

COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

Vol. 6

No. 1

Pt. 1

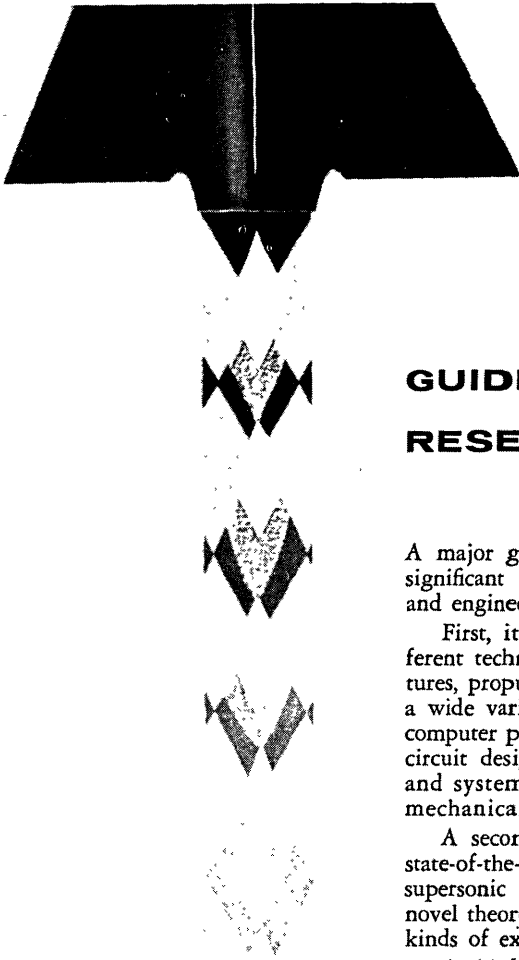
Modern Large-Scale Computer System Design
. . . Walter F. Bauer

Logical and Combinatorial Problems in Computer Design
. . . Robert McNaughton

Transistorized Magnetic Core Memory
. . . Bell Telephone Laboratories

Jan.

1957



GUIDED MISSILE RESEARCH and DEVELOPMENT

A major guided missile research and development program has several significant characteristics that are of particular interest to the scientist and engineer.

First, it requires concurrent development work in a number of different technical areas such as guidance and control, aerodynamics, structures, propulsion and warhead. Each of these large areas in turn contains a wide variety of specialized technical activities. As an example, digital computer projects in the guidance and control area involve logical design, circuit design, programming, data conversion and handling, component and system reliability, input-output design, and environmental and mechanical design.

A second characteristic is frequently the requirement for important state-of-the-art advances in several of the technical areas. For instance, the supersonic airframe needed for a new missile may necessitate not only novel theoretical calculations, but also the design and performance of new kinds of experiments.

A third characteristic of missile development work is that such close interrelationships exist among the various technical areas that the entire project must be treated as a single, indivisible entity. For example, what is done in the guidance portion of the system can affect directly what must be done in the propulsion and airframe portions of the system, and vice versa.

These characteristics make it clear why such work must be organized around strong teams of scientists and engineers. Further, for such teams to realize their full potential, they must be headed by competent scientists and engineers to provide the proper technical management. And finally, all aspects of the organization and its procedures must be tailored carefully to maximize the effectiveness of the technical people.

Principles such as these have guided The Ramo-Wooldridge Corporation in carrying out its responsibility for overall systems engineering and technical direction for the Air Force Intercontinental and Intermediate Range Ballistic Missiles. These major programs are characterized by their importance to the national welfare and by the high degree of challenge they offer to the qualified engineer and scientist.

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COMPUTERS AND AUTOMATION

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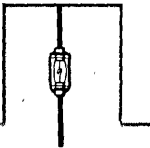
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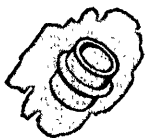
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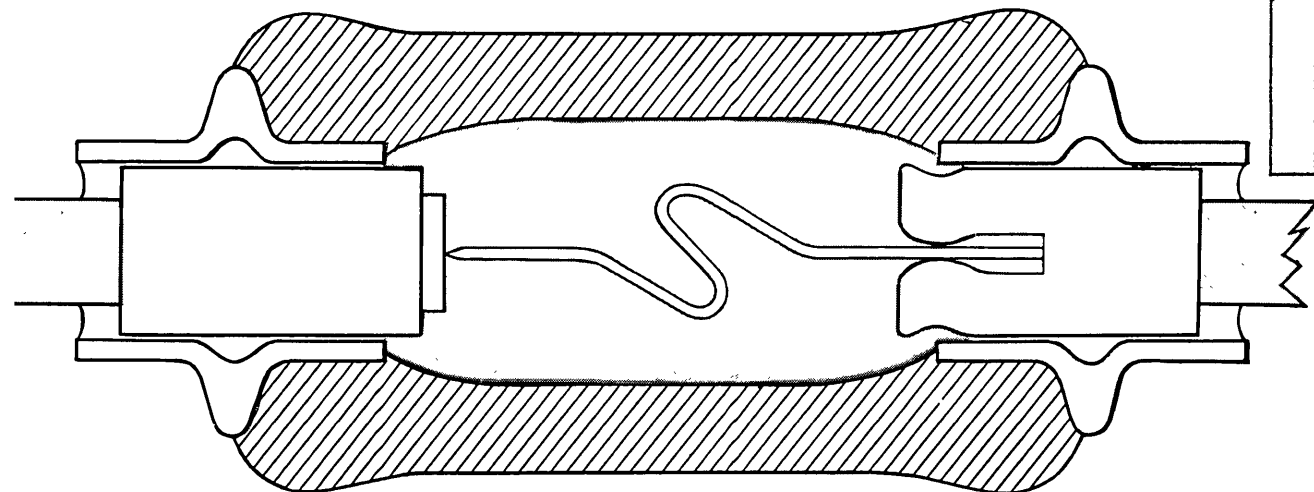


Metal eyelet—fused to glass tubing—provides strong construction and builds in provision for cooler operation. In Sylvania's metal to-glass package, heat is dissipated by the eyelets and leads.



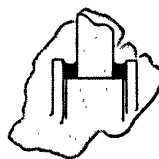
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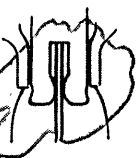
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THE EDITOR'S NOTES

EDUCATION AND COMPUTERS — I

This issue of "Computers and Automation", vol. 6, no. 1, starts our sixth year of publication. For the first time we publish an issue in two parts, Part 1, a regular issue, and Part 2, "Education and Computers, Report No. 1". Why?

At the Eastern Joint Computer Conference in New York, December 10 to 12, at the luncheon for the press on December 10, at the cocktail party that evening, at the meeting of the Council of the Association for Computing Machinery the evening of December 11, and at the meeting of the Joint Computer Conference Committee the evening of December 12, your editor noticed among other things a sense of concern and urgency and even distress about something new. The subject was not machines, nor scientific frontiers in machines, nor programming — but people. The marvelous machines that we in the computer field have been making, the marvelous promises of help that these machines offer to human beings and their enterprises, are setting up a vast demand for people to come into the computer field. And not just any people, but educated people. Nearly every organization in the computer field is trying to hire educated people.

And of course the computer field is not alone in needing educated people. The aircraft industry, the electronics industry generally, a great many branches of science, the executive ranks of business and industry, the teaching profession itself — all are hunting for educated people. In "Computers and Automation" for July we published some sad but important comparisons, which we repeat in Part 2 of this issue on page 50.

It has never been a policy of ours to "let George do it". Here is a need where "Computers and Automation" might help. Let's try. Part 2, "Education and Computers, Report No. 1" is the first step in trying. We hope there will be many more steps we can take. You, our readers — please write us, tell us, advise us.

WHO'S WHO IN THE COMPUTER FIELD, 1956-7

Here is a brief report as of December 20 (January issue press time) on the status of "Who's Who in the Computer Field, 1956-7". (This is an extra number of "Computers and Automation",

price \$15, to be published early in 1957, which we expect will contain names, addresses, and some information for an estimated 10,000 computer people.) We have received several thousand Who's Who entry forms, including, for example, 62 from Ramo-Wooldridge alone. We have collated these entry forms with all names and addresses of persons whom we know of as interested in computers, and all Who's Who entries published June 1955 and later. We are busily producing final copy for the first part of the alphabet. It now looks as if we may get the Who's Who to press in January.

As to orders, we have received to date about 130, or about 1/4 of what we estimated we would receive by this time. Evidently, not many people want the Who's Who, and it looks again like an unreasonable undertaking.

—————

SPECIAL ISSUES OF "COMPUTERS AND AUTOMATION"

The June issue of "Computers and Automation" in each year commencing with 1955 is a special issue, "The Computer Directory", containing a cumulative "Roster of Organizations" and a cumulative "Roster of Products and Services in the Computer Field", and other reference information.

In early 1957, we shall publish Edition No. 2 of a cumulative "Who's Who in the Computer Field", as an extra number of "Computers and Automation". For more information, see page 38.

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MODERN LARGE SCALE COMPUTER SYSTEM DESIGN

WALTER F. BAUER
The Ramo-Wooldridge Corporation
Los Angeles, Calif.

(This report arises from lectures the author has given in the special summer sessions on computers given at the University of Michigan in 1954, 1955 and 1956.)

The objective of this report is to provide a survey of modern computer system design technology especially as it pertains to the use of large-scale systems for commercial and scientific purposes. The areas to be discussed are: Memory Devices, Information Storage and Internal Checking, Operating Speeds, Instruction Logic, and Input-Output and Off-Line Equipment. The components or design aspects of a number of modern computer systems will be referred to including the IBM-701, IBM-704, IBM-705, NORC, BIZMAC, UNIVAC I, UNIVAC II, Univac Scientific Models 1103 and 1103A, and the LARC. These are the computers available for rent or purchase, or built by organizations which rent or sell computers. Occasionally other computers will be referred to. Under System Design, the Project ERMA machine and the Office of Air Controller machine will be briefly discussed. In this survey and comparison, emphasis will be placed on the unusual or especially commendable aspects of the system.

Conspicuous by its absence here is a Bibliography of articles on the various machines and techniques presented. In this most rapidly changing field, most new developments are almost never found in books, and are seldom found in journals. The information recorded here was gained through reading manufacturers' reports and brochures, through discussions with manufacturers' agents, and through conversations with computer people generally. Manufacturers' reports, brochures, and discussions are available for the asking.

Memory Devices

The first operating stored program computer, the SEAC computer of the National Bureau of Standards, was equipped with mercury delay line memory. A short time later the ERA-1101 computer appeared with its magnetic drum memory. Again within approximately one year's time, the first cathode ray tube storage machines ap-

peared, the first one of which, and most notable, was the Whirlwind I computer at M. I. T. The family of Institute for Advanced Study machines involved the Williams tube-type storage which was somewhat different in design from that of the M. I. T. storage tube design. More recently the trend is toward the magnetic core memory. The first machines of commercial availability which were produced with magnetic core memories were the Univac Scientific, Model 1103 computers, and the first one delivered went to the Operations Research Office of Johns Hopkins University in July, 1954. All succeeding 1103 type computers and the 1103A types to follow have magnetic core memories. With the more modern computers, again commercially available, the IBM-702 had electrostatic storage as did the 701. The 704 and 705 are equipped with magnetic core memories. The UNIVAC I is the only computer ever produced commercially with a mercury delay line type memory. Its successor, the UNIVAC II, to become available this year will involve a magnetic core memory for the basic high-speed internal storage device.

Thus the significant trend in memory devices is toward magnetic core memory. Early electrostatic memories were of rather low reliability. They required frequent adjustments during normal operating periods, and frequently the machine designers found it desirable to re-design deflection circuitries and other associated equipment. The result was that after two or three years of improvement gained through trial, error, and bitter experience, electrostatic storage became a reliable instrument and computers using this memory were very frequently recording reliability figures higher than 90%. However, the potential reliability of the magnetic core type is considerably greater. In private correspondence with William Papias of M. I. T., this writer received the following information in regards memory reliability of Whirlwind I after the replacement of the electrostatic memory with the core: "The main interval between memory parity alarms increased from a few hours to about

two weeks, while the maximum interval went up from a few days to approximately six weeks. Specific memory maintenance time was reduced from a large figure to a couple hours per month". Thus, the reliability measured in terms of intervals between parity alarms or as represented by maintenance time increased by a factor of at least 10 in this case. Since probably upwards of 70% of the down time caused by electronic component failure (not including electro-mechanical devices) of a computer can be attributed to memory device failures, overall computer reliability will jump considerably.

Besides the advantages over electrostatic and mercury delay line type memories in areas of reliability, magnetic cores offer a tremendous speed advantage. The average access time with the mercury delay lines in the SEAC computer is 192 microseconds. This can be compared with the 6-10 microseconds access time with the core memories. Magnetic cores offer only a slight margin of greater speed over electrostatic types since electrostatic memories usually operate in the 10 or 12 microsecond region (some considerably higher), whereas magnetic cores operate in the 6-8 microsecond region. Specifications and characteristics of a number of modern computers are given in Table 1. The 4 microsecond memory cycle of the LARC computer as presented there is essentially an effective cycle since the design is such that there is a 2 microsecond overlap between the next operation and the last 2 microseconds of the normal 6 microsecond cycle time of the memory — that is, the normal memory cycle involves something like the following: 2 microseconds for select and 2 microseconds for the destructive read. Selection of the next read is performed simultaneously with re-writing the information destructed in the reading operation.

It is generally agreed among computer designers that the conventional ferrite core cannot be switched at speeds which would result in basic cycles considerably less than 4 microseconds. Certain investigations continue in the direction of non-destructive read techniques. Also, it is expected that the future will show shorter memory accesses with a magnetic device called the "film wafer". In this technique, the resulting magnetic field is extremely low in power and consequently can be switched at extremely high rates. Signal amplification and reliability will be the critical obstacles in this development.

Memory sizes are increasing as fast as memory speeds. The conventional high-speed

computer for scientific purposes has 4,096 words of magnetic core storage with options of 8,000 and 12,000 words, and in some cases an optional 32,000 word core memory. Table 1 lists the memory sizes available, together with certain optional sizes. High capacity, ultra-high access memories are necessary in scientific computing activities. Most large-scale scientific installations are happy with 4,000 to 8,000 words of high-speed storage. The IBM Corporation has announced the future availability of a 32,000 word magnetic core storage. The three options available are 4,000, 8,000, and 32,000 words with respective monthly rental figures of approximately \$6,000.00, \$12,000.00 and \$15,000.00. The difference in rental price between 8,000 words of core storage and 16,000 words of drum storage, as compared with 32,000 words core storage, is almost negligible. Because of this, most installations who have need for 8,000 words of magnetic core and a considerable amount of drum storage are ordering the 32,000 word core storage. Presently, up to 12,000 words of magnetic core storage are available on the 1103A computer, together with 16,000 words of drum storage. It is expected that optional replacement of the magnetic drum with magnetic core will be announced soon.

Dr. Edward Teller of the University of California Radiation Laboratory at Livermore which wrote the specifications for and ordered the LARC computer, opined at the Western Joint Computer Conference in San Francisco in January, 1956, that the 50-100,000 words of high-speed storage to which people have occasionally referred, does not appear on the horizon as a necessity for the hydrodynamics applications of that group. Essentially, the Livermore group feels that the 20,000 words of core storage will suffice. The interest in the 32,000 words of core storage in connection with the IBM computers as referred to above largely results only from the fact that the small increase in price is attractive even in view of the increase, only moderate, in flexibility and convenience with the capacious high-speed storage. There is little doubt, however, that the future will see many problems requiring 32,000 word, or larger, core memories.

The need for a moderate-speed, medium access and high volume storage for commercial purposes is great, however. IBM has recently announced the IBM-305 Magnetic Disc memory. This memory will allow relatively low access to 5 million characters of information stored on discs to which reading and recording heads will travel for read and write operations. Remington Rand had included in their LARC proposal a magnetic disc file which would allow access to each of two million words of information in less than one

second. This has been removed from the LARC equipment complement but a reasonable guess is that equipment of this type is contemplated for future systems.

On Table 1 there is also included the drum storage available on the various computers. The drums on the 701, 704, and 705 computers turn at rates which give maximum access times of 100, 25, and 16 milliseconds respectively. The drum on the Univac Scientific models turns at about 1800 r.p.m. with a consequent maximum access time of 35 milliseconds. The addressing scheme on the Univac Scientific drums is such that each of the 16,384 words can be addressed directly and can be used as an operand in the instructions. There is a trend in magnetic drum storage devices toward a higher pulse density with more modern techniques such as non-return-to-zero recording. This results in greater storage capacity for a given size drum and a higher transfer rate after the waiting or access time. It is of small consequence to the user except for the fact that it will probably result in a lower cost per item stored on magnetic drum. All of the magnetic drums on these computers are of the "single head type"—that is, one head is used for both reading and writing on each track. It is also interesting to note that since these drums are used for semi-bulk storage, no schemes for reducing access time such as the circulating registers on the ElectroData computer and the Bendix G-15 computer are in evidence.

On Table 2 there is recorded the major characteristics of the various tape units used with the large-scale computers. It is interesting to note that all of the tapes involve the parity bit for checking. Also, all of these tape units record the information as 6 bits plus a parity check bit plus a bit serving as a timing channel. The horizontal parity bit on the IBM 727 tape units is an innovation and involves forming parity bits for each of the 6 information channels of the entire unit record after each record is recorded. In the case of a parity bit failure with the Uniservo I and II equipments, the information is re-read automatically twice with bias voltages changed, and the parity bit re-checked each time. The Uniservo I equipment to be used with the first models of the 1103A involves, in addition to the parity check bit, the placing of a certain code word in a register upon the occurrence of a parity bit failure. By means of programming, the information can be re-read with high and low bias voltages with the expectation that such re-reading will be performed correctly.

The obvious trend with magnetic tapes is toward an increase in speed and recording density. For example, the transfer rate of the tapes used on the 1103A will be ten times greater than the Raytheon units used with the 1103, and at a later date the Uniservo II equipments will provide an increase factor of about 16 over the Raytheon units. The very high transfer rate on the special magnetic tapes of the NORC computer is achieved primarily by the high recording density of 510 pulses per inch, and 140 inches per second tape speed.

It is interesting to note that none of these computers have the means to accomplish independent tape search. We refer to the ability to command a search for a particular block of information on magnetic tape and have the search carried out while computation proceeds. This feature is found on many of the smaller drum computers. While simultaneous read and write is possible with both the Univac and IBM-705, it is interesting to note that complete flexibility such as simultaneous writing on two or more tape units is still an item for the future in large-scale system design. IBM plans to announce a modification of the 704 which will allow this.

Information Storage and Internal Checking

There exists a definite trend in large-scale computer system design toward the handling of numerical information in decimal form and the ability to handle the full keyboard of alphabetic characters. The scientific computers now on the market still use the binary type of internal storage; however, it is likely that the 704 and the 1103A will be the last scientific computers to use the internal binary number system. This will probably be true despite the feelings of certain groups using scientific calculators that the storage of numerical information in binary form has distinct advantages in performing the complicated programming logic desired in scientific applications. It is entirely possible that future scientific computers will include the logic to handle both decimal and binary information.

The internal checks mentioned in Table 3 involve that checking performed in the machine in the control unit and in transfers between the various units such as transfers between the memory unit and control unit. We have discussed checking features above in connection with magnetic tape units.

Perhaps the situation in regards internal checking which is most in evidence is that internal

System Design

TABLE 1
COMPUTER STORAGE

<u>Computer</u>	<u>Memory Type</u>	<u>High Speed Storage* Access Time</u>	<u>High Speed Storage Capacity</u>	<u>Drum Memory</u>
IBM-701	Cathode Ray Tube or Magnetic Core	12	2,048 or 4,096	8192 words
IBM-704	Magnetic Core	12	4,096, 8,192 or 32,768 words	8192 or 16,384 words
IBM-702	Cathode Ray Tube	23	10,000 characters	60,000 characters
IBM-705	Magnetic Core	17	20,000 characters	60,000 characters
NORC	Cathode Ray Tube	8	3,600 words	- - -
BIZMAC	Magnetic Core	20	4,096 characters	16,368 or 32,736 characters
UNIVAC I	Mercury Delay Line	400 (max.)	1,000 words	- - -
UNIVAC II	Magnetic Core	40	2,000-10,000 words	- - -
Univac Scientific Model 1103	Cathode Ray Tube or Magnetic Core	12 8	1,024 words	16,384 words
Univac Scientific Model 1103A	Magnetic Core	8	4,096, 8,192 or 12,288 words	16,384 words
LARC	Magnetic Core	4	20,000-97,500 words	3,000,000 words

*in microseconds

TABLE 2
MAGNETIC TAPE UNITS

<u>Computer</u>	<u>Tape Checking</u>	<u>Magnetic Tape Type</u>	<u>Transfer Rate</u>
IBM-701 Model 1	Parity bit	Type 726	1250 words / second
IBM-701 Model 2			2500 words / second
IBM-702	{ Vertical and Horizontal Parity bit }	} Type 727	15,000 char / second
IBM-704			2500 words / second
IBM-705			15,000 char / second
NORC	Bit count-modulo four Digit count Illegal Combinations	Modified Type 727	4,000 words / second
BIZMAC	Parity bit	Special	10,000 char / second
UNIVAC I	Parity bit, character count, and automatic re-read	Uniservo I	12,800 char / second
UNIVAC II	Parity bit, character count, and automatic re-read	Uniservo II	20,000 char / second

(Table 2 continued on next page)

Computers and Automation

(Table 2: continued from preceding page)

<u>Computer</u>	<u>Tape Checking</u>	<u>Magnetic Tape Type</u>	<u>Transfer Rate</u>
Univac Scientific Model 1103	Double recording	Raytheon.	200 words / second
Univac Scientific Model 1103A	Parity bit and character count	Uniservo II*	3,300 words / second
LARC	Parity bit, character count, and automatic re-read	Uniservo II	2,000 words / second

*first models equipped with Uniservo I with parity bit and character count checks

TABLE 3
INFORMATION STORAGE

<u>Computer</u>	<u>Word or Character Length</u>	<u>Storage Item Type</u>	<u>Internal Checking</u>
IBM-701, 704	36 binary digits/word	Binary	- - -
IBM-702, 705	6 binary digits/char.	Decimal-Alphabetic	Instruction verification, Parity on transfer
NORC	16 decimal digits and sign/word	Decimal	Bit count and arithmetic check
UNIVAC I, II	11 characters and sign (or character)/word	Decimal-Alphabetic	Parity on transfer, arithmetic check
BIZMAC	6 binary digits/char.	Decimal-Alphabetic	Instruction verification Parity on Transfer Parallel arithmetic and control
Univac Scientific Model 1103, 1103A	36 binary digits/word	Binary	- - -
LARC	11 decimal digits and sign/word	Decimal	Parity on transfer Illegal combination check

checking features are increasing in number. One notices that the 701 and 1103 had no internal checking at all. The trend is seen especially in the computers for business. This is probably due to the fact that one number wrong out of a thousand numbers is not catastrophic in scientific work; usually the scientist knows on the basis of reasonableness what to expect and can ferret out the incorrect value from many. Also, many scientific problems allow a natural check. For example, the answer to a linear system of algebraic equations can be checked by re-substitution thereby allowing, in a few seconds, a complete check on hours of computer time. In the case of the business application, however, one wrong answer often means an irate employee or customer (or ex-customer). Another factor may be the rather conservation outlook which the businessman has toward electronic devices.

