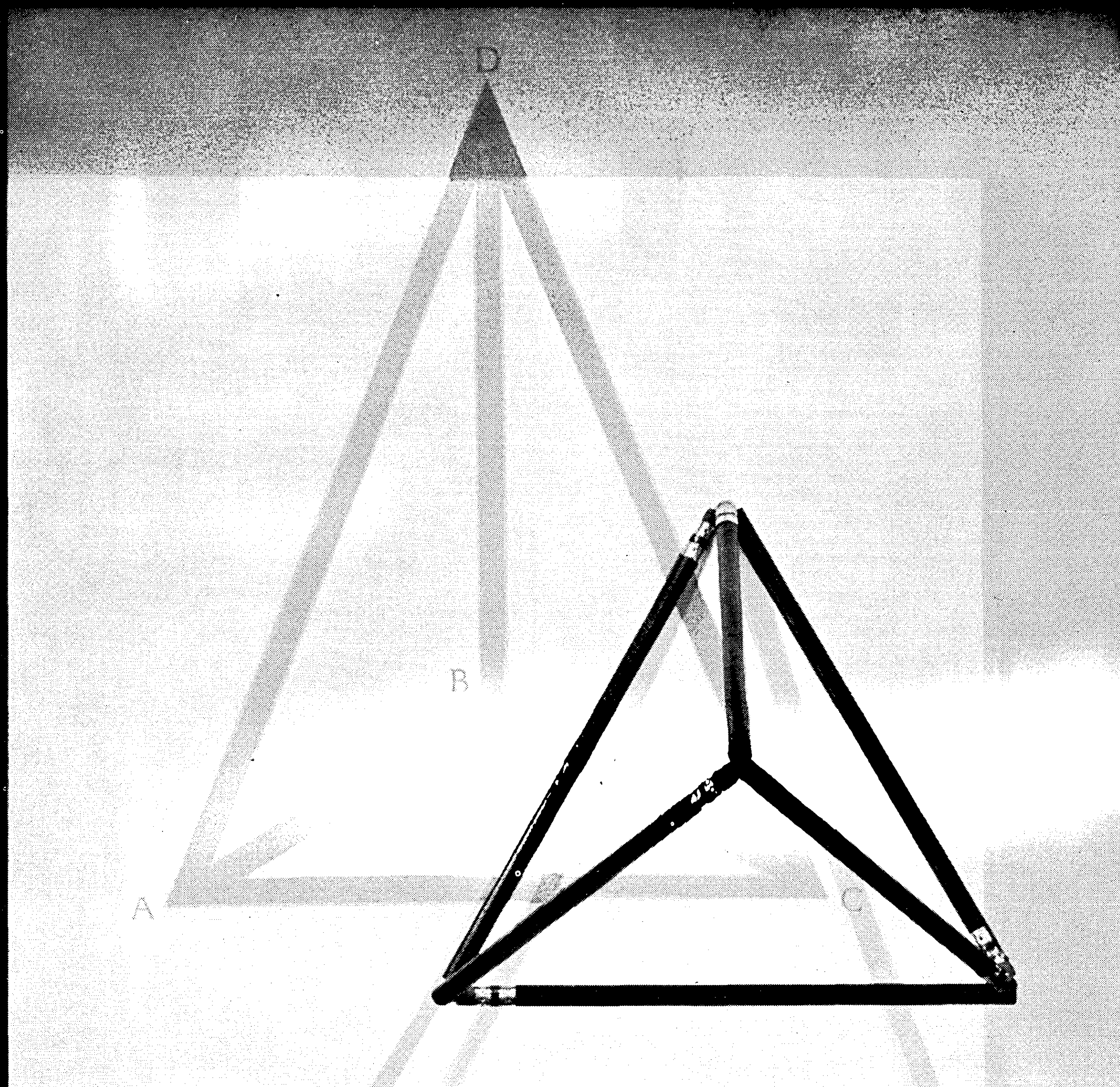
Annual Pictorial Issue / December, 1962

computers and automation

Weather Forecasting Is Being STRETCHed to Greater Accuracy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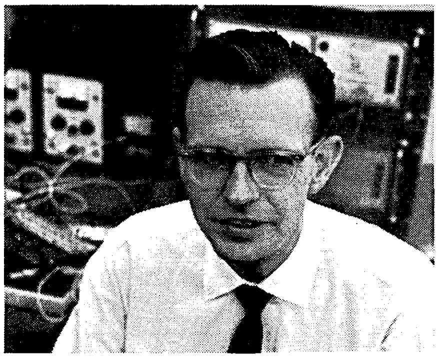
Mean Time to Failure: 2,000 Computer Hours

According to Robert M. Beck, V.P.—Engineering for Scientific Data Systems, Inc., "it is now logical to expect a full year of 40 to 50 operating hours per week from a digital computer, without failure." Beck's opinion, based on the reliability program for Scientific Data's 900 Series computers, represents "a balanced philosophy going far beyond a component count numbers game."



BECK

Circuit design is critical. According to Beck, "we consider circuit noise as the paramount design consideration with respect to computing reliability and therefore use noise rejection networks at both the input and output of all active circuit elements. Further, our circuits have wide built-in tolerances — for example, voltages may vary by as much as 36% without affecting computer operation. Silicon transistors allow for operation to 130°F. to eliminate the need for inherently unreliable air conditioners."

Reduced component count. Beck continued, "once it is established that circuits are reliable and tolerances are wide, reduction of component count becomes a major factor. At SDS, we use new techniques that reduce component count by a factor of from 3 to 5 with a corresponding increase in reliability."

Input/Output reliability. Beck further stated: "Digital I/O equipment is unreliable by its very nature (i.e. the failure ratio between a paper tape punch and a computer is 1,000,000 to 1). Therefore, the computer, with its great inherent reliability, is the best available entity for detecting and compensating for I/O error. Our 900 Series input/output schemes are designed so that the computer operates in closed loop synchronization with its I/O equipment, automatically monitoring every input signal, rejecting errors and initiating recycling of correct data. In addition, we have made design allowances for input signals with the worst possible noise, amplitude, chatter and timing."

"We are certain that our new 900 Series Computers place a new standard on predictable computing reliability."

An IBM STRETCH computer is being used at the U. S. Weather Bureau to study the origin and development of such weather conditions as hurricanes, blizzards, and tornadoes, and yes, even sunny days. *Story and more pictures on page 36.*

computers and automation

DECEMBER, 1962
VOL. XI, NO. 12

computers and data processors: construction, applications, and implications, including automation

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Readers' and Editor's Forum

A CLARIFICATION

To the Editor:

I would like to thank Leon Jacobson and Patrick J. McGovern, Jr., the authors of "Computer Simulation of a National Economy" in the August issue of **Computers and Automation,** for the very good review of my group's work that was included in their article. Of course, like anyone whose work is reviewed by others, I found a few inaccuracies. I would not quibble about secondary points, but there was one statement that I would like to see corrected, lest your readers type me as a person who draws broad conclusions from too narrow a set of experiments. On the last page of the article (p. 16) it is stated:

> "Eight runs in total were made on the computer. . . . Holland states that, on the basis of these eight runs, he was able to graph a sample history of India for a twenty-year period. He could gage the effects of various policies on the exchange rates, on the balance of payments, on the rate of inflation, on GNP, on per capita income, and on gross real investment in various sectors."

This is really too much to find out from a sample history, or even from the eight histories produced by eight runs. The fact is that Gillespie, Tencer, and I made nearly 200 runs, of which about 90 were finally used for analysis—the remainder having been useful only for learning how to use the model. From the analysis of the 90 runs, we drew a few conclusions, which were not particularly related to Indian problems. Probably Messrs. Jacobson and McGovern were misled by the small number of runs in the only presentation of results that has so far been published—in my article "Simulation of an Economy with Development and Trade Problems" in the *American Economic Review* for June, 1962. That article is primarily an exposition of the simulation approach as applied to a national economy, with a few illustrative results. The rest of the results and the principal analysis will appear in a book by Robert W. Gillespie and me, which is now being edited for publication some time in 1963.

It is true, as indicated in Jacobson's and McGovern's article, that I consider this particular study to have little bearing on Indian policy. At the same time, I wholeheartedly concur in the hope that the art of economic-system simulation will, in the future, help provide more rational foundations for economic policy decisions and will thereby help alleviate economic hardship and discontent. These aims are basic to the Simulmatics Corporation's project for improving the technique and using it to assist in development planning and plan evaluation in Latin America.

Thanks are due to **Computers and Automation** for presenting a clear and objective discussion of simulation of a national economy.

Yours very truly,
EDWARD P. HOLLAND
The Simulmatics Corp.
New York 22, N. Y.

PROGRAMMING FOR CHECKOUT WORKSHOP

The Computer Programming Subcommittee of the Computing Devices Committee of the AIEE is planning a workshop on Programming Languages for Automatic Checkout. Anyone interested in attending such a workshop is invited to send his name, address, and a short resume of his work in this area to:

Burton H. Went
Battelle Memorial Institute
505 King Avenue
Columbus 1, Ohio

A time and place will be selected, depending on the response, and invitations will be sent.

A HYPHENATED VERSE

To the Editor:

Your article entitled "Hyphen Deletion Causes Missile Demise" (**Computers and Automation,** Sept., 1962, p. 6) prompts the following:

VENUS TRY FLAP

Beat the drums and blow the whistle
Sound the trumpet, send the fife in
First, the anti (hyphen) missile
Now, the anti-missile hyphen.

Sincerely,
EDMUND CONTI
Technical Operations Research
Bethesda, Maryland

MORE LIGHT—AND A DEAD HEAT

Most readers will recall reading about the recent advances in laser technology, which resulted in the emission of coherent light from a special gallium-arsenide junction by passing an electric current through the semiconductor crystal. This achievement was apparently achieved almost simultaneously at a number of laboratories, and the press releases that followed the achievements had some curious hints of their own phase, err . . . phrase coherency.

(Please turn to page 18)

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OPERATOR J. L.

*AN ERROR IS ANY REDUCTION BELOW 50% OR ANY INCREASE IN NOISE EXCEEDING 10% OF NORMAL SIGNAL AMPLITUDE WHEN RECORDING 556 NRZ PULSES PER INCH ON SEVEN .035 INCH TRACKS PER 1/2" TAPE

A HISTORY OF WRITING COMPILERS

Donald E. Knuth
California Institute of Technology
Pasadena, Calif.

Compilers—their origin, development and operation. The author, the creator of three compilers himself, includes a useful dose of compiler writing "how-to-do-it."

In the field of programming for computers, the time seems to be ripe for a look back at the evolution of techniques used in writing algebraic compilers. People with experience writing translators should profit by some reflection on the historical trends; and people who are more accustomed to using compilers than to creating them, will perhaps feel more familiar with compilers if they see how such programs evolved. This article therefore attempts to review briefly the history of techniques for writing a compiler.

A great development of compiler languages, of course, has taken place, as well as of techniques for translating them, but we will concern ourselves primarily with the techniques.

The first compilers came into being about the same time that I was becoming exposed to computers. You might say that I learned computing from reading a listing in the assembly language SOAP I (Symbolic Optimum Assembly Program I) of the first compiler IT (Internal Translator).[1] An enormous number of compilers have been written since then; I cannot, of course, claim to be familiar with even most of them. I am only vaguely aware of the developments in the Soviet Union and in Europe. But I have examined closely the internal workings and machine language of a large number of American compilers produced by various groups all over the country, and I hope the ones I have examined represent a good cross-section. Also I have written three compilers (in the summers of 1958, 1960, and 1962) and each of these three looks quite different from the other two, reflecting the changing times. This is the background from which this article is written.

A true history gives dates of events and names of people, but I will not do that. In this field there has been an unusual amount of parallel discovery of the same technique by people working independently. Perhaps you remember the time when three different people, in the same month, sent in the same idea for counting binary ones in a computer word to the *Communications of the ACM*. The literature of compiling has many, many accounts of what is essentially the same thing, by people who were obviously unaware that others had made the same discovery. I read somewhere recently that the GAT compiler, written at the University of Michigan, was written using an algorithm due to the Soviet Academician A. P. Yershov, and I'll wager this comes as quite a surprise to the people at Michigan who weren't consciously borrowing a Russian compiler algorithm. Other references give credit to H. Kanner's algorithm, or that of A. Oettinger, or B. Arden and R. Graham, or K. Samelson and F. L. Bauer, or H. Huskey and W. H. Wattenburg, etc., etc. I know of several other people who invented the same thing and never published it. The question as to who was really the first to discover a certain technique will probably never be answered, but it is not really important. In fact this latter question has very little meaning, since those named above and others discovered to a greater or less degree various aspects of a technique, and it has been polished up through the years into a very pretty algorithm which none of the originators fully realized. So I cannot give credit to one without giving it to all; let it suffice to say merely that the compiling art has been advanced by many people with many ingenious ideas. Of course Dr. Alan Perlis and his co-workers at Purdue and Carnegie deserve credit for showing that compiling is possible in the first place.

(Based on a talk given at the Annual Meeting of the Association for Computing Machinery, Syracuse, N. Y., Sept. 4-7, 1962)

Decomposition of Formulas

So much for introductory remarks. Try now for a moment to imagine that nobody has ever written a compiler before, but that somebody has asked you to write one. Chances are that one difficulty will overshadow all the others in your mind, namely how to translate arithmetic expressions. We all recognize algebraic formulas simply by looking at them and reading them off; but how can this be done by a machine, without asking it to be able to "think" first? Take for example [(Y * Z) + (W * V)] − X, where "*" stands for multiplication; we must systematically begin with the formula and find a way to evaluate it taking one step at a time.

The first solution to this problem, used in the IT compiler, was based on the concept of parenthesis levels. When I learned algebra, we were taught to use parentheses first, then brackets around the parentheses, then braces, and if we had to go farther, we used extra large parentheses or something. I think the first time I was taught that only parentheses were really necessary was when I learned a compiler language. (This concept was well known to logicians but I doubt if it was generally known until compiler languages became popular.)

We can draw a kind of "contour map" of an expression, going up one unit for each left parenthesis, and going down one unit for each right parenthesis, and the "altitude" thus achieved is the so-called parenthesis level. (See Figure 1.) In the IT compiler a maximum parenthesis level of ten was allowed, and the formulas were processed by breaking them into levels. Precedence or rank of operators was not recognized; for example, A + B / C was A + (B / C) and A / B + C was A / (B + C).

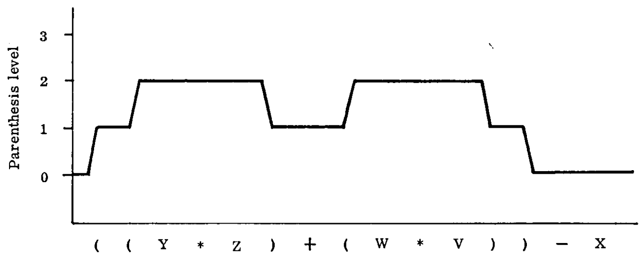


Figure 1. "Contour map" of the expression ((Y * Z) + (W * V)) − X

In order to see how a translation algorithm might be organized around the concept of parenthesis level, we can investigate the method shown in Figure 2, which shows a grossly simplified version of the IT algorithm. It goes something like this: A binary operator has a corresponding so-called anti-operator such that,

A op B = B anti-op A.

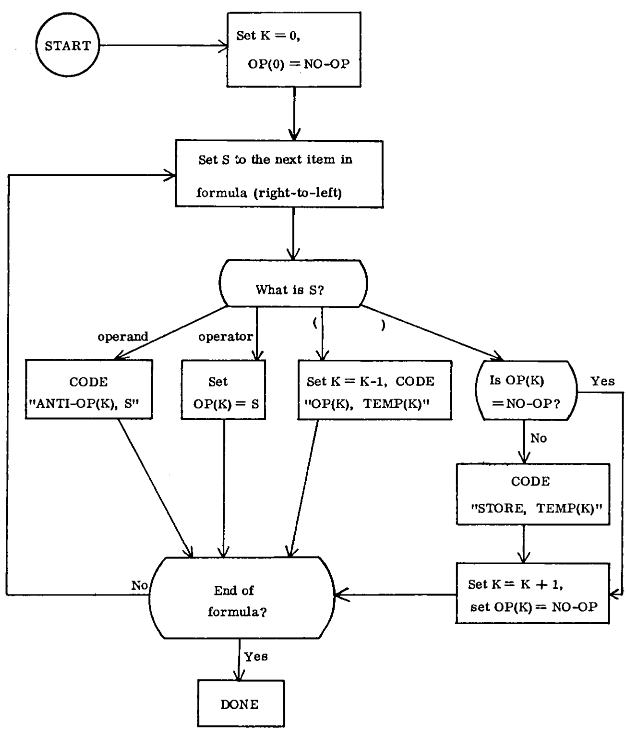


Figure 2. Translation based on parenthesis levels, without considering precedence of operators

Since A + B = B + A, plus is its own anti-op; and the anti-op of "/" is "inverse divide." Remington Rand computers tend to have only the "inverse divide" command, and IBM computers tend to have only the "divide" command in the machine language, but for simplicity we will assume that both commands are on our machine, and that there is even an "inverse subtract" command. We will also think of NO-OP ("no-operation") and LOAD as anti-operators of each other, and if you want some justification for this you should ponder over the formulas

LOAD (b) = 0 + b NO-OP (b) = b + 0.

The algorithm is roughly:

Take the next item, from right to left in the formula.

Then branch four ways, depending on the type of item:

1. For an operand (a variable or constant), output machine language code "anti-op (K), operand"; the counter K represents the parenthesis level and it starts out at zero; and there is a ten-place OP table, OP (0) through OP (9). The meaning of "anti-op (K)" is, "The anti-operator of OP (K)."
2. For an operator, save this operator in position OP (K) of the OP table.
3. For a left parenthesis, decrease K by 1, and then output the machine language code "OP (K), TEMP (K)." TEMP (K) is the Kth temporary storage cell.
4. For a right parenthesis, check first if OP (K) = "NO-OP," and if not, output the code "STORE, TEMP (K)." Then increase K by 1, and set OP (K) equal to "NO-OP" for the new value of K.

Repeat the above process until the end of the formula is reached. This whole process will be clear if we look at a play-by-play account of the method as it acts on the formula "((Y*Z) + (W*V)) − X." This is given in Figure 3. The interested reader will learn a lot if he tries to revise the method to work from left to right rather than right to left. Right to left was used here because it was done that way in IT; an equally simple algorithm which goes from left to right can be given, and it is instructive to discover what changes are necessary.

To the basic concept represented by the preceding algorithm, a large amount of material has to be added to handle subscripting, function calls, constants, mixed fixed and floating-point arithmetic, and so on.

Item	OP Table			Code Produced
	NO-OP			
X	NO-OP			LOAD X
-	-			
)	-	NO-OP		STORE TEMP(0)
)	-	NO-OP	NO-OP	
V	-	NO-OP	NO-OP	LOAD V
*	-	NO-OP	*	
W	-	NO-OP	*	MULTIPLY W
(	-	NO-OP		NO-OP TEMP (1)
+	-	+		(note: a NO-OP may be deleted from the code)
)	-	+	NO-OP	STORE TEMP (1)
Z	-	+	NO-OP	LOAD Z
*	-	+	*	
Y	-	+	*	MULTIPLY Y
(	-	+		ADD TEMP (1)
(	-			SUBTRACT TEMP(0)

Figure 3. Item by item action produced by the parenthesis-level method in Figure 2 when it is applied to the formula ((Y*Z)+(W*V))-X. Notice how the OP-table, if tipped on its side and reflected, corresponds to the contour map in Figure 1.

Operator Precedence

The lack of operator priority (often called precedence or hierarchy) in the IT language was the most frequent single cause of errors by the users of that compiler. So people hunted for ways to supply the hierarchy automatically. The IT parenthesis-level scheme didn't lend itself to this very readily. An ingenious idea used in the first FORTRAN compiler was to surround binary operators with peculiar-looking parentheses:

+ and − were replaced by))) + (((and))) − (((
* and / were replaced by)) * ((and)) / ((
** was replaced by) ** (

and then an extra "(((" at the left end ")))" at the right were tacked on. The resulting formula is properly parenthesized, believe it or not. For example, if we consider "(X + Y) + W/Z," we obtain

((((X))) + (((Y)))) + (((W))/((Z))).

This is admittedly highly redundant, but extra parentheses need not affect the resulting machine language code. After the above replacements are made, a parenthesis-level method can be applied to the resulting formulas.

A close examination of this process later showed that it isn't really necessary to insert the parentheses at all; the same effect can be achieved by merely comparing *adjacent* operators, and doing first the operation with higher priority. This led to another approach to the translation problem, namely to start moving along the statement until finding something which can be done, then going back and doing it, going forward to get more, and so on. This is the idea of essentially looking for an inner pair of parentheses, then working outward, rather than the "outside-in" approach of parenthesis levels mentioned earlier. The new idea had the advantage that it could be easily adapted to handle operator hierarchies, and this led directly to the efficient scheme which is used (in so many equivalent guises) nowadays. The modern technique was discovered in several ways; another way to run across it is to write a program to translate from arithmetic statements to expressions in "Polish notation"—a parenthesis-free way to represent formulas—and then to write a second program to translate from Polish notation to machine language. Each program is rather trivial in itself, and the combination of the two programs gives the same algorithm as discovered in other ways.

Shortly I will discuss the details of the new algorithm, but first I will list the main "bright ideas" which went into its discovery:

(1) The first bright idea was the realization that information which is saved for further use when translating can be conveniently kept in a *stack* (which is also known as a *nest* or *push-down* or *cellar* or *yo-yo list* or *last-in-first-out* or *first-in-last-out*, etc.; the number of different names indicates the number of different discoverers of the algorithm). A stack is distinguished from other types of tables by the fact that only the item at the "top" of the stack (i.e., the youngest item, the one placed on most recently) is actually important at any given time. An example of this occurred in the parenthesis-level method, where the OP table was really a stack. With the new method, the height of the stack takes the place of the former parenthesis level.

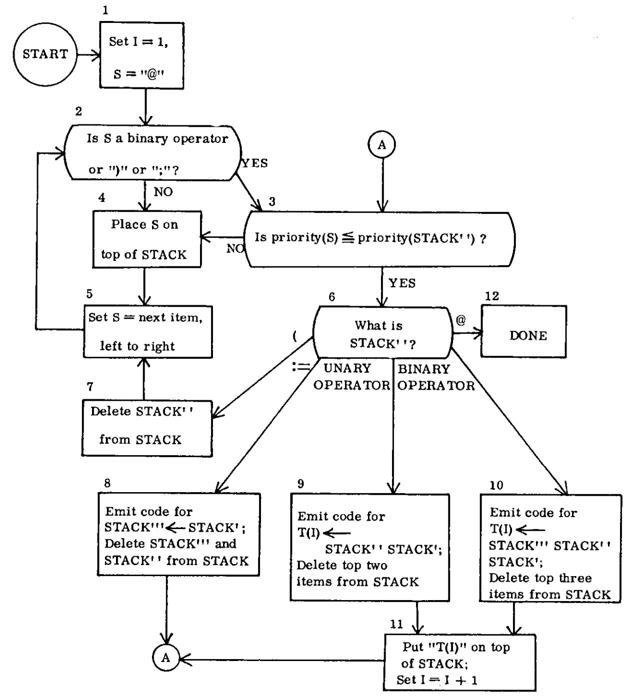


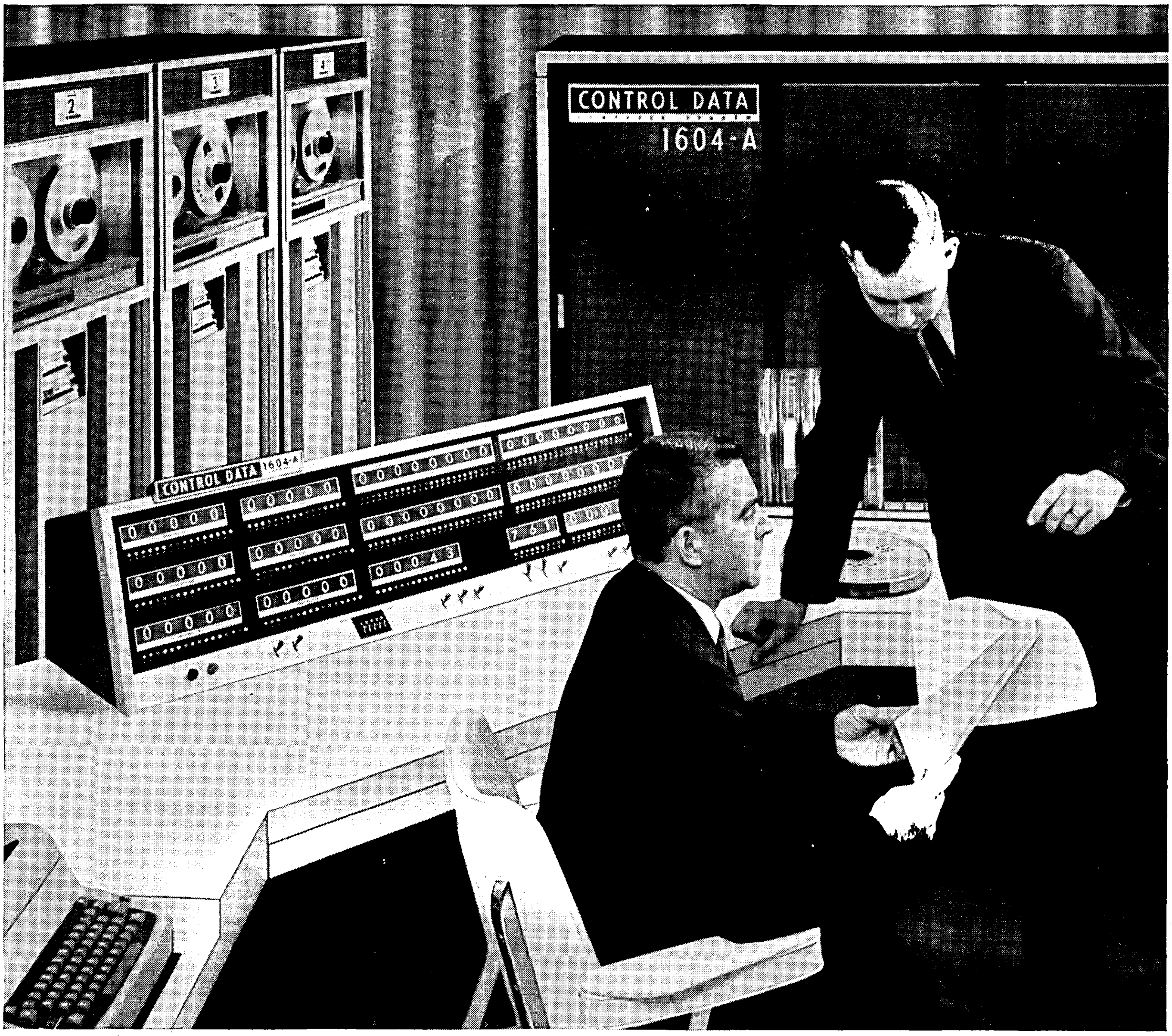
Figure 4. A version of the "modern" translation algorithm. The notation STACK' denotes the top item in STACK, STACK'' signifies the next from the top, and so on.

Table 1

Priority	Symbols
0	@ ; := ( )
1	+ -
2	* / ÷
3	↑
4	ABS SQRT etc.

(2) The second bright idea was that comparison of adjacent operator priorities provides a valuable criterion, and no more than this is needed to properly interpret a formula.

(3) The third bright idea was that parentheses can be treated as operators with priorities, giving a more elegant algorithm.



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Now we will study the new algorithm, which is given in Figure 4. We start by assigning priority numbers to symbols, according to Table 1. Here ":=" stands for the replacement operation, " " for exponentiation, and "÷" for integer division as in ALGOL. Functions of a single variable are unary operators which have priority 4 in the chart.

A rough description of Figure 4 can be given as follows: We "scan" along the expression (left to right this time) until we find some operation which can be performed *regardless* of what will occur in the remainder of the expression. The actual precise conditions for this appear in boxes 2 and 3 of the flow chart. As soon as we see something we can definitely do regardless of future input, we do it; meanwhile we save the unused portion of the formula in STACK. The formula is followed on the right by a semicolon.

Box 1 starts out by setting the counter I to one, and artificially inserts the character "@" at the left end of the statement to mark the left boundary.

Box 2 tests the item S; if S is a binary arithmetic operator (add, subtract, multiply, divide, integer divide, or raise to a power) or a right parenthesis or a semicolon, this may initiate some action. Otherwise S is a variable, a constant, a left parenthesis, the replacement operator, the symbol @, or a unary operator such as ABS or negation, and then we merely go to box 4 to save S on the stack for future action.

Box 3 is the all-important hierarchy test. The second item from the top of STACK is an operator (if all is working properly), and if it has higher priority in the table than S has, or if they have equal priority, the time has come to initiate compiler action. However, if S has higher priority, we must wait for future developments, so we merely go to box 4.

Box 4 puts S on top of the STACK to save it for later action.

Box 5 steps along to the next item in the formula.

Box 6 is the entry to various generators; we now branch to the generator for the operator which is second from the top of STACK.

Box 7, the left parenthesis generator, merely removes the left parenthesis from the middle of STACK.

Box 8 is the replacement generator; the top three items of STACK are of the form X := Z. The code for this is now generated, and only Z is left on the STACK.

Box 9 is the generator for a unary operator; the top two items of STACK are of the form OP X, and we compile the code for "T (I) := OP X." T (I) represents the *I*-th computed result.

Box 10 is the generator for a binary operator; the top three items of STACK are of the form X OP Y, and we compile the code for "T (I) := X OP Y."

Box 11 puts the result of the previous computation, T (I), as an operand on STACK, and advances I by 1, then returns to the priority test.

Box 12 is the generator for the symbol @ which is entered when the entire statement has been translated.

Notice that the algorithm given in Figure 4 handles more complex input than that in Figure 2. While the earlier flow chart applied only to formulas with binary operations and parentheses, the new one can also be used for unary operators, and multiple assignment statements and it treats operator priorities properly. As an example of the operation of Figure 4, a snapshot description of the method applied to the statement "U := V := X + COS (Y * Z) / W;" is given in Figure 5.) Here COS stands for "cosine of.")

STACK	S	INPUT	CODE
	@	U := V := X + COS(Y * Z) / W ;	
@	U	:= V := X + COS(Y * Z) / W ;	
@ U	:=	V := X + COS(Y * Z) / W ;	
@ U :=	V	:= X + COS(Y * Z) / W ;	
@ U := V	:=	X + COS(Y * Z) / W ;	
@ U := V :=	X	+ COS(Y * Z) / W ;	
@ U := V := X	+	COS(Y * Z) / W ;	
@ U := V := X +	COS	(Y * Z) / W ;	
@ U := V := X + COS	(	Y * Z) / W ;	
@ U := V := X + COS(	Y	* Z) / W ;	
@ U := V := X + COS(Y	*	Z) / W ;	
@ U := V := X + COS(Y *	Z	) / W ;	
@ U := V := X + COS(Y * Z	)	/ W ;	
@ U := V := X + COS(T_1	)	/ W ;	T(1) := Y * Z
@ U := V := X + COS T_1	/	W ;	
@ U := V := X + T_2	/	W ;	T(2) := COS(T(1))
@ U := V := X + T_2 /	W	;	
@ U := V := X + T_2 / W	;		
@ U := V := X + T_3	;		T(3) := T(2) / W
@ U := V := T_4	;		T(4) := X + T(3)
@ U := T_4	;		V := T(4)
@ T_4	;		U := T(4)

Figure 5. Snapshots of the algorithm of Figure 4 applied to the replacement statement "U := V := X + COS(Y * Z) / W ;".

With this statement, all of the input gets put onto the STACK until the right parenthesis is sensed. The right parenthesis forces out the multiplication operator, and then it also forces out the matching left parenthesis. Then the "/" symbol causes COS to be computed, and finally the ending semicolon triggers all of the remaining operators.

Once again, it would be a worthwhile exercise for the reader to try to modify the algorithm; this time to make it go from right to left, rather than from left to right. (Hint: the test in box 3 should not branch to box 6 on equality, lest X − Y − Z be translated incorrectly. It will also be convenient to assign the priority "−1" to a left parenthesis!)

The Object Program Produced

Let us turn back now to our original problem; you are supposed to write a compiler, remember? Your first worry, that of how to systematically decompose formulas, has been pretty well settled by now; the next problem is to generate efficient machine language code. The vast majority of the literature on compilers deals with the analysis of algebraic expressions, and comparatively little has ever been written about generation of the object program (which is the really important part). Due to all the research which has gone

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The 1604/1604-A is not only a powerful, reliable, efficient computer, providing more computations per dollar expended, it is a computer that's "programmer designed" . . . one that together with its software will simply and quickly serve the needs of the programming personnel who use it. Consider these software packages.

FORTRAN 62 Fortran 62 for the 1604/1604-A has all the ease and efficiency of older Fortran systems, plus featuring rapid compile times. Most significant in this new Fortran system, however, are the input/output statements which allow the programmer to take advantage of the buffering capabilities of a modern computer. For example, the statement BUFFER IN (5,0) (A,B) initiates a transfer of information from peripheral equipment #5, recorded in even parity to a region of common memory, starting with variable A and ending with variable B. Meanwhile, computation can continue. At a later time, this statement may be executed IF (UNIT, 5) N1, N2, N3, N4, causing transfer of control to statement N1 if the information transfer is satisfactorily completed, to N2 if the transfer is not completed, to N3 if an end-of-file mark is encountered and to N4 if an error is apparent after the transfer is completed. Companion statements, ENCODE and DECODE, may be used in conjunction with the buffering statements to provide format control over conversion of variables.

