into the stratosphere and higher. Tremendous amounts of energy are generated in order to challenge space, time and gravity. Supersonic flight demands microsecond coordination of many complex automatic systems responsible for effective operation; and there is no margin for error. Precise information regarding airspeed, air temperature, air pressure, and angle of attack must be derived, even while these factors are continually and rapidly changing. Both the automatic controls and the indicators the pilot (if any) reads, require information of this kind fed into them.

This information is provided by a complex airborne device called the Central Air Data Computer, designed and manufactured by Eclipse-Pioneer Division of Bendix Aviation Corporation. This computer supplies to other systems of the aircraft the critical data concerning the atmosphere through which the aircraft is flying. This information is obtained from measurements directly involving the airstream surrounding the aircraft. By means of mechanical differential gear assemblies, and computing and correcting cams, various desired output functions of the sensed variables are computed: Mach number, true airspeed, air pressure, altitude, free stream air temperature, air density, and some more. All of them play an important part in such flight operations as fire control, flight and power plant management, automatic systems such as the autopilot, and determination of range and flight path in navigation.

Essential to the precise functioning of gears, mechanical differentials, and servo loops, are a dozen or more small cams, the size of a 50c piece, used at various critical points in a single computer. The accuracy required is so delicate and stringent that the various radii are computed and machined to the nearest ten thousandths of an inch, and approximately 1400 radii must be calculated for one cam.

PROBLEM: How compute and machine those cams?

The Bendix G-15 General Purpose Computer was put to work, to complete the radii. Hundreds of thousands of equations that would take an engineer 3 years to calculate solutions for and possibly a 4th year to check the solutions, were solved in 40 hours.

The following is a sample of the computer typeout. This becomes the data used by the jigborer in cutting the cam.

MACH	ANGLE (degrees)	RADIUS (inches)
.179	0.	.8125
.179	.	.8117
.179	.	.8110
.179	.	.8102
.180	1.	.8095
.180	.	.8087
.180	.	.8080
.181	.	.8072
.181	2.	.8065
.181	.	.8057
.182	.	.8050
.182		.8042
.182	3.	.8035
.183	.	.8027
.183	.	.8019
.183	.	.8012
.183	4.	.8004
.184	.	.7997
.184	.	.7989
.184	.	.7982

Most cam designs can now be solved in two days of programming and debugging — checking the program for errors — and with three hours of computation and typeout time. Conservatively, this represents a time saving of 150 to 1 for an average cam. For a more complicated cam, this may represent a 200 to 1 or even greater saving. And the cost saving may be 50 to 1.

This assignment is typical of the demands of micropackaging with high accuracy performance, found in all guided missile engineering problems. Not so long ago, creating the design of a simple two-dimensional master cam took three to five weeks of an engineer's time for manual computation alone, and then two weeks of a skilled worker's time cutting the cam. If design specifications were to change during this period the entire process was started over again. Such a method is as much adapted to the high criteria and tight schedule of today, as is a horse and buggy to a freeway.

With the aid of a G-15 General Purpose Computer, Eclipse-Pioneer Division recently completed computations for some 50 rocker arm cams. Figuring conservatively, the computer solved six to eight thousand equations for each cam solution. To perform the computations manually requires approximately four to five weeks per cam and the results still remain unchecked and lack resolution and angular definition.

It is becoming increasingly common that "automation in mathematics" is not just a nice thing to have, but an urgent necessity. Waste motion is an obvious extravagance to be avoided on an assembly line. Waste mental energy in research and engineering departments is an extravagance of equal seriousness.

In the first year's operation of the G-15 computer installation, the computer was working an average of 52 hours per week. Also, the Bendix DA-1, digital differential analyzer accessory, was added to the system February 1957; it is being used in the solution of differential equations.

[Please turn to page 20]

A Component Case History:

INFORMATION STORAGE DEVICES: A KEY TO AUTOMATION

Part 1

Richard J. Bengston
Battelle Memorial Institute
Columbus, Ohio

and

Joseph E. Smith, Jr.
Bryant Gage and Spindle Div.
Bryant, Chucking Grinder Co.
Springfield, Vt.

The first information storage device used while computing and calculating is of course the human mind. But it forgets — quite easily.

Man probably began to supplement his memory — to try to avoid forgetting — by using piles of stone, notches on sticks, and later crude drawings. His success with these methods led to the development of written languages, and methods of reproducing the languages. Thus, he provided himself with devices for organized information storage: monuments, scrolls, slates, paper and ink, books, ledgers, filing systems. The development of civilization rapidly increased the need for computation and record keeping.

Modern Information Storage

Many significant mathematical, mechanical, and electronic inventions have aided in the development of information storage devices made of hardware. Punched cards were developed in the early 1800's to control automatic weaving machines; in the 1890's they were applied to digital calculations of census figures. After that time, punched cards became, until recently, the standard method of storing information in offices where a large volume of computation must be performed; they allowed machines to replace human beings in the processing of data. Cards did this by providing a low-cost, large-capacity memory that was intelligible to properly programmed machinery. This was a major advance in information storage and data processing.

Electronic Computers

In the 1940's, 50 odd years after punched cards were applied to office work, the next major advance in information storage took place, the development of electromechanical and electronic computers containing new types of information storage devices. A modern electronic computer can calculate over 1000 times faster than electromechanical punched card equipment. One sign of the need for this greater speed is the rapid increase in clerical workers in recent years. It is estimated that between 1940 and 1954, the number of clerical workers in the United States increased 50 per cent faster than total employees. This increase occurred in spite of great strides in office mechanization by mechanical methods. If electronic automation can release these clerical workers for other productive work, the potential savings to business are huge.

Initial Information Storage Devices

The first information storage devices used in computers had to be developed to give the computer information much faster than was possible with punched cards. This problem was solved by coding a bank of vacuum tubes so that the sequence of their "on" or "off" states would express a binary code for numbers or words. This allowed information to be put into or taken out of storage at electronic speeds of less than a millisecond, rather than the half second required with a punched card even after it is in the right place for reading.

Since several vacuum tubes, plus associated circuits, were required to store each digit, a large-capacity memory using vacuum tubes was costly, bulky, and unreliable. Better high-speed memories were needed.

The next two developments were the mercury acoustic delay line and the cathode ray tube, as information storage devices. In the mercury acoustic delay line, information was "stored" dynamically in a large tank of mercury as a circulating train of pulses or absences of pulses. This type of memory was still bulky and inconvenient; its reliability depended on precise temperature control. The storage of information on the face of a cathode ray tube as the presence or absence of charged spots, although giving rapid access introduced still greater problems of reliability.

Electromagnetic Storage

The next two information storage devices were magnetic drums and magnetic tape. In both devices, information is stored as polarized or oppositely polarized or unmagnetized spots on a magnetic coating. This coating is on the surface of a revolving drum or on or in the surface of magnetic tape.

In the case of the rotating drum (a cylinder), information can be written on to or read off from the drum in a few thousandths of a second, since the entire drum surface is scanned by the heads during each complete revolution. Low cost, high capacity, exceptional reliability, and random access times of a few milliseconds are the outstanding characteristics of magnetic drums. They are widely used today as primary memories for small-sized and medium-sized computers, and as auxiliary memories for large-sized computers.

Magnetic drums have one major shortcoming. It is virtually impossible at the present state of the art to rotate drums fast enough to achieve access time much below one millisecond, whereas access times of a few microseconds are desirable for large computers. To fill this need, arrays of small magnetic cores of ferrites have been developed. Although more costly and bulky, and somewhat less reliable than drums, cores can give random access times of less than ten microseconds. They have rapidly become the standard primary memories for large-sized computers. They are frequently supplemented by large-capacity magnetic drum memories.

In addition, magnetic disc memories have developed. Although discs have received less attention than drums, major improvements in magnetic disc devices can be expected in the near future.

For storage of information external to the computer, magnetic tape has been very widely applied. It bridges the gap between conventional records including punched cards, and the electronic computer internal memory. Data are regularly fed into and taken out of a computer by means of magnetic tape.

Magnetic recording tape was developed in Germany in 1935. It was not introduced into the U. S. until 1945 at the close of World War II. It rapidly became the standard method for recording film sound tracks, phonograph record masters, and radio programs. It was adapted for use with electronic computers in the early 1950's. Magnetic tape is expected eventually to replace many present conventional records. Although there are legal and other problems involved in magnetic records, these problems are not considered insurmountable. The potential saving in space and handling is huge, since a single roll of magnetic tape can store the same information that requires millions of punched cards. For example, a three-inch wide by twelve-inch diameter roll of tape is equivalent to over 35,000,000 punch cards — a large room full of cards.

Future possibilities for information-storage devices include: ferro-electric materials such as barium titanate to replace ferromagnetic cores, and photographic emulsion records to replace magnetic tape. Although both these devices offer potential advantages such as higher capacity per unit volume and perhaps lower cost, the technical problems involved are still formidable.

Other Information Storage Needs

Besides the use of modern information storage devices in computers, there are other needs. Books, magazines, and quantities of different kinds of printed, typed, and written records are, of course, an outstanding example of information storage. The need to condense and to make accessible these conventional records is placing a tremendous demand on new information storage devices such as magnetic tape, microfilm, microcards, etc.

Audio memories are important in communications. Magnetic tape is widely used as a medium for radio recordings. This use is increasing as magnetic tapes are offered to the retail market in competition with mechanical-storage phonograph records. The armed forces are currently testing drum memories for giving audio instructions to aircraft pilots. Advantages over live instructions include higher speed, pronunciation more easily understood, and no chance for making mistakes in wording.

Video memories other than photographic film are rapidly becoming important. Magnetic tape will replace much of the photographic film to record television programs in 1958. Magnetic drums are being used by Bell Telephone Laboratories in the transmission of the picture in the developmental "visual telephone" where users can *see* each other. Magnetic drums will probably find wide use in the transmission of television programs in the future. Drums will store the information that describes the picture, and only changes in the picture will be transmitted as they occur. Thus, much smaller capacity transmission channels will be required than needed with conventional full-picture transmission. Other specialized applications for magnetic drum memories are in slow-scan television and radar equipment.

Geophysical exploration requires storage of information for several exploration techniques. In such methods as electrical logging, seismic prospecting, magnetometer surveys, and other exploration methods, large quantities of data must be compared. Also, precise time intervals are often important in geological logging. The magnetic memory records data rapidly during prospecting, but readout can be slowed down and/or repeated to allow accurate, attentive, detailed analysis of data recorded.

Other information storage needs include:

Analog recording
Analog time delay
Transient reading
Speech analysis
Phase shifting
Delayed telemetering
Temporary recording of dictation and court proceedings
Nonhuman telephone answering
Expansion (in time) of data.

Market Size

Electronic data processing is a new field. The first truly electronic computer (Eniac) was finished in 1946, but it was not until 1955, that computers actually reached the production phase of their development. More general-purpose computers were built in 1955 than in the 11 previous years combined. A combination of factors contributed to this sudden increase in sales:

(1) The acceptance of electronic computers as valuable tools for office mechanization.
(2) The tapping of a broader market potential by introduction of medium-sized and small-sized computers.
(3) Programming methods that greatly reduced the effort required to set up problems.
(4) Increased component reliability.
(5) Larger memory capacities.
(6) Development of many accessory devices to increase the flexibility of computers.
(7) Extensive research on computer applications.

Annual sales figures for electronic computers are not readily available. Published estimates are somewhat incomplete and contradictory. But, in our opinion, the market for electronic digital computers and associated equipment, was about $½ billion in 1956 and will be about $1 billion in 1960 and $1½ billion in 1964.

This estimate is probably conservative. It is based on growth in present applications in scientific, office and military applications. Major new developments in the field, such as substantial reductions in computer prices, additional large-scale applications in factory automation, or major advances in data-processing techniques could cause markets to grow faster than estimated.

Possible future developments in automation and information storage may be outlined briefly as follows:

- The increasing complexity and speed of military systems will require a much higher degree of automation in the future, both on the ground and in the air. Information storage devices of sizes and speeds now considered impractical, will be used.
- Radically new systems of information storage will be developed for large-sized and medium-sized corporations. These will depend on magnetic tape or discs or other memories that will allow data to be made available in seconds or less.
- Planning and control of production processes and even entire plants will be automated electronically in the future. Sales information will be fed to the

systems, and finished goods will be produced, packaged, and loaded for shipment automatically.

