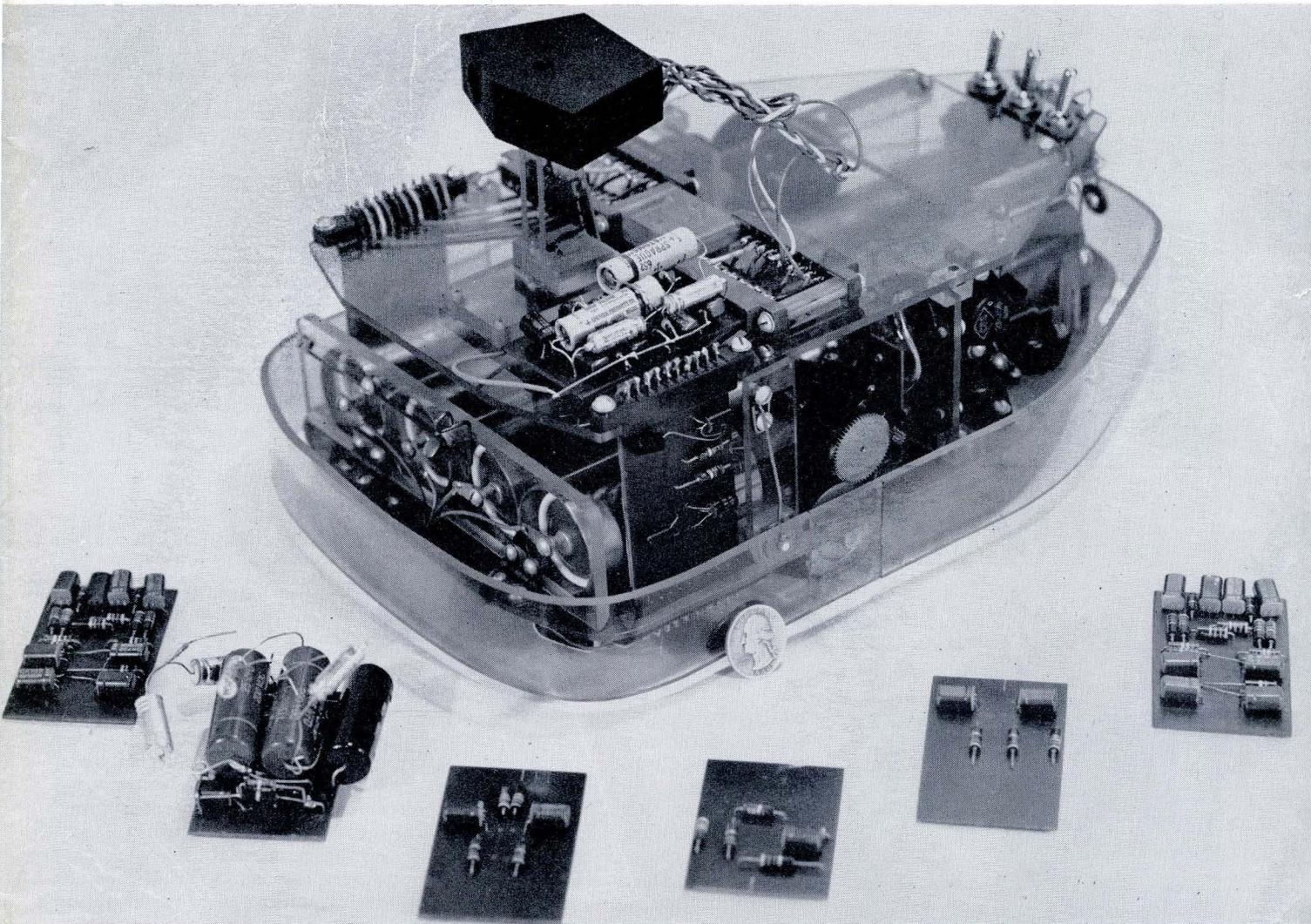


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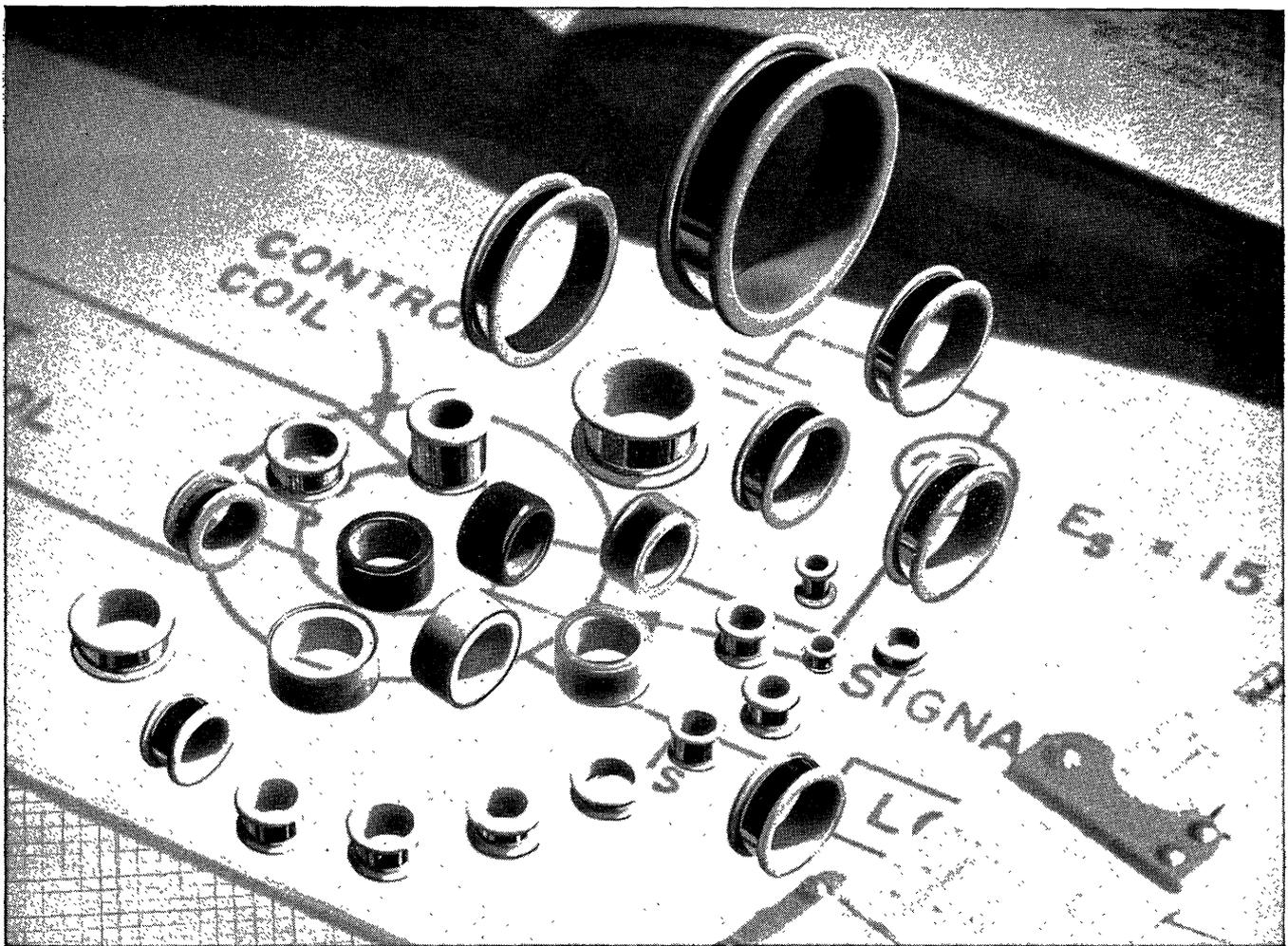
VOL. 7 - NO. 2

An Electro-Mechanical Model of Simple Animals

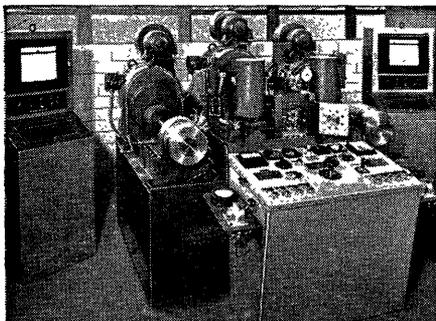
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Readers' and Editor's Forum

FRONT COVER: MACHINA VERSATILIS

THE FRONT COVER (which is also Figure 1 of the first article in this issue) shows an electro-mechanical animal, the September, 1957, model of Machina Versatilis, made by Ivan Sutherland. This machine is a successor to the earlier models made by William R. Sutherland and Malcolm G. Mugglin. This machine has two wheels forward (each separately driven) and one rolling caster rear (none visible in the picture), two "eyes" (photoelectric cells) inside the dark plastic at the top of the central post, and a bumper of plastic all the way around, to sense obstacles. The coin gives an idea of the size. Different plug-in circuits vary the behavior and the intelligence of the animal.

CO-OPERATION IN HORROR

ONE OF the papers recently submitted to COMPUTERS and AUTOMATION to consider for publication was entitled something like "diffusion calculations on the [trade name] electronic computer." It came from a writer at the U.S. Army Chemical Corps, and referred to a "chemical munition, which is designed to disseminate an agent in the form of a gaseous or aerosol cloud which will travel near the surface of the earth." The phrase "poison gas" was avoided, but that is the concept which leapt into your editor's mind.

This paper reminded me of some of the problems which the Nazis put into arithmetic books for young German boys to study in the days when Hitler was developing the Nazi state. One problem, as I remember, asked the youngster to calculate how many bombs would be required to destroy a circular town, given that one bomb would destroy such and such an area, and given the diameter of the town.

I can well imagine that if automatic electronic digital computers had been available in Nazi Germany, they would have been applied to computations such as finding out how much nerve gas would be economically necessary to kill stated numbers and distributions of Jews in the concentration camps of Buchenwald, Dachau, Maidanek, . . . (The Nazis in fact put to death over 6,000,000 Jews, unarmed and captive.)

There are weapons which can be used for defense and not for offense, like a radar warning network. There are weapons that can be used for defense and for offense both, like a fighter aircraft. And there are weapons that can be used for offense only, like poison gas and biological warfare, such as the spreading of a mortal disease that only one combatant has an antitoxin for. (Incidentally successful biological warfare is probably more scientifically efficient than any kind of atomic bomb, because it selects human beings and puts them to death, leaving enemy property intact and the air of Earth uncontaminated by any radioactivity—a weapon completely "clean" in the language of the Atomic Energy Commission.)

COMPUTERS and AUTOMATION for February, 1958

To look back in history, there are other weapons used for offense only, and especially against captives: torture, starvation, operations to change the character or virility of a prisoner, the torture of a prisoner's wife and children in front of him, . . .

All these fields are open to science, the scientific method of investigation and experiment, the solving of intricate problems by automatic computing machinery.

But is there no *horror point*?

Is there no point at which a self-respecting human being should say "I cannot do this—I cannot study this, investigate this, publish this . . . I cannot have anything to do with this: this is horrible"?

President Eisenhower on Jan. 10 in his State of the Union Message to Congress said "In the last analysis, there is only one solution to the grim problems that lie ahead. The world must stop the present plunge toward more and more destructive weapons of war, and turn the corner that will start our steps firmly on the path toward lasting peace."

In agreement with that view, we trust that it will be a very long time if ever before COMPUTERS and AUTOMATION publishes articles dealing with "diffusion calculations" on the spreading of poison gas.

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- Military Electronics
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Abstracts outlining the subject matter of the paper should be forwarded promptly for consideration by the technical program committee; closing date is February 28. Address all entries or inquiries to the Technical Program Chairman, IRE 7th Region Conference, Senator Hotel, Sacramento, California.

[Please turn to page 13]

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An Electro-Mechanical Model of Simple Animals

William R. Sutherland
Malcolm G. Mugglin, and
Ivan Sutherland

Scarsdale and Troy, N.Y.

(Based in part on a thesis submitted by W. R. Sutherland and M. G. Mugglin to the Department of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N.Y.)

OUR SUBJECT lies in a novel and relatively unexplored field: to make a machine that mimics some of the characteristics of living things. To do this requires a combination of electronics and biology; yet it is difficult to bridge the gap between two fields so far apart. However, we have constructed and studied some electro-mechanical models of simple animal life, and the purpose of this article is to report on what we have studied and constructed and to discuss some of the implications.

We should like to acknowledge our indebtedness to W. Grey Walter, Claude Shannon, W. R. Ashby, and other scientists who have examined automata and robots, either theoretically or with working models. For example, W. Ross Ashby in England has built a device which he calls a homeostat. It behaves like a sleeping cat which when poked finds a comfortable position and goes back to sleep. It has a very large number of possible stable states so that whenever it is disturbed it methodically searches until a new stable state results.

W. Grey Walter has published an account of the "life and habits" of an electro-mechanical creature which he built and named mock-biologically "Machina Speculatrix." When placed in a room or other suitable environment it would immediately *begin to explore* following a cycloidal pattern. Speculatrix would turn from its wanderings to investigate lights. It was attracted to light of medium intensity and repelled from strong light. When it bumped into an obstacle it would back and turn until it had freed itself. During the time it was escaping from an obstacle, Speculatrix had no interest for lights. This singleness of purpose is necessary for it to avoid becoming caught on the horns of a dilemma. Neither could it be caught between two lights of equal intensity but would go first to one and then to the other. It was also capable of recognizing itself in a mirror because of a pilot light on the creature itself. Last but by no means least, when its battery began to run down it would seek out its "hut" and go there to be recharged. A later attachment was added to the animal so that it could learn. This involved the analogy of a conditioned reflex so that it could be taught that "sound means light" and hence would come into the room on hearing a whistle.

It is becoming increasingly apparent today that there are similarities between the behavior of electronically controlled machines and that of certain animals. Since we design computing machines to carry out operations

that seem logical to us, we should not be so surprised when they show some of the same tendencies and susceptibilities that animals do; nevertheless we are. Somehow we find it difficult to admit that machines may behave in a life-like manner.

An electro-mechanical model has many advantages over the animal it imitates. Parts are interchangeable, closer control and measurement are possible, and a better understanding of the mechanisms involved may be afforded.

Desirable Characteristics

Some of the characteristics that are inherent in animals are difficult to accomplish in machines. The problem of learning and forgetting is one of these. Computing machines learn instantly and retain the information intact until cleared, whereupon they forget instantly as well. This is a desirable characteristic in a computing machine but is not a characteristic of life, which learns slowly and forgets slowly. The same objection may be raised in the case of Claude Shannon's mechanical mouse which fidgets its way through a maze bumping into the walls until it eventually reaches its goal. The second time it goes through the maze it remembers its way perfectly making no mistakes. It does not forget unless the machine is turned off, clearing the memory. A more life-like model should learn gradually through repeated trials and forget slowly if the experience is not repeated.

Another problem is that of getting some sort of unpredictable or experimental behavior. This is a rather knotty problem, and in the machines we have constructed it is solved in only a limited fashion, but in a way not inconsistent with the machine's low intelligence. The machine has a set of alternatives to choose from when it encounters a given situation. Which alternative it chooses is tied in with the problem of learning as we shall see presently. However, it should be obvious that if the model is to have any interest for most investigators, it must be somewhat unpredictable.

Another important characteristic to put in a life-like machine is curiosity. When placed in a strange environment, an animal will begin to explore, encountering many varied situations. This was lacking in one of our earlier models. The lazy thing just couldn't be bothered to look for some fun but preferred to sit idly until something stimulating it came along.

A model of an animal should also have a more than

passing interest in its surroundings. It should actively seek some goal such as a light as a moth does. Curiosity plus goal-seeking provides a basis on which more complex behavior can be built.

It is of course inevitable that such a model will run into many obstacles during its explorations. Some means of escaping from these "stumbling blocks" must be provided.

A group or small society of these mechanical animals must also have some way of communicating in a very simple fashion. Without this characteristic there would be little chance of getting any cooperation or analogous group behavior.

Finally, it is important to point out that there is a difference between models that imitate the *appearance* of life and those that imitate the *behavior* of living organisms. There was at one time a toy beetle on the market that illustrates this point quite well. It had two rear driving wheels and a front transverse driving wheel. It was so constructed that a feeler was in contact with the table top where it rested and the feeler was long enough and positioned so that it prevented the transverse driving wheel from resting on the table. The beetle would run forward until its feeler ran off the edge. The transverse driving wheel then would fall on the table and turn the beetle away from the edge. The same type of mechanism has also been mounted in a toy car. The important thing is not whether it looks like a beetle or an automobile, but rather that we have here a mechanism with a built-in "instinct" for self-preservation in a hostile environment.

These are some of the desirable characteristics of a model of animal life; however it is sometimes a problem of no mean proportions to design a working mechanism having these characteristics.

Power for Electro-Mechanical Animals

All life depends on energy obtained from some kind of food. A model of life must likewise obtain energy and should be able to store it for future use. However, the choice of a power supply for a model animal is somewhat limited. The power supply must be portable and therefore reasonably light; it must be independent of its environment except for "meal-times;" and it must not be too difficult to construct.

