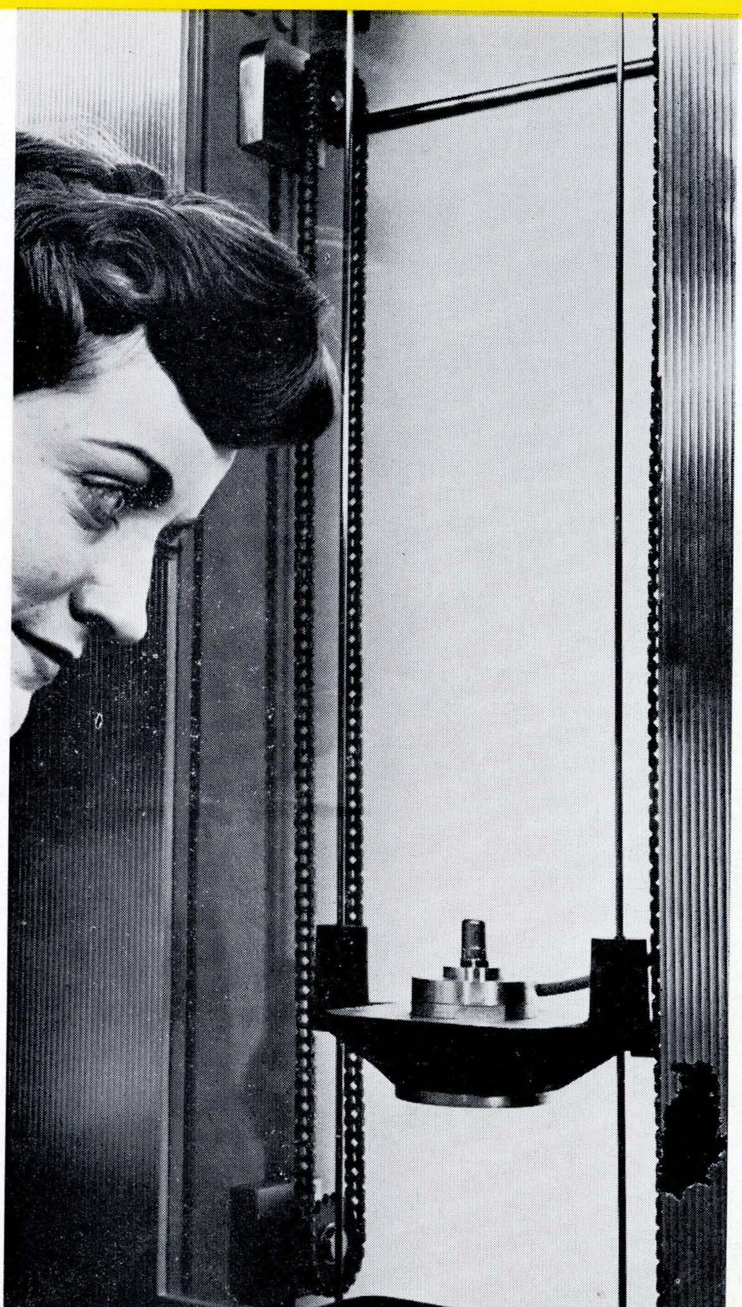
COMPUTERS
and AUTOMATION

DATA PROCESSING • CYBERNETICS • ROBOTS



International Conference on Information Processing, — the Opening

A General Problem-Solving Program for a Computer

The Application of a Computer to Bank Accounting

JULY
1959
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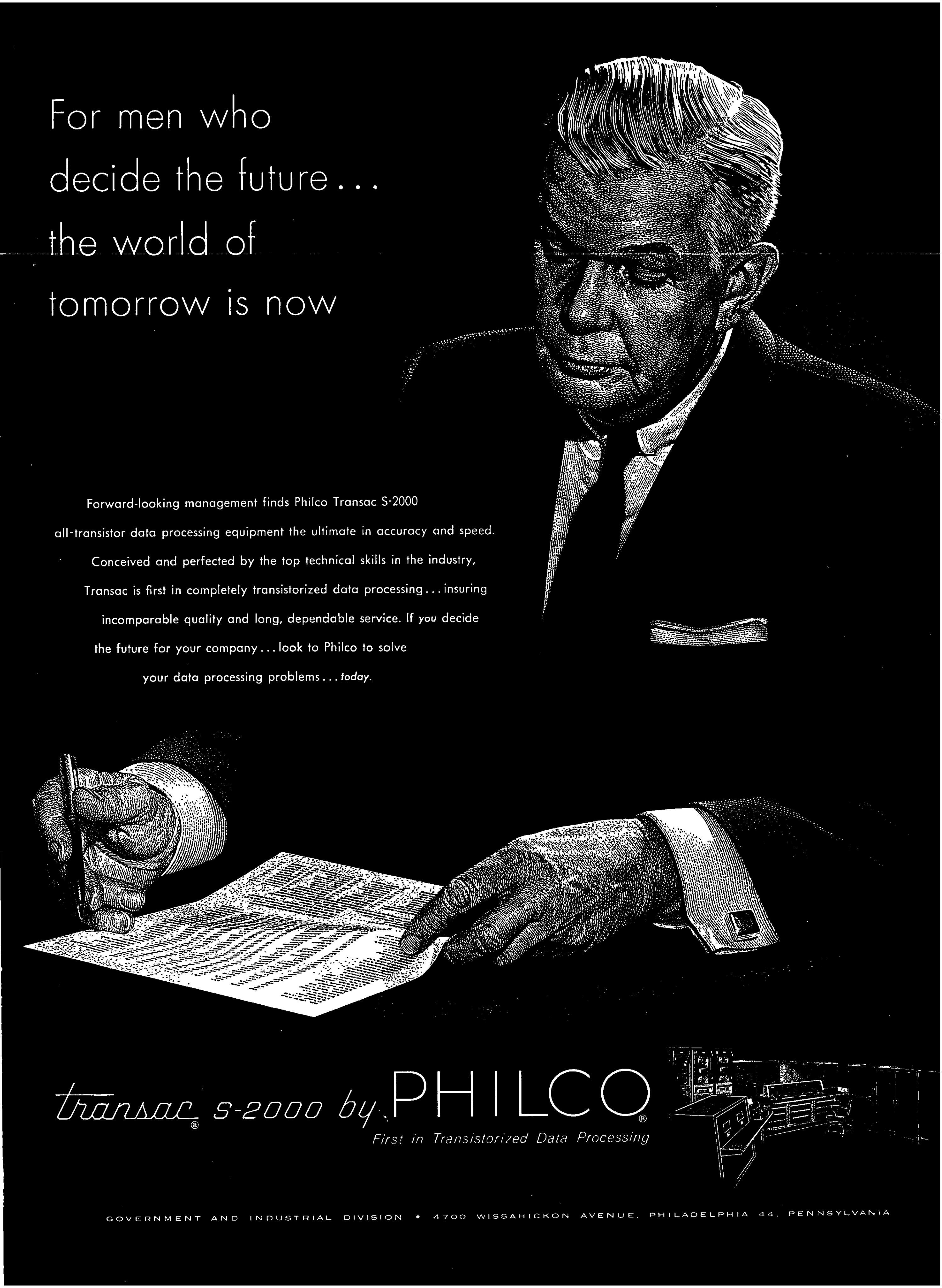
VOL. 8 - NO. 7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COMPUTERS and AUTOMATION

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FRONT COVER

ARTICLES

FOR BETTER EDUCATION

READERS' AND EDITOR'S FORUM

REFERENCE INFORMATION

INDEX OF NOTICES

Readers' and Editor's Forum

FRONT COVER: NUVISTOR TUBE (RCA) UNDERGOING SHOCK TEST

The front cover shows an electronic tube of a new type called Nuvistor being tested in a special drop test of guillotine-type. The tube operates normally while undergoing repeated blows with an impact equal to hundreds of times its own weight, up to 850 times the force of gravity.

This type of tube is being developed by RCA Electron Tube Division, and is expected to be mass-produced in 1960. In size, it fits inside a thimble. It contains no mica or glass, but is made chiefly of steel, molybdenum, tungsten, and ceramic. It operates between plus 660 degrees Fahrenheit and minus 320 degrees in liquid nitrogen. The joints in the complete tube are processed at white heat, 2000 degrees F., in a brazing furnace and then in a vacuum exhaust furnace. It is constructed using cylindrical shapes and cantilever supports, to resist vibration and shock. It requires much less power than previous tubes.

It will be used in high speed data processors and television sets, and for many other commercial, entertainment, and military purposes. The name comes from "nueva" meaning "new" and "vista" meaning "look."

ON DEBUGGING A COMPUTER

W. T. Gant
Shell Oil Co.
Midland, Texas

I have a comment concerning the article by C. R. Blair "On Economical Debugging" in the May 1959 issue of **Computers and Automation.** Mr. Blair suggests an efficient console that will waste less computer time than many waste today. This is certainly a step in the right direction but why stop short here? Why not develop debugging aids that will also include anything practical that one can do at a console? Some installations aren't far from such sophistication today. With this approach one not only increases the efficiency but also saves the expense of the extra hardware of the console.

I for one will be glad when the computer manufacturer leaves the console off completely except for maintenance. In fact, I wonder if, in time, a console will really be justified there.

COMPUTER OR MAN IN SPACE?

I. From S. Danishevsky

Harvard Univ.
Cambridge 38, Mass.

When one thinks of a computer, he envisions a massive, room-filling structure, with numerous cabinets, storages, and printers.

It is interesting if disconcerting to note then, that in a recent article in "Time," Dr. James Van Allen is quoted as having said "Man is a fabulous nuisance in space, right now." Dr. Van Allen goes on to point out that instruments are lighter, less demanding, and are also sensitive to many things a person's senses ignore.

Either man is considerably larger than he thinks he is, or the computer smaller.

II. From the Editor

There exist very powerful automatic digital computers which occupy only a small space, particularly those constructed for airborne applications. In the future computers will be smaller still.

It really will be easier to send instruments with computer "brains" to explore space and report, than to send men. For example, it would be relatively easy to send a computer through the recently discovered belt of strong radiation around the earth. A man would need heavy shielding. Also, it would make little difference if the computer could not return. The man might not like to be certain of no return.

THE LIMITS OF COMPUTER POWER

Edmund C. Berkeley

On MAY 28 in the mail we received the printed text of the 55 papers which were given at the International Conference on Information Processing in Paris June 13 to 20. In the next few days we spent about eight hours examining and reading them. Many of these papers are fascinating for they deal with the present frontiers of the powers of computers — even if some of the papers are comprehensible only to persons with advanced mathematical knowledge.

Of these papers, we have at this time chosen three for publication in whole or in part in **Computers and Automation,** one U.S.S.R., one British, and one U.S.A., — because among many closely competing papers, these in particular seem to contain both interesting ideas and evidence of accomplishment, and seem to throw a bright light into the future development of computers and the directions in which they will be applied. These three papers are:

"Machine Translation Methods and their Application to Anglo-Russian Scheme" by I. K. Belskaya, Academy of Sciences of the U.S.S.R.

"Time Sharing in Large Fast Computers," by C. Strachey, National Research Development Corp., London

"Report on a General Problem-Solving Program" by A. Newell and J. C. Shaw, the Rand Corp., and H. A. Simon, Carnegie Inst. of Technology

Other Frontiers

Of course there are other frontier fields besides those alluded to in the titles of the foregoing papers. One more field is for a computer to deal not only with digits and symbols, not only with words and their relations, but with meanings. We quote from the paper "A Reduction Method for Non-Arithmetic Data and Its Ap-

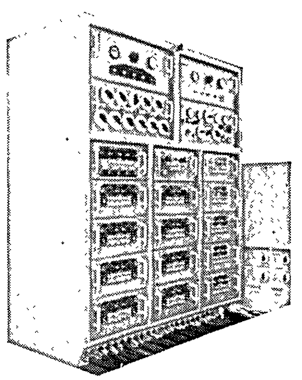
[Please turn to page 29]

Here's how General Electric solves typical DC power-supply problems

for computers and special applications

PROBLEM

"We need to devote our engineering time to designing our electronic circuitry . . . not the power components."



SOLUTION

This is a frequent problem facing computer manufacturers. General Electric's Rectifier Department has complete engineering and manufacturing capability not only to design and apply all types of power supplies, but also to incorporate power supplies into completely integrated systems.

These systems could include load distribution, supply sequencing, protection for power supply and load, and complete power distribution. Let General Electric tackle your DC power problems such as those associated with load IR drop, "cross talk," and other nuisance-type problems plaguing your engineers.

PROBLEM

"It's always a problem making sure transistorized equipment is safe from its power supply."

SOLUTION

To alleviate this problem, General Electric has developed several methods of making transistorized equipment safer in this respect. With G-E protective circuits, shorting a plus high-voltage bus to a plus or minus low-voltage bus would not cause the low-voltage bus to exceed a small percentage of nominal rated value.

General Electric power supplies protect completely transistorized pieces of equipment from large losses due to over-voltage failures.

PROBLEM

"My power supply requirements fluctuate so much . . . big jobs, little jobs, all in between."

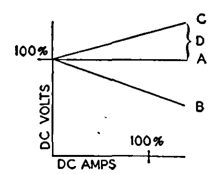
SOLUTION

G.E. has built individual power supplies and complete systems ranging from less than one watt up to 35,000 kilowatts. These power supplies span the complete range of DC power—regulated and unregulated—applying all types of components. G-E experience includes completely transistorized supplies, and supplies with the new controlled rectifier, magnetic amplifiers, voltage stabilizing transformers, and motor-alternator "brute force" systems.

PROBLEM

"We have a real low-voltage power distribution problem with our computer."

SOLUTION



Low-voltage distribution problems can be handled easily through load compensation. Curve "A" is net desired no-load to full-load regulation at load point. "B" is regulation at load without remote sensing or load compensation. "C" represents IR compensation in power supply itself. "D" is amount of IR or load compensation.

NO MATTER WHAT your computer and other special power-supply problems are, General Electric can help you economize—economize by helping you free your engineers of these problems. For more information on power-supply products and services, contact your nearest General Electric Apparatus Sales Office or write to Section D535-2, General Electric Company, Schenectady, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

International Conference On Information Processing —The Opening

Paris, France, June 15-20, 1959—June 15 Opening

The first session of the International Conference on Information Processing took place in the historic central lecture room of the Sorbonne, of the University of Paris, at 11:00 a.m. on June 15. All the other sessions of the conference took place in the beautiful and up-to-the-minute building of the United Nations Educational Scientific and Cultural Organization, at the Place de Fontenoy, in Paris. (See the picture.) Registration at the conference on the first day totaled over 1300.

The principal address at the opening was by Professor Howard H. Aiken, Harvard University, President of the Conference. There were four other speakers:

— Mr. Rene Maheu, acting Director General, UNESCO;

— Mr. André Danjon, director of the Paris Observatory and President of the French Computing Association;

— Mr. Hugues Vinel, representative of the French Minister of State in Charge of Scientific Research; and

— Prof. Pierre Auger, Secretary-General of the Conference.

Following are brief summaries of four of these addresses.

I.

Howard H. Aiken — "With Opportunity and Power Comes Responsibility for the Wise Use of Computer Ideas"

First, I want to congratulate UNESCO and the small group which has made the preparations for this conference. We all are greatly indebted to them.

A short review of past developments in the computer field will show the position we are now in, and the reason why we are here, and will help us extrapolate to the next decades.

The first two problems which the computer field faced at the beginning were these: constructing a computing device which would work; and showing that we could solve scientific problems set by other people. How far behind are these problems now!

Now we see very great improvements. Among the improvements are solid-state components, computers becoming smaller and faster, and an improved theory of switching. This theory leads to the foundations of a theory of systems.

The application of machine ideas is having great effects in many different ways: on commercial enterprises; on the control of machinery; and in a great variety of other fields — automatic translation of languages, the composition of music, the making of concordances, ...

The information-processing aspect of every segment of human activity is becoming our interest.

No group attending any conference ever faced so many challenging problems with so much chance of success and so great a potential influence on the lives of people and society in general, as do the members of this conference.

With opportunity and power comes responsibility — responsibility for the wise application of computer ideas for the public interest, for "l'humanité entier."

II.

R. Maheu — "The Free Exchange of Ideas and Knowledge"

This is the second large-scale international scientific conference organized by Unesco in Paris — the first, held in 1957, covered the use of radio-isotopes in scientific research. In bringing scientists together at such conferences Unesco is fulfilling its mandate "to encourage the unrestricted pursuit of objective truth and the free exchange of ideas and knowledge," to quote the words of its constitution.

It is impossible to-day to imagine a large factory, a large government office, or a large research laboratory, without a computation service in which a few of these machines replace a large number of specialized computing staff.

One cannot even say that these machines take the place of men, because in fact they enable the performance of operations which would be practically impossible because of the number of man hours they would require.

