COMPUTERS
AND
AUTOMATION

CYBERNETICS · ROBOTS · AUTOMATIC CONTROL

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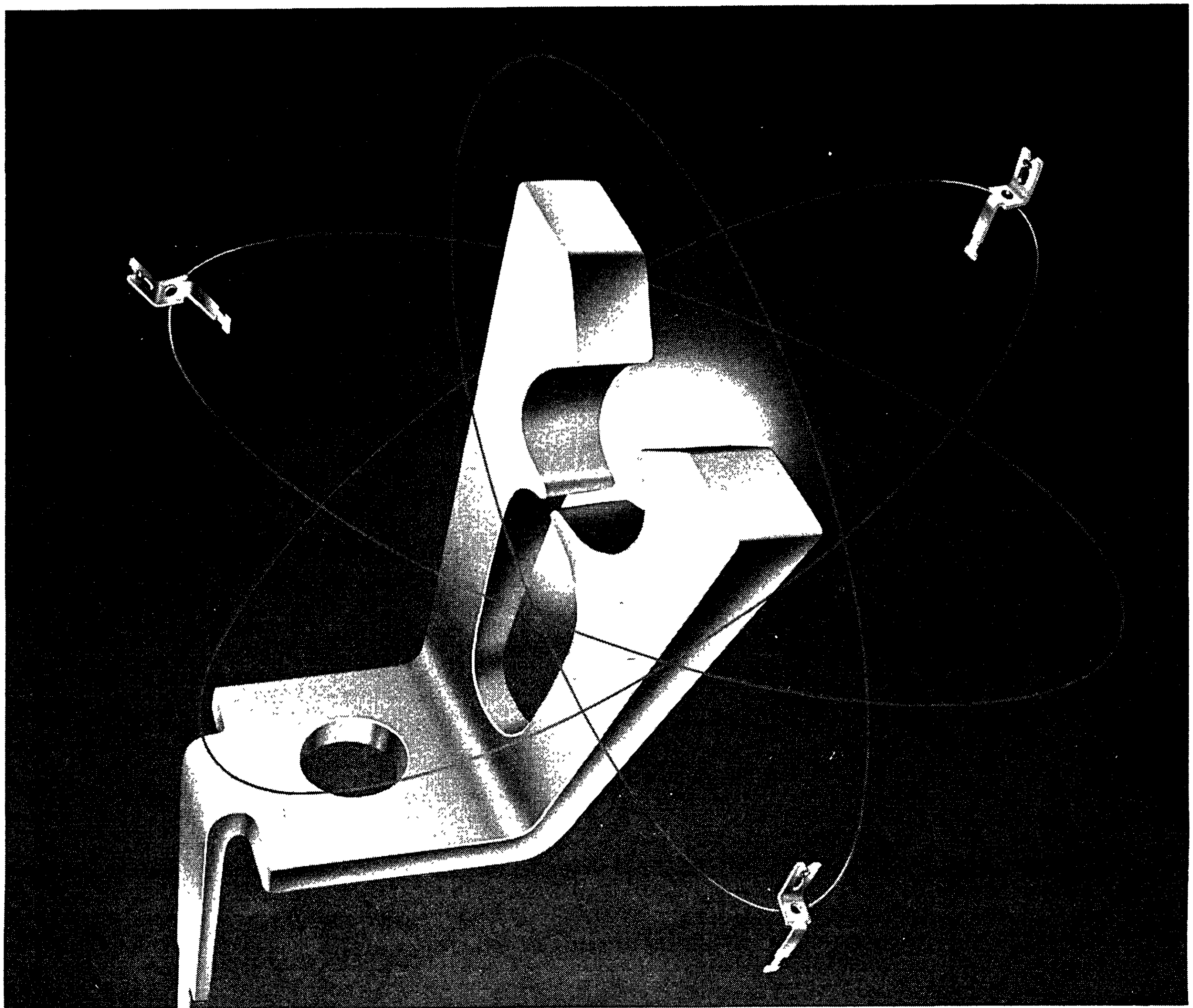

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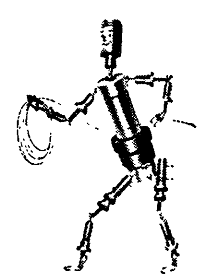

COMPUTERS AND AUTOMATION

CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

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THE EDITOR'S NOTES

COMPUTER DIRECTORY

The June, 1955, issue of COMPUTERS AND AUTOMATION is expected to be a "Computer Directory". The present plans in regard to this directory issue are as follows:

Part 1 of the directory will be the second edition of "Who's Who in the Computing Machinery Field" which we published in 1953-54. It will contain names and some information about all persons whom we know of or can find who are really interested in computers. Entries will be free. If there are 4000 such persons and 80 entries to a page, this part of the directory will be 50 pages long.

If you are "really interested in computers" and desire to have an up-to-date entry for you in this directory, please send us your name and address and ask for a who's who entry form, or else complete the "Identification" and "Who's Who Entry Form" in the style that is published in the magazine (see page 46), and send the entry form to us.

Part 2 of the directory will be a cumulative "Roster of Organizations in the Computing Machinery Field" based on the roster regularly published in COMPUTERS AND AUTOMATION, with entries expanded to some extent. Entries in this roster will also be free, in order that it may be as complete as possible. This part of the directory may be 20 pages long. If you know of any changes, additions, or corrections, which should appear in the Roster of Organizations which we publish, we would be grateful to you for sending them to us.

Part 3 of the directory will be the first edition of "The Computing Machinery Field: Products and Services For Sale." It will be a compendium of descriptions, pictures, etc., of machinery, systems, components, services, etc., for computing and data-handling. Organizations will be invited to submit descriptions of their products and services for inclusion in this part, at an advertising cost which will be substantially less than our regular advertising rates; if the description fits exactly with editorial requirements, and can be photooffset as it stands, the cost will be much less still. Details are still being worked out at the time this issue is going to press, but should be available about February 10. It is anticipated that 50 to 150 pages of information, descriptions, and advertising may make up this part.

If you are the sales director or advertising director of an organization having any such products, please send us (1) title, organization, your name and address, (2) the total number of different products and services that you would like to have mentioned or described in this compendium, and (3) a list of the names or identification of such products and services. We will then send you entry forms for reporting their particulars. At least some of the information can probably be reported free in the directory issue.

The closing date for most parts of the directory issue will be about April 20.

SCIENCE FICTION

A precursor of much good work in many fields of science, including the field of computers and automation, is scientific speculation -- imagination running ahead of the facts, a happy faculty of conjecture, the formation of shrewd guesses without sufficient evidence or proof. In fact, some years ago the editor of a well-known magazine spoke of the need for a "Society for Scientific Speculation". The society in fact though not in form does exist: the writers and readers of science fiction. Invention and discovery is often preceded by a fertile mind playing with an idea in the make-believe world of science fiction. Jules Verne's "Twenty Thousand Leagues under the Sea" preceded the first nuclear powered submarine, appropriately called The Nautilus.

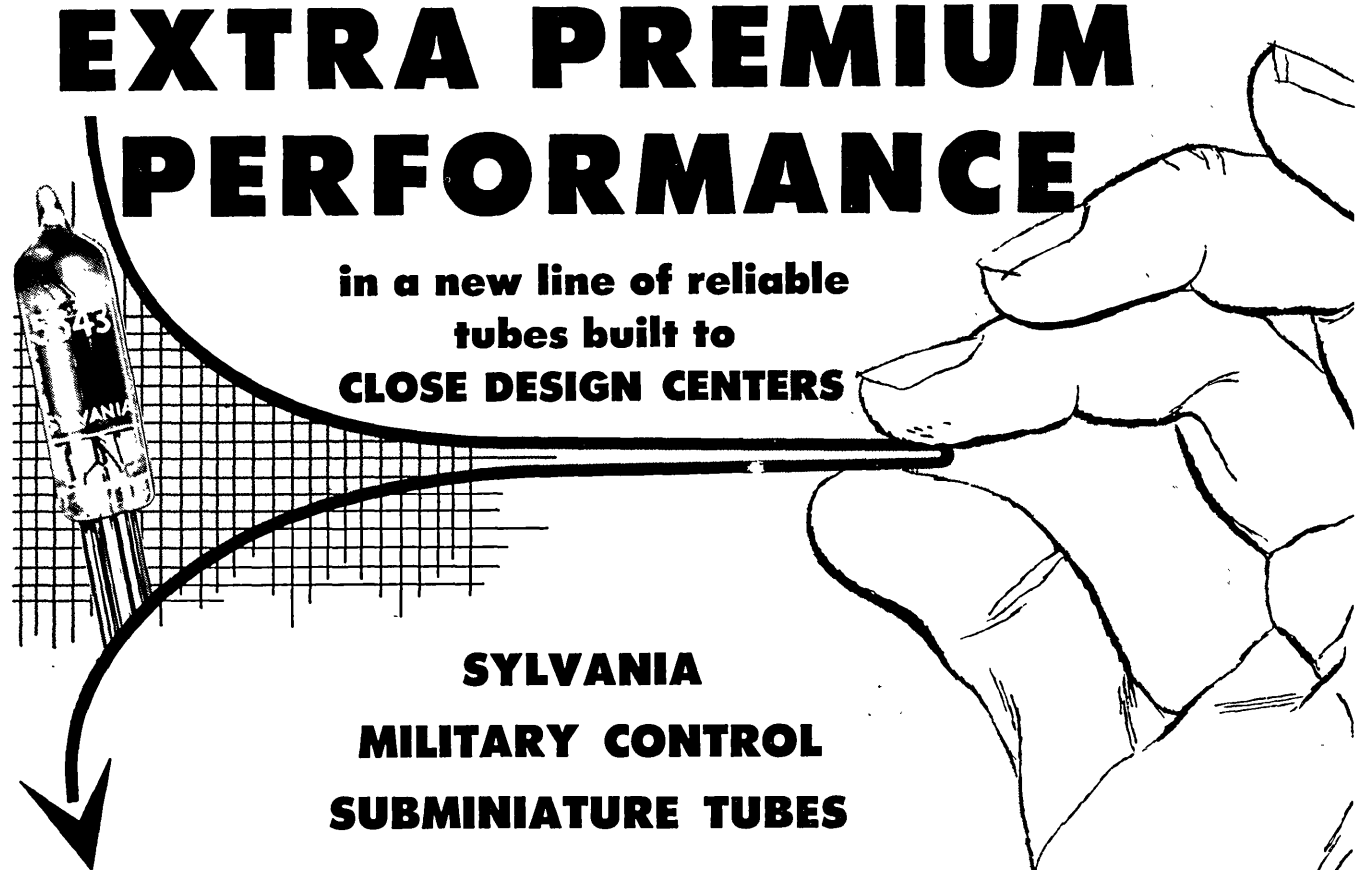
For a long time, we have felt that some of the fascination of the subject of computers and robots, machines that might think, was well expressed by certain science fiction. Beginning with this issue, COMPUTERS AND AUTOMATION will print or reprint from time to time science fiction, and similar material that stirs the imagination, if it contains something of significance to computers and automation. Any suggestions from our readers will be welcomed.

It may not seem highbrow or austere or Olympian to publish fiction in this kind of magazine, but so long as the ideas contained therein are significant and stirring, and the story an entertaining one, we fulfil our purpose of investigating computers and automation, and their implications and applications. Besides, there are many devotees of science fiction among computer men, and newcomers to our field should have the opportunity to read some of the good stories that have explored ideas about computers, robots, cybernetics, and automation. If any person is disinclined to read such a story, he should pass it by.

(continued on page 29)

ANNOUNCING

EXTRA PREMIUM PERFORMANCE



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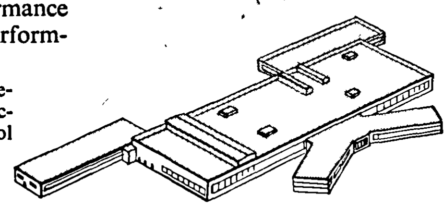

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PROBLEMS FOR STUDENTS OF COMPUTERS

John W. Carr, III
Engineering Research Institute, University of Michigan, Ypsilanti, Mich.

The University of Michigan gives a course "Methods in High-Speed Computation" (M173-174), in which each student has access to the MIDAC (Michigan Digital Automatic Computer). During the first semester, the course emphasizes the logical structure of digital computers, number systems, input-output, and programming. During the second semester the emphasis is on modern numerical analysis. During the first semester each student is assigned a "term problem", to be solved before the end of the first semester. He may choose the problem from the list below. This list has been devised to stress the logical powers of digital computers in performing complicated problems automatically. They may prove useful, therefore, in training courses, indoctrinating new programmers, or in demonstrating the power of automatic computation.

Instructions

The following problems will constitute an important part of your grade. The problems should be completed, with a written report of history, difficulties involved, etc., and handed in by the date of the final examination. Each student should select one problem from the list. A substitute problem may be selected if accepted by the instructor.

1. Nim

Design a program for MIDAC to play Nim. MIDAC is to print out the instructions for playing the game, ask for the decision as to the first player, call for values to be typed in, type out continuing sequence of play, and indicate the finish of game and the winner.(1)

2. Tic-Tac-Toe

Program MIDAC to play "Tic-Tac-Toe". MIDAC prints out instructions for playing the game, asks for decision as to first player, calls for values to be typed in, types out continuing sequence of play, and indicates finish of game, and winner.(2)

3. Machine Control

Design subroutines for MIDAC in the standard conventional form, first coded and tested via Floating Address form and later translated into "present address relative" form. Do both listed:

a. Subroutine for printing out counter, instruction, and contents of α and β in case of overflow occurring. Subroutine to be entered from position zero upon transfer because of overflow, but to be stored in an arbitrary position.

b. Subroutine for setting up the overflow condition (000 cell) to normal or halt, (combined with [a]) so that after machine calls for one word from the keyboard the proper substitution will be made.

4. Sorting

Design a routine for sorting an arbitrary sequence of digital numbers stored on the magnetic drum. Call in the numbers in smaller blocks, sort them, then merge the blocks into larger ones.(3)

5. Machine Control

Write a program for subroutines for MIDAC as in problem 3 to give the following:

a. Upon sending the number of words and initial address to locations 510 and 511 (or in one word) transfer these words <u>to</u> the drum with a memory sum, storing the memory sum as an extra (last) word on the drum.

b. Upon sending the number of words and initial address to 510 and 511 (or in one word), call in these words <u>from</u> the drum with a memory sum, and compare with the memory sum already sent out to the drum. If the two are the same, proceed. If not, call in from the drum again, up to 5 times. After 5 incorrect transfers, print out an error halt. Restore the contents of the all-zero cell.

c. Include both routines described above in a. and b. in one connected routine.

6. Machine Control

Write a program for two companion subroutines for MIDAC as in problem 3 that will perform the following:

a. Read in a sequence of single characters, and store them in the form of seven six-bit characters to a word, placing a "stop-tag" of some sort in the last word.

b. Print out the sequence of single characters, stored as seven six-bit characters to a word, stopping at the "stop-tag".

7. Desk Calculator Simulation

Using typewriter keys to simulate addition, subtraction, multiplication, etc., write a program that will cause MIDAC to act like a desk calculator with typewriter keyboard input. Make input and output work in decimals.

8. Random Number Production

Program a subroutine so that upon transferring control to the subroutine, a "pseudo-random" binary digital number will appear in location 511. Devise a second method of procedure so that the pseudo-random sequence can be restarted at the beginning.

9. Money Changing

First, devise a "money changing routine" for MIDAC, so that when a coin or bill is given to pay a charge, the proper change item by item is typed out. For example, 17 cents out of a five dollar bill: 4 dollars, one fifty-cent piece, one twenty-five cent piece, one nickel, 3 pennies.

Extend the above routine so that given an initial amount of change, the machine will make change in a fashion that will lessen the danger of running out of a particular denomination, or if it does run out, that alternate change sequences will be printed out.

10. Income Tax

Program a routine that given the annual wage, number of dependents, and withholding tax, and assuming a 10% deduction, the machine will give the income tax owed the government.

11. Mean and Standard Deviation

Given a sequence of up to 2000 digital numbers, store them on the drum, obtain their mean and standard deviation, and print out these two values in decimal.

12. Justified Typing

Devise a program that will make the MIDAC simulate a justified typewriter, so that after a line of English language has been typed in, the machine will adjust the spacing throughout so as to give flush left and flush right margins and even spacing between words.

13. Encoding

Select a particular method of cryptographic cipher and devise a procedure so that MIDAC will accept English and print out the coded result, and vice versa.

14. Language Translation

Set up a 50-word German-English or French-English dictionary and devise a program for MIDAC to give a literal translation when a sentence in one or the other language is typed in.

15. Symbolic Logic

Devise a program that will solve standard, but involved, problems in the propositional calculus.(1)

16. British Money Changing

Program a procedure that will make change in the British monetary system automatically (two farthings make a half-penny, two half-pennies make a penny, twelve pence make a shilling, twenty shillings make a pound).

17. Learning

Devise a procedure to show that MIDAC can be taught to "learn". For example, given an initial random behavior, can you instruct the machine to favor "approved" behavior patterns over "disapproved"? (Reference, Oettinger, "Philosophical Magazine", 1952).

18. Morse Coding

Write a program that will accept standard English and print out the Morse Code (dot-dash) equivalent.

19. Musical Transposition

Devise a program that will transpose any tune from one key to any other specified key.

20. Betting Odds

Devise a program that will continuously change the odds on a set of horses as money is bet on each in turn.

21. Limited Conversation

Devise a program that will make MIDAC perform what appears to be a reasonably lucid conversation about one particular subject (for example, the weather).

[So far no student has tried problem 21, which is a difficult problem indeed (an obvious challenge to approximate A. M. Turing's definition of a machine's "thinking"), but that problem has caused numerous comments and discussion among members of the class. Several tentative schemes have already been proposed.]

22. Telephone Exchange Simulation

Devise a program in which MIDAC simulates an automatic telephone exchange, giving "busy" signals, etc.

23. Proportional Representation Balloting

The Proportional Representation (Hare-Spence) System is used in campus balloting for the Student Legislature. Devise a program on MIDAC that will count the ballots according to the rules of this election procedure.

24. Pseudo-Random Bridge Hands

Using the pseudo-random number routine of problem 7 (or a similar one in the MIDAC Subroutine Library), devise a routine to print out pseudo-random sequences of bridge hands.

25. Bridge Playing

Program the MIDAC to play a rudimentary game of bridge, e.g., follow suit, trump, not renege, "third in hand play as high as can", etc.