FORTRAN 63 Control Data's Fortran 63 will be available early in 1963 and will include all Fortran 62 statements. It will provide even further extensions to the Fortran language. With Fortran 63 it will be possible to declare variables by type . . . integer, real, double precision, complex and logical. Conditional transfers will be effected on logical as well as arithmetic expressions. Memory allocation at run-time will be accomplished through array dimensions expressed as parameters of subprograms. Compile time will be just as fast. Extensive Do-loop examination during compiling will ensure optimum use of index registers. The result will be an object program comparable in efficiency to a hand-coded object program. Storage allocation and buffering capabilities of Fortran 63 make it applicable to a new class of programs previously restricted to machine language.

1604/1604-A COBOL Statements in Control Data's Common Business Oriented Language will closely resemble an English language statement, and will yield a program which serves as its own documentation. Control Data's Cobal will be ready in early 1963.

ALGOL Control Data will also have an Algol compiler early in 1963. Compiling speed will be fast and it will feature load-and-go operation. It will compile an efficient object code while retaining most of the features of Algol 60.

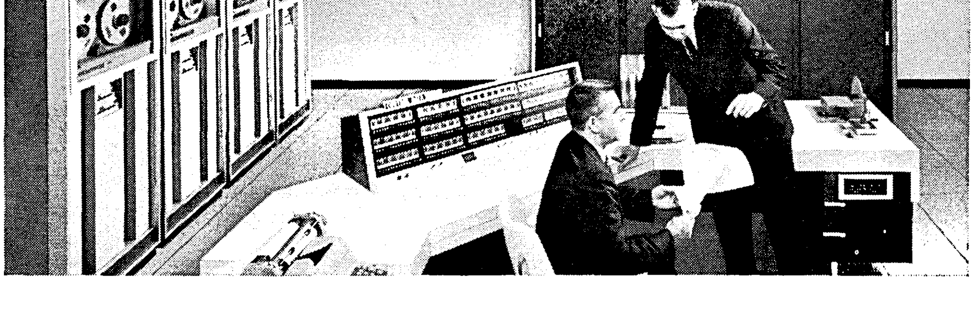
CODAP Control Data's assembler for the 1604/1604-A is CODAP. It provides a convenient symbolic machine language and enables automatic conversion of decimal and octal constants as they occur within a program.

CO-OP MONITOR CO-OP MONITOR is a master system which controls input/output, program interrupt and the use of a real-time clock without sacrificing flexibility. All Control Data compilers and assemblers operate within this system and object programs can be linked together by the loader in the CO-OP MONITOR system.

PERT Control Data's Program Evaluation and Review Technique provides management with an orderly and rapid planning and evaluation method, having print-out capabilities which keep the user easily in touch with the progress of his project.

CDM2 Control Data's linear programming system is written in Fortran and uses the Revised Simplex Method. It includes a master control system with maximum flexibility. Operating in single precision, it is considerably faster than competitive linear programming techniques. This is possible because of the 1604/1604-A 48-bit word length and the use of checking features which assure the preservation of significance.

UPWARDS COMPATIBILITY Software systems compatible with the above are being implemented on the Control Data 3600 Computer, so that programming done for the 1604/1604-A can be used on the 3600 Computer. Additional, proven programming systems (including JOVIAL) are available through the CO-OP users organization.



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into recognition of formulas, this syntactical analysis is today the most trivial part of writing a compiler. A person cannot really begin to write a good compiler until he sits down and takes a good look at the object computer, and figures out exactly what code should come out of it, given each statement. So far we have just discussed the input to the compiler; but as everyone knows, output is the important thing.

The earliest compilers sometimes turned out shockingly poor machine code. For example, one compiler (which I will not name) would compute

A = B + C

with the sequence of instructions

```
LOAD    B
STORE   working-storage-1
LOAD    C
STORE   working-storage-2
LOAD    working-storage-1
ADD     working-storage-2
STORE   working-storage-1
LOAD    working-storage-1
STORE   A
```

plus several NO-OP instructions thrown in. This sequence computes the correct answer all right; but another compiler for the same computer later achieved a 7:1 reduction ratio in the number of instructions compiled in a typical program. This is, of course, an extreme example, but notice that the IT compiler algorithm turned out the instructions LOAD X, STORE TEMP (0) in Figure 3 and these two instructions are quite unnecessary. Most of the early compilers would do this. (The first FORTRAN compiler, on the other hand, took fairly great care to produce efficient code, although the methods used were quite painful.) One of the first attempts to eliminate extraneous instructions was to go ahead and compile them as usual, but later to recognize that they were unnecessary and at that point to "uncompile" them, removing them from the code. In this case, the object code was being used as a stack. A fairly elaborate algorithm was used, so that from:

```
LOAD NEGATIVE ABSOLUTE  A
STORE                   TEMP
LOAD                    B
MULTIPLY                C
ADD                     TEMP,
```

the code

```
LOAD                    B
MULTIPLY                C
SUBTRACT ABSOLUTE           A
```

would be produced.

With the "modern" algorithm, however, this saving of temporary storage is accomplished so easily it is virtually a free byproduct of the method.

It is interesting to pursue this matter further, however, and to consider the expression

A * B + (C * D + E * F).

Suppose we have a fancy machine with two accumulators; the modern algorithm, adapted in a straightforward way, would produce

```
LOAD   1   A
MULT   1   B
LOAD   2   C
MULT   2   D
STORE  2   TEMP
LOAD   2   E
MULT   2   F
ADD    2   TEMP
ADD    1   ACCUMULATOR-2.
```

The STORE in TEMP could have been saved if A * B had been computed last; in other words, we should prefer to write

(C * D + E * F) + A * B.

Our modern algorithm was effectively able to rewrite "A + B * C" as "B * C + A" but could not make the switch on higher order expressions. This leads to a "generalized modern algorithm" for an n-register machine, which scans formulas until it gets to an expression which cannot be computed with less than n registers before it starts to produce object code. For n = 1 this gives the former algorithm, and for n > 1 it gives some small improvement in minimizing temporary storage. The latter method requires more structure to its list than a simple push-down stack, however. There is even a generalization to a "zero-register" machine, in which it is immaterial what order is used for calculation. (This would be a machine similar to the Burroughs B-5000 except having only one fast register at the top of its stack; a Polish-notation machine with $n + 1$ fast registers would use a temporary storage minimization algorithm equivalent to that for a conventional machine with n accumulators for optimum efficiency.)

Many refinements can easily be added to the modern algorithm to help produce better code. For example, a sign can be attached to each operand, so that computed results can be negated and algebraic identities can be employed. COS (A − B * C) can be calculated by

```
LOAD     B
MULT     C
ADD      A
RETURN JUMP   COS;
```

that is, the machine can easily rewrite the expression as COS (B * C − A). A similar technique which I haven't seen published yet, although it is fairly old, is to attach an absolute value tag also, so that the ADD ABSOLUTE and similar instructions can be utilized on various object machines. Attaching a type indicator (fixed or floating point) to operands and computed partial results is another obvious extension.

A refinement which is only slightly more difficult to add is to treat groups of statements together so that if no labels intervene between statements it is possible to remember what the preceding statement left in the accumulator.

A whole series of interesting techniques has been designed to optimize the use of index registers in loops. Most of these require several passes. I must mention briefly the question of many passes vs. one pass. It is well nigh impossible nowadays to define exactly what a "pass" is. Back in the old days the number of passes was the number of times we took the cards out of the punch hopper, put them in the reader, and perhaps changed plugboards. But now

there are so-called one-pass compilers for sequential machines. How many passes is a load-and-go compiler?[2] Probably zero passes since it takes one less than one pass.

Ignoring the difficulty of defining a pass, however, we can find many arguments pro and con about relative merits. The one-pass compiler is considerably faster because multipass schemes spend a good deal of time physically generating an intermediate language and later translating it back again. But there are on the other hand many things which cannot be done well in one pass, such as checking for common subexpressions and optimizing loops. Many programmers, however, are not concerned with such refinements; if they wanted a really good object program they would have it written in machine language by an expert programmer. I can't settle the argument, but I do think it is a valid point that there should not be n passes if the object programs produced are not noticeably better than could be done in n −1 passes.

Organization of the Compiler

I have tried to point out that most compilers use essentially the same techniques in different guises for formula translation. The real place where they differ is in their organization and timing of the basic components; in the structure of their programs. I will discuss briefly the principal types of organization.

A. Symbol Pairs

IT and RUNCIBLE and many other compilers were organized around a symbol pair concept. At the close of each operation, the two symbols L and R are moved; L R, next character L (right to left scanning). Then the pair LR is looked up in a table, thus giving the entry to a generator program for this case. Any information that was needed for future use was stored in tables. There were several push-down lists (stacks), but nobody realized it at the time. Beyond this the organization was pretty much of a hodgepodge which couldn't be broken into logical parts. These compilers grew like Topsy and were the result of several years of patching. The program was so interwoven that every time something was changed in RUNCIBLE, six other seemingly unrelated things would fail. And we had the entire compilation process in just as disorganized a fashion in our minds. We knew it was correct and why, but to explain it to anyone required at least 100 boxes on a horrible flow chart, which actually couldn't be untangled. That was the algorithm, and it worked, and it fitted onto the IBM 650 drum, but it was a mess. For all anybody knew at that time, however, that was the only way it could be done.

B. Operator Pairs

A next step is to use operator pairs rather than symbol pairs to control the operation. The operands distribute themselves nicely between operators, so an essentially identical plan as the above can be used, except adjacent operators are used to reference a table of generators. This gives some economy over the previous method, since operands are put into a single class. This type of organization is used in the Neliac compilers and the generator tables are called CO-NO or NO-CO tables by the authors. I understand CO-NO tables are especially good for translating input programs written in Hawaiian.

C. Simple Scan

Further improvement can be gained by lumping *operators* into classes, as well as operands. Only a few classes of operators are actually necessary; e.g., for FORTRAN, we would have perhaps four classes of operators:

(1) Those which require immediate action when first sensed, e.g., READ, DO.

(2) Those which are placed immediately on the stack when first sensed, e.g., SIN (for "sine of"), ABS (for "absolute value of"), left parenthesis.

(3) Those which are not placed on the stack until their priority is more than the preceding operator, e.g., binary operators.

(4) Those which are never placed on the stack but their priority is used as in (3) to force out previous operators, e.g., comma, semicolon.

The main control is along the lines of the modern algorithm given in Figure 4, with an input routine to condense identifiers and constants into single items. Usually, however, many stacks are used instead of one, for convenience, typically including some of the following:

(1) Operand stack

(2) Operator stack (it is quite helpful to separate 1 and 2, although not necessary)

(3) Mode stack (this gives the meaning of commas)

(4) Subscript stack (where computed subscripts wait their turn)

(5) Temp storage stack (a list of locations available for temporary storage cells in the object program)

(6) DO stack (for controlling DO loops)

and so on.

D. Recursive Organization

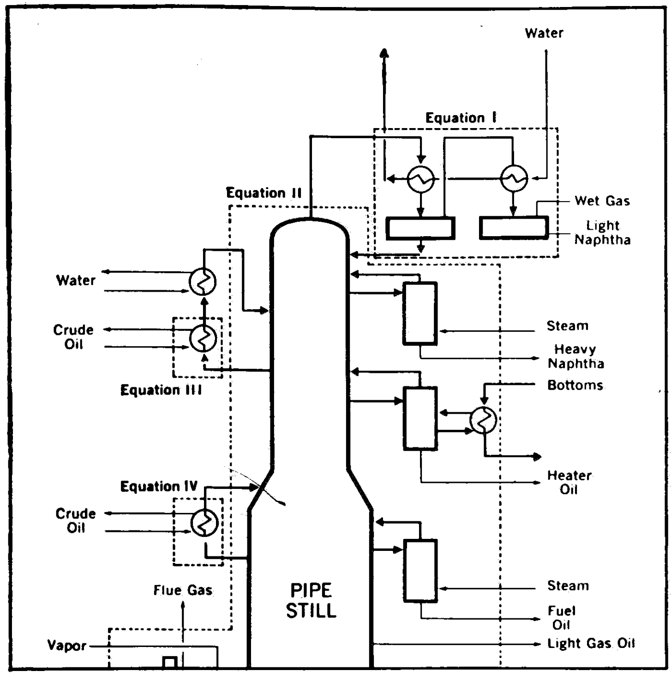
Some recent compilers are written with generators that work recursively. Typically when a construct (part of a formula) is recognized as being of a certain syntactical type, its generator is brought out. Somehow the end of the construct is detected, and this causes the generator to go into action. For example, there might be a generator for variables. If it happens to encounter an array variable, the "expression" generator will be entered for the subscript, and *it* may call on the variable generator, which may call on the expression generator, etc. Delimiters are used to take generators out of control at the appropriate time. Examples of such compilers are the threaded-list compiler at Carnegie Tech and the B5000 Algol compiler at Burroughs.

E. Syntax-directed Compilers

Another form of recursive compiler is called "syntax-directed," and is very closely related to the former type. Such a compiler is, theoretically, completely general, since it is built to operate from an arbitrary syntax list (description of the language) and

IBM asks basic questions in control systems

How can we keep changes from becoming errors?



This flow diagram shows a data processing systems engineer's analysis of the major control problems in a petroleum distillation process.

1. Reactor heat balance equation:

$$m_1\dot{y}_1 = \sum_{i=1}^{5} q_i T_i x_i - \left(\sum_{i=1}^{5} x_i - y_6\right) y_1 h_1 - Q_2(y_1 + a) \sum_{i=1}^{5} x_i + Q_5 - Q_3$$

2. Over-all heat balance equation:

$$\dot{Q} = m_1\dot{y}_1 + m_2\dot{y}_2 = \sum_{i=1}^{6} q_i T_i x_i - \left[\left(\sum_{i=1}^{5} x_i - y_6\right) y_1 h_1 + (x_6 + y_7) y_2 h_2\right]$$

$$+ Q_1 y_7 - Q_2(y_1 + a) \sum_{i=1}^{5} x_i - (Q_3 + Q_4)$$

3. Over-all coke balance equation:

$$\dot{C} = y_6 - y_7$$

4. Steady state coke burning equation:

$$y_7 = \frac{(b - cy_4)\, x_6}{(cy_4 + 1)\frac{H}{M_H} + \frac{(1 - H)}{M_c}\frac{(2k + cy_4 + 1)}{k + 1}}$$

These equations are the mathematical model for a catalytic cracking process. A similar model would be formulated for controlling the process at left.

As military and business operations grow more complex, they become more difficult to manage. The dynamics of large-scale operations shift so rapidly that management is often unaware of changes until after they have taken place. To keep complex operations performing properly, IBM is developing fully automatic systems and man-machine systems which detect variances from prescribed limits and take action on them before serious problems can arise.

Fully automatic closed-loop systems encounter unusual environmental and diagnostic problems. To prevent bending of large missiles during powered flight, IBM engineers are studying digital filter techniques which suppress bending-mode vibrations sensed in the attitude control loops. To formulate the mathematical model of the world's largest crude-oil distillation unit, it was necessary for IBM scientists to determine the relationships between 20 independent and 60 constrained variables, and the conditions of the process. Using linear programming techniques, they were then able to establish operating limits which would produce optimum process performance.

Criteria for man-machine systems, in which the computer assists human beings in control and decision making, are less easy to define. Operating limits, or set points, are seldom predetermined. For example, the design of a military system depends on knowledge of field operations, such as the information an army commander needs to utilize his forces most efficiently.

In addition, "human elements" add to the empirical nature of man-machine systems. Timely change-of-status reports lose their significance unless human beings can understand them immediately. IBM systems engineers are conducting extensive studies to establish the most effective ways of conveying information from machines to men. They are analyzing the information exchange which makes possible each step in different manufacturing and military operations. Out of their research may come the dynamic, real-time operational control systems of tomorrow.

If you have been searching for an opportunity to make important contributions in control systems, software development, research, machine organization, or any of the other fields in which IBM scientists and engineers are finding answers to basic questions, please contact us. Manager of Professional Employment, IBM Corporation, Dept. 539Z, 590 Madison Avenue, New York 22, New York. IBM is an Equal Opportunity Employer.

an arbitrary semantics list (description of the meaning of the language in terms of the object computer). These are still in the experimental stages, and with apologies to Ned Irons and the other researchers I must say they appear to be primarily of theoretical interest at the present time. The syntax of a language has to be carefully rewritten in order to produce efficient object code, and the creation of semantical tables is as cumbersome a job as writing generators for ordinary compilers. Compilers organized along the lines of C or D can be easily modified for all but major language revisions; so no great advantage to syntax-directed compilers has been proved as yet. I certainly do not want to discourage anyone from working on a syntax-directed compiler, for there is good reason to believe that significant strides forward in this direction are possible and that syntax-directed compilers will be very important in the future. On the contrary, I hope to stimulate more people towards working in this potentially fruitful area which has as yet been unable to compete with handmade compilers. As we have seen, the recognition of syntax is one of the simpler facets of compiling; a good deal of research needs yet to be done to simplify the real problem of how to produce efficient code once the syntax has been recognized.

F. Multi-pass Compilers

A fairly large number of compilers operate in two passes; the first pass is organized something like class C above, and it produces a pseudo-code analogous to the "T(I) := Y * Z" output of Figure 4. The second pass uses this pseudo-code to generate the object program. I would classify such compilers under category C.

This last category of compiler organization is rather for those expensive compilers which consist of *many* separate passes. Such compilers defy simple explanation, and the only way to learn to know them is to spend a good deal of time studying what each pass does and how it fits into the whole scheme. There is usually very little in common between two such compilers, and all I can say is that the well-written ones of this type usually are built around some major modification of a one-pass compiler, designed to produce more efficient object programs from a more thorough analysis of the source program.

References

A complete bibliography of the compiler literature is hard to give; actually it would be quite distressing to try to read many of the articles. This will happen because so many of them are about how that particular author discovered the same thing as other authors (although it may take several hours to realize what he has discovered and what he hasn't). Therefore, I will give only a short bibliography, for use by those interested in pursuing the subject further.

The complexity in the first translators is indicated in two articles:

D. Knuth, "RUNCIBLE—Algebraic Translation on a Limited Computer," *Communications of the ACM,* November, 1959. In this article I include a flow chart of a portion of the RUNCIBLE compiler, and also make the untrue statement that such an algorithm may well be the only possible one to use on a small computer such as the IBM 650.

Peter Sheridan, "The Arithmetic Translator-Compiler of the IBM Fortran Automatic Coding System," *Communications of the ACM,* February, 1959. This article is rather heavy reading, but it will at least impress the reader with the complexity of the algorithm.

Neliac compilers are discussed as the principal subject of the book "Machine Independent Computer Programming" by Maurice Halstead, Spartan Books, Washington, D. C., 1962. "NO-CO" is a term used by the authors of Neliac meaning "Next-Operator—Current-Operator."

Excellent expositions for the beginner of the modern scanning algorithm have been written by Robert Floyd: "An Algorithm for Coding Efficient Arithmetic Operations," *Communications of the ACM,* January, 1961, and "A Descriptive Language for Symbol Manipulation," *ACM Journal,* October, 1961.

Finally, to study the organization of various compilers, the entire January 1961 issue of the ACM Communications is recommended. Of special interest is "The Internal Organization of the MAD Translator," by B. Arden, B. Galler, and R. Graham. This is one of the few articles in the literature which discusses some general methods for generation of the object program without a separate generator for each special case.

[1] "Internal Translator (IT); A Compiler for the IBM 650," by H. A. Perlis, J. W. Smith, and H. R. Van Zoeren, Carnegie Institute of Technology Computer Center, Pittsburgh, Pa., 1956.

[2] A *load-and-go compiler* is one in which a person enters as input some algebraic statements, and the compiler translates these into machine language and immediately transfers control to this new program. Thus with a "load-and-go compiler" the first output consists of the answers.

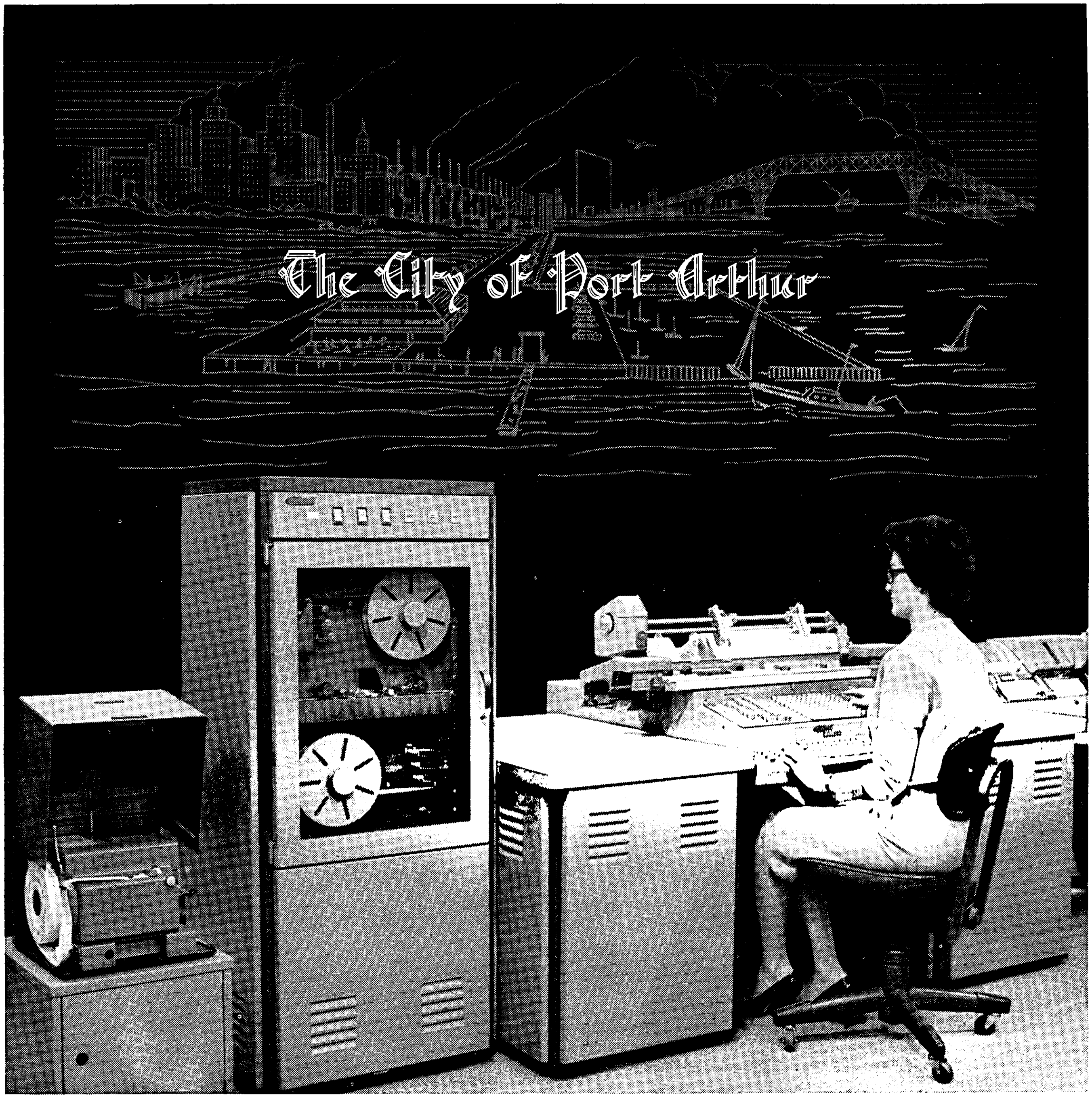
READERS' AND EDITOR'S FORUM

(Continued from page 6)

For example, in an IBM release dated November 1, 1962, the following paragraph was contained: "Incoherent light produced from such diodes had previously been observed in a number of laboratories. However, the IBM device is the first known to exhibit laser action."

The same day GE's Research Laboratory released a press packet that contained the paragraph: "The ability of gallium-arsenide junctions to produce infrared light has been previously observed in several laboratories. The General Electric device is the first to generate coherent light . . . "

So pity the life of the over-worked news editor no longer! If technology, and its heralds, continue to progress with such smooth consistency, the news editor of the future may only have to keep a collection of ink pad stamps carrying leading corporate names on his desk, and be able to run the same "fresh" story four or five times merely by altering the blurb with a few applications of the proper hand stamp. Ah, at last, automatic journalism.



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Programming A Large Real-Time System

Mark Koschmann
and R. E. Moir
Aries Corporation
Minneapolis, Minn.

The principles of program design, elaboration, integration, and documentation for large real-time computer systems.

Programming a large-scale system requires proportionately more organized effort than a small system. Examples of large-scale systems include the tactical data system of the U. S. Navy, and the air traffic control system of phase I of the Federal Aeronautics Authority. Just as simple extensions of punched card processing techniques lead to an inefficient utilization of small to medium scale data processors, the organization of a large-scale programming effort requires techniques that are more orderly than those that may suffice for smaller scale systems.

This article reports an orderly approach for the successful implementation of large-scale systems. These guidelines have evolved through many man-years of experience with several large-scale systems.

The key method of insuring the success of a large-scale system is to provide for proper design, adequate controls, and planning while the application is in the formative stages. Once established, these guidelines are effective in maintaining the orderly change that all data processing systems undergo during their growth; and in addition, these guidelines can restore management control of installations that have had less successful experience.

Stages

The successful development of a large, real-time program depends on orderly and well-defined procedures. These procedures consist of specific tasks to be accomplished with detailed schedules containing "bench-marks" and deadlines for completion of each task. The individual tasks establish definite programming stages.

The four major programming stages are (see Figure 1): (1) Program Design, (2) Subroutine Development, (3) Program Integration, and (4) Documentation.

Subroutine Development involves four substages: (a) Flow Charting, (b) Coding, (c) Assembling or Compiling, and (d) Subroutine Testing.

Program Integration involves three substages: (a) Cataloguing, (b) Assembling or Compiling, and (c) Program Testing.

Although the stages are basically sequential, program integration can and should begin before every subroutine is completed, and preliminary documentation should proceed concurrently with the other stages. The detection of errors during program integration requires corrections at the subroutine development stage. Both program integration and subroutine development require changes of program design when certain problems are encountered.

Program Design

The primary input to the program design is a report on the system processing requirements. This report, generated by a system design effort, lays out the general demands required of the central processor and external storage, specifies the logical interface characteristics between the central processor and other system hardware, and schedules the completion date for the various subsystems of the total system development.

The result of the program design is a report on program specifications. This includes a detailed description of the data formats, subprograms, major subroutines, and executive routine. It establishes all the conventions, rules, and restrictions for all programmers, and it sets forth all schedules for the various stages of the program development.

Simulators and Test Data

For the successful completion of the program, a separate development should occur simultaneously with the program stages. This is the development of simulators, test data, etc., which are tremendous aids to the subroutine and the system program testing periods. The reports on processing requirements and program specifications furnish the necessary information to program the simulator and test data. The development of these programs follows the same stages as given for the system program.

Developmental Stages

The purpose of the developmental stages is to produce a program which satisfies the processing requirements of the particular system. The requirements which are established by the system design effort are the primary input to the program design stage. A program design team receives these requirements and lays out a complete method in the form of specifica-

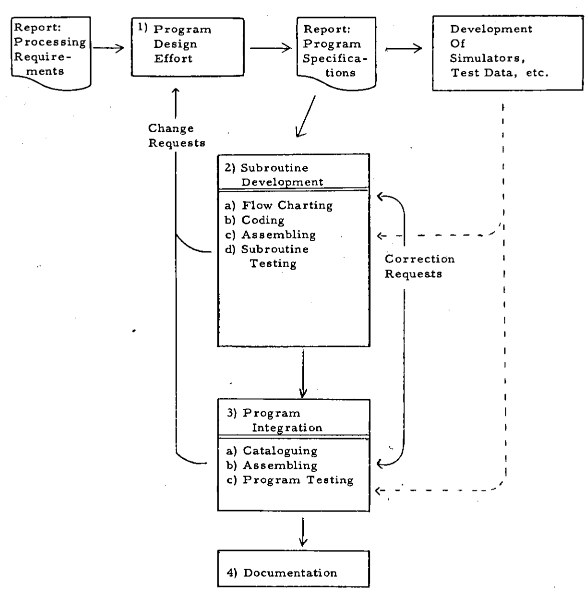


Figure 1 - Program Development

tions to implement a program which makes the system operational.

Generally the program design team consists of a small group of very experienced individuals. This group interprets the processing requirements report, designs the over-all program, establishes in detail the approach philosophy, and sets forth solutions for many anticipated problems. Many troublesome areas can be eliminated by the adherence to one, good approach and method. It is the function of the program design team to formulate this approach and then firmly require that this approach be followed.

Processing Requirements Report

Before the program design team can design a large program, a clear and detailed statement must specify the system processing requirements. This statement is generally prepared by the system design team, often in cooperation with the program design team. The requirements report should include: (1) a complete description of the interfaces of the central processor and all external equipment, (2) the total amount of data required to be processed, (3) the timing restraints imposed on the system, (4) the purpose and characteristics of each piece of equipment, and (5) the system functions that the central processor must perform.

Program Specifications

The program specifications report prepared by the program design team contains a group of program specifications which are necessary before flow charting of the problem can begin. Three categories of information should be specified: (1) the format of the major units of data, (2) a broad statement of the functions to be performed by each major area of the program, and (3) a set of programming conventions to guarantee compatability between the various parts of the program. Many of these specifications will be influenced by the characteristics of the standard software package available for use with the computer equipment selected, such as, an Assembly System or Compiler. To fully utilize the features of this system, therefore, the program designers should be thoroughly familiar with this standard software.

Data Formats

The data formats to be specified at this point will refer largely to tabular data. An example may be a track table which has certain specified units of information for each aircraft which is being tracked. There are two commonly used formats for storing such tabular information. All data fields for one aircraft may be grouped together, followed by all data fields for the next aircraft, and so on. Alternatively, the first data field for the first aircraft may be directly followed by the first data field for each of the other aircraft; these in turn would be followed by the second data unit for each aircraft, etc. Regardless of which format is selected, a mnemonic label or symbolic address should be assigned to each whole word or multi-word data field for the first aircraft. These labels should be assigned according to the rules given in the manual describing the standard assembly system to be used.

In addition to assigning labels to the data, consideration should be given to the total length of each table. For some tables it will probably be desirable to assign a fixed length. For others it may be preferable to retain the ability to assign table length at the time of allocation; this can be done by assigning a mnemonic name to a parameter which indicates table length.

Having established the data formats, the next step is to diagram the over-all structure of the program, with a broad definition of the functions to be performed by each major part of the program.

Executive Routine

The main control routine, or executive, should be specified in detail, showing how it executes the major computational "subprograms." The structure of the executive routine will be determined largely by the real-time requirements of the program. For example, if a particular subprogram must be executed at regular time intervals, it is the function of the executive to see that this is done.

In addition to defining the executive and its subprograms, the program design team should try to determine whether there are certain types of operations which will be performed by many parts of the program. Some examples might be input, output, mathematical function evaluation, table search, or character code translation. Each of these operations should be defined as a subroutine.

Each subprogram or subroutine should be described by some standardized data page. These data pages should include the name of the subroutine, the labels of the entrances, names of all other subroutines executed by this subroutine, and the names of all "system" data altered or referred to by this subroutine. "System" data here means any data which is used by more than one subroutine.

Subroutine Conventions

It is assumed that the program will contain a large number of subroutines written by many different programmers. Since this is the case, it is important to set down a set of programming conventions to guarantee compatability between the subroutines. Some desirable conventions are:

(1) The use of labels should be restricted to insure that different programmers do not use the same label in different subroutines. Suggestion: it may be desirable to require that each label begin with a group of letters identifying the subroutine in which the label occurs.

(2) Conventions regarding the use of arithmetic registers should be established. It should be decided whether subroutines will be permitted to alter the contents of registers without resetting them.

(3) Flow charting symbols should be standardized.

(4) Standards of documentation should be established. Like the other conventions, this will improve communication between programmers.

The sections below on flow charting, coding and documentation include a more detailed discussion of programming conventions.

Subroutine Development

When the program specifications report is completed, the development of the individual subroutines can begin. The specifications serve as a reference manual for all programmers. Since the over-all design establishes the interrelations among all subprograms, major subroutines and system data, the development of the subroutines can progress in parallel. The development of a single subroutine involves four stages: (1) Flow Charting, (2) Coding, (3) Assembling, and (4) Subroutine Testing.

Flow Charting

Flow charting is the process of displaying the major functions, decisions, and control of a subroutine by geometric figures and lines. This helps the programmer quickly visualize the steps that the subroutine must perform to accomplish its intended purpose. The flow chart then serves as a guide from which the subroutine can be coded in a straight forward manner.

Before actual flow charting begins, it is important to establish a uniform set of flow chart symbols and conventions. Various sets of flow chart symbols are in use, but usually they include symbols for the following types of operations: computations, decisions, subroutines, entrances, exits and connectors, input-output, flags, and stops. The conventions should also specify such details as size of paper, primary direction of flow (vertical or horizontal), and how connectors are to be numbered or lettered.

With regard to the connectors, it may be desirable to establish a convention by which each connector can be immediately associated with the corresponding Assembler Language label in the coded subroutine. For example, the convention might be something like the following:

(a) All connectors shown on flow charts must be numbered.