Thus man's intellectual power has been increased in an extraordinary manner by placing at his disposal inexhaustible memories and automatic calculation organs capable of ultra-rapid consultation, which can perform in a few seconds what once required weeks to accomplish.

III.

A. Danjon — "Programs That Used to Be Madness"

The invention of electronic mathematical computers,

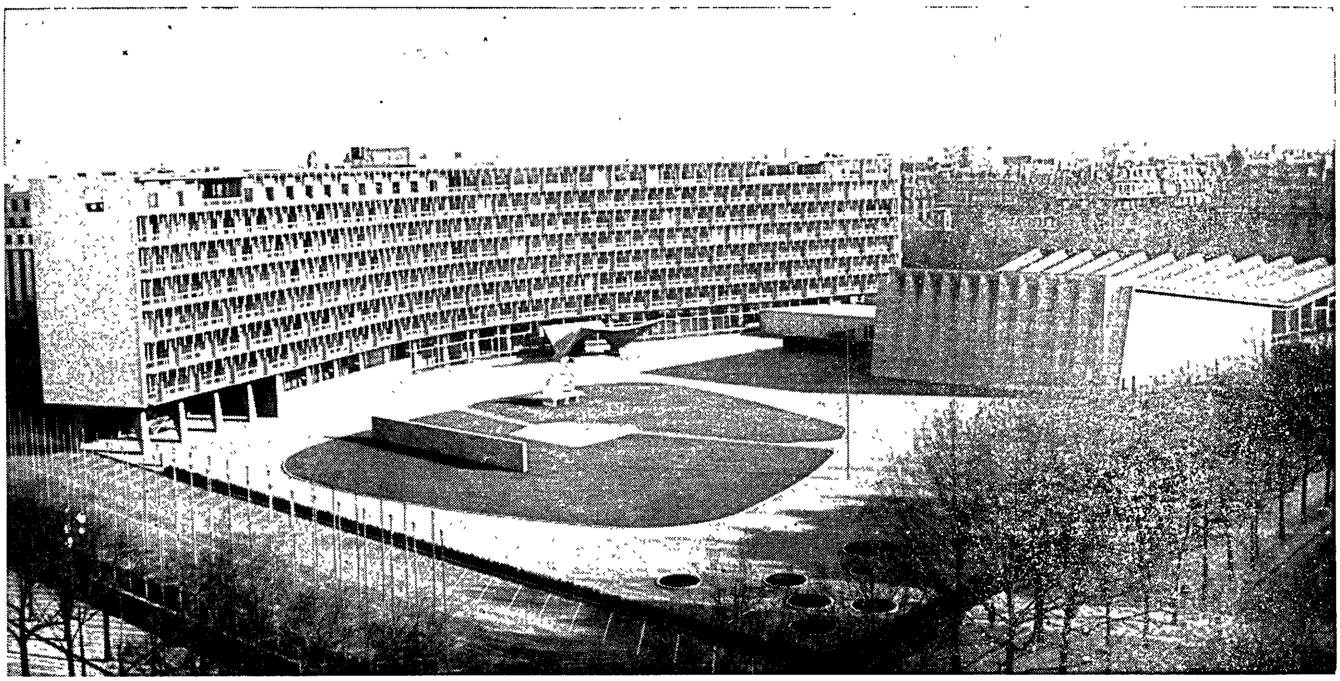


Figure 1 — The UNESCO Building in Place de Fontenoy, Paris.

going back only fifteen years, deserves to be considered a landmark in the history of science in the same way as the invention of lenses or the microscope.

The ambitious program of the International Geophysical Year would have been pure madness if we had not been certain of being able to analyze very rapidly all the data gathered from the entire surface of the earth.

The use of electronics has given a big impulse to astronomy, geodesy, geophysics (all traditionally big consumers of numbers), atomic physics, crystallography, genetics, biometry, and the social sciences, by opening hitherto-closed fields to their research workers.

An electronic computer would have made it easier for the French astronomer Le Verrier to have discovered Neptune in 1845. It would have also helped him in his studies of the irregularities in the long-term movement of the perihelion of Mercury's orbit; but it would not have made it unnecessary for Einstein to conceive the theory of relativity, no more than a machine perfectly aware of all theories in classical physics would have made it unnecessary for Becquerel to discover radioactivity.

IV.

H. Vinel — "A Choice of Various Solutions"

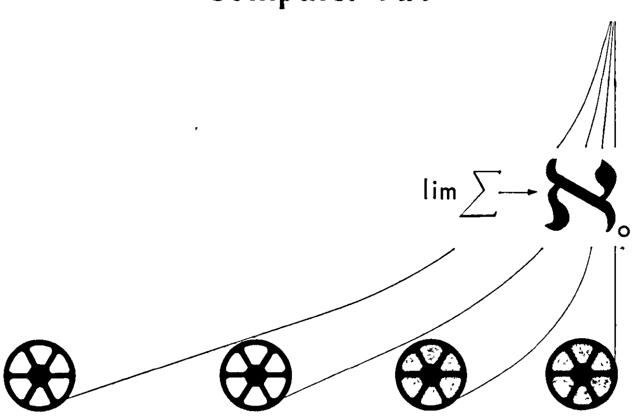
Paris has become for a few days the meeting ground of the world's most eminent mathematicians, in addition to being the site of Unesco's permanent headquarters.

This conference should not only determine the logical structures of machines but, perhaps, it should also achieve a realization of their limits.

These machines have already served mankind, occasionally in military research, but also and above all in seeking the scientific knowledge which will be able to create our welfare of tomorrow.

The present-day complexity of science and technology requires a choice of various solutions. Only with electronic processing can this be done within acceptable time-limits. To take some recent examples from our own country, this was how calculations were produced for the remarkable aircraft, the Caravelle; and this was how the plan for developing natural gas resources at Lacq was worked out.

Computer Art



This design symbolizes the enormous storage capacity of magnetic tape to store information. Its motif expresses: from the computer field — magnetic tape and magnetic tape reels, which may contain over 2400 feet of tape and over 100 million binary digits of information; from analytic geometry — asymptotic curves pointing to infinity; from calculus — the mathematical expression meaning "the limit of the sum approaches"; and from mathematical logic — the Hebrew character aleph with a zero subscript (aleph naught), which was the sign used by Georg Cantor to designate the first transfinite cardinal number, the infinity of the class of natural numbers 1, 2, 3, 4, ... , which is also the infinity of all even numbers, of all rational fractions, and of a variety of other classes.

A GENERAL PROBLEM-SOLVING PROGRAM FOR A COMPUTER

A. Newell and J. C. Shaw, The RAND Corporation, and H. A. Simon, Carnegie Institute of Technology

(Paper given at the International Conference on Information Processing, Paris, France, June 13-20, 1959)

This paper deals with the theory of problem solving. It describes a program for a digital computer, called General Problem Solver I (GPS), which is part of an investigation into the extremely complex processes that are involved in intelligent, adaptive, and creative behavior. Our principal means of investigation is synthesis: programming large digital computers to exhibit intelligent behavior, studying the structure of these computer programs, and examining the problem-solving and other adaptive behaviors that the programs produce.

A *problem* exists whenever a problem solver desires some outcome or state of affairs that he does not immediately know how to attain. Imperfect knowledge about how to proceed is at the core of the genuinely problematic. Of course, some initial information is always available. A genuine problem-solving process involves the repeated use of available information to initiate exploration, which discloses, in turn, more information until a way to attain the solution is finally discovered.

Many kinds of information can aid in solving problems: information may suggest the order in which possible solutions should be examined; it may rule out a whole class of solutions previously thought possible; it may provide a cheap test to distinguish likely from unlikely possibilities; and so on. All these kinds of information are *heuristics* — things that aid discovery. Heuristics seldom provide infallible guidance; they give practical knowledge, possessing only empirical validity. Often they "work," but the results are variable and success is seldom guaranteed.

The theory of problem solving is concerned with discovering and understanding systems of heuristics. What kinds are there? How do very general injunctions ("Draw a figure" or "Simplify") exert their effects? What heuristics do humans actually use? How are new heuristics discovered? And so on. GPS, the program described in this paper, contributes to the theory of problem solving by embodying two very general systems of heuristics — means-ends analysis and planning — within an organization that allows them to be applied to varying subject matters.

GPS grew out of an earlier computer program, the Logic Theorist (5, 8), which discovered proofs to theorems in the sentential calculus of Whitehead and Russell. It exhibited considerable problem-solving ability. Its heuristics were largely based on the introspections of its designers, and were closely tied to the subject matter of symbolic logic.

The effectiveness of the Logic Theorist led to revised programs aimed at simulating in detail the problem-solving behavior of human subjects in the psychological laboratory. The human data were obtained by asking college sophomores to solve problems in symbolic logic, "thinking aloud" as much as possible while they worked. GPS is the program we constructed to describe as closely as possible the behavior of the laboratory subjects as revealed in their oral comments and in the steps they wrote down in working the problems. How far it is successful in simulating the subjects' behavior — its usefulness as a phychological theory of human thinking — will be reported elsewhere (7).

We shall first describe the overall structure of GPS, and the kinds of problems it can tackle. Then we shall describe two important systems of heuristics it employs. The first is the heuristic of means-ends analysis, which we shall illustrate with the tasks of proving theorems in symbolic logic and proving simple trigonometric identities. The second is the heuristic of constructing general plans of solutions, which we shall illustrate, again, with symbolic logic.

The Executive Program and the Task Environment

GPS operates on problems that can be formulated in terms of *objects* and *operators*. An operator is something than can be applied to certain objects to produce different objects (as a saw applied to logs produces boards). The objects can be characterized by the *features* they possess, and by the *differences* that can be observed between pairs of objects. Operators may be restricted to apply to only certain kinds of objects; and there may be operators that are applied to several objects as inputs, producing one or more objects as output (as the operation of adding two numbers produces a third number, their sum).

Various problems can be formulated in a task environment containing objects and operators: to find a way to transform a given object into another; to find an object possessing a given feature; to modify an object so that a given operator may be applied to it; and so on. In chess, for example, if we take chess positions as the objects and legal moves as the operators, then moves produce new positions (objects) from old. Not every move can be made in every position. The problem in chess is to get from a given object — the current position — to an object having a specified feature (a position in which the opponent's King is checkmated).

The problem of proving therems in a formal mathematical system is readily put in the same form. Here the objects are theorems, while the operators are the admissible rules of inference. To prove a theorem is to transform some initial objects — the axioms — into a specified object — the desired theorem. Similarly, in integrating functions in closed form, the objects are the mathematical expressions; the operators are the operations of algebra, together with formulas that define special functions like sine and cosine. Integration in closed form is an operation that does not apply directly to every object — if it did, there would be no problem. Integration involves transforming a given object into an equivalent object that is integrable, where equivalence is defined by the set of operations that can be applied.

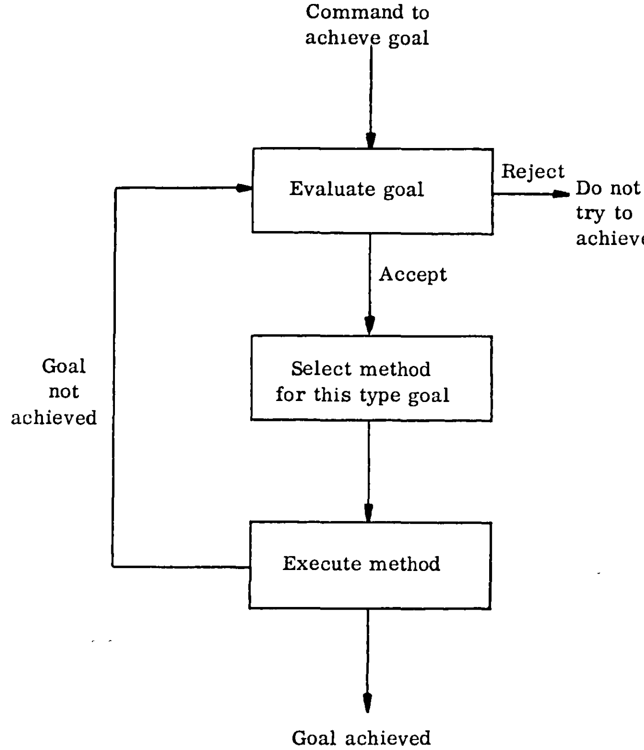
Consructing a computer program can also be described as a problem in these same terms. Here, the objects are possible contents of the computer memory; the operators are computer instructions that alter the memory content. A program is a sequence of operators that transforms one state of memory into another; the programming problem is to find such a sequence when certain features of the initial and terminal states are specified.

To operate generally within a task environment characterized by objects and operators, GPS needs several main components:

1. A vocabulary, for talking about the task environment, containing terms like: object, operator, difference, feature, Object #34, Operator #7.
2. A vocabulary, dealing with the organization of the problem-solving processes, containing terms like: goal type, method, evaluation, Goal Type #2, Method #1, Goal #14.
3. A set of programs defining the terms of the problem-solving vocabulary by terms in the vocabulary for describing the task environment. (We shall provide a number of examples presently.)
4. A set of programs (correlative definitions) applying the terms of the task-environment vocabulary to a particular environment: symbolic logic, trigonometry, algebra, integral calculus. (These will also be illustrated in some detail.)

Items 2 and 3 of the above list, together with the common nouns, but not the proper nouns, of item 1 constitute GPS, properly speaking. Item 4 and the proper nouns of item 1 are required to give GPS the capacity to solve problems relating to a specified subject matter. Speaking broadly, the core of GPS consists of some general, but fairly powerful, problem-solving heuristics. To apply these heuristics to a particular problem domain, GPS must be augmented by the definitions and rules of mathematics or logic that describe that domain, and then must be given a problem or series of problems to solve. The justification for calling GPS "general" lies in this factorization of problem-solving heuristics from subject matter, and its ability to use the same heuristics to deal with different subjects.

Fig. 1 — Executive organization of GPS



Let us look more closely at the problem-solving vocabulary and heuristics. To specify problems and subproblems, GPS has a discrete set of *goal types.* We shall introduce two of these initially:

Goal Type #1: Find a way to transform object *a* into object *b.* (The objects, *a* and *b,* may be any objects defined in specifying the task environment. The phrase "way to transform" implies "by applying a sequence of operators from the task environment.")

Goal Type #2: Apply operator *q* to object *a* (or to an object obtained from *a* by admissible transformations).

Finding a proof of a theorem (object *b*) from axioms (object *a*) is an example of a Type #1 goal; integrating (operator *q*) an expression (object *a*) is an example of a Type #2 goal.

The executive organization of GPS, shown in Figure 1, is very simple. With each goal type is associated a set of *methods* related to achieving goals of that type. When an attempt is made to achieve a goal, it is first evaluated to see whether it is worthwhile achieving and whether achievement seems likely. If so, one of the methods is selected and executed. This either leads to success or to a repetition of the loop.

The principal heuristics of GPS are imbedded in the methods. All the heuristics apply the following general principle:

The principle of subgoal reduction: Make progress by substituting for the achievement of a goal the achievement of a set of easier goals.

This is, indeed, only a heuristic principle, and it is not as self-evident as it may appear. For example, none of the programs so far written for chess or checkers makes essential use of the principle (1, 3, 6).

The constant use of this principle makes GPS a highly recursive program, for the attempt to achieve one goal leads to other goals, and these, in turn, to still other goals. Thus, identical goal types and methods are used many times simultaneously at various levels in the goal structure in solving a single problem. Application of the principle also combines the goals and methods into organized systems of heuristics, rather than establishing each method as an independent heuristic. We shall provide examples of two such systems in this paper.

Functional or Means-ends Analysis

Means-ends analysis, one of the most frequently used problem-solving heuristics, is typified by the following kind of common sense argument:

> I want to take my son to nursery school. What's the difference between what I have and what I want? One of distance. What changes distance? My automobile. My automobile won't work. What's needed to make it work? A new battery. What has new batteries? An auto repair shop. I want the repair shop to put in a new battery; but the shop doesn't know I need one. What is the difficulty? One of communication. What allows communications? A telephone . . . And so on.

This kind of analysis — classifying things in terms of the functions they serve, and oscillating among ends, functions required, and means that perform them — forms the basic system of heuristic of GPS. More precisely, this means-ends system of heuristic assumes the following:

1. If an object is given that is not the desired one, differences will be detectable between the available object and the desired object.
2. Operators affect some features of their operands and leave others unchanged. Hence operators can be characterized by the changes they produce and can be used to try to eliminate differences between the objects to which they are applied and desired objects.
3. Some differences will prove more difficult to affect than others. It is profitable, therefore, to try to eliminate "difficult" differences, even at the cost of introducing new differences of lesser difficulty. This process can be repeated as long as progress is being made toward eliminating the more difficult differences.