A gasoline or steam engine would be light and easily "fed" but, besides being difficult to connect to the driving wheels, a convenient size is not available. Furthermore, the fumes are a problem.

Compressed air would be a better source of power. We have experimented with an air tank and a windshield wiper motor and found that, although this system worked, it was too hard to control. Then too, high pressure air is not easily available.

A storage battery seems to be the most practical. It has some disadvantages, namely a low energy storage, high weight, and a long recharging time, but these are outweighed by its availability and ease of connection. Previous experience that we had with the electro-mechanical squirrel Squee of E. C. Berkeley, which used a six volt Willard wet battery, showed that a higher voltage source was definitely desirable. A higher voltage system would have less current drain, simplifying the control problem and extending the operating time between chargings. A surplus 28 volt Willard battery of

reasonable size was available and was the supply of the June 1957 models. In addition, some small but powerful 28 volt, DC series wound motors were cannibalized from surplus fans and became the driving motors.

But subsequently we transistorized and lightened the whole model animal. The September 1957 model (see Figure 1) contains three sets of dry batteries: about ten size D flashlight batteries; about six penlite batteries (for the transistors); and 2 Burgess 67½ volt batteries.

Steering and Driving

For steering, both Walter's Turtle and Berkeley's Squee made use of a single front wheel for both steering and driving. There were two rear wheels for support, free-running, much like a child's tricycle. This method has at least one serious drawback: it is mechanically difficult to construct. The driving motor must be mounted on the steering column, making it bulky and requiring brushes and slip rings. Therefore, we decided to use two independent front driving wheels and one free-rolling rear caster. Driving one wheel or the other provides a method of steering somewhat analogous to that of a caterpillar tractor.

Our first model animal (Spring, 1956) showed the advantages of these basic changes. As expected, the driving and steering systems worked well, and the higher voltage was a definite asset. Nevertheless this animal still left much to be desired. Its bumpers were unsatisfactory, and the battery needed to be mounted so as to be accessible without dismantling the machine. In addition the dynamotor, which was the plate supply for the vacuum tubes, drew too much current. We decided to switch to transistors and get rid of the vacuum tubes. Doing this had double effect; it eliminated not only the dynamotor but the filament current as well.

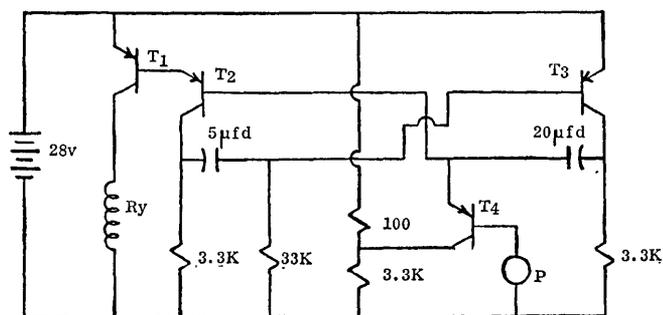
During the summer and fall of 1956 we started constructing a second model, which included desirable features lacking in the first model. The second model had a cast aluminum body, and its battery could be removed through the bottom. The battery was covered by a plastic case which supported the bumpers and many of the components. The bumpers themselves were bent out of plastic and hung from the battery case by four spring wires.

Permanent Senses and Active Responses

Once the power supply and the basic mechanics of the model were decided upon and worked out, our next problem was making the permanent senses. These senses are sight, hearing, and touch; and the responses are moving, squealing, and lighting up.

To control the motors, we need relays, but instead of a simple on-off control, each relay was run by a multivibrator, which pulsed it periodically (see Figure 2). Varying the repetition rate of the pulses provided a variable motor speed. This system proved to be quite satisfactory. The only drawback is sparking at the relay contacts. Each motor had an additional relay to control its direction (see Figure 3).

The model's eyes directly controlled the repetition rate of the multivibrator. The motor relays receive a pulse every two to five seconds when the model is in complete darkness. When the eye sees light, its resistance decreases, the pulses become more frequent, and the motor speed increases.



Circuit

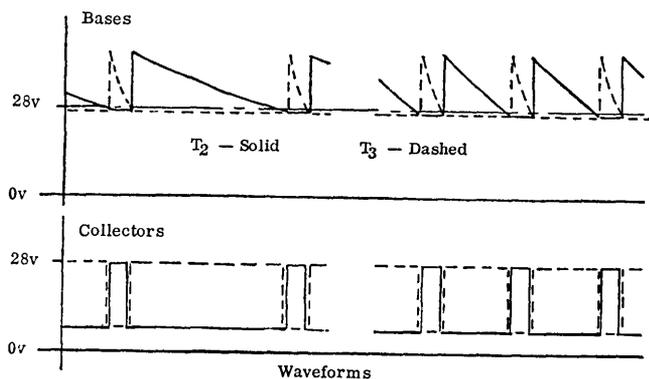


Figure 2. Multivibrator Motor Control. Note how T_4 provides a variable time constant which changes the spacing of the short on-pulses. T_1, T_2, T_3 — Cleveite 1032. Ry — Motor relay. T_4 — Raytheon CK 722, low leakage. P — Photocell, Clairex CL 3.

Each eye consists of a cadmium selenide "retina" (photo-cell) mounted in an eye socket. The socket limits the field of vision to a 30° cone. The eyes are mounted on a circular "head" so that the animal may be made to look in any direction. If the eyes are set at a slightly diverging angle, a light directly ahead will be seen by both eyes while a light moving to one side will pass out of one eye's field of vision before the other's. Connecting each eye to the opposite motor enables the model to follow a light. A light illuminating only one eye will drive the opposite motor, turning the machine until both eyes see equally well. If the head is pointed forward, lights are attractive. If the head is positioned sideways, a wary circling results. If made to look "over its shoulder," the model slinks away from the light like some forlorn nocturnal creature.

The plastic bumpers provide the model animal's sense of touch, enabling him to detect obstacles. The circuit adopted for obstacle evasion is shown in Figure 4. Each motor's direction is controlled by a neon tube oscillator and oscillates between forward and reverse. The two oscillators are independent of each other, making the resulting motion a random jiggling that will eventually take the animal clear of the obstacle. The rest of the circuit is a delay which continues the jiggling for about three seconds after the bump signal ceases.

Communication

The one construction problem we did not finish to our satisfaction was communication between animals. Making a voice was easy, but the model's ear was an

inherently difficult problem. The motors are noisy; the ear must reject this noise but yet pick up sounds from the other animals. This means either using a very loud "voice" in each animal or else filtering out the motor noise. Several attempts at filtering were made, none successful. So it seemed best to bypass the problem by moving the frequency into the rf range. 425 megacycles provides a reasonable antenna size ($\frac{1}{4}$ wavelength is 7 inches) and we had a small transmitter for that frequency. The receiver for each animal, however, has not yet been built. The use of this "hearing aid" transmitter to rebroadcast audible sound should cause no change in the external behavior of the model. In fact an observer could not tell the difference.

The last response included is a light mounted on each animal and controlled by a relay (see Figure 5). At present the light is connected so that it is on when the animal is moving slowly and goes out when motion becomes rapid.

To make the models versatile the components are mounted in interchangeable printed circuits. The wiring is made from a copper clad formica board by protecting the desired layout with tape, and then etching away the undesired copper.

The animal's brain, where the senses are connected to the responses, is also easily changed. It is mounted on a small chassis which plugs into the animal. Thus by changing brains a cowardly animal may be made into a ferocious beast.

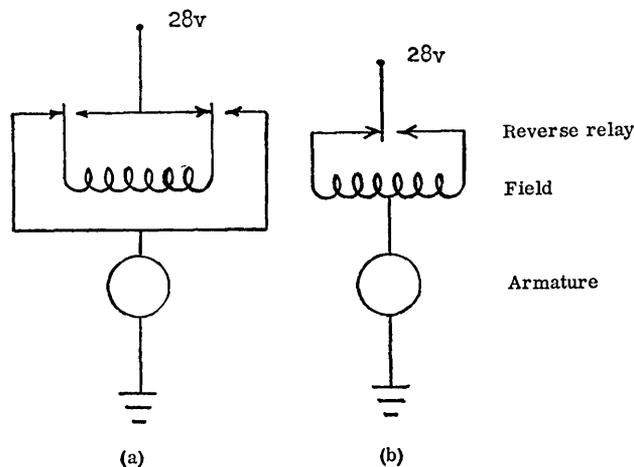


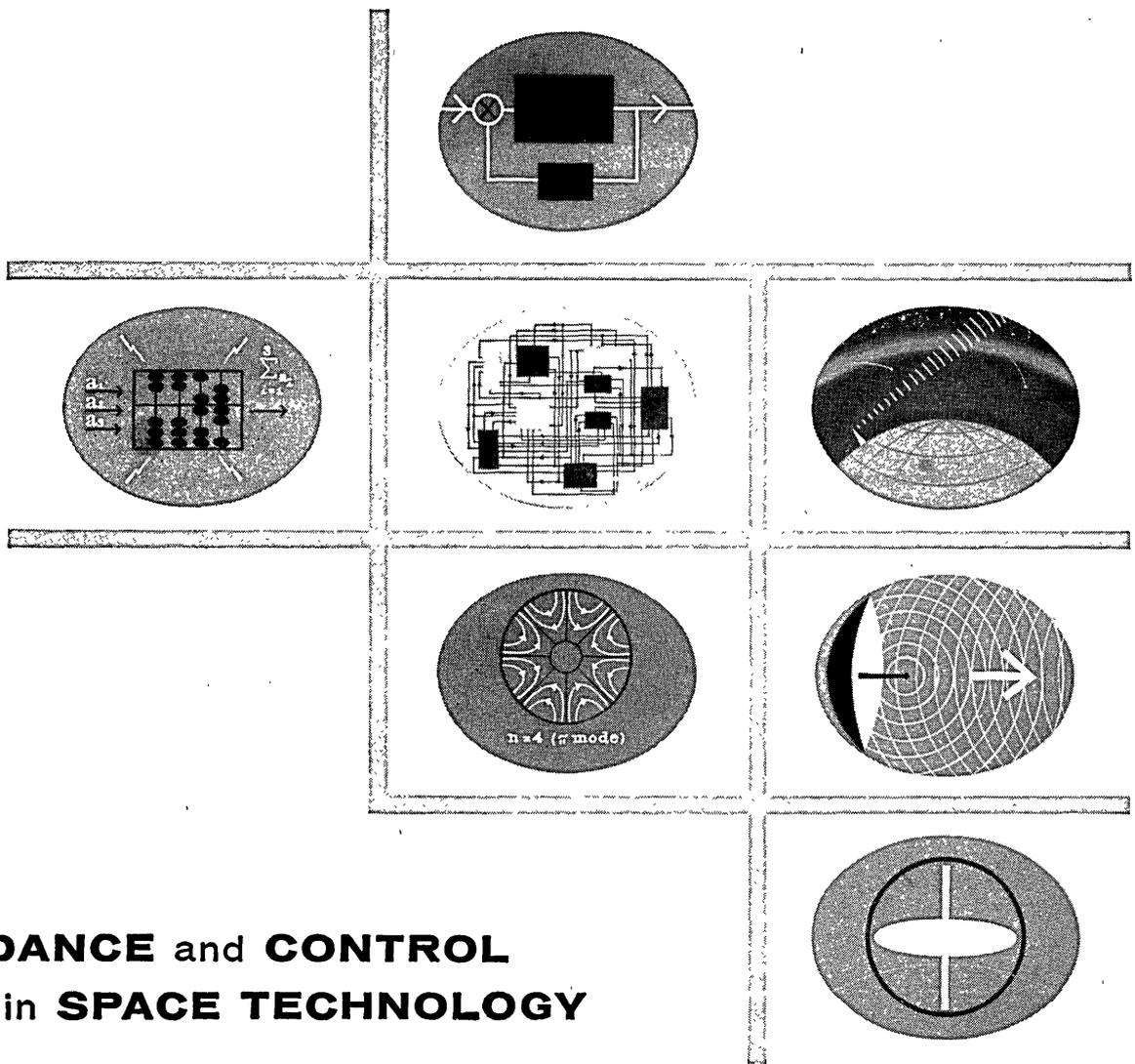
Figure 3. Motor Direction Control

Characteristics of a Brain

The most basic type of behavior is instinctive. Instinct is possessed by all animals. In fact, the lower forms of life operate purely as a result of it. If we were to consider the brain of an animal as a "black box," instinct would dictate that the inputs and outputs be directly connected. That is, the same stimulus would always produce the same response.

As we progress up the ladder toward higher forms of life, we find what might be called a "capacity for learning." This implies that there is a physical provision for switching between stimuli and responses, whether this provision is ever used or not. It is, there-

[Continued on page 23]



GUIDANCE and CONTROL in SPACE TECHNOLOGY

It is becoming increasingly apparent that many of the techniques and analyses, and much of the equipment, developed for the present Air Force ICBM-IRBM programs will have a wide future application in space technology. For instance, many of the guidance and control techniques for ICBM's are applicable to the space vehicles of the near future.

An important element of these applications is precision. The precision required of the guidance and control system for vehicles aimed at the moon or one of the planets is not substantially greater than that required for the Air Force ICBM-IRBM programs. And, the precision needed to guide a vehicle into a near-circular orbit of Earth is even less than that required for ICBM's.

The problem of communication with lunar and planetary vehicles is, of course, made more difficult by the much greater distances involved. This, however, is not an insurmountable difficulty if today's trends continue in the use of higher transmitted power, narrower communication bandwidths and amplifiers with very low noise-figures.

The problems of operating electronic equipment in the space beyond our atmosphere are already encountered on present ballistic missile trajectories. The principal difference in the case of space vehicle applications is the

requirement for longer equipment lifetimes. Electronic equipment and power supplies will have to last for several hours or days or weeks, instead of a few minutes, under conditions of vacuum pressure, zero "g" fields, and bombardment by micrometeorites, high-energy particles, and radiation.

The preceding examples serve to illustrate some of the ways in which the ICBM-IRBM programs are advancing the basic techniques of space technology.

Since 1954, Space Technology Laboratories has been providing over-all systems engineering for these programs. Both in support of this responsibility and in anticipation of future system requirements, the Laboratories are presently engaged in a wide variety of advanced analytical and experimental work directed toward the exploration of new approaches in space vehicle electronics, propulsion, and structures.

The scope of STL's work requires a staff of unusual technical breadth and competence. Engineers and scientists who are interested in advanced experimental development projects (as distinct from development for manufacturing, in which STL is not engaged) are invited to investigate the many opportunities on the Laboratories' Technical Staff.

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Comparing Digital Computing Systems: An Increasing Problem

John A. McGann

Alwac Corp. and Consultant
Williston Park, N.Y.

THE CHOICE between differing systems and approaches is a problem plaguing consultants, prospective users, and manufacturers of digital computers, alike. This mounting problem can be divided into two areas for exploration: the development of overlapping scales of equipment; and the advancing capabilities of peripheral equipment. A third area, the potentialities of special purpose devices in integrated systems, could be a further area to be considered; but the first two areas will be sufficient, however, to illustrate the topic being discussed.

When the approach to data processing problems was as simple as the input, memory, arithmetic, control, and output explanations of computers, the evaluation of a system was much less of a problem. Input, output, and files were defined; time was approximated; and cost was calculated. The early proposals prepared by consultants or manufacturers seemed to present a straightforward justification of a system under consideration. Many problems in applying systems had not come to the surface; but the concept of a definite array of equipment to do a job was not clouded with the considerations of alternate arrays utilizing differing system approaches.

Overlapping Scales

The first area of difficulty in planning occurred with the appearance of computing systems covering a wide range of costs and capabilities. The large-scale Univac, E.R.A., and I.B.M. 700 systems, and the medium-scale I.B.M. 650, Alwac, and Datatron systems, originally divided the field into the fixed and separated areas just mentioned. Then, developments of peripheral equipment made it possible to build up the price of the medium systems mentioned, and of more recent medium systems such as the File Computer, until the cost as well as processing capabilities in some instances fell into the large-scale range. This encouraged competition between medium-scale computers utilizing a variety of input-output equipment and larger systems.

The same effect can be noted between the large scale systems mentioned and the "giants" that have recently appeared on the market, such as Datamatic, Bizmac, etc. The problem is more intense between the medium and large scale systems, however, since there are more systems available in these areas.

Also, there are systems under development which will fall in between the scale classifications mentioned, and this will add to the difficulties of comparison. It has been suggested that these systems, which include the Alwac 800, N.C.R. 304, and Datatron 220, be classified as intermediate, but there will be a tendency to discuss their capabilities as large-scale and show that their prices start in the medium-scale region.