(b) When a subroutine is coded, the programmer must label each instruction which corresponds to a connector on the flow chart. The label which is used must consist of the subroutine name followed by the connector number.

Adopting standard conventions such as the above sometimes seems to be unnecessary work. It will be found, however, that such standardization makes it easier to compare a flow chart with the coding. This aids debugging, and is especially helpful when it becomes necessary to make program modifications.

Coding

Once the logical flow of a subroutine has been charted, the coding can begin. Coding is the process of translating a flow chart into a language acceptable to the computer or acceptable to a compiler or assembler which then translates the language into machine instructions. The coding of subroutines is not a difficult process if a good assembler or compiler is available which has certain desirable features.

The compiler or assembly system used should be a sophisticated, thoroughly-checked, programming aid which provides either a problem-oriented language or an easily remembered language for symbolic instruction, symbolic addressing, macro-instructions, and all the commonly needed input/output operations for magnetic tape, magnetic drums, printer, card reader and punch, and console typewriter. All computer instructions should be expressible in mnemonic form. Symbolic addressing permits subroutine corrections to be made easily. The assembler operations should establish good standards for the subroutine concept, such as: (1) a header operation for each subroutine that gives the subroutine name, programmer's name, and date of latest modification, (2) a standard means of starting all subroutines, and (3) a means of exiting normally from a subroutine.

The coding of input/output routines is always a difficult task. For the standard input/output subsystems, general routines should be available through the assembler. These routines should be referenced by operations, such as: (1) request all tape functions to be performed, (2) request drum operations, (3) output data on the high speed printer, (4) control the reading and punching of cards, (5) cause the content of specified storage registers to be typed by the console typewriter, and (6) cause a message to test to be typed.

Assembling

When a subroutine is coded it is ready for debugging and testing. The subroutine must first, however, be translated from mnemonic code to machine code before it can be tested on the computer. This translation is accomplished by an assembly system, which also performs many other valuable functions. A description of the assembly process adequately explains these functions and the assistance they provide the programmer.

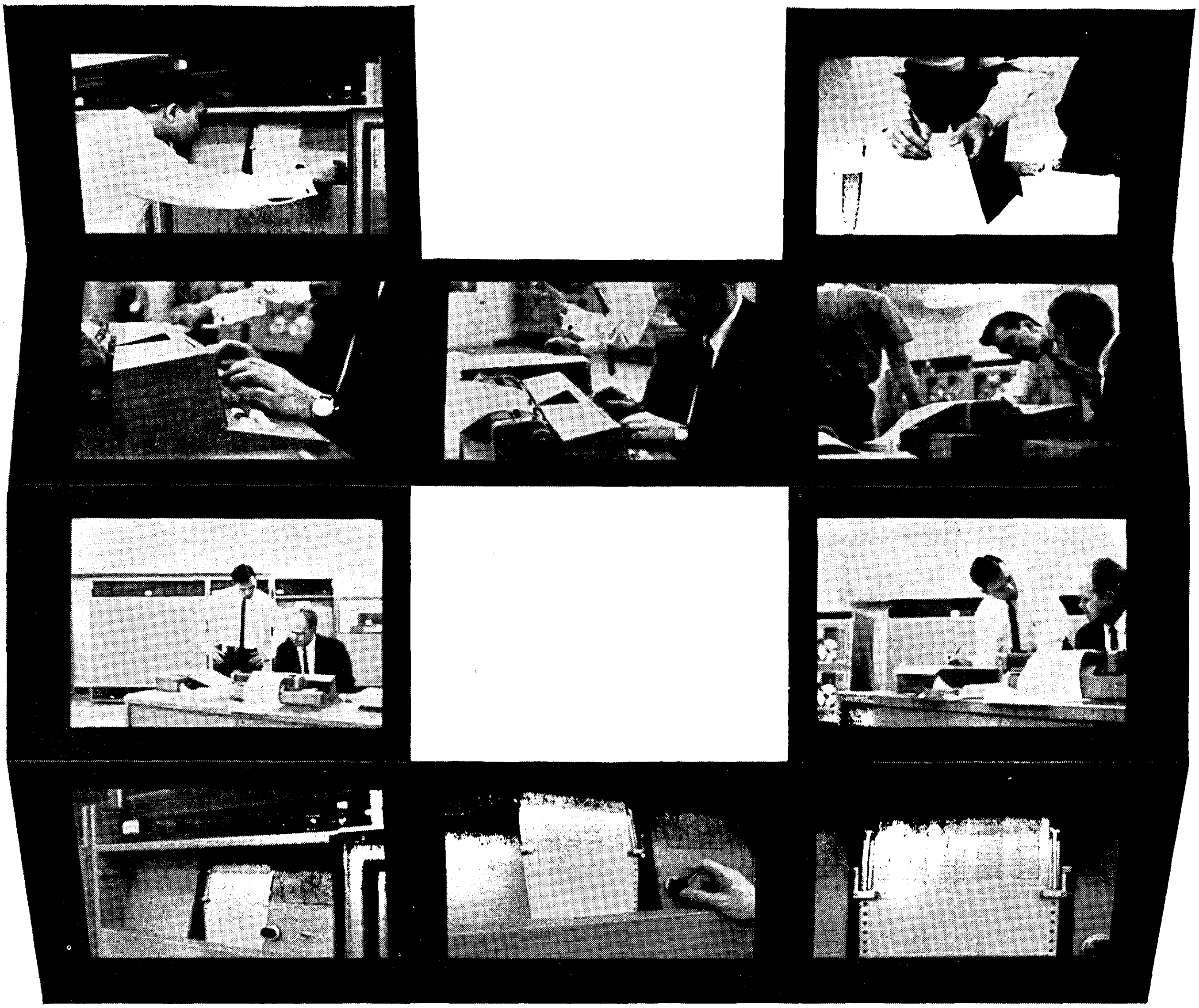
The subroutine coding can be prepared on paper tape, 80 column cards, or magnetic tape for input to the assembler. As the subroutines load into the assembler, many errors in the format are detected. These errors can generally be categorized as infractions of rules and conventions established for all programmers.

The standardization which an assembler imposes upon a large group of programmers is often enough reason to have an assembling stage. Since an assembler accepts only subroutines coded in accordance with certain conventions and restrictions, all subroutines must be similar in form. Program integration would be virtually impossible without this consistency. Of course, an assembler performs many services beyond that of a policeman.

The primary function of an assembling process is to allocate absolute or relative addresses to symbolic addresses of the subroutine input coding. This permits the programmer to code ignoring the exact memory locations to which the subroutine will eventually be assigned.

If desired, the assembler should automatically assign absolute or relative addresses to all symbolic addresses or labels. Frequently, however, the programmer needs to override this type of automatic feature. For these instances, the programmer can assign absolute addresses to a specified list of labels, equate labels to other labels or simple arithmetic expressions of labels, and delete a previously allocated label.

The resulting machine coded subroutine may be outputed in two formats. These are: (1) absolute



FROM EVERY POINT OF VIEW...

BENDIX G-20 COMPUTER SYSTEMS PROVIDE MAXIMUM PROGRAMMING COMPATIBILITY

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format, which must be loaded into a pre-established memory area and (2) relocatable format, which can be loaded in any memory area. The memory area is specified at load time. Both these forms can be obtained on magnetic tape or paper tape.

The assembler should provide edited outputs which assist the programmer with subroutine testing and documentation. Some of these outputs should be: (1) information which states the number of instructions in the machine coded routine and the memory areas which it occupies, (2) a side-by-side listing of symbolic addresses (labels) with their corresponding absolute or relative addresses, either in the order as they were assembled, or sorted alphabetically as to labels, or sorted numerically as to addresses. These outputs should be available on either a high speed printer or typewriter via paper tape.

When the subroutine is assembled and an output obtained, the subroutine is ready for testing.

Subroutine Testing

Too frequently programmers overlook the importance of thoroughly testing subroutines as individual units. Even though complete testing of a subroutine cannot be accomplished until it is integrated into the program, conscientious subroutine testing can greatly reduce the time required for program integration.

To test effectively, an environment which resembles the actual real-time situation should be established. This can be done in part by simulators and system test data.

The proper debugging aids greatly reduce the problems of subroutine testing.

Some assemblers operate in two modes. One mode includes all the desired debugging aids in the running program. Subroutine testing generally takes place in this mode. Once the subroutine is checked out, the assembly system can exclude the debugging aids, operating in the other mode.

The programmer refers to the debugging aids by inserting the assembler debugging operations in the appropriate places of the subroutine. These operations are: (1) Define areas of memory to which other debugging operations apply, (2) Copy one area of memory into another area of core memory (its image), (3) Copy one area of memory on an area of the drum, (4) Test a specified area of memory with its image, and print out all word differences (this is a very powerful debugging tool), (5) Print the contents of specific registers, and (6) Print the contents of a specified area.

Another valuable debugging aid is a Trace Debugging Routine. A Trace executes each instruction of the subroutine in an interpretive manner and prints the contents of the computer registers at each step.

Some of the errors which are detected are the result of wrong coding. The coding must then be corrected, the subroutine reassembled, and the testing continued. Other errors are caused by inaccurate flow charts, or data pages, in which case the corresponding stages must be repeated.

The importance of subroutine testing cannot be overstressed, nor can the need of proper debugging aids, which greatly assist the programmer to perform effective testing.

Program Integration

When the subroutines are developed and thoroughly tested they are ready to be integrated into the system program. Frequently, integration and testing of subprograms precede the assembling of the entire system program. The integration involves three stages: (1) Cataloguing, (2) Assembling, and (3) Program Testing.

Cataloguing

The first stage of integration consists of cataloguing the subroutines or building a library of subroutines on magnetic tape. The library contains the subroutines in the mnemonic, symbolic address form. This prepares the subroutines for the assembling stage. The library provides a convenient place for: (1) central control (indicates what is done and what needs to be done), (2) a simple, single source for the assembly process, (3) numerous error-detecting schemes, and (4) a documentation source.

A librarian program should furnish the capability to adequately perform the necessary functions of the cataloguing stage.

This program normally contains the following maintenance operations with which to construct and update the subroutine library. These are: (1) Add new subroutines to the library, (2) Replace an existing subroutine with a corrected or modified one, (3) Remove a subroutine from the library, and (4) Insert new subroutines in exact locations in the library.

These maintenance operations permit the user to keep a central, up-to-date file of currently corrected subroutines.

The librarian program should record all transactions requested of it. The record includes the library action or operation, the name of the programmer who initiated the action and the date on which the action took place. This record provides an excellent chronicle of all subroutine modification and program revisions.

Current documentation is always a difficult achievement in any development. The librarian should have editing operations which print various types of information about the subroutine on the library. Some of these editing operations are: (1) Print the chronicle of all the library maintenance operations, (2) Print the names of all subroutines in the library, and with each name, the names of all lower level subroutines to which the subroutine refers, (3) List the actual coding (in Assembler source language) of all subroutines, (4) List only the coding of those subroutines having a special *key,* (5) List only the coding of those subroutines specified by name.

These operations provide a very convenient method to prepare the necessary subroutine documentation needed for control and communication among many programmers. This documentation gives to those responsible for program integration the ability to see the "big picture" and quickly locate troublesome areas, inconsistencies, and the absence of certain subroutines.

When all the subroutines for a program or a subprogram are catalogued on a library, the development proceeds to the program assembly stage.

Program Assembling

The input to the program assembling stage is the subroutine library. The subroutines which compose the program are selectively retrieved from the library, assembled together and translated to machine code. This process involves all the functions described above under "Assembling" and the same advantages are realized. The process, however, is on a much larger scale.

The Assembler should include a scheme for retrieving subroutines from the library. Such a scheme involves a "linking or chain" concept which links together all subroutine references. If a subroutine is retrieved, all lower level subroutines should be automatically included. If a subroutine of the chain is missing an error should be indicated. This assures to a large extent the completeness of the program.

The Assembler should provide retrieving operations which permit the programmer to selectively include various chains and groups of subroutines in the program. Some of these are: (1) Select all those subroutines with the same key or subname and (2) Select those subroutines specifically listed, and all their lower level subroutines.

Once the desired program is retrieved from the library on to another magnetic tape, the Assembler can allocate and edit the entire program. The resulting absolute machine-coded program is then ready for elaborate testing.

Program Testing

Although the subroutines perform correctly as single modules, program testing detects and isolates many errors which are the result of misunderstanding, incorrect program design, wrong specifications, etc.

As with subroutine testing, the debugging aids of an Assembler can be of great assistance in isolating and detecting errors. Correction requests are made of the subroutine development stage in which the various functions must be repeated.

Simulators and test data can be used if the actual environment is not available. Final testing must, however, occur in the real-life situation for a trial period before the program can be declared operational.

Documentation

To use and maintain the operational program, a thorough and complete set of documentation is needed. The documentation should be kept current and made available to the user. Too frequently, program developments have been unsuccessful, because this final stage was not emphasized sufficiently.

The documentation should include the following items:

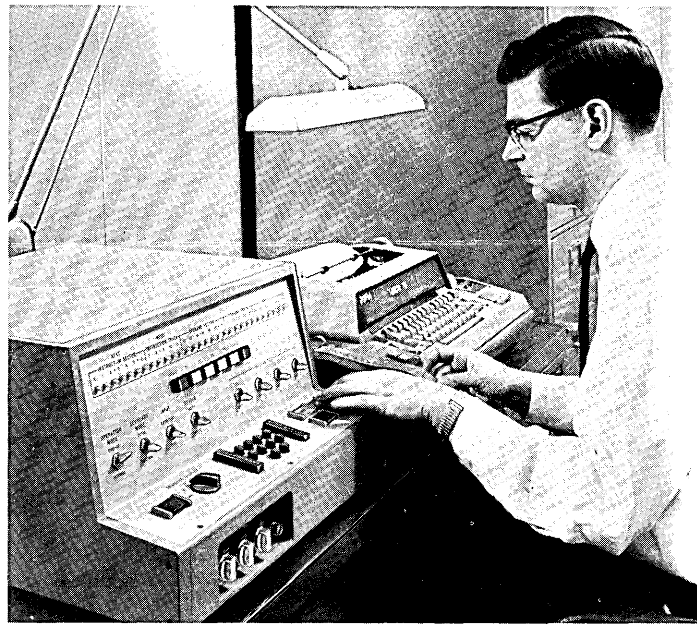
(1) A clear description of the program design—data formats, subprograms, special techniques used, and major subroutines.

(2) Operating instructions which describe in detail the steps required to initiate and control the program.

(3) Flow charts and data pages for all subroutines, and

(4) Lists of the coded instructions for all subroutines, memory layout and allocation charts, and all other edited information provided by the assembly system.

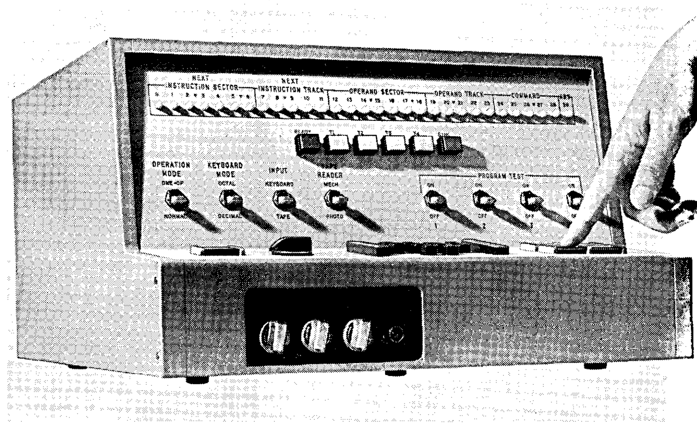
DIGITAL



L-2010 GENERAL PURPOSE COMPUTER
Librascope Division
General Precision Inc.
Glendale 1, Calif.

The L-2010 computer has been developed to provide military users with a fast, economical computer to handle data-processing and computing tasks that have been considered either too costly to solve with large computers or too complex for existing small, general-purpose computers.

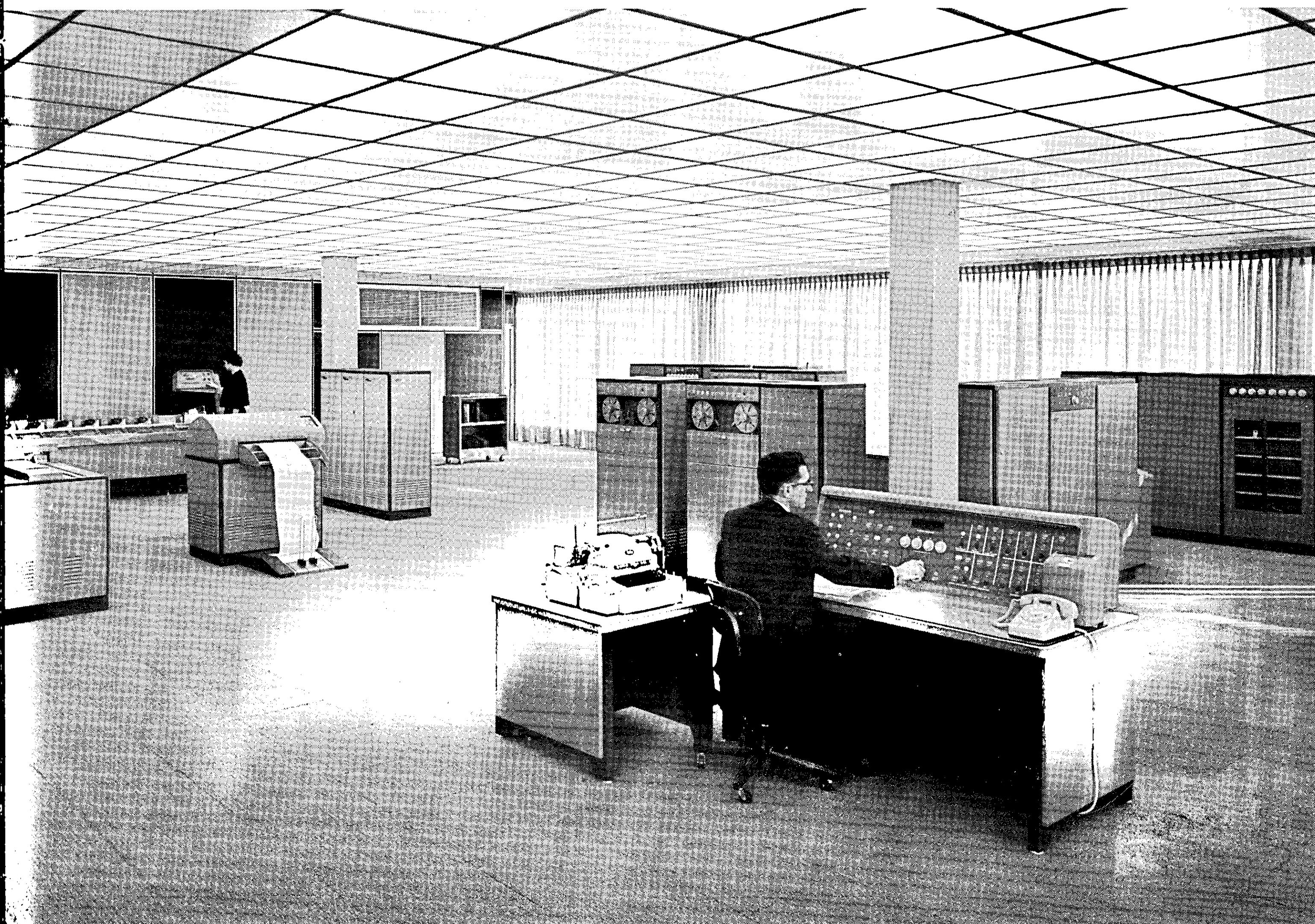
The unit weighs 60 pounds and measures only 2 cubic feet in volume. It can be portable, rack-mounted or operated on a desk-top.



The solid-state device has a magnetic disk memory capacity of 4096 words. Access time is 78 usec. for addition or subtraction, 156 usec. minimum to 2.42 msec. maximum for multiplication, and 234 usec. minimum to 2.5 msec. maximum for division. Internal organization permits direct or buffered communication with input/output devices. The L-2010 uses a keyboard and a mechanical or photoelectric paper-tape reader for direct inputs; for direct outputs, the computer uses a 100-character-per-second paper-tape punch, a typewriter, and the control-panel display. The L-2010 can be operated manually, semiautomatically, or automatically.

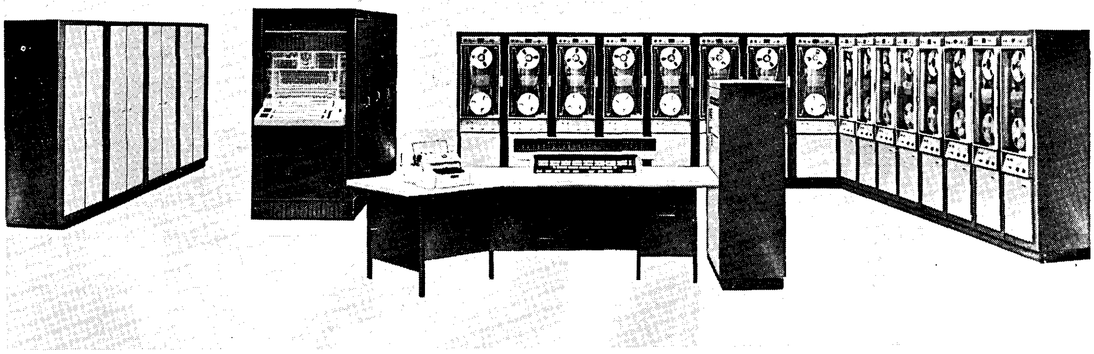
The L-2010 can be used for target-motion analysis, navigation computations, ballistic computations, system simulation, automatic system checkout, and other ship and ground-based applications.

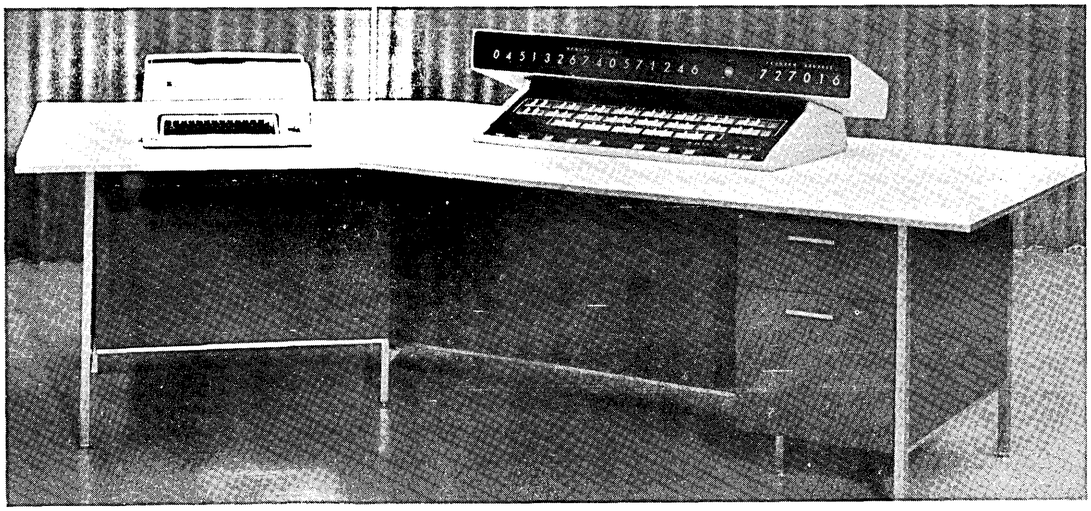
COMPUTERS



NCR DATA PROCESSING CENTER
The National Cash Register Company
Dayton 9, Ohio

A complete system of punched tape accounting for laundries, dry cleaners, and other textile maintenance industries is offered by NCR. In this system, the punched tape becomes the connecting link between low-cost, tape-punching equipment, (located in the laundry office or in the accountant's office), and large-scale computers which produce the final reports. Management reports are produced automatically at the NCR Data Processing Center nearest the punched tape user. The account numbers used, in a punched tape system of bookkeeping, are the same as those in the Uniform Account Classification, Special Report 190 of the American Institute of Laundering. No pre-printed forms are needed. Customer accounts are confidential and protected by computer codes. The picture shows a typical NCR Data Processing Center.



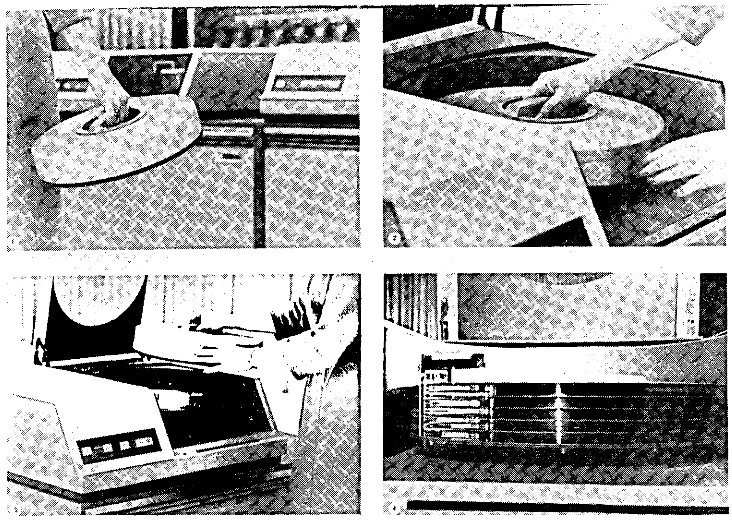


PHILCO 212 COMPUTER SYSTEM
Philco Corporation
Computer Division
Willow Grove, Pa.

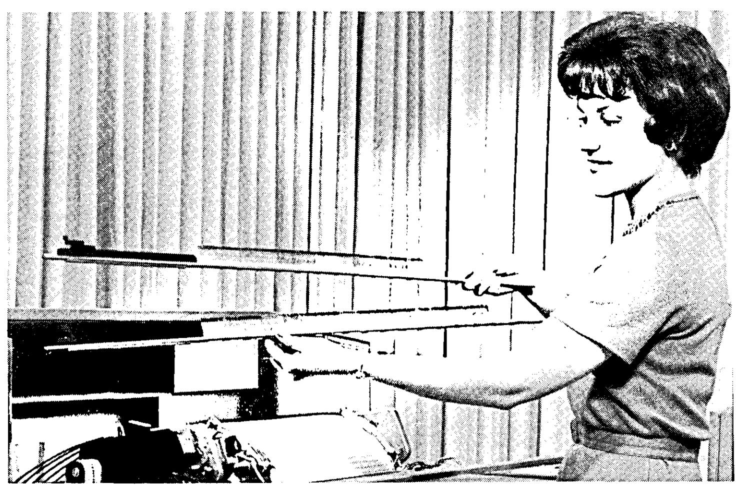
The 212 Computer System is made up of the Philco 212 central processor, a one-microsecond memory, 240,000 character-per-second magnetic tape units, and selected input-output devices connected to the Philco 1000 satellite computer. The Central Processor, on exhibition for the first time at the Fall Joint Computer Conference in Philadelphia, has single precision operands consisting of 48 bits including sign, providing accuracy to 14 decimal places. Two full operands may be added or subtracted in 0.55 microseconds. The Philco 212 performs the following four operations concurrently on four or more sequential instructions: 1) accesses memory for a pair of instructions 2) decodes an instruction, obtains operand 3) performs arithmetic operations, and 4) stores result. Memory access time is a small fraction of one microsecond. The 212 operates in conjunction with one microsecond high-speed magnetic core memory, available with 16,384, 32,768, or 65,536 words. A full range of input-output units is available. The Philco 212 retains program compatibility with earlier models of the 2000 system.

IBM 1440 -- NEW LOW COST DATA PROCESSING SYSTEM
International Business Machines Corp.
Data Processing Division
White Plains, N.Y.

A new compact computer, called the IBM 1440, is described as a low-cost computer for small and medium-size business firms. Five newly developed devices are included in the system. The 1441 processing unit uses magnetic core storage in which all positions are addressable. Core storage cycle is 11.1 microseconds. A new card-read-punch device, the 1442, uses the solar cell principle to read information from punched cards directly to the central computing unit. It reads 80-column IBM cards serially at up to 400 cards per minute. The 1447 console contains the operating keys, dials and switches that permit operator control over the system. In the picture, a computer operator (right foreground) is shown loading a disk pack on one of the 1440's disk storage drives. Seen behind the console (in the top picture) is the printer; the card read-punch is at the right of the printer; and the processing unit is behind the disk drives.

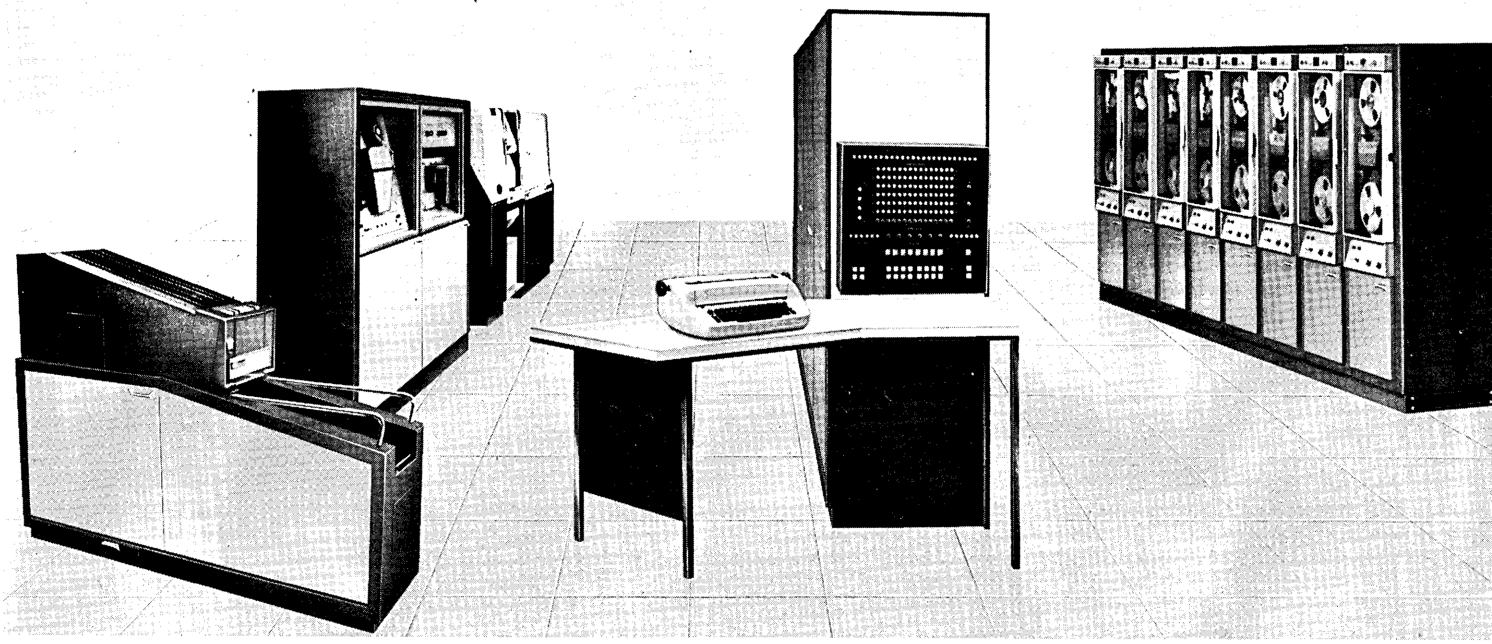


A major advance in memory technology, which has been introduced in this system, is the disk storage drive, the IBM 1311. The disk storage drive has six 14-inch memory disks packaged in containers which can be removed and replaced in a matter of seconds. Disk packages can be stored on shelves like books. Each holds six magnetic memory disks with a combined storage capacity of nearly 3,000,000 alphameric characters. Up to five 1311 disk storage drives may be attached to the system providing a maximum on-line capacity of almost 15,000,000 characters of information. Disk packs are interchangeable providing the 1440 with a large random and sequential data storage capacity. The 1311 disk storage drive can also be used with other IBM systems. The second photo shows an operator loading a memory disk pack. In sequence (1) operator carries disk pack containing six 14-inch memory disks to the 1440 (2) she places the disks on the disk storage drive spindle (3) removes the pack cover and (4) the equipment is ready to operate. Disk packs weigh less than 10 pounds.



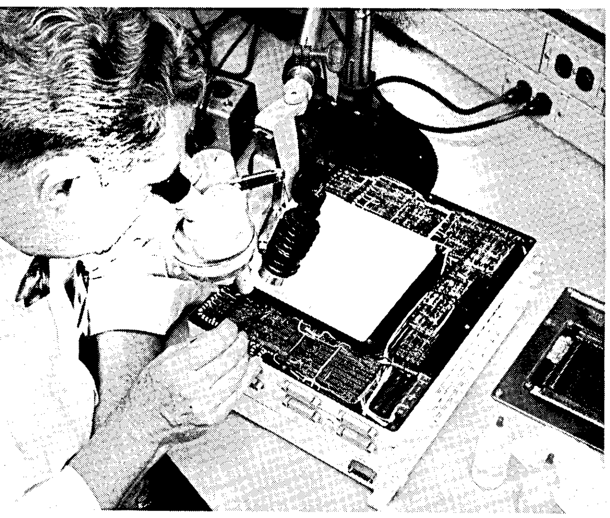
Five interchangeable type bars give the new 1443 printer a variety of speeds, printing up to 430 lines a minute. In the picture at the right, an operator holds two of these five removable type bars. Each type bar contains the alphabet, numbers and various combinations of special characters, or just numbers and special characters alone. With the numerical type bar -- all that is required for some jobs -- the printer operates nearly three times as fast as with the combination bar.