To incorporate this heuristic in GPS, we expand the vocabulary of goal types to include:

Goal Type #3: Reduce the difference, *d,* between object *a* and object *b* by modifying *a.*

The core of the system of functional analysis is given by three methods, one associated with each of the three goal types, as shown in Figure 2. Method #1, associated with Goal Type #1, consists in: (a) matching the objects *a* and *b* to find a difference, *d,* between them; (b) setting up the Type #3 subgoal of reducing *d,* which if successful produces a new transformed object *c;* (c) setting up the Type #1 subgoal of transforming *c* into *b.* If this last goal is achieved, the original Type #1 goal is achieved. The match in step (a) tests for the more important differences first. It also automatically makes substitutions for free variables.

Method #2, for achieving a Type #2 goal, consists in: (a) determining if the operator can be applied by setting up a Type #1 goal for transforming *a* into C(*q*), the input form of *q*; (b) if successful, the output object is produced from P(*q*), the output form of *q*. This method is appropriate where the operator is given by two forms, one describing the input, or conditions, and the other the output, or product. The examples given in this paper have operators of this kind. Variants of this method exist for an operator given by a program, defined iteratively, or defined recursively.

Method #3, for achieving a Type #3 goal, consists in: (a) searching for an operator that is relevant to reducing the difference, *d*; (b) if one is found, setting up the Type #2 goal of applying the operator, which if successful produces the modified object.

Application to Symbolic Logic. This system of heuristics already gives GPS some problem-solving ability. We can apply GPS to a simple problem in symbolic logic. To do so we must provide correlative definitions for objects, operators, and differences. These are summarized in Figure 3. We must also associate with each difference the operators that are relevant to modifying it. For logic this is accomplished explicitly by the table of connections in Figure 3. These connections are given to GPS, but it is not difficult to write a program that will permit GPS itself to infer the connections from the lists of operators and differences. (E.g., comparing the right side of R1 with its left side, we find they have the difference $\triangle$P, for the symbols A and B appear in opposite orders on the two sides; hence, there is a connection between $\triangle$P, and R1.) Finally, we provide criteria of progress, in terms of a list of the differences in order of difficulty.

An illustrative logic problem and its solution are shown in Figure 4. The object, L1, is given, and GPS is required to derive the object, L0. The problem is stated to GPS in the form of a Type #1 goal; (Goal 1) Find a

Fig. 2 — Methods for means-ends analysis.

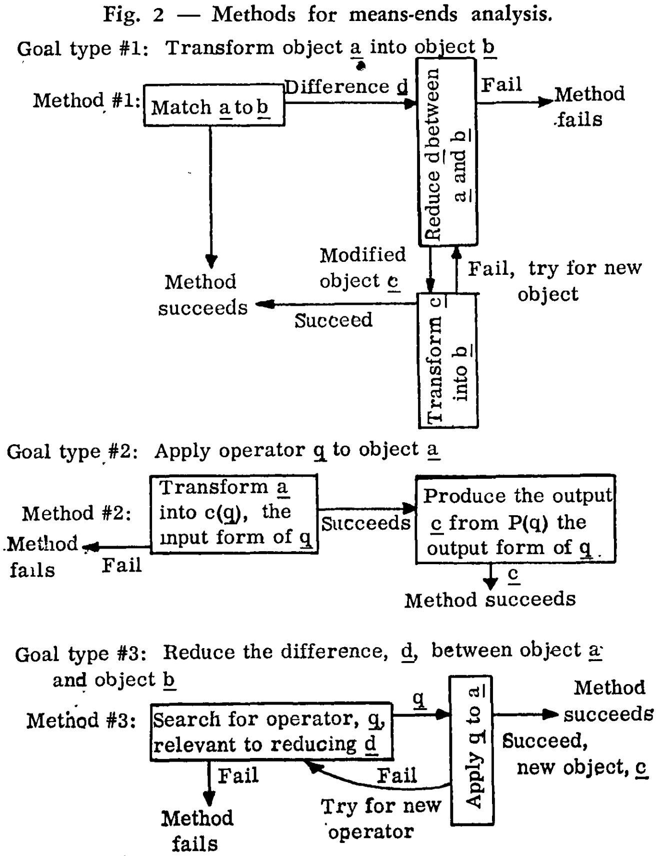


Figure 3

Figure 3a. Symbolic Logic Task Environment, Part I.

Objects. Expressions are built up recursively from *variables,* P, Q, R, ..., three binary connectives, ., ⊃, v, and the unary prefix, —, called tilde. Examples of objects: P, —Q, PvQ, (—R.P) ⊃ —Q. Double Tildes cancel as in ordinary algebra: — —Q =Q.

Operators. There are twelve operators, given in the form $C(q) \rightarrow P(q)$, where $C(q)$ is the *input form,* and $P(q)$ is the *output form.* Thus anything of the form at the tail of an arrow can be transformed into the corresponding expression at the head of the arrow. A double arrow means the transformation works both ways. The *abstracted operators,* used in the planning method, are given in the right-hand column opposite the operator.

	Operators	*Abstract Operators*
R1	AvB → BvA, A.B → B.A	Identity
R2	A ⊃ B → —B ⊃ —A	Identity
R3	AvA ⟷ A, A.A ⟷ A	(AA) ⟷ A
R4	Av(BvC) ⟷ (AvB)vC, A. (B.C) ⟷ (A.B).C	A(BC) ⟷ (AB)C
R5	AvB ⟷ —(—A.—B)	Identity
R6	A ⊃ B ⟷ —AvB	Identity
R7	Av(B.C) ⟷ (AvB) . (AvC), A.(BvC) ⟷ (A.B)v(A.C)	A(BC) ⟷ (AB) (AC)
R8	A.B → A, A.B → B	(AB) → A
R9	A → AvX (X is an expression.)	A → (AX)
R10	[A, B] → A.B (Two expressions input.)	[A, B] → (AB)
R11	[A ⊃ B, A] → B (Two expressions input.)	[(AB), A] → B
R12	[A ⊃ B, B ⊃ C] → A⊃C (Two expressions input.)	[(AB), (BC)] → (AC)

Differences. The differences apply to subexpressions as well as total expressions, and several differences may exist simultaneously for the same expressions.

△V A variable appears in one expression that does not in the other. E.g., PvP differs by +V from PvQ, since it needs a Q; P ⊃ R differs by —V from R, since it needs to lose the P.

△N A variable occurs different numbers of times in the two expressions. E.g., P.Q differs from (P.Q) ⊃ Q by +N, since it needs another Q; PvP differs from P by —N, since it needs to reduce the number of P's.

△T There is a difference in the "sign" of the two expressions; e.g., Q versus —Q, or —(PvR) versus PvR.

△C There is a difference in binary connective; e.g., P ⊃ Q versus PvQ.

△G There is a difference in grouping; e.g., Pv(QvR) versus (PvQ)vR.

△P There is a position difference in the components of the two expressions; e.g., P ⊃ (QvR) versus (QvR) ⊃ P.

Figure 3b. Symbolic Logic Task Environment, Part II.

Connections between Differences and Operators. A +, —, or x in a cell means that the operator in the column of the cell affects the difference in the row of the cell. + in the first row means +V, — means —V, etc. The stars show the differences and operators that remain after abstracting, and thus mark the reduced table of connections used in the abstract task environment for planning.

			*	*			*	*	*	*	*	*
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
*△V								—	+	+	—	x
*△N			x				x	—	+	+	—	x
△T		x			x	x						
△C					x	x	x					
*△G				x			x					
△P	x	x										

Criteria of progress. All differences in subexpressions are less important than differences in expressions. For a pair of expressions the differences are ranked: +V, —V, +N, —N, △T, △C, △G, △P, from most important to least. E.g., △T is more important in —(PvQ) versus P ⊃ Q, but △C is more important in —PvQ versus P ⊃ Q.

way to transform L1 into L0. By Figure 2, this goal type calls for Method #1. Comparison of L1 and L0 shows that they have the difference, △P; for the "R" is on the left end of L1, but on the right end of L0. GPS now erects the Type #3 goal: (Goal 2) Reduce △P between L1 and L0. Goal Type #3 calls for application of Method #3. Since the table of connections (Figure 3) shows that R1 is relevant to reducing △P, GPS erects the Type #2 goal: (Goal 3) Apply operator R1 to L1. The reader can follow the remaining steps that lead to the solution from Figure 4. The resulting derivation may be summarized:

Object	*Operator*
L1 = R. (—P⊃Q)	
L2 = (—P⊃Q).R	Apply R1 to L1
L3 = (P v Q).R	Apply R6 to left side of L2
L4 = (Q v P).R	Apply R1 to left side of L3
L4 is identical with L0	Q. E. D.

GPS can solve problems a good deal more difficult than the simple one illustrated. To make full use of the twelve operators, an additional method is added to the Type #3 goal that searches the available objects for the additional input required in rules R10, R11, and R12.

Application to Trigonometry. GPS is a general problem solver to the extent that its heuristics can be applied to varying subject matters, given the appropriate correlative definitions. Elementary algebra and calculus provides a subject matter distinct from logic, and Figure 5 shows the fragment of this task environment necessary for GPS to try to prove some simple trigonometric identities. The objects are now algebraic and trigonometric expressions; and the operators perform factorization, algebraic simplification, and trigonometric transformation. The differences are the same as in logic, except for two omissions, which are related to the associative and commutative laws. In logic these must be performed explicitly, whereas in ordinary algebra a notation is used that makes these laws implicit

Figure 4. Example of means-ends analysis in logic.

Given: $L1 = R.(-P \supset Q)$
Obtain: $L0 = (QvP).R$
Goal 1: Transform L1 into L0.
  Match produces position difference ($\triangle P$).
  Goal 2: Reduce $\triangle P$ between L1 and L0.
    First operator found is R1.
    Goal 3: Apply R1 to L1.
    Goal 4: Transform L1 into C(R1).
    Match succeeds with $A = R$ and $B = -P \supset Q$.
    Produce new object:
    $L2 = (-P \supset Q).R$
  Goal 5: Transform L2 into L0.
    Match produces connective difference ($\triangle C$) in left subexpression.
    Goal 6: Reduce $\triangle C$ between left of L2 and left of L0.
    First operator found is R5.
    Goal 7: Apply R5 to left of L2.
    Goal 8: Transform left of L2 into C(R5).
    Match produces connective difference ($\triangle C$) in left subexpression.
    Goal 9: Reduce $\triangle C$ between left of L2 and C(R5).
    Goal rejected: difference is no easier than difference in Goal 6.
    Second operator found is R6.
    Goal 10: Apply R6 to left of L2.
    Goal 11: Transform left of L2 into C(R6).
    Match succeeds with $A = -P$ and $B = Q$.
    Produce new object:
    $L3 = (PvQ).R$
Goal 12: Transform L3 into L0.
    Match produces position difference ($\triangle P$) in left subexpression.
    Goal 13: Reduce $\triangle P$ between left of L3 and left of L0.
    First operator found is R1.
    Goal 14: Apply R1 to left of L3.
    Goal 15: Transform left of L3 into C(R1).
    Match succeeds with $A = P$ and $B = Q$.
    Produce new object:
    $L4 = (QvP).R$
    Goal 16: Transform L4 into L0.
    Match shows L4 is identical with L0, QED.

and their operation automatic. The connections between differences and operators is not made via a simple table, as in logic, but requires a comparison of the object with the output form of the operator. The criteria of progress remain the same as for logic.

GPS can now attempt to prove a trigonometric identity like:

$$(\tan + \cot) \sin \cos = 1$$

This is given as the problem of transforming the left side, which becomes L1, into the right side, LO. The process of solving the problem, which involves 33 goals and subgoals, is shown in Figure 6, which is to be interpreted in exactly the same way as Figure 4, with the help of Figures 2 and 5, except that the methods are not mentioned explicitly.

Planning as a Problem-Solving Technique

The second system of heuristic used by GPS is a form of planning that allows GPS to construct a proposed solution in general terms before working out the details. It acts as an antidote to the limitation of means-ends analysis in seeing only one step ahead. It also provides an example of the use of an auxiliary problem in a different task environment to aid in the solution of a problem.* Planning is incorporated in GPS by adding a new method, Method #4, to the repertoire of the Type #1 goal.

This *Planning Method* (see Figure 7) consists in (a) *abstracting* by omitting certain details of the original objects and operators, (b) forming the corresponding problem in the abstract task environment, (c) when the abstract problem has been solved, using its solution to pro-

Figure 5. Trigonometry task environment

Objects. Ordinary algebraic expressions, including the trigonometric functions. The associative and commutative laws are implicit in the notation: the program can select freely which terms to use in an expression like $(x + y + z)$.

Operators.

A0 — *Combine:* recursively defined to apply the following elementary identities from the innermost subexpressions to the main expression:
(1) $A + (B + C) \rightarrow A + B + C$, $A(BC) \rightarrow ABC$
(2) $A + O \rightarrow A$, $A + A \rightarrow 2A$, $A - A \rightarrow O$
(3) $AO \rightarrow O$, $A1 \rightarrow A$, $AA \rightarrow A^2$, $A^B A^C \rightarrow A^{B+C}$
(4) $A^0 \rightarrow 1$, $O^A \rightarrow O$, $A^1 \rightarrow A$, $(A^B)^C \rightarrow A^{BC}$

A1 — $(A - B)(A + B) \longleftrightarrow A^2 - B^2$
A2 — $(A + B)^2 \longleftrightarrow A^2 + 2AB + B^2$
A3 — $A(B + C) \longleftrightarrow AB + AC$
T1 — $\tan x \longleftrightarrow 1/\cot x$
T2 — $(\tan x)(\cot x) \longleftrightarrow 1$
T3 — $\tan x \longleftrightarrow \sin x / \cos x$
T4 — $\cot x \longleftrightarrow \cos x / \sin x$
T5 — $\sin^2 x + \cos^2 x \longleftrightarrow 1$

Differences. Defined as in logic: $\triangle V$, $\triangle N$, $\triangle C$, $\triangle T$, and $\triangle G$ and $\triangle P$ do not occur in algebra, since associativity and commutativity are built into the programs for handling expressions. The trigonometric functions are detected by $\triangle V$ and $\triangle N$.

Connections between Differences and Operators. A +, —, or x in a cell means that the operator in the column of the cell affects the difference in the row of the cell. A t means that the test defined at the bottom is applied.

	A0	A1	A2	A3	T1	T2	T3	T4	T5
$\triangle V$	—				t	t	t	t	t
$\triangle C$	x	x	x	x					
$\triangle N$	—	x	x	x	t	t	t	t	t
$\triangle T$	x								

Test t: accept if other functions in output form already occur in expression.

Criteria of progress. Defined as in logic, but with $\triangle C$ more important than $\triangle N$ or $\triangle P$.

* See the work of H. Gelernter and N. Rochester on theorem proving programs for plane geometry (2), where the geometric diagram provides an example of a *very powerful* auxiliary problemlem space.