26. Intelligence Test Learning

Devise a program demonstrating the ability of MIDAC to "learn" in the following fashion: Give MIDAC a true-false "intelligence" test (with responses at random), and insert a "grade" into the machine. Repeat the test and insert a second "grade", etc. Instruct the machine so that it will "learn" the correct set of answers.

Midac

MIDAC is a serial, binary machine with a three-address instruction code and a basic 45-bit word. Primary storage consists of 512 words of acoustic-delay-line storage. Secondary storage consists of 6,144 words of serial-access magnetic drum space. Input-output is completely alphanumeric via photo-electric tape reader and Flexowriter electric typewriter. An automatic overflow device similar to that on the UNIVAC transfers control automatically to a specific location (000). Subroutines may be stored on the drum in a "present-address relative" form that allows direct call-in to primary storage for subroutine variables. Input-output is through the MAGIC (Michigan Automatic General Integrated Computation) system, with floating addresses and complete input translation.

A second computational system, the EASIAC, operating at 30 operations per second as compared to MIDAC'S average 800 operations per second, may be used for easy instruction programming.

References

(1) Bowden, V. B., Faster Than Thought, Pitman, 1953.

(2) Booth, A. D. and Booth, C., Automatic Digital Calculators, Butterworth, 1952.

(3) Burks, C. W., Herman Goldstine, and John von Neumann, "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument", Army Ordnance Corps.

- END -

Recognizing Spoken Sounds by Means of a Computer

Andrew D. Booth
Birkbeck College, London, England

During the past decade, engineers working in the communications industry have devoted much attention to the possibility of devising circuits which will "recognise" the sounds emitted by human beings in the process of telephone conversation. The ultimate object of this particular type of study lies in the possibility of restricting the necessary band-width for intelligible transmission of speech and also, to a less extent, of rendering the transmission less susceptible to noise pick-up.

Much of the work which has been carried out has made use of sound-spectra, that is, analyses of the frequency patterns which are produced in typical words. Equipment has necessarily demonstrated that some half dozen frequencies indicate by their occurrence and strength the nature of the spoken word. Conversely, the pattern thus produced has been used to regenerate the speech at a later stage.

In considering the problems of input to a mechanical translator, I have been led to consider the applicability of some of these systems, and as a result to conclude that they were too complicated and too liable to error for serious use. This, in turn, suggested a process which is analogous with the standard character disc method of printed symbol recognition[1]. This process will now be described.

In the first place it is necessary to consider the process in two parts: the analysis of a standard set of sounds; the comparison of an unknown sound with the results of the analyses.

To eliminate the effects of dialect and individual pronunciation the person who is to use the equipment at a given time first records the words to be recognised and allows the machine to submit these records to analysis. At a later time the same speaker may repeat some or all of the recorded words and the machine, by essentially arithmetical processes, proceeds to recognise them. The method of accomplishing this result will now be described.

The first part of the process of analysis consists in generating a voltage waveform from the output of a microphone. This involves only the use of standard amplifying equipment. A typical portion of a voltage output is shown in Figure 1.

It is evident that much of the detail in a given sound will be carried by relatively high frequency harmonics of the type shown at H. The fundamental frequency F F, on the other hand, is mainly a function of the chest and mouth resonances of the speaker.

To give due weight to the higher harmonics the voltage output is applied to a filter circuit of the differentiating type[2] and the result will then resemble that shown in Figure 2.

Although the effect of the higher harmonics is now more strongly marked, the output is still not quite satisfactory for the present purpose. It is therefore passed through an amplitude standardising circuit[3] and appears finally in the form given in Figure 3.

The analysis is then made in the following manner: First, the amplitude standardised output is applied to a binary counter. The contents of this counter are then sampled at successive time intervals during the occurrence of the sound. The sample numbers, which represent the number of axis crossings of the waveform of Figure 3 in the respective sample intervals, are sent to the storage of the computing machine with which the recognition equipment is to be used. We shall call these sample numbers S_{ij}, $(i = 1, \ldots, n)$, $(j = 1, \ldots, w)$ where i is an index representing the number of the sample for a particular spoken word j. Thus, when all the words which are to be recognised have been examined, the store of the computer will contain all of the numbers S_{ij}.

In practice it turns out that about 5 samples each containing 4 bits are sufficient to characterise the spoken words zero, one, two, up to nine. It proves convenient to store these in the first part of a standard computer word. The remainder of the word can then contain those digits which are needed to give the binary or other coded equivalent of the spoken word.

To use the machine for recognition of an unknown word, it is merely necessary to perform the analysis described above on the unknown word. This results in the generation of a set of numbers: u_i, $i = 1, \ldots, n$
By purely arithmetic means the machine now forms:

$$M_j = \sum_{i=1}^{n} |(u_i - S_{ij})| \ , \quad j = 1, \ldots, w$$

for each of the samples S. The unknown character is then taken to be that for which M_j is a minimum.

(continued on page 31)

THE SIGNIFICANCE OF THE NEW COMPUTER NORC

Part I

W. J. Eckert
Watson Scientific Computing Laboratory, New York, N. Y.

(Part I is a report based on notes taken by E. C. Berkeley, as Dr. Eckert spoke to members of the press on November 30, 1954, at the Annex of the Watson Scientific Computing Laboratory.)

Large automatic digital computers have been in existence for about ten years. During that time their speed, reliability, and capacity have been multiplied by a factor of 20,000 or 30,000. NORC, the computer that we are demonstrating today, represents a jump of about 20 in the factor. For the largest scientific problems this machine is about 20 times faster than the best previous computer. This is the main significance of NORC.

During the past five years, our ideas of the nature of an electronic general-purpose calculator have become fairly definite. A general-purpose calculator should solve almost any type of numerical problem presented to it. An example of a large, fast computer of this type is the IBM 701. There are about twenty of them now in operation in science and in industry. In designing the NORC, we were interested in a computer that would be most effective on those problems beyond the reach of the fastest existing machines, in particular, problems that would take months or years on the 701.

For these problems an unusual premium is placed on speed, capacity, convenience, and reliability.

Speed

The productive speed of a calculator depends upon the speed of all of its components. For its input and output, the NORC has achieved a new record of speed -- reading and recording on magnetic tapes at the rate of 70,000 characters a second. The NORC multiplies two 13-digit numbers in 31 microseconds. It performs 15,000 complete arithmetical operations in a second; a complete operation includes finding the instruction and operands in the storage, checking the operation, and storing the result.

Capacity

The NORC has the capacity to accept problems involving a large amount of data and long sets of instructions. It handles numbers in the form of sets of 16 decimal digits — 13 decimal digits for the number, one digit for the algebraic sign, and two digits for the location of the decimal point (in a range from +30 to -30). We need this number of digits and this range of decimal point because in all mathematics, especially when the amount of calculation becomes voluminous, there is attrition of numbers. In order to obtain two or three significant digits at the end of a computation, you often need to have thirteen decimal digits at the beginning.

Another aspect of the capacity of the NORC consists of the magnetic tapes. On each tape there are four channels, and since 510 binary digits can be placed on a length of one inch, we can pack 510 characters in an inch of tape. Eight tape units are associated with the NORC, and each unit contains 1200 feet of tape. Information can be read from or recorded on a tape in 0.01 second.

Convenience

In regard to convenience, we have in mind mainly the convenience for the mathematician who is using the machine and should not be bothered by machine peculiarities. The more complicated the problem, the less the mathematician should be required to worry about the details of giving information to the machine. Therefore, the NORC is decimal, and it automatically takes care of the number of decimals, either on the basis of a floating point or a specified number of decimals. The commands that are used for the control of the NORC are very simple. Since recordings on magnetic tape constitute the language that the NORC likes and punched cards constitute the language that people like, the installation of NORC has a separate machine to translate punched card language onto magnetic tapes and magnetic tape language into punched cards.

Another aspect of the convenience of the NORC is that, because the tapes are very fast, there is no intermediate storage. Electrostatic storage applies for fast "memory" and magnetic tapes apply for both intermediate and slow "memory". The property of being able to satisfy the requirements for a large intermediate storage, which most problems impose, by means of magnetic tapes is a material advantage.

Reliability

Reliability, of course, in a machine of the type of NORC is of the utmost importance. Great efforts have been made in the development of this machine to secure a type of reliability that we have not had in the past. As a result of the engineering that has been applied to the NORC, we expect a billion operations between errors. In order to achieve this high degree of accuracy, as few kinds of equipment as possible have been put into the machine, and the circuits have been engineered with extreme care. The major part of the machine includes only a few types of plug-in units. One-half of all of the circuitry in the calculator consists of only six types of pluggable units. Prevention of trouble is achieved by carefully scheduled maintenance operations. Automatic checking has been built into the machine.

Features

Unusual engineering features of the NORC include: the ultra-high-speed tapes, improved electronic circuits; the logical organization; the small number of different types of plug-in units; and special equipment for dynamic testing of these units away from the calculator. The mathine does not use the conventional "flip-flop" so widely used in previous calculators. Instead, a new type of "dynamic pulse circuit" is the basic element in the machine. These circuits, in which no pulse lives longer than a millionth of a second, have introduced a new order of reliability.

Problems

The problems that have been put on the machine for shake-down, or testing, purposes have been two Navy problems and one Columbia University problem. The first Navy problem is a problem in what is called "cavitation". When a missile enters the water, it is surrounded by a cavity or envelope of froth and vacuum. (see Figures 1 and 2). If the cavity is so big that fin and rudder surfaces do not touch the water, control of the missile is impaired or lost; if the cavity is small enough so that these steering surfaces do engage the water, control is maintained. The mathematical theory of this problem is well known, but it has not been practical to compute it with any previous computer.

The second problem that is being tried out on the NORC is a problem of impact under supersonic conditions for different shapes of a missile. One calculation for this problem that required several hundred hours on an earlier large electronic computer was completed on the NORC in forty-two minutes.

The third problem, proposed by Columbia physicists, involves a study of atoms and molecules and their description by a single fundamental theory. It involves the solution of Schrödinger's equation; the calculations for a single simple case require a billion arithmetical operations. The solution for the first few cases should lead to material knowledge that will be of assistance to scientists everywhere, and should indicate the extent to which it is possible to apply these numerical methods to the more complicated and difficult cases.

Since this machine is capable of solving problems beyond the capacity of previous calculators, it can make its greatest contribution to science by being used primarily for those problems just within its reach.

The NORC was assembled at the Annex of the Watson Scientific Computing Laboratory at 612 West 115 Street, New York, and the trial operations are taking place there. It was designed and built as a research and development project by IBM for the Naval Bureau of Ordnance.

The calculator will be moved to the Naval Proving Ground, Dahlgren, Virginia, about March 1. It is understood that the Bureau of Ordnance of the U. S. Navy will make the machine available to other agencies for the solution of suitable problems.

Part II

STATISTICS

(Part II is a report based on other information learned.)

Tapes

Number of tape units	8
Density of polarized spots	510 per inch of length of tape
Number of channels	4 across the tape
Number of characters	510 per inch of length of tape
Speed of tape	140 inches a second
Information rate	70,000 characters a second
Starting and stopping time for the tape	8 thousandths of a second

Electrostatic Memory

Number of words	2000
Access time	8 microseconds

Arithmetic

Number system	Decimal
Size of words	13 decimal digits, algebraic sign, 2 decimal digits for location of decimal point, and check digits.
Decimal point procedure	automatic floating decimal point, or specified location of point
Multiplication time	31 millionths of a second
Addition time	15 millionths of a second
Complete operations including floating decimal point procedure and address modification	15,000 a second

Printing, Etc.

Number of printers	2
Speed	300 characters a second

Calculation continues during printing, and the speed of calculation is reduced less than 3% while the printers are in operation.

Instruction system	3 address
Mode of operation	Parallel operation per four binary digits corresponding to one decimal digit, serial operation per decimal digit
Main types of plug-in circuits constituting half the machine	Six: one pulse delay line (two types); driver; inverter or logical "NOT" circuit; logical "AND" circuit; logical "OR" circuit
Cost	2½ million dollars
Contract	A research and development project under a contract between the Navy and IBM

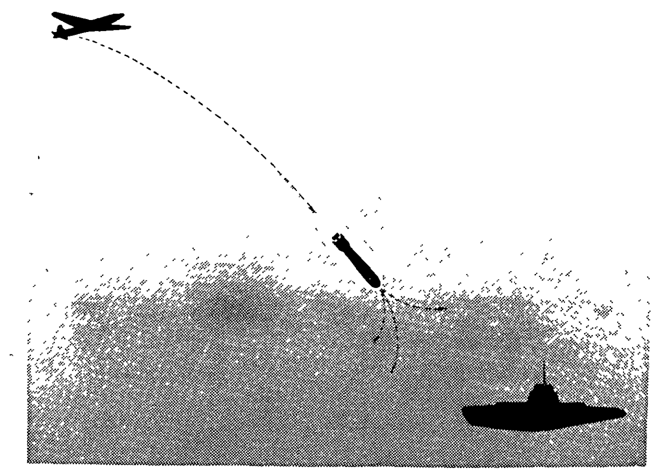

Figure 1. One ordnance research problem too lengthy on previous computers is the "cavitation" problem, which can be solved by the NORC (Naval Ordnance Research Calculator) within practicable time limits. This involves determining the size and shape of the cavity or envelope of comparatively empty space that forms around an object moving through water. Billions of computations are required. In the case of the missile shown in this simplified diagram, its size, shape, speed and other factors are such that control is lost because steering surfaces do not touch the water owing to the cavity's excessive size.

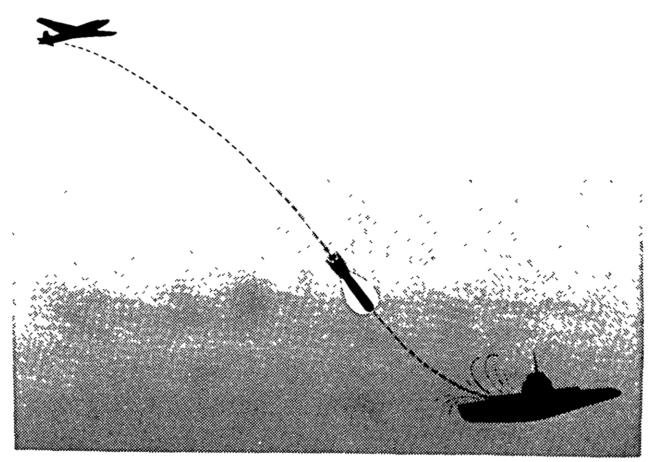

Figure 2. In this illustration of the "cavitation" problem the missile produces a smaller cavity. Here, fin and rudder surfaces engage the water, insuring a more accurate course to the target.

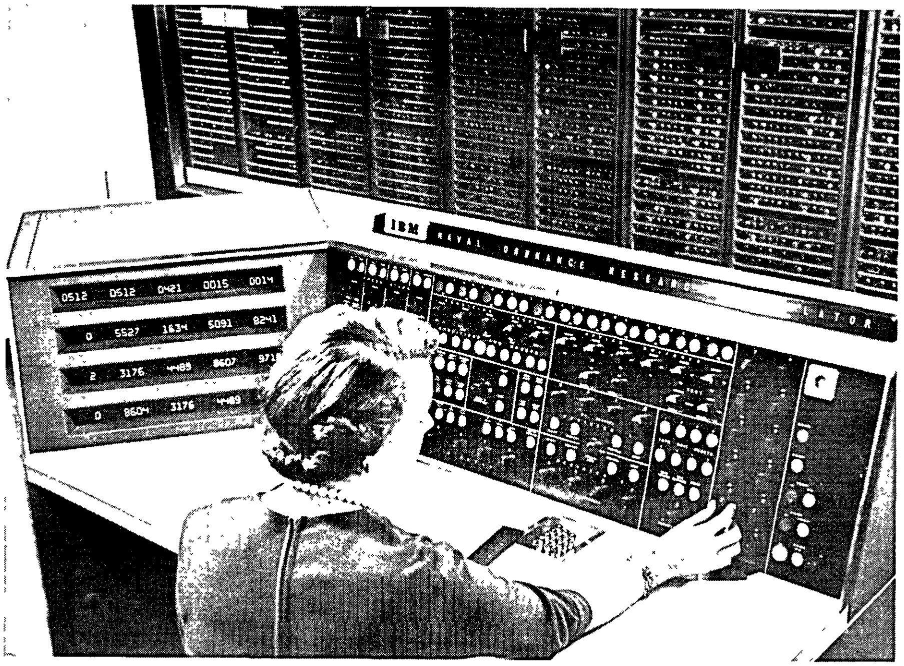

Figure 3. The control console of the NORC. Switches can be used to start and stop the machine and to modify the written program. In normal operation, however, the calculator proceeds automatically according to instructions, recorded on magnetic tape, without control by the operator. Any number or instruction in the calculator can be shown on the faces of the monitor cathode ray tubes, at left. Selected portions of the program can also be examined in slow motion through this display.

Figure 4. Logical and arithmetical section of NORC, consisting of plug-in units containing vacuum tubes, resistors, condensers, and crystal diodes.

- END -

THE FINAN — SEER

E. L. Locke

(Reprinted with permission from 'Astounding Science Fiction', October, 1949, vol. 44, no. 2.— Although this story is more than five years old, it might have been written only yesterday. — Editor)

The speaker went on. And on. And on. "... I want to remind you that I am the only real business man among you. I am the only one here that ever met a payroll and so I know just how to handle this situation. Now when I was running my butcher shop in Carteret, New Jersey, I found ways and means to keep my business solvent. I tell you it was a tough job because it was a credit store and you should have seen how many of my customers were deadbeats. I --"

A quiet but sarcastic voice cut in, "I don't doubt that the Professor of Meat Cutting was able to devise ways and means. After all, I understand the high incidence of corpulence among butchers is not entirely accidental. Large stomachs have their uses in the weighing process."

A beet-red color suffused the face of the first speaker and strangling sounds came out of his throat. Before he could collect himself to retort, a silver-haired, dignified-looking man got up from the head of the conference table and said: "Gentlemen, let us stop this bickering. Your remarks, Professor Bronson, were uncalled for, and I think you owe Professor Schultz an apology. On the other hand, I am afraid that Professor Schultz's business experience is not precisely the type that will extricate Trent University from its troubles. Let us review the problem briefly and see if this time we can get some constructive suggestions.

"The roots of our problem extend back several years. Our endowment fund at that time was invested entirely in government and utility bonds. The steady decline in interest rates forced our trustees to seek higher yields. Since a number of them belong to ... ah ... the financial fraternity, they convinced the other trustees that the thing to do was to invest in common stocks."

At this point he was interrupted by the physicist, Professor Andrew James. He was an unusually young man to hold a full professorship, being still in his middle thirties. He held the newly created chair of Applied Physics in tribute to his abilities as an idea man who had established a solid reputation in industrial work. He asked: "What was wrong with that, Dean Fairbanks?"