The consultant or prospective user realizes that his system considerations must not only include the approaches that could be taken with a large-scale system but also those that could be taken with a medium-scale (or intermediate) system utilizing a stated quantity of peripheral equipment. These considerations may also have to pit a large-scale system against 2 or 3 medium-scale systems. The two or three medium-scale computers might approach the job in the same fashion as a large-scale computer; or they might divide the job vertically, each computer handling a specific phase of the total job. The accompanying diagrams (Figure 1 and Figure 2) illustrate this difference in system approach in terms of a generalized area of file maintenance, inventory control.

This job shown in Figure 1 could be divided on two medium scale computers so that half of the master file would be updated on Computer 1 and the other half would be updated on Computer 2. Or, the job could be divided vertically as shown in Figure 2.

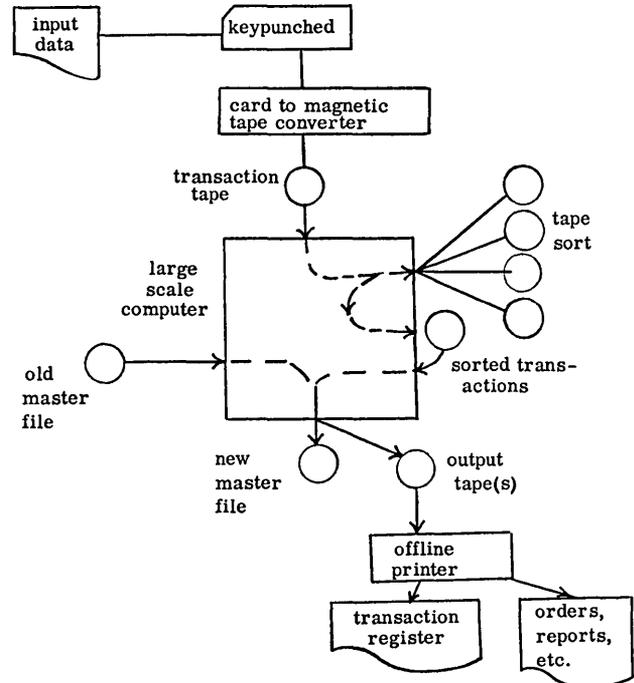


Figure 1. Inventory Control on a Large Computer (Generalized)

Of course there are other variations of these systems. In addition, the cost of one large system may be so high as to allow a three computer system to compete. Before discussing other approaches, it will be necessary to explore peripheral equipment. Then, a more extensive

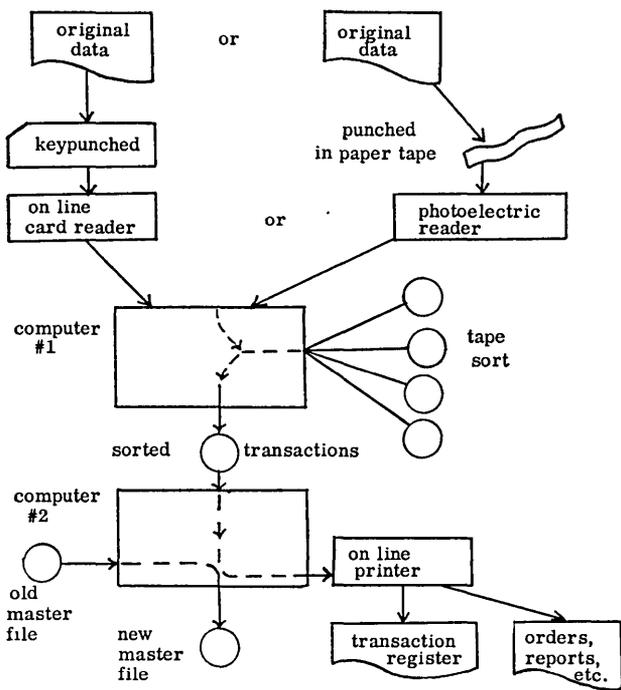


Figure 2. Inventory Control Using Two Medium-Scale Computers

comparison of systems and an elaboration of techniques of comparison can be introduced.

The Capabilities of Peripheral Equipment

Peripheral equipment has expanded to embrace a variety of on-line and off-line equipment. The on-line equipment, or devices which operate directly from or to the computer, include card readers and punches, paper tape readers and punches, low-speed and high-speed printers, magnetic tape systems, and random access devices. The off-line devices which operate to or from magnetic tape apart from the central computer, include card readers and punches, low and high-speed printers, and graph plotting devices.

The development of efficient on-line buffering and editing devices has made it difficult to compare the relative benefits of on-line and off-line equipment. In effect, it may be possible to prepare efficient techniques utilizing either alternative although particular problems may favor the concentration of output for off-line printing, reading input in order from an on-line device, etc.

In addition to the foregoing deluge of possibilities, magnetic tape systems have been improved and modified. It is now possible to search magnetic tape systems for a specific field of data recorded on tape or to search for a location on tape. Some tape systems have also been provided with buffers that make simultaneous tape work possible. On-line record searching, and random access from normal tape units, are applications possible with these tape systems.

This situation in regard to peripheral equipment has made it possible for a problem to be processed in a variety of ways utilizing the same computer with different arrays of associated equipment. Consequently, the prospective user, consultant, or manufacturer must constantly juggle different arrays and varying approaches as processing is planned.

Moreover, this problem is hardly static: the equipment available can hardly be isolated and examined, for there are not only new computers but new peripheral devices flowing from the cornucopia of the industry.

Varying System Approaches Illustrated

Let us consider some more variations of equipment for the inventory problem, different arrays of equipment and different system approaches, all directed toward a generalized inventory control application.

Figure 3 shows two medium-scale computers dividing the job horizontally. This system could also provide output by having both computers supply an output magnetic tape for off-line printing by a high-speed printer.

Figure 4 shows a vertical division of processing, accomplished with an off-line sorting of transactions, and selection of active records by an off-line magnetic tape processing device.

Figure 5 shows a medium-scale computer with one (or more) random access units. Two or more medium-scale random storage systems could divide the job horizontally.

Figure 6 shows one (or more) medium scale systems using advanced magnetic tape drives and an additional form of input, on-line typewriters or add-punches.

The inventory file could be rewritten weekly, monthly, etc., with the additions incorporated. For the tape systems which can search on the actual contents of a word, the additions would be inserted in an account number order in accordance with the dictates of the particular application or company. In the systems which search for a location, the additions would be placed in open spots or at the end of the file in accordance with the computer techniques of calculating location.

Figure 7 shows a medium-scale system dividing the inventory on different types of storage as to frequency of activity.

There are many additional areas in which these systems may vary, such as:

1. Inquiry: (a) an on-line manual system; (b) an off-line magnetic tape or drum inquiry system; (c) special inquiry transactions entered through the normal

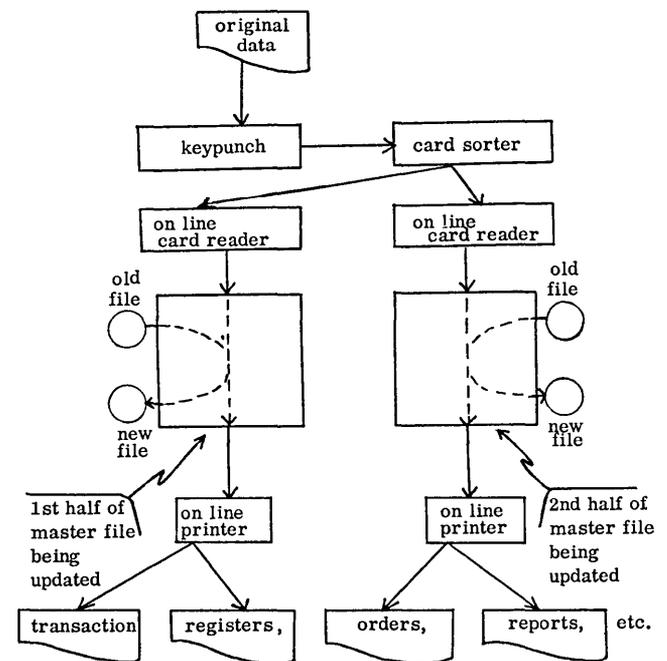


Figure 3

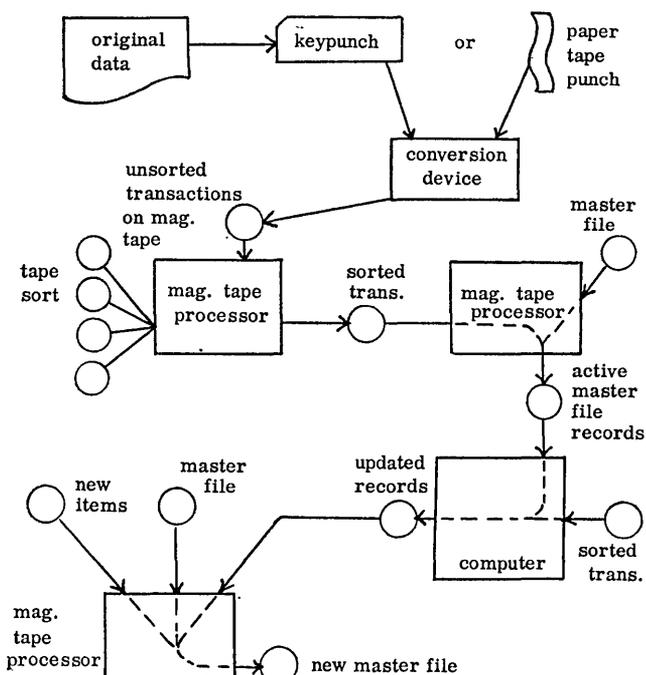


Figure 4

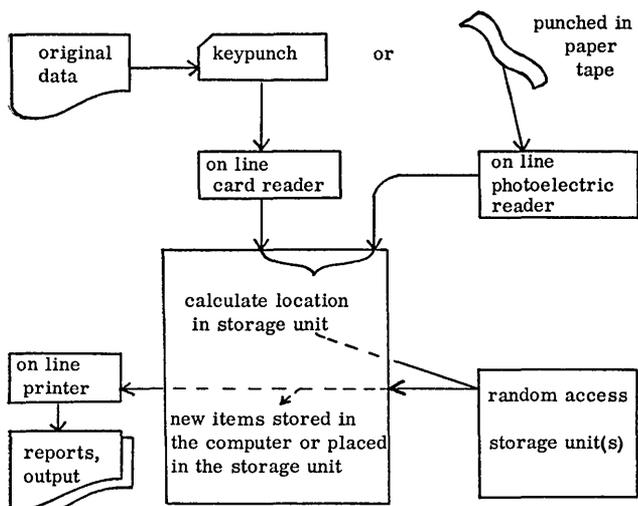


Figure 5

(a) and (b). The first two digits of a 5-digit account number might refer to a general area of computer storage. The last three digits might refer to the requirements of the application. This would reduce computer searching or look-up to some extent. (d) Computer searching could also be reduced by having the computer generate the tape or drum location of a particular record by a mathematical treatment of the account number used. If this were done, there would be limitations upon the account numbers chosen for new accounts outside of the computer area. In the generation of a location from an account number (or from a name and address), redundancy, or the generation of the same location from different alphanumeric combinations is always possible.

The Problem of Multiplicity

These facts illustrate the multiplicity of choices that are available in planning a data processing installation. These choices involve not only many arrays of equipment but also the variety of system approaches that are possible with different devices.

The multiplicity of choices, however, has its advantages. In fact, the major aspects are encouraging for the development of commercial and scientific data processing. The greater range of capabilities that are now available, make this possible.

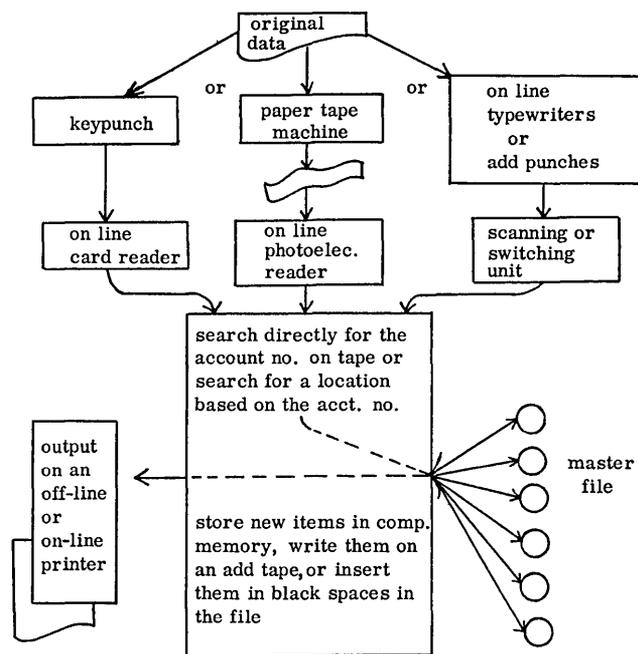


Figure 6

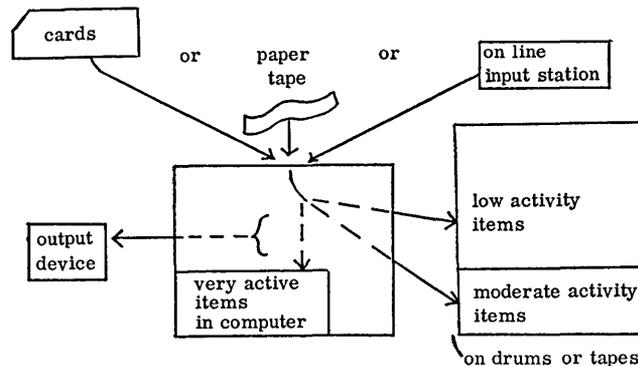


Figure 7

input scheme; (d) an off-line printout to be used for inquiries; (e) special inquiry periods during which the computer is to be interrogated with on-line devices.

2. Final output preparation: (a) the output may be prepared with on-line or off-line printers (an off-line printer will make a tape available, the one used to create the printout, for other purposes such as off-line inquiry, permanent records, source of later printouts, etc.); (b) one high speed printer with a plugboard (but no counters), or two or more low-speed printers with plugboards and counters could be employed. Both types of printers can be employed on-line or off-line.

3. Account number system: (a) The account number system can be determined outside of the computer area in relation to the requirements of the particular company and application. (b) The account number system can be determined by computer area requirements. The account number could refer to the location of a particular record on magnetic tape or on a drum. (c) The account number system could be a mixture of the types

The greater range of capabilities has a strong influence on system planning. The prospective user can devote more attention to his requirements and less to the reorganization that previously might have been necessary in order to make use of the limited capabilities of a computing system. Although a prospective user may find it helpful to understand the types of devices that are present in the field, he may not have to know fine details of particular devices.

Since each manufacturer will try to interest a prospect in the most economic system using his own equipment when he is competing against other manufacturers, much of the burden of weighing peripheral systems is removed from the prospect and placed on the manufacturer. The prospect can examine proposals from the standpoint of asking which system will accomplish the job for the least amount of cost (direct and indirect). The computing systems, together with peripheral equipment, which are most favorable, can be examined further.

Safeguards in this type of examination should be introduced, however. It might be necessary to test part of a job at a contract computing center on equipment like the equipment being considered or examine a production line or installation already using the equipment. These steps would be for the two purposes: to make sure that the machinery is or will be available; to make sure that it can accomplish the processing being considered.

Many computer prospects, however, are rather overwhelmed with the comparison of various systems and conflicting system approaches. For them the general type of approach discussed may not be usable. Sometimes these prospects may have to pioneer systems themselves, or await future developments, and study for some time the experience of others. However, in general, the present variety of computing systems has brought the possibilities of electronic data processing to a much larger market of users. Their solution to the multiplicity of choices will basically depend on cost, power, air conditioning, space, inquiry time, personnel, system material (reels of magnetic tape, paper, etc.), etc. These parameters will be computed for many different combinations of equipment, until solution very likely to be the best is reached.

Readers' and Editor's Forum

[Continued from page 4]

WESTERN JOINT COMPUTER CONFERENCE — LOS ANGELES, MAY 6 TO 8, 1958

David Parry
Los Angeles, Calif.

A NATIONAL SYMPOSIUM on modern computer design methods and application techniques, at which leading authorities in the field will argue the relative merits of various systems and components, will take place in Los Angeles beginning May 6 at the Ambassador Hotel, at the 1958 Western Joint Computer Conference. An unusual panel discussion, with the general theme of "Contrasts in Computers," will devote three full days to a thorough debate of six controversial subjects in the field of computer design and application.

The idea, according to Montgomery Phister, Jr., Technical Program Chairman, is that: many different organ-

izations all over the United States are designing and using computers in many different ways. Each organization has developed its own set of procedures and, although it is aware of other ways of doing things, it is generally convinced its own way is the best. The purpose of the debate is to bring these contradictory points of view together at one place and time so that they can be argued and compared.

The topics scheduled for this debate are: "Logical Design Methods," contrasting block diagrams and logical equations; "Active Elements for the Machine," contrasting magnetic cores, cryotrons, transistors, and special vacuum tubes; "Logical Circuitry for Transistor Computers," examining the comparative values of resistor-transistor, direct-coupled, symmetrical and STRETCH logic and "Solution of Ordinary Differential Equations," which will consider the relative advantages, in this respect, of general-purpose computers, analog computers, combination digital and analog, and digital differential analyzers; "Command Structure;" and "Very Large Files."