The design of Univac I centered around the requirements of the Bureau of Census, for the first Univac was delivered there in 1951. The Bureau specifications called for a machine having ample checking features for the assurance of the correct processing of the large amount of census data. In the Univac this was accomplished by building parallel arithmetic units and control units which perform the operations twice, simultaneously and independently, followed by an appropriate check. The trend is away from such parallel construction which implies duplicate equipment and toward other types such as parity checks on transfer. Despite certain shortcomings evident today, it is amazing that the Univac, designed 7-8 years ago, has withstood the test of time in the face of extremely rapid technological improvements.

Some of the more common checks in use today are as follows:

1. Parallel arithmetic
2. Parity bit on transfer
3. Illegitimate combination
4. Arithmetic checks
5. Instruction verification.

The parallel arithmetic check of the Univac has been described above. Parity bit check on transfer is perhaps most commonly used today. On each transfer between the various units the parity bit is checked and the machine halted or a signal initiated upon the detection of an improper parity. The illegitimate combination check implies that a check is made to see whether the character code is legitimate or whether the instruction code is in the computer repertoire. With the character code

check for computers performing decimal arithmetic the four binary digits (or, in some cases six binary digits) representing one of the digits from 0 to 9 would be checked to see if the combinations 10 through 15 were present. This type of check is very popular in medium-speed computer design, and is included, as examples, in the Datatron and IBM-650.

The arithmetic check usually involves the carrying of a check digit along with operands in the arithmetic operations. These check digits remain invariant under the operation. As a result of the same operation performed on the check digit a check can be made to determine whether that digit is appropriate to the result. This type check is found on the NORC computer. The bit count check of the NORC is essentially a parity bit but sums the binary digits modulo 4 rather than modulo 2 as with the parity bit.

The instruction verification check is found on the IBM-702 and IBM-705 computers and involves checking an instruction while it is being performed to determine whether the instruction code digits are legal and have been interpreted correctly.

Operating Speeds

In Table 4 there is shown the operation times for the computers. All operation times include the appropriate number of accesses to the memory including the access time necessary to get the instruction itself. This implies 2 accesses for the 704, 3 accesses with the 1103, and 4 with the NORC. Arithmetic operation times on the 702, 705, and the BIZMAC, those computers intended solely for business applications, are based on the assumption that all operands are 5 digits in length.

No important trends are in evidence here except the obvious one that computing times for the scientific computers is drastically reduced with the announcement of each new system. The most recently announced computer, the LARC, has the remarkable addition time of 4 microseconds, achieved mainly by an overlap between instruction execution and memory access. Recently, the University of California Radiation Laboratory at Los Alamos asked for bids on a computer which would have an addition time less than one microsecond including memory access. The response to this request is the IBM-STRETCH Project which will result in a computer considerably more advanced than the LARC.

There are a number of interesting comparisons. For scientific computations the 704 enjoys a wide margin of speed over its predecessor, the 701, besides the floating point feature which the 701 does not have. Since the 1103A is almost completely program-compatible with the 1103, the differences in time reflect only the difference in operating speeds between the electrostatic and the magnetic core memories. The add and divide times for the 1103 (1103A) are seen to be considerably slower than those of the 704, while the multiply times are comparable. The NORC will most likely be the fastest computer in operation until early 1958 when the LARC appears. No figures are available for the STRETCH computer to be announced by IBM for operation about 1960.

Operating speeds for the commercial computers are considerably less important. The core memory of the 705 has given it a considerable speed advantage over the 702. The greatly increased speed of the Univac II over its predecessor Univac I will no doubt allow greater convenience and flexibility in those commercial applications where computation must proceed simultaneously with tape transfers as it does in most cases.

Instruction Logic

A short time ago a divergence of opinion close to a controversy existed between the advocates of the single address logic and advocates of the multiple (usually three, sometimes four) address logic. In 1951 the SEAC and Mark III computers with their four-and three-address logic were compared with the Whirlwind and ERA-1101 with their single address logic. Champions of the single address got a big boost when the so-called Princeton (Institute for Advanced Study, or von Neumann) machines and the IBM machines appeared. Except for the NORC and the 1103 and 1103A, all the large-scale computers of Table 5 have single address instruction structure, thus indicating the rather general acceptance of the advantages of single-address logic.

Advocates of the single-address logic say that it is natural — that the programming processes are similar to those of a desk calculator, the accumulator of the high-speed device having the central dials as its counterpart on the mechanical device. Despite the advantages, certain important disadvantages exist in a hypothetical system where there is an accumulator and one can use instructions, each with a single address. Take, as a simple example, evaluating the algebraic expression $ab + cd$. After multiplying a by

b , the result must be removed from the accumulator so that the product cd can be formed there. Later ab is essentially returned to the accumulator for formation of the final value. As another example, suppose in the commercial application a part number is being searched for. The part number is stored in the accumulator and is compared with, say, part numbers from magnetic tape. As each part number is compared with the one sought, the number is removed from the accumulator so that it can be used for address modification. In each of these cases it seems desirable to have a second accumulator and an instruction logic which can make use of either one. In each of the examples cited approximately one out of six instructions could be saved by the second accumulator.

Advocates of multiple addressing schemes point to the flexibility and convenience in using two and three address instructions in logical and transfer of control operations. Consider the conditional transfer of control operation. Advocates of the two address logic, for example, would point out that the two branches of the program are clearly and explicitly given in the instruction; the contents of address X is compared with the accumulator and control either reverts to the next instruction or to Y, the other address given. These people would say that this is handled awkwardly in the single address scheme where two instructions are necessary to handle the normal program bifurcation: one to form the difference between the quantity in X and the accumulator, another to transfer if that difference is positive.

Nevertheless, the single-address instruction logic, in overall evaluation probably scores highest, for, besides advantages to the user, it offers certain simplicity in the control components. However, the addressing system apparently gaining popularity may be referred to as the "augmented single address" or the "one-and-one-half address logic". In this logic there is only one address, and, therefore, only one operand involved in operations with the accumulator. However, the accumulator has a number of parts or a number of special registers are available for use with certain orders. The normal operations are modified (or subdivided) into similar operations but dealing with a special part of the accumulator or a special register. Although none of the large-scale systems have progressed far along these lines, the IBM-705 does indeed have a total of 16 accumulator registers, each one of which is available for addition and comparison operations.

The idea of having certain special registers is certainly not new. Most single address comput-

ers have an "x register" or something equivalent. However, there will no doubt be an increasing use of these registers for greater flexibility and more powerful operations.

The "polynomial multiply" instruction is an example. This rather new instruction takes the contents of the accumulator, multiplies it by the contents of address A, adds the product to contents of B, leaving the result in the accumulator. One sees that with this process one makes one step in evaluating the polynomial in the "inside out" manner as indicated by

$$\left\{ \dots \left[(A_n X + A_{n-1}) X + A_{n-2} \right] X \dots \right\} + A_0$$

This operation is performed very frequently in scientific computation. The Univac Scientific Model 1103A will be equipped with this instruction. No special X register is necessary with the 1103A since it has a two-address scheme. However, the future will no doubt see more of these special registers with their attendant flexibility. As a matter of fact, the LARC will have two decimal digits of the instruction word reserved to specify (up to 100) special arithmetic registers. IBM will soon announce changes in the 704 which will be along the lines of more powerful instructions such as the polynomial multiply mentioned above.

Let us examine Table 5 containing an evaluation of the instruction logic of six large-scale computers intended primarily for scientific applications, and Univac I and II, intended mostly for commercial applications but used to great extent in scientific work. Despite the fact that the 705 is not listed in the table, it should be realized that its variable word length operation means that it can be profitably used on many scientific problems, especially those involving extra-precision or programmed floating point.

"Address Modification" is the first category. A computer with the B-register for automatic address modification gets the "excellent" rating, all others the "fair" rating except the 1103 and 1103A which have the "repeat" feature which allows automatic address modification with less flexibility. The B-register is an important feature, since machines equipped with it probably use 15-20 percent less storage for instructions and operate about 10 percent faster on representative problems.

The next category, "overflow handling", involves the provisions for the detection and handling of overflow in arithmetic operations. The 701, 704, NORC, Univac I, and II all have the ability to

interrogate by means of the program whether overflow has occurred and, therefore, the ability to correct it quickly and automatically by means of the program. Optionally, these computers will halt on overflow detection. The 1103 and 1103A have only an alarm which stops the computer on alarm detection. The LARC will have a complete detection system which will allow an automatic jump to one of a number of registers depending on the operation producing the overflow. Overflow handling with the floating point computers (704, NORC, 1103A) is not as important as with those having only fixed point operations.

"Program Checking" features are those designed to help the programmer in rapid programming mistake diagnosis. The 701, NORC, and 1103-1103A have virtually no built-in features for mistake diagnosis. The Univac I and II have breakpoints which allow the programmer to halt the computer (or cause change of control) at specified points in the program. The 704 has a "trapping mode" which allows high-speed tracing of the program by causing control jump to special cells and the wherewithal to return when the program reaches any jump instruction. The LARC will have an elaborate breakpoint system and will, in addition, allow the programmer to address the "current instruction counter" directly. Also, the address of the "last jump" will be filed and will be available directly to the programmer. This provides the wherewithal for the development of extremely high-speed, complete program "debugging" routines.

The "Arithmetic Operations" category refers to the part of the machine logic designed to make arithmetic easy and convenient. Taken into account here are instructions for double precision, floating point (by programming), and ease of accomplishment of arithmetic operations. It is comparatively somewhat awkward on the Univac I-II to perform addition since three instructions (one and one-half words) are necessary. Also the Univac I-II does not have a double length accumulator convenient in arithmetic operations. The 1103-1103A has the multiply-add instruction which allows, in one instruction, a multiplication and an addition of the product to a previously obtained quantity, and provides, with the use of the repeat instruction, evaluation of a vector inner product $(a_1 b_1 + a_2 b_2 + \dots + a_n b_n)$ with only two instructions. As previously mentioned, the 1103A will be equipped with a polynomial multiply instruction in floating point. The most recently designed computer, the LARC, will have a host of instructions for convenient arithmetic operations. Included, for example, are instructions which will actually perform double precision

Computers and Automation

TABLE 4
OPERATING SPEEDS
Multiplication Speed
(in microseconds)

Computer	Addition Speed (in microseconds)		Multiplication Speed (in microseconds)		Division (in microseconds)	
	Fixed	Floating	Fixed	Floating	Fixed	Floating
IBM-701	60	--	456	--	456	--
IBM-702***	253	--	1058	--	2380	--
IBM-704	24	84	240	204	240	216
IBM-705***	119	--	799	--	1819	--
NORC	56	56	72	72	272	272
BIZMAC	420	--	2324	--	--	--
UNIVAC I	520	--	2200	--	4000	--
UNIVAC II	200	--	1880	--	3680	--
Univac Scientific Model 1103	55	--	276	--	500	--
Univac Scientific Model 1103A	42	181	270	262	490	664
LARC	4	4	12	12	60	60

All times include memory accesses for instruction and operands.

*** Assumes 5-digit operands

TABLE 5
INSTRUCTION LOGIC EVALUATION

Computer	Address Modification	Overflow Handling	Program Checking	Arithmetic Operations	Logical
IBM-701	Fair	Good	Fair	Good	Fair
IBM-704	Excellent	Good	Good	Good	Good
NORC	Excellent	Good	Fair	Good	Good
UNIVAC I, II*	Fair	Good	Good	Fair	Fair
UNIVAC Scientific 1103, 1103A	Good	Fair	Fair	Good	Excellent
LARC	Excellent	Excellent	Excellent	Excellent	Excellent

*The UNIVAC is included here although not primarily a machine for scientific calculation.

arithmetic operations.

The rating on "Arithmetic Operations" ignores the great programming convenience in floating point. The 704, the NORC, and the LARC all have the feature. Later models of the 1103A will be equipped with floating point.

The column of Table 5 headed "Logical" refers to all aspects of the instruction logic which are non-mathematical and are not specifically mentioned in the remaining columns. Included here are all those instructions which reduce the programmer's "red-tape" such as subroutine handling, extraction of parts of the computer word, etc. The IBM-704 has the "logical and" and "logical or" commands which are powerful and flexible. The 701 does not have the ability to "file the current instruction register" to make subroutine handling smoother. The 704 does have this feature which is used in conjunction with the index registers.

The 1103-1103A, with its two address logic, has a complete set of jump instructions which are easy to use. One of these is a "Q-jump" which examines the left-most bit of the quotient register and jumps control or does not jump, depending on the presence of a binary 0 or 1, and then shifts left one binary digit. This allows the storage of a complete jump sequence in readily available form. The 1103-1103A also has the "interpret instruction" which jumps control to a specific cell and files the instruction counter, thereby allowing 30 digits to the program to specify any interpreting language he wishes handled by subroutines. The 1103A has an "interrupt feature" by means of which an external equipment operating asynchronous to the computer can interrupt the program and cause transfer of control to a specific cell with the instruction counter filed for later access. This allows programming convenience in input-output operations, and also allows application to devices such as analog-digital conversion devices. The LARC has a complete complement of instructions of this type. A rather unusual instruction is one which performs a "logical inclusion" test, thereby checking whether the binary ones in a word are included in the binary ones of another.

A discussion of future trends in instruction logic turns to the LARC. This machine will have addressable error registers for overflow of various causes, arithmetic error, and transfer error. Presumably bits will be introduced into these registers for program interrogation and subsequent automatic program handling. Also, all B-registers will be directly addressable as well as the current

instruction counter and the counter at performance of the last jump instruction. The addressability of all these counters will be of great convenience to the programmer and will no doubt be generally found in all future large-scale system design.

There are two ways of handling overflow, arithmetic and transfer errors: 1) have bits introduced into certain cells (or flip-flops set) which are later interrogated, or 2) have control transferred to a cell upon occurrence of one of these conditions. The former way is the design of the 701, 704, and 705. It is not clear at this early date what the design of the LARC in this regard will be. It is the opinion of this writer that the second method is more desirable. Automatic transfer to the appropriate error register will allow uniform treatment of the condition by all programmers. Also, placing the appropriate command in the error register to handle possible errors will be similar to setting a manual switch by automatic programming means; it should be realized that putting a halt instruction in the register would correspond to putting the overflow switch (or other switch) in the halt position. As a last reason for the first method, it will reduce the amount of program instructions in cases where a uniform treatment of a given type of error is possible over a large portion of the program as is usually the case.

The interrupt feature of the 1103A will no doubt be embodied in many future computers. It is available as an optional feature on the 704. This feature, which allows program interruption by equipment operating asynchronous to the computer, will allow, for example, greatly simplified timing of the row-read instructions in card reading operations. Also, it will allow convenience in the use of analog-digital conversion devices, for with it a clock source outside the computer can tell the computer when a new quantity has been (is to be) sampled. As a matter of fact, future computers would do well to have perhaps as many as five interrupt channels so that interruption due to five different causes can be distinguished.

The overall trend in instruction logic is to provide an increase in programmer convenience and automatic machine operation to reduce idle time. These increases are at the expense of complexity of computer design and construction and will result in more expensive computers. An increase in programmer convenience is necessary for survival in this era of the national programmer shortage. The two most important additions for programmer convenience are the B-register and floating point. Others, mentioned above, will follow. The other

item, the increase in automatic operation, is just as essential in this era of high-speed and high cost computer operation. The implicit cost of the non-productive computer time used while the machine operator reaches for a manual switch is appalling and will become even more so. In the future all large-scale machines of good design will have the ability to change all switches at high speed by program control. Future changes on the 704 will include this feature. Duty cycles of computers will be increased; it will not be unusual for computers to work on two problems simultaneously by means of an interrupt feature. Other inclusions will be available for increased automaticity. The Whirlwind I computer at M. I. T. already has the ability to interrogate a time clock (also optionally available on the 704) under program control and has an "idling alarm" which, if not interrogated in the program at regular intervals sounds and informs the operator of the idling of the computer or its being caught in a tight program loop.

System Design

The system design of most computers available today for rent or purchase can be called conventional. This system design consists of a central data processing unit with copious numbers of input-output devices with which it communicates. This communication, as will be discussed in more detail further below, is implemented by the central processor having the ability, under program control, to start an external equipment in motion and to transfer information from its memory to a limited buffer storage device from which the information is taken by the external equipment. In this design the system performs only one operation at a time — the operation in regards external or auxiliary equipment is serial. The important trend from this conventional system is toward one with larger buffering storage and simultaneous operation of many auxiliary equipments. This trend is best illustrated by the system design of four computing or data processing systems: ERMA, the Electronic Recording Machine - Accounting; the RCA BIZMAC; the OAC Computer, Office of Air Controller; and the LARC. The OAC computer is designed to handle the large scheduling and logistics problems of the Air Force, and ERMA is a system designed at Stanford Research Institute for the Bank of America. The BIZMAC, the only one of the four in the hands of a user, and LARC have been referred to previously. The ERMA will be built by General Electric and will no doubt involve a construction (and sales) program beyond the 30-odd machines intended for the Bank of America. This writer

does not know whether the OAC computer will be built.

Project ERMA was conceived to build a machine to handle the commercial account problem — check handling and accounting — for the Bank of America, probably America's largest bank. As illustrated by Figure 1, the system consists of an input device which reads check and deposit data into a magnetic drum processor. Periodically, information from drum storage is read from the drum memory onto magnetic tapes for subsequent printing of customer statements. A sorter, completely apart from the rest of the system, sorts checks for return to the customer along with the statement.

With this system all checks and deposit slips will have a customer account number printed on them with a "magnetic ink". Customers use the standard forms or pay extra for the unusual handling of non-standard forms. Clerks working at 5-10 input stations input the dollar amounts of the checks or deposit slips by means of keyboards. The machine automatically reads the account number and the two pieces of information are recorded on a magnetic drum. Also recorded on the magnetic drum is the customer's balance and information on the "holding" or "stopping payment" of checks. If no hold or stop payment action takes place, the amount of the check (or deposit) is deducted (added) to the balance. Periodically and automatically, as the drum fills, information is tapped off the drum, sorted by account numbers, edited and recorded on tape to provide the desired account statement to the customer.

The ERMA machine is strictly speaking not a computer but is rather a special purpose device much like the Speed Tally system for mail order house use or the Reservisor for airline seat reservation handling. The operators can exercise little control on the course of events, no programming is necessary or possible and, by and large, the machine performs the same operations day to day. However, it must be said that the very real problem of handling checking accounts is handled reasonably well by a system which allows a simultaneous input, data processing, and data output.

The system design of the BIZMAC is unusual or at least does not closely resemble the conventional computer system design. As indicated in Figure 2, the system can be thought of as five groups of components each using tape units of the magnetic Tape File. The computer is general purpose with magnetic core and magnetic drum internal memory, and can read and write information onto the tape units. The sorter is a special purpose computer

System Design

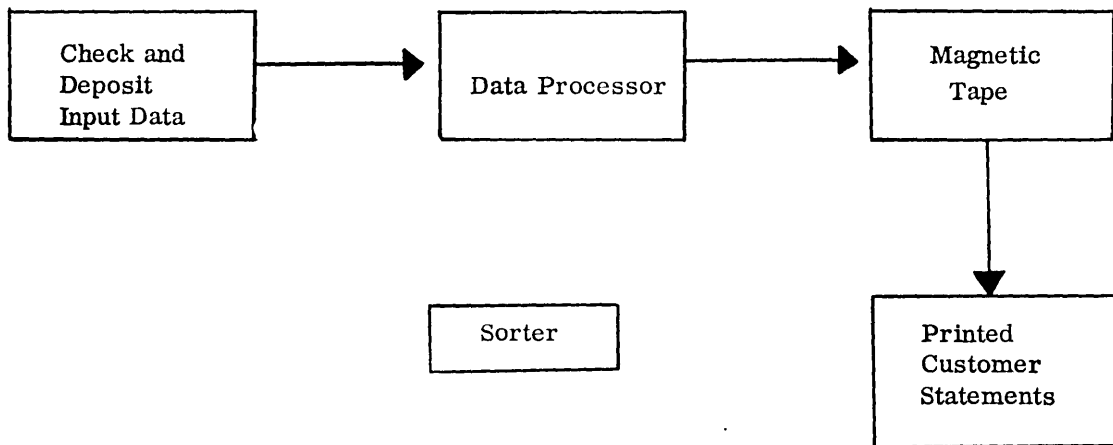


Figure 1

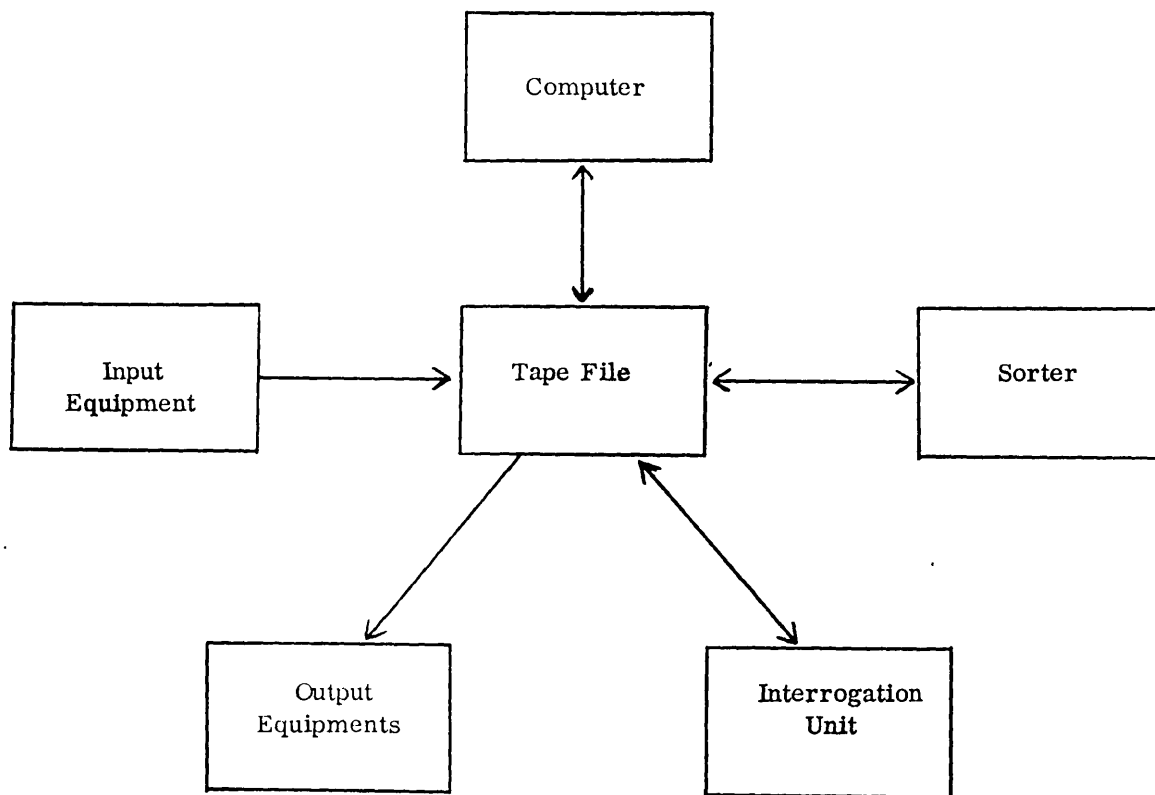


Figure 2

for arranging, merging, and extracting data stored in the tape file. The interrogation unit has facility for selecting a particular message from the tape file and printing it locally. The output equipments consist of a high-speed, 600 line/minute printer, high-speed camera allowing 4,000 character per second output, and a paper tape punch. Each of these is magnetic tape-driven. The input equipments which input data to the Tape File consist of a magnetic tape input, and an IBM card input. In addition to the input-output equipments described there is a keyboard machine to produce paper tape and a typewriter which is paper tape driven.