"Why nothing, Professor James, as a matter of principle. The income was raised quite appreciably--for a time, that is. Then we were hit by what appeared to be a minor recession, and then the trouble started."

Professor James interrupted again: "I thought these Wall-Streeters knew all the ins and outs. Why didn't they sell short?"

"The answer to that is that their statisticians told them that a turn was coming and so they hung on. As a matter of fact, our Department of Economics was consulted. I understand that they arrived at the same conclusion after applying the best mathematical techniques. Why, I believe that they analyzed the past performance of the market by applying the theory of Fourier Series, and then extrapolated the result." He added wryly: "The results were rather unfortunate.

"Then, in desperation, the trustees started to ... er ... switch, I believe they called it. However, their steps were dogged by misfortune. Recently I was informed that unless the university can recoup its losses, we shall be forced to curtail our operations. I therefore called this meeting of the faculty to see if there were any ideas for extricating our university from its financial morass." Then he added with a wan smile on his face, "After all, gentlemen, college professors are popularly believed to be profound thinkers. Let us at least make an attempt to validate that belief."

Professor James spoke up again: "Suppose that we do come up with a solution. What guarantees have we that the trustees will not reject our solution as the impractical dreamings of 'long hairs'?"

The dean looked thoughtful for a moment before replying: "I do not want to trespass in the domain of our colleagues in the Department of Applied Psychology, but it did appear to me that our trustees are in such a desperate position that they will clutch at any solution. Then he smiled a bit and continued, "I can just see the headlines in our sensational press. 'BROKERS BREAK COLLEGE.' You can imagine what that would do to the fast vanishing reputation of financiers for astuteness."

A mild-looking man of slight build, apparently in his fifties, spoke up rather hesitantly, "I must say that I am disappointed that my friends in Economics thought that

Fourier Series were appropriate to this sort of problem. I had the impression that Economics was not an exact science and that the mathematical techniques used were rudimentary, but it does shock me a bit that they were that naive."

The mathematician had addressed his remarks to Professor Johnsrud of Economics. The latter was a large man who secretly cherished a slightly physical resemblance to the late J. P. Morgan. He had often felt that the resemblance was more than one of appearance. Given a slightly different set of circumstances, he often reflected, he could have matched Morgan's financial achievements. Thus, though he was a man of undoubted ability, he tended to overestimate it and was quick to resent any apparent slights. Accordingly, he jumped to his feet and spoke with considerable asperity: "Newcomb, I believe that someone, a mathematician no doubt, once claimed that God must have been a mathematician. You mathematicians have never forgotten that. Let me remind you that the converse of that proposition is not true. It is easy to be wise after the event. What would you have had us use?"

"My dear Johnsrud, I did not intend to hurt your feelings. It does seem to me that you might at least have used the Theory of Stationary Time Series. In the last war the theory was well developed in connection with the problem of predicting the future position of enemy aircraft, when the data on its present position was distorted by extraneous disturbances."

Johnsrud was still sulking when he asked: "And how far ahead were they able to predict with this wonderful mathematical tool?"

"Oh, about two seconds, if my memory serves me correctly."

Johnsrud smiled in a superior manner, slowly swept his glance around the conference table and merely said: "I thought so."

"That does not invalidate the principle of the thing. I want to add that since then we have acquired an even more potent attack on just such problems. I am referring to the book by Morgenstern and von Neuman, 'Theory of Games and Economic Behavior.' It seems to me that we should exploit the possibilities of this viewpoint."

Professor James spoke up: "The last part of the title seems as though the material may be apposite. Can you tell us a little something about it, Professor Newcomb?"

"I am afraid that anything I can say at the moment would not convey an adequate impression of the depth and scope of the method. Briefly, in most games and, of course, in all business deals, the opponents have incomplete information. For the sake of simplicity let us say that there are only two players. Player A has a number of courses of action open to him at any given stage. For any specific course he knows that his opponent B has the choice of a number of replies. A then calculates what his chances are for any one of the possible replies B can make. A then assumes another of his possible courses of action and again calculates his chances for all possible replies B can make, et cetera. Of course, B is assumed to be doing exactly the same thing. Each player can, on the basis of his calculations, use the strategy that makes his probability of winning a maximum. Is that clear, Professor James?"

"Not exactly. Can you give a simple example?"

"Yes, I believe I can, if I may have the use of the blackboard. This example was devised at Princeton precisely for the purpose of providing a simple illustration of the principles involved. Assume that each of two players has a red ace and a black ace: A also has a black deuce and B a red deuce. The players match cards for color. The rules are that if the chosen cards have the same color B pays A and vice versa, except that, if both cards are deuces, it is a draw, and if both cards are aces, payment is one unit; with ace against deuces, two units. The scheme of payments is shown in the table I am now putting on the blackboard."

		Black ace	Red ace	Red deuce (B)
	Black ace	1	-1	-2
(A)	Red ace	-1	1	1
	Black deuce	2	-1	0

"For instance, if A plays his black ace and B does likewise, A wins a point; if on the other hand B should play his red ace or his red deuce, A pays B one or two points, respectively. Suppose that this game goes on for a long time, what do you think the strategies of the respective players will be, Professor James?"

"I would say offhand that the play should be at random, since the table indicates that this is a perfectly fair game."

"You are mistaken, Professor James. This is a crooked game, despite appearances. With the best strategy B can devise, assuming that A does likewise, B will lose a fifth of a point per game in the long run. A's best strategy is to play his red ace three fifths of the time, and his black ace not at all. On the other hand B should play his black ace two fifths of the time and not play his red deuce at all. Of course, the real problem is how to find these fractions."

He turned toward James whose face wore a puzzled look, and continued: "Maybe it would be better if I showed you how it works out for the random play you suggested. Suppose A thinks his best strategy is to play each of his cards one third of the time. Suppose he guesses that B will play the black ace. If A plays the black ace, he will win one third of a point. If he plays the red ace, he loses one third. Finally if he should play his black deuce, he wins two thirds of a point. Thus on the assumption that B plays the black ace, A's long run expectation is a win of two thirds of a point per game. But remember, B may not be playing at random. If B should play his red ace, the same type of calculation shows that A's expectation is now a loss of one third of a point. Similarly if B plays the red deuce, A again stands to lose one third of a point. Now A has the right to assume that B will try to play as intelligently as he possibly can. It follows then that if A plays at random and B plays intelligently, A can expect to lose one third of a point on the average. What A has to do is to figure out his line of play so that the smallest of his expectations, no matter what B does, is made as large as possible. It turns out that the best strategy for A is that which I first mentioned, namely zero, three fifths, and two fifths. Of course B can do a similar calculation but he finds to his sorrow that his best strategy, namely, two fifths, three fifths and zero still loses one fifth of a point per game."

Johnsrud had listened carefully but nevertheless managed to sound bored as he spoke up: "This is all very interesting, no doubt, but how is this to help us? Did you have in mind that the university should send us to participate in floating crap games?"

Newcomb smiled and said: "You know, that never occurred to me. Maybe it isn't such a bad idea. What I had in mind was that you could figure out a way to apply this to operating in the stock market. You know the various factors that enter into stock movements, and I thought you could list these factors and make up the required matrix." Then he added rather plaintively, "At least I assumed that you could do it."

Johnsrud rose to the bait and snapped out: "Certainly I can do it. But it seems to me that you can not make a big killing in the market with this scheme, and that is exactly what we need to do."

Professor James cut in at this point: "Are you quite sure that that is a necessary assumption? It seems to me that our real trouble is that the loss in dividends has cut into our income. Therefore, I think that all we need to accomplish is to win an amount which is equivalent to the normal yield of the stocks."

"Well, perhaps you are right, Professor James. I shall get to work at once and setup the matrix. Why I can think of dozens of factors right now that would go into it and I don't doubt that when I buckle down to work I may find as many as several hundred." Then his face did a double take. "Something just occurred to me. From the example you gave, it seems to me for a complicated problem a lot of computing will be necessary. Who will do this work, Newcomb, and how long will it take to solve for the best strategy?"

"I must confess that I had not given that phase any thought. I assumed that the two computrices we have in our Statistical Laboratory could do it on their Monroes. As to the time required, let me think. If the matrix is M x N, there is an M+N fold infinity of combinations to be tried, but, of course, we have to worry only about our end. That reduces to an M-fold infinity which should help a lot. Then I have in mind certain theorems which would permit us to converge on a solution. All in all, I should say it would take several years of computation."

The answer left Johnsrud thoroughly exasperated and his tone showed it. "You propose a scheme that will take several years to evaluate the strategy for a single day's operation. It is now my turn to say that while I knew that mathematicians were naive, I did not think that they were that naive."

Professor James stepped in again at this point: "Really, gentlemen, there is no need for recrimination. I believe there is a way out of this. As I see it, you, Professor Johnsrud, agree that the idea is basically sound and the only problem is to get the computation done quickly. Why not make use of the electronic calculator our department is working on? I believe it is now being debugged and should be ready for use soon."

"I must admit," said Newcomb, "that the use of a machine had not occurred to me. I don't believe in them, you know, at least not for mathematics. However, in the case of necessity, such as now existing, I should remain open minded."

Dean Fairbanks had been following the argument with intentness. When he saw that three of the best men were in essential agreement, he thought that the matter had better be acted on at once. So he rose to his feet and said: "Gentlemen, it begins to look as if a possible solution has been uncovered. I suggest therefore, that Professors Johnsrud, Newcomb, and James constitute themselves a committee to act on this proposal. Let me know when you have worked out a modus operandi, and I shall take up the matter with the trustees. As I intimated before, there shouldn't be any difficulty on this score. Now unless someone else has a comment to make, I shall adjourn the meeting."

Excerpt from Shell's column in the New York Tabloid, November 2nd:

"This scribe has heard that a certain university, not so far from here, is in financial difficulties, the trustees having lost the university's shirt in the stock market. It is now rumored that the long hairs have taken matters into their own hands. They have cooked up a scheme to play the market with the aid of a mechanical brain. The wolves of Wall Street are said to be licking their chops in anticipation. Will someone kindly have a barrel ready for our long-haired friends?"

Excerpt from Shell's column in the New York Tabloid, February 17th:

"It was this scribe who first tipped you off that a certain university was going to try its luck in the stock market with a mechanical brain. The brain, which has been named "ANDROID" -- to you lugs, A Numerical Dopester Robot; Operations Investigated and Developed -- is apparently a lot smarter than the Street credited it with being. Your scribe has heard that it has been taking the Market to the cleaners to the tune of two hundred Gs a day. Save that barrel, the wolves may need it."

Professors Johnsrud, Newcomb and James marched into Dean Fairbanks' office. He waved them to chairs and after they had settled themselves, said: "I called you together so that we could review our recent operations in the stock market. It is almost time for my report to the trustees, and I wish to be well armed with facts."

Professor Johnsrud glanced at his colleagues and interpreted their silence as an invitation to act as spokesman. He cleared his throat and said: "If you had asked that question yesterday, I would have said that our operations are completely successful. Today, I am not quite so sure."

The dean's raised eyebrows prompted him to continue. "You see, Fairbanks, since the machine operates on a probability basis, a plot of our operations against time is not a smooth curve. We have a winning run, followed by a losing one and so forth. Of course, the integrated effect of our operations is easily known. All that we need to do is look at our running profit and loss account. This shows that our average daily proft has been about twenty thousand dollars a day."

The dean interjected, "I was aware that you have done very well. In fact our financial embarrassment is a thing of the past. Just why are you worred, Johnsrud?"

"I am not really worried. It is Newcomb who thinks that we are in trouble. Perhaps he had better tell you about it."

"You may remember that, when we first considered our financial difficulties, I pointed out the existence of a mathematical technique known as the 'Theory of Stationary Time Series.' I mentioned that it was used as a means of predicting the mean trend of a fluctuating phenomena. Out of curiosity, I applied this theory to the data of our day to day operations. I calculated the auto-correlation function and if I interpret it correctly, our mean trend has reversed. On the basis of this I think we shall lose a considerable sum unless we act at once."

The dean turned to Johnsrud. "I take it that you are not in full agreement with Newcomb's views?"

"That is right. There may be something in what he says. I would not care to reject his findings outright. If there is one thing that my years of experience with economic phenomena have taught me, it is to look out for the unexpected. However, I find it difficult to share Newcomb's pessimism because, after all, just look at our comfortable bank balance. Besides, I'm sure my matrix takes every important factor into account. I therefore suggest that we let matters go on for the present and see if this trend really shows up."

The dean turned to James. "Do you have any definite views on this matter?"

"No, I can't say that I have. I have no physical intuitions concerning it. While I have a lot of respect for mathematics, I still have a vague distrust for statistical methods, except of course, in Quantum Mechanics."

"In that case," said the dean, "suppose we wait and see. Good day, gentlemen."

Excerpt from Shell's column in the New York Tabloid April 1st:

"News has reached this scribe's ears that the battle of wits has turned against Android. The super-brain has been taking a shellacking from the wolves. Does anyone here want to buy a certain university cheap?"

It was late in June and the campus seemed deserted except for a pair of men walking slowly, engaged in conversation.

"Whatever gave you the idea, James, to do what you did? If I may say so, it was a masterpiece of reasoning."

"Thanks, Newcomb, but I really can't claim that it was pure reason. Actually it was something in my subconscious that put the factors together. Are you familiar with Heisenberg's Uncertainty Principle?"

The older man nodded. "Yes, but what does that have to do with it?"

"Just this. Your use of the Stationary Time Series theory predicted that we were going to lose our shirts. Later events amply justified your predictions. I was mulling over our troubles and was getting nowhere in finding a solution. Just to relax and turn my mind into other channels, I picked up a text on Quantum Physics and started reading. I happened to open to the chapter on the Uncertainty Principle. There was a description of that old problem, the determination of the position and velocity of an electron, using a radiation probe. You know the answer to that one. The radiation reacts with the electron and gives it a kick."

"I think I see. You mean that our machine was perturbing the market?"

"Exactly. I then searched through our matrix and found that we did not include a factor for the perturbing effect. Since we felt that our operations were on a relatively modest scale, it did not occur to any of us that such a factor should be included. However, the newspaper publicity exaggerated the effectiveness of our machine. I believe Shell, the news columnist, claimed our winnings to be two hundred thousand dollars a day. Actually it was about a tenth of that amount. As a result, professional market operators formed pools more frequently than normal, and this had the effect of introducing new factors for which we had made no allowance.

"The answer was obvious. All I had to do was to punch into the memory a set of instructions that the matrix should be modified by the machine itself, so as to make the predicted auto-correlation function positive. However, to make the machine's job easier, I included a new row and column in the matrix to take care of the Shell effect. And that is all there was to it."

"That may be, James. I still feel that it was a great idea. Our troubles are over now."

"Yes, and now that we are on sound financial ground, we should pull out of the market rather soon. We shall have to do it in any case, within say six months. I suppose you have heard what is happening?"

"No, I don't think so."

James chuckled a bit and said: "It is a perfectly natural thing. We have built a better mousetrap and the rest of the world is copying our design. Several groups of operators have placed orders for their own electronic calculators. When these are delivered, we shall no longer have an advantage. If we should still be in need of money, maybe we shall have to take up Johnsrud's suggestion and play the floating crap games." He paused a moment and added in great good humor, "An idea just came to me. How would you like me to fix you up with a miniature transceiver, disguised as a hearing aid? We could send you to participate in those floaters. The players' bets would be picked up by the vest microphone and the machine would feed you the betting odds through the earpiece. Just think what a wonderful setup it would be! No? Well, I suppose not. To change the subject slightly, there is something that still bothers me. You remember that three-card game you used as an illustration?"

"Yes. What about it?"

"Just why is that a crooked game?"

- END -

BULK SUBSCRIPTION RATES

These rates apply to subscriptions coming in together direct to the publisher. For example, if 5 subscriptions come in together, the saving on each one-year subscription will be 25 percent, and on each two-year subscription will be 33 percent. The bulk subscription rates, depending on the number of simultaneous subscriptions received, are shown below:

Table 1 — Bulk Subscription Rates
(United States)

Number of Simultaneous Subscriptions	Rate for Each Subscription, and Resulting Saving to Subscriber: One Year	Two Year
10 or more	\$3.00, 33%	\$5.40, 40%
5 to 9	3.33, 25	6.00, 33
4	3.75, 17	7.00, 22
3	4.00, 11	7.50, 17
2	4.25, 5	8.00, 11

For Canada, add 50 cents for each year; outside of the United States and Canada, add \$1.00 for each year.

Approaching Automation in a Casualty Insurance Company

Carl O. Orkild, Manager
Methods Research Department, Continental Casualty Company, Chicago, Ill.

The Continental Casualty Company is currently making a study of electronic data processing systems as a possible means to further mechanize office routines in the company's home office located in Chicago.

The Continental Casualty Company and its subsidiary, the Transportation Insurance Company, for the year ending December 31, 1953, earned premiums totaling about $137 million, and incurred losses and claim expenses totaling about $80 million and underwriting expenses totaling about $48 million. Earned premiums would correspond to net billings for a manufacturing company. The losses and claim expenses incurred would be equivalent, in a rough sense, to the cost of materials. The underwriting expenses would correspond to the manufacturing, overhead, and distribution costs for such a company.

Flexible Length of Records

The feature of flexible length of records which an electronic data processing system provides was of particular interest to the company when the approach to such a system began. It offered the hope of a greater standardization of procedures than was previously possible with the 80 column punch card. The problem lies essentially in the fact that the company's premium income is literally made up of a million here and a million there, each requiring its own unique data processing routines. When handled by punched cards, the procedures are complicated, limited, and relatively inflexible.

The company sells five basic categories of insurance: accident and health, casualty, fidelity and surety, fire, and reinsurance. Accident and health is further broken down into ten sales divisions; casualty, to six; and so the company has 19 sales divisions in all. Each division is organized, with certain variations, into four types of activities; Agency (sales); Underwriting (review of risks for acceptance or modification); Collection (billing and collection); and Claims (settlement of claim losses). In addition, there are centralized departments for accounting, mailing, advertising, etc., servicing the entire company.

The Magnitude of Savings Possible

Any company considering an electronic data processing system must first estimate the magnitude of savings possible. In a casualty insurance company the potential savings fall into two major categories:

1. Replacing present clerical and punch card operations with an electronic data processing system, and in such case salaries and machine rentals would be the main items;

2. Controlling claim losses and related claim settlement expenses in proper relationship to premiums earned. With the prompt and more comprehensive information available with an electronic data processing system, it appears that a highly sensitive sales program would be possible.