- New concepts will be applied to the storage of information and processing of data in department stores, chain stores, banks, wholesale distributors, and other commercial enterprise with large numbers of daily transactions. Purchases selected from display stock will be delivered automatically to pickup points or made ready for delivery.
- Automation of transportation activities such as passenger reservations, freight routing, and materials handling will increase rapidly. On-time operations with more efficient utilization of equipment will result.
- Simple computers will be used in homes to aid household operations. Lights, windows, appliances, etc., will be controlled by computers.

Information-Storage Devices

Automation, whether in the office, bank, military installation, or factory, depends on the automatic availability to the machines of pertinent information. In a factory, the information often may be easily provided to a machine tool by specially shaped cams. In an office calculating the payroll for a few hundred employees, punched cards can readily supply the information to mechanical handlers and computers. But in large offices where many data must be handled and many computations made, and if electronic computers are to operate at economic speeds, the information must be in other than mechanical form.

Criteria for Information-Storage Devices

In automation applications, the properties of the information storage device or memory are central to the good functioning of an electronic computer. The capacity, the permanence, the recall time, and the reliability of the information storage device are of vital importance to the solution of problems. Thus, the major criteria for an information-storage device are:

- *Access time* — the time required to transfer information from the memory unit through the associated circuitry to the point of need. This should approach zero.
- *Capacity* — the number of bits, digits, alphabetic characters, or numeric or alphabetic words that the memory unit can hold at one time. This should be high per unit volume.
- *Reliability* — the ability of a memory unit to accurately accept, retain, and to give up information as required. This should approach 100 per cent. It should operate with only routine maintenance for the life of the computer.
- *Cost* — the total installed cost of a complete memory system (the basic memory device, plus associated accessories and circuitry) per bit of information. This should be as low as possible.
- *Sensitivity to environmental factors* — the effect of temperature, humidity, and dust on the operation of the memory unit. The memory should be insensitive to such factors.
- *Permanence* — the ability of the memory unit to retain information. This can be an inherent characteristic as with magnetic tape or drums, or it may rely on electrical energy as in an acoustic delay line or flip-flop memory. Inherent permanence is highly desirable.

Classes of Information Storage

Devices for storing information can be classified according to their functions. A convenient breakdown includes five classes:

- *Primary computer memory* — This is also referred to as the inner, high-speed, or working memory. It is the memory that exchanges information with the computer's arithmetic unit in the actual solution of problems. Information from other memory units must be transferred to the primary memory before the information can be used in computation.
- *Auxiliary computer memory* — This is also known as the intermediate-speed memory. It is often used to store computation programs, often-used constants, and other data to supplement the primary memory.
- *External memory* — This is also called the permanent, low-speed or file memory. It stores the large volume of data to be operated upon by the computer.
- *Buffer* — This is a special type of memory used to store, temporarily, information that is being transferred from one memory device to another. It compensates for differences in speed or other characteristics between the two memories it "buffers."
- *Delay line* — This is a special type of memory used to store information for a fixed period of usually a few seconds or less and then to release it, thus introducing a delay.

[To be continued in the May issue]

THINKING TO SOME PURPOSE

"It has a tendency to daydream."

Automatic Quality Control Computers and Other Machine Control Computers

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SOMETIMES we long for our old days developing training aids and fire control systems, when an additional computer rack or two, and several dozen servo shafts was par for a development project. But we found that you can't tempt a machine builder with a computer console that looks like a DC-7 Operational Flight Trainer. Also, Uncle Sam doesn't pick up the "cost plus" tab on industrial machine control development. We learned that expensive military design habits must be unlearned before practical machine control systems can be realized.

In discussing machine control systems with our clients and prospects, we find that it is prudent to go easy in the use of the word *Computer.* One of our first lessons when we started our independent consultant practice a few years ago, was that our interest in computer control of industrial machines is not necessarily shared by machine builders. As our background includes work with simulators, operational flight trainers, training aids, and fire control, it was natural for us to favor the use of computer techniques for industrial machine control. At the slightest encouragement (real or fancied) we would present the compelling advantages of computer control. Our typical prospective client's reaction consisted of bated breath and glazed eyeballs. The ones who recovered from the shock first would cheer us up with left-handed compliments, such as, "You are too wild eyed for us;" "You are years ahead of the field;" "This is great science fiction;" "Come off of cloud 7." The accolade was seldom accompanied by the rustle of purchase orders for design services.

We had to face the facts. Amber & Amber was ready for computer control, but Industry wasn't. To the average machine builder and designer, the word *computer* connotes a rather large equipment, such as Univac. While what we had in mind, was a black box or two, a servo here and there, and the usual potentiometers and "unitized sub assemblies." To us, *computer* meant collection of "hardware," no matter how small, that had a computer *function.* Our control computers are "special purpose, electro-mechanical, analog, equation solvers" of the popular "servo-potentiometer type." In fact, "there are no small giants," so the average person can't help concluding that there are no junior size "giant brains," the term applied to computers by popular literature.

We couldn't deny that the missionary job on our hands of (selling computer control), was greater than the control engineering job. The point we had to put over is that the computers we advocate for use in machine control systems are small and simple. They are limited purpose devices, not general purpose differential analyzers and digital computers. While our pet *control computers* are no match to the "big jobs" when it comes to speed, flexibility, and scope of operation, control computers (which evolve naturally from servo control systems), do their specific job most effectively.

"Negative Feedback"

"Experience is a great teacher. Fools refuse to learn from any other." This proverb, attributed to Benjamin Franklin's *Poor Richard* is certainly still applicable. To benefit other advocates of computer-control for industrial machines, we dedicate the following lessons we learned in our attempts to break into the field of computer control.

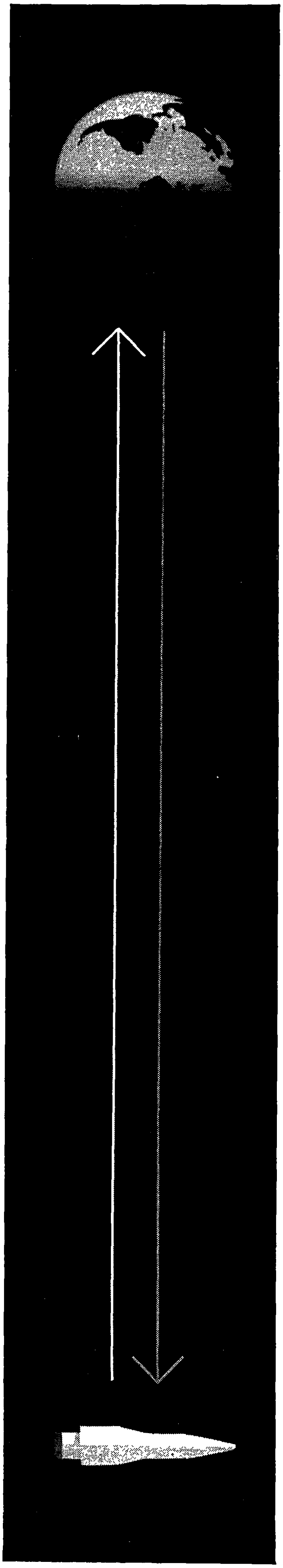
1. Industry will never go for computer-control unless first convinced that such control is indispensable.
2. Computer-control must evolve naturally, from the simple control systems now prevalent. Evolution, not revolution, is the theme.
3. Computer-control would be more readily accepted by Industry if it solved one of their immediate problems.
4. Once one type of computer control was commonplace in Industry, this foot-in-the-door would permit a general break-through, and the concept of sophisticated computer-machine combinations would then be more readily accepted by management.

Automation

We all know that today's automation consists mostly of open loop mechanization: a number of automatic cycle machines and materials handling devices in series. Little feedback control, much less computer control, is used in "Detroit Brand" automation. It is obvious that feedback and computer control must evolve in a natural manner from existing control systems. This is "proved" by tracing the evolution of automation, as follows:

1. Hand tools came first.
2. Then came manually operated mechanisms, such as block-and-tackle, screw-jack, and hand drill.
3. Then came power tools, such as flour mill, saw mill, grinders, steam hammers, and now electric-drills and electric power hand-held saws.
4. Then came power-feed power tools, such as the radial drill, lathe, metal mill, and grinder.
5. Then came the automatic-cycle machine, such as the screw machine, turret lathes, nail machine, bottle blowing machine — the "automatics."
6. Then came automation: a number of "Automatics," including materials-handling machines, in an integrated series.

For all practical purposes, this is the status of automation today. Extrapolating our evolutionary process, we can



STATISTICAL COMMUNICATION TECHNIQUES and SPACE TECHNOLOGY

The transmission of information to the earth from a ballistic missile or a space vehicle presents unusual problems in communications. With severe limitations on equipment size and power, the communication system must operate in the presence of receiver noise and interference from the radio environment, including terrestrial sources and, for longer ranges, sources in space. Statistical communication techniques are valuable tools in achieving reliable communications under these difficult conditions. These techniques, by providing means for coding and decoding information and for determining the amount of information which can be sent, make possible the use of low-strength signals which otherwise could not be sorted out from the background of interference and noise.

The statistical approach is also important in the development of systems with a high degree of immunity to electronic countermeasures. The less regular or predictable the nature of transmitted waveforms, the less likelihood there is that interference will prove effective against the communication system. However, it is necessary to design the system to take maximum advantage of the near-random waveform characteristics.

Future space vehicles inherently will impose greater demands on communication systems. Systems for guidance, tracking, and data transmission through space to the moon or the nearer planets are now real goals in space technology. In the development of such systems, statistical communication techniques can be expected to play a significant role.

At Space Technology Laboratories, both experimental and analytical work are proceeding in the application of statistical techniques to the problems of space vehicle electronics. This work illustrates the advanced research and development activities in STL's Electronics Laboratory and the emphasis upon the application of new techniques to the requirements of space technology.

Both in support of its over-all systems engineering responsibility for the Air Force Ballistic Missile programs, and in anticipation of future system requirements, STL is engaged in a wide variety of research and experimental effort. Projects are in progress in aerodynamics, propulsion, structures, and electronics.

The scope of activity at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding the many opportunities on the Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA readily see the approaching phases of industrial mechanization, which are:

7. Feedback control of industrial machines, permitting self-correction.
8. Computer control of industrial machines, by means of small, special purpose, "machine control computers."
9. Control of complete industrial processes by means of the true "giant brain" master controller and computer, with the necessary auxiliary programming and memory systems.

This philosophy on the future of control clarified our objectives. We should concentrate on feedback control and on simple machine-computer combinations. Until these were well accepted by American Industry, the "big-job," the giant brain, a factory control computer was best left to the science-fiction crowd.

Feedback Control

It is safe to say that feedback is the backbone of control engineering. So the use of feedback for the control of industrial machinery seems to be obvious to any control system designers. Feedback control is attractive to machine builders, too. But feedback control is not easy to achieve. At the risk of amplifying the obvious, here is why there has been little feedback control of industrial machines up to now.

The process variables that are controlled in an industrial machine, are usually physical size dimensions. These controlled dimensions are subject to statistical variability. In setting up a closed loop control system, we can seldom refer to each individual piece part size measurement, for feedback purposes, because atempting to correct for *normal* statistical "spread" is not a practical method. A sensitive control system would tend to "chase" each individual output measurement. This could easily cause "hunting," resulting in control that is less satisfactory than simple open-loop methods. To get stability under these conditions, the control system could be made sluggish, obviously an unsatisfactory solution.

What we really need for feedback control of a precision industrial machine whose product exhibits variability (which is usually the case) is a method of determining the *mean.* The *mean* — alias *machine-mean;* alias *center line of machine performance;* alias $\overline{X}$ (ex-bar) — is the simple arithmetical *average.* To determine this *average,* (a necessary criteria of machine performance for feedback control purposes), a computation is necessary, either manual or automatic.

Continuous and Discontinuous Variables

In general there are two types of machine-output variables: *continuous variables* and *discontinuous variables.* In either case, the *average* (which we prefer to call the *machine-mean*) is needed. The method of computing the *machine-mean* is somewhat different for each of the two types of machine output variables, continuous or discontinuous.

Examples of *continuous variables,* are the thickness of continuous products, such as wire, steel strip, rolled metal sections, and fibers. The *machine-mean* of such variables can be attained by integrating thickness over a sample section of length, and dividing the integral by the sample length. An easy way to do this is to integrate the thickness analog of the product, as it passes a transducer at a constant rate, for a specific integration time.