The important fact to realize about the BIZ-MAC system schematized in Figure 2 is that the whole system is not under the control of the computer. Each equipment communicates only with the Tape File. The Computer, Sorter, and Interrogation Unit control or use the Tape File, each in its own way: the Computer under program control, the Sorter and Interrogation Unit as a result of manual switch initiation. The various units are manually connected to the Tape File by means of a control console plugboard. Apparently only the computer can select tape units at high speeds and in complex logical situations. Once certain manual plug-ins have been effected the system does allow simultaneous operation of the many units. The Sorter, although it can work simultaneously with the computer, is of somewhat limited processing power, and the Interrogation Unit can only search for file items. The Input-Output Units operate to and from magnetic tapes like most equipment offered by Remington Rand and IBM.

The design of the OAC computer would allow it to handle the large matrix operations of Air Force program scheduling. Since that application is not fully or finally defined, the design is such as to allow expansion to a greater number of units or substitution of faster units for slower ones. Particular emphasis was placed on the input-output problem and the resultant scheme essentially uses the entire memory as input-output buffer storage.

The system shown schematically in Figure 3 consists of a high-speed memory which communicates with three devices: the Program Control unit consisting of the arithmetic and control sections, the Memory Checking and Regeneration unit, and the Input-Output units. Under program control the computer will command transfers to input-output units from the memory. Transfers can occur simultaneously with normal computation except for time-sharing a shift register. The time scheduling of all in-out operations will be handled independent of the

central computer control so that these operations will not interrupt normal computing; an input-output instruction causes a transfer to be accomplished subsequently as computing continues. Accesses to the memory by the arithmetic and control units will proceed simultaneously (or will be dove-tailed) with the accesses for input-output operations. The plan also calls for a separate Memory Checking and Regenerating unit which will proceed simultaneously, with its necessary memory accesses, with the operation of the computing and input-output functions.

Clearly the system design of the OAC computer allows the possibility of conflicts in the interaction of the various components. The conflict of two units requiring a simultaneous access to the memory is avoided by assigning certain machine cycles to the various units similar to the "time slot" idea of the LARC described below or the buffering concept on the modified 704. Conflicts between input-output devices for the high-speed memory are also avoided by setting up a time schedule by which each device, in turn, has access to the memory. Certain conflicts are not unavoidable and will cause an interlock condition to be set up until the conflict no longer exists. For example, if a transfer into the memory is not completed before an access to the same part of the memory occurs, the computer automatically idles until the transfer is completed. One sees that with this system design the input-output can proceed almost completely simultaneously with computation since essentially the entire memory is used as an input-output buffer register.

The LARC represents the most ambitious design of any system yet made available for general public information. The accent here is on modular construction: units comprising the system will be self-sufficient even for air-conditioning and may be added to or deleted from the normal system complement. The heart of the system consists of a number of Computing Units and one Input-Output Processor tied to a common information bus. The Processor is tied to a number of memory units. Two Computing Units, besides the Processor, and as many as 39 memory units, each with 2500 words of high-speed storage and complete selection circuitry, are possible.*

*The LARC system as initially ordered by the Livermore Radiation Laboratory will consist of one Computing Unit, one Input-Output Processor, 8 Memory Units (20,000 Words), 12 magnetic drums (three million words storage), 4 Uniservo magnetic tapes, a 600 line per minute printer and a Charactron Tube.

Twenty-four drums (six million words) and forty Uniservo II tape units, a 600 line per minute printer, a 25,000 character per second Charactron Tube (see Input-Output Equipments below), can be integrated into the system under control of the Input-Output Processor. Reference is made to Figure 4 for a schematic of the system. The computer is controlled by a number of consoles.

The system design of the LARC carries the idea of simultaneous operation of major units much further than in any other system while still keeping the desirable features of flexibility and the qualities of a single integrated automatic system. The Computing Units (CU) and the Input-Output Processor (I-O P) are complete computers in themselves except for memory storage. The Processor will have a complete set of input-output instructions in addition to the arithmetic and logical ones but will be slower in operating speed than the CU's, its add operation requiring 16 microseconds. Each CU and the Processor will be able to operate on any quantity stored in the Memory Units (MU's). The CU's are designed for the basic computing function while the Processor is designed primarily to handle data transfers to and from the MU's.

It has been mentioned earlier that the LARC gains much of its computing speed by overlapping parts of successive operations in executing an instruction. This time-overlap is again seen in the use of the CU's and Processor in an interesting "time slot" technique for using the MU's. Since only one unit can use the information bus to the MU's, the four microsecond memory cycle is divided into eight one-half microsecond time slots, with each communicating unit assigned certain slots. The units then use the bus during the slots to address the memory. It will be possible, for example, for a CU to address Memory Unit 1 and 2 and the Processor address Unit 3 so that the three accesses are performed in only six microseconds, rather than approximately 15 microseconds without overlap.

In the full-blown LARC system it will be possible to use one or more CU's on one problem, along with the Processor, or to use the CU's on different problems, each sharing the Processor. Communication between the units will be possible. For example, a CU will be able to signal a Processor that certain quantities have now been computed and require editing for output to tape units or transfer to drum storage. Most likely the system will operate as follows: upon the Processor's receipt of a signal from the CU it will examine a memory cell into which the CU has placed a code

word to specify the input-output or transfer operation desired.

It is interesting to note that among these four large-scale processing systems chosen for their unique system design, two are intended for business purposes and two for scientific. Moreover, an important difference exists between the two pairs: the scientific computers largely operate as one large, integrated system in which all activities of input-output and processing are handled automatically in a pre-programmed sequence. In this sense the scientific computers are more conventional. However, all of these computers show the important trend of simultaneous operation of major components allowed by duplicating certain processing components and allowing intricate simultaneous use of a memory storage by the processor and input-output devices.

Perhaps it should be emphasized here that the discussion of the system aspects of ERMA and BIZMAC does not imply that these designs are endorsed over the IBM-705 or UNIVAC II. As a matter of fact, a comparison of these general purpose machines with the special purpose ERMA would be inappropriate. In connection with the remark made above concerning the trend toward simultaneous input-output and processing, it is pointed out that this trend was started by the 705 and UNIVAC systems with their off-line card (or keyboard) to magnetic tape devices and their magnetic tape-driven printers.

There seems to be little doubt that the automatic system concept has been carried much further in the case of the OAC computer and the LARC than with the ERMA or BIZMAC. Also, there seems to be little doubt that the large scale systems for business or science in use 5-10 years from now will more closely resemble the former pair than the latter. It seems certain that the completely automatic, pre-programmed machine will replace the manual, step-by-step operation. One easily imagines a LARC-type computer, for example, performing sorting with its Input-Output Processor simultaneously with central data processing with an occasional and automatic interrupt from central control to perform an input-output function. In the past five years the computer design and the design of the system around the computer has shown a strong trend toward saving expensive machine time. This has been evidenced on one hand by systems which allow computation to proceed during in-out cycles and on the other hand by allowing only professional operators (not programmers) to operate machines. This will

become even more important in the future and the change from manual head-scratching-at-control-console to automatic operation throughout will become mandatory.

Another trend in system design which is just beginning is that toward "microprogramming". With this technique computers are designed to allow the programmer to construct his own computer instructions from "microinstructions". A typical microinstruction might be "shift left one binary digit" or "round the number in the accumulator according to the 37th digit". Later, selection and composition of microprogrammed instruction will be done by plugboards or at electronic speeds under stored program control. To this writer's knowledge, only two university groups in the country have shown active interest: Servomechanisms Laboratory of M. I. T., and Numerical Analysis Research at University of California at Los Angeles.

The form for microprogramming in system design is not now clearly seen nor is the extent to which the techniques will be applied. The future may well depend on the speed with which microprogrammed instructions can operate. If every microinstruction requires many time-consuming memory accesses, the operation speed will be slow and the technique unpopular. One recalls the fact that five years ago most computer users were content to perform floating point operations by interpretive programs even though the operating speeds were painfully slow. Later, the need became great to include floating point operations as hardware modifications. As soon as a microprogrammed instruction becomes popular, users will want to have it included as hardware unless it operates as fast as it would as a permanent hardware modification. Indeed, the computer of the future will probably have instruction repertoires 200-300 instructions in length and may have no need for a microprogramming facility.

Input-Output and Off-Line Equipments

Input-output equipment is here defined as that equipment used to get information into and out of the internal memory of the computer. Off-line equipments are those not directly connected to the computer and are usually means of transferring information from one external medium to another. Generally, the development of this electro-mechanical equipment has lagged behind the development of the computer proper. In the computer development of the last decade, it was difficult to foresee

the need for a scientific computer to output words at the 2,000 word per second rates we have today and extensive commercial applications still seemed more than ten years away.

In 1951, before the magnetic wire system was developed, the SEAC computer, not a fast computer by today's standards, was badly out of balance; its paper tape read-and-punch input-output equipment required about 25 minutes to fill the entire 512-word memory. The use of punched card equipments with computer systems greatly helped the situation, especially when the IBM-701 was developed with its scheme for "dove-tailing" computing and input-output. More recently, magnetic tape devices have caused still further amelioration. Recently, cathode ray tube equipments have appeared which are even faster.

Besides speed, reliability has always been a problem. With most computing systems over half the down time is caused by input-output failures. As with speed, reliability has increased greatly during the years. Probably the greatest motivation for increased speed and reliability has been the use of computers for business applications. However, it is true that the increased complexity of computation systems for scientific applications has also increased the emphasis on input-output equipments. It is a most significant fact that almost all the orders for the Univac Scientific 1103A systems include the Remington-Rand 600 line per minute printer.

In the early days of computers whenever an input-output function was called for, computation was interrupted while the asynchronous input-output equipment performed its operation. The Univac was the first computer to allow simultaneous computing and input-output (magnetic tape) operation. The IBM-701 computer first allowed simultaneous computing and input-output operations with a multiplicity of input-output devices. Thus the first input-output buffering systems were used.

In general, an input-output buffering storage system is designed for the purpose of allowing the computer to place information in the storage at computer speeds, leaving the information there for removal at the output equipment's rate, usually considerably slower. This does imply that a system of interlocks is necessary to allow for the possibility of poorly timed operations. Figure 5 illustrates an idealized buffering system, "single-stepped", since the buffer only holds one item of information. When the Computer communicates with the Buffer, the computer is locked-out and the

System Design

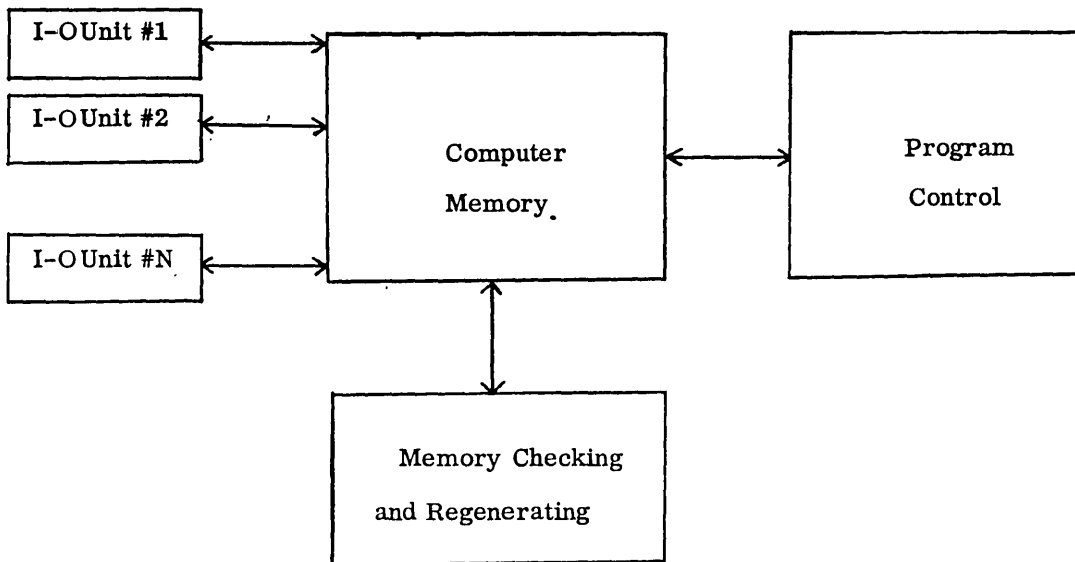


Figure 3

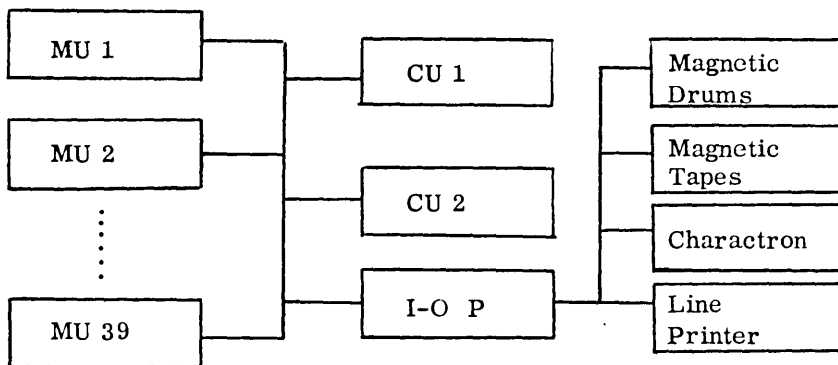


Figure 4

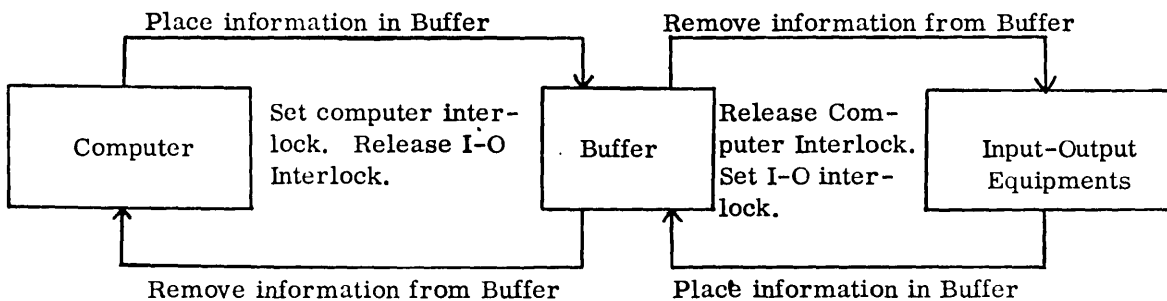


Figure 5

I-O interlock is released, allowing communication of the Buffer with the Input-Output. When communication of the I-O with the Buffer occurs the computer interlock is released and the I-O interlock set. In most cases the input-output equipment is "free-running" which implies that, during output, the output equipment continually and periodically samples the buffer. Information must be there or the interlock causes an alarm. By the same token, if the computer attempts to deposit a number in the Buffer and the computer interlock is not released, the computer will idle until the release occurs. Similar statements can be made about input.

The input-output buffering system of the 1103A is similar to the one described above. Two buffer registers are available. To choose an input-output device a code word is placed in the buffer. This starts the device in motion. Transfers then occur as described above. The system has the advantage that practically any kind of device can be attached to the buffer. Also two or more devices can be operated simultaneously. IBM will soon announce improved buffering with the 704. Under the new system two one-word buffers will allow tape transfers to proceed with minimum program control, and almost completely independent of normal computing. This much-needed change has not been announced thus far for the 1103A.

Clearly the larger such a Buffer storage is, the more useful it is. The 80 character buffer storage for card input-output on the IBM-705 allows much more economical operation than in the 701 where half-card rows were the maximum used. IBM's Tape Record Coordinator, Type 777, is essentially a 1024-character buffer which allows more convenient tape transfers. The 60-word input and output buffers of the Univac, the first computer to have extensive buffering, are still among the largest buffers available today.

A buffering system much more flexible than the system described above, is one where the buffer storage has a capacity of more than one computer word, or better than this, the buffer stores any number of words up to some large number. In this system, the item drawn out by the input-output device is the one which has been in the buffer longest. Telemeter Magnetics, an affiliate of International Telemeter in Los Angeles, actually makes a magnetic core buffer register of such a design.

Input-output buffering takes an important step forward in the system design of the OAC

computer and the LARC. With both of these computers, essentially the entire memory is buffer storage. Thus, almost completely independent operation between the computer and the input-output units is effected, with only the time-sharing of a high-speed information bus or shift register involved.

Punched paper tape has been used extensively as a computer information medium. Earlier Teletype readers and punches operated at about four characters per second. More recently the Flexowriter has come into favor because of its higher speed (8-10 characters per second) for reading and punching. For higher speed input, Ferranti, Limited, of England, has made a photo-electric paper tape reader which reads at 200 characters per second and, utilizing a well-engineered clutch device, can "stop on a character". The "Ferranti Reader" is in extensive use in this country and in England. The Teletype Company makes a 25-character per second punch as well as a 60-character per second punch. Of all the large scale systems mentioned here, only the 1103A uses paper tape as an input-output medium (in addition to punched cards). Flexowriters are used off-line to punch and read tape. On-line a 60-character per second punch and Ferranti Reader are used.

Punched cards are, of course, infinitely more popular than punched paper tape. The universal use of the punched card in business accounts for much of this popularity. Paper tape users who try punched cards find them much more convenient, for they are easily stacked and placed in a neat form for handling which is certainly not the case for paper tape, which requires awkward, inconvenient, manual handling. International Business Machines makes all of the punched card equipment used with computers in this country except for the Bull equipment on the 1103.** The Bull Company of France makes an 80-column, 12-row card reproducer which is licensed for use in this country by Remington Rand Univac. With this equipment, cards are read and punched under computer control at 120 cards per minute. With Bull equipment, a serious (for scientific uses) limitation exists: approximately only 140 holes can be punched in any card which implies that the card cannot safely be used to receive a full card's worth of binary information from the computer.

As a natural consequence of its accounting machine business, IBM makes a full range of

**Recently, RCA announced the availability of certain punched card equipments with the BIZ-MAC system.

punched card readers and punches. The Type 711 Model 1 card reader operates at 150 cards per minute and is used with the 701 computer. The Type 711 Model 2 reader, used with the 704, operates at 250 cards per minute. The Type 712 operates at 250 cards per minute and is used with the 702. The Type 714 is approximately the same as the 712 but has a control panel available which the 712 does not and is used with the 705. The Type 721 card punch operates at 100 cards per minute as does the Type 722, a later version used on the 702 and 705 systems. With all off-line equipment where a card reader is necessary, the 714 is used.

Except for the Charactron, to be discussed further below, and the camera device on the RCA-BIZMAC, non-mechanical printers are not important for use with most large scale systems, especially those discussed here. To be sure, many such devices have undergone some development as for example, the development of Atomic Instrument Company* which uses Teledeltos paper, or that of General Electric Laboratory* which uses Ferro-magnetography. However, these developments have not assumed a role of primary importance for use with large scale computing systems.

Electric typewriters have been used extensively for output of large systems but more recently have been on the decline, except for use in monitoring, in favor of line printers. Confining our discussion momentarily to on-line devices, the one in greatest use is the IBM 716 and 717 printers. Both print at 150 lines per minute and both designs are modified 407 Accounting Machine designs. The 716 has a control panel while the 717, in use with the 702, and 705, does not. The Bull Company makes a 150 line per minute printer which is available on 1103 and 1103A systems. A serious limitation of the Bull equipment is that only approximately 32 characters can be printed.

But the equipment commanding the most attention (and highest rental fees) are those used off-line in transferring data at high speeds to and from magnetic tape. Off-line equipment transferring data from cards to printed page — the familiar accounting machine, from paper tape to cards, or from paper tape to printed page have been available in many forms for many years. The magnetic tape-driven equipments are a development of only the last few years.

The Eckhert-Mauchly Corporation, now part of Sperry-Rand, was the first to develop equipment to place information directly onto magnetic tape and directly remove that information. The Unityper, available since about 1951, allows direct keyboard-to-magnetic tape recording. The Unityper, still in use with Univac systems allows characters to be stored on tape in 120-character "blockettes" for subsequent read-in into the computer. The Uniprinter, also available when the first Univac was completed, is essentially an electric typewriter which prints information stored on magnetic tape at a printing rate of 10 characters per second.

One of the most serious faults of the Unityper is that items cannot be changed on a tape without re-recording the entire record. Also, automatic verification of information is not possible — tapes are either read by the Uniprinter and checked by reading, or two tapes are independently prepared for subsequent machine check. Sperry-Rand has under development a Tape Verifier which will appear this year. It will allow flexible, complete operation for original recording and tape verification.