To determine the magnitude of replacement possible in the area of salaries and machine rentals, department by department was reviewed. The departments were grouped into two categories: those directly affected and those not directly affected. The current total of salaries and machine rentals, $535,000 per month, was allocated $210,000 to those departments directly affected and $325,000 to those not directly affected. The purpose of the allocation was to compare the dollar total of the affected departments against the cost of an electronic system. As the system was developed, the affected $210,000 could then be allocated into what would be replaced and what would not be replaced.

If certain percentages as shown in Table 1 of the affected $210,000 could be replaced by an electronic system then the amounts shown in the second column could be applied against the cost of such a system. Using Table 1 and the stated rental costs of the various systems, it may be seen that a 2% saving would justify consideration of an IBM 650; 5%, an ElectroData computer; 12%, an IBM 702; and 17%, an IBM 705.

In sales, any estimate of the saving possible in this company would have to be based on judgment alone. But one fragment of information available, in 1953, was that if claim losses and related claim settlement expenses could have been reduced by only one tenth of one percent, a saving of approximately $6,500 per month could have been realized. To accomplish such a saving two types of forecasts would have to be prepared monthly immediately after the close of the accounting month.

Table 1

% of $210,000	Amount that could be applied against an electronic installation
2%	$ 4,200
5%	10,500
7%	14,700
10%	21,000
12%	25,200
15%	31,500
17%	35,700
20%	42,000

In insurance, the product is sold before the actual costs are known. With present reporting methods, a time lag of some months occurs before changes in claim loss experience become apparent. The first type of forecast made possible by improved and faster data processing would be early reports on policy form experience, giving an indication of the future relative profitableness of the various lines of insurance. Guided by this, the sales program of the company could be modified in time to avoid heavy losses. The second type of forecast rendered possible would be early reports on the company's agents evaluating their profitability to the company. Using an adverse report as an early warning of trouble, the agency department affected would be able to focus attention on a particular agent's problems, and either help him to solve them, or cancel his contract and mark his business for non-renewal. Under present procedures, an agent gets into trouble before it can be detected and the remedy applied, and thus the company will have suffered moderate to heavy losses.

Types of Equipment Considered

To develop an outline of an electronic system for the company, three levels of equipment were considered:

Level 1: The IBM 650, representing a system offering punch card input-output and internal storage using a magnetic drum of 2,000 ten digit words.

Level 2: The ElectroData 30-203, representing a system offering punch card input-output, magnetic tape input-output, and internal storage using a magnetic drum of 4,080 ten digit words.

Level 3: The IBM 705, representing a system offering punch card input-output, magnetic tape input-output, and internal storage of 20,000 decimal digits using magnetic cores.

Currently, six specific procedures, typical of various phases of the company's operations, are being programmed for each of these machines to determine the limitations of each machine. The six procedures selected represented: distribution; file maintenance; and computations using several base files.

1. The statistical reports of the Disability Division of Accident and Health. These involve the distribution of 125,000 entries per month into six reports; state, inforce, agent, city-county tax, policy form, and selected policy forms by year of birth.

2. The billing files of the Intermediate Division of Accident and Health. These involved the maintenance of a file containing name, address, and statistical coding for 280,000 policies. This file is the basis for billing accounts directly to policyholders, processing remittances as returned, putting through statistical entries, and paying agents their commission.

3. The collection routine for the General Group Division of Accident and Health. This consists of clerical operations which refer to several base files, manually prepare report forms, process reports as returned, distribute by formula the premium received, and compute the graded commission to be paid.

4. The operations of the Payroll Department. These consist of distribution, file maintenance, and computations using several base files.

5. The agent-broker statements for the Casualty agents. These involve distribution, file maintenance, and computations.

6. The statistical reports for the Cas-

ualty business. These require the distribution of 50,000 entries per month into four reports: state, in-force, agent, and city-county tax.

The Ultimate System

As the above work has progressed, an ultimate system has begun to be visioned. The diagram of Figure 1 displays a preliminary sketch of the system as applied to the Accident and Health operation. In Figure 1, each disk represents a magnetic tape unit; the center box represents the computer's main section. As the study progresses, there will be changes; the system as installed may of course vary considerably from that described below.

Input

1. Master Record. A set of 100 or more reels of tape containing unit records for each policyholder giving complete information that could be required for underwriting review, claim settlement, renewal billing, statistical-accounting reports, and actuarial studies.

2. Changes. New policyholders, lapses, changes in coverage, change of address, etc., including any changes to be brought into information carried in the master record.

3. Underwriting Lookups. Upon receipt of an application for insurance, the application would be checked to determine that it conforms to the procedure pattern and for entry of certain key codes. Then the applications would be abstracted on a standard form, spacing over information not yet available. The typed sheet would be attached to the application as record of entry to the system. The paper tape prepared by the typing operation would be converted to magnetic tape and put in order with all other underwriting lookups for the same day.

   In addition to new applications, the underwriting lookups would include calls for unit records on policyholders that have requested changes in existing policies or are under review.

   In the case of a new application, the underwriting lookups will require the computation of premium, the completion of coding, and, as output, the unit records for policies previously issued to the individual.

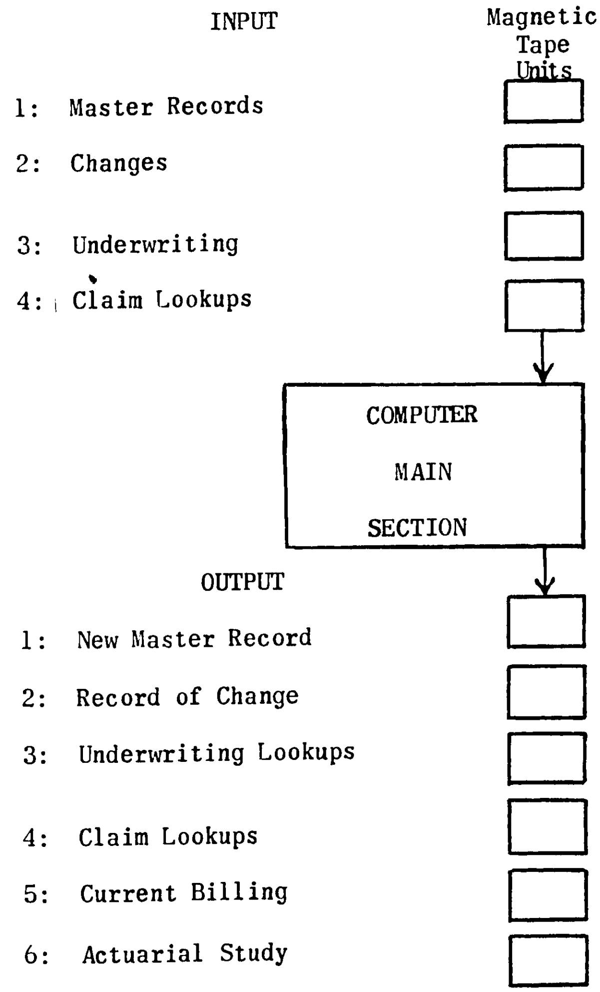

Figure 1

Sketch of application of the electronic data processing system to the Accident and Health Division.

4. Claim Lookups. Upon receipt of the notice of a new claim, a call would be typed for the unit record for the policyholder.

Output

1. New Master Record. The new master record, equal to the old master record modified by the information contained in the change tape.

2. Record of Change. The complete unit record for every record that was changed in any way. This tape would be used to prepare record of change slips to be attached to the application files.

3. Underwriting Lookups. The complete unit records for all previous policies for individuals with applications pending, a skeleton unit record for each application, and complete unit records for all policies under review are on this tape. The tape would be used to print out the unit records on a standard form and then would be merged with the previous "pending underwriting review" tape. The skeleton unit record for the application would be printed out in skeleton form on the standard unit record sheet. This sheet would be filled in and possibly modified during the underwriting review. Upon approval by the underwriting department of the application, this sheet would be used to abstract the modifications and fill-ins so that the unit record for the application can be completed. Through the use of the computer the approved application can be pulled from the "pending underwriting review" tape; this information would be combined with the modifications and fill-ins to form a complete unit record; and this could be added to the change tape and a "policy issue" tape prepared.

4. Claim Lookups. The complete unit record for every policy on which there is a new claim is recorded on this tape. The tape would be used to print out the unit records on a standard claim adjusting form for the claim adjuster's use and then would be merged with the previous "pending claim" tape.

   The standard claim adjusting form would be used by the adjuster to indicate any action he may deem necessary. This information would be abstracted from the above sheet for entry to the system. It would then be matched up with the unit record on the claim in the "pending claim" tape and the action requested would be carried out, such as, the preparation of a mailing sticker to send out forms to be completed by the claimant or the writing of a draft to reimburse the claimant for hospital bills, etc.

5. Current Billings. The information required to bill and to prepare the statistical-accounting reports is drawn from the master unit record and formed into a collection unit record.

   The tape would be used to prepare a "direct bill premium notice" tape. From this tape prepunched punch card premium notices can be prepared for those policyholders whose premium is collected directly from the Home Office; a "direct bill-due and uncollected" tape can be merged with the standing "due and uncollected" tape for the processing of the direct bill notices as returned; an "agency collect listing" tape can be made from which premium due listings can be prepared to be mailed to agents, employers, etc.; and finally an "agency collect-due and uncollected" tape can be made to process the reports as returned.

   As the direct bill notices are returned a conversion to magnetic tape would be made for processing against the standing "due and uncollected" tape. As the reports from agents, employers, etc., are received, each report would be handled as a unit abstracting the exceptions on each report which would then be converted to magnetic tape for processing against the "agency collect-due and uncollected" tape.

6. Actuarial Study. The requirements in this case would vary as requested by the Actuarial Department. In general, this tape would be used to draw off all information on a type of coverage or type of policyholder for study, analysis and report by the Actuarial Department.

As currently envisioned, the operation portrayed by the diagram would be put on the machine at night after the closing of the office so the results would be available at the opening of the office the following morning.

Next Steps

It is anticipated that as a result of programming these procedures, and evaluating the results, it should be possible to answer reasonably the questions:

What are the expected savings —large, medium, or small?

What should the system be?

What type of equipment should be used?

What should be the time schedule of installation?

What will be the cost of conversion?

What will be the effect on departmental organization?

- END -

ROSTER OF AUTOMATIC COMPUTERS

(Cumulative, information as of January 3, 1955)

The purpose of this list is to report automatic computers in existence (all that are known to us). Each entry, when complete, gives: name of computer (and interpretation of letters) / maker and place where made; if quantity is 1 or 2, place where computer is located / purpose of computer, nature of computer, approximate size or capacity of computer, and quantity of computer in existence. Some words like "Model" and "Type" have been omitted from names of computers; usually the initial letters of the company name have been substituted.

If only the name of the computer has been learned, a reference where the computer is mentioned or described is given.

In most cases the maker of the computer is the key to more information about the computer; the maker may be looked up in the "Roster of Organizations" which we publish (the last cumulative listing is in the November, 1954, issue of "Computers and Automation".)

Abbreviations: The key to the special abbreviations follows:

Purpose (p)
Gp General purpose
Sp Special purpose

Nature of Computer (c)
Dc Digital computer
Ac Analog computer
Ec Electronic computer
Rc Relay computer
Mc Mechanical computer

Size (s)
Ss Small size or low capacity
Ms Medium size or medium capacity
Ls Large size or large capacity

Quantity (q)
0q Zero (i.e., unfinished or dismantled)
1q One
2q Two
Sq Small quantity, about 2 to 6
Mq Medium quantity, about 7 to 30
Lq Large quantity, over 30
?q Unknown quantity

Some other abbreviations have been used which can be easily guessed, like those in a telephone book.

We plan to keep this list up to date from time to time, and we shall be very grateful for any information which any reader is able to send us.

LIST

ABC (Automatic Binary Computer) / Air Force Cambridge Research Center, Cambridge, Mass.; located there / Gp EDc Ms 1q
Abel -- same as the ONR Relay Computer, which see
Ace (Automatic Computing Engine -- pilot model) / National Physical Laboratory, Teddington, England; located there / Gp EDc Ms 1q
Ace (Automatic Computing Engine -- engineered model) / English Electric Co., Stafford, Eng / Gp EDc Ms ?q
Aeracom (Bureau of Aeronautics Analog Computer) / Aerial Measurements Laboratory, Northwestern Univ, Evanston, Ill; located there / Gp EAc Ls 1q
Alwac / Logistics Research Inc, Redondo Beach, Calif / Gp EDc Ms Sq
Amos (Automatic computer Ministry of Supply) -- a Ferranti computer; see Ferranti
Anacom (Analog Computer) / Westinghouse Electric Co, Pittsburgh; located there / Gp EAc Ls 1q
Analog Computer / Electronic Associates, Long Branch, N J / Gp EAc Ls ?q
Anser (Analog Simulator and Computer) 300-A / Davies Laboratories, Inc, Riverdale, Md / Sp EAc ?s 0q
Aperc (All Purpose Electronic (Rayon) Computer) Birkbeck College, Longon, Eng; located at British Rayon Research, Manchester, Eng / Gp EDc Ms 1q
Apexc (All Purpose Electronic X-ray Computer) / Birkbeck College, Univ of London, London, England; located there / Gp EDc Ms 1q
Arc (Automatic Relay Computer) / Birkbeck College, Univ of London, London, England; located there / Gp RDc Ms 1q
Arra (Automatische Relais Rekenmachine Amsterdam) / Mathematisch Centrum, Amsterdam, the Netherlands; located there / Gp EDc (not relay) Ls 1q
Ascc (Automatic Sequence Controlled Calculator) -- SEE: IBM Harvard Automatic Sequence Controlled Calculator, or Harvard Mark I
Avidac (Argonne Version Institute's Digital Automatic Computer) / Argonne Natl Lab, Chicago; located there / Gp EDc Ls 1q
Barber-Colman-Stibitz Computer / Barber-Colman Co., Rockford, Ill; located there / Gp EDc Ss 1q
Bark (Binary Automatic Relay "K"omputer) / Swedish Board for Computing Machines, Drottninggatan 95A, Stockholm, Sweden; located there / Gp RDc Ls 1q
Beac (Boeing Electronic Analog Computer) / Boeing Airplane Co, Seattle / Gp EAc Ms Mq
Bell Model V / Bell Telephone Labs, New York; located at Ballistic Research Laboratories, Aberdeen Proving Ground, Aberdeen, Md / Gp RDc Ls 2q
Bell Model VI / Bell Telephone Labs, Murray Hill, N J ; located there / Gp RDc Ms 1q
Bendix Digital Differential Analyzer D 12 / Bendix Computer Div, Bendix Aviation Corp, Los Angeles, Calif / Sp EDc Ms Sq
Bendix G-15A / Bendix Computer Div, Bendix Aviation Corp, Los Angeles, Calif / Gp EDc Ms Sq

Bendix G-15D / Bendix Computer Div, Bendix Aviation Corp, Los Angeles, Calif / Gp (digital differential analyzer) EDAc Ms Oq

Besk (Binar Elecktronisk Sekvens-Kalkylator)/Swedish Board for Computing Machines, Drottninggatan 95A, Stockholm, Sweden; located there / Gp EDc Ls 1q

Binac (Binary Automatic Computer) / Eckert-Mauchly Div, Remington-Rand, Phila, Pa; located at Northrop Aircraft, Hawthorne, Calif / Gp EDc Ss 1q

Burroughs E 101 / Burroughs Corp, Phila / Gp EDc Ss Sq

Burroughs Laboratory Computer / Burroughs Adding Machine Co, Phila, Pa; located there / Sp EDc Ls 1-2q

Burroughs Unitized Digital Electronic Computer / Burroughs Corp; located at Wayne Univ, Compn Lab, Detroit / Gp EDc Ls 1q

Cadac -- SEE CRC

Caldic (California Digital Computer) / Univ of Calif, Berkeley, Calif; located there / Gp EDc Ms 1q

CEC 30-201 / Consolidated Engrg Co, Pasadena, Calif / Gp EDc Ss Sq

CEC 36-101 (Consolidated Engrg Corp. 36-101) ElectroData Corp, affiliate of Consol Engrg Corp, Pasadena, Calif / Gp EDc Ls Sq

Circle Computer / Hogan Labs, New York, & Nuclear Development Assoc, White Plains, N Y / Gp EDc Ss Sq

Computer / Dynamic Analysis and Control Laboratory, Mass Inst of Technology, Cambridge, Mass; located there / Gp EAc Ls 1q

Computer / Electronics Div, AERE, Harwell, England; located there / EDc

Computer / Haller, Raymond, and Brown, State College, Pa; located there / Sp EDc Ss 1q

Computer / Imperial College, Univ of London, London; located there / Gp RDc ?s 1q

Computer / Mathematisch Centrum, Amsterdam, Netherlands; located there / Gp RDc Ls 1q

Computer / Naval Special Devices Center, Pt Washington, N Y; located there / Gp Dc Ls 1q

Computers / Academy NAUK, Leningrad, and other groups, USSR; located Leningrad and ? / Gp EDAc Ls, etc ?q / referred to in "The Soviet Union: Automatic Digital Computer Research " by T Fortuna, "Computers and Automation", Sept, 1953

Computyper / Friden Calculating Machine Co, San Leandro, Calif / Gp MDc Ss ?q

CRC 101 (Comp Res Corp 101) / National Cash Register Co, Electronics Division, Hawthorne, Calif / Sp EDc ?s ?q

CRC 102 (also called Cadac 102; Computer Research Corporation 102) / National Cash Register Co, Electronics Division, Hawthorne, Calif; located at Project Lincoln, Mass Inst of Technology, Bedford Airport, Mass / Gp EDc Ls 1q

CRC 102A (also called Cadac 102A; Computer Research Corporation 102A) / National Cash Register Co, Electronic Computer Division, Hawthorne, Calif / Gp EDc Ls Mq

CRC 102D / National Cash Register Co, Electronic Computer Div, Hawthorne, Calif / Gp EDc Ls Sq

CRC 105 (Computer Research Corporation 105)/ National Cash Register Co, Electronics Div, Hawthorne, Calif / Sp (decimal digital differential analyzer) EDc Ls Mq

CRC 107 (Computer Research Corporation) / National Cash Register Co, Electronics Div, Hawthorne, Calif / Gp EDc Ls Sq

CSIRO Mark I / Radiophysics Div, Commonwealth Sci and Indus Res Org, Sydney, Australia; located there / Gp RDc Ms 1q

Cuba (Calculator Universel Binaire de l'Armement) / Société d'Electronique et d'Automatisme; Paris, France; located at Laboratoire Central de l'Armement, Paris, France / Gp EDc Ls 1q