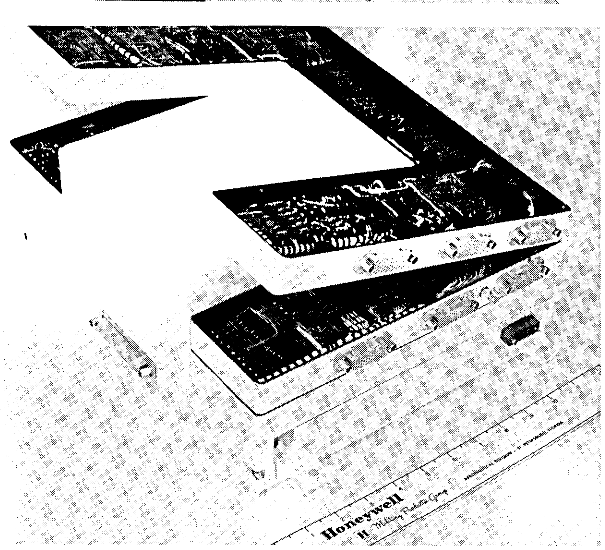
Automatic programming aids come with the computer at no extra charge. These include three programs for banks, two for insurance companies, a medical service package for hospitals, and programs for schools, trucking firms, and retail stores.



PHILCO 1000 COMPUTER
Philco Corporation
Philadelphia 34, Pa.

This is the Philco 1000 computer, a satellite system for the Philco 2000. It is an integral part of the large system complex. Due to its modularity the Philco 1000 also becomes a general purpose data processor with a wide variety of applications. Philco 1000's multiple operational characteristics are achieved through a technique of buffering input-output devices with the main core storage of the 1000 system.





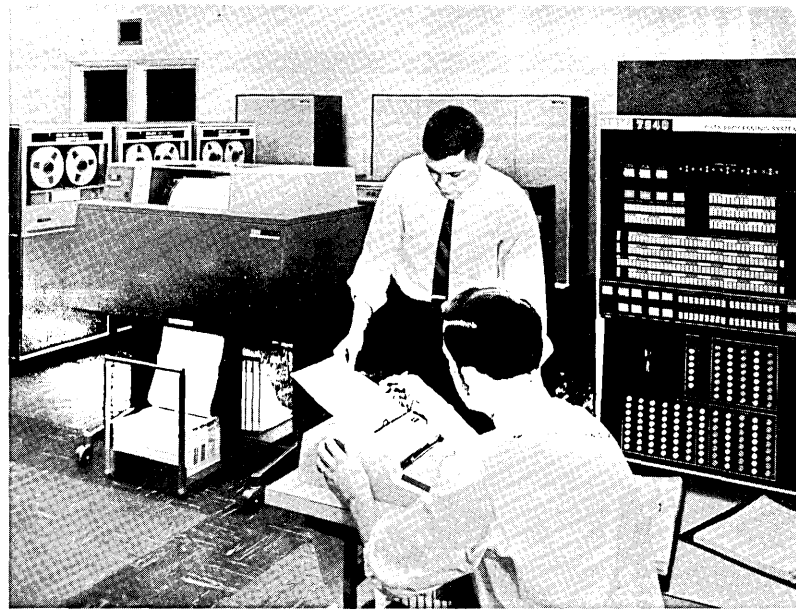
PICO -- NEW SUBMINIATURE COMPUTER
Minneapolis-Honeywell Regulator Company
Military Products Group
Minneapolis 40, Minn.

This new subminiature computer, called Pico, is said to be capable of guiding any space or airborne vehicle requiring inertial guidance or navigation. The general purpose digital computer does a complete 24-bit add cycle including access time in just 12 microseconds. Its solid-state biaxial non-destructive readout ferrite core memory eliminates the need for rotating magnetic drums. One of the logic modules is shown undergoing visual inspection in the picture at the left.

Pico consists of four U-shaped trays filled with electronics and stacked one on top of another and a separate memory unit which is tucked within the "U" of the trays. The trays are hinged to swing open like the pages of a book so that maintenance can be carried out without having to shut off the whole computer. An entire tray can be disconnected, removed and replaced by a spare within minutes to assure a minimum of lost operating time. The basic 3072-word memory can be easily expanded to 8192 words. Pico weighs some 20 pounds, is about the size of a portable typewriter, and requires only 46 watts to operate.

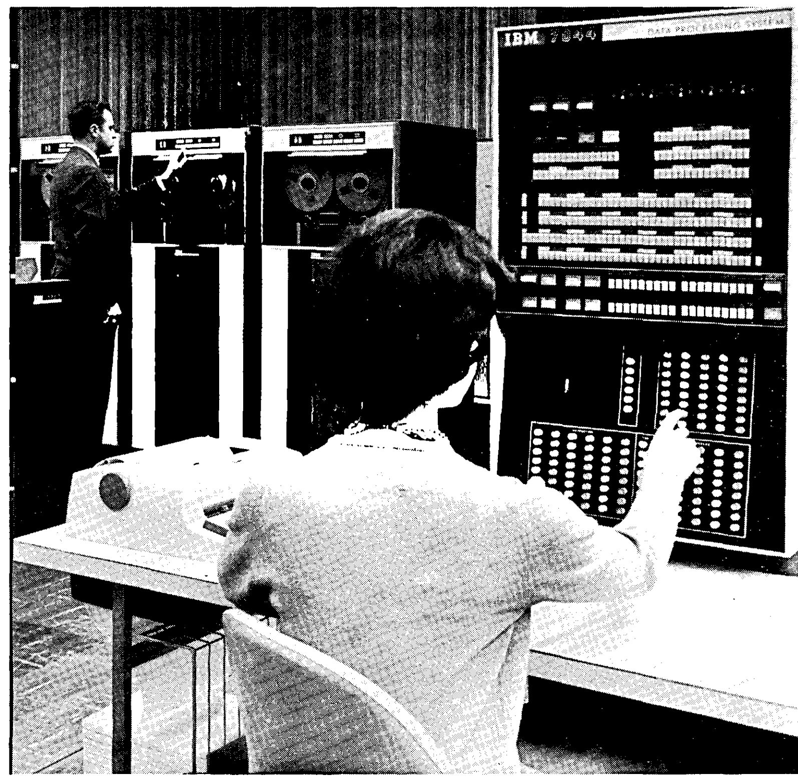
In its present form it is described as strictly a military and space computer with no place in the world of commercial business devices. The company's Electronic Data Processing Division in Boston is investigating the possibilities of bringing Pico's capabilities down to earth where they can benefit the business world also.

IBM 7040
International Business Machines Corporation
Data Processing Division
White Plains, N.Y.



The IBM 7040 and 7044 are compatible with each other, with a wide variety of input-output equipment, and with the IBM 1401. A typical configuration of the 7040 contains a card read-punch, high-speed printer, and low-cost magnetic tapes. A basic system could be expanded in stages to include high-speed tape drives, magnetic disk files and an on-line IBM 1401 data processing system. A typewriter built into the computer's console will print messages during testing and "debugging" of programs.

IBM 7044 DATA PROCESSING SYSTEM



The 7044 data processing system is one of the fastest computers yet developed by IBM. Memory access time is 2.5 microseconds. In one second it can perform 400,000 logical decisions, 200,000 additions or subtractions, 33,333 multiplications or 20,000 divisions. Data recorded in paper tape or transmitted over wire is accepted by this system. It also can be linked to such devices as analog-to-digital converters, radar, microwave transmitters, and telemetering equipment. From the console, a design model of which is shown at the right, instructions and data can be keyed into the 7044 system.

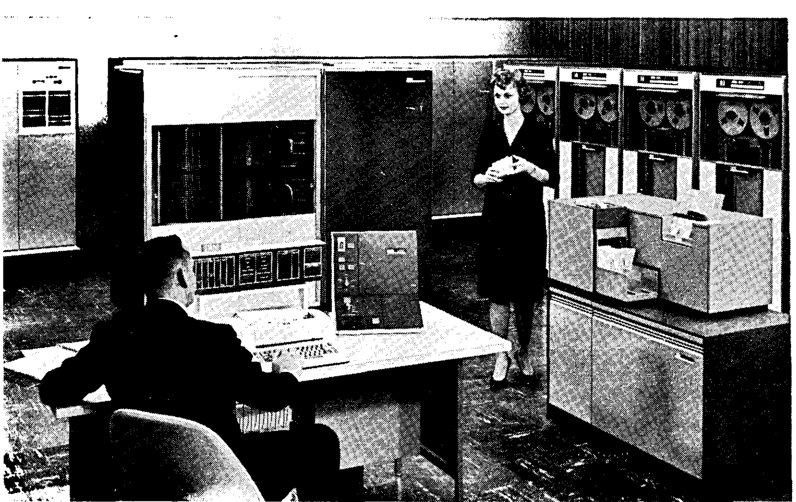
IBM 7094 SCIENTIFIC DATA PROCESSING SYSTEM

The IBM 7094 is the newest and most powerful member of this company's line of medium-to-large-scale scientific data processing systems. The operator is shown loading a magnetic tape cartridge into a Hypertape unit that enables the computer to accept and record data at speeds up to 170,000 characters a second. The 7094 has instantaneous access to up to 280 million characters of information stored on magnetic disks in IBM 1301 disk storage units (upper left).

NCR 315 BANK SYSTEM
The National Cash Register Company
Dayton 9, Ohio

Comptroller-Vice President Adolph Breiner, Jr., Meadow Brook National Bank, West Hempstead, Long Island, starts the automatic processing of special checking accounts using the NCR 315 automated banking system. The computer system is now programmed to process the bank's 130,000 demand deposit accounts. During the next two years the 315 will also handle the centralized consumer credit department with about 70,000 accounts and the centralized mortgage department with 12,500 accounts.

IBM 7010 DATA PROCESSING SYSTEM
IBM 1710 CONSOLE TYPEWRITER OUTPUT
International Business Machines Corp.
Data Processing Division
White Plains, N.Y.

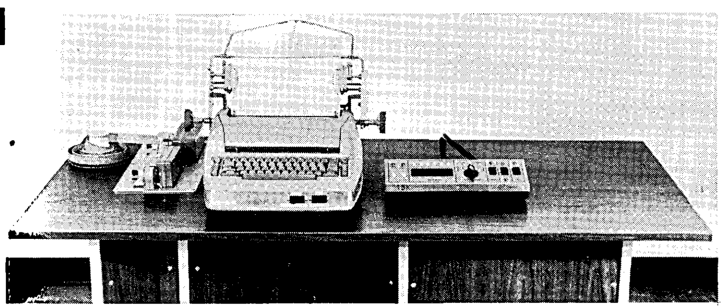


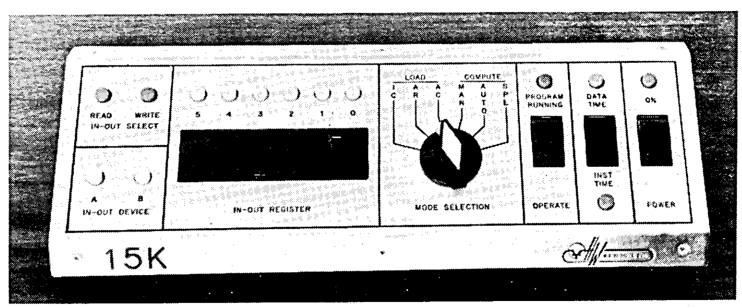
Operators are shown checking the console typewriter output of the new large-scale IBM 7010 data processing system. The IBM 1415 console Model II for operator control and communication with the entire system will print out any information contained in storage, either in full or on an exception basis. Also shown here are a new high-speed card reader, left of the operator's console, and a series of magnetic tape drive units.

The IBM 7010 data processing system provides a growth pattern for computing, combining the power of IBM's large-scale 7000 series with the data handling capabilities of the IBM 1400 series. The new computer is compatible with the IBM 1410 and has internal processing speeds up to three-and-a-half times as fast. At the right (in the lower picture) the operator prepares to place cards in the system's 1442 card reader, capable of reading 80-column punched cards at up to 400 a minute. Other units shown are, from left to right behind the console, the disk file control, a high-capacity 1301 disk file and magnetic tape drives. The 7010 system is useful in areas such as finance, brokerage, chain and wholesale, communications, education, fire and casualty insurance, life insurance, general manufacturing, government, petroleum, public utilities, retail, textiles and transportation.

BASICPAC -- MEDIUM SIZE MILITARY COMPUTER
Philco Corporation
Philadelphia 34, Pa.

This new member of the Fieldata family of data processors is designed to bring the speed and convenience of electronic computation to the army in the battlefield. All "torture" and operational acceptance tests have been completed successfully. Basicpac is essentially a medium-size, medium to high speed computer. Compactness is achieved through maximum use of semi-conductors in dense packages. Solid state circuitry is used throughout. The general purpose programming and maintenance control panel needs only minimal computer knowledge to operate. The Basicpac central processor is made up of four functional units: arithmetic, program, memory and control units. The arithmetic unit performs arithmetic operations on binary numbers in a serial-parallel mode. The program unit stores and decodes instructions, generates control signals, provides for address modification and storage and generates basic timing signals for the entire system. The memory unit provides random access to 4096 words of internal storage. High speed, coincident-current magnetic core storage is used. The control unit contains the displays and controls for operation, programming and maintenance. Colonel James M. Kimbrough Jr., commanding officer of the U.S. Army Electronics Research and Development Laboratories, Fort Monmouth, N.J., is shown with Dr. S. Dean Wanlass, vice president of Philco Corporation's Computer Division, as they "check out" the control console of Basicpac.





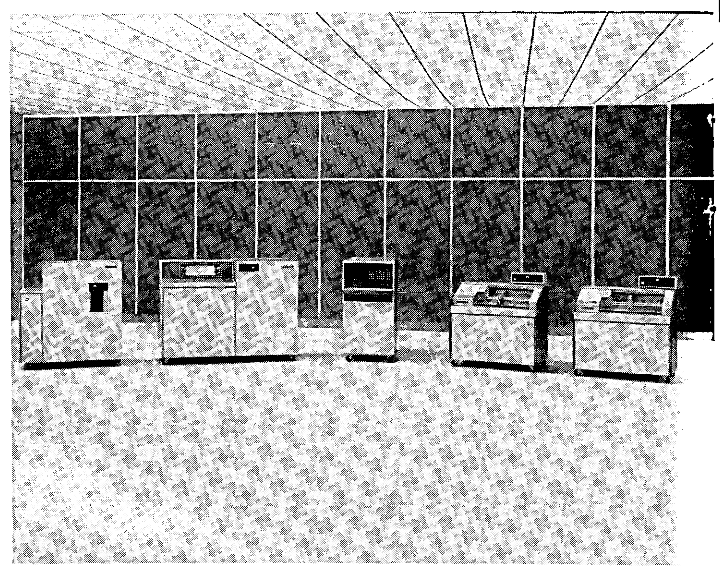
H-W MODEL 15K COMPUTER
H-W Electronics, Inc.
Natick, Mass.

Model 15K is a new low cost, portable electronic digital computer. Punched tape and typewriter are used for both input and output. The programmer enters information in the customary decimal notation and receives results in the same form. The paper tape reader and punch operate at 20 characters per second. The typewriter, a modified IBM Selectric, has an output speed of 15 characters per second. Internal processing continues while I/O devices are operating. A maximum of four input and four output devices may be connected to the standard machine. Internal storage is provided by a magnetic drum of 4096 word capacity. Twelve instructions are provided plus 12 spares for special uses. The H-W 15K computer satisfies almost all business office and engineering applications. It rents for approximately $500 per month.

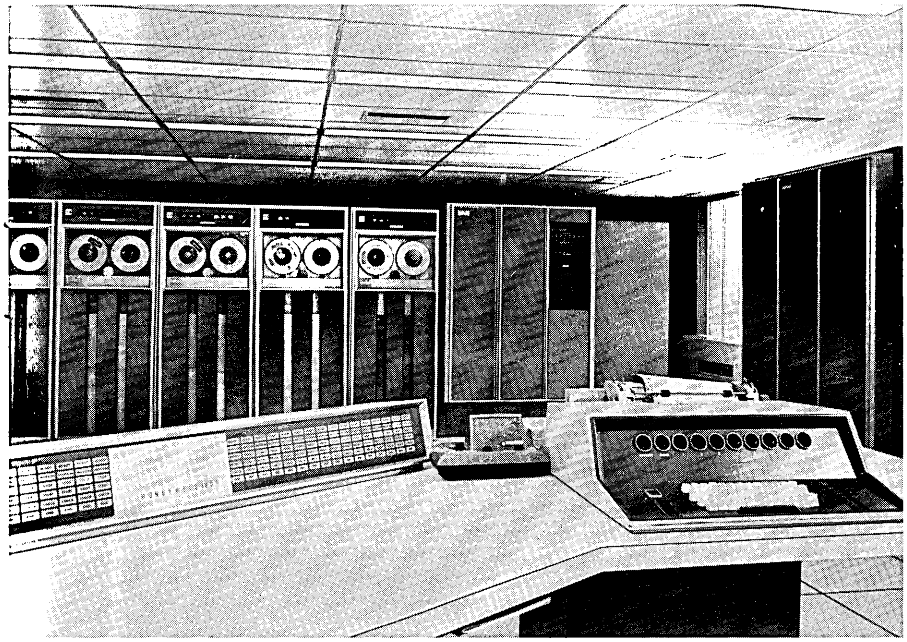
UNIVAC 1107 THIN-FILM MEMORY COMPUTER
UNIVAC Division, Sperry Rand Corp.
New York, N.Y.

The UNIVAC 1107 is the first computer to use thin magnetic film memory. Announced this summer, the solid-state data processing system has been designed to solve both complex problems off-line and real-time problems on-line. The thin magnetic film memory permits the 1107 to reach internal referencing speeds measured in nanoseconds. The system also uses a ferrite-core memory of from 16,384 to 65,536 words, depending on the requirements of the user. A versatile input/output section can accommodate a wide range of peripheral equipment. The 1107 can also communicate with many other real-time devices, such as analog-to-digital and digital-to-analog converters, printing telegraph equipment, display systems and other data processing devices. Applications for the UNIVAC 1107 include scientific computation, digital communication and switching systems, logistics and intelligence systems, traffic control, and inventory and scheduling systems.

BURROUGHS 260 PUNCHED CARD COMPUTER SYSTEM
Burroughs Corporation
Detroit 32, Mich.



The B260 is a "workhorse" machine designed to sell in the low-price range, and yet handle high volume business data processing. It can accomplish in a single run much of the collating, calculating, summarizing, summary punching, and printing which presently require multiple runs on conventional punched card equipment. A maximum system consists of a central computer, two card readers, a card punch, and a printer. The B260 receives information from punched card reading units, computes data in a solid state central processor and provides answers either in the form of punched cards or printed reports. The paper tape reader operates at speeds of either 400 or 1000 characters per second, and can handle 5, 6, 7 or 8 channel tape interchangeably. Rewind speed of the reader is 1000 characters per second. Paper tape subsystems are optional and are compatible with most data collection and transmission devices.



HONEYWELL 1800
Minneapolis-Honeywell Regulator Co.
Electronic Data Processing Division
Wellesley, Mass.

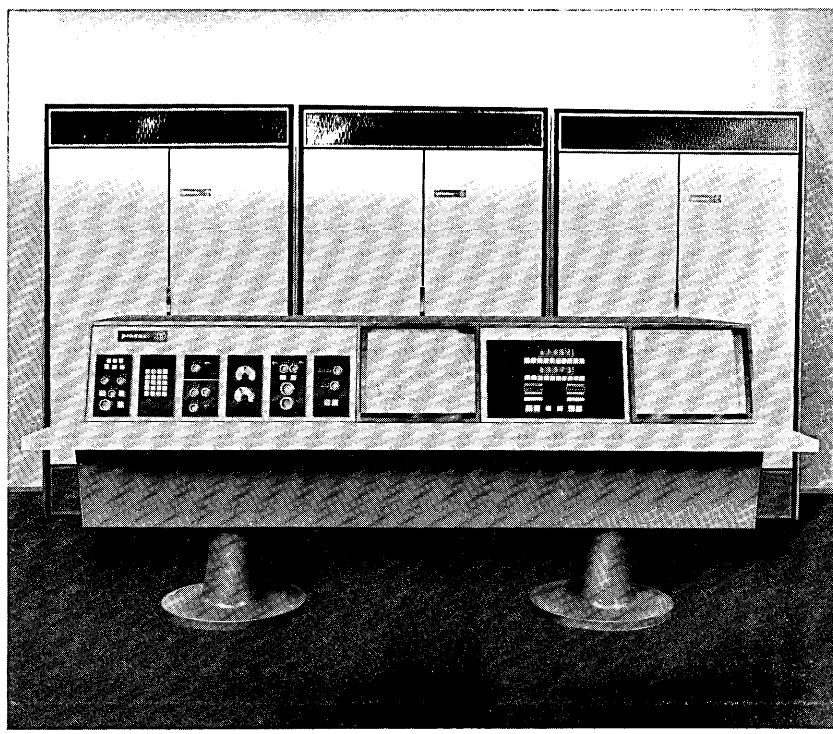
The Honeywell 1800 Series has been developed for very large business and scientific applications. It consists of a powerful central processor and a very fast arithmetic (floating-point) unit. The new central processor (Model 1801) has an internal operating speed of more than 120,000 three-address operations per second for typical arithmetic instructions, such as additions and subtractions. Memory cycle speed is 2 microseconds. The new floating-point unit (Model 1801B) will operate at nanosecond (billionth of a second) speeds when used in conjunction with the new 1801 central processor. The 1800 Series equipment is compatible with Honeywell 800 peripheral devices and automatic programming aids.

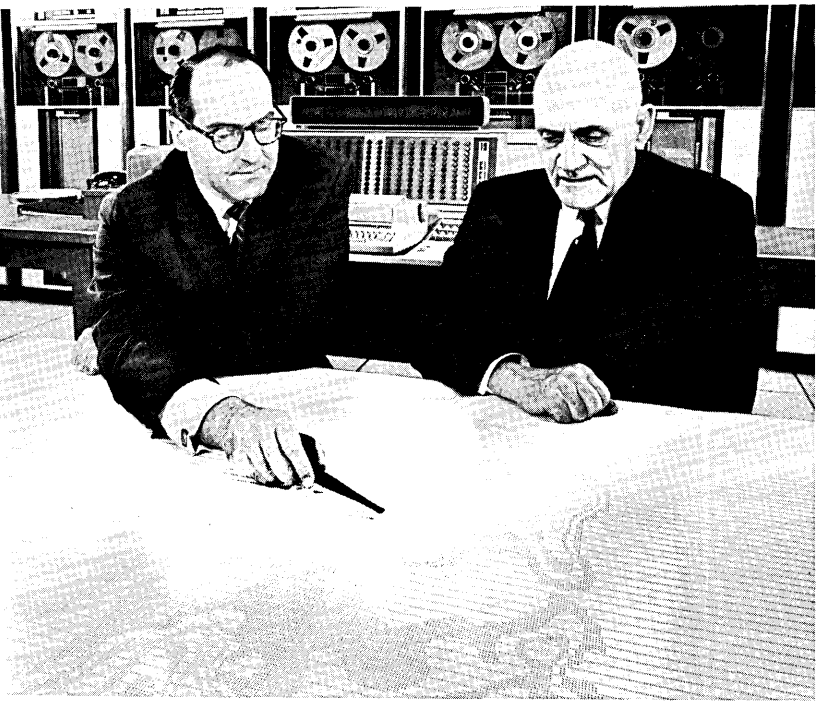
PRODAC 500 SERIES COMPUTER SYSTEM
Westinghouse Electric Corp.
Pittsburgh 30, Pa.

The PRODAC 500 Series, a new family of control computer systems, were announced under a joint design and development program between Westinghouse and the UNIVAC Division of Sperry Rand Corp. The systems incorporate UNIVAC computers as a major component. The new computer systems were specifically developed for on-line process control applications. The PRODAC 510 and PRODAC 580 were the first two systems in the new line to be introduced. Both units are essentially identical, using standardized components, a common language, and programming. Their primary difference is that the PRODAC 580 system is more flexible and has the capacity to process a much greater quantity of information concurrently.

The PRODAC 510 finds its principal application in controlling single-process systems, and in data logging, monitoring, and results computation on electric utility systems.

The PRODAC 580 is used for computer control of automatic steam plants, automatic rolling mills for the steel industry, and applications where several processes are controlled by a single computer.





FRONT COVER STORY

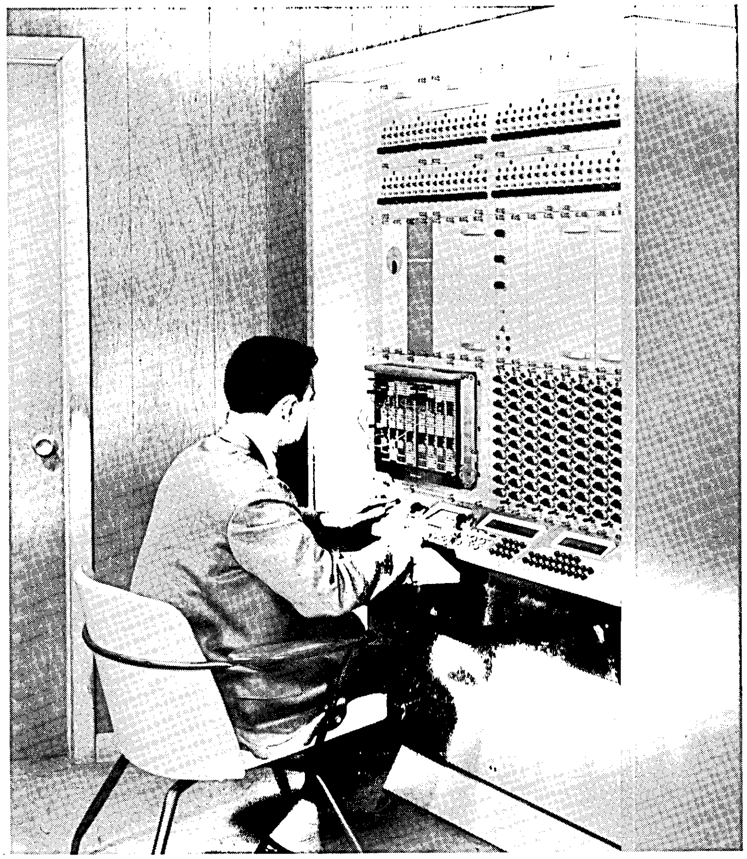
IBM STRETCH COMPUTER USED AT WEATHER BUREAU
International Business Machines Corp.
Federal Systems Division
Rockville, Md.

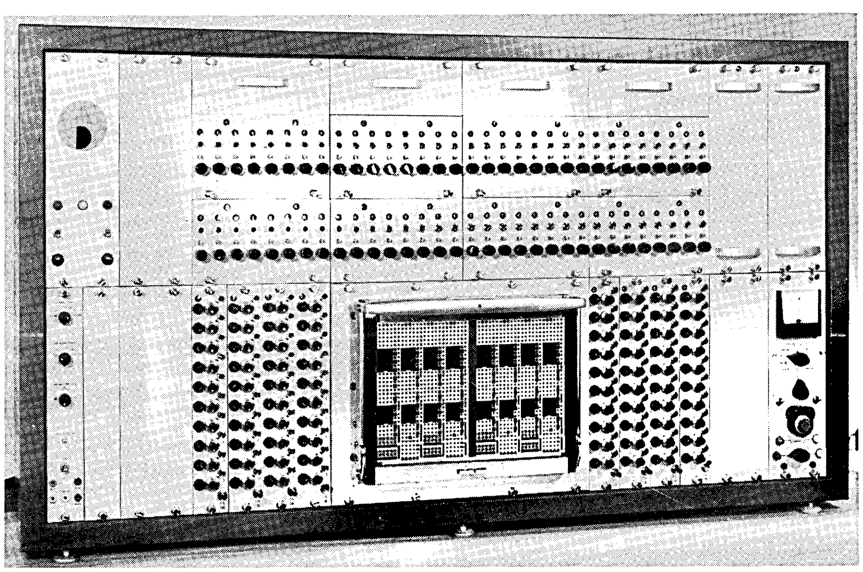
Dr. F. W. Reichelderfer (right, Chief of the U.S. Weather Bureau, and Dr. Joseph Smagorinsky, Chief of the General Circulation Research Laboratory in Washington, D.C., examine an elevation contour map of the Northern Hemisphere as printed out by the STRETCH computer built by IBM. Topographic contours are used as part of the input data needed to simulate weather processes. This simulator provides a means for controlled experimental studies of weather problems which cannot be undertaken in other types of laboratories. Weather events ranging in scale from a single thundercloud to world-wide weather will be simulated by the computer. The total program involves over 15,000 instructions to the computer in STRETCH language. The magnitude of the calculations involved can be gauged from the fact that over ten billion computer operations may be required for each single day of computed weather.

The U.S. Department of Commerce Weather Bureau uses the IBM STRETCH computer to develop and test new theories of atmospheric behavior. The computer is used by meteorologists to simulate global weather in the laboratory. The STRETCH console, at which an operator is seated, has ninety-six binary keys and switches, each of which can be programmed to perform any specific function desired. The keyboard, switches, lights, digital display and console printer all are subject to programmed interpretation and control. Magnetic tape units can be seen in the background. The Weather Bureau STRETCH system has two magnetic core storage units of 16,384 words each and four magnetic core storage units of 8192 words each -- a total core storage of 65,536 words. Instruction addresses allow a capacity of up to 262,144 words for future expansion. Since the system is organized to operate several of these storage units at the same time, a continuous flow of more than a million words a second can take place, with a peak flow rate capability of about 2.8 million words a second.

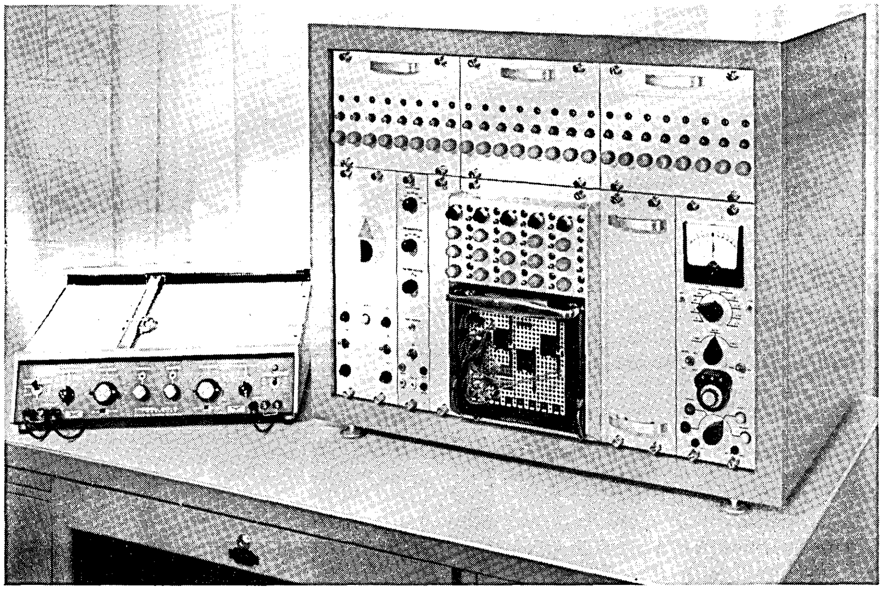
ANALOG COMPUTERS

NEW ANALOG COMPUTERS --
64 AMPLIFIERS
Applied Dynamics, Inc.
Ann Arbor, Mich.





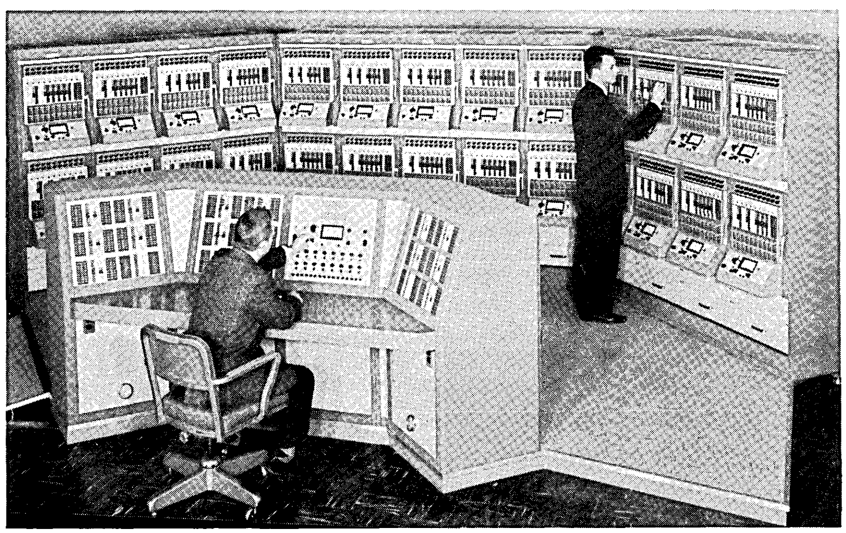
This new, 64-amplifier electronic analog computer comes in two models -- AD-2-64PB, a table top device with removable, color-coded patchboard (at left); the other, the AD-2-64PBC (above), a console model with complete pushbutton control and monitoring. The computer, in its typical, fully-expanded form, includes 64 amplifiers, 80 potentiometers, 16 multipliers, 8 generators, 80 external trunks, 6 electronic comparators, 2 DPDT electronic switches, 8 electronic track and hold units, and 10 diode networks. Real time, fast time, repetitive, and iterative operation are available. All non-linear components are solid-state. The AD-2-64PB is compatible to other computers with a ±100 volt reference.