Besides the Uniprinter and Unityper, Sperry-Rand has machines to transfer information from magnetic tapes to punched cards and vice-versa. The magnetic-tape-to-punched card converter takes information from Univac tapes to the conventional 80-column, 12-row cards at a rate of 120 cards per minute. The punched card-to-magnetic tape converter places information stored on the conventional cards and places it onto magnetic tape at the rate of 240 cards per minute. This machine is somewhat unusually in the sense that a suction mechanism picks cards from the hopper pile rather than the "picker-knife" mechanism usually seen. Equipment made and rented by International Business Machines are very similar in function and operating speeds. In addition, the IBM-774 or Tape Data Selector, allows an arbitrary selection of magnetic tape data for simultaneous output onto two or more devices such as card punches or accounting machines.

Magnetic tape controlled line printers are a most important new development. These machines with printing rates of 500 lines per second and upward are as expensive to buy or rent as many small magnetic drum computers and, in many cases, take up more space. Two line printers will be discussed here in some detail: the IBM-719 or 720, or 730 and the Remington Rand High Speed Printer. Another such printer will be

*See, for example, "Non-mechanical High-Speed Printers" by R. J. Rossheim, Proceedings of the Eastern Joint Computer Conference, March, 1953.

TRANSISTORIZED MAGNETIC CORE MEMORY

Bell Telephone Laboratories
New York 14, N. Y.

Transistors, invented at Bell Telephone Laboratories, are under intensive investigation to determine their suitability in such applications as airborne electronic computers. A current phase of this investigation at Bell Laboratories is a study to determine feasibility of a large coincident-current magnetic core which is operated entirely by transistors. Mr. E. L. Younker, in a talk before the National Conference on Aeronautical Electronics, discussed transistor circuits which have been developed and are being tested for use in such a memory. Experience to date, he reports, indicates that a transistor-driven memory of this kind is entirely feasible and quite attractive.

A block diagram of the memory system is shown in Figure 1. It includes the memory proper, or storage array, magnetic core switches for selecting the desired memory locations, and transistor amplifiers.

Two basic types of amplifier circuits are employed in the memory: drive amplifiers, which provide currents for switching the magnetic cores; and read amplifiers, used to amplify the signal obtained from a switched core to a level which can drive circuits associated with the memory.

Drive Amplifiers

Three drive amplifier designs, known as the digit inhibit, selection switch set, and memory drive, are employed in the complete memory system. To switch the memory cores, a drive of 320 milliamperes-turns lasting at least four microseconds is required. The memory is operated with coincident currents applied to single turn windings on the memory cores. Therefore, the digit inhibit and memory drive amplifiers must provide current pulses of about 160 milliamperes lasting at least four microseconds. The cores in the magnetic selector switch have multiturn windings. The selection switch set amplifier must provide current pulses of about 70 milliamperes lasting for five microseconds.

A schematic of the digit inhibit amplifier is shown in Figure 2. Two germanium alloy junction transistors, one a low-level (TR1) and the other a high-level unit (TR2), are employed in this am-

plifier. Normally TR1 is conducting, so that its collector is near ground potential. Thus TR2 is cutoff and no current flows through the magnetic core load. When a digit inhibit signal is received, TR1 is cutoff and its collector starts towards -8V. This carries the base of the output transistor negative and it starts to conduct. Collector current very quickly reaches a value set by limiting resistor R3. At the end of the digit inhibit signal, TR1 again starts to conduct, bringing its collector near ground and turning off TR2. Current through L1, which cannot drop to zero abruptly, is forced to flow into the base of TR2, resulting in very rapid switching.

The selection switch set amplifier is quite similar to Figure 2 except that R3 is 330 ohms, and the applied voltage at the selection switch set winding is -20V. Output current requirements are less than 100 ma., so the base input is decreased by increasing R1.

The memory drive amplifier, very similar in general arrangement to Figure 2, supplies the current which resets the selection switch and flows through the selected address of the memory. The required 200 milliamperes pulses are obtained from a circuit where the collector supply voltage is -20 volts and R3 is about 70 ohms.

Read Amplifier

The read amplifier must accept the output of a digit plane and develop an output which can control a base current of about 1 ma. in a memory control unit transistor. The digit plane output may be a pulse of either positive or negative polarity, making it necessary for a polarity-reversing scheme to be employed so that an output of the same polarity will be obtained regardless of the polarity of the input pulse. This can all be done by the circuit shown in Figure 3.

Transistor TR1 is biased so that it amplifies both positive and negative pulses. These pulses are fed to a full wave bridge rectifier so that regardless of polarity, each input pulse to the bridge produces an output pulse which is further amplified by TR2.

Transistorized Core Memory

Output of the read amplifier is combined with an accurately-timed "strobe" signal in a gate circuit. In order for the voltage at point F (Figure 3) to change, both TR3 and TR4 must be cutoff simultaneously, which occurs when the output of the read amplifier is a "one" at the same time that the strobe signal is applied.

Over-all Memory System

The complete developmental magnetic core memory can store 1024 eighteen bit numbers. To accomplish this, 18,432 memory cores and 48 switch cores are employed. Transistor complement includes 98 low-level and 62 high-level units. Total power consumption is less than 50 watts.

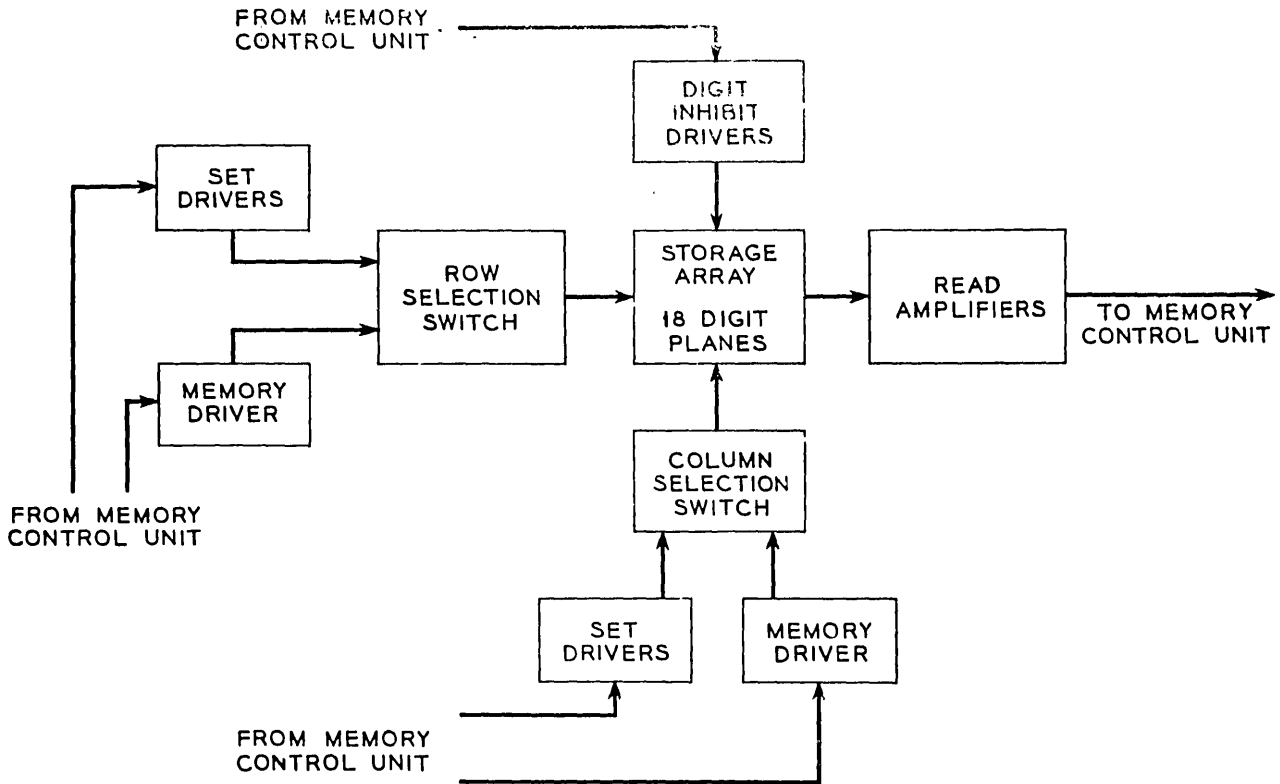


FIG. 1 BLOCK DIAGRAM OF MEMORY SYSTEM

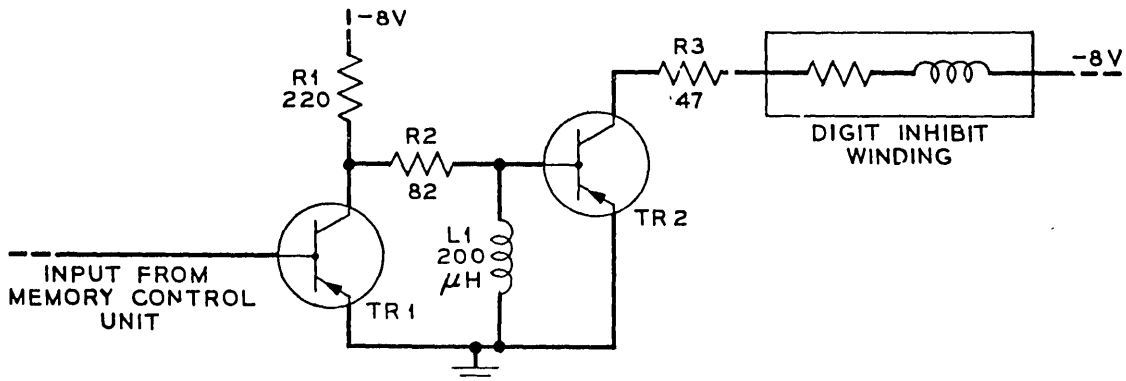


FIG. 2 SCHEMATIC OF DIGIT INHIBIT AMPLIFIER

(cont'd on page 36)

1957 WESTERN JOINT COMPUTER CONFERENCE

LOS ANGELES, FEB. 26-28, 1957, AND

ASSOCIATION FOR COMPUTING MACHINERY SYMPOSIUM, MARCH 1

The 1957 Western Joint Computer Conference will be held at the Statler Hotel in Los Angeles, Feb. 26-28, 1957. The conference is sponsored by the Institute of Radio Engineers, the Association for Computing Machinery, and the American Institute of Electrical Engineers. The theme of the conference is "Techniques for Reliability". The papers of the conference will be organized in two parallel sessions, from Tuesday afternoon to Thursday afternoon.

The Los Angeles Chapter of the Association for Computing Machinery is sponsoring a symposium on Friday, March 1, at the Statler Hotel in Los Angeles. The subject of this symposium is "New Computers — A Report from the Manufacturers".

Following is the preliminary program for the 1957 Western Joint Computer Conference (the program for the ACM Chapter Symposium):

Welcome: John L. Barnes,
Systems Laboratories Corp.,
Conference Chairman

Keynote

Speaker: Mr. James H. Bridges,
Chief of Electronics,
Office of the Assistant Secretary of
Defense

Tuesday Afternoon

Session I. Mathematics of Reliability

1. Mathematics of Reliability
Boldyreff, Rand Corporation
2. Design of Experiments
John Hofmann, Systems Laboratories
3. On Prediction of System Performance
from Information on Component Performance
John R. Rosenblatt, National Bureau
of Standards

4. Evaluation of Failure Data
H. I. Zagor, Arma Division, American
Bosch Arma Corporation

Session II. New Systems A

1. A Digital System Simulator
W. E. Smith, Aeronutronic Systems, Inc.
2. Factors Influencing the Design of the
New High Speed Input-Output System for
the Florida Automatic Computer (FLAC)
C. F. Sumner, R. C. A. Service Co.
3. The I. B. M. RAMAC System-Memory
Unit Operation
D. Royse, International Business
Machines
4. The I. B. M. RAMAC System — Inquiry
Station Operation
H. A. Reitfort, International Business
Machines

Wednesday Morning

February 27, 1957

Session III: Applications

1. Reliability in Business System
Herbert T. Glantz, John Diebold and
Associates
2. Panel Discussion: A Report from the
Users

Session IV: New Components

1. An RCA High Performance Tape Trans-
port System
S. Baybick and R. E. Montijo, Radio
Corporation of America
2. A Medium Speed Magnetic Core Memory
G. E. Valenty, Remington Rand UNIVAC

3. Millimicrosecond Transistor Switching Techniques

E. J. Slobodzinski and H. S. Yourke,
I. B. M. Research Center

4. New High Speed Magnetic Phenomena
E. L. Newhouse, Radio Corp. of America

Wednesday Afternoon

Session V: Component Reliability

1. Packaging Techniques
W. E. Dombert, Burroughs Corp.
2. Accuracy Control Systems for Magnetic Core Memories
A. Katz, A. G. Jones, G. Rezet,
Radio Corporation of America
3. Design of a Basic Computer Building Block
J. Alman, P. Phipps, D. Wilson,
Remington Rand Univac
4. Error Detection in Redundant Systems
S. Schneider and D. H. Wagner,
Burroughs Research Center

Session VI: Analog Computer Equipment

1. Analog Logarithmic and Antilogarithmic Circuits Using Switching Transistors
A. J. Sohiewe, K. Chen, Westinghouse Electric Corporation
2. High Speed Digital-to-Analog Conversion by Integration of a Variable Rate Pulse Train
A. D. Glick, Minneapolis-Honeywell Regulator Company
3. A Reliable Method of Drift Stabilization and Error Detection in Large Scale Analog Computers
E. E. Eddey, Goodyear Aircraft Corp.
4. A New Method of Verifying Analog Computer Problems and Performances
W. C. Meilander, Goodyear Aircraft Corp.

Thursday Morning
February 28, 1957

Session VII: Programming for Reliability

1. Diagnostic Techniques Improve Reliability
Grems, Smith and Stadler,
Boeing Airplane Company
2. Error Detection and Error Correction in Real Time Digital Computers
A. Ralston, Bell Telephone Laboratories
3. The FORTRAN Automatic Coding System, Description and Users' Reports
International Business Machines

Session VIII: New Systems B

- The Lincoln TX-2 System, of Lincoln Laboratory, Mass. Inst. of Tech.
1. The Lincoln TX-2 Computer
W. A. Clark
 2. Functional Description of the TX-2
J. M. Frankovitch
 3. The TX-2 Input-Output System
J. W. Forgie
 4. Memory Units of the TX-2
R. L. Best
 5. Standardized Circuitry of the TX-2
K. H. Olsen

Thursday Afternoon
February 28, 1957

Session IX: Systems Reliability

1. The Interpretation and Attainment of Reliability in Industrial Data Systems
B. K. Smith, Beckman Instruments, Inc.
2. Accuracy Control in the R. C. A. BIZMAC System
I. Cohen, J. G. Smith, and A. M. Spielberg

(cont'd on page 34)

LOGICAL AND COMBINATORIAL PROBLEMS IN COMPUTER DESIGN

ROBERT McNAUGHTON
Stanford University
Applied Mathematics and Statistics Laboratory
Stanford, Calif.

Engineers who work on large scale digital computers and similar devices are faced with increasingly difficult problems of a logical or combinatorial nature. The difficulties enter mostly when one tries to minimize a circuit made up of given materials and constructed for some precisely defined purpose. The existence of these problems and their potentiality for raising academic interest is a good justification for the young and growing field of computer logic. The logician and the pure mathematician may or may not be able to solve such problems, but in any case, I think, would be interested in knowing what they are.

In order to bridge this gap, we have decided to ask persons who have possibly faced some of these engineering problems directly or indirectly, We desire to collect problems. After having collected a large number of these problems, we may publish them in a report without solutions, as an attempt to stimulate interested in the field of computer logic.

In case any of your readers is interested in supplying problems, let me give you an idea of the kind of problem in computer logic which I am interested in collecting. It is a mathematically definite problem of a logical nature related to computer circuits or other similarly constructed circuits. This formulation requires some explanations.

(1) Mathematical definiteness. The problem must be abstractly formulated without containing any concepts which are essentially related to the "real world". For example, consider the following problem: construct the cheapest possible circuit by means of which two 16 digit binary numbers can be added using amplifiers, wires, diodes, resistors, and using a fixed voltage supply and ground. This problem contains reference to amplifiers, rectifiers, etc., which are clearly not abstract mathematical entities. To solve this problem, one would have to know everything the engineer knows, such as how to use resistors, what the relative cost of amplifiers to rectifiers is, etc.

(2) Logical nature. Computer circuits have lately given rise to logical problems because it is convenient to assume that any part of the computer circuit can take on, at any given time, one of two states, e. g., closed or open, on or off, and high potential or low potential. . These can be profitably regarded as if they were the two truth-values, truth and falsity, or the numbers 0 and 1, or the Boolean universe set and null set. Any problem which relates to a circuit for which this assumption can be made I am willing to say has a logical nature (realizing that I am using the word "logic" in a rather broad sense), even though the problem may not otherwise appear to fit into the category of logic at all. An example of a non-logical problem connected with circuits is any problem having to do with varying resistors and currents. (Problems connected with many-valued logic are not meant to be excluded. But as far as I can see, they are rare in computer logic.)

(3) It is not essential that these problems be obtained from computers. Telephone switching circuits provide a good example of a source of logical problems.

An example of a problem in computer logic formulated in a desirable manner is the following. A two terminal contact circuit composed of single pole, double throw switches connected by wires having a minimum number of contacts (i. e., switches) is to be constructed subject to the following conditions: (1) there are n input variables s_1, \dots, s_n each of which is 1 or 0 at any time, (2) each switch is connected to one of these s_i , in such a way that it is closed in one direction if s_i is 1 and closed in the other if s_i is 0, and (3) the two terminals are to be connected by the circuit under certain specified conditions, and not connected under the remaining conditions, on the unputs s_1, \dots, s_n . Note that the problem is logical in that the variables are either 0 or 1, a switch is either closed one way or closed the other, and the two terminals are either connected by the circuit or not (depending on the setting of the switches). Although the problem contains reference to empirical entities

(cont'd on page 31)

IBM YORKTOWN RESEARCH CENTER

International Business Machines Corp.,
New York, N. Y.

Plans for a new IBM Research Center in Yorktown, New York, 38 miles north of New York City, have been announced by International Business Machines Corporation. Options have been taken on 224 acres of land situated between the Taconic States Parkway and Pines Bridge Road. Completion of negotiations awaits necessary zoning changes permitting construction of modern, landscaped facilities to house laboratories and administrative offices. The research staff is expected to number approximately 1,600.

The announcement follows the creation earlier this year of a separate group within the IBM engineering organization to consolidate all fundamental research aimed at improving the company's products. The work of this group will be guided by Dr. Emanuel R. Piore, recently appointed IBM Director of Research and formerly Chief Scientist of the Office of Naval Research.

"We believe that a major research effort such as ours flourishes best in its own surroundings," said Mr. Thomas J. Watson, Jr., President of IBM. "The Westchester County site on which we hope to build is located midway between Poughkeepsie and New York City. It was selected not only with an eye to accessibility but to the considerable cultural and educational opportunities in the area. These are of great importance to scientists, whose interests individually and as a group are extremely varied."

No manufacturing operations of any kind will take place at the IBM Research Center. Instead, the best architectural skills will be employed to provide a "Research Community" which blends with its pleasant Westchester County setting. The site consists of rolling, slightly-wooded countryside adjacent to parkways, estates, small houses and farmlands. It contains two brooks, a small pond, and cleared fields bordered by rows of trees. Construction will harmonize with these natural features, while establishing a new mark in originality and utility of design. The aim is to enable those assigned there to operate at the highest level of creativity and personal efficiency.

Members of the present IBM Research Laboratories in Poughkeepsie will move to the new site over a period of two years or more. The

space vacated in Poughkeepsie by research personnel is to be occupied by expanding Product Development activities, which will remain there together with plans for the manufacture of electronic data processing machines and other products.

The research to be conducted at the new center covers a broad range. Much of it is in solid state physics, dealing with the ferro-magnetic substances which are eliminating vacuum and cathode ray tubes in electronic computers and replacing them with transistors and magnetic core memories. Research of this kind has already resulted in the development by IBM of electronic systems of greater speed, compactness, and reliability.

Yorktown is to be the center, but not the sole location, of all company research activity. IBM also has research laboratories in San Jose, California, New York City, and Zurich, Switzerland. The new facilities will be visited by staff members from these installations, as well as by technical consultants and educators from other research and scientific institutions throughout the world. In addition, the center will be the scene of regular scientific meetings and seminars.

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LOGICAL PROBLEMS
(cont'd from page 30)

such as double-throw switches and wires, the problem is formulated in such a way as to have an abstract interpretation. In order to solve the problem, one does not have to know how the variables control the switches or what kind of wire must be used, or etc. And it is not necessary to know how much wire and double-throw switches cost; one is told simply to minimize the number of contacts. The cost of the circuit is here defined as the number of contacts and from then on the problem is mathematically definite, even though complicated engineering considerations may have led up to this definition. (Of course there are problems more general than this one such as the one in which there may be more than two terminals.)

If any of your readers has a problem which is not quite mathematically definite, please send it on anyway, for it may be possible to convert it here into perhaps a number of different problems, each of which is mathematically definite. I have outlined the criteria of a desirably formulated problem only in order to give an idea of the kind of problem we are interested in.

-END-

available with RCA-BIZMAC systems.

The Remington Rand printer operates at 600 lines per minute, printing 120-character blockettes in 130 possible positions, with 51 different characters available in each position. Printing is accomplished by hammers which hit revolving type wheels at precise moments to select the appropriate character. Control is maintained by a number of means. A plugboard is available for the following: select characters from the blockette for selected placement in the 130 positions; multiple printing of certain character positions (10 duplicated, arbitrary positions are available, the difference between 120 in the blockette and the 130 printing positions); multi-line printing of characters; line spacing; and zero suppression. Control of fast feed — skipping lines — is available by means of a 7-channel paper tape loop which is used in conjunction with the first character (a non-printing character) stored in the blockette. A breakpoint switch, when set, will cause the machine to halt whenever the breakpoint symbol appears in the blockette. Fast-feed of the printer occurs at 20 inches per second. The printer has four pieces of equipment: the printer, a magnetic tape unit, a memory unit, and a power supply unit. The last two units require a supply of chilled water for cooling.

IBM makes three magnetic tape-driven high-speed line printers, all three very similar. The Type 719 operates at 1000 lines per minute with 60 printing positions, Type 720 operates at 500 lines per minute with 120 printing positions, and Type 730, 1000 lines per minute with 120 printing positions. In each case, printing of each character is accomplished by selection of a pattern of wires chosen from a 5 x 7 array. Fast feed is performed at about 50 inches per second for 4-5 inch skips on the 719 and 730, and at 25 inches per second on the 720. A paper tape loop in conjunction with the first character stored in the record control skips. No plugboard is available to control information; all such control is accomplished during the initial recording of the information on tape.