Figure 6. Example of means-ends analysis in trigonometry

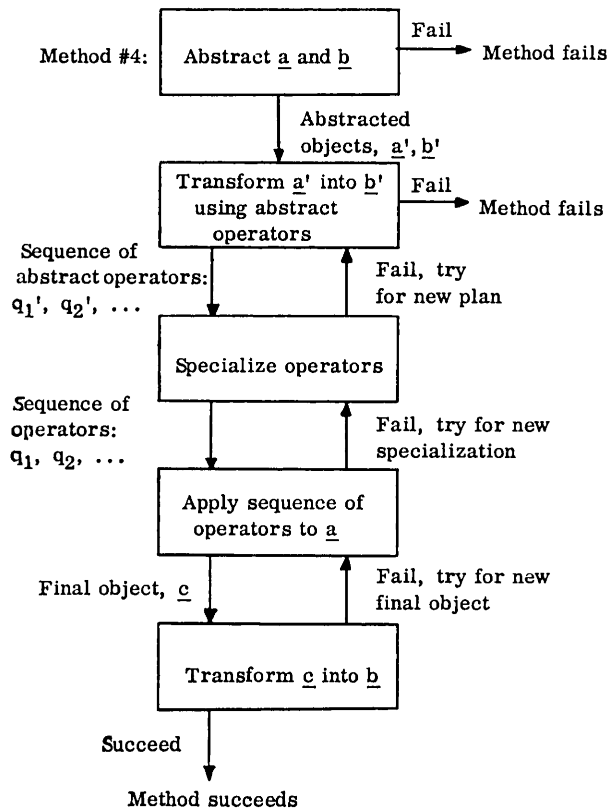
Given: L1 = (tan x + cot x) sin x cos x
Obtain: L0 = 1
Goal 1: Transform L1 into L0.
  Goal 2: reduce —V between L1 and L0 (tan).
    Goal 3: Apply A0 (combine) to L0 [no change produced].
    Goal 4: Apply T1 to L1.
    Goal 5: Transform L1 into C(T1) [succeeds]
    L2 = [(1/cot x) + cot x] sin x cos x
  Goal 6: Transform L2 into L0.
    Goal 7: Reduce —V between L2 and L0 (cot).
    Goal 8: Apply A0 to L2 [no change produced].
    Goal 9: Apply T4 to L2.
    Goal 10: Transform L2 into C(T4) [succeeds].
    L3 = [(1/(cos x/sin x)) + (cos x/sin x)] sin x cos x
    Goal 11: Transform L3 into L0.
    Goal 12: Reduce —V between L3 and L0 (cos).
    Goal 13: Apply A0 to L3:
    L4 = [(sin x/cos x) + (cos x/sin x)] sin x cos x
    Goal 14: Transform L4 into L0.
    Goal 15: Reduce —V between L4 and L0 (sin).
    Goal 16: Apply A0 to L4 [no change produced].
    Goal 17: Apply T5 to L4.
    Goal 18: Transform L4 into C(T5).
    Goal 19: Reduce △C between L4 and C(T5) (. to +).
    Goal 20: Apply A0 to L4 [no change produced].
    Goal 21: Apply A1 to L4.
    Goal 22: Transform L4 into C(A1).
    Goal 23: Reduce △C between L4 and C(A1) [reject].
    Goal 24: Apply A3 to L4.
    Goal 25: Transform L4 into C(A3) [succeeds].
    L5 = [sin x/cos x]sin x cos x + [cos x/sin x]sin x cos x
    Goal 26: Transform L5 into C(T5).
    Goal 27: Reduce △C between left of L5 and left of C(T5).
    Goal 28: Apply A0 to left of L5:
    L6 = $\sin^2 x$ + [cos x/sin x]sin x cos x
    Goal 29: Transform L6 into C(T5).
    Goal 30: Reduce △C between right of L6 and right of C(T
    Goal 31: Apply A0 to right of L6:
    L7 = $\sin^2 x + \cos^2 x$
    Goal 32: Transform L7 into C(T5) [succeeds].
    L8 = 1
    Goal 33: Transform L8 into L0 [identical], QED.

vide a plan for solving the original problem, (d) translating the plan back into the original task environment and executing it. The power of the method rests on two facts. First, the entire machinery of GPS can be used to solve the abstract problem in its appropriate task environment; and, because of the suppression of detail, this is usually a simpler problem (having fewer steps) than the original one. Second, the subproblems that make up the plan are collectively simpler (each having few steps) than the original problem. Since the exploration required to solve a problem generally increases exponentially with the number of steps in the solution, replacement of a single large problem with several smaller problems, the sum of whose lengths is about equal to the length of the original problem, may reduce the problem difficulty by whole orders of magnitude.

Figure 8 shows the Planning Method applied to a problem of symbolic logic. The particular abstraction scheme that is illustrated ignores differences among connectives and the order of symbols (△C and △P), replacing, for example, "(R⊃—P) . (—R⊃Q)" with "(PR) (QR)". The operators are similarly abstracted, so that "AvB→BvA"

Fig. 7 — Planning Method

Goal type #1: Transform object a into object b



becomes "(AB)→(AB)"—i.e., the identity operator — and "A.B→A" becomes "(AB)→A", as shown in Figure 3. The abstracted problem, Transform A1 into AO, has several solutions in the abstracted task environment. One of these may be summarized:

	Object	*Operation*
A1	(PR) (QR)	
A2	(PR)	Apply R8 to get left side of A1
A3	(QR)	Apply R8 to get right side of A1
	(PQ)	Apply R12 to A2 and A3
But	(PQ) is identical with AO	Q. E. D.

Transforming A1 into AO is the abstract equivalent of the problem of transforming L1 into LO. The former is solved by applying the abstracted operators corresponding to R8, R8, and R12 in sequence. Hence (Figure 9, Goal 4) a plan for solving the original problem is to try to apply R8 to L1 (obtaining a new object whose abstract equivalent is (PR), applying R8 to the other side of L1 (obtaining an object corresponding to (QR)), applying R12 to the objects thus obtained, and finally, transforming this new object (which should be an abstract equivalent of L0) into L0. Each of the first three parts of this plan constitutes a Type #2 goal in the original task environ-

Figure 8. Example of planning in logic.

Given: L1 = (R⊃—P). (—R⊃Q)
Obtain: L0 = —(—Q.P)
Goal 1: Transform L1 into L0 [Method #1 fails; now Method #4 is tried].
Abstract L1 and L0:
A1 = (PR) (QR)
A0 = (PQ)
Goal 2: Transform A1 into A0 [using abstracted operators].
Several plans are generated [details are omitted]:
P1 = R8, R11, R12.
P2 = R8, R8, R12.
P3 = . . .
Goal 3: Apply P1 to L1 [fails, details are omitted].
Goal 4: Apply P2 to L1.
Goal 5: Apply R8 to L1.
Goal 6: Transform L1 into C(R8) [succeeds].
L2 = R⊃—P
Goal 7: Apply R8 to L1.
Goal 8: Transform L1 into C(R8) [succeeds].
L3 = —R⊃Q
Goal 9: Apply R12 to L2 and L3.
Goal 10: Transform L2 and L3 into C(R12) [L2 fits B⊃C].
Goal 11: Reduce △P between L3 and C(R12) (A⊃B with B = R).
Goal 12: Apply R2 to L3.
Goal 13: Transform L3 into C(R2) [succeeds].
L4 = —Q⊃R
Goal 14: Transform L2 and L4 into C(R12) [succeeds].
L5 = —Q⊃—P
Goal 15: Transform L5 into L0.
Goal 16: Reduce △T between L5 and L0.
Goal 17: Apply R2 to L5 [fails, details omitted].
Goal 18: Apply R5 to L5.
Goal 19: Transform L5 into C(R5).
Goal 20: Reduce △C between L5 and C(R5).
Goal 21: Apply R5 to L5 [reject].
Goal 22: Apply R6 to L5.
Goal 23: Transform L5 into C(R6) [succeeds].
L6 = Qv—P
Goal 24: Transform L6 into C(R5) [succeeds].
L7 = —(—Q.P)
Goal 25: Transform L7 into L0 [identical], QED.

ment — that is, it requires the application of a specified operator to a specified expression. These three Type #2 goals are Goals 5, 7, and 9, respectively, in Figure 8. The first two are achieved almost trivially, and the third requires only five subgoals. The result is the expression, L5, which is to be transformed to L0, as indicated, by a Type #1 goal (Goal 15). Note that achieving the plan only involves operators that become the identity operator upon abstraction.

Like the other heuristics, the planning heuristic offers no guarantees that it will always work. It may generate no plan, a single plan, or several. More serious, a plan may turn out to be illusory — it may prove impossible to carry it out. The first plan generated in the illustrative problem, for example — R8, R11, R12 — does not provide a basis for a valid derivation when it is translated back to the concrete task environment. The time wasted in fruitless efforts to execute invalid plans must be counted in evaluating the planning heuristic, but even when allowance is made for this cost, the heuristic remains a very powerful one.

Conclusion

We have now described the principal heuristics that are used by GPS, and have shown how these heuristics enable it to solve problems. Although limitations of space prevent full discussion, we would like to conclude by mentioning several aspects of GPS that have received inadequate treatment in this paper.

1. GPS requires additional goals and methods, and we have investigated a number of these to varying degrees. For example, in many problems features of objects come to play a larger role than differences between objects — e.g., control of center in chess. A goal and methods similar to Type #3 are needed to handle features. Solving single equations in one variable also requires a new goal and new methods, embodying such heuristics as operating on both sides of an equation to isolate the variable. This goal is already needed in trigonometry to recognize that $(\sin^4 x - \cos^4 x)$ is of the form $(y^2 - z^2)$, so that it can be factored. Already GPS can handle algebraic simplification with its present repertoire, and integration of relatively simple expressions with the aid of a table of integrals. There is some hope, as the example introducing means-ends analysis indicates, that GPS may be capable of the common sense thinking that gets most humans through the details of each day's living.

2. GPS is given very little information about a task environment, and deals with the most general features of it. Beyond a point, most of the heuristics of GPS will be devoted to discovering special systems of heuristics for particular subject matters. In trigonometry, for example, GPS needs to be able to learn such heuristics as "reduce everything to sines and cosines," and "follow a trigonometric step with an algebraic step." In fact it followed these roughly in the example given, but only in a cumbersome fashion. The one narrow piece of learning we have mentioned — associating differences with operators — is a start in this direction.

3. Realizing programs with GPS on a computer is a major programming task. Much of our research effort has gone into the design of programming languages (information processing languages) that make the writing of such programs practicable. We must refer the reader to other publications for a description of this work (4, 9). However, we should like to emphasize that our description of GPS in this paper ignores all information handling problems: how to keep track of the goals; how to associate with them the necessary information, and retrieve it; how to add methods to an already running system; and so on. These technical problems form a large part of the problem of creating intelligent programs.

4. In this paper we have also underemphasized the role of the evaluation step — the opportunity to reject a goal before any effort is spent upon it. The methods are generative, producing possible solutions. They are only heuristic, and so will produce many more possibilities than can be explored. The evaluation applies additional heuristics to select the more profitable paths, and strongly affects the problem-solving ability of GPS. The means-ends analysis is a general heuristic because progress can be evaluated in the same general terms as the methods. More specific evaluations will again require learning.

5. Limitations of space have forced our examples to focus on the correct solution path. They do not convey properly the amount of selection, and trial and error. This is particularly unfortunate, since viewed dramatically, problem-solving is the battle of selection techniques against a space of possibilities that keeps expanding exponentially (5, 7).

REFERENCES

1. A. Bernstein, *et al.*, "A chess-playing program for the IBM 704," *Proceedings of the* 1958 *Western Joint Computer Conference,* May (1958).
2. J. Kister, *et al.*, "Experiments in chess," *J. Assoc. for Computing Machinery,* 4,2, April (1957).
3. H. L. Gelernter and N. Rochester, "Intelligent behavior in problem-solving machines," *IBM Journal of Research and Development,* 2,4, October (1958).
4. A. Newell and J. C. Shaw, "Programming the Logic Theory Machine," *Proceedings of the* 1957 *Western Joint Computer Conference,* February (1957).
5. A. Newell, J. C. Shaw, and H. A. Simon, "Empirical explorations of the Logic Theory Machine," *Proceedings of the 1957 Western Joint Computer Conference,* February (1957).
6. A Newell, J. C. Shaw, and H. A. Simon, "Chess playing programs and the problem of complexity," *IBM Journal of Research and Development,* 2, 4, October (1958).
7. A. Newell, J. C. Shaw, and H. A. Simon, "The processes of creative thinking," P-1320, The RAND Corporation, Santa Monica, California, August (1958).
8. A. Newell and H. A. Simon, "The Logic Theory Machine," *Transactions on Information Theory,* IT-2, No. 3, September (1956).
9. J. C. Shaw, *et al.*, "A command structure for complex information processing," *Proceedings of the* 1958 *Western Joint Computer Conference,* May (1958).

THE APPLICATION OF A COMPUTER TO BANK ACCOUNTING

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IN CONNECTION WITH the celebration of its 175th Anniversary, Mr. Lloyd D. Brace, President of The First National Bank of Boston, made the following observation: "Through the years the Bank and the Old Colony Trust Company (an affiliate of The First) have become more and more financial institutions doing business with hundreds of thousands of people, rather than with a relatively few wealthy merchants and others as in colonial times.

". . . our growth has been outstanding, particularly in the last 25 years . . . . New services have played an important part in this progress. Many of these services, such as the Common Trust Fund, Special Checking Accounts, the First Plan for automobile financing, and the unique Revolving Loan Plan, called First Check-Credit, are designed to meet the banking needs of people in all walks of life."

Trend to Retail Banking

This trend to retail banking, as it is sometimes called, has been characteristic of the vast majority of the banks throughout the country. It has been accompanied moreover by an ever-increasing need to find more economical, and more efficient, ways of processing increasing volumes of data resulting from continued growth and the new services offered by the banks.

In common with many of the banks throughout the country, the Methods Department of The First National Bank of Boston has been devoting its time for many years to seeking out new and better ways of doing things. As early as 1950, they began to take cognizance of the existence and development of computer systems which might be used in data processing systems. In 1954, it became quite evident that developments in this field were such as to warrant the assignment of at least one of our senior methods analysts to its study on a full-time basis. Thereafter, their research activities became somewhat more intensified.

First, we decided to attempt to find some practical means of determining the answer to two basic questions: (1) Could we use electronic data processing equipment in any one or more of our applications effectively? (2) If the answer to the first question was "yes," what equipment should we use?

Large Files of Data

Let us turn our attention to the first of these two problems — that of whether or not we might use electronics at all. Of the more than 90 different types of services which we offer to our customers, there are several requiring the manipulation of large files of data — such as check handling for approximately 108,000 customers, Personal Trust accounting, Instalment Loan accounting for approximately 65,000 borrowers, Commercial Loans, Mortgage Loans, and Factoring Accounts involving records for some 78,000 debtors' accounts, Corporate Trust accounting, involving 765,000 accounts, Payroll, some 83,000 Savings Accounts, personal money orders, and others. Some have already been mechanized to a considerable extent through extensive use of such modern techniques as those involving punched card equipment. Others have changed little over the years and encompass a tremendous volume of paper work. We could, of course, have selected one specific application — perhaps one of those least mechanized — and attempted to introduce the use of an electronic system in that area. This approach, however, seemed to be too limited in nature. We reasoned that a general-purpose computer system — if it lived up to its name — could be used to handle the work involved in various applications. So we tried a different approach.

Two Extremes

We examined our larger applications with a view to selecting the two of them that might represent the extremes in requirements for data processing — that is, the upper and lower limits of data processing requirements that any particular system could be called upon to handle. As a result of these studies, we selected two applications — the Deposit Accounting function and the Corporate Trust operation. Here were two that were diametrically opposed to each other. To round off figures, we were processing more than 220,000 items on the average day against 100,000 checking accounts. 48% of these accounts were active in a given day. A fixed record length might readily be assigned to each master record which would accommodate the largest as well as the smallest account. A substantial number of mathematical operations were required to process the accounts. Little alphabetic information was involved, it being presently limited to the name and address, which must be referred to ordinarily but once a month in order to prepare statements to our customers. We had to process more than 900 inquiries a day against the file, most of which required an immediate answer. While at first blush, it would seem that the files should best be kept in alphabetical order, it developed that there was no requirement that we do so. The file could be operated efficiently with a numeric numbering system.

On the other hand, the Corporate Trust function involved a tremendous file with relatively few items to be posted — actually 68/100ths of 1% would be affected daily. The file must be kept in alphabetical sequence. It was largely alphabetic in nature, and very little in the way of mathematical work was required. The record length necessary was variable, running from as few as 167 characters of information in one account to more than 47,000 characters of information in another. Inquiries that must be answered by reference to the file were relatively few and far between, and in most instances could be scheduled.

All our other operations seemed to fall between these two, in so far as data processing requirements were concerned. Notably, they were the two largest applications and, at the same time, the two that required the greatest amount of clerical effort. In contrast, some of our other larger applications have been operated since as early as 1931 on punched card tabulating equipment.

What EDP Equipment?

With a complete set of statistics available relative to current operations in these two areas, we turned our attention to the electronic data processing equipment available and proceeded to attempt to evaluate whether or not any of it might do our job. To program both applications in their entirety would be an exhausting job. We, therefore, tried to analyze the problem and to reach some common basis for comparing different types of equipment.

File Maintenance

We concluded that file maintenance in accounting procedures was the most difficult and the most repetitive and time-consuming operation. By file maintenance, we mean the preservation of a record of each account and updating it with the daily transactions, in order that it might be available at all times for the preparation of the multitude of reports that are required to operate a business. We therefore determined to initially limit our studies to this phase of our data processing problems.

Speed of Processing Files

Next, we determined that, within each of the three areas in which computers are classified — that is, small, medium, and large — the internal speeds of the computers then available were not significantly different. Far more important were the speeds with which these devices could process files — that is, their ability to read and write large volumes of data in order to locate the account, to bring in the transaction, and to write out an updated account. Hence, we determined to measure the relative merits of various computer systems in terms of the time which it would require to read master files and transactions, and to write the new master files for the two applications selected for that purpose.

In each instance, the records were established in such a fashion as to make the most efficient use of each of the systems tested, and to take into consideration the limitations and advantages peculiar to each such system. We started in the medium-sized computer field and selected one of the better known computers in this area, feeling that if we found that one medium-sized computer might reasonably perform the work, we would examine the other competitive models, in turn.

Amount of Processing Required

The results of these studies indicated that we might process our Deposit Accounting application and 1/10th of our Corporate Trust file in 30 hours of machine time. Thus, it became obvious that we would need two such systems, operated on at least two shifts in each 24-hour period, and at least 4 operating staffs to operate them, in order to handle only two applications. The cost of these systems, without consideration of the personnel involved, more than exceeded the cost of a large-scale system. No time would be available to add other applications without adding additional systems. The obvious conclusion was that the medium-sized computer system could not fulfill our over-all data processing requirements.