In addition to the panel discussions, individual papers will be presented during the course of the conference, which is scheduled for May 6, 7 and 8.

SMALL AUTOMATIC COMPUTERS AND INPUT/OUTPUT EQUIPMENT — A REPORT FROM THE MANUFACTURERS — MAY 9, 1958

Fred Gruenberger
Santa Monica, Calif.

THE LOS ANGELES Chapter of the Association for Computing Machinery is sponsoring a one-day symposium on the topic "Small Automatic Computers and Input/Output Equipment — A Report from the Manufacturers." This symposium is in conjunction with and immediately following the 1958 Western Joint Computer Conference, and will be held on May 9, 1958.

The program will be announced shortly. The talks will be restricted to the newest, most advanced, and most recently publicized equipment, and will stress the viewpoint of the user of the equipment, rather than the logical designer or circuit designer.

A similar symposium held in conjunction with the 1957 Western Joint Computer Conference was devoted to large-scale computers, and attracted over 600 people.

Persons interested should write for further information to Program Chairman, Fred Gruenberger, The RAND Corporation, 1700 Main Street, Santa Monica, California.

INTERNATIONAL CONFERENCE ON SCIENTIFIC INFORMATION — REQUEST FOR PAPERS

Secretariat, ICSI
National Academy of Sciences
Washington 25, D.C.

WE WISH to ask for the co-operation of COMPUTERS and AUTOMATION in publicizing the plans for the International Conference on Scientific Information, which is to be held in Washington in November of 1958.

We are very eager that those persons in the computer field who are interested in the problems of storage and retrieval of scientific information shall have an oppor-

[Please turn to page 32]

Automatic Programming for Business Applications

Grace M. Hopper

Automatic Programming Development

Remington Rand Univac Division

Sperry Rand Corporation

Philadelphia, Pa.

(This paper was presented at the Armour Research Foundation symposium in Chicago, October 24, 1957, and is reprinted with permission.)

ONE OF THE elements propelling the industrial revolution was the principle of division of labor. It involved breaking down the work of the craftsman into component tasks and designing techniques and machinery to carry out these operations in order to mass-produce goods. It predicted using highly trained people only on tasks where their training was required and assigning simple, repetitive work to less skilled employees or to machines.

Studies of the costs of programming business data-processing problems indicate that these costs are too high, for the initial job of getting a system on a computer, for the changes required for normal maintenance of the programs, and for the alterations suggested by the evolution of a smoothly running system. Use of the computer itself to assume part or all of the coding burden was indicated by experience with automatic coding for mathematical and engineering problems. The substitution of the machine to execute a part of the programming task demonstrated a need for re-examination of the whole task and for evaluation of its component parts.

It was found that the definition of programming was vague. To some it meant only producing and debugging computer coding; for others it included system analysis and problem definition. Traditionally — if there can be tradition in such a youthful industry — the programmer's task had included numerical analysis and selection of the approximation technique, flow-charting, preparing computer code, debugging, and finally, supervising the production running of the problem. Programmers were selected for training on the basis of degrees or backgrounds in the mathematical and exact sciences. Learning another symbology — the computer code — was a normal development in the working life of a mathematician. The problems with which he dealt were stated in familiar concepts and symbols.

At first the professional mathematician was attracted by the new problems of minimizing storage requirements and increasing computational speeds, but it was not too long before this mathematical programmer became bored with the continual rewriting and recopying of groups of instructions which could be included by more powerful symbols. This line of thinking, together with the desire to write such "subroutines" into a pro-

gram only once in order to conserve storage space, led to the "interpretive" routines. These systems served to reduce training time, to make the computer more directly available to scientific personnel, and to shorten debugging time.

However, the interpretive routine increased computation time by the amount of time required for the interpretation of the pseudo- or macro-instructions. Compiling routines met this problem by interpreting the pseudo-code only once and writing a computer-coded program ready to run the problem. Starting in 1952, compiling routines for mathematical problems have steadily achieved greater degrees of sophistication both in the pseudo-codes and in the efficiency of the running-program produced.

Simultaneously with the development of interpretive and compiling routines, the techniques of coding in a relative notation were developed. These permitted subdivision of programs and assignment of sections to several individuals. Assembly routines are used to combine these sections, allocate storage, and reduce latency time if so required. The interpretive and compiling routines were aimed at assisting the non-coder. The assembly systems, some of which shared abilities of compilers, were designed primarily to assist the programmers and coders.

The first attempts to carry automatic coding techniques into the data-processing field met with almost complete rejection. "The programs were not of the ultimate efficiency." "The pseudo-codes were incomprehensible." "The systems were cumbersome." Reactionary programmers could not believe that a computer could produce a routine which could compete effectively with hand-tailored coding.

At this time, it became acutely necessary to re-examine the entire sequence of events by which a "problem" or business system was transferred onto an electronic computer. Clearly, there were several steps in this procedure and each step required a different type of background and training of the personnel involved. Briefly recapitulating, the discernible elements are:

<i>Type of task</i>	<i>Type of personnel required</i>
Analysis and definition	Systems, methods, and procedures personnel; business-trained.
Programming	Logically minded personnel; possibly mathematically trained.

Coding	Personnel trained in manipulation of the details of the computer code.
Operating	Personnel trained, not only in the operation of the computer, but also conversant with coding, with service routines, and with debugging aids.

On the basis of previous experience in programming scientific problems, it was clear that the first possible point of attack was to replace the coder with the machine itself, keeping in mind the hope of eventually assisting the programmers, and ultimately the system analysts. Thus the problem could be stated some two years ago as: given some form of block chart or flow chart, required a program to produce computer coding for production running. This implied designing a system including a charting technique, a pseudo-code, a method of describing data, a compiler and its library, service routines, and operating and debugging aids.

Several basic objectives could then be immediately stated.

1. The charting technique and pseudo-code to be employed must describe the system—the problem—not a computer program. This condition led to the further statement, that the pseudo-code must be independent of any particular computer hardware, that it must be easy for the analysts to use with a minimum of instruction and a minimum of new symbology to learn.

2. The system developed must produce a highly efficient production program taking full advantage of all of the computer hardware and facilities.

3. It must not only be a simple process to debug the resulting program but also, service routines must be provided to facilitate debugging and for maintenance of the compiling system, just as service routines have been developed for computers.

Since it is the task of any programming group to conserve programming effort and design routines for as many applications as possible, it was clear that any such system must be a general purpose system. Careful study of the routines and programs in use in existing installations led to a major stumbling block. In almost no case were the subroutines alike in any two installations. Where it had been possible to freely transmit the mathematical subroutines from one installation to another, it did not seem possible to exchange data-processing subroutines. While the computation of the square-root of a floating decimal number remained the same in Pittsburgh, Los Angeles, and New York, the computation of gross to net pay obviously did not remain the same even in two installations in the same city. Not only did the arithmetical steps differ, but the position and relationships of the input data in the several files varied greatly, causing corresponding subroutines to bear but a skeletal resemblance to each other. Even in the cases of common computational sequence such as FICA, and income tax deductions, differences in the data-format gave rise to different subroutines. Obviously, it is a labor beyond the power of a Hercules to persuade business establishments to use a common data-format, except in the case of forms such as those required by the Internal Revenue Service.

Two requirements then are clear:

- 1) To provide a method of describing business data; i.e., files, items, records, messages, fields, etc.

- 2) To provide a means of writing, for a particular operation, the subroutine to execute that operation on the corresponding data.

Envisioning then a system for coding business problems, the concept takes shape as a compiling system with an associated library of "generators," service and data descriptions. From the condition that the systems and methods personnel be permitted to state problems in their customary language, followed the conclusion that the pseudo-code must be English words forming comprehensive if temporarily stilted sentences. Pursuing this line of thought, each sentence must correspond to an operation to be performed by the computer. Thus the sentences become imperative instructions to the computer. Further, since such sentences are to serve for any computer, the verbs initiating these operations must be sufficiently broad in action to transcend the computer hardware. Such orders as "compare inventory-on-hand with inventory-limit, if greater, go to operation 19; otherwise go to operation 13," "deduct group-insurance-amount from adjusted-pay, increment accumulated-group-insurance, and increment total-other-deductions," carry no implication that the computer involved has either drum or magnetic-core storage. The statement "input time-data file-A, payroll file-B" carries no indication that the data has been recorded on punched-cards, paper-tape or magnetic tape. (A sample page of such pseudo-code is included in Appendix A).

The verbs of such sentences correspond to "generators" in the library of the compiler, the nouns correspond to "data descriptions" stored, either in the library or accompanying the run description. Both terms require further definition. In the case of mathematical computation, it was sufficient to use a library of "two-word floating-decimal subroutines." It was then defined and completely determined that quantities would be recorded in two computer words, the first containing the normalized mantissa and the second the required power of ten. In data-processing, the quantities treated are not necessarily numbers of a single type but will include names and addresses, deduction codes, stock numbers, and stock numbers of substitute parts. Hence the data descriptions become more complex. For example, for each file it must be stated whether or not it is multireel, whether a block or record count is desired, the form of the reel labels, and any sentinels used in the file must be named. For each item or record, its noun name, its size (if standard) must be given, accompanied by the names of any keys used in sorting or merging the items. A field descriptor must include at least the size, the position of the field in the item, the positions of its sign and decimal point along with its name. Once such descriptions have been written, meaning has been given to such nouns as master payroll file, inventory limit, stock entry, or shift-code. Each installation may thus define its own noun vocabulary as required by the work to be performed and may retain its own familiar references.

Turning to the verbs, these correspond to the "generators" stored in the tape library of the compiler. When the phrase "compare inventory-on-hand with inventory-limit" is referred to the compare generator, the reference is accompanied by the descriptors of the two nouns. The generator can then write the exact, compact section of coding required to perform the particular comparison. Where an input-output generator receives the statement, that the input is to consist of "time-data

file A and payroll file B," it refers to the file descriptions to discover that the payroll file is multi-reel and will require "servo-swaps," that its label is of the form PAYNNN YYMMDD (indicating payroll, reel NNN, date in the form year, month, day), etc. All the information necessary to write the intricate input-output coding is available to the generator. It should not be surprising that it is possible to build such powerful generating routines—a single generator may be able to produce any one of thousands of possible specific static subroutines.

The procedure of program compilation is a data-processing procedure. Two files of information are supplied: the English sentences, (the pseudo-code) stating the sequence of operations to be performed, and the data descriptions, describing the subjects of the operations. These two files of information are processed by the compiling and generating routines to produce a third file of computer instructions, the production program.

Such techniques lie at the heart of the automatic coding systems now available to produce the coding for business systems. Several such coding systems are available with varying degrees of sophistication. These routines should not be written off as just another blue-sky automatic system. The savings in programming time and costs are greater than could have been anticipated. Naturally, the routines have been challenged and put to test. One such test presented to two Flow-Matic programmers a gross to net payroll run. They were given the pay regulations, the forms for the payroll register, and blank paychecks. It required just two weeks to prepare the process-chart, write the pseudo-code, compile the program, and run, correctly, a 4000-man sample.

A second test required that a systems man be trained in writing the "English" sentences. He charted the payroll and the labor distribution for a research activity. He developed a work-book and was able to turn over to a typist—a high school graduate of last June—the job of writing pseudo-code from the process chart. She also prepared the data-descriptions from his data-formats. She typed both sets of information onto tape and turned them over to a computer operator. The operator ran them through the compiling routine and ran test data through the resulting program. The test results were returned for checking to the systems man. They were correct. Meanwhile, the systems man had been freed to continue with the charting of another run.

These two examples were selected for description because they mark the attainment of several aims. The cost of coding can be materially reduced, the elapsed time shortened, debugging almost eliminated. The men who know the problem best can define the data-processing system and make use of the best coding supplied by the experience of sophisticated programmers. What effect does this have on the overall problem? One phase has been eliminated—the coding. A second phase, that of programming the system for the computer, has been assisted. Some of the most intricate and tricky coding, the input-output, matching and ending routines, and the logical manipulations that total at least 70% of all data-processing runs, have been wrapped up in neat packages to be delivered by the generators at the insti-

gation of but two or three sentences. The systems analyst and the programmer are freed to spend their time on the definition and improvement of the system instead of on machine programming and coding.

There is a next step—two in fact. One of producing a compiler with which to make compilers and the other to advance into the area of programming itself. Building on the existing automatic coding systems, an automatic programming system will be produced. It has been proved that such routines are feasible.

Where do these steps lead? The industrial growth of this country would have been severely limited had it not been for the conceptual and technical breakthroughs which led to what is now referred to as the industrial revolution. Just so the future and ultimate application of data-processing computers in the business environment will depend upon the development of automatic techniques which will both facilitate and economize the process of application of the equipment, to new business problems. It is increasingly apparent that the surface has hardly been scratched in exploiting the potential uses of computing systems in business. However, if electronic data-processing is ever to become an automatic, instantaneous, information source for business management, methods of automatic programming and automatic information control must be developed to a degree that can hardly be imagined today.

APPENDIX A

SAMPLE PSEUDO-CODE

- (30) TEST EDUCATION (A) AGAINST 4; IF GREATER GO TO OPERATION 33; IF EQUAL GO TO OPERATION 31; AGAINST 0; IF GREATER GO TO OPERATION 37; IF EQUAL GO TO OPERATION 5; AGAINST —IF EQUAL GO TO OPERATION 36; OTHERWISE GO TO OPERATION 5.
- (31) INSERT 2 INTO EDUCATION (A).
- (32) JUMP TO OPERATION 39.
- (33) TEST EDUCATION (A) AGAINST 8; IF GREATER GO TO OPERATION 5; IF EQUAL GO TO OPERATION 36; OTHERWISE GO TO OPERATION 34.
- (34) INSERT 3 INTO EDUCATION (A).
- (35) JUMP TO OPERATION 39.
- (36) INSERT 4 INTO EDUCATION (A).
- (37) JUMP TO OPERATION 39.
- (38) INSERT 1 INTO EDUCATION (A).
- (39) TEST EMPLOYMENT (A) AGAINST 4; IF GREATER GO TO OPERATION 42; IF EQUAL GO TO OPERATION 40; AGAINST 0 IF GREATER GO TO OPERATION 45; IF EQUAL GO TO OPERATION 5 —IF EQUAL GO TO OPERATION 43; OTHERWISE GO TO OPERATION 5.
- (40) INSERT 2 INTO EMPLOYMENT (A).
- (41) JUMP TO OPERATION 46.
- (42) TEST EMPLOYMENT (A) AGAINST 5; IF EQUAL GO TO OPERATION 43; OTHERWISE GO TO OPERATION 5.
- (43) INSERT 3 INTO EMPLOYMENT (A).
- (44) JUMP TO OPERATION 46.
- (45) INSERT 1 INTO EMPLOYMENT (A).
- (46) TEST FF (A) AGAINST 5; IF GREATER GO TO OPERATION 5; IF EQUAL GO TO OPERATION 51 AGAINST 1 IF GREATER GO TO OPERATION 49; IF EQUAL GO TO OPERATION 47; AGAINST 0 IF EQUAL GO TO OPERATION 47; OTHERWISE GO TO OPERATION 5.

INDUSTRY NEWS NOTES

DIGITAL TAPE SYSTEM: 90,000 CHARACTERS PER SECOND

A NEW COMPUTER input/output system using magnetic tape now provides transfer rates as high as 90,000 six-bit characters per second. This is called the Ampex Digital Tape System, made by Ampex Corp., Redwood City, Calif. It consists of four units: a tape handler; read/write heads; a special magnetic tape; and electronic circuits. The tape handler operates at a speed of 150 inches per second; it records two six-bit characters side by side on one inch tape. Alternatively, it can record on half-inch tape. The combination of the magnetic heads, the magnetic tape, and the amplifier circuits enable the density of packing information on the tape to be 300 bits per inch. The tape handler stops and starts in less than $1\frac{1}{2}$ milliseconds. The company engineers state that a life of at least 50 million start-stop cycles may be expected.

The speed of 90,000 characters per second compares with previous high speeds of 60,000 and 15,000 characters per second, and is likely to yield a marked advantage in cases where the limiting factor on the optimum use of a fast digital computer is the input/output transfer rate.

DIGITAL COMPUTER CONTROLLING OIL PROCESS

THE first RW-300, a digital computer for controlling a process, is being installed by the Texas Company at Port Arthur, Texas, to control a polymerization unit of a refinery. The computer will produce a better product, a greater output, improved yield, and lower operating cost.

The computer, until now made by the Ramo-Wooldrige Corp., Los Angeles, will henceforth be made and sold by a new subsidiary corporation, Thompson-Ramo-Wooldrige Products, Inc., Los Angeles, which will concentrate on industrial process control.