The *machine-mean* of continuous products is obtained by solution of:

$$\overline{X} = \frac{1}{t} \int_0^t x\,dt \qquad \ldots\ldots(1)$$

where $\overline{X}$ = *machine-mean,* t = integration time, and x = continuous variable (thickness) being averaged.

The computation is not difficult to accomplish by means of a computing device, for there are a number of integrators and integrating computers on the market that can be used to do the job. Determination of the *machine-mean* of a continuous product by means of time integration is a well known technique. It is so commonplace that it is not always recognized that a computer (integrator) is being used.

Examples of *discontinuous variables* are the size dimensions of piece parts. Also, the sizes of holes, and relative locations of specific points on a work piece. The *machine-mean* of such variables can be attained by adding up all of the dimension x, in a sample, and then dividing by the number n in the sample. The arithmetic is easy, but mechanically, there is no truly easy way of doing this computation. This is why feedback control of industrial piece part machines has lagged. The equation that must be solved to get the machine mean of a *discontinuous variable* is:

$$\overline{X} = \frac{\Sigma x}{n} \qquad \ldots\ldots(2)$$

where $\overline{X}$ = *machine-mean,* n = number of parts in the sample, and x = discontinuous variable size dimension being averaged.

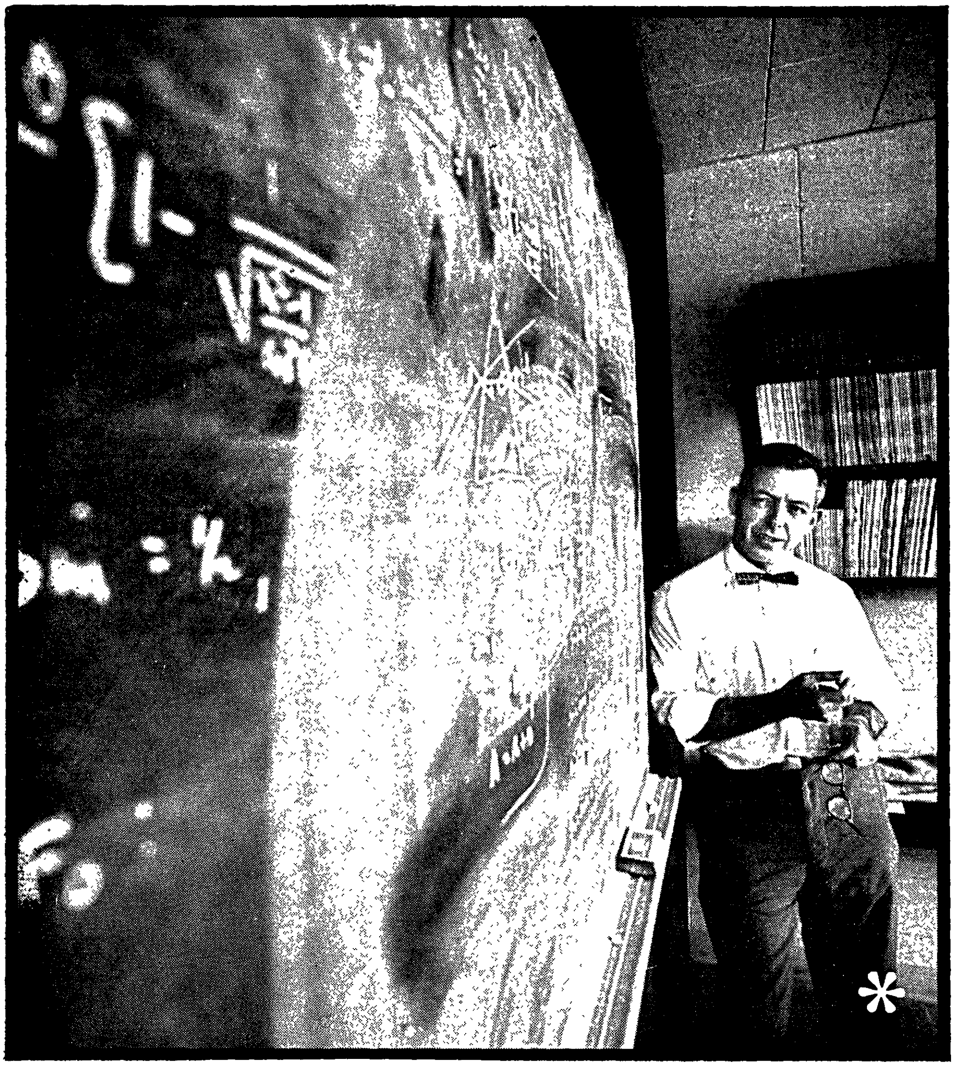
A computer solving equation 2 is more complex than one solving equation 1. This is so, because discontinuous data demands use of a data storage system, plus sequencing and programming controls.

Most industrial machines are of the piece-part type. So computers, (or equivalents, such as "pre-control") suitable for handling discontinuous data comprises a prime control engineering problem, if we are to have feedback control — to say nothing of computer control per se.

It is the authors' experience that the answer to feedback control consists of the use of comparatively simple "control computers." By use of such devices, $\overline{X}$ (*machine-mean*) of both continuous and discontinuous variables are readily obtainable. By such means ($\overline{X}$ computers) feedback control of machines that have a "spread" is practical. This is so, because an analog of $\overline{X}$ constitutes the feedback signal of machine performance, that is compared to the command or reference signal, for closed loop control.

This does not mean that there are no piece-part production machines existing that have feedback control without the use of a computer. Some machine builders have accomplished such feedback control with some success, in this manner.

Piece-parts produced by a machine are automatically measured. These measurements are "remembered" in a data storage system, such as by segregating the piece-parts. As long as several consecutive measurements fall more or less at random within a predetermined tolerance zone, it indicates that the machine is performing satisfactorily. Such distribution of measurements is attributed to the normal machine



✱ Dr. Eric Clarke, tech/ops vice president, takes a look at a problem in his office at Burlington, Mass.

an oblique look

tech/ops scientists know there are at least three ways of attacking a problem: head on, as an amphibious force hits a beach; flank-wise, as a tactician likes to strike; and *slantwise*, the offbeat way.

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dispersion. When several measurements in a group fall at one end of the tolerance zone, there is a high probability that the machine has drifted. The machine is then automatically adjusted an incremental amount, to correct for this drift. This technique is termed *pre-control,* or post process zone control.

Thus we see that feedback control of piece-part machines does not absolutely demand the use of control computers. "Pre-control," by post process zone gaging, as described above, is the pioneer method for obtaining feedback control of piece-part machines. The method does not however develop $\bar{X}$ in explicit form, which is most desirable for control purposes, in addition to mere feedback control, as will be shown.

By use of the control computer techniques, the *machine-mean* of practically any piece part machine product can be readily obtained. True, many details such as size of sample, transducers, scale factors, servos, etc. must be worked out for each application of an $\bar{X}$ computer. But functionally, the same basic $\bar{X}$ computer can be used with practically any industrial piece-part machine.

The next step in our program to encourage the use of machine control computers, was to find an industrial computer control application that evolved naturally, from a feedback control computer. We found that Statistical Quality Control was an ideal field for the development of machine control computers.

Automatic Quality Control

The use of statistical quality control methods is practically universal in the precision manufacturing industries. SQC is accomplished entirely by means of trained technicians and professionals in the field. Fortunately, once a QC system has been established in a manufacturing process of a routine nature, such as plotting variates on control charts and grinding out similar calculations, the routine aspects of Quality Control can be readily handled by control computers. This relieves the skilled QC personnel for many high-level non-routine production assignments that are unfilled at present, such as OR (operations research), and advanced production engineering.

Quality Control is a big subject, and many books and papers have been written about QC. Fortunately, a simple version of SQC exists, which can "get by" with only two main criteria. One is $\bar{X}$, which is the very same function required for feedback control. The other one, is σ (sigma), the standard-deviation. Fortunately, sigma can also be readily solved for by means of a machine control computer. As is the case with $\bar{X}$, the computational method for getting σ is somewhat different for continuous variables and for discontinuous variables. The σ computer for discontinuous variables is the more challenging problem and has the larger potential of applications. So the comments that follow are limited to the σ computer for discontinuous variables.

The function for σ is usually written as follows:

$$\sigma = \sqrt{\frac{\Sigma x^2}{n} - \bar{X}^2} \qquad \ldots\ldots(3)$$

As shown by equation 3, σ is equal to the square root of the "mean-of-the-squares" minus the "square-of-the-mean." In plain words, (and this is easier for control engineers to remember) "the *standard deviation* (σ) is the rms deviation of the observed values from their average." Equation 3 can be re-written to show that it is the equivalent of a right triangle relationship. The term $\frac{\Sigma x^2}{n}$ is the mean-square (the average of the squares of the individual measurements). Therefore, $\sqrt{\frac{\Sigma x^2}{n}}$ is the *root-mean-square,* more easily designated as X_{rms}. So

$$\left(\sqrt{\frac{\Sigma x^2}{n}}^{\,2}\right) \equiv X^2{}_{\text{rms}} \equiv \frac{\Sigma X^2}{n}$$

Consequently, equation 3 can be written as follows:

$$\sigma^2 = X^2{}_{\text{rms}} - \bar{X}^2 \qquad \ldots\ldots(4)$$

$$\bar{X}^2 + \sigma^2 = X^2{}_{\text{rms}} \qquad \ldots\ldots(5)$$

Equation 5 has the same form as the familiar Pythagorean relationship:

$$a^2 + b^2 = c^2 \qquad \ldots\ldots(6)$$

Therefore, equation 5 is amenable to solution by trigonometric methods. Equation 5 can also be shown in its equivalent complex form:

$$X_{\text{rms}} = \bar{X} + j\sigma \qquad \ldots\ldots(7)$$

which hints an electrical engineer's approach to its automatic solution.

Since a right triangle relationship exists between X_{rms}, $\bar{X}$, and σ, equation 5 can be solved by use of a synchro resolver and a positional servo. This is the practical way to do it, for solving equation 3 explicitly without taking advantage of the quadrature relationship between $\bar{X}$ and σ, would result in a computer that was needlessly complex.

A resolver does the job of solving for σ rather well — too well as a matter of fact. We not only get σ, but the resolver shaft angle also gives us the arc tangent of the ratio between σ and $\bar{X}$. Which is fine if we knew what to do with the angle. But we don't need angle (arctangent $\frac{\sigma}{\bar{X}}$) so there is no use paying for it. All we require is the absolute value of σ.

Several coffee breaks after we tried to solve for σ without a servo and resolver, the problem was "resolved." Here was the line of reasoning used: Voltage drop in a series *RC* circuit has a quadrature relationship, *so* perform the analog solution for σ with respect to $\bar{X}$ and X_{rms}, by varying *R* (or *C*).

After Automatic Quality Control

"Auto-QC" certainly isn't the end of the line for using control computers in industry. We hopefully expect that it is merely the "foot-in-the-door" we were looking for: the break-through with computer control for automation. In addition to averaging and quality control computers, we feel that the following types of control systems can be readily accomplished by means of simple servo type control computers:

Machinability — to ease the life of the busy tool engineer, by having production machines continually adjust their operating parameters for optimum tool life.

Grouped Machine Operations — to determine characteristics of an assembly from the machines that are making the piece parts — to permit machines to compensate for each other's deficiencies.

Selective Assembly — to solve the simultaneous equations of selective assembly, thereby "opening up" manufacturing tolerances.

Positioning — to position and index parts by controlled accelerations, rates, and retardation, based on dynamic solutions of the equation of motion.
  - to position machines by "dead reckoning" of integrated spatial movements.
  - to position parts by controlled catapulting, using simple fire control techniques.

Error Correction — to solve empirically determined error functions (such as synchro load error), so that negative-error-feedback can be used, to compensate for mechanical load error on remote positioners, without the need of local servos.

Optimizing — to determine best results possible consistent with existing conditions — to solve maxima-minima relationships.

Custom Design — to perform routine design calculations on the machine that manufactures the part being designed.

As indicated, the techniques we use in developing machine control computers, are similar to the techniques used by military equipment designers. A designer of operational flight trainers would feel right at home, working on machine control computers. To a large extent, the techniques of building up special purpose computers from standard "units" and components is an art. We deny that it is a "black art," however.