All Deposit Accounting in Less than ½ Hour

Next, we turned our attention to a large-scale computer. A typical system in this area, we found, was capable of performing our work as we were measuring it — in terms of reading and writing capacity — within a single shift. As a matter of fact, we found that it might handle our Deposit Accounting operation in less than three hours each day, and 1/10th of the Corporate Trust file in approximately 1.8 hours each day. If any computer system could handle our data processing problems, it must be in this category. With this in mind, we studied each of the large-scale computer systems then available and found one of them — the one which we selected — was capable of handling our Deposit Accounting operation in something less than 1/2 hour and 100%, as distinguished from 10%, of the Corporate Trust file, in a little over one hour. It should be emphasized that these, of course, are not total processing times, but only a measure used to make comparisons, since it was the area in which the major differences in equipment existed.

The results of these studies were then, for the first time, made available to the equipment manufacturers who were requested to review them and to modify them, if they felt the calculations were substantially in error.

In June of 1956, we forwarded to senior management a report outlining the studies to date and reporting our conclusions to the effect that, (a) electronic data processing equipment was available, which could do a job for us, and, (b) that it appeared that the system, which we eventually selected, would be capable of handling a substantial number of our applications on a one-shift basis, and permit adding other applications, as time went on. It was pointed out that, since the time required to do the processing on this system was substantially less than that of comparable models, at comparable prices, the machine selected, as first choice, would be the most economical of those available.

Economic Feasibility

Until this time, we had given little thought to the economic feasibility of acquiring a computer system of any type. We had merely determined the answer to two questions — could such equipment be used effectively and, if so, what specific system might best do it.

Here our Cost Department took over and began to draw some comparisons between the cost of operating the recommended system and existing costs. Time permits us to treat with this subject only briefly. Basically, the position was taken that installation and conversion costs should be amortized over a period of years. It appeared that during the first two to three years of operation, increased costs should be anticipated but that, thereafter, they might be reduced — particularly when we could acquire additional equipment of a peripheral nature, which would facilitate the transfer of data encoded on paper checks to machine language to be processed within the system. No attempt was made to reduce to figures such intangibles as continuing increases in salaries, with a consequent increase in conversion costs postponed to a later date, or the hidden costs to be found in the less efficient, but more orthodox, procedures which we follow today. Nevertheless, we believe such increases will serve as a substantial cushion to ultimately absorb any miscalculations that may have been made.

Independent Review

When we submitted what proved to be the last feasibility report to management, together with a recommendation that we acquire such equipment, we included a suggestion that our studies be reviewed by independent consultants. Subsequently, management retained a well-known management consultant firm to review the feasibility studies, and an equally well-known computer expert to examine the design and specifications of the computer — which then had not been constructed, — and advise us upon the probability of the manufacturer being able to deliver one, which would satisfactorily meet performance tests within the time limits suggested. With very minor exceptions, the consultants approved our findings and recommendations and, in turn, recommended that we proceed. Late in October, 1956, we executed a contract for a system to be installed early in 1958.

Implementation of Plans

Immediately, we began to implement plans which had been developed for the installation and operation of the equipment. The day we signed the contract, a communication was addressed individually to each of the members of our staff. This communication briefly outlined our decision to acquire such equipment and contained reassurances that its use would not adversely affect anyone's position in the Bank. Prior to this we had published, from time to time, various articles in our house organ with respect to our studies of electronic equipment. Therefore, the notice probably came as no surprise to our people. Simultaneously with the distribution of the notice, a meeting of the officers of the Bank was called. At this meeting, initial plans for the use of the equipment were outlined. Divisional and department heads were advised that we would shortly seek qualified personnel to enlist as programmers, and their co-operation in arranging for the release of any individuals, so selected, was requested.

On October 29, 1956, we inaugurated the first of several courses which were to follow, designed to train personnel and programmers in the use of the equipment. Each of these courses was so arranged that the first two days provided an over-all discussion of the system; the first two weeks, a more detailed explanation of how it operated and how it might be used; and the remaining four weeks, actual training in the details of programming. Many of our senior officers and divisional heads attended the first two days of these courses, and department managers and supervisors attended the two weeks' courses.

Training of Programmers

In all, we selected 23 people for our programming staff. The group included staff members, supervisors, or junior officers within the areas initially to be programmed, selected for their experience in these areas. In addition, the group included three persons selected for their knowledge of, and familiarity with, the installation and operation of tabulating equipment, and four who were on our Methods Department staff. Following the completion of the six weeks of basic training — provided by the manufacturer of the equipment—these people then attended classes of instruction intended to initiate them in a method of systems analysis which would be consistent in each of the areas to be programmed, and which, in our judgment, would meet the needs of an electronic installation of the type that was involved.

On January 2, 1957, the programmers were divided into three groups, one to cover Deposit Accounting, one to cover Corporate Trust work, and one to cover Loan operations — the latter includes Commercial Loans, Mortgage Loans, Instalment Loans, and our Factored Accounts. Each group consisted of one person formerly associated with the Methods Department, one person experienced in the use of tabulating equipment, and two or more who had been drawn from the Operating Departments.

Analysis of Current Operations

The first activity of each group, the most time-consuming of the entire operation, was to analyze in detail the current operations in the area to which they had been assigned. The analysis consisted of two basic factors. First, they were required to flow-chart, in detail, the flow of data from the time it entered the Bank to the time it was ultimately disposed of in our accounting procedures. The type of flow charting used was considerably different from that which you might normally expect. Only five basic symbols were used, and emphasis was placed entirely upon the form of, and the movement of data, rather than who handled it, or through what departments it passed. Very little attention was actually given to departmental lines in this analysis.

The second factor in the study was an analysis of the forms used to convey this data through our accounting procedures. A copy of each piece of paper used, whether a pre-printed form or a piece of scratch paper, completed with a typical entry, or entries, was attached to an analysis sheet which gathered for us that statistical data which is so essential to properly program a computer.

Next, each group laid out a master block diagram illustrating how they proposed to process data, using the new system. This effort was not confined to merely what the computer system was to do, but rather an over-all plan for capturing data for input in machine language at the earliest possible time, the means of capturing it, its conversion into language acceptable to the computer, what the computer was to do with it, and the nature and form of an ultimate output, which would more nearly satisfy the requirements and desires of management.

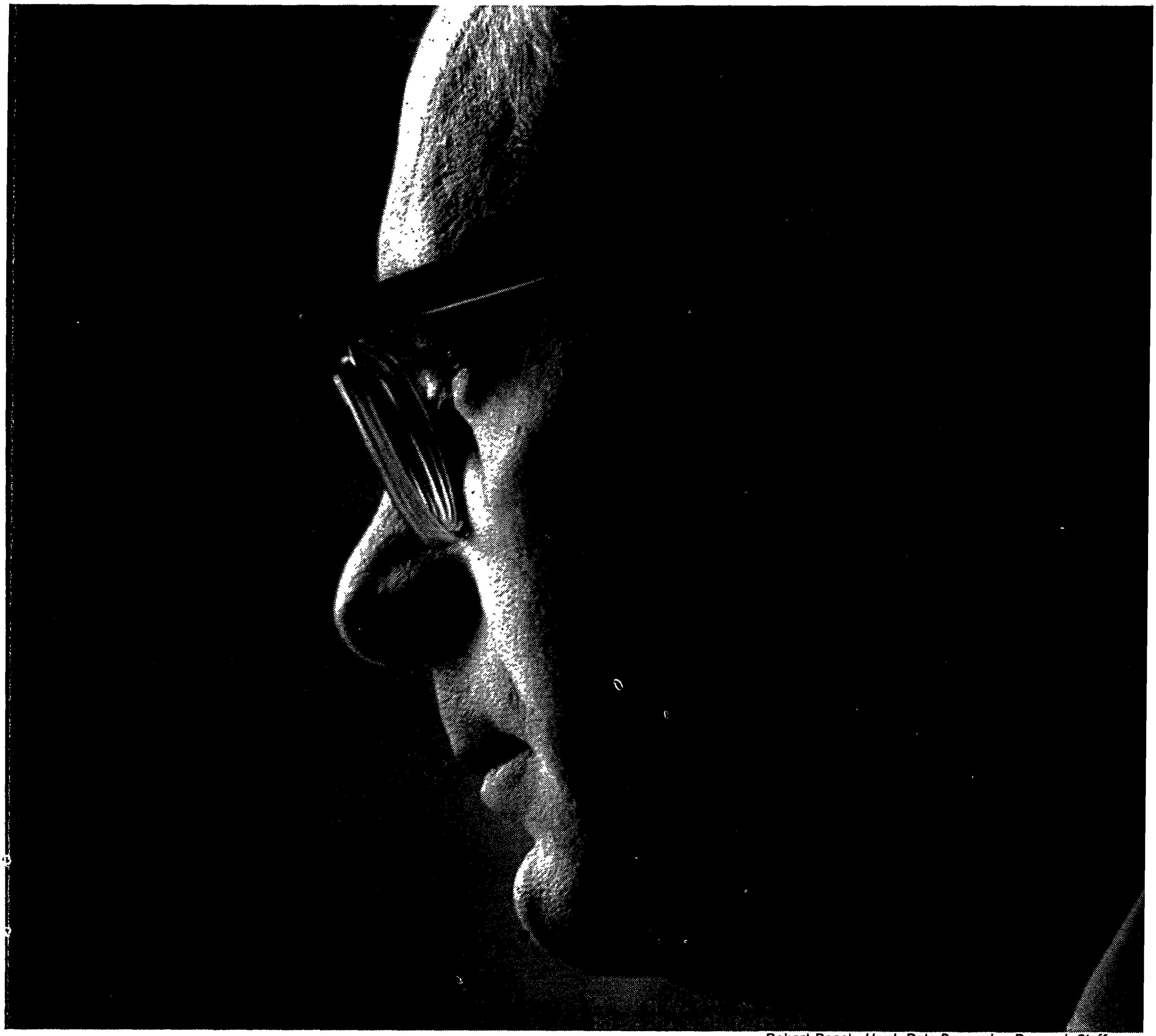
"THE PROGRAMMING FIELD is on the verge of tremendous changes. If we consider the developments in programming techniques and computer hardware that are currently in progress, these alone are enough to make one pause. Added to this are the new uses to which digital computers are being put, such as in management and process control systems. These new uses have created classes of problems for which we do not even have an adequate language to formulate the problems.

"We at SDC are aware of these imminent changes and are preparing for them by extensive activity in pure and applied research in computer programming. Realizing that a large computer based system consists of many integrated components, we are also undertaking interdisciplinary research among such diverse fields as computer programming, electrical engineering, psychology, and operations research.

"If you are a senior member of the programming profession and would like to participate in advanced research projects, you are invited to contact Mr. William Keefer at System Development Corporation, 2406 Colorado Ave., Santa Monica, Calif."

Robert Bosak

Robert Bosak, Head, Data Processing Research Staff



Robert Bosak, *Head, Data Processing Research Staff*

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SDC

SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA • LODI, NEW JERSEY

Input as a Byproduct

Once this was accomplished, a more detailed block diagram, to be used as a basis for the development of the program for the computer, was laid out, as well as actual input and output forms. Concurrently, studies were made of how the gathering of input data might be most efficiently accomplished with a minimum of clerical effort. This integrated approach to solving the problem resulted in the introduction and rather extensive use of peripheral machines in various areas throughout the Bank. As a by-product of typing or journalizing operations this equipment produces punched paper tape which, in turn, may be automatically reduced to the language of the machine. A significant advantage gained was the elimination of a substantial number of forms previously used, as well as keypunching and other copying operations, which heretofore required a considerable amount of clerical effort, and resulted in the introduction of errors into the data being processed.

Location and Reduction of Errors

It might be pertinent here to say that, through the use of this type of peripheral equipment, we have also been able to reduce errors, which initially cropped into the processing of data. It might also be interesting to know that we, as a result of practical experience with our computer system, have adopted the philosophy of letting the computer locate such errors, as do occur in the preparation of input, rather than to get involved in extensive checking operations in order to purify the data before it reaches the computer system.

Writing the Program

The last operation, of course, was to convert the block diagrams, to which we have just referred, to the coded instructions used by the machine — in other words — to write the program itself. Our estimates indicate that to date, approximately 65% of the time devoted to the development of the program was spent in defining the problem, 25% in solving it, and 10% in translating it into machine language.

Delivery of Equipment

By the fall of 1957, plans had been developed for the preparation of the site in which the machine was to be located, and toward the latter part of the year site preparations actually began. Delivery of the equipment followed shortly after the middle of April, of 1958, and, on June 2, 1958, the engineers had completed assembly of all the various units involved, and engineering tests and check-outs were commenced.

Acceptance Tests

Our contract provided for a minimum of three weeks of acceptance tests and these were started later that month. Acceptance tests were run for the required period under the general supervision of the computer expert, whom we had retained originally as a consultant. The tests included not only the operation of various routines, which we had developed for regular daily use, but also specific programs written for the purpose of testing all of the various components of the system, and each of the mechanical and electromechanical pieces of equipment associated with it. By the middle of July, we were convinced that the equipment was satisfactory in all respects, with the exception of one unit — the high-speed printer — which at that time needed some further engineering work done on it. Therefore, the system was placed on a rental basis, with the exception of the printer, on July 17, 1958. The printer and converter, as it was initially delivered to us, was essentially a prototype; after rather extensive field testing in our bank, a production model, incorporating many improvements in design, was substituted for it. We are now using this equipment to print a wide variety of reports, including statements to our checking account customers, and the preparation of heat transfer masters for the imprinting of dividend checks, envelopes, and other single documents of assorted sizes and thicknesses. We expect the output in this area to reach a volume of 10 million pieces of mail per annum.

Deposit Accounting

When the equipment was turned over to us in June, we had completed the programming for our Deposit Accounting operation. This program is a comprehensive one intended to eventually handle more than 108,000 checking accounts. Since approximately 33,000 of these accounts are in the nature of special checking accounts — where the checks themselves are in the form of punched cards and provide a ready means of input — we selected these accounts for our initial operation.

Early in June, we transferred them to magnetic tapes and began to process them on a day-to-day basis one day behind the old operation. This procedure not only assisted us to evaluate the equipment during the test period, but also enabled us to do some final polishing of the program itself.

In the middle of July, 1958, we began an attempt to operate the new system on a parrallel with the old. This attempt led to one conclusion — that one cannot, as a practical matter, operate an accounting function designed to make the most effective use of electronic equipment on a parallel basis with manual or semi-automatic systems. The use of a computer system in data processing enables one to approach problems in a considerably different manner than it is otherwise possible to do in other systems. This difference in philosophy, combined with the greater speed and the high degree of accuracy, makes it extremely difficult to draw comparisons in any intermediate stages of handling data. We found that the adjustments that were necessary to balance one system to the other were extremely cumbersome to handle on a day-to-day basis. These tests, however, did serve to convince many of our people, who were unfamiliar with this new method of data processing, of the reliability and accuracy that we could expect of the new accounting procedures, and of the equipment itself.

Abandonment of the Old System

Early in September, we altered our procedures so that we were doing our regular processing electronically and the old system followed one day behind, in order that we might make one final check of our cycled statements. At the end of that month, we abandoned the old system entirely and, since that date, have been doing this work very satisfactorily on our new equipment.

It might be of interest to note here, that the operating time on the computer for a normal day's deposit accounting — to edit, sort, and post between 20,000 and 22,000 items to approximately 33,000 accounts, includ-

ing the preparation of tapes for the printing of statements, lists of overdrafts, and numerous other special reports, is on the order of 28 to 32 minutes — figures which compare favorably with the original estimates of our research group as to the time required for this operation.

Corporate Trust Application

As we indicated earlier, other applications were being programmed and program debugging has continued. By February, of this year, we completed checking out the routines for our Corporate Trust operation; and we now have the records, with respect to all of our own stockholders, on magnetic tape files. These are being processed regularly on the new system. As rapidly as we can complete the conversion of data in our old files to tapes, we will increase this operation to include in excess of 765,000 accounts. This conversion will take some time, since we are faced with the practical problem of manually punching the equivalent of more than 5 and ½ million cards in order to translate the data in our old files into machine language.

A Calculated Key for Alphabetic Sequence

There are one or two things that are unique about this particular application. First, we believe that we are the first bank to apply fully automatic techniques to it. Second, the routine, itself, puts upon the computer the burden of calculating and assigning to each item, a key, in lieu of an account number, which, when sorted, results in arranging the files in alphabetical sequence. In a file of the size with which we are concerned, the cost of looking up and assigning numbers to each item in the file, and to each transaction affecting the file, in order to post correctly and to preserve its alphabetic sequence, is very high. Some banks have felt that this cost is sufficiently great to wipe out any gains that might otherwise be realized from other semi-automatic or automatic accounting systems requiring the numbering of accounts and have, therefore, stayed with manual systems.