MILLIONS OF TINY FERRITE MEMORY CORES

A tiny magnetic core made of ferrite, known as the M 2, has gone into use by the millions in the memories of many computers now in production. This core, made by Ferroxcube Corp., Saugerties, N.Y., has an outer diameter of 75 hundredths of an inch, an inner diameter of 48 hundredths of an inch, and a thickness of 22 hundredths of an inch. It can be switched in $1\frac{1}{2}$ microseconds, and operates at 670 milliamperes of full current.

ELECTRONIC SYSTEM FOR AVOIDING AIR COLLISIONS

A DEVICE FOR avoiding collisions among aircraft, even the fastest jet airliners, has been announced by International Telephone and Telegraph Corp. The Civil Aeronautics Board has estimated that there are four "near misses" daily among the 140,000 aircraft in flight every day in the United States; this device is designed to eliminate those hazards of collision. It uses weather

radar for its "eyes." Four miniature antennas receive the weather radar reflected impulses that have searched a 90 degree cone extending from the nose of the plane as far ahead as eight miles. The impulses feed an electronic computer which computes the possibility and chances of collision. An indicator shows a course to safety by a red arrow; a warning horn informs the pilot, who steers the plane in the direction shown. The devices contain miniaturized components, weigh about 65 pounds each, and are expected to be coming off the production line in 2 years.

DOUBLE-LENGTH DOUBLE-STRENGTH MAGNETIC TAPE

A NEW KIND of polyester film, called "50-Mylar-T," or "tempered Mylar," for making magnetic tape of greatly increased strength, has begun to be manufactured by the Dupont Co., who have supplied it in pilot quantities to makers of magnetic tape. A prestressing process realigns the molecules in the tape, increasing the tension needed to break the tape from three pounds to six pounds.

One tape manufacturer, Audio Devices, has made small quantities of new magnetic tape from this material. They have named it "Super Thin Audio Tape on Tempered Mylar," and expect to reach quantity production of the new tape in several months.

HIGH-SPEED PRINTER

A NEW ALPHANUMERIC PRINTER called the Magnityper has been finished by Potter Instrument Co., Plainview, N.Y. It contains in one housing an assembly of mechanical printing elements, electronic storage, and an electronic system for comparing. It will accept any kind of a source for digital information. It uses transistors and magnistors. In each second it can print 10 lines of 120 alphanumerical characters, selecting any of 63 different characters.

Another printer known as Model 3260 has also been finished by the company. It can print 20 lines per second of 40 alphanumerical characters.

SELECTING AREAS IN PUNCHED PAPER TAPE ACCORDING TO ADDRESS

Friden News Bureau
Friden, Inc.
San Leandro, California

A NEW MACHINE in the integrated data processing field now, for the first time, allows punched tape to complete entire accounting procedures, from creation of the original document to selection of various components for subsequent analysis.

Marketed by Friden, Inc., of San Leandro, California, under the name of Selectadata, the machine makes possible the automatic selection and sorting of data encoded in punched tape, eliminating need for conversion to punched cards within the area of its code capacity.

It permits tape to skip through a reader quickly and accurately until a preselected address code is read. A

row of seven selection keys on the front panel of the Selectadata unit (size of small end table) offers a choice of up to 127 different address codes. When used in conjunction with the firm's Flexowriter and Solenoid-Operated Adding machine, it provides a low-cost tabulator.

Connecting the adding machine by a cable extends the Selectadata's sorting capabilities. In this way totals and sub-totals of quantity, price or other numerical factors may be obtained automatically as a by-product of listing selected item classifications. Readout on the Flexowriter is accomplished automatically at speeds over 100 words per minute.

The repeat-search operation of Selectadata makes it possible to perform a new type of data processing locally, directly from by-products of the original punched tape. This has particular advantage to many smaller business firms unable to afford large tabulating systems. The machine can also serve a big need in inter-department areas of larger business to meet such requirements as sales analysis and inventory control where on-the-spot reports can be prepared quickly with relatively inexpensive equipment.

Selection of items in billing or invoicing, selection of paragraphs or items in automatic letter writing, and alternate or selective program control can be accomplished easily. To adapt to cases where limited numerical information, such as insertion of the month, day and year, is a requirement, a Manual Data Selector may be incorporated in certain models. A Duplex Control Switch also provides for either a single item searching operation, or a repeat searching operation for all items having the same address code. Compound searching is possible by insertion of a stop code in the tape, so that a second search may be manually initiated for sub-classification items.

The Selectadata also provides help to the communications field by reducing the need for transmission of detailed coded data. It is possible to use identical master Selectadata tapes at two remote locations containing all the variables covering a large variety of products. Reduction of the actual transmission to address codes cuts the time and cost of telephone or teletype wire connections.

POST OFFICE OPERATIONS---A REPORT ON PROGRESS OF MECHANIZATION

National Bureau of Standards
Washington, D.C.

METHODS AND MACHINES to speed the handling of mail are the objectives of a current research program at the National Bureau of Standards. Under the sponsorship of the Post Office Department, the Bureau has established the basic principles of a system for automatically sorting letter mail and is presently supervising development of both large- and small-capacity prototype machines that embody the concepts of this system. The task is being conducted by a group of scientists and engineers from diverse areas throughout the Bureau whose efforts are co-ordinated by I. Rotkin (on loan from the Diamond Ordnance Fuze Laboratories). The Bureau is assisting the Post Office Department as part of its advisory service and because of its specialized experience in the field of data processing machines. Most of the actual equipment construction is being placed in the hands of private industry.

The handling of mail is now a major economic problem within the Government. The Post Office Department estimates that in 1956 it handled over 48 billion pieces of letter mail alone. The amount of mail has been increasing exponentially almost since the inception of the postal service, and indications are that this rate of expansion will continue for years to come. To keep up with this tremendous growth, the Post Office Department has been seeking mechanized methods to assist its personnel. In recent years, certain engineering techniques have been perfected that could well be applied to the mechanical sorting of mail. The potentialities of some of these techniques — such as punched card sorting and coded character reading — have been investigated by the Bureau to see how they could be applied to alleviate the large-volume high-speed letter sorting problem.

The Bureau's first task was to become familiar with the

organization and operations of the Post Office Department, particularly present methods of letter mail sorting. Through the co-operation of the Department, study tours were arranged at a number of post offices. Glossaries of postal terms, sample mail distribution schemes, statistical data relevant to mail distribution, and similar publications supplied further information. From direct observation during the tours and from a study of the publications, a broad overall picture was formed of the nature and magnitude of the letter mail sorting problem.

Detailed analyses of sorting operations were then begun and the development of specifications for sorting equipment undertaken. First, the statistical distribution of the physical characteristics of letters including size, shape, color, and location of address was studied. Then statistical patterns of sorting systems were analyzed for outgoing and incoming mail in post offices. Finally, coding systems were developed for abbreviating addresses in a standardized yet unique manner for efficient use with mechanical sorting equipment. It was decided that, if envelopes were imprinted with such abbreviated addresses in a dot code similar to teletype code, all sorting could be done by machinery. Electronic readers for dot codes are already well developed, whereas readers for printed addresses are in the early stages of development and no satisfactory readers have been proposed for handwritten addresses.

Once basic principles of handling letter mail were established, the next step was to design and to build the equipment. The Bureau undertook the development of one type of sorting system and invited industry to submit proposals for similar systems based on a general presentation of the problem. As a part of this development program, a contract was awarded to the Rabinow Engineering Company to develop the elements of its proposed sorting

machine which appeared to be suitable for use in large post offices. In addition to designing the mechanical elements of the machine, this firm also developed (1) an electro-mechanical-optical translator and an alternative magnetic core translator for converting address codes into machine instructions for distribution of letters by means of a conveyor to proper output bins; (2) a code printer with equipment for presenting envelopes to a human operator and for imprinting dot codes on the envelopes according to instructions by the operator via a keyboard; and (3) a code reader with a rapid letter feed system for converting dot-coded addresses into electrical signals for input to the translator.

Before mail is presented to any machine, it goes through several auxiliary operations. It is first culled to remove the too large, too small, or too thick pieces. The letters are faced to orient the stamps properly and to present all the addresses same side up. The mail is then fed into the stamp cancelling machine. At this point it is ready to be presented to the coding operators.

The operator reads the address on the envelope and operates a keyboard similar to a typewriter keyboard. By following certain fixed and simple rules of abbreviation, the operator imprints on the back of the envelope, in dot code form, a standardized abbreviated version of the address on the envelope. The degree of abbreviation depends on the volume of mail that is normally sent to the address in question. Post offices, streets, and individual addresses which receive very large volumes of mail may be given unique single-character codes to save the coding operator's time.

The letter is then mechanically transported to a code reader. Here electronic devices produce electrical signals from the dot code which in turn are passed on to a translator. The translator is an electronic or electro-mechanical device which converts the abbreviated address information from the dot code into another set of electrical signals, identifying a proper destination bin in the distributor. The translator incorporates a memory which contains all of the necessary destination information.

This destination information from the translator is fed to the distributor. The distributor accepts the envelopes from the reader and the destination information from the translator, and delivers the letter to the proper output destination bin. From these output bins, letters are removed, tied in bundles, and put into outgoing pouches, or in the case of incoming mail sent to the carrier stations.

Mail which has already been coded at some other location bypasses the culling, facing, cancelling, and coding operations and enters directly into the reader. Incoming mail is sorted in a similar manner except that culling, facing, and cancelling may be omitted because these operations will have been performed elsewhere. The translator for incoming mail would have impressed into its memory the incoming mail scheme, and the letters would be delivered to output bins according to carrier numbers.

The same machine can sort either incoming or outgoing mail simply by changing the information stored in its memory. Changes in the distribution system do not require altering the dot code. Only the information in the memory—which can be easily modified—need be changed to keep abreast of a growing postal delivery system.

At the Bureau a different sorting device is being developed which promises to be more compact than other proposed equipment and may save space in post offices. This device is not expected to be suitable for use in large sorting offices because its use requires sorting the same batch of mail several times. It is, however, well adapted to the scale of operations in smaller offices.

A parallel problem associated with facing and cancelling letter mail is under consideration. A method is being sought to make a postage stamp more easily recognized by electro-optical devices as a unique element on an envelope. Fluorescent and phosphorescent dyes, magnetic and conducting inks, and metallic laminates are some of the possibilities that have been investigated. The most promising results seem to be with a phosphorescent ink now being perfected at the Bureau. This ink will also be used in imprinting the code on the envelope.

A BALL-POINT PENCIL---IS A COMPUTER?

Ted F. Silvey

AFL-CIO National Headquarters Staff
Washington, D.C.

WHEN BALL POINT pencils originally were produced and marketed in the United States at the close of World War II, they sold for an individual price as high as the best quality fluid ink fountain pens—as much as \$15.00 each.

As more small metal balls became available, and research developed a cheap non-smear paste ink, separate mass production of the few standard components made possible sale of the pencils at prices down to \$1.00 each. Certain fancy styles still hold a price level of \$1.60 to \$1.95 on the retail market.

The development of fast automatic machinery specially designed for manufacture of ball point pencil components and their assembly reduced the manufacturer's cost still more, and the need to move the bigger production into the market brought big quantity buying for

advertising purposes. Ball point pencils with imprinted company and product names began freely to be handed out at conventions and meetings, and as "lagniappe" with sales of other merchandise.

In December 1955 there began to appear on the U.S. market the "package deal" of multiple pencils, each one a different color. The specimen set herewith consists of a plastic case, four ball point pencils (black, red, blue, green) and a pocket clip hair comb.

The first plastic cases were solid color back and front. Some of them were slotted for school boys to wear at their waist by putting them on their belt (which is far superior to wearing toy gun six-shooters!). More recent cases have had a clear face front which gives a full window look-through.

The package deal sold for 98 cents retail. With single

ball point pencils of comparable quality selling at \$1.00 or more apiece, there was obviously a substantial price reduction.

This item of merchandise is not shoddy, but of good quality. The pencils are soundly constructed. The ink in the central tube is bright, of strong color, and there is enough of it to write without smearing for many hours. Refills are available at low cost, but with the pencils so cheap the refills are hardly worth bothering with. By the time the ink in the central tube is used up, the bright brass of the pencil tip would be tarnished in use, and the whole pencil reaching the moment to be discarded. (By unscrewing the pencil at the middle of the barrel, the simplicity of the components is easily seen.)

My inquiry of the buyer at the New York department store where these packages of pencils were on sale — dumped into bin counters for customer self-service pickup to reduce selling cost — revealed they were NOT “loss leaders” to entice people into the store so they would be tempted also to buy a high-profit item.

The department store buyer said he was selling them at a profit, but he had been required to purchase 200,000 packages to get a low enough price to do so. My inquiry later of the manufacturer revealed the price to the department store was 60 cents, and that the manufacturers' actual cost was 52 cents. The manufacturer could make a profit with a mark-up of 8 cents, to allow the department store to have a mark-up of 38 cents to cover transportation, storage, handling, breakage and other loss, and profit.

During April and May, 1956, a still newer and faster

machine for fabricating components and assembling the ball point pencils was put into use. Permission for me to see the machine when I was at the factory in New York City was refused since it is a close secret. The important point is that there is no limit except sales for the output of this machine. The manufacturer by June, 1956, is producing three million completed pencils a month. He stated he could easily turn out six million, or even 10 million a month, and asserted he would be able to go to ANY QUANTITY if he had the sales.

The total number of ball point pencils manufactured in the United States in one year at current levels of business is 700 million. This volume is produced by 24 companies. The number of workers needed for this fabulous production is insignificant. The number of people needed with money in their pocket to buy this output is highly significant — in fact gives full meaning to the point that with automation the machines and instruments can do almost everything except buy what they make!

Other consumer goods items also are being manufactured in tremendous volume. Factories with such marvelous production machinery cannot operate full time, else the quantity of goods would stack up unsold. Companies in this situation then begin to diversify their output, making various kinds of items. But not too far in the future there is the remedy of more income for workers and shorter working hours — traditional trade union answers to increased productivity from science and technology. Either the shorter work week (maybe 4 days instead of 5) or the shorter work year (11 and then 10 months instead of 12) — both with full wage or salary income — will be entirely feasible.

OIL INDUSTRY COMMENTS ON COMPUTERS

Henry Packard, Methods & Procedures, Standard Oil Company of Ohio:

“It took us a full year of preliminary planning by top supervisors to get underway . . . then we had another full year of programming and training, in which key people in each department worked with programmers from Methods and Procedures to lay out processing by the machines.”

A noted oilman, as quoted by the American Petroleum Institute:

“We in the oil business are engaged in handling and moving a very heavy, bulky, rather low-grade commodity. We search for it in the bowels of the earth. We lift it out of the ground, put it in tanks, pump it out of the tanks and through a pipeline to a refinery where we lift it again, process it, put it in more tanks, clean it up, mix it up, put it on a ship or in a tank car or a truck or another pipeline, move it again to a terminal, unload it, load it up again, haul it to a bulk plant, unload it, reload it, take it to a service station, put it in another tank, pump it out once more into the customer's automobile tank, wipe his windshield, give him free air and water, and charge him, excluding taxes, three and one-half cents a pound. What other product that requires all of that human labor and energy in its handling can be purchased for anywhere near that price?”

Robert Wilson, Chairman of the Board, Standard Oil Company of Indiana:

“. . . the country's needs for energy are expanding so rapidly (certainly more than doubling in the next 25 years) that the ultimate problem is not what fuel is going to be crowded out, but what can come along to help carry the rapidly growing load. Petroleum's present advantage in most of its fields of usefulness is so large that only a very major increase in price could prevent it from having all the business it will be able to handle far beyond the next 25 years.”

H. E. Schnurr, Asst. Comptroller, Chairman Large-Scale Electronic Computing Systems Committee, Texaco Company:

“Best estimates are that more than 60 man-years of planning and preparation will be needed before all the new computer system's talents can be used. . . . A staggering amount of preparatory work must be done. But once the preparation has been completed, the system begins paying off, impressively.

“Most management experts agree on two important points when they discuss systems like the IBM 705. The new high-speed computers won't change management principles. They simply will cut down or eliminate management's reliance on intuition. And this they agree is a

real boon. Mathematics is a precise science; intuition is a highly fallible personal talent . . . Far from eliminating the need for people, these new systems will make people more important than ever to industry."

R. W. French, Standard Oil of Ohio, vice president in charge of production, after taking a course in the use of a giant computer:

"Because of calculations never possible before now, the oil industry should be able to recover 10 times as much oil as in the past."

Texaco Company Scientist, discussing refinery simulation:

"A complete material balance under a given set of conditions can be obtained in about 15 minutes, as compared with a week or more for the hand computation. There is no doubt that computers will achieve a significant increase in operating efficiency."

Arthur F. Endres, Manager Whitney Refinery, Standard Oil Company of Indiana:

"During the past few years, high speed electronic data processing equipment has become more and more important in the petroleum industry. In equipment like the IBM 705 we have a powerful new analytical tool which permits us to substitute for the intuitive solution to complex operating problems a more systematic evaluation of the real effectiveness, risk, and cost of the various solutions."