The design of a machine control computer can proceed to advanced stages on a functional basis, with very little recourse to analytical methods. However, it has been our experience that none of the designs, no matter how good they look on paper, can skip over the very necessary breadboard stage, and then the prototype stage. Also, a machine-computer combination does ultimately demand the "full treatment." Sooner or later, a complete design analysis of the control system (which includes the machine control computer) is necessary.

Axe Grinding

In closing, we want to make a plea for more competition! Here is what we mean. We sincerely feel that computer-control (both digital and analog) is absolutely necessary, for "job-shop automation," and for high performance high-production manufacturing. For some time now, we have engaged in active propaganda, in behalf of machine-computer combinations. In fact, just send us a return envelope, for a bibliography of the dozen odd articles we have written concerning the use of machine control computers. But we need help to put computer control over. The more advocates for computer-control, the more activity there will be; and the more work in the field for everyone concerned. And greater productivity and performance results. Until we use more feedback and computers, automation control will remain mere limit switches and interlocks.

Of the available sources for computer-control missionaries, the largest group consists of the manufacturers and vendors of components for computer control, the "hardware" merchants. Industrial management, and design engineers too, once they know what can be accomplished by means of control computers, help introduce computer control into their plant, and product — that is, if the technical press gives them the word.

Independent consultants (such as we) and academicians sell no products — only know-how, ideas, and designs. Such "free lancers" are in an excellent position to advance the cause of computer-control, since they are free to use any techniques or components, to do a job, or to teach such methods objectively. They also customarily write more articles and speak at more meetings.

What we need however is that the manufacturers and vendors of computer "units," the production management staff, the designers, the consultants, and the professors at universities — all work for improved control systems. We certainly need more aggressive promoters for computer control.

Some References

1. "Analog Computers for Machine Control," G. H. Amber, *Electrical Manufacturing* (Aug, & Oct. 1955).
2. "A Yardstick for Automation," G. H. Amber, P. S. Amber, *American Machinist,* (Aug. 13, 1956).
3. "Developments in Automatic Quality Control," G. H. Amber, P. S. Amber, *Tool Engineer,* (Jan. 1956).
4. "QC Computers for Machine Control," G. H. Amber, P. S. Amber, *Electrical Manufacturing,* (July & Aug. 1956).
5. "Automatic Dull Drill Detection," G. H. Amber, AUTOMATION, (Oct. 1955).
6. "Anatomy of Automation," G. H. Amber, P. S. Amber, *Electrical Manufacturing,* (Jan. & Feb. 1958).

Miniature Complex Cams

[Continued from page 10]

Work has included the following development problems:

Computation of test points for Great Circle routes used on an Automatic Dead Reckoning Computer.
Vector solutions of true air speed, true heading, wind velocity and wind direction.
Sine-cosine shaft position converters.
Three-dimensional cam functions.
Solution of nonlinear potentiometers under load.
Rate generators and related problems.
Potentiometer settings for a measurements bridge for all possible bridge conditions.
Determination of all possible gear ratios for size 8 gearhead (2 to 7 passes for 4 specific gear and pinion combinations).
Sine-cosine potentiometer used as a phase shifter.
Tables of subsonic and supersonic pressure ratios vs Mach Number 0 to 5 to four decimal places.

Languages, Logic, Learning, and Computers

John W. Carr III

University of Michigan
Ann Arbor, Mich.

(Lecture given at the Purdue University Computer Symposium,
November 15, 1957)

THE lesson which digital computer users have been learning during the past ten years is that, oddly enough, the main use for these new information machines may not be as computers at all but rather as "symbol manipulators."

It is as a symbol manipulator — evaluating and interpreting symbols from its own environment — that the digital computer may be able to perform its most spectacular jobs.

Before the machine user can make use of this lesson, however, he must adopt an "outside-in view" of the digital computer. He must become much more problem oriented and much less equipment oriented. He must realize that it is the method of description of the problem that is important and not the actual physical hardware or even the logical structure into which the hardware is interconnected.

How does a user describe a problem? Generally he develops a correspondence or mapping between the elements and relationships of the real world and a set of symbols, that he, and later the machine, is to manipulate or act upon.

Languages

Ordered and meaningful sequences of such symbols are what human beings have learned to call languages. Therefore, one of the major problems of the user of these machines is first to understand, and later to be able to construct, languages descriptive of his problems. These languages, unlike the natural languages (English, German, Russian) are much more ordered, much more precise, much more readily deciphered and translated by the machines themselves into the machines' own internal language.

The definition of such a language, described intuitively, is

1. A set of symbols making up the basic elements of the language;
2. A recursive definition of strings of symbols, called for example, "words," "phrases," "clauses," "sentences," or "constants," "operands," "relations," "propositions," "statements." The first group of names of strings obviously describes the structure of one of the natural languages, such as English. The second group of names of strings comes from a description of the language of arithmetic.

The importance of *recursive* definitions cannot be overemphasized. As an example, many different entities in English have "name-like" qualities. One such collection of words is the class of nouns, of which "Tom" is an example. But there are other noun-like elements in English, made up of recursive combinations of noun-like elements as well as other parts of speech, which combine to make strings of symbols that again behave like nouns. For example, a combination of a pronoun, noun, and verb in that order — "what Tom said" — again has a noun-like quality, and can, just as "Tom" in "Tom said it" be used in a noun-like manner: "What Tom said was funny." The latter three-word element — a noun-like clause — can be included recursively in another clause: "What what Tom said meant, I don't know." One can recurse again, according to this definition, to obtain still another perfectly legal, but semantically confusing statement: "What what what Tom said meant had to do with the war was not apparent."

Similarly, in a formal machine input language for computers, such as the IT language of Professor Perlis, recursive definitions are the heart of the structure. For example, "y_1" is an operand, as is "sin (y_1)" and "$y_1$sin (y_1)" to quote an obvious example.

Formation and Transformation Rules

This set of recursive definitions of acceptable strings in a language make up the "formation rules" of the language, that complete set of rules by which any possible "sentence" or acceptable string in a language may be generated. In addition, as everyday natural language users we are all familiar with a second set of language rules, the "transformation rules," a complete set of rules transforming all "equivalent" sentences one into another. Here the idea of "equivalence" has to be elaborated; generally, intuitively it is based upon agreement with some external model.

For example, one of the transformation rules that is accepted in English is that adverbial phrases modifying verbs and the subjects of the verbs may be interchanged. Thus, "In the square stood the City Hall" and "The City Hall stood in the square" are equivalent sentences. Their equivalence can be based on an actual City Hall sitting in a square, as well as on certain unwritten transformation rules of English governing positions of phrases and subjects.

Another example of two identically equivalent strings, transformed one into another by transformation rules in arithmetic, is "$z = x + y$" and "$z = y + x$." In a certain single address computer, three equivalent strings might be

```
CLA  1000      CLA  0027      CLA  1000
ADD 0027       ADD 1000       JMP  0005
STO  0045      STO  0045      ADD  0027
                              JMP  0006
                              JMP  0003
                              STO  0045
```

These equivalences, and the implicit transformation rules that take one such string of symbols into another, are the key to the "efficiency problem" of automatic programming, in which one attempts to have a computer re-order the output of a compiler so as to produce coding which is "best" in some sense — "fastest," "requiring least storage," etc.

Another example of symbol manipulation under such transformation rules is two strings in English: "Some men

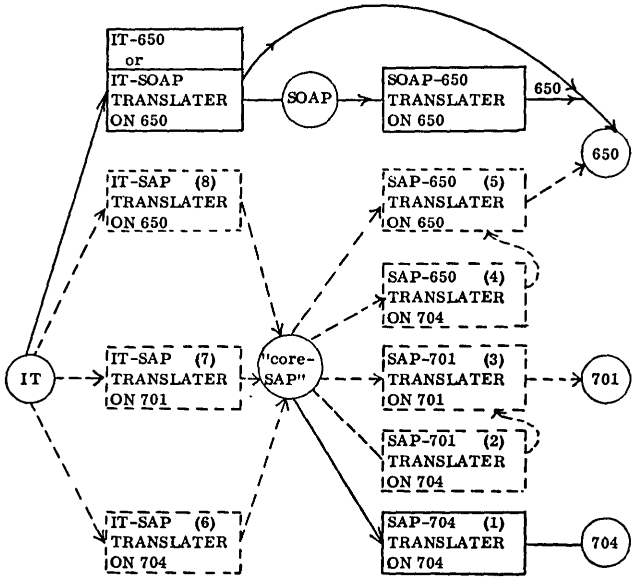

Figure 1. Proposed Language Structure

Solid lines indicate presently available Structure.
Sequence of procedure:

1. **Write box (3) translator in "core-SAP" language. Translate with box (1), yielding box (2). Translate with box (2) yielding box (3). (Perform on 704)**
2. **Write boxes (6) and (7) at one time in "core-SAP" language. Translate with boxes (1) and (2) to yield boxes (6) and (7). (Perform on 704)**
3. **Write box (5) in "core-SAP" language. Translate with box (1) to yield box (4). Translate with box (4) to yield box (5).**
4. **Translate program of (6) and (7) with box (4) to yield box (8). (Perform on 704)**

This allows the translations to be done on the most powerful machine (704) in every case. The efficiency of steps 3 and 4 is questionable. Steps 2, 3, and 4 could all be done on the Type 701.

---

are liars" and "It is not true that all men are not liars." English speaking individuals are mainly in agreement that these are equivalent sentences; if the English words are abstracted into obviously corresponding symbols, one would have two similarly equivalent strings:

$$(\exists m)(m \in L), \sim(\forall m)(m \notin L)$$

In this case, a person speaking German, French, Russian, or almost any natural language would agree as to this equivalence, once he had made identifications between words in his language and the symbols. A digital computer, moreover, can be programmed to perform the same transformations on the above symbols as does a human being. The use of computers as symbol manipulators, therefore, offers opportunities to use them to solve problems in the area of languages and meaning, induction and deduction. The development of the first simple problem-oriented input languages for computers is the first step in this direction.

Translation

We have already seen the development of several of the languages: the IT (Internal Translator) for the Type-650 and Datatron developed by Professor A. J. Perlis at Purdue and later Carnegie Tech; Fortran, developed for the Type-704; Unimatic and Unicode, developed for the Univac machines. At the University of Michigan, we are working on problems of compatibility between such languages. Our first job is to develop versions of the simplest of these languages (IT) for a new machine now planned to be installed at the University. Concurrent with this is an investigation into generalized translation procedures from, for example, IT to Fortran. These would be planned for *any* machine. (The inverse translation has already been made by IBM, but for one specific machine only.) The overall goal at which we would like to aim is a general method by which a computer itself could automatically construct a translator from any one such language to another. Complete compatibility among such languages would then be a reality.

(Many other laboratories — Carnegie Tech, Case Institute, IBM-New York, Sperry Rand-Philadelphia — are also working on the same problem.)

A Multi-Machine Problem

Some practical considerations of the technique of emphasizing languages rather than computer structure can be seen in a proposed solution of the following problem at the University of Michigan: "An IBM-650 computer is at present in use on the campus. A Type-701 computer is tentatively to be installed about August 1, 1958. An IBM-704 computer would be scheduled for about March 1959 to replace the Type 701. These computers are entirely different, programs written in the machine language are not compatible one with another, command structure is different, (one-plus-one address, two single-address instructions per word, one single-address instruction per word), arithmetic is different (decimal floating-point, binary fixed point, binary floating point). One would like to be able to use these computers up to the day of their departure and on the day of the next one's arrival, with interchange of problems and yet efficiency. Can this be done?"

The answer, we feel, is "yes," and is contained in Figure 1. The solution calls for a "core-SAP" language, a subset of the command list of the pseudo-language for the Type 704, the Share Assembly Program. This would be able to be run on the Type 701 as well as Type 704. The first job would be to write a SAP-to-701 translator in this "core-SAP" language. It could be immediately taken to the nearest 704 and checked out. It can then be immediately used to translate itself over into 701 language long before the 701 is ever delivered. Similarly if the IT-to-701 translation is also written in "core-SAP" language, it too can be translated on the 704 into 701 language and also into 704 language.