NEW ANALOG COMPUTER -- 24 AMPLIFIERS
Applied Dynamics, Inc.
Ann Arbor, Mich.

The AD-2-24PB, a new compact 24-amplifier computer, is expected to find its major users among schools and medical institutions, where a broad range of problems must be solved, but within a restricted budget. The computer is small enough to fit on a desk top. The operator's tasks are simplified by a removable patch panel, pushbutton monitoring, and front panel access to coefficient potentiometer fuses. Modular construction permits expansion to 24-amplifier capacity and the addition of interchangeable multipliers and diode function generators, one at a time. High-speed repetitive operation can be introduced by a switch which allows selection of compute periods ranging from 1.00 to 0.025 second. The AD-2-24PB is compatible with all Applied Dynamics' and most other makes of analog computers.

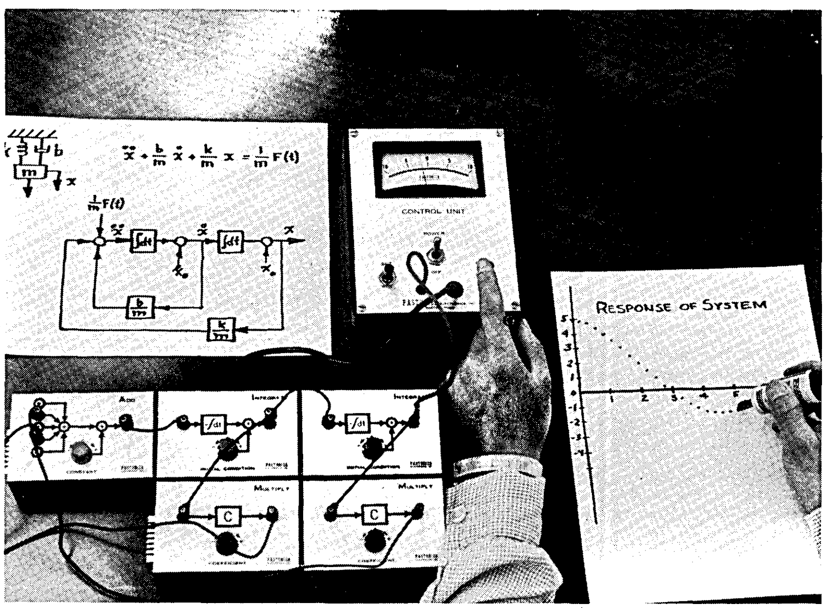
A large, transistorized analog computer system is shown undergoing final inspection and checkout at EAI. The system was built under a contract from the U.S. Signal Corps.



ANALOG COMPUTER SYSTEM FOR U.S. SIGNAL CORPS
Electronic Associates, Inc.
Long Branch, N.J.

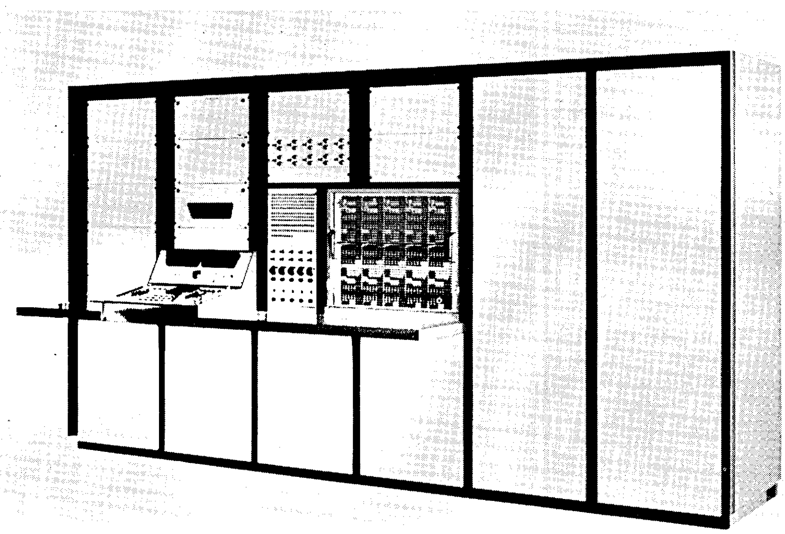
The Model NTC-18 is the second of the series of SkeduFlo computers. The computer is approximately 50 pounds in weight, including the carrying case. NTC-18 has a scheduling capacity of 18 jobs. It spots critical jobs immediately from neon lamp indicators. All relevant data can be read directly from a built-in meter. Project duration, amount of slack or float, earliest job starting times and latest job completion times, are all available for direct reading. Late-lights can be coupled into special jobs in a project to signal when any delay or change in any part of the project schedule causes these special jobs to fail to meet a pre-selected target date. Dr. John W. Mauchly (shown with the NTC-18) said, "This computer is actually an electronic representation of the modern scheduling system used by both government and industry for the control of complex projects."

NTC-18 COMPUTER IN A SUITCASE
Mauchly Associates, Inc.
Fort Washington, Pa.



PERSONAL ANALOG COMPUTER UNIT
Pastoriza Electronics, Inc.
Boston 16, Mass.

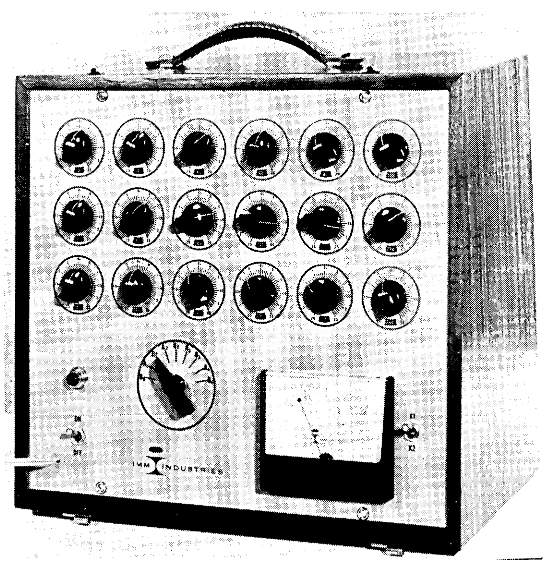
This portable analog computer has components which are a little larger than packages of king-size cigarettes. Using these computers, engineering students can solve differential equations electrically without using a computing laboratory. The self-powered sets perform mathematical operations of addition, subtraction, multiplication by a constant, and integration. Components can be assembled into groups to solve the problems commonly met in linear systems courses. Each set consists of six components: one adder, two co-efficients, two integrators and one meter control unit. The meter control device displays the answers on a numbered scale and provides control signals which freeze a solution at fixed time intervals so that numerical units can be accurately plotted by a student on his homework paper.



COMCOR CI-170 ANALOG COMPUTER
Comcor, Inc.
Denver, Colo.

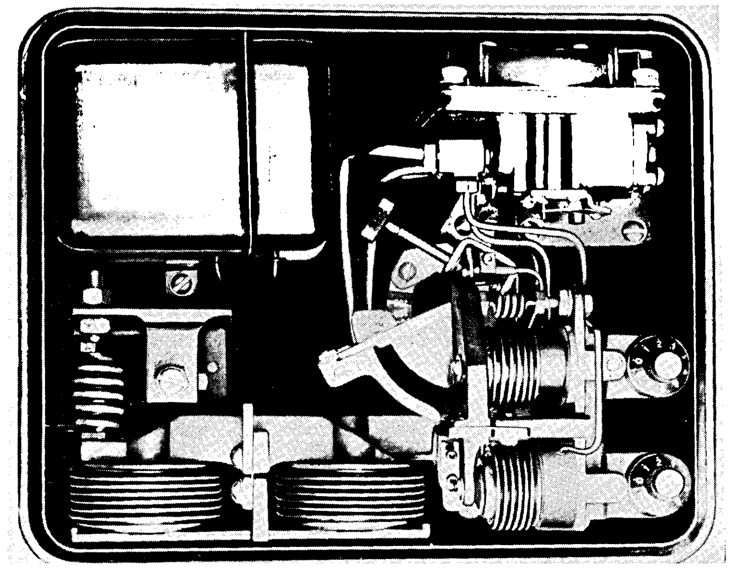
This company has introduced a new line of custom built analog computers available in a variety of configurations to fit the needs of the user. The Comcor CI-170 shown, is equipped with servo set potentiometers, servo set series type diode function generators, solid state one millivolt comparators, thirty segment .02% oven mounted quarter square multipliers, a 1000 point cross bar, the modern CI-30 Computer Control System, and high-speed repetitive operation. Input/output for the servo set equipment is executed from a high speed "Selectronic" electric typewriter equipped with a photo electric tape reader and tape punch print-out. Speeds of up to one reading per second are available with this automatic system. Faster read-out may be obtained by the addition of a high-speed printer. The machine may be controlled from most digital computers without the interface problems normally encountered with a Hybrid System.

This compact analog computer performs a Fourier analysis in three minutes. It is designed for desk-top operation and is completely portable, weighing only 19 lbs. Power requirements for the computer are 50 watts, dc to on kc. Inputs are the 18 dials, each representing an abscissa of any waveform that can be plotted. Output is the DC offset and the magnitude of the 1st, 2nd, 3rd, and 4th harmonics, read on the meter.

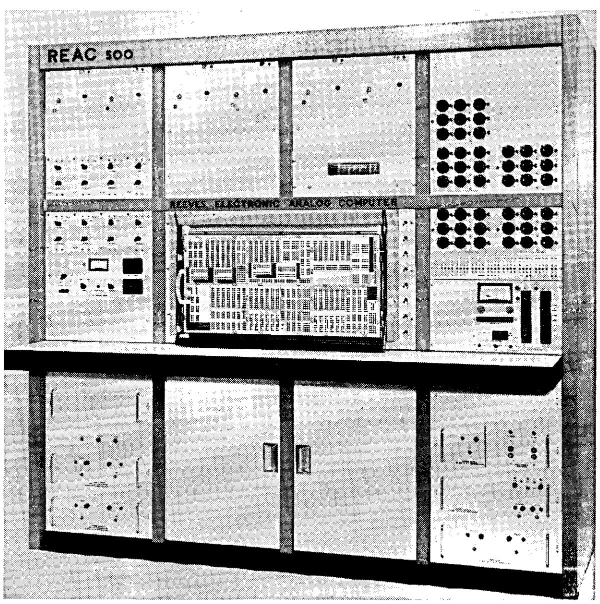


FOURIER ANALYSIS COMPUTER
IMM Industries
North Hollywood, Calif.

This pneumatic analog computer performs control functions as well as complex mathematical operations. The equipment is called the Bailey Pneumatic Analog Computer and Mini-Line® Controller. It is designed for use in pneumatic computing-control systems for flow, pressure, temperature, etc., in power and process industries. The mechanism can be installed to perform various mathematical computations and control functions. Functions performed are determined by the manner in which external connections are made.

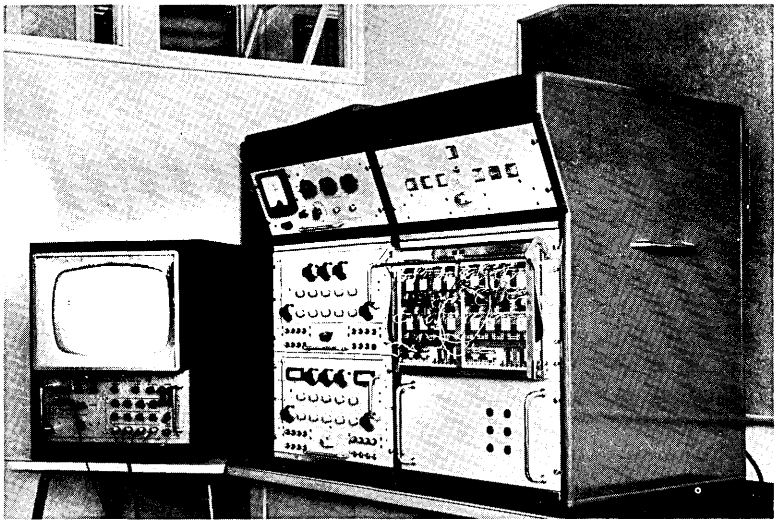


PNEUMATIC ANALOG COMPUTER AND CONTROLLER
The Bailey Meter Company
Cleveland 10, Ohio



REAC 500 ANALOG COMPUTER
Reeves Instrument Corporation
Garden City, N.Y.

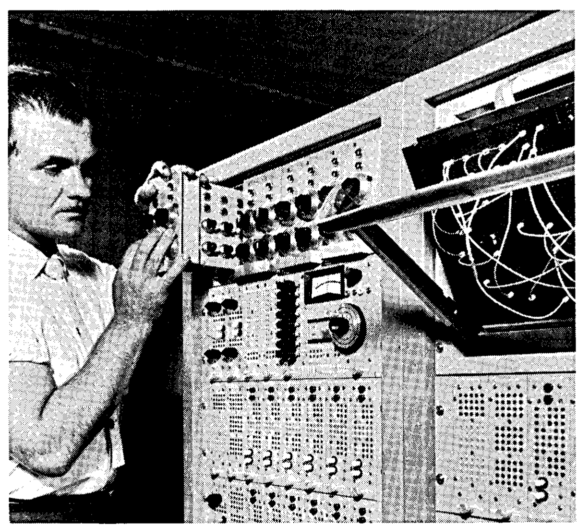
The REAC 500, latest Reeves development in the analog field, is prewired and powered to accept optional plug-in devices in order to provide maximum expansion flexibility. All necessary writing is already installed. The power supplies furnished with the standard computer can provide the additional required power. The standard REAC 500 is housed in a four-bay cabinet and includes the following computer elements: 58 operational amplifiers; 80 scale factor potentiometers; 4 power supplies; 1 reference supply; 4986 hole patchbay; control panel; component oven; and overload light panel.



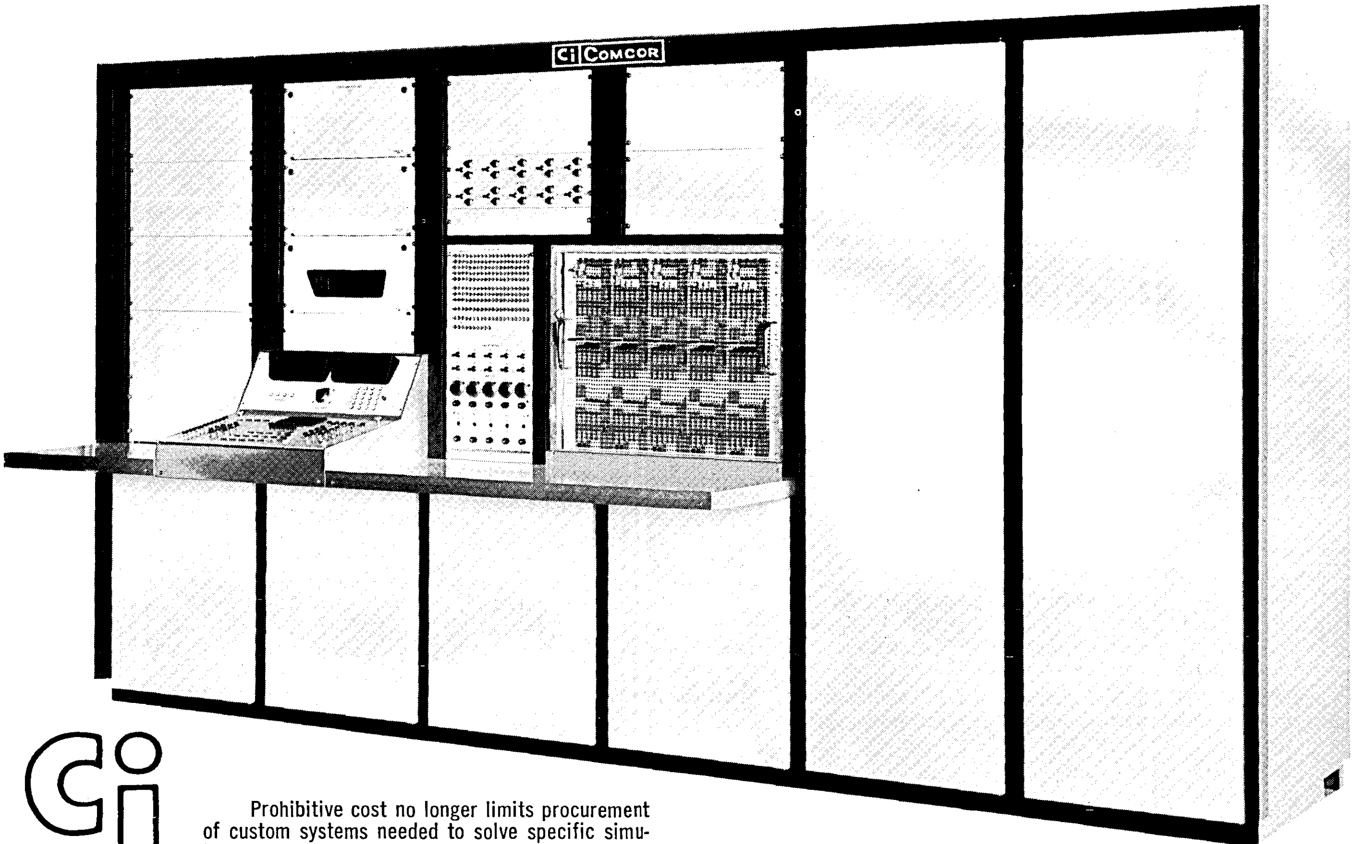
REDIFON 10/20 ANALOG COMPUTER
Redifon Limited
Computer Dept.
Crawley, Sussex, England

The Redifon 10/20 Analog Computer is designed for education and research purposes. The basic computer has 5 Twin D.C. chopper stabilized amplifiers, such as Hold, Reset and repetitive operation. A removable program board enables establishments, where more than one department uses the computer, to each have its own board and to program it prior to using the machine. All amplifiers are capable of being used as summers, integrators or to generate a non-linear function. Co-efficient potentiometers can be the 10-turn helical type or single wire-wound, or suitable combinations of both. The computer is fully wired for expansion.

This low-cost Donner 3200 has 0.01% computing components, broadband, stable amplifiers, and an ample supply of non-linear equipment and accessories. The 3200 has anywhere from 10 to 100 amplifiers, according to need. Expansion is accomplished by plugging in additional computing modules.



DONNER 3200 ANALOG COMPUTER
Systron-Donner Corp.
Donner Division
Concord, Calif.

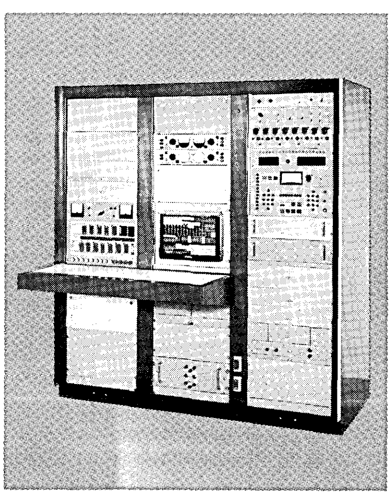


Prohibitive cost no longer limits procurement of custom systems needed to solve specific simulation problems. For now Comcor of Denver delivers custom machines—built to individual specification—at lower cost than ever before possible.

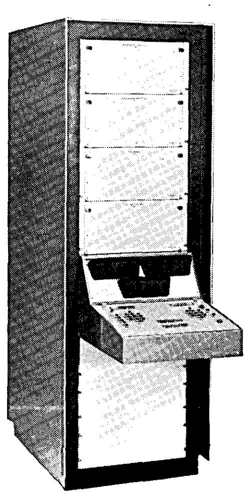
Along with economy you get performance. Comcor state-of-the-art components and concepts have introduced degrees of speed, operator convenience, reliability and accuracy unchallenged by any other computer system.

CI-170 offers high-speed repetitive and iterative operation, and is compatible with most digital computers, eliminating the interface problems normally encountered in a Hybrid System. State-of-the-art components include solid state comparators, a 1000 point cross bar, and .02% oven mounted quarter square multipliers and sin-cos generators.

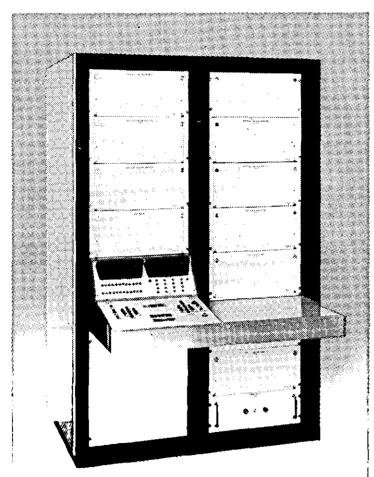
Custom Computers by Comcor



CI-171 Test Console affords functional diagnostic test capabilities for all analog components. Features include cross bar address system, temperature controlled oven, primary resistor and capacitor standards, AC and DC load device, and advanced cable well design. Configurations for all commercially available analog computer components can be incorporated in the CI-171



CI-70 Precision Potentiometer Positioning System provides fully automatic tape or card set-up for coefficient potentiometers, diode function generators and UNE's. Programming time is reduced by a factor of 5. Potentiometers are set in less than 2 seconds each, with error no more than 10 millivolts. Other features are automatic scan, automatic check-out, and automatic error indication.



Tape Set Diode Function Generator System. Comcor Servo Set DFG's are available at a cost comparable to that of hand-set units. The new CI-225 Series Type DFG boasts specifications superior to any commercially available function generator.

COMCOR INC.

430 SO. NAVAJO ST., DENVER 23, COLORADO • PHONE 777-3066, AREA CODE 303 • TWX 303-292-2936

Computing and Data Processing Newsletter

"Across the Editor's Desk"

NEW APPLICATIONS

STRAIGHT COMPUTER PREDICTION IN 19 ELECTION RACES

On election night, November 6, 1962, three teams of computer companies and broadcasting companies reported and made predictions: National Broadcasting Co. and RCA using the RCA 501 computer; Columbia Broadcasting System and IBM Corp. using IBM computers; and the newest team, American Broadcasting Co. and Honeywell EDP, using a Honeywell 400 and a Honeywell 800.

How did the newcomers do in the computerized election estimating?

The ABC-Honeywell team watched 53 key contests, tabulated 60 million votes, and made detailed predictions in 19 races for senator and governor. In the 19 races, the program, computer, and human beings made 16 correct predictions. Of the remaining three races: in one race the computer made an incorrect prediction at 10:52 pm, but later corrected itself as a result of its own program and made a correct prediction at 12:47 am. In a second race (for governor of Massachusetts), the computer "refused to predict" but the human beings chose "Volpe"; at present writing, this race is still being recounted. In the last case (for senator in Indiana), the computer made an incorrect prediction. See Table 1 on page 45. So it can be maintained that the computer (with its program) was right (or became right) in 18 out of the 19 races watched.

In making its predictions, the computer was given a new set of formulas for dealing with voting returns as they were sent in from 1350 reporting districts throughout the nation.

A master formula based on differences and weights compared incoming returns with prior returns from past races that had been previously stored in the computer. In addition, 17 special formulas controlled by the master formula were developed to analyze returns from certain reporting units with unusual and significant voting "habits". The formulas did not make use of samples of the effects of issues such as the Cuban issue or the segregation issue, etc.

The formulas took into account a comparison between historical election trends and current trends. A "plus offset" indicated a particular candidate was running ahead of historical trends; a "minus offset" showed he was lagging behind historical trends. From this information, the computer was able to make forecasting adjustments for each race early on Election Night on the basis of a small percentage of precinct reports.

Suppose that a voting unit in a selected historical race had produced a total of 3000 votes with, say, 55% Republican. Suppose that at the moment of making a prediction on Election Night, the current reported vote was 500, with 50% Republican. Then the formula would adopt a percent intermediate between 50% and 55%, as determined by weights and varying with the relation of 500 to 3000; as more votes were reported, the weights would change to favor the current percent more and more, until close to the end of the voting the weight of the past percent was reduced to zero.

If some reporting units in a state had not been heard from at all, the data from other reporting units in the same state which had been heard from, would be used as a basis for estimating.

The formulas were worked out by Mr. Richard M. Bloch, Asst. Vice Pres. of Honeywell EDP, and Dr. Reinhold Sell. The program contained about 1000 three-address instructions.

Vote tallying techniques were particularly designed to increase tabulating speed and accuracy. ABC used 3,000 persons at report centers around the nation, and Honeywell had 121 persons working on the vote tallying and reporting. Returns were collected from precincts on a county-by-county basis from each of three reporting sources — ABC News, Associated Press, and United Press International -- and sent to 16 report centers in 12 states.

The data was then transferred onto punched paper tape in a format acceptable to the computer and sent to the New York election headquarters of ABC; there it was fed directly into the computer, which automatically selected the most current return from the three sources. The computer read the paper tape at the rate of 24,000 words per minute. The use of paper tape of special format eliminated putting returns on punch cards for computer processing.

Automatic checks by the computers on paper tape input, the numerical range of reported returns, the total vote in each county, and the total vote in each state were also made to help obtain accurate reporting and predicting. In addition, corrective procedures for erroneous input were incorporated in the computer's programming.

The larger computer ran three different programs simultaneously throughout election night. Two programs controlled the input of data from paper tape into the computer for processing, while a third program tallied votes, analyzed returns using the formulas, and controlled the printing of prediction information for the 19 races.

Table 1 shows the detailed report of races, predictions, and score.

TABLE 1

Race	State	Contest	Time of Prediction	Computer Predicts That	Will Be Elected By....%	Final Actual Percent	(1 for "right" 0 for "wrong") Score
1	Ky.	Sen.	6:56 pm	Morton	53	52.4	1
2	N.Y.	Gov.	8:19 "	Rockefeller	sweep	54.3	1
3	N.Y.	Sen.	10:02 "	Javits	52	58.8	1
4	Mich.	Gov.	11:09 "	Romney	51.1	51.4	1
5	Ohio	Sen.	9:16 "	Lausche	over 55	61.4	1
6	Ohio	Gov.	9:17 "	Rhodes	53	58	1
7	Calif.	Gov.	3:00 am	Brown	will be close	53.6	1
8	Ill.	Sen.	10:15 pm	Dirksen	51.9	52.4	1
9	Wis.	Sen.	10:52 "	Wiley	between 50 and 51	47.8	½
	Wis.	Sen.	12:47 am	Nelson	51	52.2	
10	Conn.	Sen.	7:56 pm	Ribicoff	55	51.3	1
11	Conn.	Gov.	7:56 "	Dempsey	55	53.2	1
12	Pa.	Sen.	10:06 "	Clark	52	51.3	1
13	Pa.	Gov.	10:06 "	Scranton	53	55.5	1
14	Calif.	Sen.	12:56 am	Kuchel	will be re-elected	55.4	1
15	Mass.	Sen.	9:18 pm	Edward M. Kennedy	will be elected	55.6	1
16	Mass.	Gov.	10:52 "	in the Volpe-Peabody race	(1) refused to predict; (2) human beings said "Volpe"	Being recounted	½
17	Ind.	Sen.	7:43 "	Capehart	53	49.7	0
18	Minn.	Gov.	1:50 am	Rolvaag	51.5	50.1	1
19	Wis.	Gov.	2:28 "	Reynolds	50.8	50.5	1

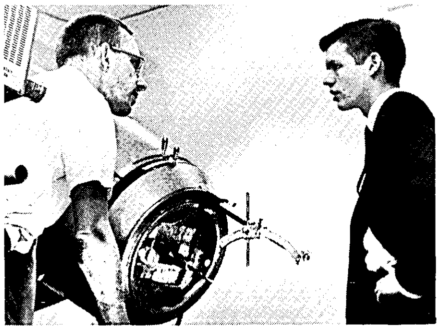
NEW COMPUTER TECHNIQUES RANGE FROM CRIME SOLUTION TO PLANNING RADIATION THERAPY

New computer techniques under development to expand the problem-solving capabilities of data processing equipment cover a wide range of human activities. IBM recently held a Symposium at which more than 100 reports outlined new directions in computing science. The advanced computer techniques include methods of matching criminals with unsolved crimes, helping select college students for enrollment, controlling water resources and planning radiation treatment.

In the field of medicine, data processing equipment already is used for such purposes as simulating disease patterns and handling statistical research. At the University of Cincinnati College of Medicine, a program has been developed which uses a computer system to handle the data involved in bombarding a tumor with radiation. The problem is to direct precise amounts of radiation at the tumor from several directions, in order to destroy the tumor without damaging surrounding tissues.

A therapist decides on a treatment plan. Information about the plan is fed into the computer; then the output data is analyzed to determine whether the plan is suitable. If not, he can use the computer to manipulate factors in order to improve the treatment.

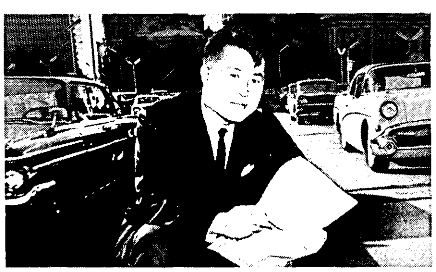
U.S. Navy doctors in Pensacola, Fla. are using a computer to determine a student's chances for completing the Navy's arduous 18-month pilot training program.



-- A Cobalt 60 unit, used to bombard tumors with radiation, is being studied by James J. Weinkam (right), IBM systems engineering, Cincinnati, and Dr. Hamilton Boone of the Cincinnati General Hospital. The closed-circuit TV camera (far-left) is used to observe patients during treatment.

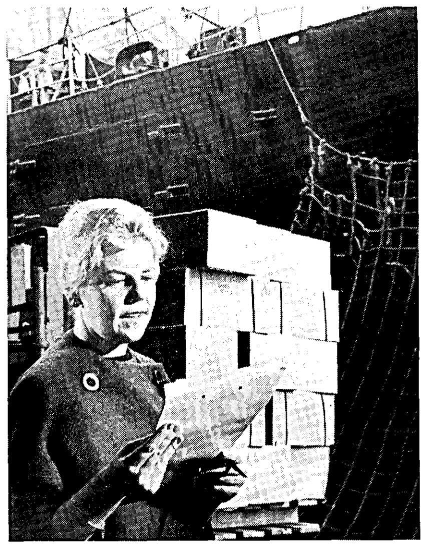
Dr. Hans H. Zinsser of New York City's Columbia Presbyterian Medical Center, using an IBM 7090 computer to analyze and relate 800 different symptoms and factors for each of 350 patients ill with pyelonephritis, has discovered the disease is actually four separate diseases responsible for five percent of all deaths in this country today.

In local government, a computer technique which would help untangle city traffic jams involves mathematical simulation of traffic on a large network of streets. The computer system would evaluate the merit of adjusting the timing of signal lights or making other changes to speed the flow of traffic. If timing changes are warranted, they would be sent directly to the traffic light by the computer system.



-- Traffic patterns, on an approach to the Brooklyn Bridge, are being studied by S. Y. Rhee, a member of IBM's systems engineering staff in New York. Mr. Rhee has developed a computer technique to help speed traffic through city arteries.

California's Bureau of Criminal Identification and Investigation and IBM are making preliminary tests of a technique of establishing and correlating criminal patterns with an electronic computer. The purpose is threefold: to match crime patterns against patterns of known criminals in order to establish a list of suspects; to develop a series of crimes which may have been committed by an individual arrested for one offense; and to develop a list of unsolved crimes which appear to have been committed by the same unknown criminal.



-- Women, as well as men, are part of IBM's systems engineering force. Pat McGoldrick, manager of the systems engineering staff at IBM's Brooklyn branch office, scans cargo manifests at the U.S. Army's Transportation Terminal in Brooklyn, N.Y. A large-scale computer system, designed with the technical assistance of her staff, prepares the paper work for shipping freight to Army units in Europe, Greenland and other Atlantic posts.

The use of computers in engineering, in agriculture and in industry were among the reports outlined. The systems engineers are bridging the gap between new computer theories and new computer uses.

UNION DIME GOES "ON-LINE"

New York's first "on-line" electronic system for depositors' accounts was inaugurated at Union Dime Savings Bank. Instantaneous access to the memory and calculating ability of an electronic computer has been put at the fingertips of all tellers at the bank's main office and branches. The system can handle 5 and 6-digit numbers at the rate of 5000 additions per second. Tellers can process and record each deposit and withdrawal in less than one second for any of the bank's 160,000 accounts.

-- Warner D. Orvis makes the first deposit inaugurating the Teleregister TELEFILE system at the Union Dime Savings Bank, New York. The touch of a button by the teller instantaneously records the deposit which Mr. Orvis is making on an account his grandfather opened prior to the Civil War. The account was opened by Joseph U. Orvis on May 18, 1859, the bank's first day of business, and has been handed down through the family to Warner D. Orvis.

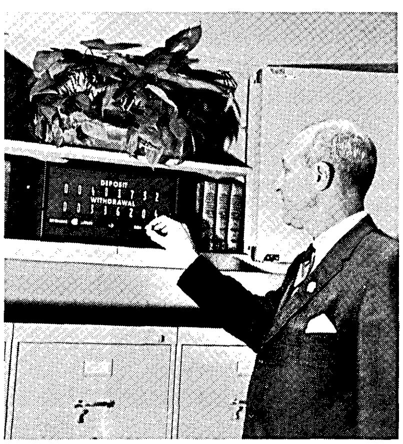
The new system was designed and produced by The Teleregister Corporation, Stamford, Conn. The major parts of equipment are twin solid-state computers, five magnetic data storage drums, four magnetic tape handlers, and 31 teller machines. In addition, there is automatic electronic communications gear which directs the flow of data traffic between the teller stations and the computers.