Davis Computer / USAF Inst of Tech, Wright-Patterson Air Force Base, Dayton, Ohio; located there / Sp EAc Ms 1q

Deuce / - / referred to in footnote 7 in "Computing Bit by Bit" by A L Samuel, in "Proc IRE", Oct, 1953, p 1225

Diad (Drum Information Assembler and Dispatcher) / Bell Telephone Labs, Murray Hill, N J; located there / Sp Dc Ls 1q

Differential Analyzer No. 1 / MIT Electrical Engrg Dept, Mass Inst of Technology, Cambridge, Mass; located at Wayne Univ Compn Lab, Detroit, Mich / Gp MAc Ls 1q

Differential Analyzer / General Electric Co, Schenectady; located there / Gp MAc Ls 1q

Differential Analyzer / Moore School of Electrical Engrg, Univ of Pa, Phila; located there / Gp MAc Ls 1q

Differential Analyzer No. 2 / MIT Electrical Engrg Dept, Cambridge, Mass; located there / Gp EAc Ls 1q

Dyseac ("di-" -second - Standards Eastern Automatic Computer) / National Bureau of Standards, Washington; mounted on a truck / Gp EDc Ls 1q

Ease (Electronic Analog Simulating Equipment) / Berkeley Division, Beckman Instrument Co, Richmond, Calif / Gp EAc ?s ?q

Edsac / Univ Mathematical Lab, Cambridge, England; located there / Gp EDc Ls 1q

Edvac (Electronic Discrete Variable Automatic Computer) / Moore School of Electrical Engrg, Univ of Pa, Phila; located at Ballistic Research Labs, Aberdeen Proving Ground, Aberdeen, Md / Gp EDc Ls 1q

Elecom 100 / Electronic Computer Division of Underwood Corp, L I City, N Y / Gp EDc Ss Sq

Elecom 120 / Electronic Computer Division of Underwood Corp, L I City, N Y / Gp EDc Ss Sq

Elecom 200 (also called Ordfiac) / Electronic Computer Division of Underwood Corp, L I City, N Y; located at Letterkenny Ordnance Depot, ? / Gp EDc Ls 1q

Elliot 402 / Elliott Brothers, Computing Machine Division, Borehamwood, Herts, Eng / Gp EDc Ls ?q

Elliott-NRDC Computer 401 Mk 1 /Elliott Brothers Res Labs, Borehamwood, Herts, England; located there / Gp EDc Ls 1q

Eniac (Electronic numerical integrator and calculator) / Moore School of Electrical Engrg, Univ of Pa, Phila, Pa, and Ballistic Res Lab, Aberdeen, Md; located at Ballistic Research Labs, Aberdeen / Gp EDc Ls 1q

ERA 1101, 1102, 1103 / Engineering Res Assoc Div of Remington Rand, St Paul, Minn / Gp EDc Ls Sq

Ferranti / Ferranti Electric Co, Moston, Manchester, England / Gp EDc Ls Mq

Ferut -- the Ferranti computer at the University of Toronto; SEE Ferranti

Flac (Florida Automatic Computer) / Air Force Missile Test Center, Patrick AFB, Fla; located there / Gp EDc Ls 1q

G 1 (Göttingen) / Max-Planck-Institut für Physik, Göttingen, Germany; located there / Sp EDc Ss lq

G 2 (Göttingen) / Max-Planck-Institut für Physik, Göttingen, Germany / Gp EDc Ls lq

Gamma 3 / Compagnie des Machines Bull, Paris, France / Gp EDc Ms Mq

GEDA (Goodyear Electronic Differential Analyzer) L2, L3, N3 (linear and non-linear models) / Goodyear Aircraft Corp, Akron, Ohio / Gp EAc ?s ?q

Harvard Mark I -- SEE: IBM Automatic Sequence Controlled Calculator

Harvard Mark II / Harvard Compn Lab, Cambridge, Mass; located at Naval Proving Ground, Dahlgren, Va / Gp RDc Ls lq

Harvard Mark III / Harvard Compn Lab, Cambridge, Mass; located at Naval Proving Ground, Dahlgren, Va / Gp EDc Ls lq

Harvard Mark IV / Harvard Compn Lab, Cambridge, Mass; located there / Gp EDc Ls lq

Harwell Computer / Atomic Energy Research Establishment, Harwell, Berkshire, Eng; located there / Sp REDc (dekatrons) Ms lq

HEC (Hollerith Electronic Computers) 1 and 2 / British Tabulating Machines Co, London, Eng / ?p ?c ?s ?q

Hughes Airborne Control Computer / Hughes Res & Dev Labs, Culver City, Calif / GSp EDc Ms ?q

Hurricane Computer -- SEE: Raydac

IAS Computer -- SEE: Inst for Advanced Study Computer

IBM 602A (Calculating Punch) / International Business Machines Corp., New York / Gp (short sequences) RDc Ss Lq

IBM 604 (Electronic Calculating Punch) / International Business Machines Corp, New York / Gp (60 program steps) EDc Ss Lq

IBM 607 (Electronic Calculator) / International Business Machines Corp, New York / Gp (140 program steps) EDc Ss Mq

IBM 650 (IBM Magnetic Drum Calculator) / International Business Machines Corp, New York / Gp EDc Ms Sq

IBM 701 (Electronic Data Processing Machine for Scientific Purposes) / International Business Machines Corp, New York / Gp EDc Ls Mq

IBM 702 (Electronic Data Processing Machine for Business Purposes) / International Business Machines Corp, New York / Gp EDc Ls Sq

IBM 703 (Electronic Data Processing Machine for File Maintenance) / International Business Machines Corp, New York / Sp EDc Ls ?q

IBM 704 (Electronic Data Processing Machine for Scientific Purposes) / International Business Machines Corp, New York / Gp EDc Ls ?q

IBM Automatic Sequence Controlled Calculator, or Harvard Mark I / International Business Machines Corp, Endicott, N Y, and Harvard Univ, Cambridge / located at Harvard Compn Lab, Cambridge, Mass / Gp RDc Ls lq

IBM Card Programmed Calculator / International Business Machines Corp, New York, N Y / Gp EDc Ms lq

IBM SSEC (Selective Sequence Electronic Calculator) / International Business Machines Corp, New York, N Y / Gp EDc Ls 0q (dismantled)

Icce (Imperial College Computing Engine) / Imperial College of Science and Technology, London, Eng; located there / Gp Rc Ls lq

IDA Electronic Slide Rule / Computer Corp of America, N Y / Gp EAc ?s ?q

Illiac (Univ of Illinois Automatic Computer) / Univ of Illinois, Urbana, Ill; located there / Gp EDc Ls lq

Institute for Advanced Study Computer / Inst for Advanced Study, Princeton, N J; located there / Gp EDc Ls lq

Institut Blaise Pascal Computer / - / referred to in a report by L Couffignal in the "Proceedings of a Second Symposium", edited by H H Aiken, Harvard University Press, 1951, p 374

IRSIA-FRNS Computer / Bell Telephone Mfg Co, Antwerp, Belgium / Gp EDc Ls lq

Jaincomp A, B, Bl / Jacobs Instrument Co, Bethesda, Md / Sp EDc Ss Sq

Jaincomp C / Jacobs Instrument Co, Bethesda, Md / Sp EDc Ss lq

Jaincomp D / Jacobs Instrument Co, Bethesda, Md / Sp EDc Ss Sq

Johnniac -- same as the Rand Computer, which see

Junior Johnniac -- SEE Rand Junior Johnniac

Kalin-Burkhart Logical Truth Calculator / T A Kalin & W Burkhart, Cambridge, Mass; located at Monrobot Corp, Morris Plains, N J / Sp Rc Ss lq

Leo / - / referred to in report by J M M Pinkerton in "Electronic Engrg" vol 23 (1951), p 142

Leo (Lyons Electronic Office) / J Lyons and Co, Ltd, London; located there / Gp EDc (like Edsac) ls lq

Logistics Computer / Engineering Res Assoc Div, Remington Rand, St Paul; located at Logistics Research Project, George Washington Univ, Washington, D C / Sp EDc Ls lq

Lorpgac / - / mentioned in footnote 7 in "Computing Bit by Bit" A L Samuel, in "Proc IRE", Oct 1953, p 1225

Los Alamos Computer -- same as Maniac, which SEE

Madam / - / referred to in report by F C Williams and others, in "Proc Instn of Elec Engrs", vol 98 (1951), p 13

Maddida (Magnetic Drum Digital Differential Analyzer) / Bendix Computer Div, Los Angeles, Calif / Gp EDAc Ms Sq

Magic (Magnetic and Germanium Integer Calculator) / Wharf Engrg Laboratories, Fenny Compton, Warwickshire, Eng / ?p EDc ?s ?q

Magnetronic Reservisor / The Teleregister Corp, Stamford, Conn; located at American Airlines, La Guardia Airport, New York / Sp (reservations inventory) EDc Ls lq

Manchester Computer / Univ of Manchester, England; located there / Gp EDc Ls lq

Manchester Electronic Computer -- same as Ferranti computer, which SEE

Maniac (Mathematical Analyzer, Numerical Integrator and Computer) / Los Alamos Scientific Laboratory, Los Alamos, New Mexico; located there / Gp EDc Ls lq

Mark 22 Computer (Bell Telephone Model IV computer) / Bell Telephone Laboratories, New York; located at Naval Research Laboratory, Washington, D C / Sp RDc Ls lq

Midac (Michigan Digital Automatic Computer) / Willow Run Res Cr, Univ of Michigan, Ypsilanti, Mich; located there / Gp EDc Ls lq

Milac (Miller Analog Computer) / William Miller Instruments, Inc, Pasadena, Calif / Gp EAc Ls Sq

Minac (Minimal Automatic Computer) / Digital Computing Group, California Inst of Technology, Pasadena, Calif / Gp EDc Ss 0q

Miniac / Marchant Research Inc, Oakland, Calif / Gp EDc Ss 2q

Monrobot (V, MU, etc) / Monrobot Corp, Morris Plains, N J / Gp EDc Ls Mq

Mosaic (Ministry of Supply Arithmetical Integrator and Calculator) / Post Office Research Section, London, Eng; located at Radar Research Establishment, Malvern, Eng / Gp EDc Ls lq

MSAC (Moore School Automatic Computer) / Moore School of Electrical Engrg, Univ of Pa, Phila, Pa; located there / Gp EDc Ls 0q

Narec (Naval Research Laboratory Computer)/ Naval Res Lab, Washington, D C; located there / Gp EDc Ls lq

NBS Computer -- same as Seac, which SEE

Network Analyzer / Franklin Inst Labs for Research and Development, Phila / Gp EAc Ls lq

Network Analyzer -- AC / General Electric Company, Schenectady; located there / Gp EAc Ls lq

Network Analyzer -- AC / Westinghouse Electric Co, Pittsburgh; located there / Gp EAc Ls lq

Network Analyzer -- DC / General Electric Company, Schenectady; located there / Gp EAc Ls lq

Network Analyzer -- DC / Westinghouse Electric Co, Pittsburgh; located there / Gp EAc Ls lq

Nicholas (Nickel Delay-Line Storage Computer) / Elliott Brothers Res Labs, Borehamwood, Herts, England; located there / Gp EDc Ss lq

Norc (Naval Ordnance Research Computer) / International Business Machines, New York; to go to Naval Proving Ground, Dahlgren, Va / Gp EDc Ls lq

Norwegian Computer / Central Institute, Royal Norwegian Council for Scientific and Industrial Research, Norway; located at Norwegian Computing Centre, Oslo University, Blindern, Norway / Gp EDc Ms lq

Oarac / General Electric Co, Syracuse, N Y; located at U S Air Force, Aeronautical Research Lab, Wright-Patterson Air Force Base, Dayton, Ohio / Gp EDc Ms lq

Omibac / Aeronautical and Ordnance Systems Div, General Electric Co, Schenectady, N Y; located there / Gp EDc Ls lq

ONR Relay Computer (Office of Naval Research)/ - ; located at Logistics Research Project, George Washington Univ, Washington, D C / Gp RDc Ms lq

Oracle (Oak Ridge Automatic Computer & Logical Engine) / Argonne Natl Lab, Chicago; located at Oak Ridge Natl Lab, Oak Ridge, Tenn / Gp EDc Ls lq

Ordfiac -- same as Elecom 200, which SEE

Ordvac / Univ of Illinois, Urbana, Ill; located at Ballistic Research Labs, Aberdeen Proving Ground, Aberdeen, Md / Gp EDc Ls lq

Perm (Programmgesteuerte Elektronenrechenmaschine, Munchen) / Technische Hochschule, Munich, Germany / Gp EDc Ls lq

Philbrick Computer / G A Philbrick Res, Inc, Boston / Gp EAc Ms Lq

Ptera (Postal Telecommunications Electronic Automatic Calculator) / Central Laboratory of the Postal and Telecommunications Services, the Hague, Netherlands / Gp EDc Ls lq

R-PAC (Recorder Playback Automatic Computer) / Penn State College, State College, Pa; located there / Sp EAc Ss lq

R 4 S / Eidgenossische Technische Hochschule, Zurich, Switz; to be located there / Gp EDc Ls 0q

Rand Computer / Rand Corp, Santa Monica, Calif; located there / Gp EDc Ls lq

Rand Junior Johnniac / Rand Corp, Santa Monica, Calif; located there / Sp EDc Ss lq

Rascal (Royal Air Force Sequence Controlled Calculator Mark II) / Royal Aircraft Establishment, Farnborough, Hampshire, Eng; located there / Gp EDc Ms lq

Raydac (Raytheon Digital Computer) / Raytheon Mfg Co, Waltham, Mass; located at Naval Air Missile Test Center, Pt Mugu, Calif / Gp EDc Ls lq

Reac 200, 300 / Reeves Instrument Co, New York / Gp EAc Ls Ms Lq

Rechenautomat IPM / Institut für Praktische Mathematik, Technische Hochschule, Darmstadt, Germany; located there / Gp EDc Ls lq

Remington Rand 409-2 and 409-2R / Remington Rand, Inc., New York / Gp REDc Ss Mq

Remington Rand 1101, 1103 -- same as ERA 1101, 1103, which SEE

Remington-Rand 409 Computer / Remington Rand, New York / Gp EDc Ss ?q

S-FAC (Structure Factor Analog Computer) / Penn State College, State College, Pa; located there / Sp EAc Ss lq

Seac (Standards Eastern Automatic Computer) / National Bureau of Standards, Washington, D C ; located there / Gp EDc Ls lq

Sec (Simple Electronic Computer) / Birkbeck College, Univ of London, London, England / located there / Sp EDc Ss ?q

Simon / Berkeley Enterprises, Inc, New York, and others / Sp RDc Ss 3q

Simplac (Simple Automatic Electronic Computer) / Berkeley Enterprises, Inc, New York / Gp EDc Ss 0q

Spec (Special Purpose Electronic Computer) or USAF-Fairchild Computer / NEPA Project, Fairchild Engine and Airplane Co, Oak Ridge, Tenn / Sp EDc Ms 0q (dismantled)

Statac (Statistical Automatic Computer)/National Bureau of Standards, Washington, D C; located there / Sp Dc ?s lq

Stevens Institute of Technology Digital Differential Analyzer / Experimental Towing Tank, Stevens Institute of Technology, Hoboken, N J / Sp EDc Ms lq

Swac (Standards Western Automatic Computer)/ National Bureau of Standards, Los Angeles, Calif; located there / Gp EDc Ls lq

TAC (Tokyo Automatic Computer) / Tokyo Shibaura Electric Manufacturing Co, Tokyo, Japan; located at the Univ of Tokyo, Tokyo, Japan / Gp EDc Ls lq

TC-1 / International Telemeter Corp, Los Angeles, Calif / Gp EDc Ls 0q

Tokyo Mark I / Laboratory of Applied Mathematics, Electrotechnical Laboratory, Tokyo, Japan; located there / Sp RDc Ss lq

Tokyo Mark II / Laboratory of Applied Mathematics, Electrotechnical Laboratory, Tokyo, Japan; located there / Gp RDc Ls lq

TRE Computer (Telecommunications Research Establishment Computer) / Telecommunications Research Establishment, Great Malvern, England; located there / Gp EDc Ls lq

Typhoon Computer / Radio Corporation of America, Princeton Laboratories, N J ; located ? / Gp EAc Ls lq

Udec II (Unitized Digital Electronic Computer) / Burroughs Corp, Electronic Instruments Div, 1209 Vine St, Phila, Pa / Gp EDc Ls lq

(continued on page 29)

Forum

DEBUGGING COMPUTER PROGRAMS

D. D. McCracken
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A major factor in the cost of coding problems for automatic digital computers seems to be the correcting of errors in a program as originally written -- usually called "debugging" the program. Recent issues of "Computers and Automation" contain several references to this fact. It may appear that with sufficient experience, coders would become so adept at coding that errors would become practically nonexistent. Such is unhappily not the case, for a variety of reasons.

First, we are very often concerned with coders who simply have not yet acquired much experience, the growth of computing being what it is. Second, coding a large problem can be exacting in the extreme; there may be literally thousands of places to make mistakes, and it is not sufficient for a program to be almost right. Finally, the actual coding of a problem, once the planning and analysis and block-diagramming is done, is usually not very interesting to the person capable of those first three steps. It can be a difficult task to try to concentrate on the job for several hours or days. You write the address of pi when you should have written the address of pi-over-two; you refer to a location today, forgetting that yesterday you changed it to something else. One good approach at this point is careful record-keeping in the coding process, but this doesn't get at the fundamental problem, which is achieving concentration. Mistakes of the type suggested by the examples are often the result of not paying close attention -- which, as any coder will tell you, is hard to do for eight straight hours. In many cases individual offices would be a major improvement: how can you really concentrate when someone two desks away is telling a good story? It must be recognized also that people vary greatly in their ability and willingness to pay careful, consistent attention to detail, over periods of days.

Even with careful work, however, the basic problem still remains. As a matter of experience, there is something wrong with just about every program when it is first written; careful people will have fewer errors, not zero errors.

There are several approaches to the problem of how to find the errors; these will be discussed later, for first we should develop a criterion for judging these approaches, a criterion which has a bearing on several aspects of the administration of a computing installation.

We speak of problems that are output-limited, i.e., can run only as fast as the output device of the computer. Others are limited by the basic arithmetic speed of the machine, etc. There are analogous situations in the overall operation of the computer in the organization, situations which I choose to call computer-limited, people-limited, and problem-limited. The organization that is computer-limited has plenty of work to do and lots of people, but not enough computing time to do all the work. It is typified by the picture of half a dozen programmers or coders always waiting to get on the machine, and by tight scheduling of machine time. The organization which is people-limited has lots of work and machine time but not a large enough staff. It is typified by the query, "Anybody want the machine?" and by the luxury of programmers sitting at the controls and thinking, trying to figure out what's wrong with a program. The organization that is problem-limited has not enough work to do; this seldom occurs, but when it does occur, we hear the confident assertion, "There's plenty of work out there. All we have to do is go out and do a little missionary work."