This procedure is entirely practical because the 704 is generally (but not completely) an expanded version of the 701. Whether a similar sequence of steps can be taken to use the same "core-SAP" language with the Type 650 is still in doubt. If it can be, students can be trained beginning at once on a present computer to learn the languages that will be used on the next machine next August and a third machine in 1959. The advantages of this are obvious.

[Please turn to page 25]

BOOKS
and
OTHER
PUBLICATIONS

(List published in COMPUTERS and AUTOMATION, Vol. 7, No. 4, April, 1958.)

WE PUBLISH HERE citations and brief reviews of books, articles, papers, 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.**

Wainer, Eugene / Ferroelectric Devices / Wright Air Development Center, U.S. Air Force, Wright-Patterson Air Force Base, Ohio, distributed by Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. / 1956, photo-offset, 130 pp., cost $3.75.

This report presents the results and conclusions of work at a contractor's plant to discover the practicality and stability of ferroelectric devices. It covers an extensive investigation into ferro-electric systems and the effects of impurities upon such systems.

Navy Mathematical Computing Advisory Panel and Office of Naval Research, joint sponsors / Symposium on Advanced Programming Methods for Digital Computers, PB121670 / Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. / 1956, photo-offset, 83 pp., $2.25.

This reports the June 28-29, 1956, symposium on programming methods for digital computers sponsored by the Navy Mathematical Computing Advisory Panel. Thirteen papers are printed, including "Automatic Coding Principles," "Development of Common Language Automatic Programming Systems," "Production of Large Computer Programs," "Advanced Programming Techniques with Smaller Computers, etc." "SHARE — A Study in the Reduction of Redundant Programming Effort Through the Promotion of Inter-Installation Communication," "Associative Machine Languages," etc. All are intended to meet a need for evaluating the impact of advanced programming techniques on electronic computer installations.

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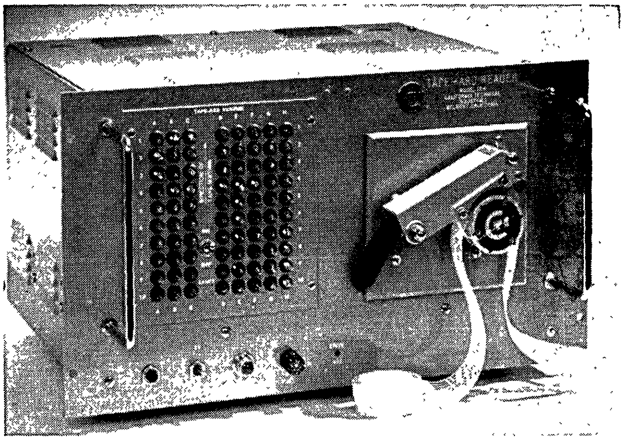
INDUSTRY NEWS NOTES

TAPE READER FOR PROGRAMMING MANUFACTURING OPERATIONS

Designed for programming automatic machinery and automatic manufacturing equipment, a new tape reader called the "Tape-Ard" Reader has been developed by California Technical Industries, division of Textron Inc., Belmont, Calif. The reader provides 80 bits of control information at each positioning. A standard, 1-inch, perforated paper or paper-mylar tape affords a convenient means of programming and handling a fixed sequence of data. The reading is achieved with a reading head that covers 10 transverse rows of 8 holes each. A "Verifier" panel of neon lamps duplicates the 8-by-10-hole pattern of an entire frame, and is used to rapidly check newly punched tapes.

Only 35 milliseconds is required to advance the tape to a new frame. Stepping can be controlled both automatically by a simple circuit closure in the accompanying equipment and manually with the "Step" button on the front panel. The reader will operate in excess of fifteen 80-hole frames per second; however, for continuous, high-speed operation a maximum rate of 6 frames per second is recommended.



Contacts are conservatively rated at 100 milliamperes, and connections to the contacts are made through two 50-pin connectors at the back of the unit. A common return is made through the drum which drives the tape. Operated by a motor and clutch, the drum positively indexes the tape, without kickback or overshoot.

The complete unit, including the reader, tape drive mechanism, and Verifier, is contained in a cabinet with a 10-½ by 19 inch panel. Power required is single-phase, 60-cps, 375 watts. Companion units that will be available shortly are a novel Tape Punch that will facilitate the punching operation and a Tape Duplicator that coordinates the Punch with the Reader for automatically reproducing copies of an original tape or quickly editing and revising old tapes.

Languages, Logic, Learning, and Computers

[Continued from page 22]

Efficiency

The problems of efficiency have been often emphasized by programmers who believe strongly in the continuance of hand-programming over translational techniques. There have been several techniques proposed for this. One, method used with Fortran, but as yet unpublished, makes use of basic transformation rules of the computer language. The only published descriptions of such techniques are a series of papers by Soviet mathematicians of stature, including Ianov, Kantorovich, Markov, and Razumovskii. These reports are exceedingly brief, but may be interpreted as indicating a high degree of Soviet effort centered on language translation, automatic programming, and automatic mathematical analysis, an area into which United States computer users have not as yet ventured.

The important new idea to the machine user in this field is that much of the theoretical work necessary to constructing these generalized translators has already been worked out by mathematical logicians. Very useful symbology and translation algorithms have been studied by such mathematical logicians as Turing, Post, Markov, and others. Mathematical logic is the formal study of such generalized languages, of how to translate them, how to determine the correctness of strings of symbols, etc.

It is apparent that the future of today's average computer programmer will rise or fall on his ability to adjust to the logical-mathematical nature of these new techniques using languages. The need for continued adult education, on-the-job training, or refresher courses for programmers is very evident if they are not to find their basic skill — computer programming efficiency — overwhelmed by the abilities of the machines themselves. The programmers must raise their own level of training so that they can deal with global problems of problem strategy rather than detail, which will be handled by the computers themselves, if they are to survive.

Learning

A new area in which digital computer users are venturing in depth for the first time is that of learning theory. This has long been the province of psychologists only, but the digital computer allows human beings for the first time to *synthesize* not merely to analyze, learning processes. The study of games such as checkers and, lately, chess by Strachey, Samuel, Ulam, Keister, and others has allowed simple learning models to be included in programs. Such procedures, when perfected, will begin to be used in all varieties of computer problem solving. "Inductive behavior" in the form of a theorem-proving program has just been developed by Newell and Simon. If such procedures can be understood and extended, it may be possible for machines to begin planning how decisions should be made, rather than merely making them.

At first glance, the idea that a mechanistic device such as a computer, whose activities are "completely understood" by its user, should play games, prove theorems, or begin to perform in any manner at all like human beings, obviously much more complex and almost completely not understood at all as to their structure — this idea appears ridiculous on the face of it. However, if we were to perform a series of experiments on humans and other organisms in this world, we would find a great similarity:

1. A man is driving a car. He *sees* a red light (a symbol input) and presses his foot down on the brake (a symbol output).
2. A man is in a restaurant. The waitress says "What will you have?" (a string of symbols input); and he answers, "Coffee" (a symbol out).
3. A letter comes into a shipping department of a mail-order house (a string of symbols in); a shipping order goes out to the warehouse (a string of symbols out.)
4. A programmer takes a set of equations (symbols in) and writes a machine code (symbols out).
5. The captain of a boat feels a breath of wind on his cheek (a symbol input); he tells his mate to hoist a sail (a string of symbols out).
6. A banker reads a headline in a newspaper (a symbol in); he phones a broker and sells 1000 shares of stock (a symbol out).
7. A mathematician reads an article in a journal (a string of symbols in); he writes down a conjecture (symbols out).

Most computer users would willingly say that a digital computer could perform satisfactorily as a substitute for the organism in 3; grudgingly, in 4; but not at all in any of the others.

We would like, however, to call this act of input of language followed by output of language "symbol manipulation," an ability which is held, apparently, (based on a series of far more "hypothetical experiments" than the few listed) by all living organisms, by many large man-made organizations, and by general purpose digital computers.

Universal Machines

A. M. Turing, a British logician who first helped design several British digital computers as well as study the fundamentals of logic, showed first that a machine now called a "Universal Turing Machine" with a very few internal states and a few simple abilities (read a "zero" or "one," write a "zero" or "one," move to a next reading or writing position) could behave like any other such machine, no matter how many symbols it could read or write, no matter how many internal states it had or how complex it was internally.

On the basis of experiments and observations on human beings, shipping departments, mathematicians, and digital computers, one can say definitely only that they take in symbols and put out other symbols in response. One can therefore make the following conjecture, based on Turing's proof about universal machines:

1. The internal structure of living beings, including humans, can be abstractly described as a symbol manipulator.
2. Any actions of living beings, if sufficiently understood, can be described by a program for such a symbol manipulator, provided it has enough resources.
3. Digital computers can manipulate symbols, although at present only crudely, and have all the features of Universal Turing Machines.
4. Therefore digital computers within their resources (speed and storage) can duplicate the behavior of human beings, from ordering coffee to conjecturing theorems.

If this conjecture is true, and there appears to be no better working hypotheses available at present for computer users to labor under, then the area of symbol manipulation with electronic information machines may have the highest possible pay-off. Digital computer users, as individuals in a frontier field, should tend to be extremely tolerant of any novel or unusual ideas, even if iconoclastic with respect to talents developed in the past few years of machine development and use. Users must experiment and evaluate each new frontier effort as it is proposed — on its merits only.

The Future for Programmers

All these frontier efforts point the way towards the future education of the professional computer user — persons who today are called "programmers." They must be mathematically capable, if involved in scientific problems, of performing numerical analysis; in business problems they must understand the structure and control of large systems. Beyond this, they must have a working understanding of formal languages, of the logical theories behind them, and of the mathematics describing self-improvement or "learning" on the part of the computers. This background stands as a challenge to present computer programmers; their education can only really begin once they learn to use machines in the sense understood at present.

Multi-million dollar equipments are theoretically able not only to make decisions but also to plan how decisions should be made. Also they are theoretically able to improve their performance on the basis of their environment. Therefore, the efficient use of such machines demands that their users know enough about the machine's capabilities to bring the use of the machines in these areas down from the range of theory into the land of everyday performance.

Readers' and Editor's Forum

[Continued from page 9]

ters runs whose unavoidable requirements at different times cause all three limitations to exist. On a punched card computer, for example, one may wait while cards are run in; at times extended periods of calculation are needed, and perhaps other activities may halt while periodic heavy punching of results occurs.

2. There is a qualitative and not just a quantitative difference between what a computer can do and what men or other machine combinations can do, primarily because of speed considerations. Proponents of the quantitative view tend to regard the computer as merely a giant tabulating machine. Therefore, I cannot agree that the lowest cost per unit of data processing is the ultimate goal of enlightened computer users, even if short-range emphasis tends to be placed upon this. Many people feel that the use of a computer as a tool by which management can control a business will prove more significant than clerical cost reduction.

The large-scale business user of automatic computers certainly wants as much internal processing speed as he can get from such machines, though even he may question the cost of such capabilities. The great potential market for business computers, however, lies in the range of medium to small scale machines as the success of the IBM 650 has established. Most of these potential users want performance, of course, but at a price. They may very well be willing to sacrifice some of the possible speed of computers in order to get increased flexibility and a price they can afford to pay.

ASSOCIATION FOR COMPUTING MACHINERY, LOS ANGELES CHAPTER SYMPOSIUM, MAY 9, 1958 — PROGRAM

Fred Gruenberger
Los Angeles, Calif.

Following is a copy of the program for the May 9th symposium on

SMALL AUTOMATIC COMPUTERS AND INPUT/OUTPUT EQUIPMENT — A REPORT FIOM THE MANUFACTURERS

This symposium is sponsored by the Los Angeles Chapter of the Association for Computing Machinery in conjunction with, and immediately following, the 1958 Western Joint Computer Conference.

A similar symposium which was held in conjunction with last year's WJCC attracted over 600 people.

Morning Session: Owen Mock, Chairman 9:30 A.M.

1. CHARACTER READER FOR BANK DATA PROCESSOR / R. H. HAGOPIAN, General Electric Co., Computer Department, Erma Systems Laboratory, Palo Alto, Calif.
2. SELFCHEK — A NEW COMMON LANGUAGE / CLYDE C. HEASLY, JR., Intelligent Machines Research Corp., Alexandria, Va.
3. THE DATAMATIC 1000 MODEL 1400 OUTPUT SYSTEM / IRMA WYMAN, DATAmatic, Newton Highlands, Mass.
4. HIGH SPEED COMPUTER OUTPUT DEVICES UTILIZING THE CHARACTRON SHAPED BEAM TUBE / HENRY M. TAYLOR, Stromberg-Carlson Co., San Diego, Calif.