We are frequently asked "If you can maintain an alphabetical file in this way in this operation, why do you not follow the same procedure with respect to all other files?" The answer is that, in this particular type of file, a substantial proportion of the daily transactions consists of opening and closing of accounts and there is no practical way of controlling input to the system so that account numbers are reflected in the data. Every transaction must be looked up, and a number assigned to it, if a numbering system is to be used. On the other hand, in an operation such as the handling of checking accounts, there are relatively few accounts opened or closed from day to day, and practically all of the transactions affecting it can be pre-coded with an account number, so that it is readily available when the check or deposit is presented to the Bank. The low activity in the file also has some bearing, since the amount of time required for the computer to calculate the key would be quite significant if approximately 10% or more of the accounts were to be affected on a daily basis.

Loan Operations

In addition to the two applications which we are presently operating on the computer system, we are rapidly completing basic programs for our loan operations, and we expect to add them to our electronic data processing during the next few months. Thereafter, we shall turn our attention to such other services as Personal Trust, Payroll, Savings Accounting, Expense Distribution, and others. In our best judgment, at the present time, it appears that we will be able to handle all of these applications on the computer, which we have installed, and, as time goes on, that we will need only to expand the peripheral equipment, such as the printers, to take care of these additions as well as the increases in volume that we expect to realize.

Certain Important Points

We have taken some time to outline our experiences in approaching the use of electronics for data processing, and installing and operating a computer system. We hope that you will accept this outline as being in the nature of a progress report, and that it may be of some help to potential users of electronic equipment, both large and small, as well as to those interested in the manufacture of such equipment. We know that many of you, who have not already done so, are capable of accomplishing the same task and, undoubtedly, with better results. Perhaps our progress will encourage some of you to take another critical look at this tool for business. For those of you who might be so inclined, we might, by way of summarization, emphasize the following points:

1. The use of electronics should be of paramount interest to senior management, who must determine the result that they wish to accomplish and be willing to support rather drastic changes in organization — if need be. Select one or two individuals in whom you have implicit confidence and

who have an over-all knowledge of the business and an over-all interest in its success, to study the potentials to be found in the use of such equipment, and to direct the installation and its operation, if a computer should be ultimately selected. While much can be said in favor of committees, they frequently result in extensive and expensive periods of research and little in the way of decision.

2. Make your own evaluations. Don't depend upon the manufacturers. It has been said that electronic engineers understand the mechanics of the computer but rarely the mechanics of the company. It is much easier to teach the machine to someone who understands the business, and who is progressive and willing to accept new ideas, than it is to teach one who knows the machine all of the intricacies of your business.
3. Consider all of your accounting problems — not just the one or two that may be foremost in your mind because they are the most critical from one viewpoint or another. A computer should not be considered as another bookkeeping or tabulating machine to be super-imposed upon one or more existing operations — nor ordinarily should it be left to individual departments to decide how or why a computer should be used.
4. If the use of a computer is indicated, you have a right to anticipate better quality of work as well as the ability to handle greater quantities. Question the adequacy and efficiency of present methods, but in doing so, ascertain whether or not you are talking to the men who designed them. And, remember that quality and quantity can be materially dissipated by the insistence that information shall be provided exactly as it always has been.
5. If you decide that electronics is a tool that you can apply to your business, select the hardware that will not only perform best for you now, but that will perform, at least, equally as well, in so far as you are able to judge, five years from now. A system that is limited to fulfilling only your present requirements and permitting no expansion or changes in methods may well lead you into substantial and expensive changes later — changes which can wipe out all of the advantages that might be gained as a result of the initial installation.

General Usefulness of EDP

In conclusion, may I say that the electronic computer is a tool which, when put to proper use, will serve banks and other service businesses, as well as industrial organizations, in solving a wide variety of data processing problems. Studies which we have conducted have convinced us that this tool can be useful to a wide range of firms of various sizes. Appropriately, electronic data processing systems are available in a variety of sizes, and they are priced accordingly. Businessmen should not arbitrarily assume that their organizations are "too small" to make it economically feasible for them to use these tools. To the contrary, we must avoid such ill-considered conclusions, and examine carefully into the possibility of whether or not such equipment will aid us along the road to success in our business.

FOR BETTER EDUCATION — REPORT OF PROGRESS

IN THE APRIL issue of "Computers and Automation," page 6, we published an announcement of the "Division for Better Education." This was a call to members of the Association for Computing Machinery and/or readers of "Computers and Automation" to become concerned with the quality of education in elementary and secondary schools and to become active.

We said the quality of such education is "one of the most important factors bearing on the training of young people for doing good work in mathematics, science, and computing machinery"; "the plan is to form a Division for Better Education; to put together and distribute a list of names and addresses of persons interested in this field; to set up close contact between members of this division; and to exchange information and discussion, and if feasible arrange local meetings." We remarked that "with 30 to 50 percent of young people entering college who cannot read adequately for college work, our concern must reach beyond the territory of just mathematics, science, and automatic computers in junior and senior years of high school."

The following people, 19 up to the end of May, have sent in the reply form, and are therefore members so far of the Division for Better Education. Even at so early a time as this, it seems that 2 people in Philadelphia, 2 people in New York, 5 people in Denville, N.J., and probably 3 or 4 people in California are close enough together so that they can start talking with each other and exchanging information and opinions.

California		
	Mr. P. L. Lindley	373 E. Cucamonga, Claremont
	Mr. L. D. Kovach	Engrg Computing, B-250, Douglas Aircraft Co., Inc., El Segundo
	Mr. H. Arthur Hatch	250 Middlefield Rd., Menlo Park
	Mr. Joseph L. Neumiller	c/o Folgers Coffee Co., 101 Howard St., San Francisco
	Mr. G. Eric McAllister	Computer Coordinator, Dept. G31, Douglas Aircraft Co., Santa Monica
	Mr. J. G. Luter	1322 W. 222nd St., Torrance
Delaware		
	Mr. Walter E. Trabbold	Asst. Comptroller, Bank of Delaware, 6th & Market Sts., Wilmington
Louisiana		
	Mr. Wilbur D. Wright	United Gas Corp., Research Lab., 8015 St. Vincent Ave., Shreveport
New Jersey		
	Mr. Joseph Behar	Thiokol Chemical Corp., Reaction Motors Div., Denville
	Mr. Robert Behnke	Thiokol Chemical Corp., Reaction Motors Div., Denville
	Mr. Duncan Morrill	Thiokol Chemical Corp., Reaction Motors Div., Denville
	Mr. Richard Robinson	Thiokol Chemical Corp., Reaction Motors Div., Denville
	Mr. Jesse Perry	Thiokol Chemical Corp., Reaction Motors Div., Denville
New York		
	Mr. Ed Burnett	513 Ave. of the Americas, New York 11
	Mr. George Hagan	27 Sycamore Ave., Floral Park, L.I.
North Carolina		
	Mr. Alfred B. Gough	Outdoor Lighting Dept., General Electric Co., Hendersonville
Pennsylvania		
	Dr. George W. Patterson	Moore School of Elec. Engrg., Univ. of Pa., Philadelphia 4
	Mr. W. Gilmore Tower	Smith Kline & French Labs., 1500 Spring Garden St., Philadelphia 1
	Miss Mary Lister	531 W. Fairmount Ave., State College

The above people are invited and encouraged to get in touch with each other, either directly or through us. The first step is to become informed and exchange information.

BETTER EDUCATION QUESTIONNAIRE

To each person who has responded so far we have sent out the following questionnaire. We think the four books and the two organizations listed in this questionnaire are a very good introduction to the great problem of better education in the United States today.

As soon as we have a statistically significant group of replies to the questionnaire, we shall report further.

BETTER EDUCATION QUESTIONNAIRE

From the
DIVISION FOR BETTER EDUCATION
c/o Computers and Automation
815 Washington St.
Newtonville 60, Mass.

1. Are any of your own children in public schools in your community? ....

   If so, in what grades? ....

2. Are you satisfied with the quality of education which children in your community are receiving in public schools? ....

   In what ways do you think it good? ....

   ....

   In what ways do you think it not good? ....

   ....

3. Have you read any of the following books related to education?

   a. "The American High School Today," by Dr. James B. Conant, McGraw Hill Book Co., New York, N.Y., 141 pp, $1.00 ☐ Yes ☐ No

   b. "Other Schools and Ours", by Edmund J. King, Rinehart & Co., Inc., New York, N.Y., 1958, 234 pp. ☐ Yes ☐ No

   c. "Education and Freedom," by H. G. Rickover, Vice Admiral, U.S.N., E. P. Dutton & Co., Inc., New York, N.Y., 1959, 256 pp. ☐ Yes ☐ No

   d. "Great Issues in Education," 3 vols., various authors, Great Books Foundation, Chicago, Ill., 1956 ☐ Yes ☐ No

4. Have you contacted either of the following organizations?

   a. National Citizens Council for Better Schools, 9 East 40 St., New York, N.Y.; (publishes "Better Schools") ☐ Yes ☐ No

   b. Council for Basic Education, 208 Union Trust Bldg., Washington 5, D.C.; (publishes "The Bulletin") ☐ Yes ☐ No

5. Have you engaged in any activities that you hoped would improve education in your community? .... In what ways? ....

   ....

   What do you think you may have accomplished? ....

   ....

   ....

6. Any remarks? ....

   ....

   ....

Name .... Address ....

When you have filled in this questionnaire to the extent you conveniently can, please return it to Edmund C. Berkeley, DIVISION FOR BETTER EDUCATION, c/o Computers and Automation, 815 Washington St., Newtonville 60, Mass.

RED TAPE STORY

In regard to the announcement (through "channels") to members of the Association for Computing Machinery of the ACM Division for Better Education, there has occurred a comedy of errors, delays, tugging at cross purposes, and red tape. One expression of it is a file covering 51 pages of letters and other communications up to June 1.

The story begins Nov. 3, 1958, when the plan for an "ACM Division for Better Education" was proposed; the plan was approved at the beginning of January; and the issue since then has been over whether (1) to send out a mailing to the members of the ACM, or (2) to announce the plan in the pages of the "Communications of the ACM."

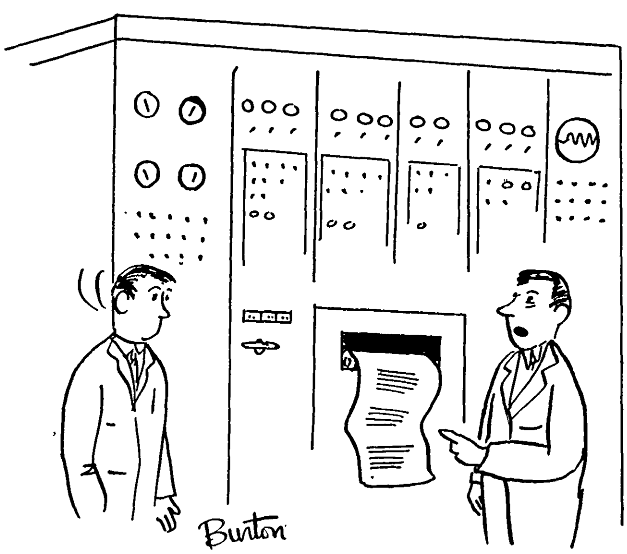
All that has appeared so far is an announcement in the "Communications of the ACM" on page 5 of the April issue, which read as follows:

> **ACM Secondary Education Committee**
>
> Edmund C. Berkeley, Chairman of the Secondary Education Committee, is compiling a mailing list of ACM members who are concerned about the quality of education in the elementary and secondary schools in relation to computers. Interested persons should write to him at 815 Washington St., Newtonville 60, Mass.

This notice is both incomplete and incorrect. For example, it makes no mention of the "ACM Division for Better Education," nor plans for organizing discussion and exchange of information, etc. Also, it is simply not true that we are concerned about the "quality of education in secondary schools in relation to computers" — we are concerned about the "quality of education in elementary and secondary schools in regard to reading, writing, arithmetic, science, and related subjects," because these are the important foundation subjects (in schools) on which capacity to do good work in computer and other scientific fields is later built.

We have asked the editor of "News and Notices" in the "Communications of the ACM" for a correct and complete announcement, but have received up to July 1 only a statement that what he has printed is all that he sees fit to print.

FAITHFUL SERVANT



"I think this computer's gone nuts. Look, it is saying that it's been thrifty, industrious, loyal, courteous, accurate, speedy, ... , and should not be replaced by a more modern computer."

LETTERS

For those who have not seen or do not remember the April issue report on "Education and Computers" we print here again the two letters:

To: All Members of the Association for Computing Machinery.

From: Edmund C. Berkeley, Chairman, A.C.M. Secondary Education Committee, 815 Washington St., Newtonville 60, Mass.

The quality of education in elementary and secondary schools is one of the most important factors bearing on the training of young people for doing good work in mathematics, science, and computing machinery.

As chairman of this committee of the Association, I am eager to find out the names and addresses of all ACM members who are interested in and concerned about the quality of education in:

reading	mathematics
writing	science, and
arithmetic	related subjects

— the quality of such education actually being produced in the schools in their neighborhoods.

The plan is: to form an "ACM Division For Better Education"; to put together and distribute a list of names and addresses of all ACM members interested in this field; to set up in this ACM division close contact between all such members; and to exchange information and discussion, and if feasible, arrange local meetings. This plan has the approval of Dr. Paul Brock, Chairman of the Education Committee of the ACM, and Dr. Richard W. Hamming, President of the Association.

With 30 to 50 percent of young people entering college who cannot read adequately for college work, our concern must reach beyond the territory of just mathematics, science, and automatic computers in junior and senior years of high school.

Would you please return the following reply form (or a copy of it) if you are interested in being in the ACM "Division For Better Education"?

If you have any remarks, comments, ideas, suggestions, references, etc., related to this subject of better education, I will be glad to receive them.

If you would like to work on any projects in this division, please tell me.

To: All Readers of Computers and Automation who do not happen to be members of Association for Computing Machinery.

In reference to the above letter, if you are interested in being in the C&A Division for Better Education (which will operate in parallel with the corresponding ACM division and for the same purposes), will you please return the following reply form (or a copy of it)?

- -

REPLY FORM (may be copied on any piece of paper)
To: E. C. Berkeley
815 Washington Street
Newtonville 60, Mass.

I am interested in better education and its relation to automatic computers. Please include me in the "Division for Better Education."

I am ☐
a member of the ACM.
I am not ☐

Remarks ....

....

My name and address are attached.

Readers' and Editor's Forum

[Continued from page 6]

plication to Thesauric Translation," by A. F. Parker-Rhodes and R. M. Needham, Cambridge Language Research Unit, Cambridge, England:

> "Among the essential requirements for a practicable machine translation procedure is some way of presenting what we call the 'meaning' of a word such that calculations can be made upon meanings, as in arithmetic we make calculations upon numbers. . . . ."

Still another field is making machines that are constructed like human brains with neurons, which can recognize patterns or imitate the learning that a human being shows. We quote from the paper of D. G. Willis, Lockheed Corp., Palo Alto, Calif., "Plastic Neurons as Memory Elements":

> "When we attempt to use conventional computer techniques to solve one of those complex problems frequently described as 'pattern recognition' or 'learning,' we usually find some major difficulties facing us. Often we can design or program a machine, or at least state how a machine should be designed or programmed, to solve the problem. But to mechanize the design or to prepare and run the program turns out to require orders of magnitude more time, memory capacity, or hardware, than we have available, and we have to abandon our solution as being hopelessly uneconomical.
>
> "Yet, every day we can observe working models of machines solving these kinds of problems with remarkable efficiency. These are of course human brains. They are machines about whose internal organization we have only the faintest understanding, which are constructed from logical elements which we understand only very poorly, and which are significantly different from the kind of logical elements we use to construct man-made computing machines. Since our conventional techniques seem inadequate to find economical solutions to the pattern recognition and learning problems, it is proper to investigate the functioning of the human brain, and particularly the functioning of its individual logical elements in the hope that we may find some new or better approach to the solution of these complex problems. . . . ."

Successes, up to a Limit

The papers as a whole show that significant successes are being attained in fields of application that a few years ago only "dreamers" would have said that machines could handle. And, now, with the International Conference on Information Processing as a vantage point, we can think of the next 20 or 50 or 100 or 200 years of computer development. The vista that opens in front of us is that "all language and thought will become calculable like mathematics," that no problems of handling information are basically outside of the power of the automatic computer to solve or at least attack.

In fact, the automatic handling of information by machines has no limit of complexity or quantity beyond a certain physical limit, which we can roughly estimate. We can estimate it from (1) number of arithmetical and logical operations per second, (2) amount and nature of machine equipment, (3) number of years of operation.

Suppose that the average number of arithmetical and logical operations that a computer can carry out per second is 10^5.