An oil company user of a giant computer:

"The cost savings are not the critical thing. We must decide: Do we or do we not need this information? If we need it, as in the case of cost control, it is worth money to us."

Esso, in announcing its marketing data processing center:

"Through gains in speed and accuracy, the new center will improve customer accounting service greatly and permit us to keep pace with the inevitable growth and expansion in the marketing of oil products. The steadily increasing demand for energy, and the comparable rise in the volume of statistical work make the use of the most modern methods not a luxury, but a necessity."

Anonymous:

"Accurate estimates of the effects of fracturing a well, of steam injection, of water flooding, and of acidizing (to mention a few cases) promise to yield very quick payouts for the mathematical and computer work involved."

Frank S. Slick, Comptroller, Ohio Oil Co.:

"The new computer will not only perform with greater facility the growing volume of work formerly processed on the old model, but will allow us to enter many new fields of data processing. The capacity, speed, and accuracy makes it possible to furnish management with frequent and timely computations on volumes of day-to-day business transactions and operating data. Our management can use these computations as an aid in making decisions affecting the operations and growth of the company to the benefit of our customers, stockholders, and employees."

J. W. Davis, Esso Standard Oil Company:

"In discussing these (linear programming) applications, we don't wish to imply that we 'turned the crank' and out

came a profitable solution. In many areas, as we formulated the problems, we found we needed data we didn't have, and sometimes it was necessary to ask for a sizeable laboratory or plant test program to obtain the data we needed. If solutions involved operations or dispositions of stocks that differed markedly from past experiences, we had to pilot blends . . . or operate under test conditions until we felt sure the solution recommended was sound."

INSTRUCTION



"A 40,000-word book of instruction accompanies the computer, and by the time the staff becomes familiar with it, it's obsolete and must be replaced with a new one."

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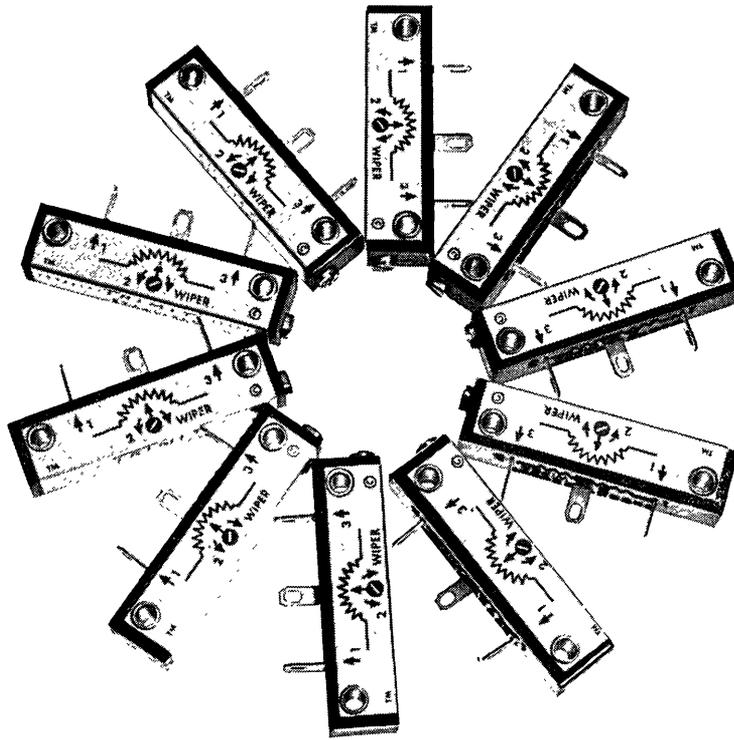
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An Electro-Mechanical Model of Simple Animals

[Continued from page 8]

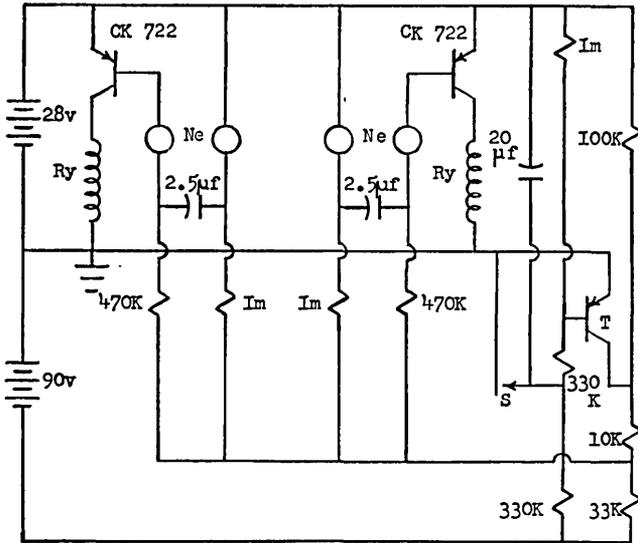


Figure 4. Improved Obstacle Evasion Circuit. T—Raytheon CK 722. Ry—Reverse relays. S—Bump contact.

fore, physically possible for the animal to change its behavior to meet the circumstances of the moment.

Obviously, two other characteristics are necessary before learning can take place. These are memory and association. One must not only recall but correlate past experiences before they become significant.

The highest function of a brain might be termed "intelligent behavior." This consists in making choices which are shaped by the learning process. Whether a

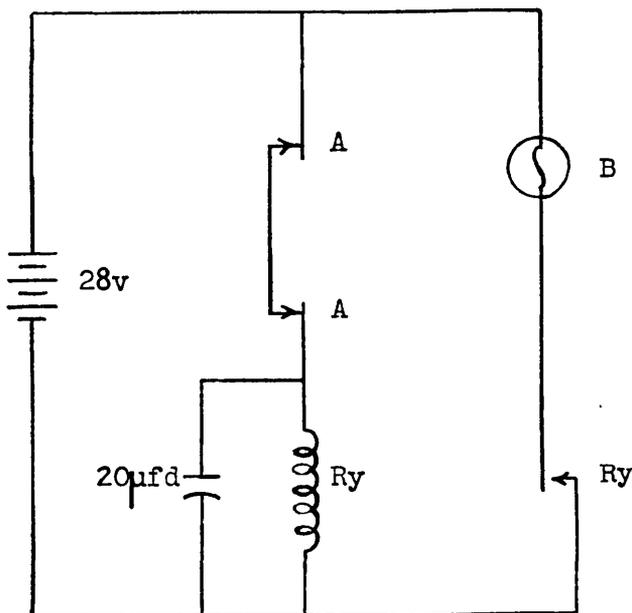


Figure 5. Light Control. A—Contact on motor control relay. B—Light Bulb.

choice is "intelligent" or not depends on whether the results are beneficial or not.

The problem is to design circuits possessing these

characteristics. Instinct is easy to imitate. Any behavior of a machine where a given input always produces the same output may be said to operate by "instinct." A capacity for learning is also easy to provide. All that is necessary is to design the model in such a way that there are many possible connections between the inputs and outputs of the "black box." Both of these characteristics were incorporated into our model.

As was previously mentioned, however, the problem of designing a memory that would learn and forget slowly seemed to be difficult. Walter's *Machina Docilis* had a memory that consisted of a slowly-dying oscillation in its conditioned reflex circuit. This type of a memory has a tendency to be unstable and somewhat complicated. Obviously what is needed is a physical phenomenon which has a long time constant and is electrically detectable (see Figure 6). After consideration of many highly impractical schemes, the answer turned out to be ridiculously easy. A thermistor potted in plaster of paris and mounted inside a hollow, ceramic resistor has exactly the desired characteristics. The phenomenon that has the slowly decaying characteristic is the temperature of the unit. Electrical energy is put into the ceramic resistor and is changed into heat. The thermistor has a high negative temperature coefficient of resistivity and functions as a detector. The rate of "learning" is controlled by the resistance of the heater while the rate of "forgetting" is determined by the amount of surrounding thermal insulation. This system has some advantages. One of these is that thermistors are available in many different shapes and sizes. Another is that the method is extremely simple.

The problem of association is the problem of designing a conditioned reflex. Here again the reader is

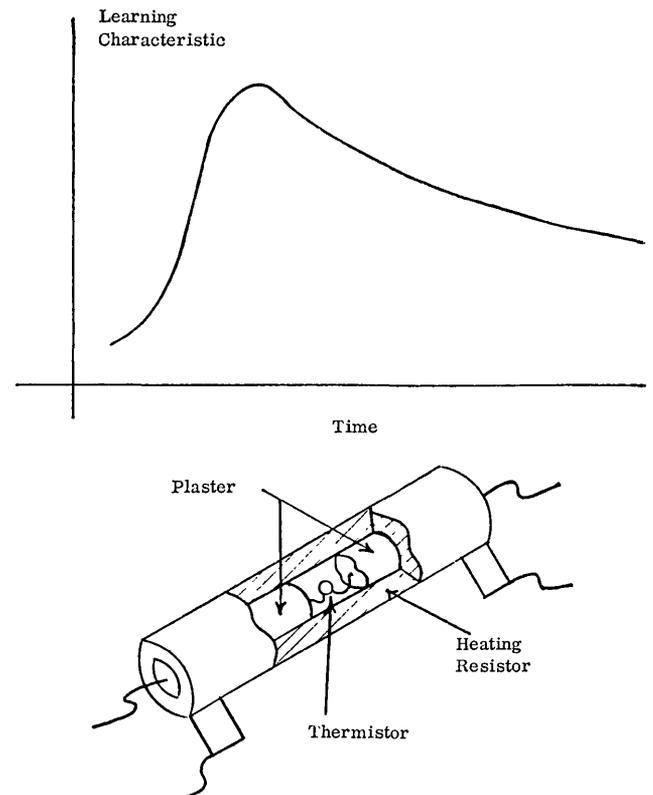


Figure 6. Learning Method

referred to W. Grey Walter's "The Living Brain." The chapter on the seven steps from chance to meaning gives an excellent discussion of the processes that are necessary for association. Dr. Walter has also built a circuit which embodies these processes. We therefore decided that rather than simply duplicate work so well done, it would be more profitable to investigate the intelligence aspect.

An intelligent being must first of all possess the power of choice. When faced with a set of properly defined alternatives, this hypothetical person must choose one alternative even if that one is to do absolutely nothing. To be properly defined, such a set of alternatives should be mutually exclusive and exhaustive. This is not really difficult to do. Cases where two alternatives overlap may be defined as new and independent alternatives, preserving the exclusive requirement. To make the set exhaustive, a "catch-all" alternative may be introduced to include everything that the model animal might do that is not one of the defined alternatives.

Each alternative has an associated probability of being chosen. The value of this probability is dependent upon many factors such as a person's previous experience, his emotional state at the time, or what he had for breakfast, perhaps. Certainly what he has learned from previous experience is not the least factor that shapes the probability distribution.

If the set of alternatives is mutually exclusive and exhaustive, then the sum of the probabilities is always unity. The effect of the learning process is to cause a redistribution or "flow" of probability between the various choices. Consider the following example. If we have a maze built in the shape of a capital T and we send a number of hungry rats through the maze, each one will be forced to choose whether to go right or to go left. If retracing is not allowed and we place food *always* on the right but *never* on the left, we should find that, on the first trial, about half will go right and half left. In other words, the probability of a particular rat going right should be about 0.5. However, after a number of trials, the probability of a rat going right should be considerably enhanced. In any given trial, we would never be able to predict which way the rat would go, but we would have a good idea of the probabilities involved. Learning, characterized by such a flow of probability may be said to complete whenever the flow ceases and the probabilities become stable. If the training is now stopped the rats should slowly but surely forget and the probabilities be correspondingly changed.

The ability of man to choose his course of action is often called free will. From a strictly external and objective point of view, it may be argued that free will means simply that the behavior of the organism is unpredictable in any given instance. The problem now facing us is to find a circuit possessing these three characteristics: learning and forgetting, its associated probability flow, and unpredictability.

In our search to find a circuit that would appear to choose quite randomly from a set of alternatives, we considered using a neon tube relaxation oscillator (see Figure 7). The operation of this circuit is such that the

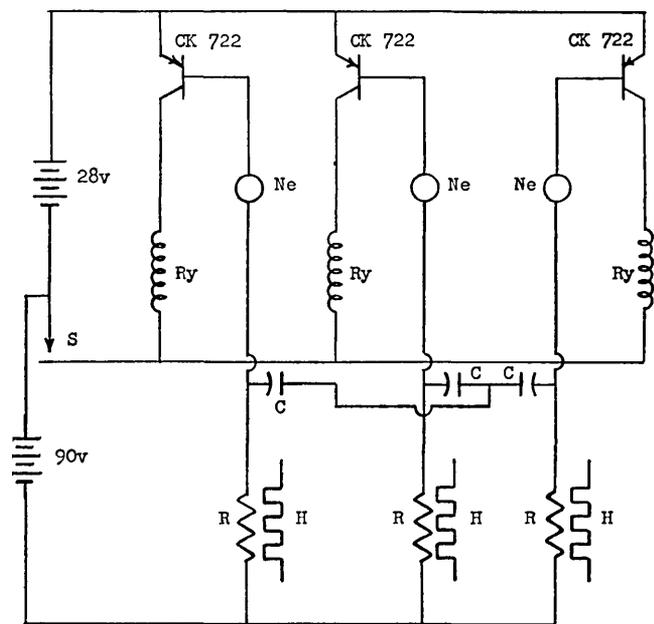


Figure 7. Probability Learning Circuit. H & R — Heating Resistor and Thermistor. C — Chosen with thermistor for desired time constant. S — Choice contact, closed momentarily.

neon tubes flash in sequence. At any given time one and only one tube is on. When the voltage across one of the others builds up enough to fire that tube, the sudden change in potential shuts off the tube that is on. Let the three tubes represent three alternative responses to a given stimulus and let whichever tube is on, at the instant the stimulus is applied, be the response that is chosen. This provides the desired unpredictability. It can easily be seen that the ratio of the time a particular tube is on to the total time for a cycle is the probability of that response being chosen.

All that is necessary to make this circuit possess the probability flow characteristic and the slow learning-forgetting characteristic is to vary the size of one of the resistors. The means of accomplishing this lies right at our finger tips. The thermistor-heater combination holds the key. The thermistor is substituted for one of the resistors and the heater is connected in such a way that the stimulus causes a brief heating current to flow. Applying heat decreases the resistance of the thermistor and increases the length of time that its associated tube is on in proportion to the others, so that the probabilities will change. What is more, they will change gradually as the thermistor heats and return even more gradually as it cools.

Our model now possesses a number of the desired characteristics under discussion:

1. Instinct — The model follows lights.
2. Capacity for Learning — The behavior of the model is flexible: there are many possible connections between inputs and outputs.
3. Memory — Thermistor and heater circuit.
4. Experimental and Unpredictable Behavior — Neon tube circuit.
5. Probability Flow — Combination of 3 and 4.

Actual Behavior of the Model

We come now to a discussion of the actual behavior of the model which we have constructed and which we have named *Machina Versatilis*.

The model is capable of following lights and is able to escape from obstacles. When the battery is placed in position and the switch is turned on, *Versatilis* begins to move. His curiosity causes him to begin to search immediately. How curious he is depends on the light level in the room. As the light gets brighter, he moves faster and faster. When a light source such as a bulb is presented to him, he turns and makes his way to it, always increasing his speed and interest as the distance grows smaller. Finally he literally comes roaring down on the light until he either runs into or passes under it.

If presented with an ordinary flashlight beam, he runs down it, sometimes wandering to one side or the other until one eye passes out of the beam, whereupon he turns back into it. In this situation, he behaves for all the world like some ungainly prototype of a guided missile. However he loses all interest for a lowly flashlight beam if the window shade is raised.

When two members of this species are turned loose together their behavior depends largely on the position of their heads. If one animal is looking forward while the other is looking backward, each will see the other's light and the one will chase the other. If both heads are turned sideways, the two will circle as if they were wary of each other. When both heads are turned forward however, they run together at full tilt and bump, scrape and fight at a great rate.

One other interesting thing ought to be mentioned. We built a toy for the animals to play with. It consists of a light mounted on a rolling platform. The animals are of course attracted to the light and appear to "have a good time" pushing it around. The more of them that can get at it at once, the merrier is the occasion.

The obstacle evasion circuit provides a good example of the model's big advantage over some animals. Initially the neon tube reversing circuits were so adjusted that the forward and reverse times were about equal. Unfortunately, this did not allow the model to escape from anything. To avoid frustrating the poor thing, it was necessary to unbalance the forward and reverse times. The model now reverses for about three times as long as it goes forward and thus manages an eventual escape from almost any situation. Changing two resistors did the trick for the model, but what can you change in a phototropic bug or moth?

Model Versus Animal

In any attempt to imitate something in the world about us, it is important to consider the success or failure of the model. How well does such a model as ours fit the biological facts of life? What characteristics does the model have in common with animals and where do they differ?