Afternoon Session: Fred Gruenberger, Chairman 1:30 P.M.

5. DATA TRANSLATORS / ERWIN TOMASH, Telemeter Magnetics, Los Angeles, Calif.
6. THE IBM TYPE 610 AUTO-POINT COMPUTER / J. A. DOWD, IBM Corp., Los Angeles, Calif.
7. THE RECOMP II DIGITAL COMPUTER / R. F. GEIGER, D. E. DUFFORD, Autonetics, Bellflower, Calif.
8. A SOLID STATE DIGITAL CONTROL COMPUTER / JOHN W. CANNON, Daystrom Systems, La Jolla, Calif.

ASSOCIATION FOR COMPUTING MACHINERY MEETING, URBANA, ILL., JUNE 11-13, 1958

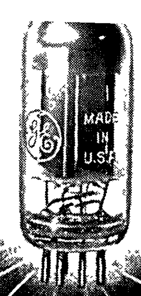
The thirteenth annual meeting of the Association for Computing Machinery will be held at the University of Illinois, Urbana, Illinois, on the 11th, 12th and 13th of June

Contributed papers have been invited. It has been the policy of the Association to allow 15 minutes for presentation and 5 minutes for discussion of these papers. Authors submitting contributed papers should have sent:

1. An abstract of not more than 200 words.
2. A three page summary (not including proofs) of the principal results and their applications.

The abstracts of accepted papers will appear in the program of the meeting. The summaries will appear as

[Please turn to page 28]



50,000 hours

...A record six-year period of continuous computer-tube operation... by General Electric 5844's, the industry's first computer tube!

Few well-planned tests are discontinued because they have become pointless. This one was —*after nearly six years.* A large computer manufacturer placed General Electric 5844 twin triodes on continuous life test under actual operating conditions. After 50,000 hours the test was terminated . . . because tube failures (a small fraction of 1 percent per thousand hours) were too few to warrant further statistical recording.

From more than a million General Electric 5844 computer tubes in actual service, the manufacturer reports a failure rate that is equally low—approximately 0.2 percent per 1,000 hours.

Look to tubes for proved dependability! Reliable long-life performance is a feature of all nine General Electric specially-designed computer types. For your military or commercial needs, specify from the list that follows! Additional facts are available from any office of the G-E Receiving Tube Department listed below.

COMPUTER TUBE TYPE	CLASSIFICATION	HEATER CURRENT IN ma, AT Ef = 6.3 v	DESIGN-MAXIMUM DC CATHODE CURRENT PER SECTION, IN ma	DESIGN-MAXIMUM PLATE DISSIPATION PER PLATE, IN WATTS	TYPICAL APPLICATION
5844	Twin triode	300	10	1.0	Medium-speed counter
5965	Twin triode	450	15	2.2 4.0 (a)	High-speed counter or amplifier
6211	Twin triode	300	14	1.4	Medium-speed counter
6414*****	Twin triode	450	17	2.0 3.6 (a)	High-speed counter or amplifier
6463	Twin triode	600	30	4.0 7.0 (a)	High-speed counter, amplifier, or core-driver
6525	Thyratron	150	Peak 60, Avg 20	. . .	Gate or relay-driver
6829*****	Twin triode	450	20	2.2 4.0 (a)	High-speed counter or amplifier
6919	Twin diode	200	3.0 (b)	. . .	Gate or clamp
7036	Heptode	300	16	0.75	High-speed gate

***** 5-Star high-reliability tube.
(6829 is built to a MIL spec.)

(a) Total both plates.

(b) Maximum DC output current per plate.

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GENERAL ELECTRIC

12-11-301

Readers' and Editor's Forum

[Continued from page 26]

preprints. It is planned that these preprints will be distributed at the time of the meeting and *at no other time.*

NERVE EXCITATION IN A SQUID SIMULATED BY ANALOG COMPUTER

A mathematical model of the squid nerve was studied on an EASE Analog Computer, made by Berkeley Division of Beckman Instruments, Richmond, Calif. The purpose of this study was to test the validity of the model by attempting to reproduce certain experimental data. The model included the variation of conductance of the nerve membrane to the transversal flow of sodium and potassium ions.

Solution of the nerve excitation equation was obtained for varying conditions of initial stimulus. By applying several values of initial voltage to the amplifier which represented the resting potential of the nerve membrane, it was possible to obtain a measure of the threshold of excitation which compared favorably with experimental measurements.

Among the results observed in this study, was the "all or nothing" nature of the nerve impulses. The nerve would fire if the excitation level exceeded a given threshold. An investigation of other effects of nerve behavior is continuing, in cooperation with the National Institute of Health, Bethesda, Maryland.

BETTER EDUCATION

Edmund C. Berkeley
815 Washington St.
Newtonville 60, Mass.

To: All readers of **Computers and Automation**

To obtain more good computer people requires better education in elementary and high schools — in science, in mathematics, and in the fundamentals — reading, writing, and arithmetic.

To obtain better education in these subjects requires work by aroused persons in every community of the United States — persons aroused to pull education in the United States up to higher standards of accomplishment.

We are starting the publication of a very simple and informal monthly report "Better Education." If you are stirred up about inadequacies in the education that your children are receiving in your community, you are invited to write us, and we will send you at least one issue of "Better Education" free.

TIT-TAT-TOE BY AUTOMATIC COMPUTER

Tom Gildersleeve
Remington Rand Univac
New York, N.Y.

A program has been coded that enables the Univac computer to engage in a game of tit-tat-toe with a human opponent. Tit-tat-toe was chosen for this purpose because of the general familiarity with its rules of play and the relative simplicity of its logic, which enables the computer to play a flawless game. Communication between the Univac computer and its luckless opponent is by means of the computer's Supervisory Control Keyboard and Printer, connected directly to the computer's memory.

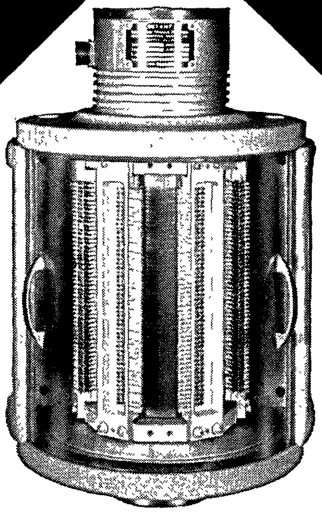
The opponent types in his move according to a code set up to indicate the squares in the tit-tat-toe board. The computer responds by printing out the configuration of the board resulting from its reply to the opponent's move. In this manner the opponent always has an up-to-date board to study. He also benefits from the advantage that he has no clerical responsibilities as far as the game is concerned; the Univac computer keeps track of the board, determines when a won or drawn position has been reached and gently reminds its opponent when he inadvertently violates the code or attempts to play in a square that is already occupied. However, despite these advantages, the opponent can, at best, draw, and if he makes but one fatal slip, the computer relentlessly grinds out its win. Knowing its resources ahead of time, it always offers its opponent the first move.

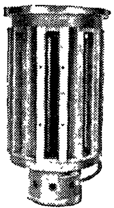
The logic of the play is of some interest. There are about 300,000 possible games of tit-tat-toe. Even for this game of very simple logic, the computer memory, which can at one time, hold all the instructions necessary to handle the million accounts of public utility companies, is not large enough to hold the instructions required to play out each one of these possibilities. The problem could have been handled by storing the required instructions on tape, and reading into the memory those particular ones which had been designed to handle the opponent's given move. But it was instead decided that all the instructions necessary to play the game should be stored in the memory at once — a sort of programmer's challenge. Consequently, it was necessary to devise a strategy. This strategy is as follows.

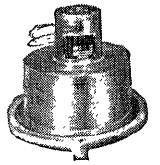
If the opponent plays in the middle square on his first move, the computer plays in the upper lefthand one. Otherwise the play is in the center square. On the opponent's second move there are certain configurations that must be specially treated to force a win or to prevent the opponent from forcing a win. The configurations are tested for, and if one is present, it is handled appropriately. Otherwise the Univac Computer resorts to the general rules by which it plays the rest of the game. These rules are as follows.

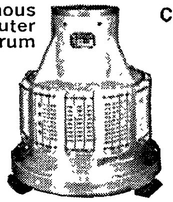
The computer pays no attention to the individual squares, but plays its strategy according to the state of what we shall refer to as the elements of the board. These elements are the three rows, the three columns and the two diagonals and are immediately recognized as those combinations of squares whose possession can yield a win. First each element is inspected for two O's (a computer symbol) and a blank square, the move yielding a win. Failing this, the computer inspects each element for two X's (the opponent's symbol) and a blank square, and finding such an element, plays in the blank square to prevent the opponent from winning. If no element fits either of the above criteria, it then searches for an element containing one O and two blanks to play in one of the blanks and force the opponent's move, thus robbing him of the opportunity to build up any threats. If there are no elements belonging to any of the above three types, a draw is announced, it congratulates its opponent and readies itself for another game. Four pairs of moves by both the computer and its opponent also results in a draw game.

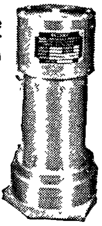
It is interesting to note that, despite the large number of permutations to be searched (a maximum of 72) to decide upon a move, the time to make this search, which coincides with the time which elapses between the end of the opponent's type-in and the computer's printout, is imperceptible to human senses. And yet, the computer always makes the optimum move.











[Continued from page 23]

Wagner, Robert W. / Introductory College Mathematics / McGraw-Hill Book Co., Inc., New York, N.Y. / 1957, printed, 430 pp., $5.00.

This book presents a mathematician's view of mathematics on a level appropriate to a college student and aims to broaden his mathematical outlook. Chapters include Numbers and Their Uses (with some treatment of the ideas of set, and one-to-one correspondence), Equations and Inequalities, Functions, Exponents and Related Functions, Angles and Trigonometric Functions, Curves and Equations, A Glimpse at the Calculus, Interest and Annuities, Statistics and Probability.

National Physical Laboratory, staff of, Department of Scientific and Industrial Research, / Modern Computing Methods, No. 16 of "Notes on Applied Science" / Her Majesty's Stationery Office, London, Eng. / 1957, printed, 129 pp., $1.89.

These computation notes are based on a series of lectures in a course "Computers for Electrical Engineering Problems." They include discussions of algebraic problems, methods for determining real and complex roots of polynomial equations, solutions of simultaneous linear equations, inversion of matrices, solutions of hyperbolic, elliptic, and parabolic partial differential equations, etc. Methods for use with desk calculators and high-speed digital equipment are both included.

Bell, William D. / A Management Guide to Electronic Computers / McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 26, N.Y. / 1957, printed, 403 pp., $6.50.

The author describes the present state of electronic business system development and predicts future developments, always telling his story so that management personnel, rather than engineering personnel, may understand it. Perhaps the more important and interesting part of the book is the second half, which gives eleven case histories of data-processing equipment applied to business problems in leading American firms. An interesting text for business management, concisely written.

Pulvari, Charles F. / Determining the Usefulness of Barium Titanate Material for Memory Devices in Large Scale Digital Calculators / Wright Air Development Center, USAF, available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. / 1956, photo-offset, 78 pp., $2.25.

This paper presents results on the production of ferroelectric materials and their storage-media properties. The paper demonstrates that they make possible the construction of an inexpensive, lightweight, small-size but large-capacity memory unit. Ample illustrations and diagrams clarify the text. A bibliography with 26 references is included.

Hammer, Preston C., editor, and 31 others / The Computing Laboratory in the University / The University of Wisconsin Press, 430 Sterling Court, Madison, Wisc. / 1957, printed, 236 pp., $6.50.

[Please turn to page 31]

These 3 New RCA Low-Cost Computer Transistors Can Open New Markets For You!

RCA now makes available low-cost high-quality transistors for reliable performance in electronic computer applications!