A customer's passbook is inserted into any of the system's window machines. The account number, amount of transaction, and necessary instructions are recorded by pressing buttons. New deposits or withdrawals are registered simultaneously on the passbook, the proof tape and the computer's records. The flow of all deposits and withdrawals is constantly computed and is available at all times.

The TELEFILE system eliminates ledger cards, manual posting, and bulky reference files (magnetic drums are used to retain account balances and a record of the current day's business, while a permanent record of all transactions is printed out). The system will process interest calculation and management reports, and may process mortgage accounting and billing, as well as handling deposit and withdrawal transactions.

-- Walter R. Williams, Jr., president of Union Dime Savings Bank, New York (right), with Walter A. Harlow, assistant controller, and the operator at the console in the TELEFILE Computer Room at the bank. The console controls the processing of all transactions made at all tellers' windows at the bank's main office and branches.

Two other savings banks in the East are also "on-line"; the Howard Savings Institute of Newark, N.J. and the Society for Savings in Hartford, Conn. Three more banks in New York are planning to have on-line systems.



-- Walter R. Williams, Jr., president of Union Dime Savings Bank, operates the Executive Monitor of TELEFILE. This device instantaneously indicates for the entire bank system up-to-the-second computation of the day's deposits and withdrawals as adjusted by each transaction.

GIANT DIRECTION FINDER AND G-20 TO STUDY THE IONOSPHERE

The University of Illinois' giant Wullenweber radio direction finder is to be teamed with the Bendix G-20 high speed computer for a major research program to study the ionosphere, the major medium of long-distance radio communications. Data will be digested by the Bendix G-20, which has ten times the memory capacity and computation speed of the famed, 14-year-old, U. of Ill. "Iliac".

Additional research sites have been established at Lubbock, Texas, where a high-frequency transmitting station is located, and at Ottawa, Canada, site of a receiving station. Signals beamed from Texas and reflected to Canada by the ionosphere approximately over the Illinois campus will provide information from straight over the direction finder, while it notes signals from stations in other directions. (The direction finder, accurate to within one-quarter of a degree, has previously noted such unusual effects as signals from Washington, D.C., arriving from the north instead of the east. Such vagaries may reveal information about the ionosphere just as reflected light may reveal information about an irregular mirror.) Data at the three points will be automatically recorded and synchronized within 1/10,000ths of a second for analysis by the G-20 computer.

The project, financed by the U.S. Office of Naval Research and the Navy's Bureau of Ships, is being carried out by the university's electrical engineering department. The U.S. Air Force is also supporting part of the program.

THE TELSTAR-COMPUTER DATA HONEYMOON

Telstar, AT&T's experimental communications satellite, is becoming a very popular figure in the computer field.

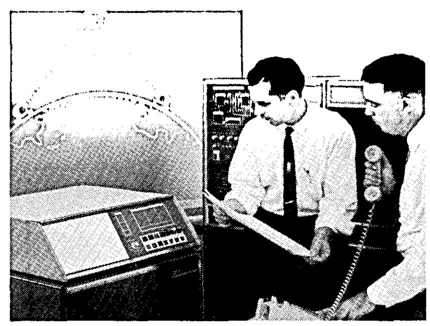
At least nine computer manufacturers to date have tested the feasibility of data transmission and collection between electronic computers in remote locations via the orbiting space satellite.

On Oct. 11, Burroughs Corp. and Honeywell EDP shared the honor of being the first computer makers to attempt to transmit computer data into outer space and back (see cover story of Nov. C&A). However, unexpected transmission difficulties at the Telstar microwave transmitter in Maine allowed only very limited success on that first attempt.

By the end of October, though, Telstar had received, amplified, and faithfully retransmitted computer data from Control Data Corp.'s 160-A computer, GE's 225, NCR's 315, Univac's 490, Tally Register's Mark 51, and IBM's 1401.

Most of the Telstar computer data transmissions have been between locations in the United States -- for example, Univac transmitted data between New York and St. Paul, Minn., while GE flashed computer input between Phoenix, Ariz. and Schenectady, N.Y.

IBM achieved intercontinental computer communication. In a 17-minute test, coded digital data was sent at a speed of 2,000 bits of information per second (equivalent to about 3,300 English words per minute) from an IBM 1401 data processing system at the IBM product development laboratory in Endicott, N.Y. to a 1401 at the IBM World Trade Corporation development engineering laboratory at La Gaude, near Nice, France. The data was transmitted directly from one computer memory to the other and back again.



-- Chester Siminitz and C. Fred Woidt of the IBM Laboratory in Endicott, N.Y. sent messages directly from this IBM 1401 computer to an identical computer in Nice, France, via the American Telephone and Telegraph Company's Telstar satellite. The engineers are shown monitoring the IBM 1009 data transmission unit, which converts BCD signals from the computer into a special transmission code.

These Telstar tests have convinced many people that satellite communication is a highly reliable means for achieving both low-speed and high-speed inter-continental transmission of computer data. The trials so far have demonstrated the reliability and compatibility between satellite media and computer data transmission requirements.

NEW INSTALLATIONS

FORD MOTOR COMPANY INSTALLING PHILCO 211

A Philco 211 computer system is being installed this month at Ford Motor Company. About 20 major applications are planned eventually for the computer, which will be located in the Rouge office building, Dearborn, Mich.

The central processor will have a 1.5 microsecond magnetic core memory, a memory capacity of 32,768 forty-eight-bit words, plus index register and floating point arithmetic capability, 16 magnetic tapes on line, and two universal controller systems, each with two tape units and one card reader, one card punch and one high-speed printer.

Orientation of key Ford personnel in the new system, and training of programmers and operators has already been started. Programmers from most Ford divisions will be trained by the end of the year.

THE COOPER UNION INSTALLS IBM 1620

The nation's oldest private, tuition-free college, The Cooper Union, Cooper Square, N.Y., has installed an IBM 1620 electronic data processing system, primarily for student and faculty use in its School of Engineering. The 1620 will be used in conjunction with existing engineering courses to solve problems such as analysis of complex structures, statistical analysis of experimental data, and the solution of mathematical equations by numerical analysis. It will also be used by faculty members in scientific research.

U. S. NAVY INSTALLS G-E 225

The U. S. Navy has installed a G-E 225 computer at the Naval Avionics Facility, Indianapolis, Indiana (NAFI), to speed the design of new electronic hardware for aircraft and missile weapon systems. The major function of the computer system is to provide mathematical solutions to new equipment requirements which NAFI engineering teams can translate into weapon systems hardware. NAFI's mission is to bridge the gap between the inception of a new electronic requirement by the Bureau of Naval Weapons and its full scale production by an industrial contractor.

CDC DELIVERS 8000 CONTROL SYSTEM TO TACOMA, WASHINGTON

An all-transistorized (solid-state) Control Data 8000 is being installed as part of an automatic hydroelectric project designed for unmanned operation under direction of the Department of Public Utilities, Tacoma, Wash.

The central control, or dispatch unit, will be installed in Tacoma, while remote control equipment will be located at the Mayfield Dam, 70 miles south of the city. The remote equipment will furnish control and indication for about 60 devices at the dam's powerhouse and switchyard. The remote control equipment will be linked to the Tacoma Dispatch headquarters by high-speed microwave that will transmit commands to the system at the dam and in turn receive digital information from the remote equipment.

Control Data Corporation is also installing its new solid-state TM-17 telemetering system which will continuously show how much power is being produced at a given time from the Mayfield Dam.

NASA ACQUIRING UNIVAC 1107 THIN-FILM MEMORY SYSTEM

The National Aeronautics and Space Administration (NASA) is acquiring a UNIVAC 1107 Thin-Film Memory System for use at the Goddard Space Flight Center at Greenbelt, Maryland. The new electronic computing system will be used to process telemetered data from satellites at millionths-of-a-second speeds.

Present plans are to have the system operational by February. The system will be operating 24 hours a day, 6 days a week.

The UNIVAC 1107, a "third generation" computing system uses high-speed thin-film control memory. The system combines logical organization, concurrent operational facilities, large core memory capacity, and a multiple interrupt provision.

SECOND MASS MEMORY DEVICE DELIVERED TO AERONUTRONIC DIVISION

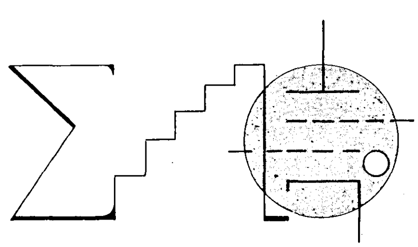
The second mass memory device for the MOBIDIC-B (Mobile Digital Computer) has been delivered to Ford Motor Company's Aeronutronic Division of Newport Beach, Calif. The memory was developed by Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corp., Waltham, Mass.

This second mass memory device will be used in connection with the Operations Central (AN/MSQ-19) electronic command post being developed by Aeronutronic. When coupled with the memory already in use, this second unit will give the MOBIDIC-B system a mass memory of more than 16.6 million words for use in its role as "program controller" for the command post. MOBIDIC is the data processing core of the command post system. It receives information from the battlefield and headquarters sources, processes the information and prepares it for visual presentation on maps and display boards.

AMERICAN GREETINGS CORPORATION TO INSTALL UNIVAC STEP 90

One of the largest greeting card suppliers in the country, the American Greetings Corp., Cleveland, Ohio, is installing a Univac Step 90 Computing System. The STEP (Simple Transition to Electronic Processing) system will enable the company to economically expand its computing capabilities in the future.

In addition to balancing and preparing accounts receivable statements, and issuing credit memos, the new system will be used throughout the year for regular sales analyses (by account and district). The Univac Solid-State STEP will also be used for planning and scheduling of production as well as processing a portion of the customer invoicing for seasonal greeting cards.



NEW FIRMS, DIVISIONS, AND MERGERS

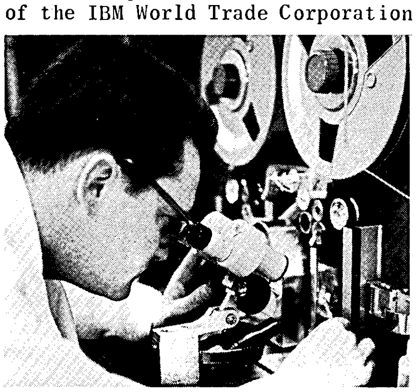
COMPUTER SCIENCES MOVES — ADDS SERVICE BUREAU, UNIVAC 1107

Computer Sciences Corporation has moved its corporate offices into the new Aerospace Center Building at the Los Angeles International Airport. CSC occupies the first three floors of the eight-story building. The new offices also house the first Univac 1107 computer to be delivered. The 1107 marks CSC's entry into commercial service bureau operations. The new CSC Service Bureau chief is Dan Mason, who has an extensive background in general purpose computer and service bureau operations.

Computer Sciences president, Fletcher Jones, also announced the opening of CSC offices in Houston, Texas, to serve the Midwest and South.

TAPE TESTING CENTER FOR 19 EASTERN STATES

The Supplies Division of International Business Machines Corporation, Poughkeepsie, N.Y. has established a magnetic tape testing center that will serve data processing systems users in 19 eastern states. The new center is the third to be established by IBM -- one, located in Minneapolis, serves the midwest and western areas, and the other, located in London, England, serves customers of the IBM World Trade Corporation.



-- Inspector at new IBM magnetic tape testing center uses scalpel to remove minute speck from magnetic tape. Dust-free jackets are worn during testing procedure.

In addition to testing reels of MYLAR® and Heavy Duty Tape, the center will offer IBM customers throughout the eastern third of the United States a retesting service for used IBM magnetic tape. At least a dozen tests -- including those for wear, noise, density and magnetic characteristics -- will be conducted at the center. If a defect found during these tests cannot be removed, the entire reel of tape on which the defect is found will be rejected.

COMPUTER CONSULTING SERVICES AND SOFTWARE PACKAGES PROVIDED BY NEW FIRM

The formation of Comress Inc. has been announced jointly by Thomas P. Reath, Pres. of Shieldtron, Inc., and Donald J. Herman, Pres. of Comress. The new Washington firm will provide computer consulting services and software packages for computer users in government and industry. The company's name is an acronym of COMputer REsearch, Systems and Software.

A computer software package has been announced, by the firm, which can be used to assist in the selection and evaluation of electronic computers and systems applications. The program known as SCERT, (Systems and Computers Evaluation and Review Technique) has been designed to include advanced decision theory techniques into the solution of the problem of computer hardware and systems evaluation. In simulating the performance of one medium-sized computer for a typical application, containing 100 computer program runs, the SCERT process will make approximately 5,775,000 calculations and decisions -- accomplishing in a few hours of computer time that which would normally take a committee several months to complete and evaluate, according to Comress.

AUERBACH ADDING COMMERCIAL EDP GROUP

Auerbach Corp., Philadelphia, Pa., has established a business information systems group to provide both technical and management services in electronic data processing for accounting and manufacturing operations. The firm has done similar work in the past for both military and business organizations, but it has been primarily devoted to providing engineering services. The new group will specialize in business applications, adding management services to the technical aspects of EDP installation.

Services will fall into three basic application areas: new systems development, current systems evaluation and conversion; and advanced systems development.

Norman Statland has been promoted from the technical to the managerial staff and will become manager of the new group.

ANELEX CORPORATION HAS NEW DIVISION

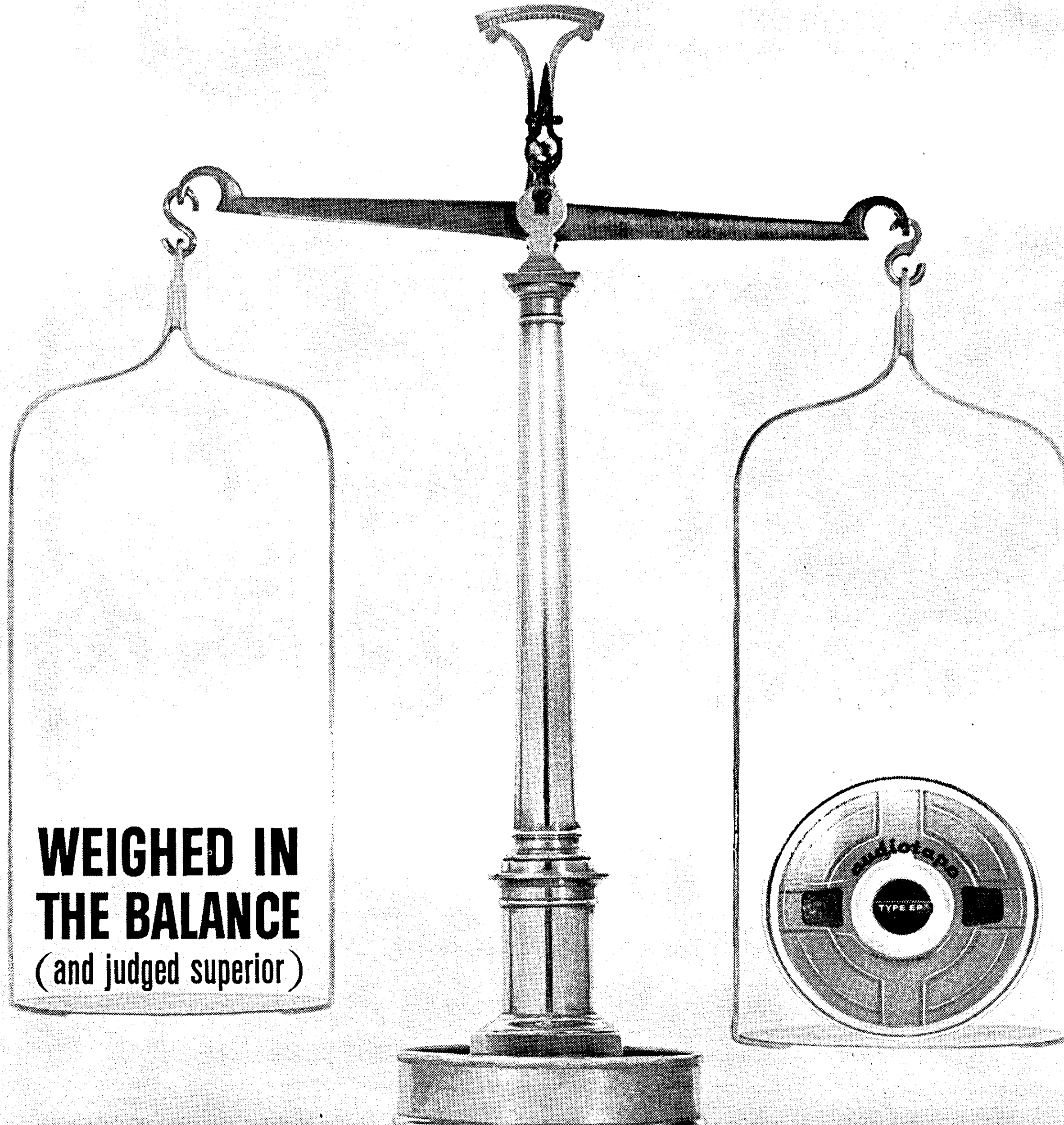
Anelex Corporation, Boston, Mass., has established a new division, the Anelex Mid West Division in Minneapolis, Minn. The initial emphasis of the new division will be on research and development. Headquarters of the new division are at 3405 48th Ave. North, Minneapolis.

Division Manager is Byron D. Smith, formerly Vice President and General Manager of Telex Inc., Data Systems Division, and Vice President, Midwest Technical Development Corp. Other members of the Division's engineering and scientific staff are: Morgan R. Walker, Robert R. Reisinger, Eugene G. Domich and A. B. Olson.

SUBSIDIARY FORMED TO PRODUCE A GENERAL PURPOSE ROBOT

Pullman, Inc., Chicago based, diversified heavy equipment and industrial engineering concern, has formed a subsidiary to produce a general purpose robot to do unpleasant jobs. The subsidiary is called Unimation, Inc.

The robot is four and a half feet high, five feet long and four feet wide. It weighs 2700 pounds and performs with a single three-and-a-half-feet long tubular arm with a two-prong clutching device at the end. Within the machine is a magnetic drum on which 200 bits of information can be stored. This electronic device can cause the metal arm to move from side to side, up and down, through a preset series of motions up to 200 in number. Its developers believe this robot could be used to take over repetitive, heavy or disagreeable chores. Only three of the machines have been built thus far.



The many customers who regularly use EP Computer Audiotape already know the secret of its popularity. But perhaps you don't. Simply stated it's this: making an extra precision computer tape requires extra manufacturing care. And that extreme care begins with the selection of base material and doesn't end until every track-inch of tape has been checked on automatic certifiers. This insures that each test pulse—as many as 161,000,000 on high density tapes—reproduces perfectly. We don't, however, expect to convince you simply through words. Instead, we urge you to try our computer tape once. We think you'll then join the thousands who specify EP Computer Audiotape and only EP Computer Audiotape.

EP COMPUTER AUDIOTAPE / AUDIO DEVICES, INC., 444 MADISON AVENUE, NEW YORK 17, N.Y.

NEW CONTRACTS

PHILCO CONTRACTS — AIR FORCE, $3-1/2 MILLION NAVY, NEARLY $6 MILLION

The U.S. Air Force has awarded Philco Corporation a $3,569,957 contract for the development of data processing equipment for The North American Air Defense Command. The system, which will use a Philco 2000 Computer, will be installed at Norad Headquarters in Colorado Springs, Colo. The system will be used for experimentation and testing of real time information systems employed for air defense command decisions through the North American continent.

Philco Corporation's Communications and Electronics Division has been awarded a $5,881,478 contract by the U.S. Navy for the production of guidance and control systems for Sidewinder 1-A missiles. Philco has been a prime contractor for Sidewinder missile equipment since 1957.

C-E-I-R SAMPLING LETTER CHARACTERISTICS FOR U. S. POST OFFICE

The Post Office Department has recently awarded C-E-I-R, Inc. a contract to develop the necessary methods and to undertake a program for collecting and analyzing statistics on the characteristics of U.S. letter mail. Sampling of the mail by teams of selected postal employees under C-E-I-R supervision is already underway in post offices in Boston, Miami, Washington, D.C., and San Francisco. As preliminary data findings and procedures are checked out, sampling operations are being widened to cover the major post offices in a total of 10 cities geographically distributed throughout the country. Information will be collected in each post office every week for a period of six months or more.

Information is being collected on the number of letters with typed or handwritten addresses, the color of ink used, the location of the line showing city and state destination, size of envelope used, and the class of mail -- regular, third, air or other special types. Even with sampling procedures, so much information will be collected that C-E-I-R and the Post Office Department will have to use high-speed computer equipment to record and analyze the data. Study of this information will lead to the development of machines that one day will read the address and sort the letters for delivery to destinations throughout the world.

UNIVAC RECEIVES ORDERS FOR UNIVAC 1004 CARD PROCESSOR

The Univac 1004 Card Processor, recently announced by the UNIVAC Division of Sperry Rand Corp. is a low-cost, business data processor which provides reading, writing, and printing speeds up to four times as fast as conventional punched-card data processing equipment. Some of the firms that have ordered 1004's in the last month and a half are:

The Century Wholesale Supply, Buffalo, N.Y. has ordered the Univac 1004 for use with its chain of 12 wholesale discount stores located in New York State and Pennsylvania.

Two Louisiana State agencies have placed orders for the card processor. One will go to the Department of Highways where it will be installed in the New Highway Building, Baton Rouge. The second system will service the Louisiana Department of Labor, in the Division of Employee Security.

Foster & Gallagher, Inc., a Peoria, Ill. mail order house, which a few months ago began offering time payment accounts to its customers, also has purchased a UNIVAC 1004 Card Processor for the handling of its accounts receivable.

TELECOMPUTING GETS IBM CONTRACT FOR TITAN DATA SYSTEMS

Data Instruments Division of Telecomputing Corp., North Hollywood, Calif., has received a contract of more than $200,000 from IBM for signal data-recording systems. The systems are militarized versions of Data Instruments' tape perforator. Metal-backed mylar tape as well as paper are used in the perforators. They are used with militarized aerospace ground equipment being manufactured by IBM to record calibration and checkout of the Inertial Guidance System in the USAF TITAN II missile. The systems being furnished to IBM are required to perforate only 27 characters per second, but they are designed to perforate up to 40 characters per second with standard equipment.

AUTONETICS RECEIVES $3.5 MILLION FOLLOW-ON CONTRACT

A follow-on contract totaling about $3.5 million for 163 radar terrain clearance computers and accessory equipment was received by Autonetics, a division of North American Aviation, Inc. from General Motors AC Spark Plug division.

The computers are the core of a terrain-avoidance system designed to give low-level flight capabilities to the Air Force's Strategic Air Command B-52 bombers.

First delivery under the follow-on program was set for last month, with final delivery in August of 1963. AC Spark Plug is systems integrator for the Air Force bombing navigation system for the B-52C and D airplanes.

BURROUGHS EDP COMPLEX ORDERED BY SOUTHERN BANK

In what is believed to be the largest single bank computer commitment ever made in the Southeast, South Carolina National Bank has ordered a $1.5 million Burroughs Corp. electronic data processing complex at its main headquarters in Columbia, S.C.

The equipment will include a B5000 information processing system and a B270, working in combination to handle the full range of financial data processing and check processing jobs for SCN's 250,000 customers across the state.

COMPUTER PRODUCTS INC. SIGNS CONTRACT WITH GE

Computer Products Inc., South Belmar, N.J. has announced the signing of a manufacturing contract with General Electric Company. The contract regards the production of the electronic firm's principal product, the Mark III general purpose analog computer. The Mark III Computer contains computing components which are capable of performing summation, integration and differentiations with respect to time, multiplication of two variables and generation of a function of a variable.

U. S. NAVAL ACADEMY BUYS 6 TR-10 COMPUTERS

Six computers for use in instructing midshipmen in analog computer techniques have been purchased by the U.S. Naval Academy from Electronic Associates, Inc., Long Branch, N.J. About 1800 first and second class (junior and senior) midshipmen will receive instruction in the various applications of analog computation.

The computers are TR-10, solid state devices, that are widely used in scientific and engineering laboratories. In addition to the computers, the Academy also purchased from EAI 36 pre-patch panels for use with the TR-10's. Use of the panels eliminates the need to tear down and repatch the computer each time a different problem is studied.

UNIVERSITY OF ALABAMA SIGNS CONTRACT FOR UNIVAC 1107

The University of Alabama and UNIVAC Division of Sperry Rand Corp. have signed a contract which will provide the university with a UNIVAC 1107. This thin-film memory computing system will be used at the university's Research Institute in Huntsville, Ala. The Research Institute is a newly established university facility intended primarily to assist the national space and missile effort through research in the aerospace physical sciences.

The computing equipment will be operated by both University and UNIVAC personnel. The 1107 will also be available for natural and social science research on the University's Tuscaloosa campus, as well as for vital medical and health research of the University Medical Center in Birmingham.

UNIVAC will use the installation as a scientific computing service center. The new center will be one of six such scientific service centers operated by the company in the United States. Use of the center will be offered to industry and government.

The University of Alabama already operates a UNIVAC solid-state 80 computer on the Tuscaloosa campus. Installation of the new equipment will be completed in the fall of 1963.

EAI TO BUILD 'HYBRID' COMPUTER FOR McDONNELL AIRCRAFT CORP.

A $650,000 "hybrid" computer will be built by Electronic Associates, Inc., Long Branch, N.J., for McDonnell Aircraft Corporation's Automation Center in St. Louis. The computer, known as HYDAC, was introduced last May and is a new concept in engineering and scientific computation. It combines many of the operational features of analog and digital computers into an integrated system. The HYDAC is an instrument for simulation not only of the flight of a space vehicle, but for duplicating exactly the logical decisions that an airborne computer has to make in controlling flight.

McDonnell is prime contractor to the National Aeronautics and Space Administration for both the Mercury Spacecraft and the two-man Gemini Spacecraft.

ELECTRADA RECEIVES AIR FORCE CONTRACT FOR DATA COM SYSTEM

The Electrada Corporation's Data Products Division, Los Angeles, Calif., has received a contract from the Electronics Systems Division of the U.S. Air Force Systems Command of over $140,000 for Electrada's DATACOM systems for integration in an intelligence data handling system. The new contract is a carry-on contract from the Air Force.

Electrada's DATACOM provides a visual display link between computers and people. It receives, transmits, stores and displays data, and permits composition and correction of messages transmitted through high-speed digital communication systems.

AMERICAN OIL ORDERS TWO MORE FARRINGTON SCANNERS

American Oil Company, the largest credit card operation under one roof, has ordered two more Farrington Optical Scanners to handle its increasing business. This will bring the number of scanners used by American to six. One machine can process as many as 50,000 customer invoices a day. These Farrington Optical Scanners read the customer tab-card invoices simultaneously punching the scanned information into the invoices for billing operations.

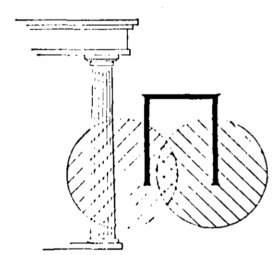
TEACHING MACHINES

MILITARY COMPUTER OPERATORS TRAINED WITH TEACHING MACHINE

An electronic teaching machine for military computer operators is in classroom use at the U.S. Army Signal Center School, Fort Monmouth, N.J. The equipment, called TAMCO (Training-Aid-for-MOBIDIC-Computer-Operators), was built by Sylvania Electric Products Inc. (a subsidiary of General Telephone & Electronics Corp.), Needham, Mass.

TAMCO is designed to train military personnel to operate MOBIDIC, the high-speed, mobile computer developed by Sylvania for the field army. The use of TAMCO as part of the curricula of the Army's Signal Center and School will release the MOBIDIC computer systems for field work rather than for the training of operators.

-- The student, foreground, is learning to operate MOBIDIC on the trainee console. The instructor, rear, monitors the problem at the master console. The flexowriter at the student's right prints out trainee's mistakes.



BUSINESS NEWS

NEW UNIVAC DEPARTMENT FORMED TO TAP $150 MILLION OEM MARKET

The UNIVAC division of Sperry Rand Corporation has announced it will market a broad range of electronic equipment to computer, communications, and control equipment manufacturers.

Initially, standard equipment utilized in the full line of UNIVAC electronic computing systems will be offered. Included will be card readers, card punches, high-speed printers, memory drums, and magnetic tape units.

The company stated, however, that it also plans full engineering, manufacturing, and marketing of special equipment and devices, as needed by the original equipment manufacturers.

In making the announcement, Dr. Rader, UNIVAC president said, "In the next two years, we estimate that the OEM market for computer peripherals will double in size to approximately $150 million annually, and, by 1970, to $350 million.

"There is no company that can offer original equipment manufacturers the complete line of proved-in-use, peripheral computer devices that UNIVAC can. Our experience, technical proficiency, and international reputation as a leader in the electronic computer industry, not only for EDP and scientific computing equipment, but also for industrial process control computers, is well known.

"Careful analysis of these manufacturers, their component needs, and the capabilities of our company, indicates that UNIVAC is in an excellent position to supply a major share of this rapidly expanding market," Rader added.

SECOND TAB CARD FIRM SUES IBM

J. J. Hackett & Co., a small Chicago tabulating card manufacturer, has filed a $33-million treble damages suit against IBM. The nearly 50 charges run the whole gamut of monopoly and discrimination allegations.

This is the second such suit against IBM in the last couple of months. The first was for $150-million by Business Appliance Corp., Camden, N.J. Both suits stem from the antitrust consent decree signed by IBM in 1956, which enabled other manufacturers to compete more effectively in the tabulating card business. IBM denies any violation of the decree.

ITT ACQUIRES GENERAL CONTROLS

A plan for the acquisition by International Telephone and Telegraph Corporation of the assets of General Controls Co. of Glendale, Calif., a leading manufacturer and supplier of automatic controls for residential, industrial and aerospace users was announced today by both companies.

The plan was announced jointly by Harold S. Geneen, president of ITT, and William A. Ray, president and founder of General Controls Co. Under the plan, a new subsidiary of ITT will acquire substantially all of the assets of General Controls Co.

Mr. Geneen said "ITT seeks to enter the controls business internationally and the acquisition of this outstanding company gives ITT a broad base of electromechanical devices on which to build for world-wide position in the manufacture and sale of automatic controls."

It is planned to continue General Controls' autonomous operation as a subsidiary of ITT in the U.S. Commercial Group under the present name, officers and management.

General Controls manufactures and supplies automatic controls to the principal airframe, chemical, and petroleum companies, and household appliance manufacturers as well as makers of heating, refrigeration and air conditioning equipment. The company employs 3,000 persons.

ITT reported record sales and revenues during the first nine months of 1962.

Sales and revenues for the first nine months of 1962 totaled $770,193,374, compared with $652,963,929 a year earlier.

Net income for the nine months' period was $27,972,419, compared with $25,132,379, or $1.52 per share in the previous nine months' period.

Orders on hand were approximately $775,000,000 compared with $716,000,000 a year ago.

NATIONAL CASH REGISTER RENTAL COSTS UP

National Cash Register Co. expects 1962 capital outlays for business machines it will rent out, rather than sell, to double the $13.3 million spent last year according to Gordon A. Lowden, executive vice president.

Capital requirements of the company's business machines rental activities were only $7 million just two years ago. The outlays are required because the NCR computers and other business machines must be built, distributed and serviced at heavy initial expense to the manufacturer, but they are paid for by the users only gradually through rental payments.

National Cash Register has sold 675 electronic data processing systems since entering the field. These systems, along with adding and accounting machines, account for about 40% of volume, Mr. Lowden said, cash registers represent 30% of sales, and business supplies and services provide the rest.

National Cash Register expects to equip its 320 offices in the U.S. with electronic data processing equipment to handle work for customers whose needs don't justify purchase or lease of larger computers.

SPERRY RAND EARNINGS DROP

A 40% drop in earnings despite a four % increase in sales for the first six months, ended Sept. 30, was reported by Sperry Rand Corp. Harry F. Vickers, president, said the drop was due to heavy expenses associated with installing and programming the new line of large scale EDP systems now being delivered to Univac Div. customers. The new line includes, the 1107, the 490 and the Univac III. Other factors noted were the weakness in some office machines lines overseas, declines in certain foreign currencies and higher depreciation.

POTTER INSTRUMENT EARNINGS UP 181% FOR FIRST QUARTER

An increase of 181% in earnings for the first quarter of its fiscal year ended Sept. 30, was reported by Potter Instrument Co., Inc. The company's earnings for the quarter rose to $144,750 over the $51,510 for the same period last year. Sales totaled $2.8 million versus $1.4

million reported for the first quarter last year.

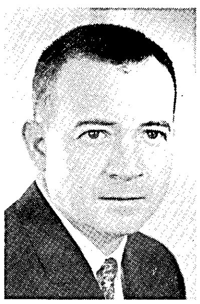
LITTON REPORTS FISCAL YEAR SALES AND EARNINGS BETTER THAN 50% HIGHER

A 61% increase in earnings and a 57% increase in sales over last year was reported by Litton Industries, Inc., for its fiscal year ended July 31. Earnings were $16,315,952, compared with $10,158,323 for last year. Sales for the fiscal year were $393,807,709 vs. $250,114,450 for last year.

PEOPLE OF NOTE

TRW HAS NEW GENERAL MANAGER

Donald L. Stevens has been appointed general manager of TRW Computers Company, a division of Thompson Ramo Wooldridge Inc. Mr. Stevens replaces Dan L. McGurk, who has resigned to accept an executive position with Scantlin Electronics, Inc.