The reader may recall that the goal-seeking mechanism has a symmetrical construction with the two eyes cross-connected to the two motors. Practically speaking, it is simply a symmetry machine controlled entirely by the light stimulus. Is this characteristic of animals?

The answer is emphatically yes! One might then ask quite legitimately, "How so? Under what conditions may we treat an animal as a mere symmetry machine?" To answer this question, the following excerpts from Loeb's *Forced Movements, Tropisms, and Animal Conduct* are presented.

"If the velocity of the chemical reactions in one eye of an insect is increased by illumination, the muscles connected with the more strongly illuminated eye are thrown into stronger tension, and if now impulses for locomotion appear in the central nervous system, they will not produce equal responses in the symmetrical muscles, but a stronger one in the muscles turning the head and body to the light. The animal will thus be compelled to change the direction of his motion and to turn to the source of light until both sides again receive equal illumination. As soon as the plane of symmetry once more goes through the source of light, both eyes again receive an equal amount of light, the tension in the symmetrical muscles becomes equal and the animal proceeds to the source of light until some other asymmetrical disturbance is introduced."

Sounds familiar, doesn't it?

"If we bring about a permanent difference in illumination of the eyes, e.g. by blackening one eye in certain insects, we can also bring about permanent circular motions."

This is also true of the model. If one eye is blinded, it will run in circles. The motor connected with the blinded eye will still run, but it will be greatly hampered in so doing.

Loeb then goes on to point out the fact that a shark's eyes always move in the opposite direction from his tail so that he always looks in the direction in which he is swimming. He also points out that changing the position of a dog's head automatically changes the tension of the leg muscles. Furthermore, operating on a dog's brain produces many strange effects. If one side is damaged, circular motions result. If the occipital lobes are damaged, forward movements are difficult and if the back halves of the cerebral hemisphere are damaged, the dog shows a tendency to run madly forward without stopping.

One further example in the biological world ought to be presented because it shows the usefulness of one particular animal's attraction to light. The caterpillar is attracted very strongly to lights, but *only* when he is hungry. This attraction induces him to climb the stems of plants to get at the leaves which are his food. When he has gorged himself however, he loses this attraction almost completely, showing very little further interest in light. This is fortunate from the caterpillar's point of view because it allows him to climb back down instead of starving to death at the top when he has eaten all the leaves.

Walter's *Speculatrix* has a somewhat similar attraction. When it returns to its charging hut, if the batteries are run down and it is "hungry," it will enter and be "fed." If the batteries are well charged however, the light is too strong and is repellent to the creature.

The ability of our model to feel its way around obstacles is somewhat similar to the methods an ant might use to get past a book placed in its path. Both have a way of bumping and feeling their way until they are free to continue on. It is interesting to note that, in the case of the model, an encounter sometimes causes it to forget what it was looking for. If it is following a light when it bumps the obstacle, it sometimes takes off in a com-

[Please turn to page 32]

BOOKS and OTHER PUBLICATIONS

(List published in COMPUTERS and AUTOMATION, Vol. 7, No. 2, February, 1958)

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

Johnson, Clarence L. / *Analog Computer Techniques* / McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y. / 1956, printed, 264 pp., \$6.00.

The purpose of this interesting and useful book is to help an engineer, whether his specialty is electronics, mechanics, chemistry, or some other field, become a competent operator of analog computers. Topics include the historical development of electronic analog computers, description of linear computer components, scale-factors, servomechanism systems, representation of nonlinear phenomena, and some specific techniques for the solution of analog computer problems. The author throughout seeks to present the material so that it may be understood by readers having a minimum knowledge of mathematics and electronics; and he includes a valuable appendix which reviews mathematical and operational concepts.

Perry, J. W., and Allen Kent / *Documentation and Information Retrieval* / The Press of Western Reserve University and Interscience Publishers, Inc., Cleveland, Ohio and 250 Fifth Ave., New York 1, N.Y. respectively / 1957, printed, 156 pp., \$5.00.

This monograph is devoted to formulating a means for characterizing important aspects of recorded information so that information may later be efficiently retrieved from large files. It sets down some basic principles for meeting today's vast problems of librarianship. The authors develop a general theory—a mathematical model—for both the more traditional library procedures, and "more recently developed systems for accomplishing selection by automatic or semi-automatic devices." The text discusses such a mathematical model, it studies cost analysis of documentation storage, it analyzes traditional and new library systems, and it includes an up-to-date glossary of terms concerned with "machine literature searching." Mathematical discussion is held always at an elementary level.

Wilkes, M. V. / *Automatic Digital Computers* / John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y. / 1956, printed, 305 pp., \$7.00.

This book, written by the Director of the University Mathematical Laboratory, Cambridge, England, is a good general introduction to the "principles underlying the design and use of digital computers." The book is clearly written, and examples and illustrations are given. It discusses the development of the digital computer, the principles of logical design, programming, construction, operation, etc.; it does not enter into detailed discussion of electronic circuit techniques.

In the discussion of switching algebra, it is to be regretted that the old confusion between a proposition and its truth value is preserved, as on page 213 in "x = 1, the proposition x is true;" a proposition (example: the Pythagorean Theorem) and its truth value (example: true, yes, correct, 1) are of course entirely distinct. The Pythagorean Theorem is not equal to 1, although the truth value of the Pythagorean Theorem is equal to 1. It is not efficient symbolic procedure to use the same symbol for a proposition and for its truth value.

Goode, Harry H., and Robert E. Machol / *System Engineering* / McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y. / 1957, printed, 552 pp., cost?

What is this book about? "For more than a decade, engineers and administrators have witnessed the emergence of a broadening approach to the problem of designing equipment. This phenomenon has been poorly understood and loosely described. It has been called *system design, system analysis*, and often the *system approach* . . . System design entails many things: a new set of tools, a new classification of parts, an organized approach, albeit seemingly chaotic, and a team of workers."

What is the table of contents like? "Part 1, Introduction; Chap. 1, Complexity—The Problem; Chap. 2, Examples of Large Scale Systems; Chap. 3, An Integrated Approach to System Design. Part 2, Probability—The Basic Tool of Exterior System Design (5 chapters). Part 3, Exterior System Design (5 chapters). Part 4, Computers—The Basic Tool of Interior System Design (7 chapters). Part 5, Interior System Design (10 chapters). Part 6, Epilogue; one chapter; Chap. 31, Economics, Test, and Evaluation, and Management."

The authors attempt to weld together the ideas and techniques, for the new field of large-scale system design. Their approach is mainly introductory, requiring a mathematical background only through elementary calculus. The book presents current system methods, discusses the new sciences useful to system design, and furnishes information concerning the functioning of system-design teams. The authors endeavor to "familiarize the reader with the language and tools of the field." A bibliography is included.

Grabbe, Eugene M., editor, and 20 others / *Automation in Business and Industry* / John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. / 1957, printed, 611 pp., \$10.00.

This book is the published form of 19 lectures (some of them expanded) given to over 700 persons as an engineering extension course in the spring of 1955 at the University of California. The subjects of the lectures include: the language of automation, feedback control systems, basic concepts of industrial instrumentation and control, analog computers, digital computers, data processing, automatic control of flight, automatic control of production of electronic equipment, digital control of machine tools, etc. The authors discuss in general terms new trends in automation, their usefulness, and promise. The book makes good background reading for the layman in industry or business.

Kemeny, John G., J. Laurie Snell, and Gerald L. Thompson / *Introduction to Finite Mathematics* / Prentice Hall, Inc., Englewood Cliffs, N.J. / 1957, printed, 372 pp., \$6.65.

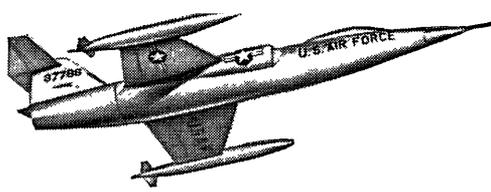
"A few years ago, the department of mathematics at Dartmouth College decided to introduce a different kind of freshman course . . . designed to introduce a student to some concepts of modern mathematics early in his college career . . . including applications to biological and social sciences . . . choosing topics which are initially close to the students' experience, which are important in modern day mathematics, and which have interesting and important applications. . . In order to write this book on an elementary level from a central point of view, we restricted ourselves to the consideration of finite problems, that is, problems which do not involve infinite sets, limiting processes, continuity, etc."

This is a good mathematics textbook on a modern college level, requiring of the reader at least two years of high school training in mathematics. The contents include: logical possibilities, truth values, statements, partitions, probability, vectors and matrices, linear programming, game theory, and applications of mathematics to the "behavioral sciences," including genetics, psychology, anthropology, and economics. The information is clearly presented; excellent exercises are included.

Fairbanks, Ralph W. / *Successful Office Automation* / Prentice-Hall, Inc., Englewood Cliffs, N.J. / 1956, printed, 355 pp., \$10.00.

This book refers to the "paperwork sea," system design, cost

[Please turn to page 36]



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AUTOMATIKA I TELEMECHANIKA

February to November, 1957

FOLLOWING are the papers appearing in the issues of *Automatika i Telemekhanika* (Automatics and Telemechanics), published by the Academy NAUK, Moscow, U.S.S.R., 1957, February (No. 2) to November (No. 11). These are taken from exchange copies sent to "Computers and Automation" by the Saltykov-Schedrin State Public Library, Leningrad, U.S.S.R. Each item ordinarily consists of: author / title / page. In some cases, the item includes all or part of the summary of the paper (each paper is printed in the journal with both a Russian and an English summary).

No. 2, February

- Aizerman, M.A., and Gantmacher, F. R. / Determination of periodic solutions in systems with a straight-line characteristic composed of line pieces parallel to the two given straight lines / 97
- Tsyppin, Ya. Z. / Correction of control and regulation pulse systems / 111
- Krasovsky, A. A. / On two-channel control systems described by equations with complex parameters / 126
- Kulebakin, V. S., and Domanitsky, S. M. / Control of speed of three-phase induction motors with bridge sensitive elements / 137
- Povarov, G. N. / A method for synthesis of computing and controlling contact circuits / Extract from author's summary: "The author generalizes Gavrilov's and Shannon's results concerning cascaded networks and proves a formula from which he deduces a simple and rapid method for synthesis of bridge-type and multiple output contact circuits. This new cascade method offers the designer a concise step-by-step algorithm resulting in considerable time saving and circuitry reduction. . . . Although the method developed here is powerful, it is no design panacea. . . ." / 145
- Slepooshkin, E. I. / Stable operation of a two-phase asynchronous servomotor with negative speed feedback / 163
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- Aizerman, M. A., and Gantmacher, F. R. / Determination of periodic solutions in systems with a straight-line characteristic composed of line pieces parallel to two given straight lines, Part II / 193
- Kutin, B. N. / On calculation of correlation functions of stationary random processes through experimental data / 201
- Gerchen Gubanov, G. V. / The investigation of the simplest relay servo-system / 223
- Berezin, S. Ya. / Improvement of dynamic properties of automatic control

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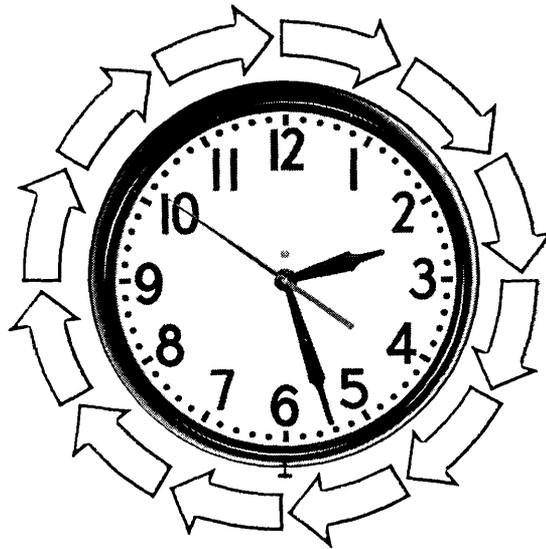
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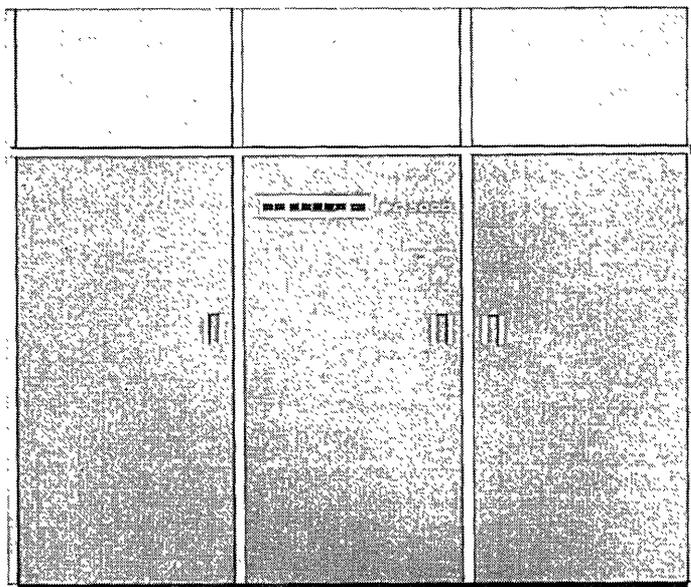
An independent nonprofit research organization, formerly a division of The Rand Corporation

- systems by employing aperiodic feedbacks / 229
- Svoboda, F. / Automatic synthesis of relay circuits / Extract from summary: "The paper describes a Czechoslovak semi-automatic experimental machine for the synthesis and analysis of combinatorial relay circuits with n switching variables, p inputs, and m outputs (n plus p plus m being not more than 12, and n being not more than 6). The machine operates with indeterminate switching functions and can be supplied at most with 384 values of 0 or 1 or either. Switching functions can be specified at most on 32 states (various substitutions of n variables). . . ." / 240
- Sotskov, B. S. / On criteria for estimation of electro-magnetic relays / 256
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- No. 5, May**
- Batkov, A. M., and Solodovnikov, V. V. / A Method of determining optimum characteristics of a certain class of self-adaptive control systems / Summary: "The paper deals with the problem of an optimum filtration for a group of linear systems with variable parameters when random inputs are applied. The filtration is considered optimum when the minimum of the sum of the squares of dynamical and mean-square errors is reached. The obtained optimum systems can be realized as self-adaptive ones, input characteristics being taken into account." / 377

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[Continued from page 13]

tunity to participate in the conference. Would you be so kind as to publish the following notice in *COMPUTERS and AUTOMATION*?

The International Conference on Scientific Information, planned for Washington, D.C., November 16-21, 1958, is sponsored by four societies: the National Academy of Science, the National Research Council, the National Science Foundation, and the American Documentation Institute.

The conference will be concerned with problems of scientific information, emphasizing in particular the storage and retrieval of information for all groups of users—from the individual scientist to the large-scale mechanized documentation centers.

The program committee is considering proposals for papers relevant to the subject matter of the conference as defined in the following seven areas which comprise the program agenda. They are:

1. Requirements of scientists for scientific literature and reference services: knowledge now available and methods of ascertaining their requirements.
2. The function and effectiveness of abstracting and indexing services for storage and retrieval of scientific information.
3. Effectiveness of scientific monographs, compendia, and specialized information centers in meeting the needs of scientists: present trends and new and proposed techniques and types of services.
4. Organization of information for storage and search: comparative characteristics of existing systems.
5. Organization of knowledge for storage and retrospective search: intellectual problems and equipment considerations in the design of new systems.
6. Organization of information for storage and retrospective search: possibility for a general theory of storage and search.
7. Responsibilities of governmental bodies, professional societies, universities, and research and industrial organizations to provide improved information services and to promote research in documentation.

All proposals for papers are being evaluated in terms of the following criteria:

1. Papers will deal with work that has not been published or presented at any open meeting. Work will be considered to have been published if it has been reproduced for general distribution in any form or if copies have been deposited in libraries where they are available to the public.
2. Papers will be directed to specialists in the field covered. Only sufficient background information will be included to serve as an adequate framework for new work described in the papers. More general background material will be indicated by references.
3. Papers dealing with systems and methods will describe these at length only when they have not been described previously. If new methods or systems are involved, these will be described in sufficient detail to enable other qualified workers to duplicate the procedures and the results. There will be sufficient information to enable qualified readers to judge the validity of results in objective terms.
4. Theoretical papers will clearly explain the factual basis from which theoretical conclusions have been drawn and will point the way to experimental methods of verifying predictions which follow from such theoretical conclusions.

Final drafts of proposed papers must be submitted by February 3, 1958. These will be reviewed by competent specialists in the various areas; accepted papers will be preprinted and distributed in advance to registrants. The plan of the conference provides that no papers will be presented orally; instead, their content will be discussed, area by area, by the authors and other participants at plenary sessions led by panels of scientists and information specialists. Observers will be welcome by registration in advance and will receive the preprints of accepted papers.

In keeping with the goal to have the conference include reports of all current research in the storage and retrieval of information, the Program Committee will be pleased to accept additional suggestions for papers. It is requested that detailed outlines be submitted as soon as possible. Inquiries as to details of the program and the established criteria for papers should be addressed to the Secretariat, International Conference on Scientific Information, National Academy of Sciences, Washington 25, D.C.