- Can low-priced, highly-reliable computer transistors help you expand into new markets?
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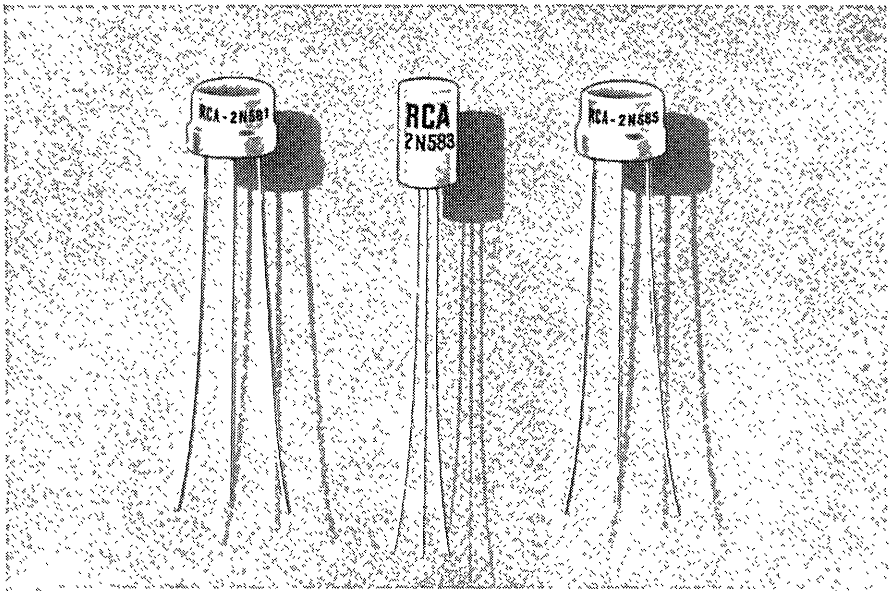
If the highly desirable combination of *reliable performance* and *low cost* have been difficult for you to find, investigate these three new RCA units: RCA-2N581, RCA-2N583, and RCA-2N585. They are specifically designed, produced and controlled for computer applications; life-tested for dependable service; electrically uniform; available in commercial quantities; and are unusually low in price.

In addition to these three new types, RCA offers a comprehensive line of transistors for your most critical computer designs. For additional information on RCA Transistors, contact your local authorized RCA Distributor or your RCA Field Representative at the office nearest you.

For technical data on RCA Transistors, write RCA Commercial Engineering, Section D-90-NN Somerville, New Jersey.



NEW GERMANIUM ALLOY-JUNCTION TRANSISTORS FOR MEDIUM-CURRENT SWITCHING SERVICE IN COMPUTER APPLICATIONS

RCA Type	Typical Alpha-Cutoff Frequency Mc	Typical DC-Current Transfer Ratio Value at Collector Ma.	Maximum Collector Ma.
2N581* (p-n-p)	8	30 at −20	−100
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RAymond 3-8361

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1625 "K" Street, N.W.
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DIstrict 7-1260

RADIO CORPORATION OF AMERICA
Semiconductor and Materials Division
Somerville, New Jersey

Books and Other Publications

[Continued from page 29]

This book is a collection of 31 papers presented by experts at the Midwest conference entitled "The Computing Laboratory in the University," held at the University of Wisconsin in 1955. The editor has collected the papers in an effort to impart perspective on the new problems created for universities by the recent rapid development of electronic computers.

One problem of great concern to universities is that arising from the lag in the training of computer operators — a lag so pronounced that computers may perhaps stand idle for want of operating personnel. As educators, universities are expected to provide personnel trained in higher mathematics and engineering; thus new equipment and efficient organization in university computing laboratories are essentials. Means for financing up-to-date computing laboratories must also be devised.

The papers collected here are intended to point up the impact of the current problems and ways for solving them. They discuss such topics as computing and the universities, applications of computing in science and industry, personnel demands — present and future, computing curriculums, computing laboratory equipment needs, and organizing and financing university computing laboratories.

Richards, R. K. / Digital Computers, Components and Circuits / D. Van Nostrand Company, Inc., 257 Fourth Ave., New York 10, N.Y. / 1957, printed, 511 pp., $10.75.

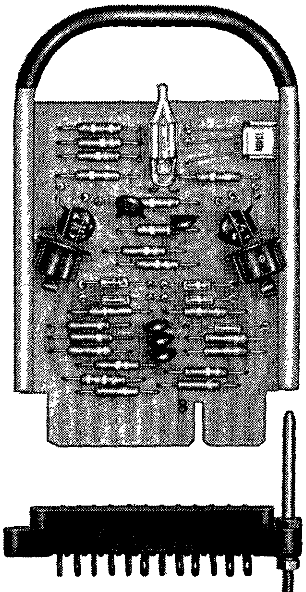
Mr. Richards proposes to provide a practical "ready source of basic engineering approaches related to digital techniques." Impressed with the transience of current design details, he stresses concepts of technique rather than such details. He desires here to supply engineers with information concerning digital computer components and circuits needed to obtain a working machine.

The text discusses the circuit logic of vacuum tube systems, transistor systems, and magnetic core systems. It discusses large capacity storage and analog-digital converters. Ample circuit illustrations are included, and bibliographical references accompany each chapter.

Alger, Philip L. / Mathematics for Science and Engineering / McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y. / 1957, printed, 360 pp., $5.50.

This author has intended to revise completely Charles P. Steinmetz's famous *Engineering Mathematics.* With Steinmetz, he does not aim to present in the one volume a complete course in mathematics; rather, he attempts to present mathematical subjects to the learner in a unified way, so that the general college or high school student will find here a supplementary unity and knowledge which will render him more adept and adequate with mathematical problems and applications in his work. The present author has also added four completely new chapters to his work, those chapters dealing with "Differentials and Integrals," "Differential Equations," "Probability" and "Mathematical Models and Electric Circuits." The author attempts, in other words, to increase the variety of mathematical tools available to the reader, all

[Please turn to page 32]



Books and Other Publications

[Continued from page 31]

the time "employing the basic symbolism and language that he learned" from his basic mathematical training.

Spangenberg, Karl R. / Fundamentals of Electron Devices / McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y. / 1957, printed, 505 pp., $10.00.

This book emphasizes the physics of electron devices. Analogous features of vacuum tubes and transistors are discussed. The author is a professor of electrical engineering and the book is intended to be an undergraduate text serving as "an introduction to electronic studies." An excellent bibliography is keyed in throughout the text; numerous supporting appendices give information pertinent to a complete understanding of the text work. The reader must have a sound mathematical background to realize the full value of the material which is presented, which includes: a brief history of electron devices, discussion of electrons and ions, electric and magnetic fields, the atom, conductors, diodes, amplifiers, oscillators, photoelectric devices, etc.

Ivall, T. E., ed. / Electronic Computers, Principles and Applications / Philosophical Library, Inc., 15 East 40th St., New York 16, N.Y. / 1956, printed, 167 pp., $10.00.

This book, first printed in Great Britain, mostly as articles in "Wireless World," is non-mathematical in presentation but does presuppose some knowledge of electricity or electronics on the part of the reader. The book attempts to give "a reasonably broad picture of electronic computing to those who . . . may be thinking of taking it up." The evolution of the computer, general principles of computing, analog and digital computing equipment, etc., are considered.

Bellman, Richard / Dynamic Programming / Princeton University Press, Princeton, N.J. / 1957, printed, 342 pp., $6.75.

This is a Rand Corporation research study. This author proposes to develop a "mathematical theory of multi-stage decision processes," calling it "dynamic programming," and he defines such processes as those employed to resolve problems when a sequence of decisions must be made. Multi-stage decision processes, he says, are to be adequate "to determine the optimal decision to be made at *any* state" of the problem system, rather than for "some *fixed* state" of the problem system.

A mathematical background through the calculus of variations is required. The word "computer" is missing from the index, and the term "computational solution" is indexed only four times.

AUTOMATIKA I TELEMECHANIKA

January, 1958

Following are citations of the papers appearing in the January, 1958, issue (Vol 19, No. 1) of *Automatika i Telemechanika* (*Automatics and Telemechanics*), published by the

[Please turn to page 33]

MANUSCRIPTS

WE ARE interested in articles, papers, reference information, and discussion relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the first of the preceding month.

ARTICLES: We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it.

Consequently, a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions.

We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 3000 words. A suggestion for an article should be submitted to us before too much work is done.

TECHNICAL PAPERS: Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable.

REFERENCE INFORMATION: We desire to print or reprint reference information: lists, rosters, abstracts, bibliographies, etc., of use to computer people. We are interested in making arrangements for systematic publication from time to time of such information, with other people besides our own staff. Anyone who would like to take the responsibility for a type of reference information should write us.

NEWS AND DISCUSSION: We desire to print news, brief discussions, arguments, announcements, letters, etc., anything, in fact, if it is not advertising and is likely to be of substantial interest to computer people.

PAYMENTS: In many cases, we make small token payments for articles and papers, if the author wishes to be paid. The rate is ordinarily ½c a word, the maximum is $15, and both depend on length in words, whether printed before, whether article or paper, etc.

All suggestions, manuscripts, and inquiries about editorial material should be addressed to: *The Editor,* COMPUTERS *and* AUTOMATION, *815 Washington Street, Newtonville 60, Mass.*

Automatika

[Continued from page 32]

Academy NAUK, Moscow, U. S. S. R. Each item ordinarily consists of: author / title / page. In some cases, the item includes all or part of the summary of the paper (each paper is printed in the journal with both a Russian and an English summary).

Popov, Vasile-Michai / On relaxation of sufficient conditions of absolute stability / Sufficient conditions of absolute stability of an automatic control system with a non-linearity in the speed characteristic of the servomotor are analyzed. It is shown that sometimes relaxation of the conditions is possible. Necessary and sufficient conditions are obtained for the case of three differential equations (with exception of special cases). / 3

Kroog, E. K., Minina, O. M. / About optimum transients in automatic control systems with limited valve position / Optimum transients are determined for control systems including regulated units with various dynamic properties and those with delay. / 10

Vasiliev, V. G. / On revaluation of accuracy of co-reproduction of disturbances by linear servosystems and by registrating systems / 26

Batkov, A. M. / Concerning the problem of the synthesis of linear dynamic systems with variable parameters / The paper deals with the determination of the differential equation of a linear dynamic system with the help of the given pulse response. / 49

Burdenkov, G. V. / Telemetering systems with code-pulse modulation / The telemetering of high-speed code-pulse devices is considered. The possibility of constructing telemetering systems based on magnetic elements with a rectangular hysteresis loop together with crystal triodes and diodes is established. The accuracy of the telemetering is evaluated. / 55

Zhozhikashvili, V. A., Mityushkin, K. G. / Relay phenomena in circuits including magnetic cores with square hysteresis loops / 64

Rozenblatt, M. A. / Dynamic characteristics of cores with square static hysteresis loops / The paper deals with the effect of eddy currents on the dynamic hysteresis loop, on the differential magnetic permeability, and on the dynamic coercive force of cores with rectangular static hysteresis loops. Formulae for dynamic hysteresis loops are obtained for sinusoidal induction, sinusoidal field intensity, and for magnetization of the core by direct current. The theoretical results are confirmed by experimental data. / 75