The IBM printers have not been in customers' hands long enough to make a thorough comparison of the two printers. However, from the standpoint of system design, certain observations can be made. Printing quality on individual characters seems to be superior with the Remington-Rand machine. Because of the type of printing, this advantage comes as no surprise. Two disadvantages of the Remington Rand type of printing appear: vertical registry of characters in their line position is not as good,

and the number of carbon copies possible is smaller. The plugboard control available on the Remington Rand machine will save considerable computer time necessary for editing output and will not be a disadvantage as long as plugboards need not be changed too frequently. The breakpoint feature of the Remington Rand machine allows certain operations the IBM counterpart does not. A big advantage of the Types 719 and 730 is, of course, the very fast speed of 1000 lines per minute.

It may be of some interest to remark here that the four organizations ordering 1103A computers, Boeing, Lockheed, Ramo-Wooldridge, and Holloman Air Force Base, are obtaining somewhat modified version of the Remington Rand printer for data reduction operations. Type wheels have been changed to remove certain characters and allow, in their place, certain vertical bars and marking symbols. Also, the gears on carriage control have been changed to allow a small spacing of 10 lines per inch instead of the usual 6. This will allow printing an analog-type plot in the reduction of telemetered data to an accuracy of one part in 480 (or two plots each at one part in 240 accuracy) at a spacing of 10 marks per inch. Such a modification of a line printer was first done (to this writer's knowledge" at the Boeing Airplane Company in 1952 when an IBM 407 accounting machine was so modified.

Another interesting means of computer output involves the use of the cathode ray tube. Because "printing" here is non-mechanical, achieved speeds are much greater. One of the first such devices was the Numeroscope, delivered to the National Bureau of Standards in 1951 by Engineering Research Associates. Another early application of the cathode ray tube for output was that used with the Whirlwind I computer at MIT. Cathode ray tube output received considerable impetus when the RAND Corporation began using a tube and a camera to record information from their 701 computer in a military application. The general design has been embodied in an output system which IBM makes available for the 704 computer. Under computer control the beam can be directed to one of 1024 x 1024 positions in a square array. Characters must be formed as combinations of those spots. An automatic X- and Y- axis generating feature is available. Output of this type is probably best used for analog-type plotting of functions and outputting graphic information like charts of figures since characters must be formed out of spots directed to the 1024 x 1024 position under complicated program control.

(cont'd on page 34)

Physicists and
mathematicians
**HOW DO YOUR
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**FIT INTO THE
AIRCRAFT
NUCLEAR
PROPULSION
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Despite the successful use of the conventional cathode ray tube for output, the need has been great for a device to output alphanumeric information at higher speeds and with greater facility.

The Charactron tube, a development of Consolidated Vultee Aircraft Corporation, San Diego, goes a long way toward satisfying that need. The future promotion and development of the tube will be under the direction of Stromberg-Carlson, another subsidiary of General Dynamics. The Charactron is designed to present alphanumeric and quantized analog plot information on the face of the tube. The electron beam is directed through a small piece of metal into which minute characters have been cut. A total of 64 characters are available and each can be directed to any one of 1024 x 1024 positions; that is, the raster of the tube is quantized into a grid of 1024 positions in the X direction and 1024 positions in the Y direction.

Although the Charactron has many applications, we confine the discussion here to its use as a computer output device. To this writer's knowledge, only one set of such equipment is in use with the commercial computers under discussion here. The tube together with camera equipment is used as an output device with the Convair 1103 computer in San Diego. In this system a 35 mm camera is used to photograph the tube, one frame at a time, develop the picture, and then project it onto a built-in screen for viewing. The film can be removed for later viewing or for making prints. Under control of the computer, characters are outputted on the face of the tube and, upon filling the tube face as desired, another film frame is brought into position for exposure. Control is achieved by placing numbers in the I-O buffer register of the 1103.

The nominal rate for the tube is 100,000 characters per second. However, after necessary computer information edition and camera control an output of about 50 words (600 characters) per second is achieved in the Convair operation. An exposed film frame can be developed and projected for viewing in 2-3 seconds. At Convair, the equipment is used mainly for "dumping" memory information for program debugging. Besides the viewer associated with the camera, a number of separate viewers are available for programmers' use.

- END -

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Session X: Programming

1. The Variable Word and Record Length Problem and the Combined Record Approach on Electronic Data Processing Systems
N. J. Dean, Ramo-Wooldridge Corp.
2. The RCA BIZMAC Sorter
B. Adler, H. P. Guerber, J. C. Hamerton, and J. F. Page, Radio Corp. of America
3. Empirical Exploration of the Logic Theory Machine
A. Newell, J. C. Shaw, and H. A. Simon, The Rand Corporation
4. Programming the Logic Theory Machine
A. Newell and J. C. Shaw, The Rand Corporation

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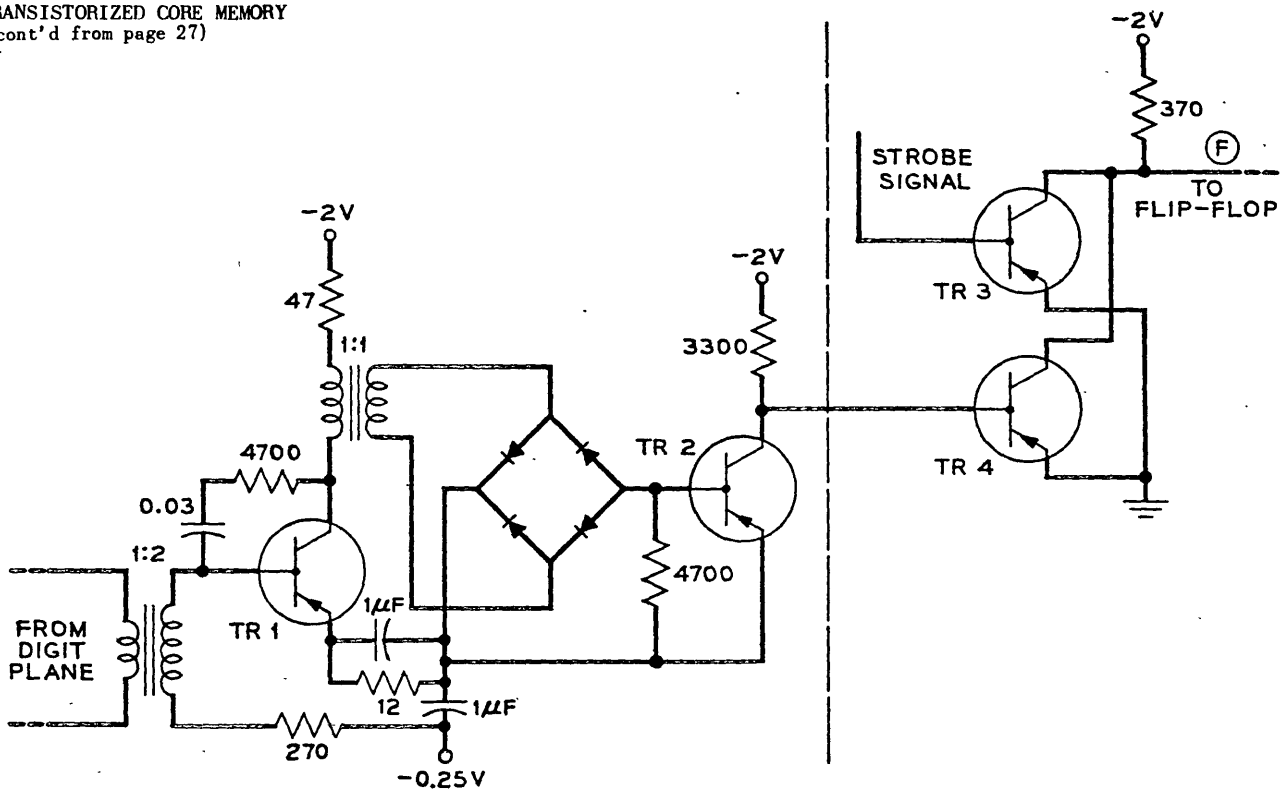


FIG. 3 READ AMPLIFIER AND STROBE CIRCUIT

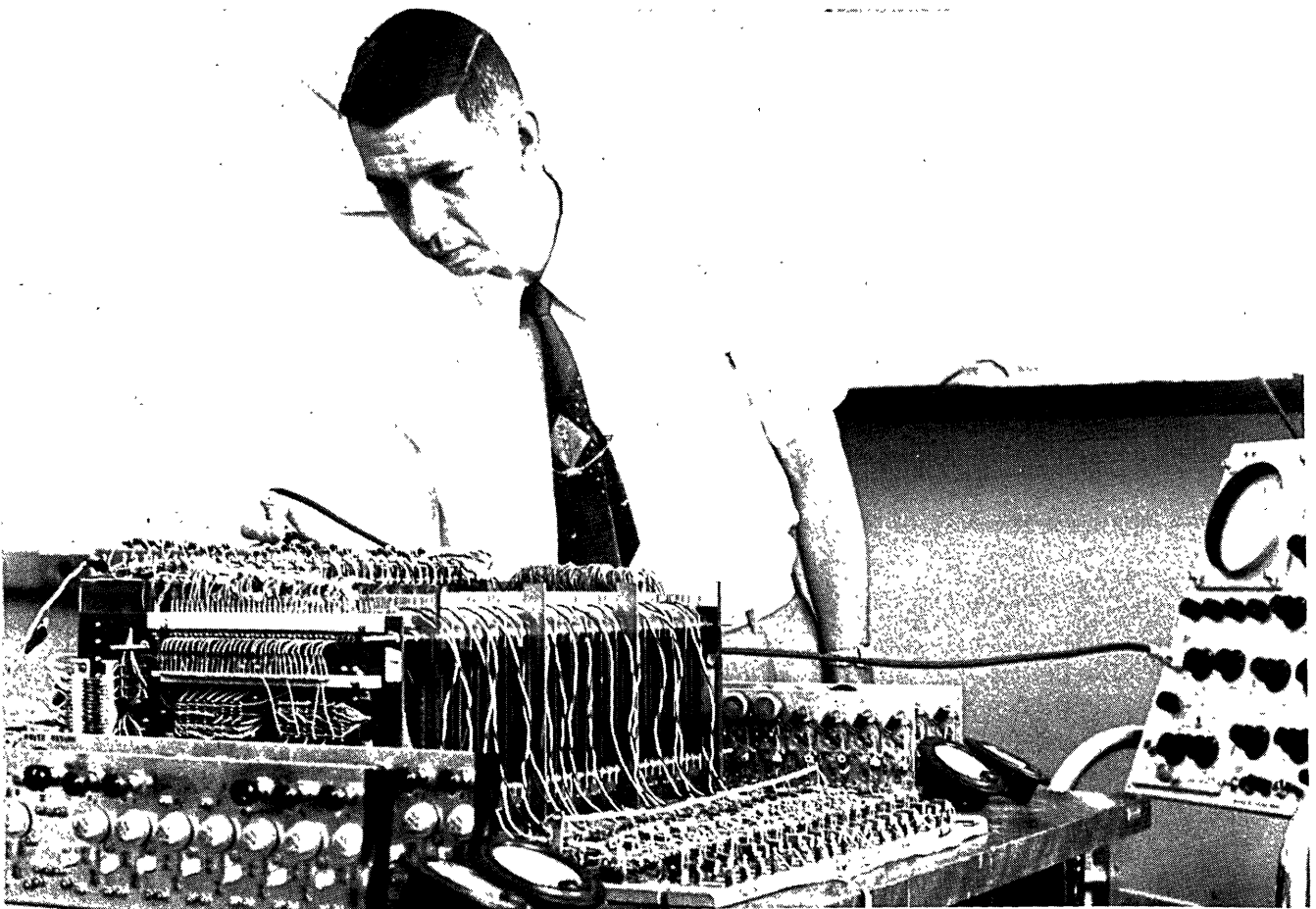


Fig. 4. Mr. E. L. Younker, an engineer in the Military Systems Studies group at Bell Telephone Laboratories, Inc., shown testing an experimental magnetic core memory system using transistorized circuitry.

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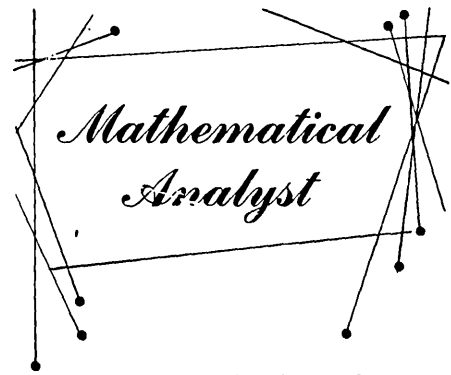
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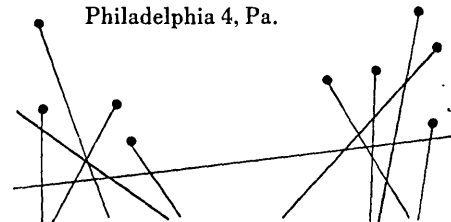
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3. APL handles technical direction of the work of many associate and sub-contractors, including 21 universities and leading industrial organizations. As a result, APL staff members enjoy a rewarding exchange of ideas and techniques with other leaders in R & D.
4. The combined facilities of APL, its associate and sub-contractors, and Government test stations provide opportunities for members of its technical staff to develop and exploit their varied capabilities in a unique environment where teamwork and individual initiative are fused.
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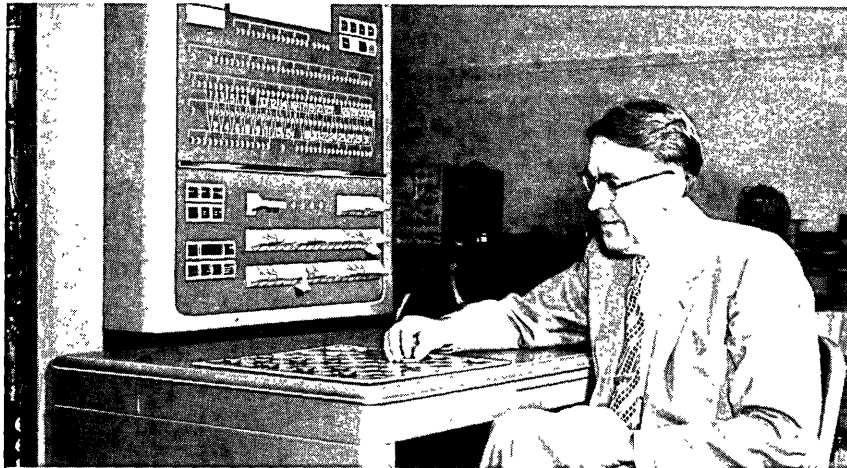
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- **Checkers with a Purpose:** unique programming of an IBM 704 scientific computer for logical decisions, anticipating a multitude of variables.
- **Molded Wiring:** how to hold electrical conductors on a non-conductor material.



Dr. Samuel at "play"

Checkers with a Purpose

Through the years, many people have been intrigued by the possibility of constructing game-playing machines, particularly chess and checkers—including L. Torrès y Quévedos in 1914, and more recently Mr. C. Strachey of England. Now Dr. A. L. Samuel of IBM has programmed the IBM 704 computer so that it is able to play a surprisingly satisfactory and even challenging checker game.

Dr. Samuel's program includes the basic rules of checkers and an equation which enables the computer to assign a white versus black merit rating to any possible arrangement of pieces on the checkerboard. A further element of the program instructs the computer to consider all possible moves and responses for a given situation, and to repeat this procedure to include from four to twenty moves in advance. The storage or memory units of the computer retain the merit rating of each option and thus enable the computer to select the "best" move and signal its selection to the operator. The next logical step will be to modify the program so that the computer will profit from its mistakes. The modified program would enable the computer to adjust the coefficients of its merit equation in the light of past experience and thus, in a sense, "learn" to play a better game.

The design of a checker-playing pro-

gram is, of course, of no importance per se. It is important, however, as part of a study of the decision-making ability of a modern computer. The game of checkers is a greatly simplified mathematical model of many real-life situations. It is useful in preliminary investigations because it requires logical decisions, offers a multitude of variations, and yet is free from extraneous and complicating features of real-life problems.

Molded Wiring

Because of the advanced nature of IBM equipment, standard electronic components frequently must be designed or redesigned to suit critical reliability requirements. This has been found to be true in the case of printed wiring panels.

In the past, production panels have been limited to flat patterns on laminated surfaces. However, a new process for printed wiring fabrication, developed by IBM's Dick Bell, Poughkeepsie Plastics Laboratory Manager, eliminates such limitations and thereby affords the design flexibility necessary to the development of future IBM equipment.

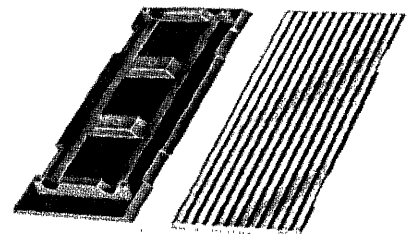
Mr. Bell's process allows the use of any moldable plastic for the support of flush electrical conductors, and permits fabrication in almost any shape desired. It eliminates the use of standard adhesives for the bonding of conductor to plastic,

thus allowing higher temperatures in fabrication and machining operations not possible where adhesives have been used.

Fundamentally, the process involves the coating of a .003" thick metal foil plate with a single-particle thickness of copper powder, which is fused to the foil under high-temperature sintering. Plastic can then be molded to the plate, to be held mechanically secure by the thousands of sphere-shaped copper powder particles.

A typical application of a molded flush circuit is illustrated below. Wire brushes are pulled over the smooth surface of this component, thus allowing proper electrical and mechanical performance. The process also provides for metallic inserts and molded holes, eliminating costly drilling. Mr. Bell points out that day by day, as this process is being put into production, new methods for improvement in fabrication are coming to light.

For a complete technical description of this process, you may obtain Mr. Bell's



Molded circuit with a shape

technical report, "A Molded Flush Circuit Process," which was presented at The Society of the Plastics Industry meeting in New York on June 14, 1956. Request IBM Bulletin 500.

• **RESEARCH** at IBM means **IDEAS** at work. For bulletin mentioned above, write International Business Machines Corp., Dept. CA-21, 590 Madison Ave., New York 22, N. Y.

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Sixteen kinds of reference information that computer people can hardly afford to be without (latest issues containing each are indicated):

Organizations:

- Roster of Organizations in the Computer Field (June, Aug. 1956)
- Roster of Computing Services (June 1956)
- Roster of Consulting Services (June 1956)

Computing Machinery and Automation:

- Types of Automatic Computing Machinery (Dec. 1955)
- Roster of Automatic Computers (June 1956)
- Outstanding Examples of Automation (July 1954)
- Commercial Automatic Computers (Dec. 1956)
- Types of Components of Automatic Computing Machinery (March 1955)

Products and Services in the Computer Field:

- Products and Services for Sale (June 1956)
- Classes of Products and Services (June 1956)

Words and Terms: Glossary of Terms and Expressions in the Computer Field (Oct. 1956)

Information and Publications:

- Books and Other Publications (many issues)
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- Roster of Magazines (Dec. 1955)
- Titles and Abstracts of Papers Given at Meetings (many issues)

People: Who's Who in the Computer Field (various issues)

ARTICLES, PAPERS, ETC.

- February, 1956 (vol.5,no.2): The Function of Automatic Programming for Computers in Business Data Processing -- R.E. Rossheim
Computers and Engineering Education -- Paul E. Stanley
The Planning Behind the IBM 702 Installation At Chrysler Corporation -- Eugene Lindstrom

- March: Organization of a Programming Library for a Digital Computer Center -- Werner L. Frank
Translating Spoken English into Written Words -- E.C. Berkeley
IBM Trust Suit Ended by Decree

- April: Computing Machines and Automation -- A.V. Astin

- Tape Identification and Rerun Procedures for Tape Data Processing Systems -- L. Eselson

- May: The Position of the University in the Field of High Speed Computation and Data Handling -- A.S. Householder
Free Use of the Toronto Computer, and Remote Programming of It -- C.C. Gotlieb and others
The Mechanized Muse -- Elizabeth W. Thomas

- June: THE COMPUTER DIRECTORY, 1956 (104 pages)
Part 1: Roster of Organizations in the Computer Field (cumulative)
Part 2: The Market Place -- The Computer Field: Products and Services for Rent or Sale (cumulative)

Part 3: Who's Who in the Computer Field (supplement)

Part 4: Roster of Automatic Computers (cumulative)

July: Solving Problems with Digital Computers -- A.S. Householder

The Operation of a Computer Away from a Central Staff -- Howard Bromberg

August: Two Electronic Computers Share a Single Problem -- National Bureau of Standards
IBM Electronic Data Processing Operations in the Midwest -- Neil D. Macdonald

Complaint by Sperry Rand Corp. in Anti-Trust Suit Against Intern. Bus. Mach Corp., & Answer and Counterclaim by IBM

September: The IBM Computer AN/FSQ-7 and the Electronic Air Defense System SAGE -- H.T. Rowe

Glass and Metal Honeycomb Type of Electrostatic Storage Memory -- General Electric Research Laboratory

The Computer Age -- Staff of Business Week
An Ocean-Based Automatic Weather Station -- National Bureau of Standards

U.S. District Court, U.S.A., Plaintiff, vs. IBM Corp., Defendant Final Judgment

October: Glossary of Terms in the Field of Computers and Automation (cumulative)
Systems Engineering in Business Data Processing -- Ned Chapin

Magnetic Ink Character Recognition in Mechanization of Check Handling

November: Use of Automatic Programming -- Walter F. Bauer

Data Problems of a Grocery Chain -- Frank A. Calhoun

The Power of the Computer -- George J. Huebner, Jr.