One way to hunt for errors is for the person who wrote the program to go over it himself, before using the computer at all. He can go over the instructions in detail; he can sort the instructions in sequence by addresses or operation and inspect the listings; he can use the computer to compile a list of cross references, and other lists. Many errors can indeed be caught by this "self-checking" method. There are however serious objections to it. For one thing, it is burdensome. Possibly a more serious difficulty lies in a coder's liability to suggestion. A glaring error may look perfectly reasonable; after all, if a person makes a "stupid" mistake once, he can make it twice -- especially after it has gained the apparent respectability of being written down.

In the post-mortem system, the program is put on the computer to run until it "dies" on the machine. The machine eventually stops due to violation of either rules built into the machine or contained in the subroutines. Sometimes the programmer stops the machine because an oscilloscope trace or a listing of results will appear wrong. The programmer then perhaps does a bit of checking by hand, traces a few instructions, or better, prints out a pertinent section of memory, which after some study enables him to locate the trouble.

(continued on page 33)

BOOKS AND OTHER PUBLICATIONS

Gordon Spenser, New York, N. Y.
(List 11, Computers and Automation, vol. 4, no. 2, Feb. 1955)

This is a list of books, articles, periodicals, and other publications which have a significant relation to computers or automation, and which have come to our attention. We shall be glad to report other information in future lists, if a review copy is sent to us. The plan of each entry is: author or editor / title / publisher or issuer / date, publication process, number of pages, price or its equivalent / a few comments. If you write to a publisher or issuer, we would appreciate your mentioning the listing in COMPUTERS AND AUTOMATION.

McCloskey, J. F., and F. N. Trefethen, editors / Operations Research for Management / The Johns Hopkins Press, Baltimore, Maryland / 1954, printed, 409+xxiv pp, $7.50 /

This book is an excellent introduction to operations research. The first of three main parts is a general discussion of the history, scope and organization of the subject, including a discussion of the relationship of management to the operations research. The second part, on methodology, reviews the use in operations research of statistics, information theory, game theory, and linear programming, and also includes a chapter by J. O. Harrison, Jr., on the use of computing machines. Limitations of computers as well as advantages are set forth. He concludes that a fast digital machine is justified only if the problem is capable of simple formulation into a linear sequence of the machine's basic operations and if the problem is highly repetitive. The final part of the volume deals with individual and interesting case studies gathered from industry, agriculture, and military applications.

Schreiber, G. R. / Automatic Selling / John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. / 1954, printed, 195 pp, $5

Designed for the businessman, salesman or investor, as well as the student or economist interested in this expanding field, this book is a comprehensive description of vending machines and services. It contains an intimate description of the field with much enthusiasm for the future tempered by warnings to the possible investor. Allusions are made to some of the technical aspects of the industry, but no technical details are given.

Clippinger, Richard F. / "Economies of the Digital Computer", pp 77-88, in the "Harvard Business Review", January-February, 1955 / Harvard University, Soldiers Field, Boston 63, Mass. / 1955, printed, $2.00 per copy, $8.00 per year, separate reprints available

Considers the use of digital computers for record keeping, management decision, and industrial research. The costs and economies of a computer installation are compared in terms of manpower for seven existing computers ranging from $2,500 to $100,000 monthly in equivalent rental cost. Further costs for an operating staff and customary peripheral equipment are discussed. Examples are given from fields of insurance and retailing. Recommendations for the size of a computer installation are made for companies on the basis of number of employees. It is suggested that small companies avail themselves of computing services, and the last Roster of Automatic Computing Services from "Computers and Automation" is reproduced.

Osborn, Roddy F. / "GE and UNIVAC: Harnessing the High-Speed Computer" pp 99-107 in the "Harvard Business Review", July-August 1954/ Harvard University, Soldiers Field, Boston 63, Mass. / 1954, printed, $2.00 per copy, $8.00 per year, separate reprints available from magazine

A review of the experience of General Electric in the installation of a UNIVAC. It is stated that the break-even point came when the computer was operated only two hours a day. A list of eleven guideposts is provided for private business when considering and planning a high-speed computer installation.

U. S. National Bureau of Standards / National Bureau of Standards Report 3786, "First Annual Progress Report on Applications of Electronic Data Processing Techniques to Supply Management Problems" / National Bureau of Standards, Washington 25, D. C./ 1954, photooffset, 62 pp, inquire NBS Office of Scientific Publications re copies

Project tasks reviewed include preliminary general analyses of areas of applicability, experimentation with a new sorting-file merging method, experimental connection of two computers to share a common task, development of a print reader, and equipment development with respect to random access devices.

Greenough, M. L., and C. C. Gordon / National Bureau of Standards Report 3634, "Technical

Details of Print Reader Demonstrator" / National Bureau of Standards, Washington 25, D. C. / 1954, photooffset, 52 pp, inquire NBS Office of Scientific Publications re copies

The memory of the print reader is in the form of optical masks, one for each possible character, plus a few control patterns. Sequentially, the machine superimposes the masks on the unknown character and continues until agreement is reached. Agreement is recognized by the amount of white space left when the photographic negative mask covers the unknown character. No white space is perfect agreement but some tolerance is allowed. Detailed discussion of the optical system and electronic circuitry is included.

Stevens, M. E. / National Bureau of Standards Report 3602, "An Experiment in Data-Processing Shared by Two Computers" / National Bureau of Standards, Washington 25, D. C./ 1954, photooffset, 32 pp, inquire NBS Office of Scientific Publications re copies

A report of the experiment linking up the SEAC and DYSEAC to share a common progress. It is concluded that such a combination is feasible providing the computer, to which general supervisory duties are assigned, is sufficiently flexible to respond effectively to a variety of external devices. Identical performance characteristics, or even language, is unnecessary.

Guterman, S. and R. D. Kodis / Magnetic Core Selection Systems / Raytheon Manufacturing Co., Waltham, Mass. / 1954?, dittoed, 28 pp, limited distribution

A discussion of the use of magnetic cores in selection systems for use in reading from or writing onto a magnetic drum. Component characteristics or circuit designs are illustrated in 14 figures.

Guterman, S., and others / Circuits to Perform Logical and Control Functions with Magnetic Cores / Raytheon Mfg. Co., Waltham, Mass./ 1954? dittoed, 34 pp, limited distribution

Logical circuits are built up from magnetic core windings whose basic blocks are an "inhibit" circuit and one of two "or" circuits. Applications are illustrated for making a two-input subtractor, a two-input adder, a multiplier, and a divider.

Ruhman, S., and others / Magnetic Shift Register Using One Core Per Bit / Raytheon Mfg. Co., Waltham, Mass. / 1953, dittoed, 16 pp, limited distribution

A description of a shift register

(continued on page 38)

(continued from page 26)

Utec (Univ of Toronto Electronic Computer) / McLellan Lab, Univ of Toronto, Toronto, Canada; located there / Sp EDc Ss lq

Univac / Eckert-Mauchly Div, Remington Rand, Inc, Phila, Pa / Gp EDc Ls Mq

Whirlwind I / Digital Computer Lab, Mass Inst of Tech, Cambridge 39, Mass; located there/ Sp EDc Ls lq

Wisc (Wisconsin Integrally Synchronized Computer) Univ of Wisconsin, Electrical Engrg Dept, Madison, Wisc; located there / Gp EDc Ls lq

X-RAC (x-ray analog computer) / Penn State College, State College, Pa; located there/ Sp EAc Ms lq

Zuse Model 5 / Konrad G Zuse, Neukirchen, Germany; located at Leitz Optical Works, Wetzlar, Germany / Gp RDc Ss lq

Zuse Model IV / Konrad G Zuse, Neukirchen, Germany; located at Swiss Federal Inst of Tech, Zurich, Switzerland / Gp RDc Ls lq

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Mac III 3 / Magnovox Research Labs, Los Angeles, Calif / Gp EDc Ms ?q

Midsac / Willow Run Research Cr, Univ of Michigan, Ypsilanti, Mich; located there / Gp EDc Ls lq

Univac 60 -- same as Remington Rand 409, which see

Univac 120 -- same as Remington Rand 409-2, which see

Univac Scientific Computer -- same as ERA 1103, which see.

- END -

THE EDITOR'S NOTES
(continued from page 4)

In this issue we reprint a good story which appeared five years ago and in which a computer plays a role. The author E. L. Locke (that is not his real name) is a mathematician and engineer as well as an author able to tell a good story. We hope you will enjoy reading or rereading the story. In the March issue we shall print a striking short story by Isaac Asimov, previously unpublished, highlighting an aspect of computing machinery.

NOTICES

Address Changes: If your address changes, please notify us giving both old and new address, and allow three weeks for the change.

- END -

Roster of Organizations in the Field of Computers and Automation

(Supplement, information as of January 10, 1955)

The purpose of this Roster is to report organizations (all that are known to us) making or developing computing machinery, or systems, or data-handling equipment, or equipment for automatic control and materials handling. In addition, some organizations making components may be included in some issues of the Roster. Each Roster entry when it becomes complete contains: name of the organization, its address and telephone number, nature of its interest in the field, kinds of activity it engages in, main products in the field, approximate number of employees, year established, and a few comments and current news items. When we do not have complete information, we put down what we have.

We seek to make this Roster as useful and informative as possible, and plan to keep it up to date in each issue. We shall be grateful for any more information, or additions or corrections that any reader is able to send us.

Although we have tried to make the Roster complete and accurate, we assume no liability for any statements expressed or implied.

This listing is a supplement to: the cumulative listing containing over 230 organizations published in the November issue of "Computers and Automation", vol. 3, no. 9, pp. 9 to 19 and 30; the supplements in the December issue, vol. 3, no. 10, p. 23, and the January issue, Vol. 4, no. 1, p. 36. This listing contains only additions or corrections as compared with previous listings.

Abbreviations

The key to the abbreviations follows:

Size
- Ls Large size, over 500 employees
- Ms Medium size, 50 to 500 employees
- Ss Small size, under 50 employees (no. in parentheses is approx. no. of employees)

When Established
- Le Long established organization (1922 or earlier)
- Me Organization established a "medium" time ago (1923 to 1941)
- Se Organization established a short time ago (1942 or later) (no. in parentheses is year of establishment)

Interest in Computers and Automation
- Dc Digital computing machinery
- Ac Analog computing machinery
- Ic Incidental interests in computing machinery
- Sc Servomechanisms
- Cc Automatic control machinery
- Mc Automatic materials handling machinery

Activities
- Ma Manufacturing activity
- Sa Selling activity
- Ra Research and development
- Ca Consulting
- Ga Government activity
- Pa Problem-solving
- Ba Buying activity
  (Used also in combinations, as in RMSa "research, manufacturing and selling activity")

*C This organization has kindly furnished us with information expressly for the purposes of the Roster and therefore our report is likely to be more complete and accurate than otherwise might be the case. (C for Checking)

ROSTER

ACR Electronics, Division of ACF Industries, Inc., 800 No. Pitt St., Alexandria, Va. / King 8-4400/ *C
Coders, decoders, servo-systems, display equipment, special instruments. Ms (200) Se (1954) Ic RMSa

Electronics Corp. of America, Business Machines Div., 77 Broadway & 10 Potter St., Cambridge 42, Mass. / Trowbridge 6-8190
Automatic inventory machines and point of sale recorders; "Magnefiles". Purchaser of W. S. Macdonald & Co. Electronic and photoelectronic controls, "photoswitches", etc. Ms Se DAIc RMSa

Canning, Sisson and Associates, 914 South Robertson Blvd., Los Angeles 35, Calif. / Bradshaw 2-4904
Consultants in utilization of electronic computers and other automatic data-handling equipment. Ss Se (1954) DACc RCPa

Ralph C. Coxhead Corp., 720 Frelinghuysen Ave., Newark 5, N. J.
Type composing of display types by photography, using a desk machine. Varitypers. Ls ?e Ic RMSa

The Gerber Scientific Instrument Co., 162 State St., Hartford, Conn. / Chapel 6-8539
Graphical-numerical computers. Ss Se (1948) Ic RMSa

Mountain Systems, Inc., 865 Franklin Ave., Thornwood, N. Y. / Pleasantville 2-3330
Data processing systems and digital computer systems. Magnetic drums. Ss (10) Se Dc RMSCa

John Oster Mfg. Co., Avionic Div., Racine, Wisc.
Fast response magnetic resolvers, etc. Ac RMSa

North American Research & Control Instruments Div., Philips Co., Inc., 750 So. Fulton Ave., Mt. Vernon, N. Y. / Mount Vernon 4-4500
Analog computers. Semi-automatic X-ray machine that determines percent of 12 different elements in a specimen . Etc. Ms (250) Se (1942) AIc RMSa

Telequipment Corp., Sea Cliff, N. Y. / Glen Cove 4-2900
Inexpensive equipment ("code stacks") for attaching to an electric typewriter, add -

(continued on page 38)

RECOGNIZING SPOKEN SOUNDS
(continued from page 9)

It is clear that this technique can be extended to the recognition of more complex sounds so long as the input speech is arranged to allow silent gaps between words. In this form it is hoped that the device will eventually allow the direct translation of spoken data.

In this brief description it has not been possible to deal with the means which are available for compensating for rate of speaking and (although this is at present unsatisfactory) for the use of one standard record with several different users. These and other practical details of the system will be published elsewhere.

References

(1) Booth, A. D., and Booth, K. H. V., "Automatic Digital Calculators", Butterworths, London, 1953, p. 68

(2) Korn, G. A., and Korn, T. M., "Electronic Analog Computers", McGraw Hill, New York, 1952, p. 11

(3) Ref. (1), p. 92

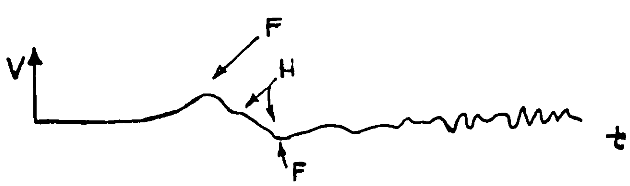


Fig. 1

Fig. 2

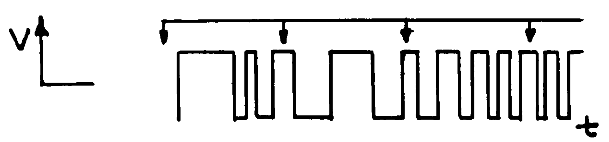


Fig. 3

- END -

COMPUTERS AND COMPUTATION, ABROAD AND HERE

Alston S. Householder
Oak Ridge National Laboratory, Oak Ridge, Tenn.

European computers contrast generally with American computers in being less ambitious: slower in speed, more limited in storage, smaller in dimension, much lower in cost. Of operating machines, it appears that only the Besk in Sweden has a speed comparable to the faster American computers, with division time below a millisecond. The Ace, at the National Physical Laboratory in England, has comparable speeds on such operations as it performs, but it has neither automatic division nor even automatic multiplication. The Edsac in England has multiplication but no division. There are quite a number of inexpensive relay machines, while the Harwell (England) computer uses cold cathode tubes, with almost negligible power consumption and phenomenally long life. The original Williams tube machine is serial, and hence slower than its American descendants. However, machines are under construction at both Cambridge and Amsterdam using magnetic cores, and hence promising high speeds.

The limitations are to be expected since a substantial proportion of the computing machines abroad are located in academic institutions, where their construction, or their use, or both, are primarily for research purposes. One gets the feeling of investigative activity, unhurried, unharried and effective, carried out along many and diverse lines. Two transistor machines are under way, both in England, one at Manchester, one at Harwell. They bear little resemblance to one another except that both will use transistors for switching and drums for storage. The Manchester machine is being built solely as an engineering experiment for the study of transistors. Of the two magnetic core machines, at Cambridge and Amsterdam, the former will use cores for switching as well as for storage, and will carry out the microprogramming scheme of M. V. Wilkes. At Zurich (Switzerland) a machine is being designed that is intended to simplify to the utmost the task of programming: floating decimal operations, the same register for all operands and results, essentially nine B-tubes, to mention a few of the features.

Commercial Computers

Mention of the academic activity is not intended to minimize by contrast the developments in other quarters. Curiously, commercial construction seems to be confined to England. Ferranti has a clear lead, their sixth machine having been delivered in the late summer to the Royal Dutch Shell Laboratories in Amsterdam. The fifth was purchased by the Italian government to be installed at Rome. The Deuce, an engineered version of the Ace, is being produced in several copies by English Electric. In a lower price range (well below $100,000.) the 402 of Elliott Bros. (England) uses nickel acoustic lines for storage, and the company promises to build to order from packaged units with accurate costing from the drawing board.

Commercial construction for another purpose is represented by Lyons Tea Company's Leo, built by the company itself for a pioneering experiment in commercial uses. Still operating on an experimental basis, Leo calculates the payroll for a sample group of employes, telling even how many of which coins (British, of course; no small achievement!) are required for each payment; and analyzes the results of market surveys. More ambitious projects await the completion of a helpmeet for Leo.

In Sweden the Bark and Besk were produced in a government research establishment. In England, National Physical Laboratory, Harwell, and Royal Aircraft Establishment, are among the governmental establishments that have built machines, or are building, or both.

Numerical Analysis

In the U. S. numerical analysis was virtually unknown until World War II. The subject was pursued by astronomers and ballisticians, the latter receiving a considerable but brief boost from the former, during World War I, principally in the person of Forest Ray Moulton. Few others took an interest, mathematicians least of all. Even today research activity in the field is dispersed, especially since the deplorable demise of the Institute for Numerical Analysis. Courses are beginning to appear in college curricula, inspired by the spread of digital computers, but extensive research interest is yet to come.

The case is quite different abroad, however, where numerical analysis has engaged the talents of outstanding mathematicians of all times. One could go far back and mention Newton and Gauss. Or one could stay within the present century and mention Whittaker and Robinson, Runge and König, Ostrowski, and Aitken, as a few examples among many others. In

(continued on page 40)

PATENTS

Hans Schroeder
Milwaukee, Wisconsin

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.