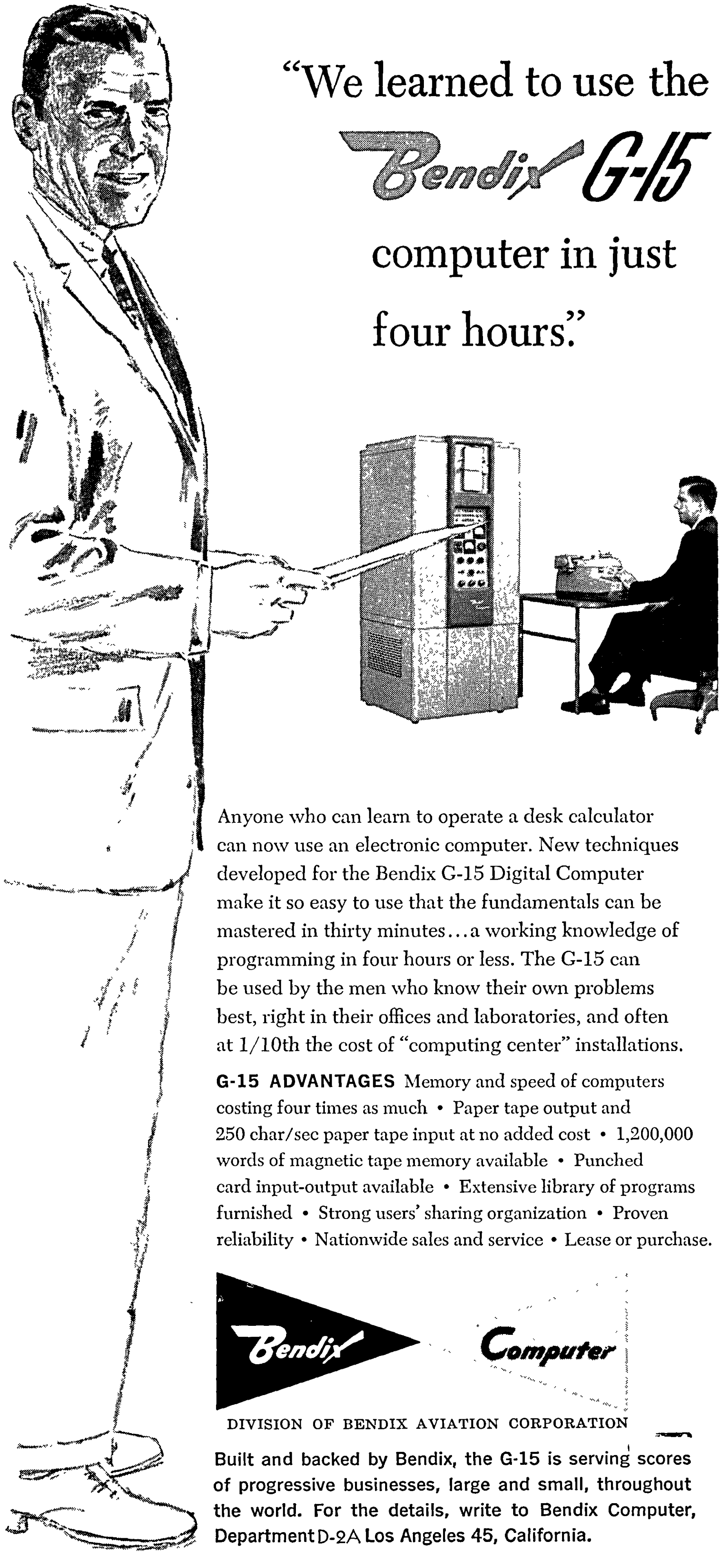
Volchkov, K. S. / Some optimum correlations for an ideal magnetic amplifier regulated by a d-c signal / The performance of an ideal saturating magnetic amplifier with an active load is analyzed. / 85

Criticism

Vertsaiser, A. L., Yakovlev, V. M. / On essential drawbacks in the terminology of the automatic control theory / 95

Chronicle

Dekabrun, I. E. / The conference on electric contacts / 99



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 computers and associated equipment from the "Official Gazette of the United States 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.

Oct. 15, 1957: 2,809,783 / Donald H. Jacobs, Brookdale, Md. / ——— / A magnetic storage device and storage units.

2,809,784 / James E. Brook, Hackensack, N.J. / Bendix Aviation Corp., Teterboro, N.J. / An electrical exponential computing apparatus.

2,810,098 / James G. Pearce and Henry T. Foster, Liverpool, Eng. / Automatic Telephone & Electric Co. Lim., Liverpool, Eng. / A high-speed hunting circuit.

2,810,102 / Marlin C. Depp and Ceasar F. Fragola, Uniondale, N.Y. / Sperry Rand Corp., Del. / A device for compensating a data transmission system for two cycle errors.

2,810,103 / Donald C. McDonald, Mount Prospect, and Arnold W. Shutler, Lake Bluff, Ill. / Cook Electric Co., Chicago, Ill. / A multiple mode servomechanism.

Oct. 22, 1957: 2,810,516 / Geoffrey C. Tootill, Camberley, Surrey, Frederic C. Williams, Romiley, Cheshire, and Tom Kilburn, Manchester, Lancashire, Eng./ National Research Development Corp., London, Eng. / An electronic digital computing device.

2,810,518 / John D. Dillon, Melbourne, Fla., and Byron O. Marshall, Jr., Pittsburgh, Pa. / ——— / An apparatus for the electronic changing of number bases.

2,810,526 / Alfred A. Rogers, Chicago, Ill. / Industrial Controls, Inc., Chicago, Ill. / A proportioning on and off controlling system for variables.

2,810,622 / Edgar A. Brown, Owego, and Charles C. Zuleeg, Vestal, N.Y. / I.B.M. Corp., New York, N.Y. / A data storage drum assembly.

2,810,901 / Hewitt D. Crane, Princeton, N.J. / R.C.A., Del. / A magnetic logic system.

2,810,903 / Donald H. Lee, Philadelphia, Pa. / Burroughs Corp., Detroit, Mich. / A device for code typing.

Oct. 29, 1957: 2,811,043 / Charles R. Bonnell, Columbia Heights, Minn. / Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. / A vertical reference and acceleration apparatus.

2,811,665 / Joseph T. McNaney, San Diego, Calif. / General Dynamics Corp., Del. / An analog data conversion system.

2,811,666 / Frederic C. Williams, Timperley, Eng. / National Research Development Corp., London, Eng. / An electronic information storing device.

2,811,683 / Fred L. Spencer, Jr., Westwood, N.J. / Bendix Aviation Corp., Teterboro, N.J. / A servo system for a low level input signal.

Nov. 5, 1957: 2,812,132 / Arthur A. Hauser, Garden City, N.Y. / Sperry Rand Corp., Del. / An electronic computing device.

2,812,133 / Brockway McMillan, Summit, N.Y. / Bell Telephone Lab., Inc., New York, N.Y. / An electron beam adding device.

2,812,134 / Hans H. Adelaar, Antwerp, Belgium / International Standard Electric Corp., New York, N.Y. / A binary electrical counting circuit.

2,812,135 / Murray W. Allen, Greenwich, New South Wales, Australia / Commonwealth Scientific and Industrial Research Organization, East Melbourne, Victoria, Australia / A binary adder-subtractor tube and circuit.

Nov. 12, 1957: No applicable patents.

Nov. 19, 1957: 2,813,675 / Thomas M. McSherry, St. Paul, Minn. / ——— / A mechanical analogue computer for use in a position indicator.

2,813,676 / Gerard R. Boyer, Montrouge, and Eugenio Estrems, Saint-Mande, France / International Business Machines Corp., New York, N.Y. / A self-complimenting electronic counter.

2,813,677 / Alfred D. Scarbrough, Los Angeles, Calif. / Hughes Aircraft Co., Del. / A high speed counter for producing electrical signals indicative of the total number of revolutions of a revolving shaft.

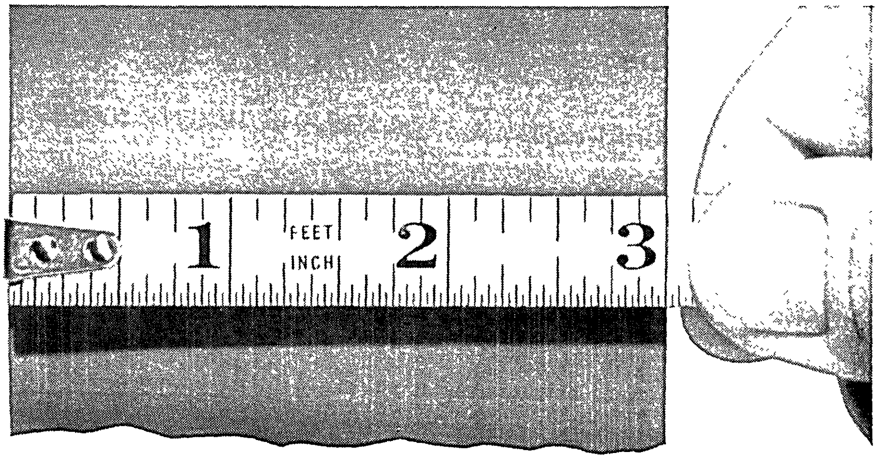
2,813,678 / Dwight D. Wilcox, Jr., Rochester, N.Y. / U.S.A. / An electronic digital computer for computing the difference in the number of pulses over two input channels.

2,814,003 / Etienne Alizon, La Celle Saint-Cloud, France / Compagnie Industrielle des Telephones, Paris, France / A binary numeration pulse counter.

2,814,005 / Sabert N. Howell, Huntington, and William Derganc, Centerport, N.Y. / U.S.A. / A self-balancing servo circuit.

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.



New business weapon in the war on paperwork

Extra-wide magnetic tape is a key factor in enabling Honeywell's DATAmatic 1000 to process business data at new record-breaking speeds. New recording techniques and the tape's greater capacity team up to exploit the electronic speeds of the central computer.

This ingenious tape helps explain DATAmatic 1000's ability to devour all sorts of business information at the rate of 900 fully punched cards a minute.

Most important, it steps up the flow of this information to and from the central computer to a peak rate of 120,000 digits per second, or a sustained speed of 60,000 digits per second.

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There is.

It holds far more business information than conventional tapes. First, because it's wider. Second, because unique recording methods now utilize its surface more completely and efficiently. Data is organized for more rapid accessibility, and to save valuable time DATAmatic 1000 can even read the tape in both directions, coming or going!

This new magnetic tape is but one of the many features of DATAmatic 1000 designed specifically for business use. That is why consideration of any business data processing program is incomplete without the facts on DATAmatic 1000.

Our applications engineers will be glad to discuss your requirements. Write for details to Walter W. Finke, President, DATAmatic Division, Dept. A3, Newton Highlands 61, Massachusetts.

Honeywell

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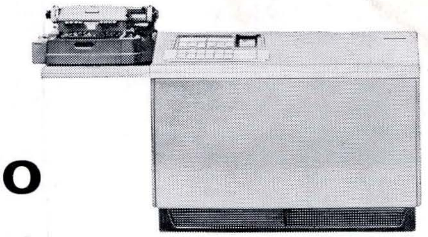
ELECTRONIC DATA PROCESSING

TODAY'S GREATEST VALUE IN ELECTRONIC COMPUTERS!

ROYAL PRECISION LGP-30



Compare it, feature by feature, with the other computers in its class

Feature	Computer A	Computer B	Computer C	Computer D	LGP-30	
Memory Size	220 words for data only	2160 words	1000 or 2000 words	84 words for data only	**4096 words for data & program (either or both)**	**LARGEST CAPACITY IN ITS CLASS**
Max. Speed Add Multiply	 20/sec. 4/sec.	 Comparable to LGP-30	 Comparable to LGP-30	 3/sec. 1/sec.	 **Over 440/sec.** **Over 50/sec.**	**SPEED EQUAL TO MANY ROOM-SIZED COMPUTERS**
Size	17 sq. ft.	6.5 sq. ft. plus table for typewriter.	45 sq. ft.	9.2 sq. ft. plus table for typewriter & control unit.	**11 sq. ft.**	**COMPACT, DESK-SIZED, COMPLETELY MOBILE**
Input-Output	Keyboard only — tape at extra cost.	Independent tape preparation at extra cost.	Extra cost peripheral equipment required.	Tape and typewriter for numerical input-output only. Independent tape preparation at extra cost.	**Tape typewriter for alpha-numeric input-output standard equipment.**	**DELIVERED COMPLETE. NO ADDITIONAL EQUIPMENT NEEDED TO PREPARE DATA, PROGRAM OR REPORTS**
No. of tubes	165	450	2,000	248	**113**	**FEWER COMPONENTS MEAN LESS MAINTENANCE, FEWER CHECKOUTS**
Voltage	220 V	110 V	220 V	110 V	**110V**	**PLUGS INTO ANY REGULAR WALL OUTLET**
Power	2.5 KW	3.0 KW	17.7 KW	1.65 KW	**1.5 KW**	**NO SPECIAL WIRING OR AIR-CONDITIONING REQUIRED**
Ease of programming & operation	Not alpha-numeric. No internal program storage.	Alpha-numeric at extra cost. 8 part instruction. Requires computer specialist.	Alpha-numeric at extra cost. Requires computer specialist.	Not alpha-numeric. No internal program storage.	**Alpha-numeric. Complete internal program storage. Standard typewriter keyboard. Simplest command structure of all.**	**EASY TO PROGRAM AND OPERATE.**
Cost Sale Rental	 $38,000 $1000/mo.	 $49,500 $1485/mo.	 $205,900 $3750/mo. up	 $55,000 $1150/mo.	 **$49,500** **$1100/mo.**	**LOWEST COST EVER FOR A COMPLETE GENERAL PURPOSE COMPUTER**

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