Mr. Stevens has been director of product planning for the RW and TRW Computers Company divisions of TRW. Prior to joining TRW, he served with the Burroughs Corporation in various capacities for eleven years. He has been awarded two patents and is the author of four technical papers.

AUTOMATION REPRESENTATIVE FOR U. S. TRADE MISSION TO ITALY

Dr. Eugene M. Grabbe, Senior Staff Consultant on Automation for Thompson Ramo Wooldridge Inc. (TRW), is one of five American businessmen appointed by the Department of Commerce to serve on a special U.S. Trade Mission to Italy. The Mission is spending five weeks in major Italian cities, concentrating its efforts on promoting U.S. trade in the machinery and equipment field. Particular emphasis is being placed on analyzing the market in automated processes such as the use of digital computers in the petroleum, chemical, steel and power industries.

IFIP REELECTS PRESIDENT

Isaac L. Auerbach, representative of the American Federation of Information Processing Societies to IFIP, has been reelected to a second three-year term as president of the International Federation for Information Processing (IFIP).

Mr. Auerbach, who presided at the IFIP Congress 62 in Munich, is president of the Auerbach Corp. of Philadelphia and Washington. He will be responsible for directing the organization of the IFIP Congress 65, to be held in New York City in May, 1965.

Dr. A. van Wijngaarden, the newly-elected vice-president of IFIP, is associated with the Mathematisch Centrum in Amsterdam, The Netherlands. Dr. Ambros P. Speiser, reelected to a second term as secretary-treasurer, is Director of the IBM Laboratory in Ruschlikon ZH, Switzerland.

EAI APPOINTS DIRECTOR OF PRINCETON COMPUTATION CENTER

Walter Brunner has been appointed Director of the Princeton Computation Center of Electronic Associates, Inc. Mr. Brunner, previously a senior applications engineer, joined EAI in 1954, the same year the Center was established. The Center, one of four which EAI operates, conducts analog computer studies in all areas of scientific research, rents computer time and conducts primary and advanced courses in analog computer techniques.

BENDIX G-15 USERS GROUP ELECTS SPAULDING PRESIDENT

The Bendix G-15 Users' Exchange Organization elected Albert K. Spaulding, a New York consulting engineer, as its new president during their 7th annual conference held in Philadelphia, Pa. Mr. Spaulding is a member of the New York City firm of Tippetts, Abbett, McCarthy and Stratton.

SHERWOOD RECEIVES AWARD

Henry F. Sherwood, Detroit, Mich., was presented with the Price, Waterhouse and Company award for the best article for the current year in the "Systems and Procedures Journal" of the Systems and Procedure Association. The President of SPA made the award, consisting of a plaque and check for $500, at the association's 15th Annual International Systems Meeting at the Hotel Statler-Hilton, Boston, Mass.

Mr. Sherwood, special assistant to the vice president of marketing for Burroughs Corporation, is the author of numerous papers on computers, automation and data processing. He has a highly specialized background in electronic data processing. The prize-winning article, which appeared in the January - February issue of the "Systems and Procedures Journal", was entitled "A Progress Report on Automatic Character Recognition".

SOFTWARE NEWS

FIRST LINEAR PROGRAM PACKAGES FOR THE H-400 AND THE H-800

Honeywell EDP has announced the development of the first linear program packages for the H-400 and the H-800 computer.

The new LP package for use with the H-400 uses Simplex Algorithm technique for mathematical computation and analysis of data and is designed to increase the scientific and operations research capabilities of existing Honeywell 400 installations. The package will be tape-oriented. Programs will be written as EASY sub-routines, which can be combined with other Honeywell 400 library routines to provide an integrated system programming capability. Equipment configuration required for using the linear programming package includes: a Honeywell 400 with 2K memory, 4 magnetic tape units, a high-speed printer, a card reader, and a multiply/divide option.

The first linear programming package for use with the Honeywell 800 computer is designed to extend capabilities of the systems in the fields of scientific problem-solving, operations research and other business, government and military applications. Basic language for the new system is AUTOMATH. The LP package consists of 14 subroutines and one main program. The system uses the Revised Simplex Method, version A, that can be used on Honeywell 800 systems with 4, 8 or 16K memories. All data is stored in the memory of the computer; tapes are not required for computation. Input can be on punched cards or tape; all output is on-line to the high-speed printer. Off-line output is possible by making a minor modification to one subroutine.

DRI and DART NEW PROGRAMMING SYSTEMS

Bonner & Moore Associates, Inc., Houston, Texas, have developed what they believe to be a significant advance in the programming of data processing problems for computers. This consists of the Data Reduction Interpreter and its expanded companion, the Data Reduction Translator, DRI and DART.

DRI/DART translates language familiar to engineering and accounting personnel into a form usable by a computer. The system also allows an open channel of communication between the user and the computer, throughout the life of the program.

The most widespread use is in such problems as operations monitoring and off-normal reporting, plant control analysis and exception reporting, and process plant yield accounting and analysis.

SNAP — A NEW NUMERICAL CONTROL PROGRAM

The Brown & Sharpe Mfg. Co., Providence 1, R.I., has announced a new numerical control program by which instructions generated by an electronic computer automatically guide the operations of a turrent drill. SNAP, for Simplified Numerical Automatic Programmer, is believed to be the first numerical control program to be marketed as an essential feature of a manufacturing firm's products. Brown & Sharpe has developed the program using an IBM 1401 electronic data processing system for two turret drills: the TURR-E-TAPE Model B and the TURR-E-TAPE A 1118.

The new SNAP program has nearly 1200 instructions on a deck of punched cards furnished by Brown & Sharpe. Specification data is fed into the computer for the particular part to be machined. The computer then calculates the instructions which, in turn, are converted to punched paper tape for input to the turret drill processor. As an additional guide to an error free system, SNAP prints a plot of the points to be machined. The parts programmer is able to check the accuracy of the descriptive statements by comparing the engineering drawing with the plot.

COMPUTING CENTERS

COMPUTER CENTER INITIATED AT WEST POINT

A computer center is being established at the United States Military Academy. Analog computer instruction has been given by the Military Academy's Department of Ordnance to all senior cadets for several years. The Academic Computer Center is a culmination of West Point plans to integrate the use of computers into its academic instruction.

When the Center is in operation every cadet will receive basic "hands-on" digital computer instruction during his plebe (freshman) year. Subsequent course work will make repeated use of the Center during the under-graduate curriculum of the cadets. The West Point faculty will use the computers as tools for teaching a variety of subjects such as mathematics, engineering and psychology. When not being used for cadet instruction, the center will be used as an aid to research, especially in the areas of psychology and leadership. Other secondary applications planned for the computer system include administrative and management data processing.

The equipment is being supplied on a rental basis by General Electric Company. One general purpose digital computer, installed during the current term, will be followed by three additional computers of the same type before the start of the next academic year.

TWO COMPUTER CENTERS LINKED BY MARTIN

The Martin Company, Baltimore, Md., will link electronic computers at two of its divisions by means of long-distance telephone lines and IBM 7287 high-speed data transmission terminals. Computer centers in Denver and Baltimore, more than 1500 miles apart, will be joined next month. The two centers are responsible for supporting a variety of engineering work on missile and space projects.

-- Martin Co. computer experts R. Carter Wells, left, and Sol James review results of computations obtained from the IBM 7090 computer system at Martin Company's - Baltimore computer center. This system has been linked with the firm's Denver computer center by high-speed data transmission equipment to make exchange of work between the two centers possible.

In using the equipment, an engineering problem will be transcribed on a magnetic tape at Denver. By processing this tape into the Denver 7287, it is automatically transmitted over the 1500 mile transmission link and will be transcribed on a tape at the Baltimore 7287. The answer is fed back to Denver in the same manner after processing through the Baltimore computer.

Eventually, Martin hopes to expand the transmission equipment to link its third computer center in Orlando, Fla.

The IBM 7287 transmits data at up to 5000 characters per second. Martin uses the IBM 7090 for scientific computation, and the IBM 7070 for business data processing. The IBM 1401 is used to support both machines.

MONTHLY COMPUTER CENSUS

The number of electronic computers installed, or in production at any one time has been increasing at a bewildering pace in the past several years. New vendors have come into the computer market, and familiar machines have gone out of production. Some new machines have been received with open arms by users -- others have been given the cold shoulder.

To aid our readers in keeping up with this mushrooming activity, the editors of COMPUTERS AND AUTOMATION present below a monthly report on the number of American-made computers installed or on order as of the preceding month. We revise this computer census monthly, so that it will serve as a "box-score" to readers interested in following the growth of the American computer industry.

Most of the figures are verified by the respective manufacturers. In cases where this is not so, estimates are made based upon information in the reference files of COMPUTERS AND AUTOMATION. The figures are then reviewed by a group of computer industry cognoscenti.

Any additions, or corrections, from informed readers will be welcomed.

AS OF NOVEMBER 20, 1962

NAME OF MANUFACTURER	NAME OF COMPUTER	SOLID STATE?	AVERAGE MONTHLY RENTAL	DATE OF FIRST INSTALLATION	NUMBER OF INSTALLATIONS	NUMBER OF UNFILLED ORDERS
Addressograph-Multigraph Corporation	EDP 900 system	Y	$7500	2/61	9	11
Advanced Scientific Instruments	ASI 210	Y	$2850	4/62	4	4
	ASI 420	Y	$12,500	-/62	0	1
Autonetics	RECOMP II	Y	$2495	11/58	130	8
	RECOMP III	Y	$1495	6/61	26	16
Bendix	G-15	N	$2150	7/55	300	2
	G-20	Y	$15,500	4/61	20	6
Burroughs	205	N	$4600	1/54	92	X
	220	N	$14,000	10/58	58	X
	E101-103	N	$875	1/56	161	X
	B250	Y	$4200	11/61	32	34
	B260	Y	$3750	11/62	1	42
	B270	Y	$7000	7/62	9	30
	B280	Y	$6500	7/62	4	16
	B5000	Y	$16,200	-	0	10
Clary	DE-60/DE-60M	Y	$675	2/60	72	9
Computer Control Co.	DDP-19	Y	$3500	6/61	1	2
	DDP-24	Y	$3000	-	0	1
	SPEC	Y	$800	5/60	8	2
Control Data Corporation	160/160A	Y	$2000/$3500	5/60 & 7/61	210	56
	1604	Y	$35,000	1/60	38	15
	3600	Y	$52,000	4/63	0	2
	6600	Y	$120,000	-	0	1
Digital Equipment Corp.	PDP-1	Y	Sold only about $500,000	12/59	32	10
	PDP-4	Y	Sold only about $100,000	8/62	5	5
El-tronics, Inc.	ALWAC IIIE	N	$2500	2/54	32	X
General Electric	210	Y	$16,000	7/59	56	20
	225	Y	$7000	1/61	62	95
General Precision	LGP-30	semi	$1300	9/56	400	20
	RPC-4000	Y	$1875	1/61	62	20
Honeywell Electronic Data Processing	H-290	Y	$3000	6/60	10	3
	H-400	Y	$8000	12/60	27	46

NAME OF MANUFACTURER	NAME OF COMPUTER	SOLID STATE?	AVERAGE MONTHLY RENTAL	DATE OF FIRST INSTALLATION	NUMBER OF INSTALLATIONS	NUMBER OF UNFILLED ORDERS
Honeywell EDP (cont'd.)	H-800	Y	$22,000	12/60	45	5
	H-1800	Y	$30,000 up	-/63	0	2
	DATAmatic 1000	N		12/57	6	X
H-W Electronics, Inc.	HW-15K	Y	$500	3/63	0	1
HRB-Singer, Inc.	SEMA 2000	Y	$700	1/62	17	18
IBM	305	N	$3600	3/62	925	X
	650-card	N	$4000	11/54	735	X
	650-RAMAC	N	$9000	11/54	262	X
	1401	Y	$2500	9/60	3450	4550
	1410	Y	$10,000	11/61	65	450
	1440	Y	$1800	4/64	0	350
	1620	Y	$2000	9/60	1250	400
	701	N	$5000	4/53	4	X
	702	N	$6900	2/55	5	X
	7030	Y	$300,000	5/61	3	X
	704	N	$32,000	12/55	89	X
	7040	Y	$14,000	6/63	0	30
	7044	Y	$26,000	6/63	0	5
	705	N	$30,000	11/55	160	X
	7070, 2, 4	Y	$24,000	3/60	240	255
	7080	Y	$55,000	8/61	36	25
	709	N	$40,000	8/58	45	X
	7090	Y	$64,000	11/59	210	145
	7094	Y	$70,000	12/62	0	3
Information Systems, Inc.	ISI-609	Y	$4000	2/58	20	3
ITT	7300 ADX	Y	$35,000	7/62	3	3
Monroe Calculating Machine Co.	Monrobot IX	N	$340	3/58	151	6
	Monrobot XI	Y	$700	6/60	210	150
National Cash Register Co.	NCR - 102	N	-	-	30	X
	- 304	Y	$14,000	1/60	30	0
	- 310	Y	$2000	5/61	27	40
	- 315	Y	$8500	5/62	25	130
	- 390	Y	$1850	5/61	260	230
Packard Bell	PB 250	Y	$1200	12/60	120	36
Philco	2000-212	Y	$68,000	-/63	0	6
	-210, 211	Y	$40,000	10/58	19	25
	1000	Y	$7010	-/63	0	12
Radio Corp. of America	Bizmac	N	-	-/56	4	X
	RCA 301	Y	$6000	2/61	154	330
	RCA 501	Y	$15,000	6/59	83	11
	RCA 601	Y	$35,000	-/63	0	6
Scientific Data Systems Inc.	SDS-910	Y	$2190	8/62	5	12
	SDS-920	Y	$2690	9/62	1	5
TRW Computer Co.	RW530	Y	$2500	8/61	14	7
UNIVAC	Solid-state 80, 90, & Step	Y	$8000	8/58	527	154
	Solid-state II	Y	$8500	9/62	2	32
	490	Y	$26,000	12/61	4	12
	1107	Y	$45,000	10/62	1	16
	III	Y	$20,000	8/62	2	65
	LARC	Y	$135,000	5/60	2	X
	1100 Series (except 1107)	N	$35,000	12/50	32	X
	I & II	N	$25,000	3/51 & 11/57	65	X
	File Computers	N	$15,000	8/56	77	1
	60 & 120	N	$1200	-/53	911	29
	1004	Y	$1500	2/63	0	925
				TOTALS	11,887	8,942

X — no longer in production

Fictional Computers And Their Themes

Marcia Ascher
Asst. Prof. of Math. and Physics
Ithaca College
Ithaca, N. Y.

A thoughtful and interesting look into the role of computers in the literature of fantasy and science fiction.

An editorial in a local newspaper (1) stated: "We are just at the beginning of the computer age. Who (but a science fiction writer) would venture to predict what lies ahead?" Although science fiction does provide fictitious views of computers of the future, its greater value lies in its concern for the social and moral aspects of technological innovations. It frequently functions as "a means of dramatizing social inquiry, as providing a fictional mode in which cultural tendencies can be isolated and judged." (2) An examination is undertaken here of the science fiction stories that concern computers; and the themes of these stories are identified and discussed.

Domination of Man by Machines

An early theme in science fiction stories dealing with mechanization was that the machines might develop a consciousness and turn on their makers. This idea is seen as early as 1872 in Samuel Butler's *Erewhon* (11). Eventually, all the machinery in Erewhon is destroyed when a philosopher suggests that by evolution the machines may become conscious, enslave man, and supersede him. In "Moxon's Master," written in 1893 by Ambrose Bierce (10), an automated chess player strangles its maker when it becomes angry at being check-mated. In Hamilton's "The Metal Giants" (1926) (23) a scientist creates a brain of metal and gives it consciousness by passing T-waves through it. When the scientist is away, the brain starts to create brainless metal giants three hundred feet high, who, under its control, are to take over the world. Fortunately, the brain is destroyed before this occurs. As is pointed out in *Inquiry Into Science Fiction* (18) during a discussion of "R.U.R.," the theme of machines turning on man "is not merely the story of Frankenstein; not merely the medieval Jewish legend of the Golem . . . , it is the fear that Man may somehow create a force which is too great for him to control. . . ."

Although modern day computers appear closer to consciousness than the machines at the turn of the century, this no longer seems to be a major theme. Perhaps one reason is that here we are only examining stories dealing with computers and computers are not usually endowed with unrestricted movement, while the logical science-fiction descendants of intelligent machines should also include robots. However, as noted by G. Conklin (17), ". . . in more modern times the concept of the robot as a nonrebelling servant has been greatly strengthened by the widespread adoption by science-fiction writers of 'The Laws of Robotics,' first formulated in the early 1940's by Isaac Asimov." These laws include: "1. A robot may not injure a human being or, through inaction, allow a human being to come to harm. 2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law."

A modern story in which the question of consciousness does arise is "Problem for Emmy" (33). A computer, referred to as Emmy, is quite awe-inspiring to those who work with it because of the complexity of the mathematical problems it can solve. However, one day it begins, uninstructed, to do simple addition and multiplication and then to type out repeatedly "Who am I?", "Who am I?". It is significant that the men responsible for the design and creation of Emmy are named Dr. Manndenker and Dr. Golemacher.

While the fear of being dominated by machines may not be uppermost in the minds of science fiction writers, it still may be one that disturbs the public. The newspaper editorial cited earlier (1), raises this fear and then consoles "those who may have uneasy feelings that machines may one day take over the world" with the reminder that "one can always pull out the plug."

Destruction of Man by Machines

A second theme, closely allied to the one just discussed, expresses a more general fear that through the misuse of technology mankind will totally destroy itself. In "The Predicting Machine" (24), the computer appears as an omniscient device that can collect data in the future and analyze it. When asked by the U.N. to describe the state of the world in 2200 A.D., the computer answers: "One world under God." Upon further questioning, the reason for this is found to be "Homo Sapiens extinct." Both "The Nine Billion Names of God" (13) and "The Maker of Computing Machines" (31) are of an allegorical nature. A computer is used in the former by a Tibetian lamasary to list all the names by which God is known. When the listing was complete "Overhead, without any fuss, the stars were going out." The latter story traces the progress of a series of computers. Toward the close of the story they have been endowed by their Maker with the desire to reach goals, the ability to evaluate success and failure in reaching these goals, and the ability to modify goals and reach them by indirect means. The Maker of computers realizes that in the next series he must make an important addition—the goal of benevolence. His son declares, as they observe the chaos below them, " 'They have invented hideous new weapons, and soon they will be able to surmount the wall that you have placed around the field. Let us destroy them quickly.' 'There is no need,' said the old man. 'They will do it for us.' "

Creativity

The two foregoing themes emphasize the pessimistic view that mankind, with the aid of technology, is headed toward extinction. While these themes do exist in science fiction stories, they do not seem to be in the majority. As is noted in *New Maps of Hell* (2): "There is here and there even a complacency about man's ability to keep his creations under physical control. . . . It is the moral and spiritual dangers of a technological civilization that exercise these writers. . . ." The major emphasis does not seem to be the statement of fears, but rather the continual reminder that the ultimate responsibility for creativeness and decisions belongs not to computers but to man.

The theme of man's responsibility for creativity is evident in *The Silver Eggheads,* "Graveyard of Dreams" and "A Feeling of Power." "Graveyard of Dreams" (29) takes place on a planet whose population is searching for a computer that is believed to have been left there during a previous war. A young man sent to Earth to study computers, returns with the realizations that his people "don't believe in the Brain as a tool to use; it's a machine god that they can bring all their troubles to" and that computers aren't smart "the people who build it are smart; a computer only knows what's fed to it. . . . But they can't imagine, they can't create, and they can't do anything a human brain can't." *The Silver Eggheads* (25) centers around a search for writers after "wordmills" (computers that have been producing all fiction works) are destroyed by a revolt of authors who have become merely ornamentation. After the machines are destroyed, they are faced with the fact "that no professional writer could visualize starting a story except in terms of pressing the Go Button of a wordmill" and that "they could not arrange words on paper in any pattern or even make words at all." In "The Feeling of Power" (5) computers have become so advanced and widespread that how they work is no longer known. A man discovers "graphitics" which is a way of doing addition, subtraction, multiplication and division with pencil and paper. The people find it hard to believe that the human mind can do what a computer can do. At the conclusion of the story, one person realizes that he has a feeling of power and satisfaction from knowing, without the aid of a computer, that $9 \times 7 = 63$.

Social Responsibility

Another important theme that is found in this story is that computers, or any technological advance, can be used for good or evil and that people are responsible for which it is to be. When "graphitics" is discovered, the government and military begin to see the possibilities for manned missiles since they would be lighter, more mobile, more intelligent and more expendable. The creator of "graphitics" commits suicide when he sees that it is not to be used for the benefit of mankind. The designer of a computer, in "The Pacifist" (14), takes a more active role in the determination of its application. While planning the machine he "began to give serious thought to the wider implications of his work. He had always been too busy, too engaged upon the immediate problems of his task, to consider his social responsibilities." As a result of these reflections he "installed what could only be called a censor circuit—he had given Karl the power of discrimination. Before solving it, Karl examined every problem fed to him. If it was concerned with pure mathematics, he co-operated and dealt with it properly. But if it was a military problem, out came one of the insults." In "Sam Hall" (3) a computer is being used to maintain an oppressive, totalitarian government. The chief programmer brings about a revolution by gradual manipulation of the memory contents. He does this by introducing data that places the blame for revolutionary acts on a fictitious person, Sam Hall, who is patterned after the hero of an English folksong by that name.

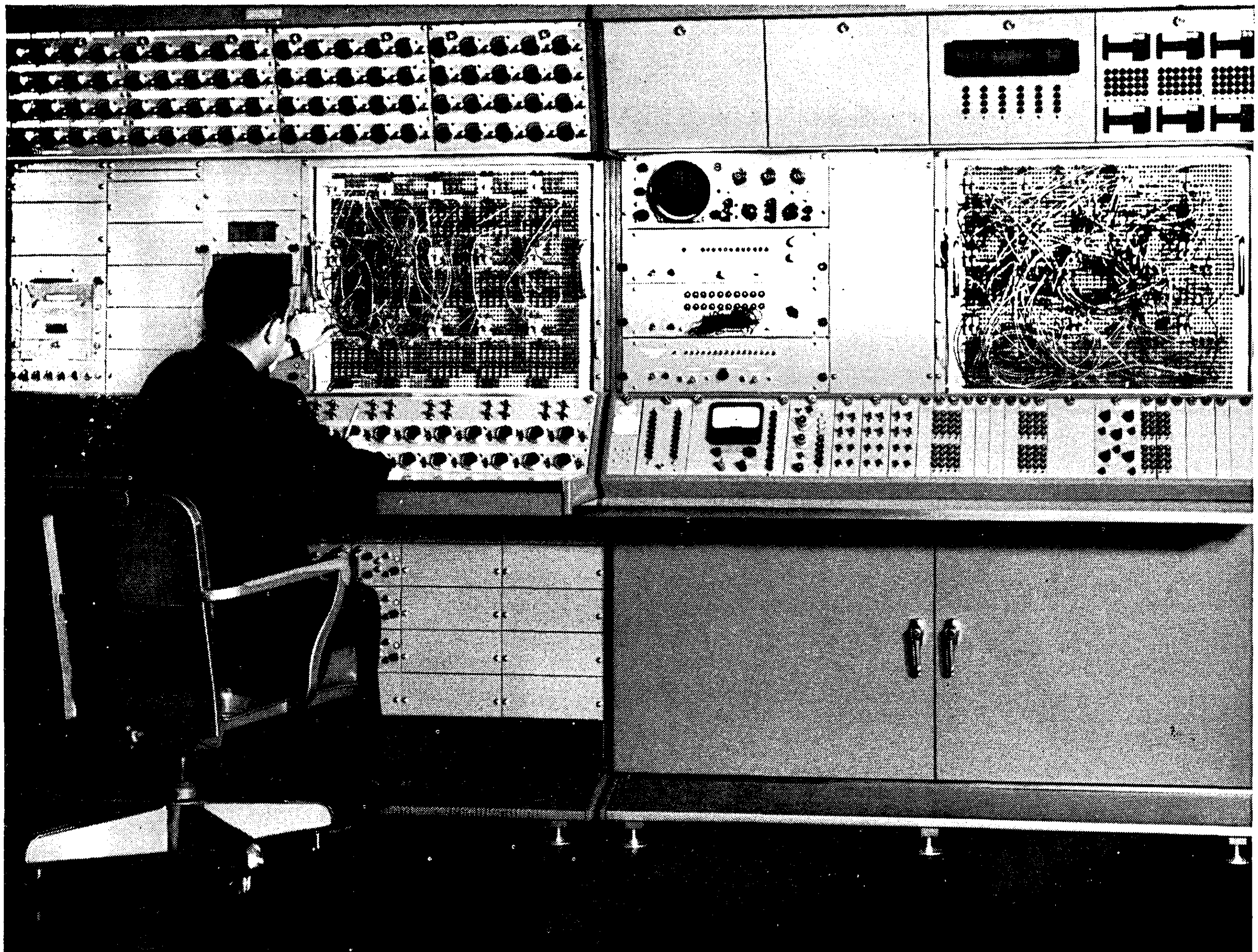
Literal Fulfilment

Another aspect of the theme of man's responsibility is that man must exercise care in giving instructions to computers because of the literal way in which computers interpret them. This is the central theme in "They've Been Working on . . . " (7) which deals with the confusion that ensues when a seemingly minor detail is omitted from the program for a computer system that controls all the routing and scheduling of a railroad. The theme is also seen in "Dumb Waiter" (28) where a computer system, which controls most of a city's routine tasks, interferes with the return of the city's population that was evacuated three years before due to a war.

Computers appear in a number of science fiction stories where they are not essential to the plot of the stories. They are then only another aspect of the environment of the distant time or place being described. In many of these cases the use of the computer is either far-fetched or vague. Examples of this are the computer used in "Divine Right" (19) where "he'd rebuilt his computer and organized his methods so well that he could get a positive index of a man's individuality from as little as five hundred words of his writing," or the computers alluded to in "Run of the Mill" (34), "The Standardized Man" (9) and "The Mold of Yancy" (20). By contrast, most of the stories in which computers play a central role share the interesting characteristic that the computer application is clearly an extension of a way that it is being applied today or an application that is currently under consideration. This seems to illustrate the idea expressed in *Pilgrims Through Space and Time* (6) that one of the methods in serious science fiction is "to predict that what will happen tomorrow is what has begun to happen today."

Elections

The application of computers to election forecasting is extended in "Franchise" (4); "the machines grew bigger and they could tell how the election would go from fewer and fewer votes. Then, at last, they built Multivac and it can tell from just one voter." The one voter does not cast a ballot but rather answers varied questions since Multivac "needs only to check certain imponderable attitudes of mind." Although written before it, "Franchise" might also be considered an extension of the work of the Simul-



INTRODUCING THE MOST VERSATILE COMPUTER FOR DYNAMIC SYSTEMS SIMULATION

EAI HYDAC Computer, Series 2000, introduces a new dimension to computer simulation by combining analog and digital operation into one integrated system. HYDAC achieves a computational efficiency well beyond the limits of either analog or digital computers alone. Moreover, it offers an economical alternative to tying a complete data processing computer to an analog computer for hybrid computation.

HYDAC combines two major sub-systems; the well-known PACE® Series 231R General Purpose Analog Computer and the new Series 350 Digital Console. The normal analog operations of summation, inversion, continuous integration, multiplication, division and function generation are performed by the analog computer while the digital system provides high-speed logic, switching and memory capability. All digital operations are accomplished by solid-state, general purpose, modular building blocks interconnected by the proven prepatch panel system. HYDAC programming follows simple analog principles, making extensive retraining of analog programmers unnecessary.

HYDAC vastly increases the range of dynamic simulations that can be performed by computers. Such applications include iteration and optimization studies, partial differential equation solutions, simulation of logic functions, transport delay and other auxiliary mathematical functions as well as high-speed incremental computation. Full information on HYDAC, the new computer for dynamic simulation, can be obtained by writing for Bulletin HC 6238.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey* matics Corporation as reported in *Newsweek* (35): "With a machine, a model, and a theory, . . . 'We knew how certain voters would make up their minds before they themselves knew.'" In another story, "2066: Election Day" (32), the computer has an even greater role in the election of a president and other current trends are also cited. On election day tests for the presidency are taken by anyone who chooses. The computer can select the most qualified since "psychological testing came of age, really became an exact science, so that it was possible to test a man thoroughly—his knowledge, his potential, his personality." The president's job has become still more difficult and burdensome and the computer is used to assist him in routine matters and also in crucial decisions. The story also focuses attention on a number of the themes that have previously been discussed. Although the computer's criteria for the selection of a president are admirable ("his honesty, his intelligence, his desire for peace") and it is protected from internal manipulation, a problem arises due to the computer's literal interpretation of instructions. It is a group of men who know precisely how the computer works who select the man the computer will choose because they know how to fool it. In particular, man's creative responsibility is emphasized to the incoming president by his predecessor: "A machine is not creative, neither is a book. Both are only the product of creative minds. Sure, SAM could hold the country together. But growth, man, there'd be no more growth! No new ideas, new solutions, change, progress, development!"

Guide, Philosopher, and Friend

In "Cybernetic Scheduler" (21) chaos results when the use of a computer for registration and scheduling in a college is extended to include pre-registration counselling to advise students what programs they are best suited for and to analyze what courses the faculty members are best suited to teach. The application of computers to the study of mental processes is the topic of "Answer" (16) and "On Handling the Data" (27). On a more humorous level "The Ultimate Copy" (12) extends computers into the field of advertising and "Computer Bergerac" (36) applies it to courtship.

In "The Ultimate Copy" (12) the computer produces cigarette advertisements that initially cause sales of all other companies to drop to zero and finally cause raiding and rioting by consumers. Data on the product and theories of psychology are combined to produce an equation which "will contain all the intellectual and emotional stimuli necessary to produce the desired reaction." While the results may be beyond expectations, the story is brought to mind when one reads that "there are many indications that the decision-and-action process of consumers will soon be simulated, or at least reduced to a systematic set of mathematical functions which can be programmed into an electronic computer" (15), or that by using linear programming and "considering the various motives for buying and not buying the optimum theme for the advertising may be developed" (22). In "Computer Bergerac" (36) the hero is a young man who is confident and competent when dealing with computers but extremely shy when dealing with women. He uses a computer as an intermediary by preparing a tape of discussions and instructions such that "each topic was to be triggered by an analysis of words sent by Betty. And Dave's tape would phrase questions so she would use key words in answering." One may become dubious as to what is fact and what is fiction when he reads the following in the *New York Herald Tribune* (38): "The news out of England, sent round the world by Reuters, shows to what ends science will reach. Scientists at Manchester University, so the story says, have built an electronic computer into which a scattered collection of words can be fed. Deep down in the brain of the machine the words are put together and rearranged into complete sentences which are then poured out in legible form. . . . One of the inventors, obviously tongue-tied in the presence of his beloved, decided to feed into the machine a whole series of endearing words, in the hope that the machine would grunt and grumble and give out with a love letter. Sure enough, it did. Presumably that inventor sent it off at once to his girl."

Chess Playing

A fictional chess-playing machine, as was previously noted, appears in "Moxon's Master" (10) as early as 1894. The application of computers to chess playing has stimulated much interest for the very reasons set forth by Edgar Allen Poe in 1835 when arguing that a commercial automated chess player was a fraud (30). His argument states that "in proportion to the progress made in a game of chess, it is the uncertainty of each ensuing move. A few moves having been made, no step is certain. Different spectators of the game would advise different moves. All then is dependent upon the variable judgment of the players. Now even granting (what should not be granted) that the movements of the Automatic Chess Player were in themselves determinate, they would be necessarily interrupted and disarranged by the indeterminate will of his antagonist." In "The 64-square Madhouse" (26) a computer is entered in an international chess competition. The programmer, who is a psychologist with a good knowledge of chess, retains the right to adjust the computer program between games and does so on the basis of the characteristics and weaknesses of the next opponent. The story contains a clear exposition of the chess-playing program and also indicates the usefulness of "a programmer-computer team, a man-made symbiotic partnership." The game of draughts is played by the computer in "God and the Machine" (8). Here a man turns all his attention to machines because he finds people too irrational and dishonest, but he constructs the program so that when faced with losing, if a random digit is even, the machine cheats.

Government

Finally, the use of computers by government agencies as data processors is extended in "Alicia Marches on Washington" (37). This story is particularly noteworthy since it appeared in *The Saturday Evening Post* and so probably received the widest circulation of any that have been discussed. It tells of a woman who is trying to return $86.16 which was erroneously

refunded to her by the Internal Revenue Service. She is finally taken to the "boss" and finds that it is a computer. This is explained by the fact that "no human brain could grasp the complexities of the system. These machines are the only ones capable of understanding what it's all about." When the woman informs the machine of her purpose it makes improbable replies, such as: "We do not make mistakes. To err is human." This unfortunate portrayal of a computer can best be described by the *Post's* blurb on the author, which says that "he convinced himself that something more fiendish than a mere human was in charge of the system."

The Gadfly

This examination of science fiction stories, although it is not all inclusive, indicates that as well as providing enjoyment they focus attention on the relationship of men and computers. As major themes some have the pessimistic view that man, through his inventions, will be destroyed while more of them emphasize that man is the controller of his inventions and so his is the responsibility for creativity and decisions, the choice of good or evil use, and the responsibility for care in execution. Most of the stories deal with computer applications that are not yet in practice but are a continuation of present trends. Two of the recurrent ideas in their extensions of computer use is that the application involves social and psychological factors and that computers play an increasing role in decision making. By presenting plausible extensions of current uses, these science fiction writers underscore the present social and moral implications of these uses. Although attempts are being made by some computing people to awaken thought and discussion on social and moral responsibilities, the added stimulus by science fiction writers should be welcomed and carefully considered since their traditional role of insightful social and scientific gadflies can be shown to have been of value in the past.