Suppose that the number of computers that can be coordinated together is 10^3.

Suppose that we are willing to wait 10 years from the stating of a problem to its answer. (There are about 3×10^7 seconds in a year.)

Then the total number of operations available for solving the problem is $10^5 \times 10^3 \times 10 \times 3 \times 10^7 = 3 \times 10^{16}$.

This then is a present day estimate of the approximate upper limit of computer power for a battery of computing machines.

Compare this with a man. Suppose that the average number of arithmetical and logical operations that he can perform is 5 per minute, and that he works 2000 hours in the course of a year. And suppose that he too will work 10 years on a problem.

Then the approximate total number of operations which he has available for solving a problem is $5 \times 60 \times 2000 = 6 \times 10^5$.

This comparison leaves out of account an important difference between computer and man. The computer takes in at each input operation, say, 15 decimal digits or 60 binary digits. The man takes in through his eyes when he looks at something probably 10 million binary digits of information which are sent along 1 million channels into his brain; and also he takes in through his ears and other senses a great deal of additional information. As a rough adjustment for this advantage, let us multiply the man's total number of operations by 10^3. Also, let us estimate that 10^4 men could work cooperatively on a problem.

Even so, the estimated limit of computer power for solving a problem is on the order of 10^{17} operations for the machine and on the order of 10^{13} operations for man.

Under these conditions we know that certain projects will never be accomplished, can never be done, are completely outside of the reach of computer power. One such project for example is writing on paper in Arabic notation all the numbers from one to 10^{100} (a googol), each obtained by adding 1 to the last number. Fortunately no sane adult person wants to do this, although once there was a certain young lady around age ten who said "Father, I am going to count to a googol before I die."

Pressure to Reach the Limits

There are certain rational projects however which press close upon the limits of computer power. Some of them seem to be related to nuclear reactor calculations, for they are security-classified. If not, where would be the pressure and funds for "faster, faster!" — leading to computers like the IBM Stretch and the Remington Rand Larc?

The theory of relativity puts a top limit on the speed with which one can travel through space. So nowadays no one expects to reach the star Alpha Centauri 4 light years away in a six months' trip. For the same relativity reason, there is a top limit to the speed of electrical pulses in a computer.

Human beings will hit the physical limits of computer power, and will then be required to find more skillful ways than the brute force of raising speed and capacity, to circumnavigate them.

SURVEY OF RECENT ARTICLES

Moses M. Berlin
Cambridge, Mass.

We publish here a survey of articles related to computers and data processors, and their applications and implications, occurring in certain magazines. We seek to cover at least the following magazines:

- Automatic Control
- Automation
- Automation and Automatic Equipment News (British)
- Business Week
- Control Engineering
- Datamation
- Electronic Design
- Electronics
- Harvard Business Review
- Industrial Research
- Instruments and Control Systems
- ISA Journal
- Proceedings of the IRE
- Management Science
- The Office
- Scientific American

The purpose of this type of reference information is to help anybody interested in computers find articles of particular relation to this field in these magazines.

For each article, we shall publish: the title of the article / the name of the author(s) / the magazine and issue where it appears / the publisher's name and address / two or three sentences telling what the article is about.

Research On Electro-Optical and Magnetic Core Logic / T. G. Marshall, Jr., and L. J. Andrews, National Cash Register Co. / PB 151257 OTS, U.S. Dept. of Commerce, Washington 25, D.C.

Discusses research aimed at advancing digital computer techniques, by studying the application of phosphor-photoconductor elements. Circuit elements can be constructed to perform the logical "or" and "and" functions, for use in digital computers. Also, reports research on a magnetic core logic system which permits a substantial reduction in the number of active elements in the circuit. The system also increases the utilization of the remaining active circuits.

Equipment Evaluation for Data Input System Design / R. L. Sisson, Canning, Sisson and Associates / Automation, vol. 6, no. 1, Jan., 1959, pp 64-71 / Automation, Penton Bldg., Cleveland 13, Ohio

The previous article dealt with the importance of error control in data processing. This, the concluding article, discusses factors involved in designing a system for successful data recording; also, the manufacturers of available equipment.

We've Found an Electronics System Pays Off in Public Relations / M. S. Greely, Manager, Data Processing Center, Michigan Hospital Service / Journal of Machine Accounting, vol. 10, no. 2, Feb., 1959, p 8 / National Machine Accountants Assn., 208 South Main St., Paris, Illinois

Michigan Blue Cross-Blue Shield finds that aside from solving their accounting and paperwork problems efficiently, the Datamatic 1000 serves as an effective public relations instrument.

What's Good for the Goose . . . ! / A. N. Borno Systems, vol. 23, no. 1, Jan.-Feb., 1959, p 22 / Systems Magazine, 315 Fourth Ave., New York 10, N.Y.

A major producer of automation machinery for industry, the Cross Co., uses a Univac electronic data processing system to establish effective production, inventory, and cost controls; and finds that the system brought a saving of over $50,000 in its first year of operation, and with a higher degree of accuracy.

Order Service, Shipping and Billing on a 305 RAMAC / D. L. Marvel, Data Processing Specialist, Specialty Motor Dept., General Electric / Journal of Machine Accounting, vol. 10, no. 1, Jan., 1959, p 10 / National Machine Accountants Assn., 208 South Main St., Paris, Illinois

The capacity to store 5 million characters on magnetic discs, and the ability to transfer this data to disc storage in approximately 3/5 of a second, enable the RAMAC to be useful in shipping and building.

One-Amplifier Simulation of Second Order Transfer Functions / L. R. Axelrod, Cook Research Lab. Div., Cook Electric Co. / Automatic Control, vol. 10, no. 3, Mar., 1959, p 58 / Reinhold Publishing Corp., 430 Park Ave., New York 2, N.Y.

Certain problems require a large amount of equipment, when applied to an analog computer. This article extends some work on the one-amplifier simulation of second order systems. The analysis of circuits leads to the simulation of such systems with either one or two outputs.

BIDEC — A Binary-to-Decimal or Decimal-to-Binary Converter / J. F. Couleur, General Electric Co., Syracuse, N.Y. / IRE Transactions on Electronic Computers, vol. EC-7, no. 4, Dec., 1958, p 313 / IRE, Inc., 1 East 79 St., New York 21, N.Y.

A description of devices to convert between the binary and decimal systems of numbers. There is no limitation on the number of digits, and the time required is relatively small.

A Magnetic Core Parallel Adder / Mao-Chao Chen, Physics Dept., Stanford University, Calif. / IRE Transactions on Electronic Computers, vol. EC-7, no. 4, Dec., 1958, p 262 / IRE, Inc., 1 East 79th St., New York 21, N.Y.

An extension of early methods of analysis of binary computer units, produces a logical design which uses magnetic core elements without the usual time limitations.

Theoretical Consideration of Computing Errors of a Slow Type Electronic Analog Computer / T. Miura, and M. Nagata, Hitachi Central Res. Lab., Tokyo, Japan / IRE Transactions on Electronic Computers, vol. EC-7, no. 4, Dec., 1958, p 306 / IRE, Inc., 1 East 79 St., New York 21, N.Y.

An approach to analyzing errors in differential equations solved by analog computers, taking into consideration the major causes for these errors; also, attempts to generalize the analytic process.

"Twistor" Shift Register / Electromechanical Design, vol. 3, no. 1, Jan., 1959, p 8 / Electromechanical Design, 1357 Washington St., West Newton 65, Mass.

A reversible, diodeless shift register using a single magnetic wire as the memory — which stores pulses when subjected to a magnetizing field — will be cheaper to build than conventional shift registers.

Programmed Servo Speeds Short-Run Production / S. B. Korin, Corporate Manufacturing Engineer, and F. B. Spencer, Staff Engineer, IBM / Electronics, vol. 32, no. 10, Mar. 6, 1959, p 54 / McGraw-Hill, 330 West 42 St., New York 36, N.Y.

Programmed servos position computer printed-circuit boards. In spite of the complexity and variety of the boards required for a particular system, a single-station inserter positions the boards in response to controller commands. Component selection and insertion are also directed by a controller.

Magnetic Head Reads Tape at Zero Speed / M. E. Anderson, Armour Research Foundation, Illinois Institute of Technology, Chicago / Electronics, vol. 32, no. 10, Mar. 6, 1959, p 58 / McGraw-Hill, 330 West 42 St., New York 36, N.Y.

A system which permits information playback at extremely slow speeds, so that the highest frequency component is within the limited bandwidth of a pen recorder. Original data is recorded at high tape speeds, but "played back" at speeds including zero inches per second, with no deterioration in the signal-to-noise ratio.

Future Demands in Office Automation / E. F. Murphy, Editor, The Automatic Office / The Automatic Office, vol. 1, no. 12, Feb., 1959, p. 1 / The Automatic Office Consultants, Inc., 9th floor, 5057 Woodward Ave., Detroit 2, Mich.

According to this author, the day of punched tape and large scale computers is over. Punched cards will prove more efficient, hence, predominant.

Generate Better Curves with Digital-Analog Techniques / M. A. Alexander / Electronic Design, vol. 7, no. 5, Mar. 4, 1959, p 40 / Hayden Publishing Co., Inc., 830 Third Ave., New York 22, N.Y.

This article discusses principles and methods of generating curvilinear functions. Accuracies which cannot be achieved in a single analog system are realized, by mixing digital and analog computer techniques.

Equipment Trust Data Processing / H. E. Mertz, Asst. Vice President and Auditor, LaSalle National Bank of Chicago / The Automatic Office, vol. 1, no. 12, Feb., 1959, p 11 / Automatic Office Consultants, Inc., 9th floor, 5057 Woodward Ave., Detroit 2, Mich.

The procedure of data processing as applied in the LaSalle National Bank. The original article appeared in "Banking," and includes new procedures to provide pertinent information.

Logical Control of Sampling Saves Computing Time / D. Hammel, Radio Corp. of America / Control Engineering, vol. 6, no. 3, Mar., 1959, p 135 / McGraw-Hill, 330 West 42 St., New York 36, N.Y.

Some systems now in use for sampling system variables — both military and industrial — suffer from inflexibility. A system has been in use for over a year, which incorporates certain features to eliminate loss of time.

Simulating Second-Order Equations / D. G. Chadwick, Asst. Professor, College of Engineering and Technology, Utah State University / Electronics, vol. 32, no. 10, Mar. 6, 1959, p 64 / McGraw-Hill, 330 West 42 St., New York 36, N.Y.

An analog technique which permits simulation of second-order differential equations, using a single operational amplifier in place of the method requiring three operational amplifiers. There is no loss in flexibility.

Russian Computer Developments / E. Grabbe, Thompson Ramo Wooldridge Inc. / Instruments and Control Systems, vol. 32, no. 2, Feb., 1959, p 256 / Instruments Publishing Co., Inc., 845 Ridge Ave., Pittsburgh 12, Pa.

Part of a talk delivered to the Los Angeles Chapter of the Association for Computing Machinery, the article describes — and compares to American computers — some of the Russian electronic data processing machines.

Computer-Designed Hydraulic Circuits and Components / L. E. Knutson, Remington Rand Univac / Automatic Control, vol. 10, no. 2, Feb., 1959, p 56 / Reinhold Publishing Corp., 430 Park Ave., New York 2, N.Y.

A discussion of the application of digital computers to hydraulic design. A general method of "computer solution" is shown, in a problem involving a straight transfer between two points, and the method is detailed to the point where coding can begin. A hydraulic design system is developed and applied to solve a hoist problem.

In Plain English: Stating a Computer Problem / Automation & Automatic Equipment News, vol. 4, no. 7, March, 1959, p 1036 / A. & A. E. N., 9 Gough Square, Fleet St., London, E. C. 4.

A problem which was submitted to the Data Processing Centre of IBM United Kingdom Ltd., is stated in "plain terms." Then, the full system of instructions which the computer is to follow, is listed. Finally, for the computer person who doesn't have a detailed knowledge of programming, a simple programming system is explained, namely, the FORTRANSIT language.

The Challenge of Space / H. A. Manoogian, Associate Editor, Electronics / Electronics, vol. 32, no. 17, April 24, 1959, pp 65-80 / McGraw-Hill, 330 West 42 St., New York 36, N.Y.

The theme of this report is "Electronics in Space," and the computer is an integral part of the equipment necessary to meet the challenge. Data processing is essential in space navigation and experimentation; one example is in inertial guidance systems, where a computer operates on accelerometer indications, providing output signals to control a space-vehicle's roll, pitch, and fuel cut-off point.

Space Age Computing / R. W. Rector, Staff Mathematician, CDRC, Space Technology Labs. / Datamation, vol. 5, no. 2, Mar.-April, 1959, p 8 / Relyea Publishing Corp., 103 Park Ave., New York 17, N.Y. /

An account of the role that the computer and data processing played in Project Able-1 (Pioneer). The requirements placed upon computers in the space probe, fall into three main categories: (1) trajectory and engineering computations, including the solutions to problems in propulsion, structures, and aerodynamics; (2) in-flight tracking and data acquisition, which concerns the computer operations necessary to obtain and process tracking information; (3) data reduction and analysis, which includes putting flight telemetry data into suitable form for interpretation.

Automata / N. P. Ruzic, Editor, Industrial Research / Industrial Research, vol. 1, no. 2, Spring, 1959, pp 47-59 / Scientific Research Pub. Corp., Inc., 200 S. Michigan Ave., Chicago 4, Illinois.

With science fiction overtones, this article describes some possibilities for future computers, of which it is said: "the differences between the new self-organizing systems — automata — and present-day computers will be as vast as the differences between computers and office adding machines." The author suggests raising computers as one would, children, from early mistakes and awkwardness, to intelligence and sophisticated thinking.

Digital-Recording Magnetic Heads / W. F. Hurley, Potter Instruments Co. / Instruments & Control Systems, vol. 32, no. 3, March, 1959, p 394 / Instruments Publishing Co., Inc., 845 Ridge Ave., Pittsburgh 12, Pa. /

"The magnetic head in a tape recording instrument serves three functions: 1) it records electric signals on magnetic tape; 2) it reads information on magnetic tape and converts it into electric signals; 3) it serves as an eraser, wiping out old information so that the tape may be re-used." Following this introduction, a survey of magnetic heads for digital tape systems, is given.

NEW PATENTS

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

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

Nov. 18, 1958 (cont'd):

2,861,259 / Albert J. Meyerhoff, Wynnewood, Pa. / Burroughs Corp., Detroit, Mich. / A balanced logical magnetic circuit.

Nov. 25, 1958: 2,861,740 / Pierre Jacques Charles Chenus, Paris, Fr. / Compagnie des Machines Bull (Societe Anonyme), Paris, Fr. / An electronic adding apparatus for adding together two numbers each represented by a serial train of pulses in coded group form.

2,861,741 / Raymond Bird, Letchworth, Eng. / The British Tabulating Machine Co., Lim., London, Eng. / An apparatus for adding a plurality of binary serial pulse trains.

2,861,742 / Geoffrey H. Stephenson, Ealing, London, Eng. / Electric and Musical Industries, Lim., Hayes, Middlesex, Eng. / An apparatus for evaluating the rate of change of one variable with respect to a second variable.

2,861,744 / Edward J. Schmitt, Collingswood, and Spencer W. Spaulding, Haddonfield, N.J. / R.C.A., a corp. of Del. / An adder checking system for verifying the arithmetic result of two binary coded operands.

2,862,127 / Fred B. Maynard, Cedar Grove, N.J. / National Union Electric Corp., Hatboro, Pa. / A binary to decimal converter tube.

2,862,139 / Frederic C. Williams, Timperley, and Tom Kilburn, Manchester, Eng. / National Research Development Corp., London, Eng. / A method of storing digital information in the form of electrostatic charges.

2,862,198 / Raymond Stuart-Williams, Pacific Palisades, Milton Rosenberg, Santa Monica, and Matthew A. Alexander, Pacific Palisades, Calif. / Telemeter Magnetics and Electronics Corp., Los Angeles, Calif. / A magnetic core memory system.

2,862,199 / John E. Scott, Rego Park, N.Y. / Sperry Rand Corp., a corp. of Del. / A magnetic drum storage system.

Dec. 2, 1958: 2,862,660 / Robert B. Purcell, China Lake, Calif. / —— / A decimal converter for an electronic binarily operated decade counter.

2,863,054 / Willis E. Dobbins, Manhattan Beach, Calif. / The National Cash Register Co., Dayton, Ohio / A logical gate correcting circuit.

2,863,135 / Norman B. Saunders, Weston, Mass. / American Machine and Foundry Co., a corp. of N.J. / A magnetic memory circuit.

Dec. 9, 1958: 2,863,710 / Benjamin Cooper, Joseph S. Wapner and John G. Roback, Brooklyn, N.Y. / Benjamin Cooper / A data recorder.