November 23, 1954: 2,695,396 / J R Anderson, Berkeley Hts, N J / Bell Tel Labs, Inc, New York, N Y / Ferro-electric storage device comprising two non-linear capacitors
2,695,397 / J R Anderson, Berkeley Hts, N J / Bell Tel Labs, Inc, New York, N Y / Circuit using ferro-electric storage device.
2,695,398 / J R Anderson, Berkeley Hts, N J / Bell Tel Labs, Inc, New York, N Y / Circuit using ferro-electric storage device

November 30, 1954: 2,695,750 / C F Kayan, New York, N Y / - / Electrical analog for analyzing fluid flow.
2,695,956 / C O Mallinckrodt, Palos Verdes Estates, Calif / Bell Tel Labs, Inc, New York, N Y / Gating circuit using dual triode and transformers
2,695,974 / A M Skellett, Madison, N J / Nat'l Union Radio Corp, Orange, N J / Two-dimensional pulse counting or registering tube of the cathode-ray type
2,695,993 / M K Haynes, Poughkeepsie, N Y / Int'l Business Mach Corp, New York, N Y / "Exclusive-or" circuit using two magnetic storage elements

December 7, 1954: 2,696,347 / A W Lo, Haddonfield, N J / Radio Corp of America / Switching cirucit using a plurality of magnetic cores
2,696,343 / J Murtagh, Jersey City, N J / - / Mechanical sliderule type calculating device
2,696,565 / W Shockley, Madison, N J / - / Electro-optical positioning control system
2,696,578 / S E Newell, Seattle, Wash / Boeing Airplane Co, Seattle, Wash / Antihunt means for electric motor positioning systems
2,696,599 / B D Holbrook, Madison, W A Malthaner, New Providence, and H E Vaughan, Chatham, N J / Bell Tel Labs, Inc, New York, N Y / Circuit for checking coded information
2,696,600 / R Serrell, Princeton, N J / Radio Corp of America / Combinational information-storage network

December 14, 1954: 2,696,946 / J W Gray, White Plains, N Y / General Precision Labs Inc / Electromechanical multiplier using a differential capacitor
2,696,947 / A A Hauser and E J Nagy, Garden City, G E White, Hempstead, and H Harris, Jr, Cedarhurst, N Y / Sperry Corporation / Gun directing system
2,697,178 / C L Isborn, Hawthorne, Calif / Nat'l Cash Register Co / Ferroresonant ring counter

* ——— * ——— *

DEBUGGING COMPUTER PROGRAMS
(continued from page 27)

Then he takes the problem off the machine, repairs the instructions, and tries again, and again, and again -- until finally a prepared example checks. Some element of the post-mortem method has to be present in every debugging scheme. Whatever else may be done to try to eliminate errors before going on the machine, there comes a time when it has to be run to see if it's OK.

A third method which in many ways has something to recommend it is the independent verifier system. Here, the original coder gives the program to another coder for checking, in the hope that the difficulties of autosuggestion and second-order boredom can be avoided. It is less likely that another person will make the same stupid mistake. Also, the first coder is forced to write clearly, use a carefully drawn flow chart, and leave a clear trail of his thinking. The method of independent verification is in extensive use at some installations.

It brings its own problems, however. The original programmer cannot just hand his program to the person next to him and say, "Look this over for me, will you?" The person next to him may feel that this is an unfair imposition on his time, or that it will cause a reduction in his own output which will reflect against him. Therefore the method must be part of the organization of the computing unit, so that everyone may expect to spend part of his time checking other people's work, and may definitely expect to earn standing on how good a job of verifying he does. It also appears that verifying takes considerably less time than coding the first time. Of course, pointing out a mistake must not be taken as a personal criticism.

Which of these methods should be used? The computer-limited installation calls for having the coders spend extra time at their desks before going on the machine, using self-checking or independent checking. The people-limited organization will probably deliberately "waste" machine time which wouldn't have been used anyway, in order not to tie up people. A deliberate choice between methods or various proportions of them is likely to be of material help to any computer organization.

- END -

Forum

AUTOMATIC PROGRAMMED COMPONENT ASSEMBLY SYSTEM

Neil Macdonald

A system for automatically placing components in subassemblies in varied types of electronic equipment is being built by General Electric for the Army Signal Corps. It is called the Automatic Component Assembly System, or ACAS. It is capable of being switched rapidly from one type of assembly operation to another type. It can be adapted immediately to work on varied sizes of circuit boards, using different types and sizes of components with up to eight leads each. An artist's sketch of the ACAS is shown in Figure 1.

The ACAS has an electronic reader, which sets up production steps from punch cards. When a different job is to be done, the reader is fed the punch card for the new job. It then sets up the ACAS to prepare components, test them, convey them if acceptable to the assembly unit, assemble them, and test the completed sub assembly, and if acceptable, approve it.

The system can be programmed to place any number of components; it is limited only by the size of the circuit boards and the size of the components to be placed.

The ACAS can place 1,600 components per hour. Attendants however are needed to load circuit boards and components, and to check operation of the system at a central control console.

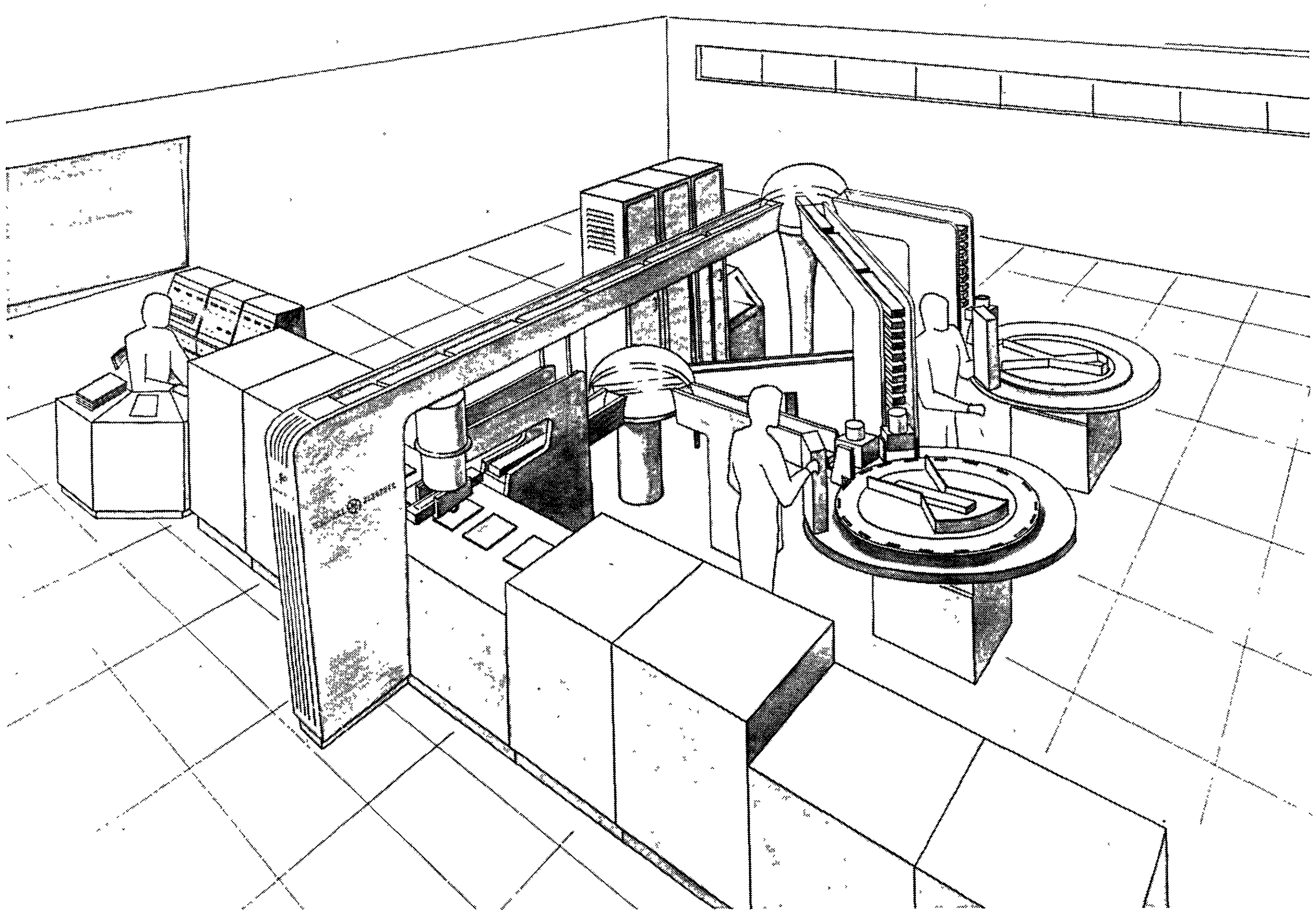


Figure 1 -- General Electric's Automatic Component Assembly System -- The placement head unit is at the left. Pallets bearing circuit boards pass beneath. The operator at the far left operates the central control desk, and feeds circuit boards into the ACAS. Two operators at the right feed components. The electronic information reader and the distribution instructions are in three vertical enclosures at the top center. The circuit boards, after being assembled, are soldered and tested in the four enclosures at the bottom, right. The ACAS can be changed immediately to place new and different components on new and different types of printed-wiring circuit boards. It is scheduled for completion in the middle of 1955.

NORC, NAVAL ORDNANCE RESEARCH CALCULATOR, just completed by INTERNATIONAL BUSINESS MACHINES for the U. S. Navy

MANUSCRIPTS

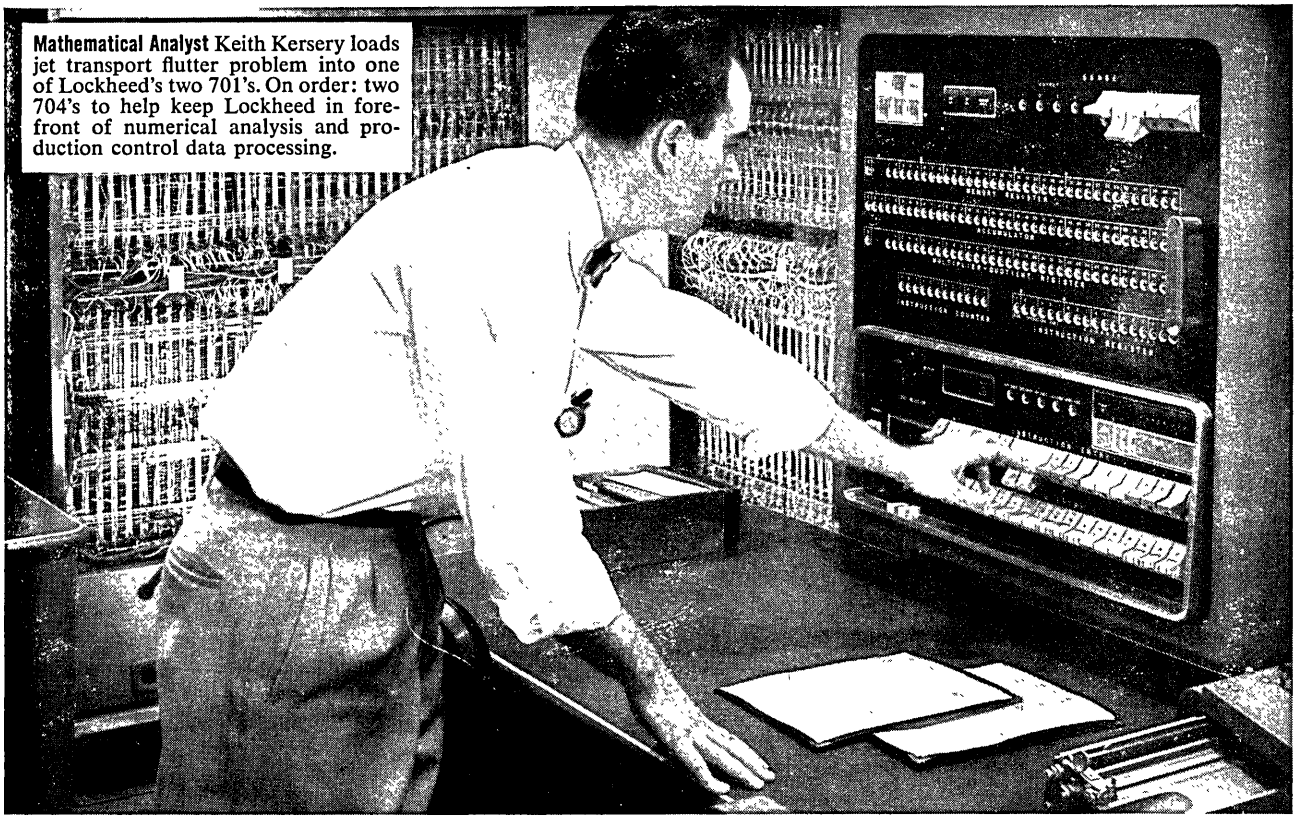
We are interested in articles, papers, and fiction relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the fifth of the preceding month.

Articles. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $40 on publication. A suggestion for an article should be submitted to us before too much work is done.

Technical Papers. Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable. No payment will be made for papers. If a manuscript is borderline, it may be returned to the author to be modified to become definitely either an article or a paper.

Fiction. We desire to print or reprint fiction which explores ideas about computing machinery, robots, cybernetics, automation, etc. and their implications, and which at

(continued on page 38)



Mathematical Analyst Keith Kersery loads jet transport flutter problem into one of Lockheed's two 701's. On order: two 704's to help keep Lockheed in forefront of numerical analysis and production control data processing.

New 701's speed Lockheed research in numerical analysis

The first airframe manufacturer to order and receive a 701 digital computer, Lockheed has now received a second 701 to handle a constantly increasing computing work load. It gives Lockheed the largest installation of digital computing machines in private industry.

Most of the work in process is classified. However, two significant features to the career-minded Mathematical Analyst are: 1) the wide variety of assignments caused by Lockheed's diversification and 2) the advanced nature of the work, which consists mainly of developing new approaches to aeronautical problems.

Career Opportunities for Mathematical Analysts

Lockheed's expanding development program in nuclear energy, turbo-prop and jet transports, radar search planes, supersonic aircraft and other classified projects has created a number of openings for Mathematical Analysts to work on the 701's.

Lockheed offers you attractive salaries; generous travel and moving allowances; an opportunity to enjoy Southern California life; and an extremely wide range of employee benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, sick leave with pay, etc.

Those interested are invited to write E. W. Des Lauriers for a brochure describing life and work at Lockheed and an application form.

LOCKHEED AIRCRAFT CORPORATION

BURBANK **CALIFORNIA**

ROSTER OF ORGANIZATIONS

(continued from page 30)

ing machine, cash register, calculator, etc., so that it may control a tape perforator and punch paper tape simultaneously with typing. Ss Se DIc RMSa

Vectron, Inc., 400 Main St., Waltham 54, Mass./ Waltham 5-8700

Special computers for accounting applications, military applications, etc. Precision potentiometers, precision gear assemblies. Etc. Ms(200) Se(1949) DIc RMSa

- END -

MANUSCRIPTS

(continued from page 36)

the same time is a good story. Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $40 on publication if not previously published, and half that if previously published.

- END -

BOOKS AND OTHER PUBLICATIONS

(continued from page 29)

where the information stored on the single magnetic core per bit is used to charge a condenser through a diode which then discharges into the core associated with the next bit.

American Bankers Association / Automation of Bank Operating Procedure / American Bankers Association, 12 East 36 St., New York 16, N. Y. / 1955, printed, 32 pp, limited distribution

A brochure that describes and delimits the problems raised by adopting automatic procedures in check handling and savings accounting. The brochure seeks to secure comments, suggestions, and ideas from those organizations, in the equipment field, who may be able to provide assistance in the design of automation equipment for banks affecting those two areas of operations.

- END -

We think machines are wonderful,
but PEOPLE WITH KNOW HOW are more important.

Our wonderful 407's, 604's, 101's, 024's, etc., and our ever more important PWKH'S are as close as air express and your telephone.

SOME OF THE PEOPLE WHO USE OUR PWKH'S

American Telephone & Telegraph
Western Electric
Johnson & Higgins
Loyalty Group of Newark
Westinghouse
Pension Planning Co.
Ideal Mutual Ins. Co.

FULL FACE AND PROFILE OF ONE OF OUR PWKH'S

S. J. Halsted, Jr.: 29—10 years in the punch card field—all in service bureaus — Account Executive and methods specialist in casualty, fire and automobile company and agency accounting and statistical work—Majored in Business Administration in college.

MACHINE STATISTICS CO.

27 THAMES STREET
NEW YORK 6, N. Y.
Tel. COrtlandt 7-3165

The independent punch card tabulating service bureau that has come the fastest with the mostest

(continued from page 32)

Germany there seems to be surprisingly little interest in digital computers, although there is a fair amount of analog equipment, but there is and always has been a considerable interest in digital computing. Elsewhere the digital computer has stimulated this interest and, conversely, the long-standing interest has made possible prodigious calculating feats on primitive equipment, as though sheer force of intellect had coaxed a Model T into providing a transcontinental stratocruise.

But hyperbole aside, it is clear that ingenuity and a fund of computational know-how have surmounted multitudes of instrumental deficiencies, and, conversely, the instrumental deficiencies have exercised the ingenuity. It is also true, to return to a point made earlier, that the machines are more commonly available for research, less commonly or less completely self-supporting, and numerical analysis is by no means least among research interests. Again one thinks of the late lamented Institute for Numerical Analysis, by comparison with the active mathematical group at the National Physical Laboratory.

FORUM: ASTRONOMICAL NUMBERS
Bill Danch, Woodstock, N. Y.

" -- Why, Rita, when I suggested that he and I go out to count the stars, I had no idea he was in automatic computing!"

Eastern Europe and Northern Asia

One wonders, naturally, what is happening farther to the east. In the open literature there is a remarkable lack of evidence of the existence of large scale digital computers anywhere between Germany and Japan. Lack of evidence, however, is by no means a proof of nonexistence. Moreover, there appeared recently in the New York Times, in an article by Benjamin Fine, an utterly terrifying picture of the lag in the training of technicians and engineers in this country as compared with tremendous advances in the Soviet Union. Stories which came out of the International Congress of Mathematicians indicated that the comparison is at least equally dismal in the basic sciences and mathematics. The picture is terrifying, but hardly unexpected, in a day when many public school authorities are telling that the little eyes are not yet ready for reading at the age of 6, 7, 8, or what have you, and that mathematics is something to be done by machinery. Just how much will we expect of electronic brains?