An Automatic Micro-Image File -- National Bureau of Standards

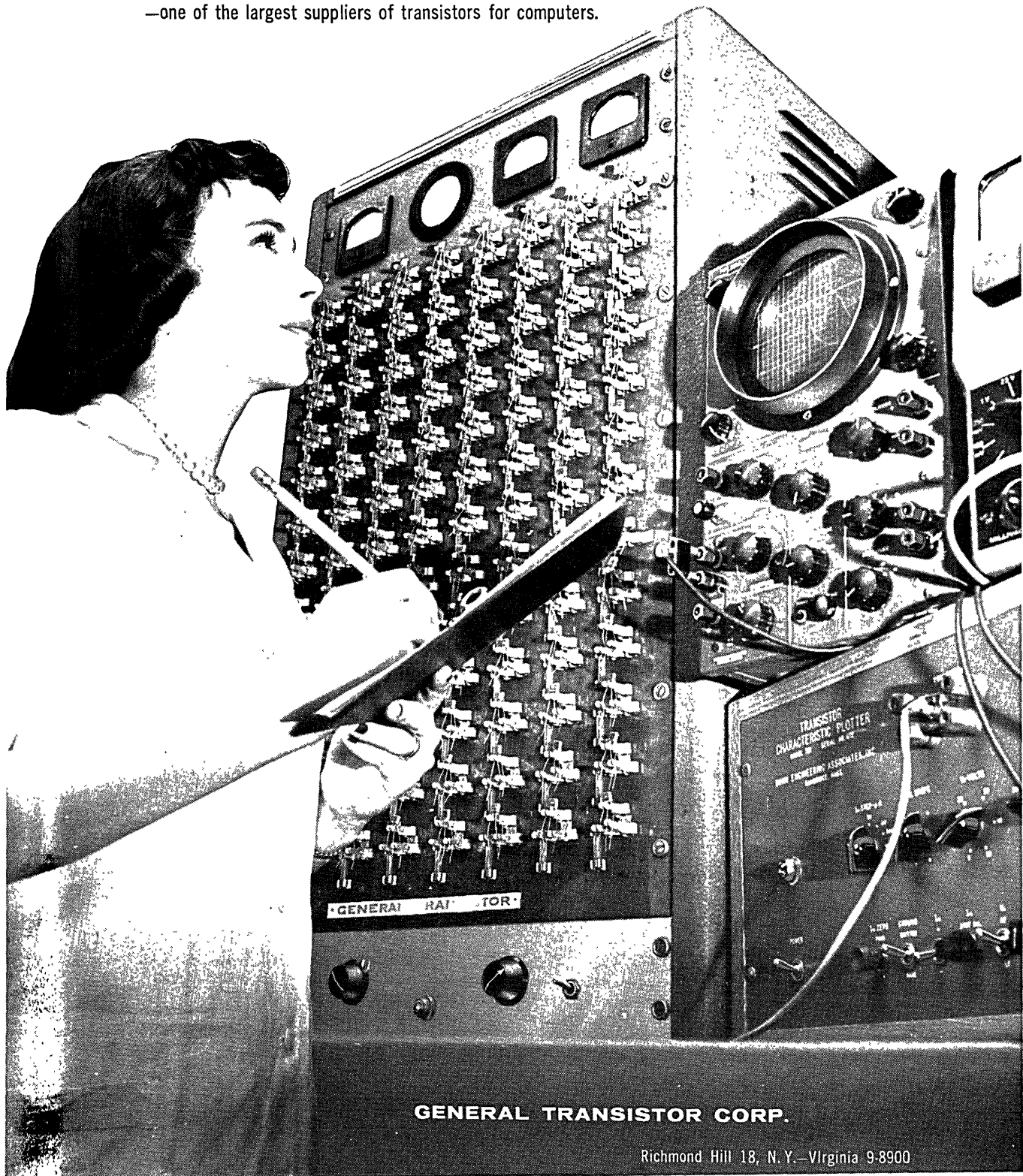
December: Indexing for Rapid Random Access Memory Systems -- Arnold I. Dumej
Self-Repairing and Reproducing Automata -- Richard L. Meier
The Computer's Challenge to Education -- Clarence B. Hilberry

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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

Oct. 2, 1956: 2,765,115 / Lawrence W. Beloungie, Watertown, Mass. / Raytheon Manufacturing Co., Newton, Mass. / An electric computer device as an arithmetic adder.

Oct. 9, 1956: 2,766,094 / Robert H. Kittleman and Ronald G. Warren, Sharon, Pa. / U. S. A. / A gyroscope course recorder.

2,766,376 / Fred B. Maynard, Cedar Grove, and Arthur Kessler, Orange, N. J. / National Union Electric Corp., Orange, N. J. / An electronic adding tube for binary addition systems and the like.

2,766,399 / Nathaniel I. Korman, Rancocas, N. J. and John R. Ford, Narberth, Pa. / U. S. A. / An electronic signal storage system.

2,766,412 / Geoffrey Huson Stephenson, Ealing, London, Eng. / Electric and Musical Industries Ltd., Hayes, Eng. / An electric servomotor system.

Oct. 16, 1956: 2,766,934 / Daniel T. Sigley, Silver Spring, and Henry Rees Mitchell, Takoma Park, Md. / - / A ballistic converter.

2,766,954 / Oscar Hugo Schuck, Minneapolis, Minn. / Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. / An automatic navigating and landing apparatus for aircraft.

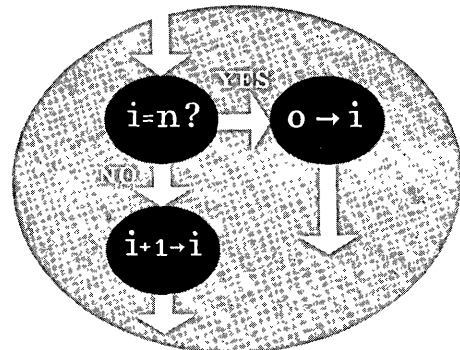
Oct. 23, 1956: 2,767,907 / Fred N. Schwend, El Monte, Calif. / Clary Corp., Calif. / Readout apparatus for computing equipment or the like.

2,767,908 / Graham Isaac Thomas, Hollinwood, Eng. / National Research Development Corp., London, Eng. / An electronic digital computing machine.

2,767,909 / William L. Morris, Idaho Falls, Idaho / Phillips Petroleum Co., Del. / A polynomial computer

2,767,910 / George Vande Sande, Greece, N. Y. / General Railway Signal Co., Rochester, N. Y. / A relay binary counter for both adding and subtracting input counts.

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GENERAL  ELECTRIC

an open letter to
Computer Programmers

The General Electric Company has announced the establishment of new facilities in Phoenix, Arizona for the development and manufacture of a full line of digital and analog, special and general purpose computers and peripheral machines. It is intended to apply this equipment to a broader range of commercial and industrial problems than has been attempted previously by any single company.

Company management is supporting this objective by building up a strong activity in the general area of computer programming. Proposed machines will be simulated on currently available equipment, research in programming methods will be undertaken, and investigation will be sponsored in information handling fields beyond engineering calculation and business data processing.

Programming will be done to support the application of ERMA, and other equipment under construction and in the logical design stage, to customer problems.

The Applications Section will operate a large IBM 704 installation, including peripheral tape equipment and auxiliary punch card machines. Analog and digital equipment of the most advanced sort will be added as available, and training in its application will be offered both within the Department and in cooperation with the appropriate schools of Arizona State College.

Senior representatives of the Applications Section will attend the Western Joint Computer Conference in Los Angeles February 26-28. Programmers and other applications people are invited to visit the General Electric suite at the convention hotel.

Or, if it is more convenient, either phone collect or send your reply in strict confidence.

Sincerely yours,

DR. H. R. J. GROSCH
Manager — Applications Section

GENERAL  ELECTRIC

COMPUTERS

1026 Van Ness • Tempe, Arizona

Memorandum from Berkeley Enterprises, Inc.
 Publisher of COMPUTERS AND AUTOMATION
 815 Washington St., Newtonville 60, Mass.

1. What is "COMPUTERS AND AUTOMATION"?

It is a monthly magazine containing articles, papers, and reference information related to computing machinery, robots, automatic control, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is \$5.50 a year in the United States. Single copies are \$1.25, except the June issue, "The Computer Directory", (1956, \$6.00; 1955, \$4.00). For the titles of articles and papers in recent issues of the magazine, see the "Back Copies" page in this issue.

2. What is the circulation? The circulation includes 2500 subscribers (as of Nov. 10); over 300 purchasers of individual back copies, and an estimated 3000 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the October issue was 3000 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue. We reserve the right not to accept advertising that does not meet our standards.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8 1/2" x 11" (ad size, 7" x 10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy

should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. PLEASE DO NOT SEND US METAL PLATES OR ELECTROS; please send reproduction proofs instead. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of a full page (ad size 7" x 10", basic rate, \$190) two-thirds page (basic rate, \$145), half page (basic rate, \$97), and quarter page (basic rate, \$55); back cover, \$370; inside front or back cover, \$230. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), \$320; four-page printed insert (two sheets), \$590. Classified advertising is sold by the word (60 cents a word) with a minimum of 20 words.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

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Ampex Corp.	The Glenn L. Martin Co.
Armour Research Found.	Monrobot Corp.
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General Electric Co.	Remington Rand, Inc.
Hughes Research and Development Lab.	Republic Aviation Corp.
International Business Machines Corp.	Sprague Electric Co.
	Sylvania Electric Products, Inc.



G. D. Schott (center), Flight Controls Department head, discusses a rocket control system with Group Engineer R. A. Fay (right) and F. G. Hudson, missile components research specialist.

FLIGHT CONTROLS THEORY

The transition from theory to reliable components is one of the most difficult phases of flight controls endeavor. At Lockheed Missile Systems Division, engineers and scientists are performing advanced work on a number of theoretical approaches that offer important practical solutions.

Two of the areas are:

- Utilization of feed-back design techniques for optimizing complex dynamic systems
- System verification by analog computer simulation

Significant developments in these and related areas have created new positions at both Sunnyvale and Van Nuys engineering centers. The complex nature of the assignments requires both flight controls experience and the ability to exercise individual initiative. Inquiries are invited.

Lockheed **MISSILE SYSTEMS DIVISION**
research and engineering staff

LOCKHEED AIRCRAFT CORPORATION

VAN NUYS • PALO ALTO • SUNNYVALE, CALIFORNIA

ADVERTISING INDEX

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions such as: What are your products? What are your services? And for each product: What is it called? What does it do? How well does it work: What are its main specifications?

Following is the index and a summary of advertisements. Each item contains: Name and address of the advertiser / subject of the advertisement / page number where it appears / CA number in case of inquiry (see note below).

- AMP Inc. (formerly Aircraft Marine Products, Inc.), 2100 Paxton St., Harrisburg, Pa. / Patchcords / Page 48 / CA No. 123
- Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y. / Magnetic Tape / Page 35 / CA No. 124
- Computers and Automation, 815 Washington St., Newtonville 60, Mass. / Back Copies, Advertising / Pages 40, 44 / CA No. 140
- Dunn & Wright, 110 East 42nd St., New York, N. Y. / Employment Opportunities / Page 35 / CA No. 125
- General Electric Co., Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio / Employment Opportunities / Page 33 / CA No. 126
- General Electric Co., Computer Dept., Phoenix, Ariz. / Employment Opportunities / Page 43 / CA No. 127
- General Electric Co., Missile & Ordnance Systems Dept., 3198 Chestnut St., Philadelphia, Pa. / Employment Opportunities / Page 37 / CA No. 128
- General Transistor Corp., 1030-11 90th Ave., Richmond Hill, N. Y. / Page 26 / CA No. 129
- International Business Machines Corp., 590 Madison Ave., New York 22, N. Y. / Research at I.B.M. / Page 39 / CA No. 130

- Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif. / Employment Opportunities / Page 47 / CA No. 131
- Johns Hopkins University, Applied Physics Laboratory, 86-41 Georgia Ave., Silver Springs, Md. / Employment Opportunities / Page 38 / CA No. 132
- Litton Industries, 336 North Foothill Road, Beverly Hills, Calif. / Employment Opportunities / Page 35 / CA No. 133
- Lockheed Aircraft Corp., Missile Systems Division, Burbank, Calif. / Flight Controls Theory / Page 45 / CA No. 134
- North American Aviation, Inc., Los Angeles, Calif. / Employment Opportunities / Page 37 / CA No. 135
- Ramo-Wooldridge Corp., 8220 Bellanca Blvd., Los Angeles 45, Calif. / Employment Opportunities / Pages 2, 42 / CA No. 136
- Republic Aviation Corp., Farmingdale, L. I., N. Y. / Employment Opportunities / Page 33 / CA No. 137
- Sperry-Rand Corp., 1902 W. Minnehaha Ave., Minneapolis, Minn. / Univac / Page 7 / CA No. 139
- Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y. / Semiconductors / Pages 4, 5 / CA No. 138

READER'S INQUIRY

If you wish more information about any products or services mentioned in one or more of these advertisements, you may circle the appropriate CA Nos. on the Reader's Inquiry Form below and send that form to us (we pay postage; see the instructions). We shall then forward your inquiries, and you will hear from the advertisers direct. If you do not wish to tear the magazine, just drop us a line on a postcard.

READER'S INQUIRY FORM

Paste label on envelope: ↓

Enclose form in envelope: ↓

4¢ Postage Will Be Paid By ---

BERKELEY ENTERPRISES, INC.

38 East 1st Street
New York 3, N. Y.

BUSINESS REPLY LABEL

NO POSTAGE STAMP NECESSARY IF MAILED IN U.S.A.

READER'S INQUIRY FORM

Name (please print).....

Your Address?.....

Your Organization?.....

Its Address?.....

Your Title?.....

Please send me additional information on the following subjects for which I have circled the CA number:

1	2	3	4	5	26	27	28	29	30	51	52	53	54	55	76	77	78	79	80	101	102	103	104	105	126	127	128	129	130
6	7	8	9	10	31	32	33	34	35	56	57	58	59	60	81	82	83	84	85	106	107	108	109	110	131	132	133	134	135
11	12	13	14	15	36	37	38	39	40	61	62	63	64	65	86	87	88	89	90	111	112	113	114	115	136	137	138	139	140
16	17	18	19	20	41	42	43	44	45	66	67	68	69	70	91	92	93	94	95	116	117	118	119	120	141	142	143	144	145
21	22	23	24	25	46	47	48	49	50	71	72	73	74	75	96	97	98	99	100	121	122	123	124	125	146	147	148	149	150

REMARKS:

FIRST CLASS

PERMIT NO 1680

Sec. 349, P. L. & R.
NEW YORK, N. Y.



IMPORTANT ACHIEVEMENTS AT JPL



The Analytical Mind and Electronic Computers

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1600 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

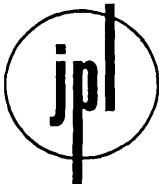
The Jet Propulsion Laboratory supports its research and development programs with extensive modern digital and analog computing systems. To this end our computer-equipment staff has made important original contributions in the development of new analog computer components, encoding techniques, and digital data handling equipment including advanced systems for handling the high volume output of supersonic wind tunnels.

Though the computing machines have made dramatic contributions to the Laboratory program, the central figures in this

drama remain the applied mathematicians, engineers, and scientists focusing their analytical minds on the problems of their respective technologies and formulating them for computing machine solutions.

Every technology applying to missile propulsion and guidance is represented on the Laboratory: aerodynamics, guidance, instrumentation, electronics, chemistry of propellants, propulsion systems, design and metallurgy. It is in this setting that applied mathematicians and computer engineers find rich opportunities for growth and achievement in scientific computation.

JOB OPPORTUNITIES
IN THESE FIELDS NOW



COMPUTERS • APPLIED MATHEMATICS • DATA HANDLING • INSTRUMENTATION
APPLIED PHYSICS • TELEMETERING • RADIO AND INERTIAL GUIDANCE
GUIDANCE ANALYSIS • SYSTEMS ANALYSIS • ELECTRO-MECHANICAL
MICROWAVES • PACKAGING • MECHANICAL ENGINEERING

JET PROPULSION LABORATORY

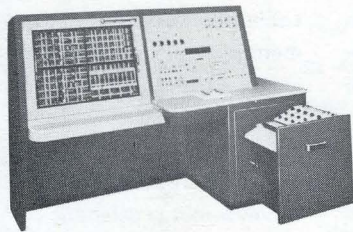
A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA • CALIFORNIA

It's New! It's Revolutionary!

AMP's **SHIELDED PATCHCORD PROGRAMMING SYSTEM** is especially designed for programming on Analog Computers, Telemetry, Test Equipment, and all types of sensitive low level circuits.

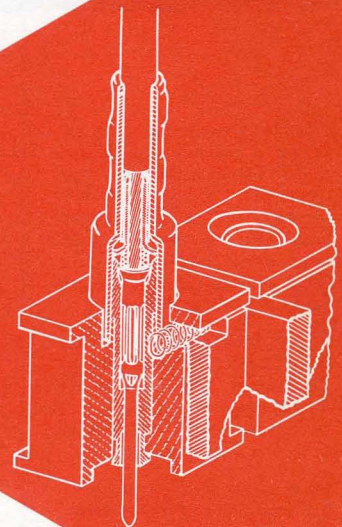
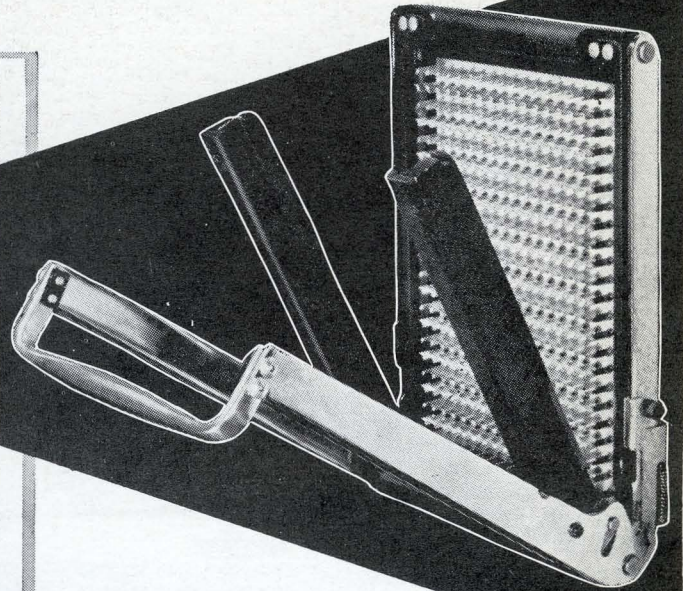
NEW DESIGN FEATURES INCLUDE:

- Fully insulated as well as shielded removable frontboard and fixed rearboard;
- "Post Patching", without shorting as required in Analog Computers and Telemetry;
- Custom Color-Coded circuit legend provided by a cellular type construction that permits individual hole identification;
- Elimination of signal leakage between circuits;
- Shielded Patchcords, with shield terminated by a contact ferrule, which connects to ground when Patchcord tip is inserted.



The illustration shows how Berkeley Division of Beckman Instruments, Inc. is using AMP's new Patchcord System in its new EASE* 1200 Analog Computer.

*Trade Mark, Berkeley Division of Beckman Instruments, Inc.



Complete information is available on this New Shielded Patchcord Programming System on request.

AMP

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Harrisburg, Pennsylvania

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EDUCATION

AND

COMPUTERS

Report No. 1

Constituting Part 2 of the January, 1957 Issue of "Computers and Automation"

Vol. 6
No. 1
Part 2

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Jan.
1957

EDUCATION AND COMPUTERS, Report No. 1

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Editor: Edmund C. Berkeley
 Advisory Committee: Howard T. Engstrom,
 Alston S. Householder

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This Part 2 (entitled "Education and Computers,
 Report No. 1") of the January 1957 issue of "Com-
 puters and Automation" is included in the subscrip-
 tion; but it may be purchased separately on request
 at \$1.00. For other information, see Part 1 of the
 January, 1957 issue.

"Computers and Automation" is entered as second
 class matter at the Post Office, New York, N. Y.

THE EDITOR'S NOTES

EDUCATION AND COMPUTERS — II

Why say "education and computers" in one
 breath? Well, basically:

- "education" is the adaptation of human
 beings to handle information reason-
 ably;
- "computers" is* the creation and adapta-
 tion of machines to handle information
 reasonably.

In January 1957 this may appear a forced par-
 allel, a strange and unreasonable way of looking at
 two different fields. In the same way, two centur-
 ies ago, the parallel between human beings doing
 physical work and steam-powered machines doing
 physical work must have seemed to bystanders
 strange, unreasonable, forced. Even fifty years
 ago the automobile was greeted with the jeer, "Oh,
 get a horse!"

Yet the relation of education and computers
 was foreshadowed in the famous paper "The Edu-
 cation of a Computer" by Dr. Grace M. Hopper,

given at the meeting of the Association for Comput-
 ing Machinery, in Pittsburgh, May, 1952.
 Many of the stupid remarks that "computers can't
 think", that "computers do only what they are pro-
 grammed to do", etc., lose sight of the fact that
 both men and computers equally have to be edu-
 cated or programmed, out of a truly marvelous
 store of knowledge accumulated through more than
 5000 years of human culture. A human being
 without any of the programming that he gets from
 school and society in his first 20 years and after-
 wards would be as utterly useless as a computer
 with no programming.

The cross-fertilization of the fields of edu-
 cation and computers is just beginning. One dire
 need — the need for more educated people in the
 computer field — has begun to act as a goad.
 This Part 2 of the January 1957 issue of "Com-
 puters and Automation" is a start of a new effort of
 ours to be of help in the important area of "Edu-
 cation and Computers".

(Note: *"Is", not "are", because the word "com-
 puters" here is being used as a singular noun
 meaning a field — we'd like to invent the word
 "computology" —, not as a plural noun meaning
 many machines)

THREE COMPARISONS

	Union of Soviet Socialist <u>Republics</u>	United <u>States</u>
1. Average number of students in class per teacher	19 or 20 and de- creasing	34 or 35 and in- creasing
2. Number of inhabitants for every bookseller	<u>Denmark</u> 7,000	<u>United States</u> 100,000
3. In New York City on June 5, 1956, in regard to competitive examinations for can- didates who are to teach mathematics in junior high schools	<u>No. of Vacancies</u> 650	<u>No. of Applicants</u> 88

— reprinted from "Opportunity
 to Learn" in "Computers and Automation", July,
 1956, vol. 5, no. 7.

EDUCATION FOR AUTOMATION

A. S. HOUSEHOLDER
Oak Ridge National Laboratory
Oak Ridge, Tenn.

Automation is bringing about the Second Industrial Revolution. We all have learned something about the dislocations which accompanied the first, as old kinds of employment disappeared and new kinds were created. In the First Revolution, the disappearance of old kinds of employment was felt most acutely. In the Second Revolution, although there is some apprehension about future unemployment, the acute shortage now and for some years to come is of people, not jobs. It is a shortage of trained professional and semi-professional workers to satisfy the mounting demands of the complex technology of the Second Industrial Revolution.

The most alarming aspect of the shortage of trained people is the incapacity of schools to prepare the rising generation to meet these new demands. The outlook for improvement is dismal. A prevailing philosophy displaces the traditional "three R's" in favor of "Reliability, Responsibility, and Righteousness," to quote one exponent. This philosophy has had its effect upon the teaching of students, and upon the selection, the training, and the motivation of teachers as well. While there are teachers grounded in the content of their subjects as well as in methodology, the number is few, and government and industry are attracting all but the most dedicated of these. So we cannot look to the schools alone to solve the problem of trained people. The rest of us, the nonteachers must lend a hand. The question is, what can we do and how?

Fortunately there are a number of things we can do, as will be illustrated below.