Dec. 16, 1958: 2,864,555 / Rolf E. Spencer and Geoffrey H. Stephenson, Ealing, London, Eng. / Electrical and Musical Industries, Lim., Hayes, Eng. / An analog function generator.

2,864,556 / Francois H. Raymond, Le Vesinet, Fr. / Societe d'Electronique et d'Automatisme, Courbevoie, Seine, Fr. / An electronic integration system.

2,864,557 / George W. Hobbs, Scotia, N.Y. / General Electric Co., a corp. of N.Y. / A number converter for translating a higher based number to that of a lower based number.

Dec. 23, 1958: 2,865,564 / Harold R. Kaiser, Woodland Hills, Claude A. Lane, Culver City, and Wilford A. Shockency, Torrance, Calif. / Hughes Aircraft Co., a corp. of Del. / A high speed electronic data conversion system.

2,866,103 / John T. Blake, Parsippany, and Austin L. Ely, Whippany, N.J. / Bell Telephone Lab., Inc., N.Y. / A diode gate and sampling circuit.

2,866,145 / Lawrence R. Peaslee, Murray Rosenblatt and Leroy U. Kelling, Waynesboro, Va. / General Electric Co., a corp. of N.Y. / An error signal developing means for position programming control system.

2,866,177 / Floyd G. Steele, La Jolla, Calif. / Digital Control Systems, Inc., a corp. of Calif. / A computer readout system.

2,866,178 / Arthur W. Lo, Elizabeth, and Walter A. Helbig, Haddonfield, N.J. / R.C.A., a corp. of Del. / A binary device.

2,866,183 / Adolph W. Awot, Marblehead, Bernard M. Gordon, Concord, and Maurice A. Meyer, Natick, Mass. / Laboratory for Electronics, Inc., Boston, Mass. / An analog-to-digital converter.

2,866,184 / John W. Gray, Pleasantville, N.Y. / General Precision Lab., Inc., a corp. of N.Y. / An analog-to-digital converter.

Dec. 30, 1958: 2,866,895 / Gerard R. Boyer, Montrouge, Fr. / I.B.M. Corp., New York, N.Y. / An electronic storage device.

2,866,896 / Rudolph A. Stampfl, Asbury Park, N.J. / U.S.A. as represented by the Sec. of the Army / A pulse converting circuit.

January 6, 1959: 2,867,752 / Hugh F. Stoddart, Newton Upper Falls, and Theodore Voutselas, Arlington, Mass. / Baird-Atomic Inc., a corp. of Mass. / A system for counting and visually indicating counts of electrical pulses.

2,867,789 / John H. MacNeill and Charles F. West, Melbourne, Fla. / U.S.A. as represented by the Sec. of the Air Force / A mercury memory tank.

2,867,790 / Benjamin M. Durfee, Binghamton, and Albert D. Miller, Vestal, N.Y. / International Business Machines Corp., New York, N.Y. / An information storage matrix.

2,867,796 / James Madison Kendall, Coral Hills, Md. / —— / An analog-to-digital converter.

2,867,797 / George B. Greene, Berkeley, and Gunnar Wahlstrom, San Francisco, Calif. / Marchant Research, Inc., a corp. of Calif. / An analog-to-digital converter.

January 13, 1959: 2,868,448 / William J. Walker, Johannesburg, Transvaal, Roland M. Walker, Rondebosch, Cape Province, and Terence O'D. Duggan and Alva Izak Archer, Johannesburg, Transvaal, Union of South Africa / —— / An electro-mechanical computing apparatus for the determination of polynomial functions and the solution of algebraic equations.

2,868,449 / John F. Brinster and Erwin Donath, Princeton, N.J. / Applied Science Corp. of Princeton, Princeton, N.J. / An apparatus for effecting nonlinear transformations of digital electrical data.

2,868,450 / Harold S. Hemstreet, Binghamton, N.Y., and Jomer D. Eckhardt, Cambridge, Mass. / Link Aviation, Inc., Binghamton, N.Y. / A decimal to binary translator.

2,868,451 / Edwin W. Bauer, Poughkeepsie, N.Y. / International Business Machines Corp., N.Y., N.Y. / A magnetic core half adder.

2,868,455 / George D. Bruce, Wappingers Falls, and Paul F. Eckelman, Hyde Park, N.Y. / International Business Machines Corp., N.Y., N.Y. / A binary counter with fast carry.

2,868,969 / Clarence F. Inniss, Oxnard, Calif. / U.S.A. as represented by the Sec. of the Navy / A diode shunt gating circuit.

2,868,999 / Alan R. Garfinkel, Forest Hills, and Stanley Oken, Utica, N.Y. / Sperry Rand Corp., Ford Inst. Co. Div., Long Island City, N.Y. / An "Exclusive OR" signal gating system.

January 20, 1959: 2,868,784 / Robert E. Thomas, Walnut Creek, Calif. / U.S.A. as represented by the U.S. Atomic Energy Commission / A multiplier circuit.

2,869,786 / David H. Jacobsohn, Chicago, Ill., and Leslie C. Merrill, Fort Wayne, Ind. / U.S.A. as represented by the U.S. Atomic Energy Commission / An adder circuit.

2,870,327 / Walter H. MacWilliams, Jr., Summit, and Robert C. Winans, Charham, N.J. / Bell Telephone Lab., Inc., New York, N.Y. / An electronic probability circuit.

2,870,436 / Milton L. Kuder, Wash., D.C. / U.S.A. as represented by the Sec. of Commerce / An electronic analogue-to-digital-converter.

2,870,437 / Gordon G. Scarrott, Manchester, and Kenneth C. Johnson, Gately, Cheadle, Eng. / Ferranti, Lim., Hollinwood, Lanchashire, Eng. / A digital-analogue converter for deriving a signal proportional to the number represented by an input train of binary digital current pulses of uniform width and height.

January 27, 1959: 2,870,960 / John E. Richardson, Los Angeles, Calif. / —— / A system for analogue computing utilizing detectors and modulators.

February 3, 1959: 2,872,106 / Floyd G. Stele, Manhattan Beach, Calif. / Northrop Aircraft Inc., Hawthorne, Calif. / A tape cam computer system.

2,872,107 / William H. Burkhart, East Orange, N.J. / Monroe Calculating Machine Co., Orange, N.J. / A serial electronic adder-subtractor computer.

2,872,109 / Blanchard D. Smith, Jr., Alexandria, Va. / U.S.A. as represented by the Secretary of the Air Force / A multiplier-integrator circuit.

2,872,111 / Lester S. Hecht, Los Angeles, Calif. / Hughes Aircraft Co., Culver City, Calif. / A serial binary arithmetic unit for performing an operation of addition or subtraction.

2,872,112 / Ivan A. Greenwood, Jr., Stamford, Conn. / General Precision Lab., Inc., a corp. of N.Y. / A right triangle solver using feedback

2,872,113 / Raymond L. Kindred, Barthesville, Okla. / Phillips Petroleum Co., a corp. of Del. / A computer for solving simultaneous equations.

2,872,593 / Robert A. Henle, Hyde Park, N.Y. / I.B.M. Corp., New York, N.Y. / A logical circuit employing junction transistors.

2,872,663 / Robert C. Kelner, Concord, and Harvey Ruberstein, Somerville, Mass. / Laboratory for Electronics, Inc., Boston, Mass. / A magnetic shift register.

2,872,666 / Roger C. Greenhalgh, Vestal, N.Y. / I.B.M. Corp., New York, N.Y. / A data transfer and translating system.

February 10, 1959: 2,873,066 / Henry F. McKenney, Weston, Mass. / Sperry Rand Corp., Ford Inst. Co., Div., L.I.C., N.Y. / An electrical multiplier.

2,873,363 / Cravens L. Wanlass, Whittier, Calif. / North American Aviation, Inc., Calif. / A logical gating system for digital computers.

2,873,385 / Barnard Ostenforf, Jr., Stamford, Conn. / Bell Telephone Lab., Inc., New York, N.Y. / A transistor data storage and gate circuit.

2,873,389 / William B. Cagle, Madison, N.J., and Werner Ulrich, New York, N.Y. / Bell Telephone Lab., Inc., New York, N.Y. / A logic circuit.

2,873,439 / Arvo A. Lahti, Pasadena, and Duncan N. MacDonald, Arcadia, Calif. / Consolidated Electrodynamics Corp., Pasadena, Calif. / A digital to analog converting apparatus.

2,873,440 / Jack B. Speller, White Plains, N.Y. / United Aircraft Corp., East Hartford, Conn. / An analogue-to-digital converter.

2,873,442 / Martin Ziserman, Hartsdale, N.Y. / United Aircraft Corp., East Hartford, Conn. / An analogue to binary coded system converter.

February 17, 1959: 2,873,911 / Warren L. Perrine, Pasadena, Calif. / Librascope, Inc., Glendale, Calif. / A mechanical integrating apparatus.

2,873,913 / Martin Hebel, Hechendorf am Pilsenee, Upper Bavaris, Germany / Eldi-Feinmechanik G.m.b.H., Hechendorf am Pilsensee, Germany / An electrical multiplier.

2,873,915 / David C. Evans, Los Angeles, Calif. / University of Utah, Salt Lake City, Utah / An analogue computer for solving simultaneous equations.

2,874,313 / John A. Githens, Morristown, N.J. / Bell Telephone Lab., Inc., New York, N.Y. / A binary data processing apparatus.

February 24, 1959: 2,874,902 / Walter G. Edwards / Hermosa Beach, Calif. / National Cash Register Co., a corp. of Md. / A digital adding circuit for generating an outgoing coded number.

March 3, 1959: 2,876,437 / Robert Royce Johnson, Pasadena, Calif. / Hughes Aircraft Co., a corp. of Del. / An electronic circuit for selectively shifting or inverting the time position of digital data.

2,876,439 / Robert D. Torrey, Philadelphia, Pa. / Sperry Rand Corp., a corp. of Del. / A binary counter.

March 10, 1959: 2,876,950 / Donald R. Daykin, Endicott, N.Y. / International Business Machines Corp., New York, N.Y. / A digital-analog computer.

2,877,449 / Gordon E. Whitney, Poughkeepsie, N.Y. / International Business Machines Corp., New York, N.Y. / An intermediate magnetic core storage circuit.

2,877,450 / Francis E. Hamilton and James J. Troy, Binghampton, and Ernest S. Hughes, Jr., Vestal, N.Y. / International Business Machines Corp., New York, N.Y. / A data storage and transfer apparatus.

March 17, 1959: 2,877,948 / Clinton O. Jorgensen, Long Beach, Calif. / Northrop Aircraft, Inc., Hawthorne, Calif. / An analogue divider for dividing an electrically represented first variable by a second.

2,878,434 / Henry R. Brown, Jr., Whittier, Calif. / North American Aviation, Inc., a corp. of Calif. / An error sensing servo component.

2,878,435 / Lewis C. Rich, Queens, and Lothair H. Rowley, Syosset, N.Y. / Sperry Rand Corp., a corp. of Del. / A servosystem with low impedance stabilization network.

2,878,463 / Herman E. Austen, Trotwood, Ohio / The National Cash Register Co., Dayton, Ohio / A magnetic data storage device.

March 24, 1959: 2,879,000 / Waldron S. Macdonald, Concord, and Matthew C. Abbott, Greenwood, Mass. / Electronics Corp. of America, Cambridge, Mass. / A digital inventory register.

2,879,001 / Arnold Weinberger, Washington, D.C., and John L. Smith, Wheaton, Md. / U.S.A. as represented by the Sec. of Commerce / A high speed binary adder having simultaneous carry generation.

2,879,002 / Ernest P. Longerich, Inkster, Mich. / Bendix Aviation Corp., Detroit, Mich. / An analog squaring and square rooting circuit.

2,879,411 / Alfred H. Faulkner, Chicago, Ill. / General Telephone Lab., Inc., a corp. of Del. / A "not and" gate circuit.

2,879,412 / Henri H. Hoge and Douglas L. Spotten, Baltimore, Md. / Westinghouse Electric Corp., East Pittsburgh, Pa. / A zener diode cross coupled bistable triggered circuit.

2,879,498 / Theodore A. Kalin, Waltham, Mass. / U.S.A. as represented by the Sec. of the Air Force / A circuit for locating a binary digit within an interval.

March 31, 1959: 2,880,392 / Robert C. Paulsen, Boonton, N.J. / International Business Machines Corp., New York, N.Y. / A digital microvolt measuring device.

2,880,406 / Douglas G. Bindon and Ivan P. V. Carter, Manchester, Eng., and Martin J. Friedman, Pisa, Italy / Ferranti Limited, Hollinwood, Lancashire, Eng. / A magnetic-core storage device for digital computers.

April 7, 1959: 2,880,934 / Lowell S. Bensky, Levittown, Pa., and Stephan M. Fillebrown, Collingswood, N.J. / Radio Corp. of America, a corp. of Del. / A pulse type reversible counting system.

2,880,935 / Thomas J. Johnson, Los Angeles, Calif. / Gilfillan Bros., Inc., Los Angeles, Calif. / An analog computer for multiplying two factors.

2,881,412 / David Loev, Philadelphia, Pa. / Burroughs Corp., Detroit, Mich. / A magnetic shift register.

2,881,413 / Munro K. Haynes, Poughkeepsie, N.Y. / I.B.M. Corp., New York, N.Y. / A resistor bias ring transfer circuit.

2,881,414 / Munro K. Haynes, Poughkeepsie, N.Y. / I.B.M. Corp., New York, N.Y. / A magnetic memory system.

2,881,415 / Claude René, Jean Dumousseau and André Edouard Joseph Chatelon, Paris, Fr. / International Standard Electric Corp., New York, N.Y. / A system for recording and selecting information.

2,881,416 / James C. Hosken, Boston, Mass. / Arthur D. Little, Inc., Cambridge, Mass. / Apparatus for converting analogue information into digital information.

2,881,417 / Charles H. Currey, Palatine, Ill. / A.C. Nielson Co., Chicago, Ill. / A decimal-to-binary converter for system for recording, listening or viewing habits of wave signal receiver users.

2,881,419 / Arthur Rothbart, Bronx, N.Y. / International Telephone and Telegraph Corp., Nutley, N.J. / A digital to analog translator.

April 14, 1959: 2,881,978 / Tom Kilburn, Davyhulme, Manchester, Eng., and Dennis L. H. Gibbings, Claremont, Tasmania, Australia / National Research Development Corp., London, Eng. / A binary serial dividing apparatus.

2,881,979 / Anthony A. Blundi, Philadelphia, Pa. / Burroughs Corp., Detroit, Mich. / A binary adder.

2,882,443 / Roy E. Nather, Walnut Creek, Calif. / U.S.A. as represented by the U.S. Atomic Energy Comm. / A high speed pulse counting circuit.

2,882,517 / Charles S. Warren, Collingswood, N.J. / Radio Corp. of America, a corp. of Del. / A memory system made up of a plurality of bistable storage elements.

2,882,518 / Frederick G. Buhrendorf, Westfield, N.J. / Bell Telephone Laboratories, Inc., New York, N.Y. / A magnetic storage system.

April 21, 1959: 2,883,106 / John W. Cornwell, Garden City, Merton L. Haselton, Rye, and Edwin L. Schmidt, Croton-on-Hudson, N.Y. / The Teleregister Corp., New York, N.Y. / A data storage and reservation system.

2,883,107 / Dante J. Domizi, Parma, Ohio / Clary Corp., San Gabriel, Calif. / A punched card sensing apparatus.

2,883,473 / Byron McDermott, Chatham Township, Morris County, N.J. / Bell Telephone Lab., Inc., New York, N.Y. / A transistor gating circuit.

2,883,474 / Walter W. Fritschi, Bayside, N.Y. / Bell Telephone Lab., Inc., New York, N.Y. / A transistor gating circuit.

2,883,525 / Daniel L. Curtis, Manhattan Beach, Calif. / Hughes Aircraft Co., Culver City, Calif. / A flip-flop for generating voltage-couple signals.

2,883,648 / Harvey Rubinstein, Somerville, and Robert C. Kelner, Concord, Mass. / Lab. for Electronics, Inc., Boston, Mass. / A magnetic shift register.

April 28, 1959: 2,884,193 / Gerhard Liebmann, Aldermaston, Eng. / Sunvic Controls, Lim., London, Eng. / An electrical analogue-computing apparatus.

2,884,615 / Alan R. Garfinkel, Forest Hills, N.Y. / Sperry Rand Corp., a corp. of Del. / A pulse coded signal separator.

2,884,618 / Herman Epstein, West Chester, Pa. / Burroughs Corp., Detroit, Mich. / A ferroelectric logical circuit.

2,884,619 / William W. Woodbury, Lewis T. Wheelock, and Gregory J. Tobin, Poughkeepsie, N.Y. / I.B.M. Corp., New York, N.Y. / An information storage system.

ADVERTISING INDEX

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