- END -

COMPUTERS AND AUTOMATION - Back Copies

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October: Flight Simulators: A New Field -- Alfred Pfanstiehl
Robots I Have Known -- Isaac Asimov
The Capacity of Computers Not to Think -- Irving Rosenthal, John H. Troll
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Economies in Design of Incomplete Selection Circuits with Diode Elements -- Arnold I. Dumey

January, 1955: Statistics and Automatic Computers -- Gordon Spenser
Eastern Joint Computer Conference, Philadelphia, Dec. 8-10, 1954 -- Milton Stoller
The Digital Differential Analyzer -- George F. Forbes
A Small High-Speed Magnetic Drum -- M. K. Taylor
An Inside-Out Magnetic Drum -- Neil Macdonald

REFERENCE INFORMATION (in various issues):

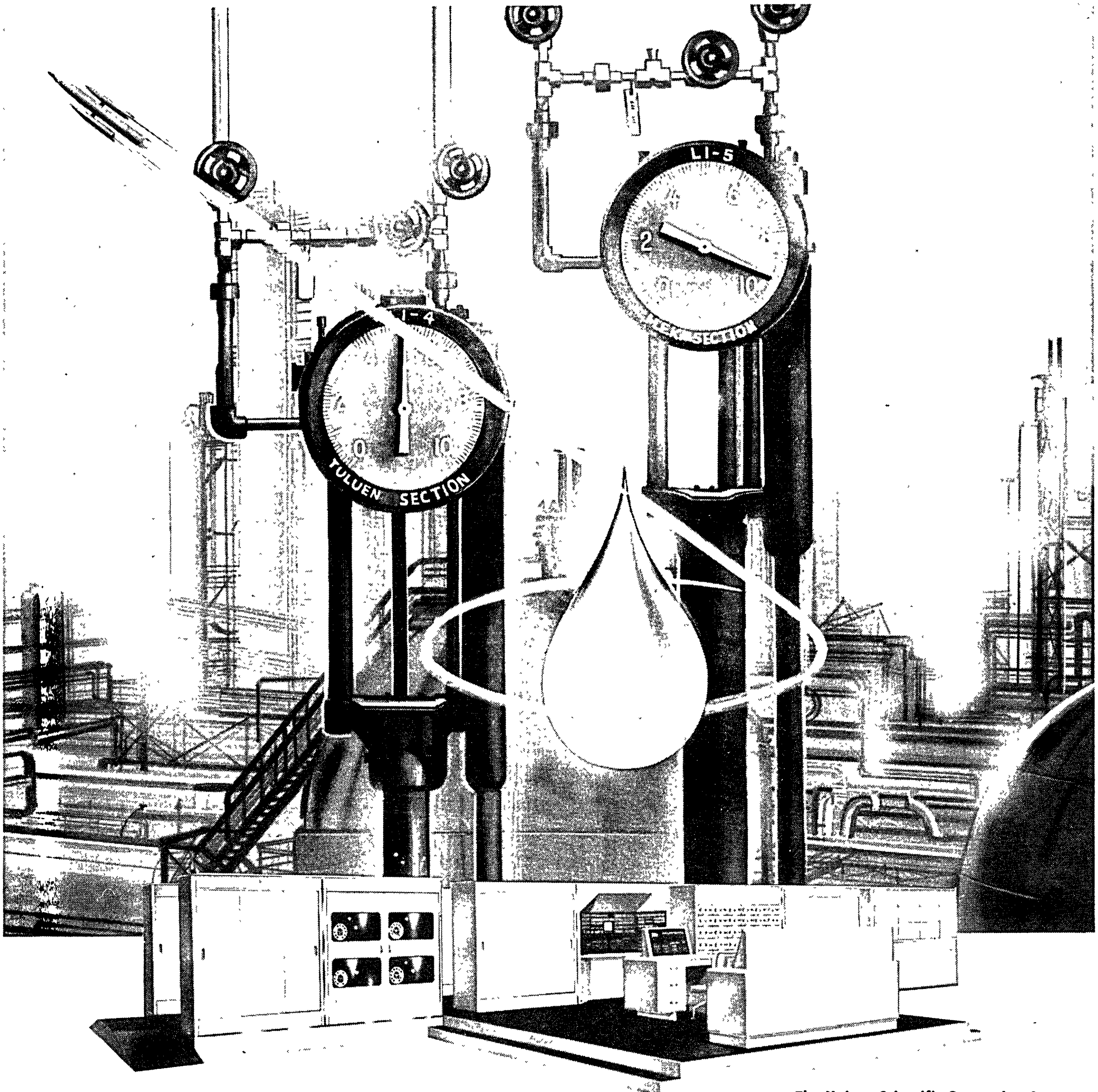
Roster of Organizations in the Field of Computers and Automation / Roster of Automatic Computing Services / Roster of Magazines Related to Computers and Automation / List of Automatic Computers / Automatic Computing Machinery -- List of Types / Who's Who in the Field of Computers and Automation / Automation -- List of Outstanding Examples / Books and Other Publications / Glossary / Patents

BACK COPIES: Price, if available, $1.25 each. Vol. 1, no. 1, Sept. 1951, to vol. 1, no. 3, July 1952: out of print. Vol. 1, no. 4, Oct. 1952: in print. Vol. 2, no. 1, Jan. 1953, to vol. 2, no. 9, Dec. 1953: in print except March, no. 2, and May, no. 4. Vol. 3, no. 1, Jan. 1954, to vol. 3, no. 10, Dec. 1954: in print.

A subscription (see rates on page 4) may be specified to begin with any issue from Dec. 1954 to date.

WRITE TO:

Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.



The Univac Scientific Computing System

Gauged To Perfection

Perfection of the finished product requires precise control in the manufacture of jet fuel. Such control is vital in the refining of oil, as it is in most industries. And, with the coming of age of automation, the controls must not only be precise—they must also be supervised automatically.

That's the function of such electronic computing systems as the Remington Rand Univac Scientific. Its ability to control, simultaneously and automatically, a wide variety of input-output devices makes the Univac Scientific ideally suited to on-line operations.

Fully automatic control requires a computing system which is able, for example, to take a meter reading, then—acting on its own instantaneous decision—throw a switch, set a rheostat, or adjust a valve. This the Univac Scientific can do easily—and much more. Operating at extremely high speeds with superb efficiency, the Univac Scientific provides large storage capacity, great programming versatility, and far greater reliability than any computer in its class.

For information about how a Univac Scientific system might be applied to your particular problem, write to . . .

ELECTRONIC COMPUTER DEPARTMENT **Remington Rand** INC ROOM 1260, 315 FOURTH AVE., NEW YORK 10

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles and reference information related to computing machinery, robots, automatic controllers, 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 $4.50 a year in the United States. Single copies are $1.25. The magazine was published monthly except June and August between March, 1953, and September, 1954; prior to March 1953 it was called "The Computing Machinery Field" and published less often than ten times a year.

2. What is the circulation? The circulation includes 1300 subscribers (as of Dec. 15); over 300 purchasers of individual back copies; and an estimated 1500 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are some 3500 or 4000 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 Dec. issue was 2100 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. A mailing to some 2000 nonsubscribers in December, 1953 (with 173 responses up to March, 1954) indicated that two-thirds of them saw the magazine (library, circulation, or friend's copy) and of these two-thirds over 93% "liked it".

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.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7"x10") 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. 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 full pages (ad size 7" by 10", basic rate, $170) and half pages (basic rate, $90); back cover, $330; inside front or back cover, $210. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $290; four-page printed insert (two sheets), $530. Classified advertising is sold by the word (50 cents a word) with a minimum of ten words. We reserve the right not to accept advertising that does not meet our standards.

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

- The Austin Co.
- Automatic Electric Co.
- Burroughs Corporation
- Federal Telephone and Radio Co.
- Ferranti Electric Co.
- Ferroxcube Corp. of America
- General Ceramics Corp.
- General Electric Co.
- Hughes Research and Development Lab.
- International Business Machines Corp.
- Ketay Manufacturing Co.
- Laboratory for Electronics
- Lockheed Aircraft Corp.
- Logistics Research, Inc.
- Machine Statistics Co.
- Monrobot Corp.
- Potter Instrument Co.
- Raytheon Mfg. Co.
- Reeves Instrument Co.
- Remington Rand, Inc.
- Sprague Electric Co.
- Sylvania Electric Products, Inc.
- Telecomputing Corp.

ADVERTISING INDEX — FEBRUARY, 1955

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? We reserve the right not to accept advertising that does not meet our standards.

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).

Cambridge Thermionic Corp., 447 Concord Ave., Cambridge 38, Mass. / Electronic Components / page 2 / CA No. 137

Computers and Automation, 36 West 11 St., New York 11, N. Y. / Back Copies, Advertising, Reply Form/ pages 42, 44, 46 / CA No. 138

Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y. / Ferranti High Speed Tape Reader / page 45 / CA No. 139

Ferroxcube Corp. of America, East Bridge St., Saugerties, N. Y. / Magnetic Core Materials / page 45 / CA No. 140

Hughes Research and Development Laboratories, Culver City, Calif. / Digital Computer Techniques/ page 31 / CA No. 141

Lockheed Aircraft Corp., Burbank, Calif. / Career Opportunities / page 37 / CA No. 142

Machine Statistics Co., 27 Thames St., New York 6, N. Y. / Punch Card Tabulating Services / page 39 / CA No. 143

Monrobot Corporation, Morris Plains, N.J. / Monrobot Computer / page 47 / CA No. 144

Ortho Filter Co., 198 Albion Ave., Paterson, N.J./ Plug-In Units / page 35 / CA No. 145

Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y. / Magnetic-Tape Handler / page 36/ CA No. 146

Raytheon Mfg. Co., Foundry Ave., Waltham, Mass./ Magnetic Shift Register / page 38 / CA No. 147

Remington Rand, Inc., 315 4th Ave., New York 10, N. Y. / Univac / page 43 / CA No. 148

Sprague Electric Co., 377 Marshall St., North Adams, Mass. / Wire-Wound Resistors, Pulse Transformers / pages 41, 48, back cover / CA No. 149

Sylvania Electric Co., 1740 Broadway, New York 19, N. Y. / Subminiature Tubes / page 5 / CA No. 150

If you wish more information about any products or services mentioned in one or more of these advertisements, you may circle the appropriate CA No.'s 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.

REPLY FORMS: Who's Who Entry; Reader's Inquiry

Paste label on envelope:↓

BUSINESS REPLY LABEL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

4¢ Postage Will Be Paid By —

BERKELEY ENTERPRISES, INC.
36 West 11th Street
New York 11, N. Y.

FIRST CLASS
PERMIT NO 1680
Sec. 34.9, P. L. & R.
NEW YORK, N. Y.

Enclose form in evelope:↓

IDENTIFICATION

Name (please print)..........

Address..........

Organization (& address)?..........

Title?..........

(Please fill in completely)

WHO'S WHO ENTRY FORM

Year of Birth?..........

MAIN INTERESTS:
( ) Design
( ) Construction
( ) Applications
( ) Sales
( ) Electronics
( ) Mathematics
( ) Business
( ) Programming
( ) Other (specify):..........

College or last school?..........

Year of entering the computing machinery field?..........

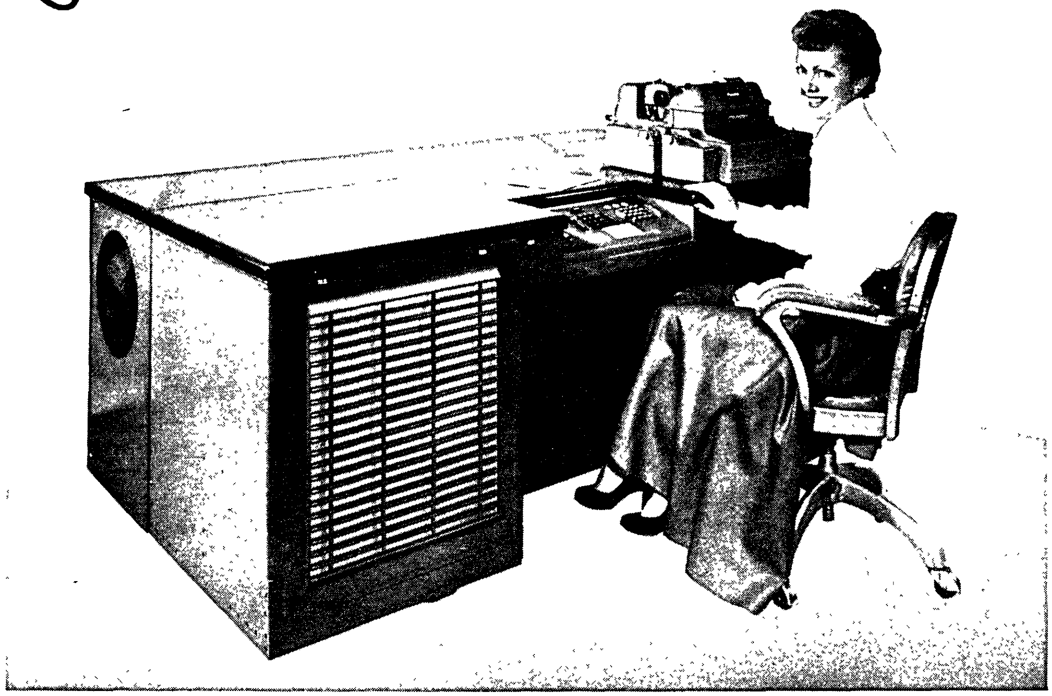
Occupation?.......... (Enclose more information about yourself if you wish — it will help in your listing.)

READER'S INQUIRY FORM

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

MONROBOT ELECTRONIC CALCULATOR



The MONROBOT is a general purpose digital computer, compact, ruggedized, reliable and reasonably priced. In the MONROBOT, decimal numbers are used. Since twenty digits are available, with a centrally located decimal point, there is no need for scaling or setting of decimal point. Neither overflow nor translation techniques are necessary. Orders are written for the calculator in virtually their original algebraic form.

Neither highly trained personnel nor extensive training effort are needed for the MONROBOT. Keyboard and automatic tape operations are counterparts of the simple programming procedures. Average office personnel become familiar with MONROBOT operation the first day. It prints out results on 8-1/2" wide paper roll, or perforates a paper tape as desired.

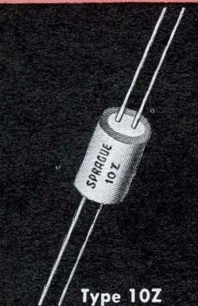
MONROBOT V is complete in one desk-size unit, ready to plug in and perform. MONROBOTS can be supplied with capacities to suit special requirements, avoiding excess investment for unnecessary facilities.

MONROBOT CORPORATION

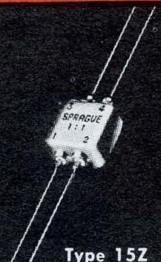
MORRIS PLAINS NEW JERSEY

A SUBSIDIARY OF MONROE CALCULATING MACHINE COMPANY choose from this complete line of

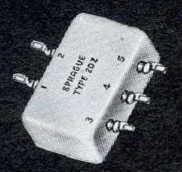
MINIATURE PULSE TRANSFORMERS



Type 10Z
tubular pulse transformer



Type 15Z
miniature bathtub pulse transformer



Type 20Z
drawn-shell bathtub pulse transformer

Type 40Z
cylindrical pulse transformer

NOW YOU CAN CHOOSE from eighteen standard pulse transformers in four major construction styles, all in quantity production at Sprague. The standard transformers covered in the table below offer a complete range of characteristics for computer circuits, blocking oscillator circuits, memory array driving circuits, etc.

These hermetically sealed units will meet such stringent military specifications as MIL-T-27, and operate at temperatures up to 85°C. Special designs are available for high acceleration and high ambient temperature operation. In addition, the electrical counterparts of each transformer can be obtained in lower cost housings designed for typical commercial environment requirements.

Complete information on this high-reliability pulse transformer line is provided in Engineering Bulletin 502A, available on letterhead request to the Technical Literature Section, Sprague Electric Company, 000 Marshall Street, North Adams, Massachusetts.

ELECTRICAL CHARACTERISTICS OF SPRAGUE PULSE TRANSFORMERS

Type No.	Turns Ratio	Pulse Width μ seconds	Rise Time μ seconds	Primary Inductance	Leakage Inductance	Repetition Rate	Load and Output	Typical Applications
10Z1	5:1	0.1	0.04	200 μH	5 μH	1 to 2 MC	15 volts 100 ohms	Used in digital computer circuitry for impedance matching and inter-stage coupling. Pulses are of sine wave type.
10Z2	4:1	0.07	0.03	200 μH	20 μH	1 to 2 MC	20 volts 100 ohms	
10Z3	1:1	0.07	0.03	125 μH	12 μH	1 to 2 MC	20 volts 200 ohms	
10Z4	3:1	0.07	0.03	160 μH	15 μH	1 to 2 MC	20 volts 100 ohms	
10Z6	4:1	0.1	0.04	200 μH	6 μH	1 to 2 MC	17 volts 100 ohms	
10Z12	1:1	0.25	0.02	200 μH	2 μH	12KC	100 volts	Blocking Oscillator
10Z13	1:1	0.33	0.07	240 μH	2 μH	2KC	50 volts	Blocking Oscillator
10Z14	7:1:1	0.50	0.05	1.2 mH	20 μH	1MC	25 volts	Impedance Matching
15Z1	3:1	5.0	0.04	7.5 mH	22 μH	10 KC	10 volts 100 ohms	Impedance Matching and Pulse Inversion
15Z2	2:1	0.5	0.07	6 mH	15 μH		40 volts	Blocking Oscillator
15Z3	5:1	10.0	0.04	12 mH	70 μH	10 KC	10 volts	Impedance Matching
15Z4	1:1.4	6.0	0.1	16 mH	15 μH	0.4 KC	15 volts	Blocking Oscillator
20Z1	5:5:1 Push-Pull	1.5	0.25	4.0 mH	0.3 MH		5 volts 10 ohms	Memory Core Current Driver
20Z3	6:1	1 to 4	0.22	18 mH	0.8 MH	250 KC (max.)	21 volts 200 ohms	Current Driver
20Z4	6:1:1	1 to 7	0.25	55 mH	0.3 MH	50 KC (max.)	22 volts 400 ohms	Current Driver and Pulse Inversion
20Z5	3:3:3:3:1	2.4	0.2	2.8 mH	0.2 MH		2.5 volts 6 ohms	Memory Core Current Driver
20Z6	11:1	6.0	0.2	90 mH	0.2 MH	50 KC (max.)	10 volts 75 ohms	Current Transformer
40Z1	7:1:1	0.50	0.05	1.2 mH	20 μH	1 MC	25 volts	Impedance Matching

Sprague, on request, will provide you with complete application engineering service for optimum results in the use of pulse transformers.

SPRAGUE® WORLD'S LARGEST CAPACITOR MANUFACTURER

Export for the Americas: Sprague Electric International Ltd., North Adams, Mass. CABLE: SPREXINT

HPB-950B