In view of the possibilities and of the need, "Computers and Automation" is instituting a new department or section of the magazine entitled "Education and Computers" or "Education for Automation". Your contributions are earnestly invited. These contributions may if you wish be in the form of letters addressed to me or to the magazine, suitable for quotation in whole or in part, telling what is being done and how it is working

out, announcing what is planned and suggesting what might be done, whether by individuals, by research laboratories, or by commercial organizations. Other kinds of contributions are also invited, such as articles and papers. If you know of a project but do not have complete information, a note from you indicating a source of information will also be welcomed. In presenting this information in these pages we hope that worth-while endeavors will be copied and that promising suggestions will be picked up by those in a position to act upon them.

The average youngster probably, and certainly the superaverage youngster, has in my opinion great potentialities for self-education given the proper motivation. So it would seem that provision of motivation is the first objective. The premise is almost self-evident since many students, do at times, come to surpass their teachers. Thus the operation is not solely lifting oneself by one's own bootstraps.

Motivation can be provided in a variety of ways such as talks before student groups, exhibits, demonstrations, perhaps games and gadgets that express or illustrate a principle or way of thinking. Another way is to distribute printed material, as, for example, General Electric has done in its little brochures entitled "Why Study Mathematics?" (Available from General Electric Co., Schenectady, N. Y.)

Such projects, though directed at students, should be informative to teachers, who should be made aware of the fact that a revolution is most certainly in progress and that yesterday's coin will be short change indeed in the world of tomorrow. Perhaps some teacher can be convinced that the superior child is exceptional, too, and deserving of attention. Certainly projects designed to inform teachers and guidance counselors are in order.

These remarks are general, but we request specific information from you our readers. The General Electric brochures mentioned above were

(cont'd on page 59)

SOCIAL AND PUBLIC RELATIONS'

RESPONSIBILITIES OF THE COMPUTER INDUSTRY

JAY W. FORRESTER
Division Head, Lincoln Laboratory, and
Director, Digital Computer Laboratory,
Mass. Inst. of Technology
Cambridge, Mass.

(Being the second part of the Luncheon Address given at the Eastern Joint Computer Conference, Boston, Nov. 1955; for the whole address, see the published proceedings, available from the Association for Computing Machinery, 2 East 63 St., New York 21, N. Y.)

..... All this leads us to some of the social and public relations' responsibilities of our new and growing industry. Look around you. We recently had a series of Congressional hearings on automation by the Subcommittee on Economic Stabilization of the Congressional Joint Committee on the Economic Report. This developed from Congressional concern over the social implications of new materials and data-handling devices. Furthermore, there is a very real fear of science and technology in the minds of large segments of our population. I heard a psychologist the other day discussing some word association studies made with elementary school students. He was very distressed by the results. He found that the public, as represented by school children, associate science and scientists with such words as evil, villain, and atom bombs. These are the things that come to mind rather than the associations you would prefer.

There is need for a better public understanding of computers for many reasons. The industry itself needs more designers. It is going to need people who are able to use, to operate, and to maintain these machines. In the papers that we have heard on banking and credit card accounting, it is clear that the public needs to understand not only how some of these new methods work, why they should be used, and how they will give a better product, but people need also to understand how they must have a certain amount of forbearance and permit some changes from our present systems of accounting, billing, and sales recording.

I propose, then, that the only place that we will be able to find all of these people (the future engineers, the operators and other non-professional workers, and the public) is to go into the high schools of the country. Graduate school is much too late a time to introduce the universal field of computation into our academic institutions. It is important that undergraduates, probably in the freshman year, be introduced to the logical preciseness of digital computer programming. As an exercise in preparing complete unambiguous descriptions, programming has a universal value and is well within the grasp of the undergraduate or even the high

school student. It is a misconception to believe that digital computers can be understood only by the engineers and mathematicians. I recently had an opportunity to observe an effort to find, in the Boston area, forty persons to be trained as computer programmers. We gave special attention to the basic traits required rather than to the particular branch of formal education. The work requires intelligence and logical reasoning; and for what we were doing, it seemed advisable that recruits should possess aptitude for spatial perception. Accountants, actuaries, and business administration students qualified. You might be interested in this example. One of the highest scores on the aptitude tests was made by a music major from a nearby women's college. The young lady came to work. The initial reaction in an engineering organization was one of raised eyebrows when she came around to her supervisor and asked what the words "sine" and "cos" meant. Within six weeks, however, she was making improvements in computer programs that had been worked out previously by experts. Computer programming requires interest, enthusiasm and a certain set of basic traits which don't necessarily go with any particular line of formal education.

In the next two decades, automation in the factory and electronic information processing in the office will free many men and women from their present types of work, and it will be necessary to attract many of these to the design, construction, maintenance, and management of electronic information-handling systems. We must reach into the high schools and to the public with the message that these new developments are understaffed and crying for more people rather than their being the bugaboo that will create unemployment.

Gabriel Hauge, who is economic advisor to President Eisenhower, three weeks ago in this room, gave a talk at the Boston Conference on Distribution in which he outlined the President's economic philosophy. One of the cornerstones of this philosophy is the anticipation of an expanding economy and a future shortage, rather than surplus, of labor. It is import-

Responsibilities

ant, therefore, that devices continue to be developed to improve our productivity per man hour. If new equipment is to be fully effective, it will require better public understanding.

Now, if you don't believe that computers are of interest to the high school level, look about you. I will cite two instances that have come up recently. We have been approached by students who want to make computer exhibits for the science fairs that are held throughout the country. As you know, students build science exhibits and have competitions, and the winner of the school goes to a state fair, etc. They want computer material in the science fairs and for school assignments. I will read you a letter which came recently:

"October 3, 1955

Dean of Electronics
Massachusetts Institute of Technology

Dear sir:

I am in the eighth grade, and I am doing a report on 'Man's Thinking Machines.' I would appreciate any pamphlets, or any other information that you have on the electronic brain, or any like instruments that are thinking machines.

Thank you very much. You can send the information to: Jon Leon, 211 Pine Point Drive, Highland Park, Illinois.

One of my future ambitions is to go to M. I. T. because I want to be an engineer.

Yours truly,

Jon Leon

JL/JWL"

We had a real problem. I am at a loss to know how to answer that letter adequately. We did the best we could. We sent him information, but I don't think it was a satisfactory answer. There isn't, so far as I know, adequate material, suitably written, to answer that kind of letter. In this, the data-processing industry is lagging behind other industries. Other people are doing more.

Let me read to you from an editorial on the back of a recent investment news letter. It's a little long, but I'd like to read it all:

"THE BACK YARD

Time and again we have been reminded by educators and industrial leaders that we are not training enough new scientists and engineers to keep pace with world scientific development — But what to do about it?

Well, a significant step in the right direction has been taken by a group out in Chicago known as 'Indus-

trial America, Inc.' They are sponsoring the distribution of American Industry Educational Hobby Kits which are produced by such well-known industrial concerns as Radio Corp. of America, Taylor Instrument Co., American Optical Co., Bauer and Black, Gemological Institute, etc.

The world famous Museum of Science and Industry in Chicago has collaborated on the design and creative side of the project and each kit contains an illustrated booklet prepared under the guidance of Encyclopedia Britannica.

Actually, these kits are scientifically planned do-it-yourself educational toys designed for the 8 to 12 - year age bracket. They pack a terrific wallop of intriguing interest to the youthful mind, and enable children to really delve into the major sciences on their own.

The electronics kit, for example, contains all the necessary parts for youngsters to learn how to transmit and receive messages on their own home-built radio sets.

With the weather kit, boys and girls can build all the instruments needed for their own complete weather station and learn how to observe and forecast weather.

The medical kit contains X-Ray Eddie, an inflatable plastic anatomical model that enables children to see how the body's blood stream, breathing, digestion, and bone structure functions. Youngsters can even take each other's blood pressure with instruments made from the kit.

Priced reasonably and available in many toy and department stores, these 'American Industry' kits should be very popular items during the coming Christmas season. Also — the scientific interest they generate may well fill our Engineering Colleges in the 1960's.

(signed) Paul Talbot

United Business Service, Boston
Weekly Bulletin
October 31, 1955"

To follow up that editorial, I went yesterday to F. A. O. Schwartz, the toy store which is three or four blocks from here, to look at such hobby kits. They are really quite impressive! They're well done! I would judge from the prices, that run around \$20, that they are completely on their own financially. I think the price is a matter of importance. They are not inexpensive toys, and they are not million dollar computers. If you look at what they do in their particular fields, you find we could do the equivalent.

Since I have not run into any opposition to the importance of contacting the high school level, I expect that most of you would agree that something should be done. The problem is, what will we do to keep from

dropping the subject with everybody agreeing but nobody doing anything. I would therefore like to make a proposal that we arrange to have a team of full-time men — perhaps five or six, one donated by each of the several large industrial concerns in this field — who would work together, not as ordinary professional committee members meeting occasionally but as full-time working men with no other goals for a period of a year, and that they do this under the auspices of the Joint Computer Committee that sponsored this conference. I have not cleared this with the Committee, but I've talked to some of the members who seem to think it is a good idea. Get some people together who are interested in this educational program and give it to them as their full-time job, give them sponsorship and support from industry, and let them go to work.

The toy kits, I have mentioned (I think it is only necessary to provide material, designs and ideas and that it would be best to let somebody already in the field, like Industrial America, Inc., carry out the manufacturing and distribution). Another approach is to make arrangements with a good author who knows the high school audience level and help him to write on computers, automation, the kind of work the people will do with these machines, and the impact they will have on society — in other words, answer the questions that the youngsters are asking. There are some very good books in the science kits along this line. Also the group could encourage exhibits for our science museums. I am very sure that the science museums would enthusiastically participate if they had a little encouragement and some sources of information. Particularly, the group should plan to help the high school science teachers in various ways, (narrated film strips, experimental supplies for lab work, etc.).

I think one of the most important educational contributions would be do-it-yourself instructions that would allow the youngsters to make things representative of computers and computing circuits, and automation and controls, out of the parts that are readily available to them without expenditure for hardware. For example, supply instructions for electronic counters made of discarded radio parts. Or, the country is strewn with perfectly good relays out of automobile voltage regulators that have been discarded because the servicemen don't know how to test them. I watched a service man work on my car. He tried to adjust a 12-volt system to 7-1/2 volts by reading the 10 volt scale of a meter that he had connected to the 50 volt range — a fine set of relays to build toy computers from when he finished.....

Now, you ask how to finance such an educational program. There are many ways, but let's take the straightforward approach of considering it a normal and important part of doing business in a new field. There are about 30,000 high schools, and they have in them about 7,000,000 students. I went through a list of industrial companies last night. By picking about five companies which are predominately in the electronic data-handling field, one totals a combined yearly sales of 1.2 billion dollars. I would suggest that these com-

panies might well afford to take one-tenth of one percent (0.1%) of sales for a joint industry educational program at the high school level. This makes a yearly budget of \$1,200,000; it is \$40 apiece in each high school. Compare this with the two, three, five percent, or higher, that each of these companies is spending on physical research to develop equipment to be sold to the bewildered public.

C. B. Caldwell, Vice-President of Sears, Roebuck for Personnel and Employee Relations, pointed out recently that we spend millions to eliminate friction in machines, but practically nothing to eliminate friction between people. We are talking here about eliminating friction and misunderstanding.

Touring lecturers now supplied by a few companies are not enough. They don't reach enough people nor the small places. They don't reach the rural communities. And let me point out that the rural communities are important. A recent analysis of names in "Who's Who in Engineering" was made on the basis of the percentage of each college's engineering graduates included. Colleges in the rural areas rank high. This survey showed Dartmouth at the top, second, University of Nebraska; fourth, Kansas; fifth, Missouri; ninth, South Dakota State; tenth, Missouri Mines; fifteenth, Iowa; and eighteenth, M. I. T. I think this is significant. The people that are on the country's farms are important to us in new technical fields.

You can look at the relationship of the computer field to the farm in an entirely different way. Perhaps we can help solve another problem that has been brought on by technological changes — the farm surplus problem whose solution has been sought by legislation rather than education. Fifty percent of our farms produce ninety percent of our food. That means that fifty percent of our farms produce ten percent of our food; it's the fifty percent that produce the small end that make the farm problem. The others can make a financial success of farming without controls and price supports.

Look at the relationship between the computer industry and the farm support program on a dollar basis. The computer industry — again the four, five or six companies which are major producers of computing equipment — pay about \$90,000,000 a year in taxes. In federal expenditures, about one percent of the federal budget goes to the farm price support program. That means that the companies in this industry are putting one percent of \$90,000,000 or \$900,000 a year into the farm price support program. That is \$30 per high school.

\$30 to \$50 per high school per year should carry a very successful program. You see, the kind of money it takes is relatively small compared with what we spend in research, compared to supporting farm programs that exist because of lack of education to lead people into other activities, compared to other public relations expenses, and indeed compared to advertising costs that try to attract engineers from the end of an educational pipeline which we are making insufficient effort to fill at its source.

HIGH SCHOOL SCIENCE EDUCATION

To: Joint Computer Committee

From: Richard W. Melville, Stanford Research Inst., Stanford, Calif.

Subject: Interim Report of the Committee on High School Science Education, November 15, 1956

Organization and Purpose

This committee was instigated as a result of the interest created by a presentation at the 1955 E. J. C. C. by Mr. J. W. Forrester. In his paper, Forrester argued that the Computer Industry has not contributed properly to the need for stirring interest in Science and Technology among the high-school age students across the country. He enumerated several areas in which public distrust or lack of information is leading young people away from scientific pursuits, and pointed out that a reversal of this trend would be most beneficial to all technical fields.

After administrative committees of the sponsoring societies of J.C.C. had met and discussed the problem, it was agreed that a committee should be organized under J. C. C. sponsorship to examine the problem in detail and make a specific proposal for future action.

Accordingly, the function was authorized and, on June 12, 1956, the writer was notified of his appointment as chairman.

Status of Past Work

During the past five months (and not on a full time basis!) the following work has been accomplished:

I. A search of available literature to try to evaluate the level of present effort in this kind of work by other groups.

A. Various groups have undertaken the job of preparing literature and text material and arranging for its publication and distribution to the schools. One such set has been prepared by RETMA covering Electricity and Electronics, Radio Servicing, etc., which have been distributed for them by McGraw-Hill. General Electric Co. has an active program of distribution of materials which they have prepared for use in the schools. General Motors has distributed this kind of material to the schools for years.

B. The Instrument Society of America is planning a "Foundation for Instrumentation Education and Research". Among their stated objectives are these two: "bringing school and college facilities up to date" and "making science more attractive to young people".

C. The Engineers' Council for Professional Development was organized in 1932 with aid to the high-school age group as its major function. This organization is presently sponsored jointly by eight of the major professional societies, including AIEE but not including IRE. (I have not been able to check the operation of this

group nationally, but involved myself in their activities in the San Francisco Bay Area this fall. There was active cooperation between the Council and the school system, with time scheduled in the school program, etc. I believe that IRE should actively support this effort, and have asked Astrahan to look into the reasons why they do not do so.)

There would be a very real advantage to contracting for the services of a "Press Clipping Service" which would scan the current newspapers and periodicals for information about efforts that are being made to help out the school program. (The cost has been estimated at \$30/ month.)

II. Contacts have been made locally with a number of school administrators and school science teachers to find out how they feel about this kind of a project. I have been advised by many that they are presently being flooded with suggestions and offers of help from organizations similar to the one which we are now proposing to organize. These other groups have similar motives and plan the same kind of approach to the problem that we are talking about. There seems little doubt that the only possibility of breaking into this heavy competition is dependent on our doing an exceedingly good job of preparing material for use in the schools and arranging for distribution. The teachers are interested in what we have to offer and need good material. A few are organizing electronics programs within their science courses, some have organized electronics laboratories and are beginning to tinker with gadgetry, but all are in need of projects tailored to the needs of the group that they are trying to interest.

These projects need to be exceedingly well organized and of a tried and true nature so that they will go smoothly through the project stage in the school shops. The projects have to sell to the student on the basis of an interesting approach and the step-by-step instructions must be infallible.

An item from the Los Angeles paper late this summer described an experiment conducted at a Los Angeles high school this summer by scientists from the research laboratories of the Hughes Aircraft Company. The idea "is to interest more young persons in technical careers in engineering". The city Board of Education and the Aircraft Company both hope the program can be expanded to include all Los Angeles senior and junior high schools within a year. In addition to providing guest speakers, the Hughes Laboratories are demonstrating expensive technical equipment not usually available to schools. These lectures are part of one phase of the program; the schools in turn are sending teachers to the Hughes Laboratories for summer employment training. Ten teachers currently are doing research work at the Culver City laboratories and at the

same time are hearing orientation lectures and taking part in discussions on scientific approaches found effective in modern day industry.

Another point that deserves consideration in our program is that of attempting to interest more of the high school girls in technical careers. The engineers have not done well with respect to the other professions. Right now, there are only three women to every 1,000 men in engineering as compared with 30 or 40 per thousand in law and medicine. It is probably true that if more talented and interested high schools were given the facts about women in engineering and the opportunities available to them, the most important step would have been taken. However, the following quotation indicates another problem area: "I spent some time in the personnel office of just about every appropriate engineering firm in a good sized eastern city and heard the phrase 'I'm sorry, we've never hired a girl engineer' many, many times. The man who needed help so badly that he was willing to take a chance on me didn't tell his boss right away that he had filled the long-vacant spot with a lady engineer."

Professor Boynton Green, recently retired from the Stanford engineering faculty, feels that the basic demand is for greater appreciation of the opportunities for youth on the part of high school teachers and councilors. "The high school attitude for a long time has been that the student must be entertained. He doesn't want to put any effort into his work and the councilor generally goes along with that idea. The student is allowed to pursue that easy-going course of study although later may well realize that had he been urged to expend a little more energy, he might have prepared himself for work in a scientific world."

The answer, at least partially, lies at the door of national professional organizations which should immediately concentrate on concrete information for high school and even grammar school councilors, he believes. Groups like the American Society for Engineering Education, of which Green is a key member in the west, must take a more active part in aiding councilors to understand the needs, preparation and rewards for prospective students, Green contends.

III. A quick search of current periodicals was made in an effort to find representative articles that would help a high school student who was trying to organize a "science project" dealing with computer type circuits.

(RN-Radio & TV News; RE-Radio & Electronics;
EL-Electronics)

A. A few were found which outlined in detail a "gadget" of some sort which has a specific end use.

1. An Electronic Slide Rule RN 12/55 pg 58
Maxine D. Kaufman W30XT
Robert E. Gardner W30DK

Construction details on a simple device which

will multiply or divide two numbers using mechanical slide rule principles.

2. Bi-Directional Counter RE 3/55 pg 132
from Bureau of Standards Technical News Bulletin

Shows circuit and description of a direction sensitive electronic counter designed to keep separate counts of objects passing in two opposite directions.

B. There are many which discuss specific circuits or circuit blocks, or describe in generalized terms the operation of various kinds of computer circuitry. These articles would be of interest to a serious student, especially if he had access to an advisor who could help him through the early stages. A few samples are listed:

1. How a Computer Works RE 2/55 pg 58
David B. Munford

These simple Basic Circuits make it easier to understand how the more complex instruments operate.

2. Flip-Flop Counter Has Expanded Range
EL 1/55 pg 149
Howard Beckwith, Ch. Engr., Walkirt Co.,
Inglewood, Calif.

Counter may have up to six stable states without using feedback or matrixing. Sequential operation of counter stages requires only one tube to conduct at a time resulting in greatly reduced power consumption.

3. The Electronic Decimal Counter RN 10/55 pg 60
Edward K. Novak

Construction details on a compact scaler incorporating a bistable multivibrator. It uses standard 12AU7 tubes.

4. Elementary Binary Arithmetic (Aerovox Research Worker 12/54)

A brief description of the binary number system which includes a number of examples of comparative arithmetic operations carried out in the decimal and binary systems.

C. A relatively small number have been published which give details about a specific device, which, while it is complete unto itself, is intended as a building block in a system:

1. A "Universal" Counter RN 2/55 pg 54
Louis E. Garner, Jr.

Details on a versatile unit of many applications which features a compact battery-powered transistor amplifier.

D. The literature has many articles which describe applications of computer-type gadgetry which are interesting and instructive. In many cases the principles developed could be applied by students to demonstrations and displays. Typical examples:

1. Jukebox Ferrite Memory .EL 10/55 pg 138

Describes how logical and control functions are performed with a 10 x 20 bit magnetic core memory to accomplish record selection in a See-burg Selecto-Matic "jukebox".

2. FOSDIC - Fast Optical Sensing Device for Input to Computers

Describes a method used to produce accurate entry of information to a computer from large tally sheets used by census takers.

The greatest need is for the release of a much larger volume of simple, "one shot" devices as in paragraph A-1 above, and for some real work on compatible, building block type projects as in paragraph C above. These projects must not involve high-cost components not available to students, but must make use of common materials obtainable at low cost or better yet, no cost at all.

Future Work of this Committee

There appear to be five distinct areas within which action can be initiated immediately: These are listed below along with some of the more obvious subdivisions of each activity. It is implied that different sub-committees should be organized for each of the five.

1. Obtain funds to finance future operation. It is felt in most quarters that funds would be made available by many, if not most, of the large industries employing computer engineers, and the large manufacturers of data processing equipment. Money could be dispersed to further the following objectives and many others.

a. The implementation of Forrester's original proposal: that a working committee of 5 to 6 full time men be employed to carry out the objectives of the program and be responsible for the coordination of the many phases involved.

b. The subsidization of the cost of apparatus and materials which would be used by the schools in demonstrations, experiments, and teaching. The purpose would be to close the gap between the cost of these items, and the money available in school budgets.

c. The direct payment of administrative costs (e.g. mailing costs, periodical search service, etc.) which will be encountered by all who are involved.

2. Establish direct communication with the schools.

It must be recognized at the outset that the success or failure of this whole effort hinges on the acceptance by

the school authorities and the teachers responsible for science education, of the goals and motives of this committee. Good Public Relations work (see #3 below) will help, but in the long run, nearly every effort to promote science education of the high-school age group must pass through the school system filter. For this reason, it is important that the feedback loop between the schools and those interested in this work be closed at the earliest possible moment and that the channel be kept clear.

It should also be clear that coordination is required between this committee and the many other groups which have been and are being organized for the same sort of purpose in related fields. For each of these groups to approach the problem independently will produce confusion at the very level where it should be avoided most carefully. (Some evidence exists that this is already happening.)