[Continued from page 25]

pletely new direction, apparently feeling that the effort necessary to attain the goal was too great.

What the Future Holds

What can be done in the future with electro-mechanical animals seems limited only by the time and funds one could devote to the problem. If a single on-off voice system is interesting, imagine what could be done with two or three voice channels on different frequencies!

Another rather obvious improvement would be to make *Machina Versatilis* able to move his own head and look about him. He could then decide, as the mood moved him, to chase lights or circle them or stand still and size up the situation.

Versatilis could also easily be made to charge his own battery but there is one thing to keep in mind. The battery should be charged slowly over a period of about twelve hours. Faster charges are possible but very bad for the battery. We wondered if the behavior of self charging would be worth the price of having the machine idle for so long a time.

Considering the possibilities for behavior, we thought of many interesting, and perhaps wild, schemes. However, they are all realizable and might possibly be valuable. Who can say?

Most practical of all and not in the least bit wild, the neon probability learning circuit should actually be installed in some electro-mechanical animals and used to make them learn.

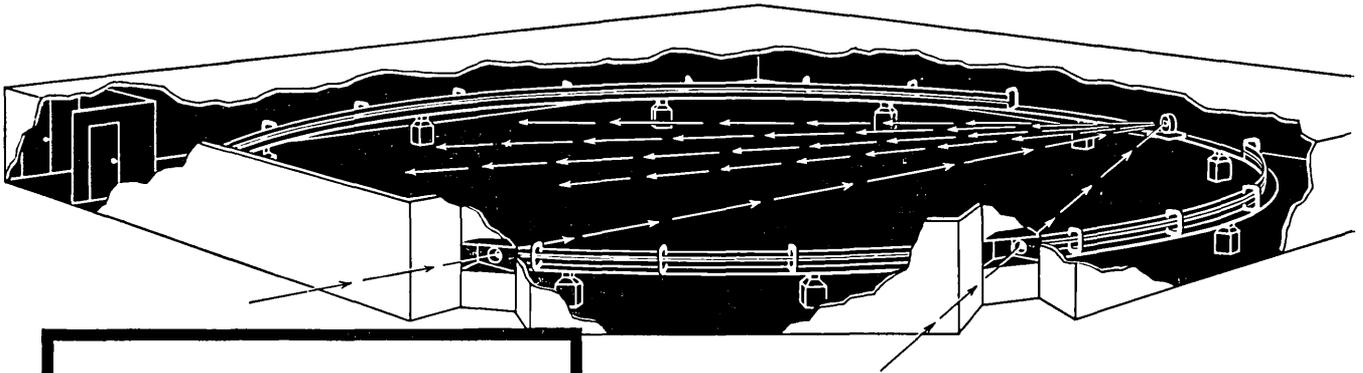
In addition, the animals could play a simple game of tag. They already can chase each other. All that is needed is a new brain that can think about being "it and not it." It would be interesting to see what various degrees of crippling of one animal would do to the proportion of the time that it would be "it."

If the animals could be given a sense of direction (simple gyroscope), they could have quite a soccer game with the toy. Two opposing teams could scrimmage for the ball.

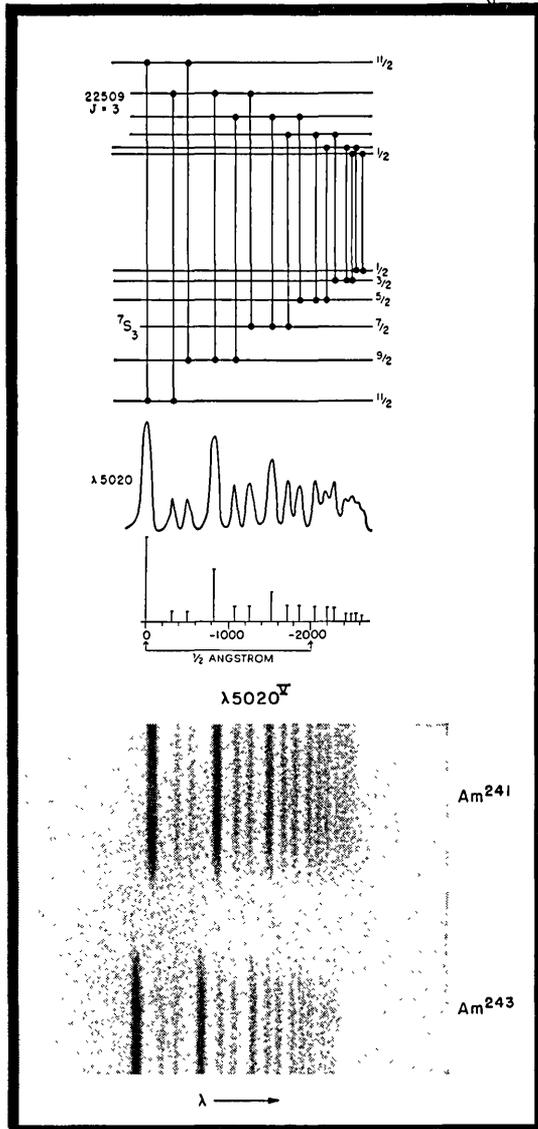
It would also be fairly easy to make the machines pay for something with steel coins, which they would find on the floor. They might hoard their money and use it when they wished to buy a charge or perhaps play a simple juke box.

A most fascinating experiment would be to introduce into the mechanical animal society a criminal who would steal the others' coins. Would the machine then learn that "crime does not pay"?

We believe that the study of behavior and thought in mechanical models of animals has a very promising future. After all, to the Greeks, electronics was not much more than the static electricity in a cat's fur.



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Automatika I Telemekhanika

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- Emelyanov, S. V. / A way of obtaining

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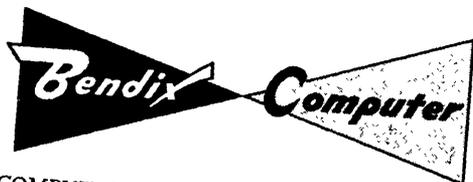
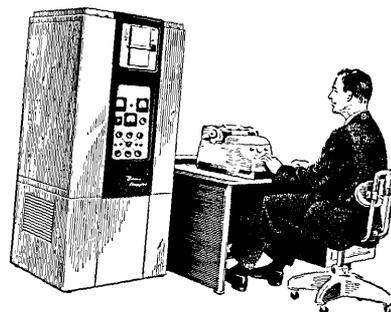
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DIVISION OF BENDIX AVIATION CORPORATION

Books and other Publications

[Continued from page 26]

comparisons, etc. A large part of this book parallels without acknowledgment Richard Hunt Brown's "Office Automation," of which the author of this book had a loaned manuscript for a number of months before "Office Automation" was published by Automation Consultants, New York. Some more of the book is based on the experience of the author as a consultant and analyst. The last chapter, Chapter 24, gives a brief account of four "office automation" installations: Gage Publishing Corp., The Reader's Digest, Alcoa, and Sylvania. There is no bibliography; there are no acknowledgments. The index contains references to only three persons, C. A. Cerami, J. H. Macdonald, and E. C. Schleh, all of them authors of Prentice Hall books. The general quality of the book is reflected in a subheading in Chapter 15, "Transition is Inevitably Troublesome — How to Be Prepared."

Becker, Esther R., and Eugene F. Murphy / *The Office in Transition* / Harper & Brothers, 49 East 33rd St., New York 16, N.Y. / 1957, printed, 190 pp., \$3.50.

The authors intend this book to aid management in meeting the problems arising from a long-term trend towards office automation. They discuss: the meaning of office automation; its probable future; methods for studying its applicability to the individual business office, for selecting the proper degree of automation, and for keeping employee morale at a peak during transition, etc. The book includes three appendices, one describing current equipment, another listing manufacturers of equipment for the automatic office, and a third listing associations, institutions and publications concerned with such equipment methods and applications.

Woodbury, David O. / *Let Erma Do It* / Harcourt, Brace & Co., 383 Madison Ave., New York, N.Y. / 1956, printed, 305 pp., \$5.00.

ERMA stands for "Electronic Recording Machine — Accounting." The book has two parts, "1. This Business About Automa-

tion," which includes chapters 1 to 15, and "2. ERMA and her Friends," chapters 15 to 26. In this book Mr. Woodbury explains automation of machines and of information to the layman. He discusses the history of automation, its meaning, our current needs for it, its usefulness in our businesses, sciences, etc. His account is informative, wide-ranging, and stimulating. Almost every reader would find out many things he did not previously know.

Remington Rand Univac, staff of / *Large Scale Digital Computers, An Annotated Bibliography* / Remington-Rand Univac, Div. of Sperry Rand Corp., 315 4th Ave., New York, N.Y. / no date (1957?), photo offset, 47 pp., free.

A good bibliography, with helpful comments, intended to simplify the research problems of persons wishing to inquire into any of the aspects of the large-scale digital computer field. General comprehensive works are given full attention; special technical subjects receive only brief mention.

Remington Rand, Univac, staff of / *Generalized Programming Extended for Univac II, A Univac Applications Research Center Report* / Remington Rand Univac Division, Sperry Rand Corp., Philadelphia, Penn. / 1957, photo offset, 66 pp., free.

The Generalized Programming system for Univac II resembles the system designed earlier for Univac I; the descriptive material presented here presupposes the reader's understanding of "Univac Generalized Programming," published by Remington Rand, New York, 1957, Pub. RRU 21. However, the GPX compiler discussed here differs from the Univac I system, first, in its single compilation of a program divided into many segments and many loads; second, in its expanded ability to select specific parts of a library routine; third, in its expanded provisions for varied library routines; fourth, in its provisions for straight-line coding insertions; fifth, for its inclusion of many new coding conventions. The written descriptive material is amply and clearly illustrated.

ADVERTISING INDEX

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

Arnold Engineering Co., Marengo, Ill. / Page 2 / W. S. Walker Advertising, Inc.

Argonne National Laboratory, P.O. Box 299, Lemont, Ill. / Page 33 / Grant-Jacoby Studios, Inc.

Bendix Aviation Corp., Computer Division, 5630 Arbor Vitae St., Los Angeles 45, Calif. / Page 35 / —

Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif. / Page 22 / Allen, Dorsey & Hatfield, Inc.

Datamatic Corp., Newton Highlands, Mass. / Page 37 / Batten, Barton, Durstine & Osborne, Inc.

John Diebold & Associates, 40 Wall St., New York 5, N.Y. / Pages 29, 30 / The Rockmore Co.

Electronic Associates, Inc., Long Branch, N.J. / Page 38 / Halsted & Van Vechten, Inc.

ESC Corp., 534 Bergen Blvd., Palisades Park, N.J. / Page 5 / Keyes, Martin & Co.

Ferrocube Corp. of America, E. Bridge St., Saugerties, N.Y. / Page 34 / Sam Groden, Inc.

General Electric Co., Owensboro, Ky. / Page 27 / Maxon, Inc.

Ramo-Wooldridge Corp., 5730 Arbor Vitae St., Los Angeles, Calif. / Page 9 / The McCarty Co.

Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex. / Page 21 / —

Stromberg Carlson, 1895 Hancock St., San Diego 12, Calif. / Page 31 / Visual and Industrial Design

System Development Corp., 2406 Colorado Ave., Santa Monica, Calif. / Page 28 / Stromberger, LaVene, McKenzie

This giant electronic brain won 8 major contracts — before it was born!

Several weeks ago, a new kind of giant electronic brain started operating in a vast business where complicated records had begun to swamp mortal man and the inadequate machinery at hand.

The name of this giant brain is "DATAmatic 1000". It is Honeywell's electronic data processing system.

But this story is *not* about the amazement of the business technicians who have been watching the DATAmatic 1000 at work. It is not about this system's record-breaking speed and unequalled capacity. Nor is it about this new brain's sizable advantage in true cost.

Skip all that for the moment. Just consider what, perhaps, is the most remarkable fact of all:

Eight of America's top organizations contracted for the two-million-dollar DATAmatic system many months ago — long before it was possible to see the physical machinery of this electronic marvel.

That is the kind of confidence they had in Honeywell engineering and scientific skill.

That is the tribute they paid to the keen engineers who had clearly taken a giant step forward in electronic data processing.

Do you wonder that Honeywell views this endorsement with pride?

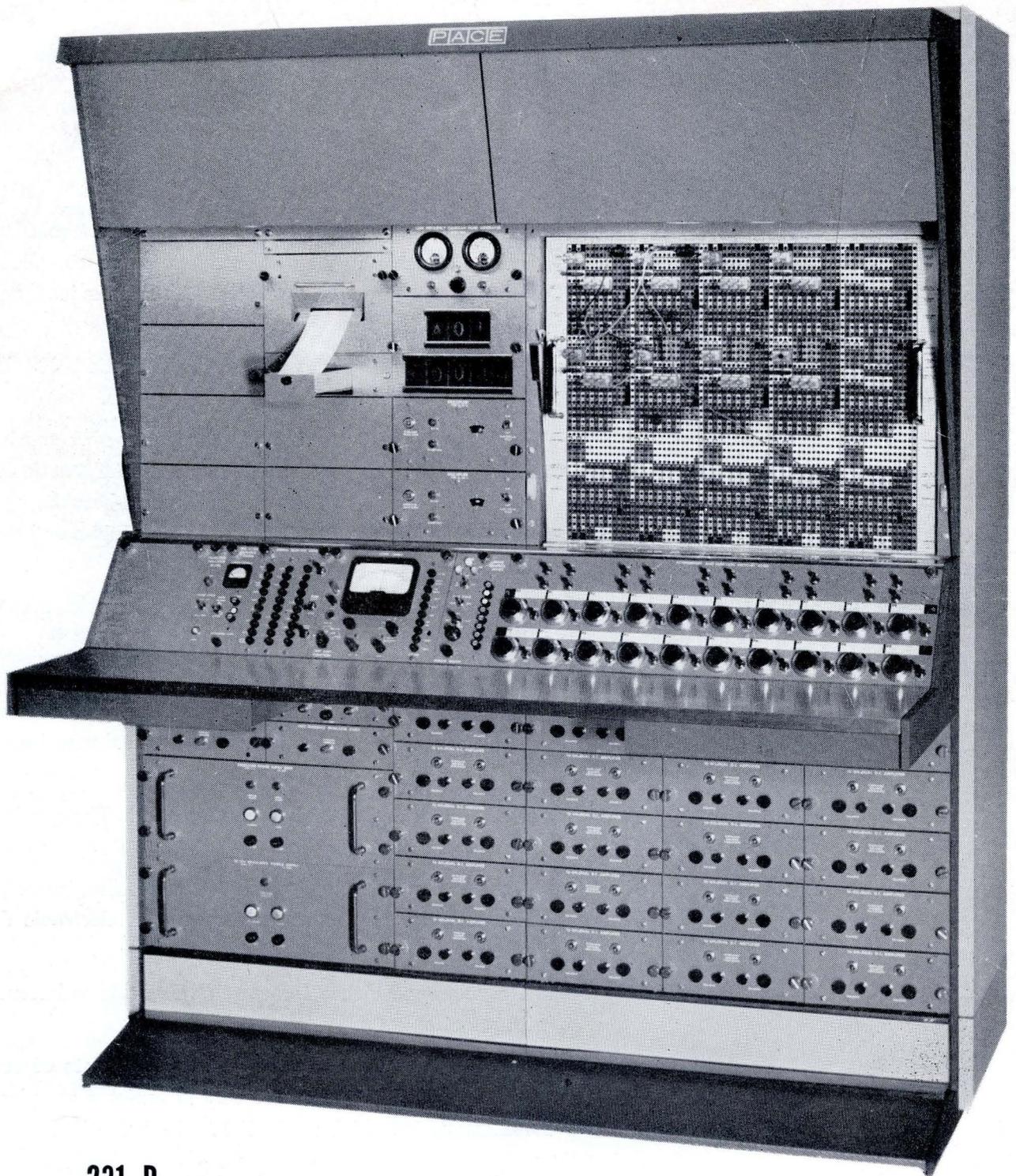
And, in view of this multi-million-dollar vote of confidence, do you wonder that leaders in business are placing DATAmatic 1000 high on the list for investigation?

Consideration of any large-scale data processing program is incomplete without the facts on DATAmatic 1000. Our applications engineers will be glad to discuss your requirements. Write for details to Walter W. Finke, President, DATAmatic, Dept. A2, Newton Highlands 61, Massachusetts.



Honeywell

 **DATAmatic**
ELECTRONIC DATA PROCESSING



231 R

Symbol of the greatest advance in analog computing techniques—announcing PACE Analog Computer Console 231 R. This console incorporates new and exclusive features that enable it to set new standards in the art of analog computing for speed, precision, and reliability. For full information, write for bulletin number CG-116, Electronic Associates, Inc., Long Branch, N. J.

Visit our booth #1212-8, IRE Show, March 24 to 27.