The efforts of this sub-committee could be directed along the following lines:

a. Placement of books and pamphlets containing stimulating materials directly into the hands of science teachers and science club advisors.

b. The production of narrated film strips, motion pictures and other visual aids and their circulation.

c. Encourage, as early as the high school freshman year, the development of precise, logical thinking.

d. Encourage active, systematic organization of guided industrial plant tours for high school students. (The cooperation of the Student Activities Committees of IRE and AIEE should be secured.)

e. Science lectures and demonstrations should be organized at the local level and complete information made available to the school system so that time can be scheduled into the school program whenever a demand exists.

f. A very important function would be to help arrange for the summer employment in interesting computer industries of the teachers who desire such employment. The possibilities of this program are tremendous and the feedback of industrial enthusiasm to the student body can be very real.

g. Each year the schools have a few outstanding students that they would like to place for summer employment. The placement of the senior graduating class in industry has been much easier than placing sophomores and juniors. However, the enthusiasm which is carried away from the summer's work by a high school graduate is lost to the high school. If the lower classmen could be helped into summer employment in computer industries and laboratories their experiences would be shared by whole classes during the following year!

3. Increase the volume of published material. The first part of this work is a straightforward Public Relations

job, with two main goals: the promotion of public understanding of the functions of computers and data processing equipment and the advantage to the public of having them in use; and an educational campaign to reduce popular resentment of science and technology and the "eggheads" who work in these fields.

The second part of this job is to provide the information and know-how which will promote the understanding necessary to encourage the use of computer-type devices by as many people at as many different levels as possible.

Both of these objectives can be met by increasing the flow of material on computer technology to the established channels of publication for popular consumption.

a. Establish a clearing house for information on the ways in which computers are being used to solve everyday problems, and the new devices which are appearing regularly from laboratories all over the country. See that this information is made available to the publishers of newspapers and magazines in a form that is useful to them and their readers.

b. Contact the already established publishers in the Radio-Electronics-TV field for details of their publication arrangements, and make these facts available to the J. C. C. membership. Encourage our members to write articles for the "do-it-yourself" and "experimenter" groups and get paid for it.

c. Make an effort to get some sound text material published and distributed that can be used by student and teachers at the high school (not college) level.

4. Create a flow of computer materials from industry sources to science teachers and science club advisors for the use of groups and individual students willing to build up experimental or demonstration type equipment. To attempt worthwhile projects in the computer arts, the student must have available a selection of computer components not easily fabricated in the school shop and not available from the local radio parts supplier. Similarly, the teacher or advisor needs supplies of a type not normally accessible to him. Two obvious sources could be tapped:

a. For "standard" demonstrations, which would be repeated in many different locations, assemblies could be supplied by the major manufacturers in "package" form, as a reasonable part of their normal advertising and public relations budgets. Some will certainly be willing to supply this material if, as discussed in Section #3 above, the demand has been created and the experimental procedure outlined. Distribution should be direct from manufacturers to school, in order to encourage maximum contact.

b. If the demand can be created, the cooperation of existing distribution facilities is assured. The school laboratories are presently utilizing the facilities of the big

mail order suppliers such as Allied Radio and Lafayette, and are presently purchasing heavily from manufacturers like Heath Company. If equipment and components for work in computing and data processing can be specified for them, these organizations would be glad to handle the distribution work.

c. A very large amount of material is being discarded constantly which would provide impetus to creative student work if it was made available. For instance, it is the practice of many suppliers of office machines to reduce old equipment to scrap in order to prevent its re-entrance to the machinery market. Such equipment is an excellent source of such components as key-switches, commutators, fractional horse-power motors, print heads, etc., which are absolute stumbling blocks to the youthful experimenter intent on creating some new (or old) device. It should be possible to divert some of this material to the science teacher or science club advisor for distribution without sacrificing the protection desired by the manufacturers against re-use of "brand-name defamation". It is not presently clear how this distribution could be handled, but certainly a way could be found.

5. Interest manufacturers of games and toys in the production for sale through normal channels, of gadgets and construction kits which will demonstrate computer principles, logic, etc. A very real demand exists today for relatively inexpensive assemblies which can be distributed via the organized toy market. Some are already working on this problem, but the need is for ideas and details. The mechanics of rewarding those who expend effort in this direction are firmly established, and the problem is one of matching the need of these suppliers for ideas, and the universal need of computer engineers for extra income.

a. Contact should be made with the toy manufacturers' "professional societies" such as:

The Toy Guidance Council
The Toy Information Bureau

b. Certain major distributors of toy materials would be willing to help—typical of these is the F. A. O. Schwartz Co., New York City.

c. Some manufacturers are already trying to hit this particular market. Industrial Associates, Inc., of Chicago is one of these.

Some Questions for the Joint Computer Executive Committee

When an attempt is made to implement the work of the sub-committees listed in the previous section, questions will be raised as to the acceptable techniques which can be followed. We would appreciate some direct help from the members of the executive committee on some of these points.

(cont'd on page 59)

1. Under Section 1, Obtaining Funds to Finance Future Operation, the identities of the people within computer organizations who control the expenditure of such funds are not known to us at this time. We would appreciate receiving information as to the specific name and address of each person who would be willing to concern himself with this problem within industry. An attempt would then be made to contact these individuals, supplying them with details of what we are trying to do and a tentative prospectus which would indicate the extent of our budget both in time and money. They would also be asked to supply personnel for this work if they were willing to do so.

2. Under Section 2, Establishment of Direct Communication with Schools, the question will undoubtedly be raised as to whether there is authority to hire professional consultants in the education field in order to aid in bridging this gap between our committee and the school systems. An expression of feeling would be helpful here.

3. Part of the work of Section 2, as well as that outlined in Section 3, Increasing the Volume of Published Material, will require direct contact between members of this committee and the membership of IRE, ACM and AIEE. Is there any restriction imposed on circulating our membership? Can this be done immediately, rather than waiting for financing to be available, and if so, what arrangements can be made for mailing and distribution costs under present JCC authority?

4. The work under Section 4, Creating a Flow of Computer Materials, should be started rather soon, since it will take a long time to get such a program under way. We would appreciate as much help as we can get in trying to devise ways to organize such a program, and if anyone has thoughts along these lines, we would very much like to hear about them.

5. Members of the JCC could perform a real service by sampling their managements for personnel policies which would bear on the hiring of: a) female engineers and technicians; b) teachers and students (high school) for temporary work during the summer.

6. This committee would appreciate receiving clippings referring to science education efforts described in periodicals and newspapers from points distributed across the country. If JCC members would ask personnel in their groups to watch for these announcements, forwarding clippings or copies to the writer, it will help us to keep up to date on progress.

- END -

distributed free of charge to students and teachers. Do you know of another such? If so, what is it like, who prepared it, who puts it out, and how is it being distributed? Do you think it might have been done better? Can you report evidence as to its use and effectiveness?

Has your organization had an open house for students or teachers, or is it planning one? If so, when, and with what kind of program? If it has been done, what was the response?

Do you have a project of your own in the field of education for science or automation or computers or such, — for which you would welcome advice, publicity, support, criticism? We hope that you our readers will report, discuss, compare, and be vocal. What can you contribute?

- END -

Editor's Note

COUNCIL FOR BASIC EDUCATION

A "Council for Basic Education" has been organized by a group of individuals who have been active in urging, through writing and speeches, increased emphasis upon fundamental intellectual disciplines in the public schools.

The Council hopes that it can help focus the scattered efforts now being made to strengthen public school education.

The founding members of the Council include: Arthur Bestor, Prof. of History, University of Illinois, and author of "Educational Wastelands"; Maynard M. Boring, Manager, Technical Personnel Division, General Electric Co., and Past President, American Society for Engineering Education; Howard A. Meyerhoff, Executive Director, Scientific Manpower Commission, Washington, D. C.; and seven more persons.

The address is: Council for Basic Education, 20-A Union Trust Bldg., Washington 5, D. C. Inquiries are welcome.

OBJECTIVE MEASURES OF EDUCATION

DONALD TRUITT
Nelleston, Conn.

For a long time I thought that as a computer man, I did not need to be too directly concerned with the education which my children and the children of my friends were getting in the public school system of our suburban community, Nelleston. According to the grapevine where I lived, the schools in our community were "good", "among the best in the country". I could see that the school buildings were very good, some of them breath-taking in their appearance and equipment. Some teachers whom I knew, I liked and respected; I believed and still believe that very likely nearly all our teachers could teach well. Sometimes I had perplexities and doubts, but they were lulled — by soft words that "teacher knows best" and "parents should not interfere", by hope, by waiting for "readiness" and "maturation", by statements that "experiments have shown" that young people in fourth, fifth, and sixth grade should not have homework, etc., etc.

About two years ago though (April 1955), I received the shock of my life — in the area of the education which my children and other children of the community were actually receiving. The description of the shock is in Part 1 below, except that names and places have been disguised.

The disguise is in order to avoid hurting people in Nelleston, who in my opinion should not be hurt. The malfunctioning of education in Nelleston and elsewhere is not to be attributed to relatively innocent individuals locally situated, but instead to a poisonous and disastrous anti-educational system, which seems to operate to a large extent unconsciously. It is clearly a phenomenon to be studied by social anthropology. About this system I shall have more to say in another article. In the meantime readers who are interested may look in: "Educational Wastelands" by Arthur E. Bestor (The Univ. of Ill. Press, Urbana, 1953, 226 pp), "Why Johnny Can't Read" by Rudolf Flesch (Harper & Bros., New York, 222 pp; also Pocket Books), "The Crisis in Education" by Bernard Iddings Bell (McGraw Hill Book Co., New York, 1949), and related books. These books (though not without faults themselves) contain provocative facts and implications about the anti-educational system; but in my

opinion the full story is more complicated, more fascinating, and perhaps more pervasively disastrous than they suggest.

In Part 2 is a brief account of my first reaction to the shock, and the questions which I put down then, for finding answers to. Since then, I have seized many opportunities to investigate, read, study, talk to people, take countermeasures in my own family, and more besides. It was revealing and stimulating to see the attention given to "education for computers" at the Eastern Joint Computer Conference in New York in December.

My main conclusion so far is that people should have "OBJECTIVE MEASURES OF EDUCATION", available in any community. They should be objective, public (nonconfidential), and understandable to anyone. The definition, description, and purpose of these measures or standards are explained more fully in Part 3 below. Such measures or standards will restore negative feedback, will restore automatic correction and control, into the educational system. Once more, control by school visiting committees will come back into local communities.

I am very sure that this is by no means all of the answer. I do know that many other computer people besides myself are intensely concerned with better education for the computer field. We can't have that without securing better education for science. And we can't have that without securing more educated graduates from high school.

Any suggestions, comments, or criticisms that any reader may be kind enough to send me (in care of "Computers and Automation") will be much appreciated.

1. SHOCK

April, 1955

Sam is a young man whom I know well, who is now 18-1/2, and who is graduating from Nelleston Trade and Vocational School this June. He is intelligent, active, keeps his own car, a 1941 Ford

Objective Measures

convertible, in running order, and does most of the repairing himself. He helps at home, is friendly, open, sincere, likable, and very often forgetful. His I. Q. was determined to be 116 some years ago. His marks in trade school are one A, a set of B's, and one C; he receives B in English. One of Sam's achievements is that a year ago he borrowed a block and tackle, moved a motor from one car to another, and after he got the motor into the second car, the second car ran. His field of concentration in trade school is cabinet-making; he is good at that, and has made some fine pieces of furniture, including a cobbler's bench. He intends to volunteer for the draft, and go into the army in the autumn. Sam was never much interested in school or in studies; he began to read for his own enjoyment when he was 16-1/2. He used to listen to the radio a great deal.

Half a dozen years ago I offered Sam a prize. If he did not smoke or drink before he was eighteen, and if he would write a report — perhaps 10 pages — giving the advantages and disadvantages of drinking and smoking and telling his own decision, and the reasons for it, I would give him a prize of \$100.

His eighteenth birthday came last November. The report was not done. I gave Sam \$20 of the reward, since he had not smoked or drunk, and six months extension, to May 5, to write his report. During the winter, during tutoring from a friend of the family, he started working on the report, and brought me a report in the early part of April. But it did not sound like Sam, and I wondered about it. After talking it over with him, I gave him \$30 more of the reward, and arranged with him to come down to my office and demonstrate in several hours there what he could do on his own.

Sam finally came to my office on Saturday, April 30. I gave him the following written-out questions to answer:

1. What are the advantages of smoking?
2. What are the disadvantages of smoking?
3. What are the advantages of drinking?
4. What are the disadvantages of drinking?
5. What is your own conclusion (decision) and why?

I told him that for the first four topics he could list the points instead of writing them out at length. I explained to him that the scoring of his answers would be based on the following points, which I wrote out, read aloud, and placed in front of him:

1. Information: completeness and accuracy; evidence of understanding.
2. Reasonableness; sensibleness; level-headedness; good logical reasoning; common sense; honesty.
3. Presentation: English; sentence structure; choice of words; spelling; conveyance of ideas from his mind to my mind.

I told him that how much of the rest of the prize I would give him would depend on this proof of what he could do on his own.

Sam worked on his examination from 10:30 to 11:55, and then coming back after lunch, from 1:45 to 3:00. Then he stopped. I asked him if he wanted more time. He said, No, he had written as much as he could. And he left, so that he could go into town to do some shopping before stores closed.

Following is a copy of what he wrote with the spelling and punctuation of the original. The handwriting for some letters was not clear; in most cases the following typed copy gives Sam the benefit of doubts as to letters.

EXHIBIT A — SAM'S OWN REPORT

Advantages of Smooking

1. Enjoyment
2. Relaxing
3. A grate many of my friends smoke.
4. the oppion of a grate many people which I value smoke and say it is not wronge.
5. My face would not brake out from eating chocolate.
6. If one smokes his appite will not be so great
7. I would not be as apt to bite my finger nales.
8. If I smoke I will help create jobs for outhur people who manufacture cigrets matche ash trays etc.
9. I may feal psycholegical relaxed.

Disadvantages of Smoking

1. Cost
2. May cause canser
3. Burns holes in clothing
4. Burns holes in table tops and furinture
5. Messey
6. Takes a lot of your streingth away.
7. The smoke may get in your eys when driving and obstruct your vue.
8. May start fires.

9. Waste of time.
10. Stain your fingers with nicotine.
11. Ash trays have to be emptied and washed.
12. Smoking stands, ash trays, matches, lighters have to be bought
13. Money saved by not smoking could be put to good use.
14. Appearance can not be as nice as it might be.
15. Bad for your teeth, may cause decay.
16. If you have become a chain smoker it is hard to brake the habit
17. It is bad for hayfever or sinases.
18. Smells the home up.
19. Unpleasnt for outhur

Advantages of Drinking

1. Enjoyment
2. Follow the crowd.
3. The oppion of of people I know and value say it is not bad.
4. Many doctors perscribe it before dinner to relax the heart.
5. Doctors also perscrib it to build up an appite. for thoes who need it.
6. Helps brake the ice a party which is illustrated in a pome. candy is But liquer
dandy is quicker
7. Manny families drink wine with dinner every day.
8. It is polite to offer it when gests come over.
9. If it is offered to you it is polite to execept.
10. I will help create jobs for outhur people
11. May help to stop minor physical discomferts such as toothache difficulty cold etc.
12. Helps to relax the nerves
13. Accepted socially.
14. If you are dipresed it will give you a lift mentally
15. I may like the taste
16. It it also good for artery trouble

Disadvantages of Drinking

1. Cost
2. One may become an alcoholic.
3. There are approximately 4,000,000 people who have troubl with drinking.
4. I may do things I wish I hadent if I get drunk
5. Breath is bad smeling
6. Makes a mess for the house wife; stains, spills
7. Have to by glasses, mixers, and pictures.
8. May loose your job.
- 9.

Conslusion

My conslusion is that drinking and smoking are not bad things to do. If I had a cigarete two or three time a day or a cigar now and then it

wouldnt be bad. On holidays and social grathings it wouldnt hert to have cocktales. If thy are booth taken moderatly no harm can come by eather smoking or drinking.

I have desided that I want to drink and smoke. A grate many of my frinds now smoke and drink and I would like to enjoy it as they do. I think I will wate untile I am twentyone and then have some one show me how.

2. REACTION

April, 1955

Sam's report appalled me on two out of three counts.

Under the heading of information, Sam's report was fairly good. It showed a serious attempt to collect data. Of course, it could have included more facts.

Under the heading of English, Sam's report was appalling to me. He had never learned to listen to the sounds in the word "opinion" and the word "appetite". He could spell "physical" but could not spell "great". He was so confused about "pitchers" and "pictures", that he had written the more difficult word for the less difficult one. He could not automatically write a sentence with a subject and a predicate: "the oppion of a grate many people which I value smoke and say it is not wrong". His total output for two and a half hours was about two pages (500 words); then he had nothing more to squeeze out. For work such as this he was getting B in English. (If he was getting B, what about the others in his class?) And more besides.

Under the heading of reasonableness and logic, Sam's report was even more appalling. He had not learned to compare his own spelling of a word "conclusion" with the word written in the questions in front of him "conclusion". He had not learned to look over his own work and be consistent in his spelling: "smooking" and "smoking", "perscribe" and "perscrib". His conclusions show no weighing of reasons: after saying "one may become an alcoholic" and "4,000,000 people have trouble with drinking", he concludes he will drink, saying not one word about how he arrives at his conclusion. After referring to "canser" as a disadvantage of smoking, he does not discuss in any way how he plans or hopes to avoid it, or why he considers the risk not very important. And more besides.

After giving Sam \$8 more of his reward,

(cont'd on page 63)

News Release

HUGHES TO GIVE FELLOWSHIPS
TO 200 IN SCIENCE

Culver City, Calif., September, 1956. — Hughes Aircraft Company has announced that it is awarding master of science fellowships to 200 young engineers and physicists from 36 states so they can continue their education while employed part-time at the electronics concern.

They will take advanced courses at University of Southern California, University of California at Los Angeles, or California Institute of Technology, and will be employed at Hughes in research and development laboratory work closely associated with their studies.

For the first time, Hughes officials also disclosed, additional fellowships have been established at Stanford, Purdue, and West Virginia Universities.

Hughes develops and manufactures electronic armament control systems carried by U.S. Air Force and Canadian jet interceptors, and produces the Falcon Air-to-air guided missile. It also makes cathode-ray tubes and several types of semiconductors, and is active in the fields of digital computers, ground radar, microwave devices and antennas, radomes, precision plastics, communication systems, and miniaturization.

The students, as members of the technical staff of the Hughes laboratories, will be considered professional engineers and scientists, and will receive salaries as well as payment for tuition, books and fees.

- END -

* OBJECTIVE MEASURES
(cont'd from page 62)

mainly for coming down to the office and "writing his exam", I just could not give him any more.

June, 1955

Sam received his diploma from the school in June. His final mark in English was not B but C.

But, apart from the prize, the test, and the diploma, I feel so sad about Sam's equipment for his life ahead of him. The responsibility for Sam's poor equipment belongs not only to Sam, but in appropriate shares to his family, his schools, and his teachers — for example, the responsibility for the fact that he has not learned enough to look at the word "conclusion" written in the questions asked him, copy it, and therefore avoid "conclusion" in his own writing. And now it is too late for family or teachers to do much more for Sam — experience must be his teacher from now on.

The problem however is far wider than Sam. It leads to a great many questions, all derived from the incontestable result of Sam — a fine quick boy with an I. Q. of 116, and his woefully poor equipment to meet the world with.

Here are some of the questions:

— Is there any way whereby parents can compare their children year by year with appropriate objective standards that parents can understand? so that parents can see and understand what their children have accomplished and should reasonably accomplish?

— Having found out the truth about the reading, writing, spelling, and arithmetic that their children can actually produce, year by year, is there any way whereby parents can decide reasonably about changes to be made? changes in teaching, schools, tutoring, watching television, listening to the radio, guidance, instruction at home, hours for being in their rooms on school nights, etc., so as to produce better results in the education of their children? (by "objective", and "understandable" I mean "can do long division, like $3598 \div 36$ " instead of "B in arithmetic" or "grade level in arithmetic, 6.3").

— Is there any way whereby young people can be scored in school objectively, instead of receiving B in English for work as bad as this?

(cont'd on page 64)

OBJECTIVE MEASURES
(cont'd from page 63)

— How can we guide and control the factors of emotion, intelligence, capacity to work hard at studying, quality of learning and teaching, etc., to produce better results in the equipment of our children?

3. MEASURES OF DEGREE OF EDUCATION THAT ARE:

- OBJECTIVE;
- PUBLIC (NONCONFIDENTIAL);
- UNDERSTANDABLE TO ANYONE

December, 1956

The product of our schools is intended to be educated young people. They are educated through high school or secondary school when they can actually do certain objective things: read well; do arithmetic well; write English fairly well; think logically rather well; have a reasonably good knowledge of history, geography, and science; spell English adequately; and perhaps most important of all, have acquired an attitude of being interested in learning more, and know how to go about learning more, so that they can learn for the rest of their lives.

It is possible to make tests of these capacities which are objective, public (nonconfidential), and understandable to anyone. For example, a businessman when interviewing a job applicant can easily and quickly test his ability to read a paragraph, write a letter, add figures, apply a formula, spell two or three syllable words, etc.

Objective

What is an objective test? It is one in which every question has an objectively right or wrong answer, and about which 99 out of 100 informed people would agree as to the answer.

Many existing standards are not objective. Grades are not objective; different teachers and different schools mark in different ways. Diplomas are not objective; there is too much pressure upon schools to give diplomas irrespective of the quality of the student's work. The doctrine of happy adjustment in school is not objective; lots of students who, in the opinion of the teacher, are happily adjusted, are unable to read, write, and do arithmetic correctly.

Public

What is a public (nonconfidential) test? It is a test which is not confidential or restricted. It is one in which (1) before the examination, the whole subject matter of all the possible questions is openly described, is free to be published, and can be studied by anyone who cares to, and (2) after the examination, the particular questions actually asked are published or are openly stated to anyone who wishes to inquire.

Tests that are confidential or restricted are of course not open to study by anyone nor to discussion by the public. They are not sufficient for the purposes of a free society. Ordinary people using their common sense cannot correlate results on such tests with the capacity of young people to do things in the real world.

Understandable

What is a test which is understandable to anyone? It is a test in which the questions are expressed in nontechnical language, expressed in terms that businessmen, taxpayers, and most adults in the community can readily understand. A large part of such questions though perhaps not all will be based on situations that commonly occur in the daily life of the community.

Use of Such Tests

As soon as the people in a community have such tests, and knowledge of objective marks on such tests, they can start exercising intelligent control over the schools in their community. They can judge the product of the schools. They can compare the product from year to year. They can try out various methods for controlling quality of the product. They can use the successful techniques of business and industry to greatly improve the product, and the methods of production.

We can then decide year by year how schools are doing their job. We can then decide whether young people graduating from high school are in actual truth being educated adequately. "Education is everybody's business", said the 1956 White House Conference on Education. But how can we run this business if we don't have objective facts about the product?

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