Speeding Up

In considering the themes and ideas highlighted in science fiction, they can be seen to be very closely related to each other and quite relevant to the current state of the "computer revolution." While computers may never physically turn on man and destroy him, their introduction into his culture has far-reaching effects. One effect is the speeding up of the tempo of selected aspects of the culture while leaving other aspects relatively untouched and, therefore, increasing the imbalance. Also the implementation of some ideas can become very rapid and so require more rapid reactions and, therefore, more rapid decisions.

Deciding

Computers are being turned to in order to make decisions more rapidly and easily in many areas. The science fiction emphasis on man's responsibility for making decisions is one that should be carefully considered as computers enter this realm increasingly. While it can be argued that in the decision process the computer gathers and analyzes the information and the actual decision is left to a human being, it is clear that the final decision is merely a last obvious step once the foundation has been set when the program is written, by the questions being asked and the information being considered germane. Computer applications have progressed from aiding in decisions about the manipulation of inanimate objects into situations dealing with manipulation of people. While these situations may be expressed mathematically, there remains the question whether such representations truly consider the pertinent factors when human beings are involved.

As computers are being applied to larger policy decisions there is the need to utilize social and psychological theories as is noted in the science fiction applications. This is complicated by the fact that the social sciences are not as specific as the physical sciences. Nevertheless, attempts are being made to cast vague ideas into a mathematical framework and so there are developed equations describing human value systems, human behavioral systems, and even numerical values for human lives. While it is doubtful that these representations are adequate, it is an even more serious question as to whether they aid or interfere with understanding. Decisions and activities based on these formulations require a philosophy of expediency rather than humanism and an environment where belief in mass society overrides the uniqueness of the individual.

Instructing

The theme in the science fiction stories emphasizing man's responsibility for care in giving instructions to computers is also of considerable importance. While the literal interpretation of instructions can lead to trouble when an erroneous instruction is given, even greater difficulties can be brought about when the analysis of a problem overlooks or misinterprets various facets of the problem. Particularly when human social and psychological factors are involved in a problem, the people analyzing the problem are responsible for realizing and admitting the limitations imposed by (1) their own competence and (2) the knowledge currently available.

Applications

The responsibility for determining the applications of computers is shared by everyone in the culture but rests largely with those who deal with computers and so are more aware of their capabilities and limitations. The ingenuity of computer people is channeled largely into military applications because this is the area in which funds are available for supporting computer usage. However, large areas of potential supporters are unaware that computer use could benefit them. If computer people would take the initiative in considering and expounding new areas of applications, support would be forthcoming and the potential of computers could be more fully realized. At best the applications of computers are determined by the goals and values of our culture. But some goals can be changed if an alternative is shown to be feasible, as in the case of disarmament versus armament. Since computers require explicit formulation of problems and since they cause effects to be achieved more rapidly, there should be pause

for thought about the cultural goals and values that are determining and being furthered by computer applications.

Another area of responsibility of computer people is highlighted by science fiction, although not stated directly by it. Science fiction helps in understanding the ideas about computers, robots, and automation held by the public. The public's image of computers depends on the information to which it has access; and that information, whether intended as fiction or as fact, seems to have fiction and fact interspersed. The public appears to be in need of more information and understanding about this new innovation which increasingly affects them.

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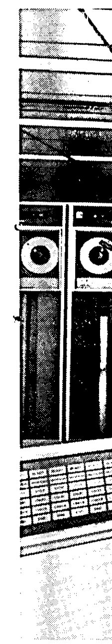
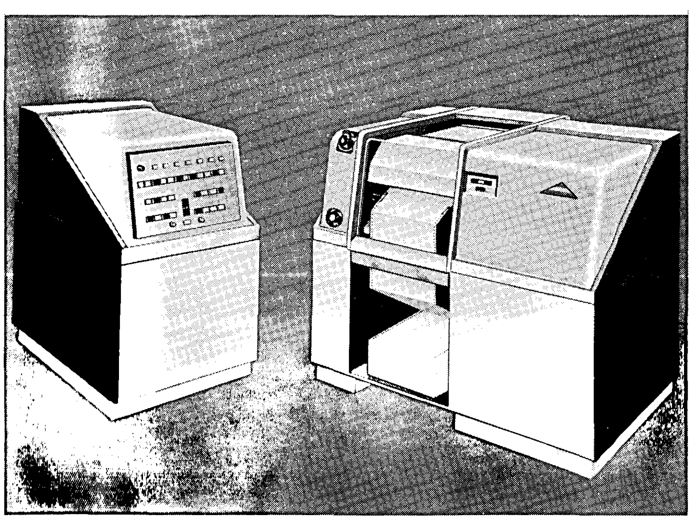


INPUT / OUTPUT EQUIPMENT

H207 LINE PRINTER
Holley Computer Products Co.
Warren, Mich.

A new model of the H207 medium-speed line printer has a print ribbon claimed to have three times former life. When 64 characters are printed, line speed is 300 lines per minute. Interchangeable print drums (see photo insert) allow increased speed when a large selection of characters is not needed. A swing-up drum arm permits easy forms loading. A printer control, cabinet, and buffer for character serial input are optional with the print head.

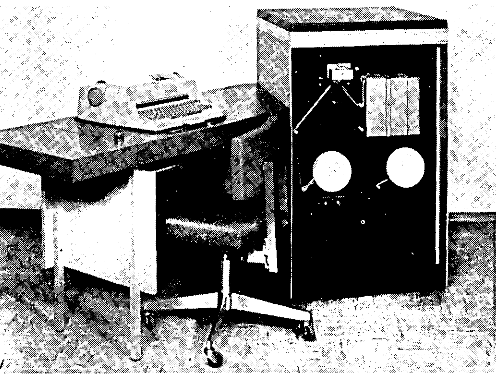
HIGH SPEED PRINT STATION &
HIGH SPEED PRINTER SYSTEM
Anelex Corp.
Boston 14, Mass.



The High Speed Print Station (at left in photo) is a complete off-line printing system for use with heavy duty commercial and scientific computers which now operate without the benefit of high speed read-out. The Print Station, operating from either high or low density magnetic tape, prints both FORTRAN and COBOL at the rate of 1000 lines per minute. Standard Print Rolls contain 132 columns with 48 characters in each column: 26 letters, 10 digits and 12 symbols of the customers choice.

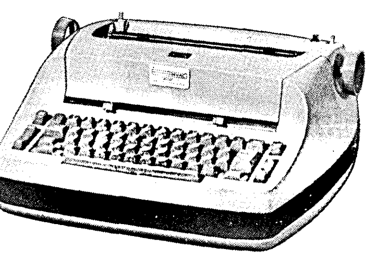
The High Speed Printer System, Series 4-1000, (at right of photo) combines in a single housing, all power electronics and their controls, buffers and logic, and the new Series 4-1000 print head. The standard models provide 120 columns, 10 columns per inch and six lines per inch. Normal print speed is 1000 lines per minute. The system also has Anelex's "penetration control", which makes possible adjustment of print density to compensate for a greater or lesser number of carbons or for varying thickness of paper.

TALLY MARK 45 TAPE OPERATED SELECTRIC TYPEWRITER SYSTEM
Tally Register Corporation
Seattle, Wash.



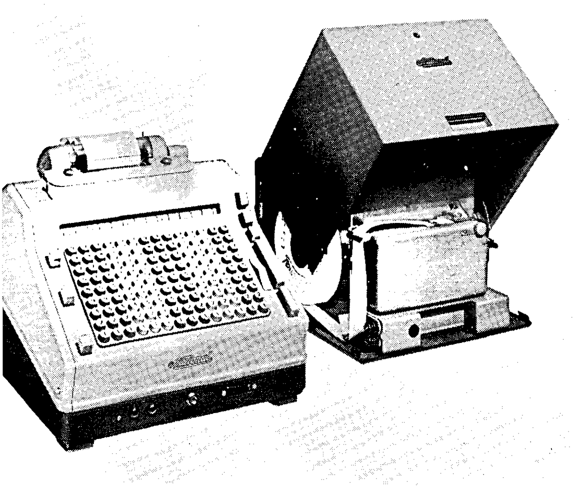
The Mark 45 system has three modes of operation: 1) tape preparation from data entered on the Selectric keyboard at up to 15-1/2 characters per second; 2) print-out and data retrieval from perforated tape at 15-1/2 characters per second; and 3) simultaneous reperforation and hard copy printout. Control features of the Mark 45 system permit codes for format functions such as carriage return, tab, index, back space, etc., to be produced automatically as the operator types. A bi-directional perforator deletes errors from the tape automatically as the typist backspaces and x's out her errors on the hard copy.

MODEL TTR-200, TYPEWRITER-TRANSMITTER/RECEIVER
Invac Corporation
Waltham 54, Mass.



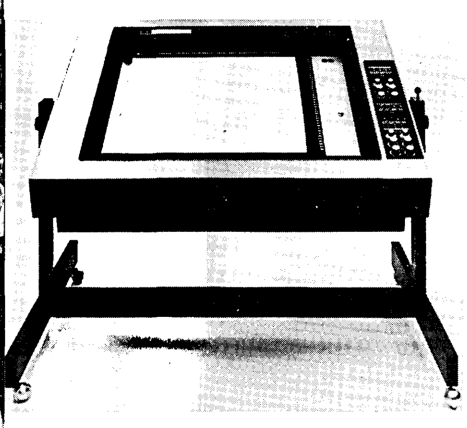
Model TTR-200 is a photoelectric, solid state device having no contacts and low RFI. There is closed loop, ready-busy signal for synchronizing typewriter to computer. Operation speed is 15.5 characters/sec. An 8½" or 13" writing line is available. Input/output typewriter equipment may be used as: on-line computer device; off-line device for data preparation; communication transmitter/receiver; inquiry and reply device in data processing and information retrieval systems; data logger for process control, data collection, and checkout systems.

NCR TAPE-PUNCHING ADDING MACHINE
The National Cash Register Co.
Dayton 9, Ohio



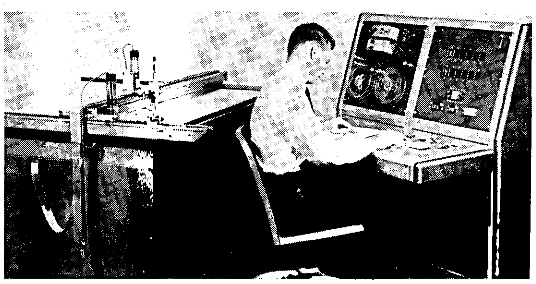
This machine translates information into machine language for computer use. The NCR tape-punching adding machine is programmed to operate the punched tape recorder automatically. An amount entered in the keyboard, adds into the machine total, prints on the adding machine tape, and is punched into the paper tape in code. An operator needs only to read printed tape to know what was recorded on punched tape. Corrections can be made before punched tape is sent off for processing.

SINGLE ARM PLOTTING BOARD
Computer Systems, Inc.
Monmouth Junction, N.J.



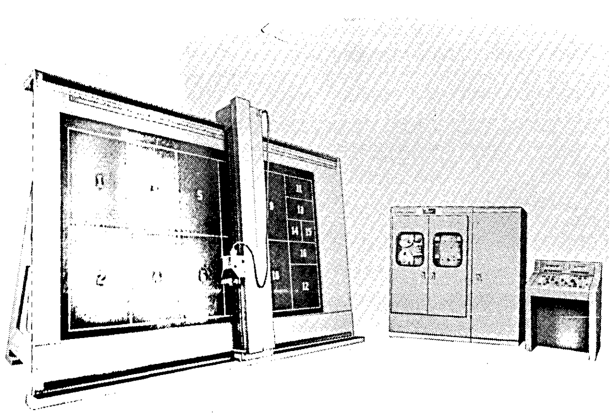
The Model 3305 transistorized single-arm plotting board for analog and digital computer application graphically expresses variables applied in the form of D/C potentials, plotting the curve formed by one variable (X) against another (Y). Plotted curves can represent a variety of data, including analog and digital computer readouts, laboratory test data and business charts or graphs. An electroluminescent panel is used to backlight the full 30 x 30 inch plotting area. Rigidity of the plotting surface is maintained by a specially-designed honeycomb aluminum base. Resistance to abrasion is provided by the plastic writing surface. All major assemblies are plug-in modules.

THE AERO DIGITORK -- a numerically controlled X and Y plotter
Aero Service Corp.
A division of Litton Industries
Philadelphia 20, Pa.



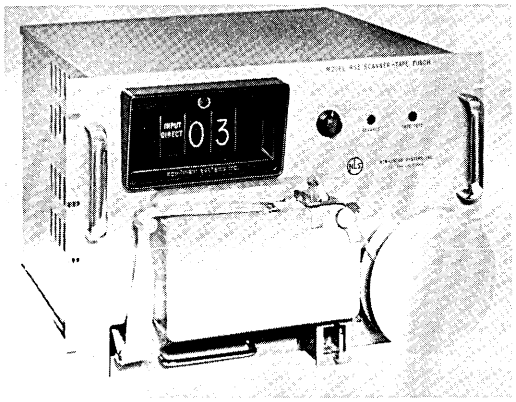
The Aero Digitork, an automatic X and Y plotter, uses Digitork stepping motors as mechanical actuators for the plotting table mechanism. These electrical motors respond to digital commands, manual controls, punched tape or cards and magnetic tape. The result is automatically programmed plotting over a 47¼ in. x 47¼ in. surface to ±.0025 of an inch. The plotter has path control; it is capable of producing a series of lines parallel to X and Y axes; and automatic accelerate and decelerate controls prevent overshoot, both in point plot and continuous line operation. Some applications include use in printed circuitry work, aircraft and automotive lofting, turbine blade design and charting flow patterns.

MODEL A-6-12 PLOTTING SYSTEM
The Gerber Scientific Instrument Co.
Hartford, Conn.



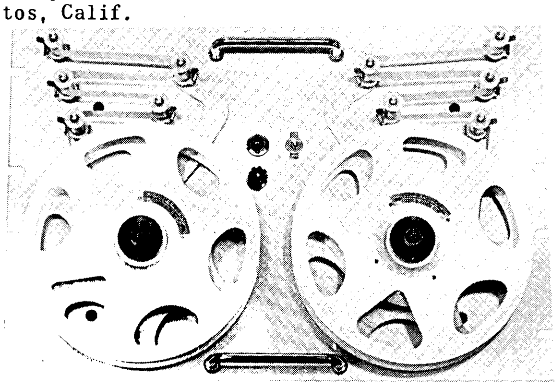
A new Magnetic Tape Controlled Plotting System is capable of drawing lines with an accuracy of ±0.001 inch (per foot) at speeds up to 300 inches per minute, and within ±0.002 inch (per foot) at speeds up to 500 inches per minute. Lines may be drawn in four colors, and 46 characters may be printed at the rate of over two per second. The system operates automatically from magnetic tape, or manually from the control console. The new plotter complex consists of four main parts (see photo left to right): the Plotter Table (6' x 12'); the Bendix Control Unit; the Power Distribution Cabinet; and the Control Console. Highly accurate engineering and assembly drawings, high-precision layouts, patterns and templates can be drawn on either sheet metal or paper at high speeds.

DATA LOGGER, NLS RS3
Non-Linear Systems, Inc.
Del Mar, Calif.



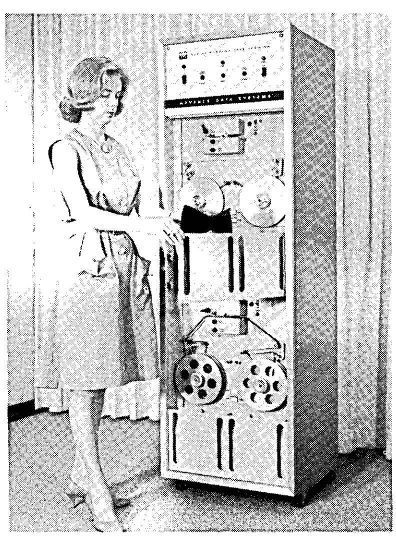
The NLS RS3 will automatically scan up to 20 input channels, feed the readings through a digital voltmeter and provide a punched tape record of each 4-digit measurement with its input channel number. The RS3 can accomodate any 5, 6, 7 or 8 channel tape code. Coding can be changed by shifting diodes on a plug-in circuit board or by interchanging prewired plug-in boards. Punching speed is 20 characters per second, nominal. Applications for the RS3 include automatic data logging and testing in electronic and electrical system check out, industrial process supervision and control, nuclear research, medical electronics, and data collection at remote sub-stations for power utilities and pipelines.

PANEL TAPE MINDER
Cycle Equipment Co.
Los Gatos, Calif.



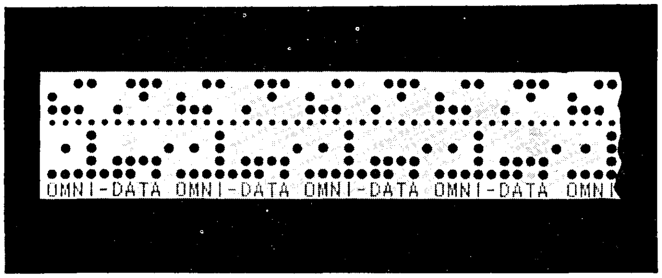
This new line of panel tape minders is versatile enough to be adapted to any type of perforated tape installation. The individual panel tape minders can be positioned for right or left feeding, as well as from above or below. Cycle Panel Mount No. 800, shown in the photograph, has at the right an 8" reel tape feeder fitted with a 2" core holder, and at the left an 8" reel winder, on a standard 19" wide radio relay rack panel. The tape goes from the feeder to the tape punching equipment, such as the BRPE Punch, and then is wound on the winding unit. Speeds are available up to 15" and 20" per second.

PUNCHED TAPE VERIFIER, ADS-04
Advanced Data Systems Corp.
Los Angeles 25, Calif.



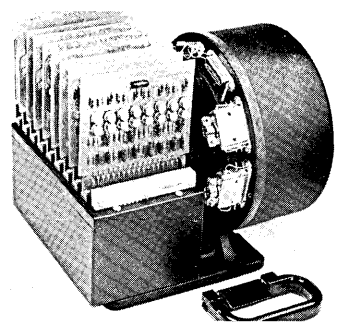
The ADS-04 is designed for use in preparation of tape programs used in missile checkout equipment, missile guidance computers, and numerically controlled machine tools. The tape verifier achieves a high degree of reliability by the use of 1) photo electric tape readers which can detect dirt and chad not detectable with mechanical readers; 2) tapes which stop on each character during comparison; 3) visible and/or audible indication of error; 4) verifier which will not advance tapes until reset when error occurs; and 5) semiconductor circuitry and modular construction. In addition to handling paper tape, the ADS-04 will operate with oiled paper, mylar, or aluminum-mylar laminate in lengths up to 1000 feet, spooled or fanfold, in any combination and at speeds up to 60 characters per second.

ELECTROSTATIC TAPE
Omnitronics, Inc.
Subsidiary of Borg-Warner
Philadelphia 23, Pa.



The new OMNI-DATA Edge-Interpreting Punched-Tape Recorder uses the high speed and accuracy of reflected-light photoreading and electrostatic recording for incorporating edge interpretation in existing punched-tape systems. The only modification to the punching and handling system is the substitution of OMNI-DATA electrostatic paper tape for whatever tape is presently used. There is no change needed in the usual handling, punching, and storage methods. The Punched-Tape Recorder consists of two stations: a unidirectional OMNI-DATA photoreader, which reads previously punched codes at 600 characters a second; and an OMNI-DATA electronic strip printer, which converts the data to alphanumeric equivalents and records them serially along the edge of the tape at the same speed. A section of 1-inch OMNI-DATA electrostatic tape, with punched codes and recorded alphanumeric characters along the margin, is shown in the photograph.

MAGNETIC STORAGE DRUM, MODEL 4-20
Cognitronics Co.
Braircliff Manor, N.Y.

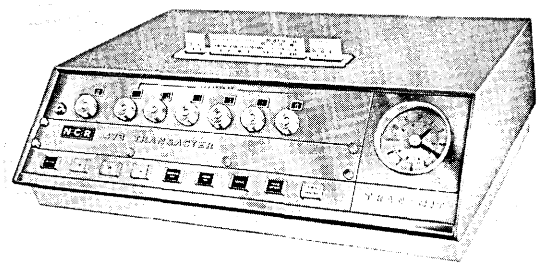


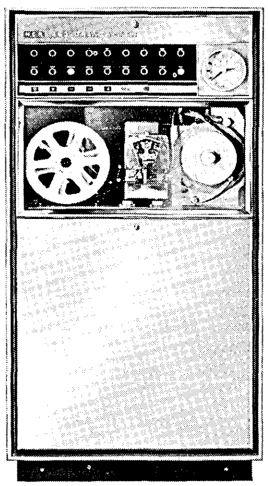
The Model 4-20 is a high speed drum access storage component for data reduction and processing systems or other related applications. The device has a dust cover enclosure which serves as an isolator to thermal shock. Heavy duty shock mounts insure stable operation in the presence of mechanical vibration. The pulley and belt drive provide flexibility for selecting drum speeds up to 25,000 rpm. The drum has a capacity of up to forty-four tracks whose heads are individually adjustable. Connections to the drum are made through spring-locked connectors. Matching printed circuitry for reading, writing and electronic switching is optionally available.

MONRO-CARD MAGNETIC RECORD
Monroe Calculating Machine Co.
Litton Industries, Business Machines Group
Orange, N.J.

The Monro-Card magnetic record is the size and shape of an ordinary tabulating card, but with a magnetic oxide coating. Capacities of either 1500 or 800 digits of information are available. The Monro-Card magnetic record permits stored information to be up-dated, changed or erased without destroying the original data document.

NCR 473 DATA INPUT
NCR 463 CENTRAL COMPILER
The National Cash Register Co.
Dayton 9, Ohio

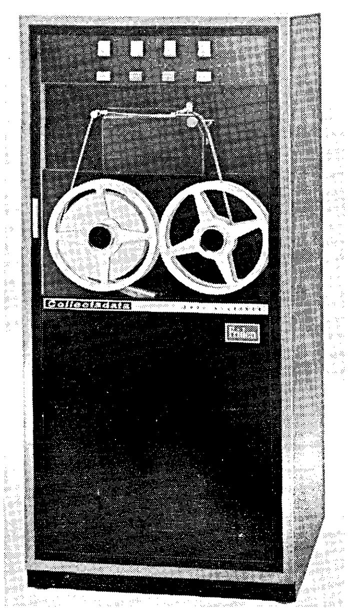




The NCR 473 transmits data at the rate of 60 characters per second. Maximum message length is 146 characters -- 130 from the input station and 16 from the compiler. The message format and length is programmed by internal plugboard wiring. The desired program is selected by dialing the proper message code. Each program determines and enforces what data will be transmitted and in the order in which it will be sent. There are ten basic message programs for transaction code, and by using modifiers, as many as 30 identification codes are available. Data input stations are connected by a single trunkline cable to the Compiler. Input stations can be located up to 2.7 miles from the compiler.

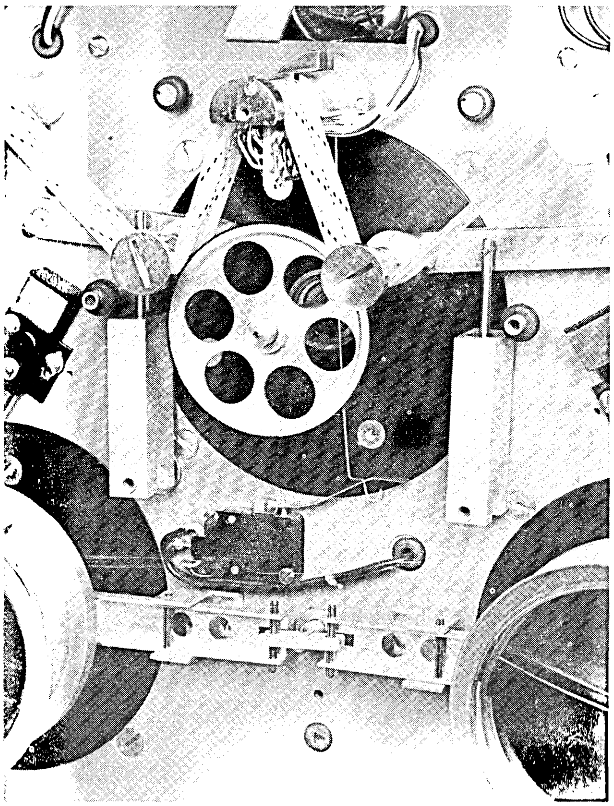
The NCR 463 Central Compiler punches 60 alphanumeric characters per second. Reel capacity is 1500 feet. Output is on 1 inch paper tape, dry or oiled. Eight channel IBM code is standard but any desired code may be obtained with the addition of the Master Translator to the Compiler. The Compiler can add up to 16 alphanumeric characters of information to the message received from the input station. Maximum message length for a single transaction is 146. Parity check is performed on all checkable codes at the time of punching. Pulse checks are also performed.

COLLECTADATA 3031 RECEIVER
Friden, Inc.
San Leandro, Calif.

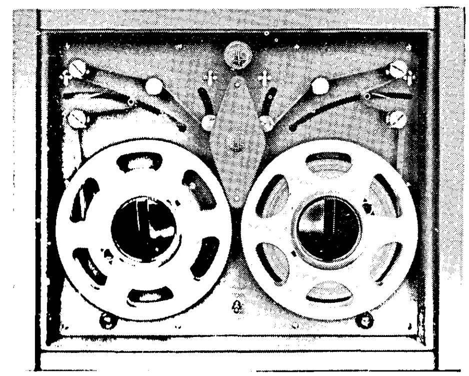


Model 3031 receives and punches into 8-channel tape information transmitted from the various points of origin. It contains tape handling mechanisms, control logic, and provides its own power and that of all transmitters on the same cable line.

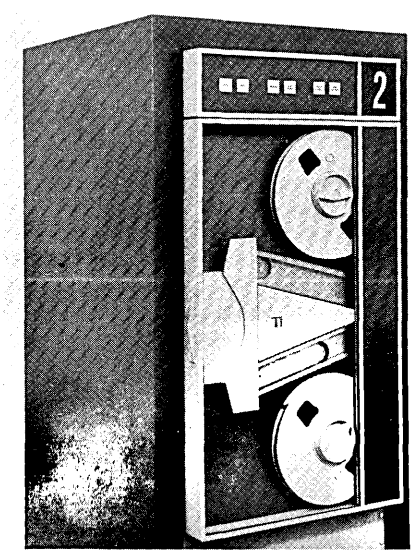
PHOTOELECTRIC TAPE READER, MODEL 300R
and PRINTED MOTOR CAPSTAN DRIVE
Photocircuits Corp.
Glen Cove, N.Y.



The photoelectric tape reader, Model 300R, (shown in photo below) uses printed circuit motors for both tape transport capstan and the reel servos. The printed motor capstan drive is shown in the picture at the left. Movement of the tape over the read head is controlled by the rubber covered capstan wheel connected directly to the shaft of a printed motor. Ball bearing rollers hold the tape gently against the capstan wheel, and insure that tape movement is in exact accord with capstan rotation. Use of the printed motor for tape transport allows free-running reading speeds of 400 characters per second and asynchronous (line-by-line) speeds of 300 characters per second without the use of brakes, clutches or pinch rollers.

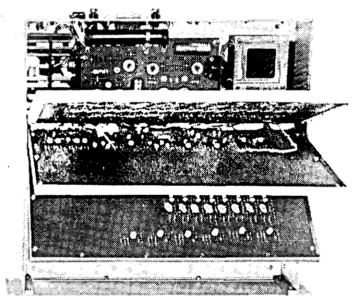


D 2020 DIGITAL MAGNETIC TAPE UNIT
Datamec Corp.
Mountain View, Calif.



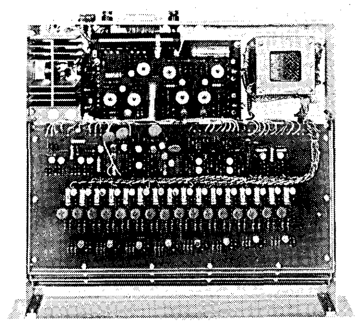
This magnetic tape device is suited to applications on small and medium scale computers and off-line systems where there are non-technical personnel and where long term continuous operation and low maintenance are required. The D 2020 is IBM compatible for tape formats of 200 and 556 bits per inch and has a 30 inches per second bi-directional drive with a 5 ms start and 1.5 ms stop. The series includes the transport, low and dual density signal electronics, and a complete group of options.

COMPUTER COMPONENTS

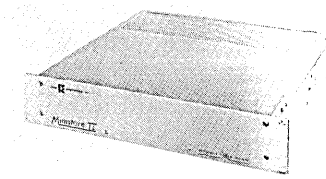


MINISTORE, A RANDOM ACCESS MAGNETIC CORE MEMORY
Rese Engineering Inc.
Philadelphia 20, Pa.

New circuit design and packaging are reported to yield lower cost, smaller overall size, and lower operating power for these memory planes. Pivoted printed circuit cards illustrate packaging technique of using universal boards with high packing density that can accept all the circuits required to cover storage capacities from 64 to 1024 words having a word length of 2, 4, 6 or 8 binary bits.

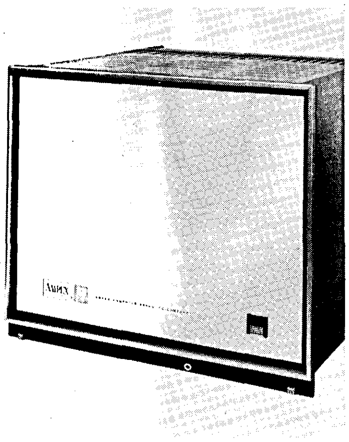


An interior view from the top shows the magnetic core storage array (upper right hand corner) and universal printed circuit boards containing core driving and sensing circuits. The complete memory is packaged in a standard 19 inch relay rack 3 1/2 inches high and 16 inches long.



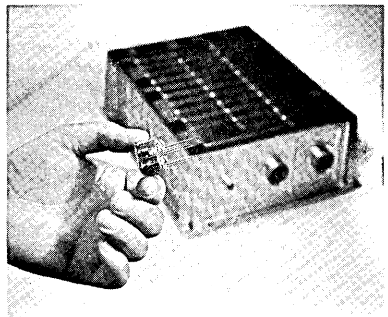
Ministore is all solid state design and is assembled from printed circuit logic cards. Data is stored and retrieved in parallel form. All core driving and sensing circuits are internal to the equipment. Applications for Ministore include its use as a working memory for a small digital computer, for input/output buffering, tape storage buffering, format control, data communications, and for use in special purpose data handling systems.

L



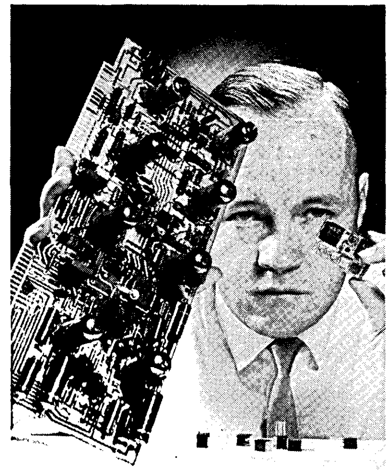
THE RVQ, FERRITE CORE MEMORY
Ampex Corporation
Redwood City, Calif.

The RVQ is designed for use with computers requiring small to medium storage capacity. It is available in 128, 256, 512, 1024, 2048, and 4096 word sizes and has an access time of 2.5 usec. Operating modes of the RVQ are: standard-random access with clear-write, read-regenerate, load and unload cycles.



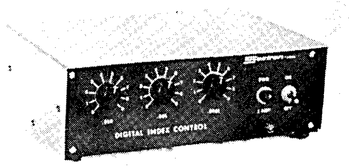
L-90 HIGH-SPEED MICROCIRCUIT
General Precision, Inc.
Librascope Division
Glendale 1, Calif.

This is an operating developmental model of a 20-megacycle flip-flop microcircuit for use in the L-90 aerospace computer developed by this company. The unit uses two integrated circuits for the flip-flop functions.



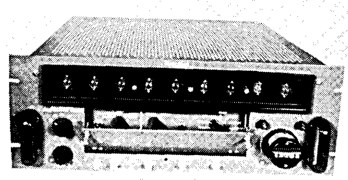
MINIATURIZED MICROMODULES
Goodyear Aircraft Corp.
Akron 16, Ohio

Engineer Harry Hellman is holding a miniaturized version of an amplifier which will do the same job as the complex tube-type device in his other hand. The micromodules, shown in the foreground, are fingertip-size units which contain 10 to 16 wafer-thin transistors, diodes, resistors, capacitors and inductors.



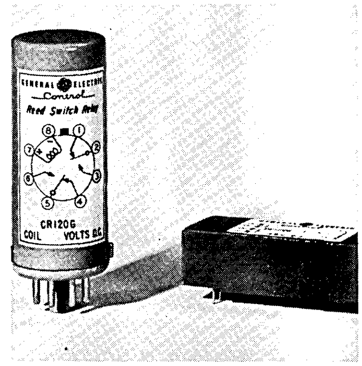
DIGITAL INDEX CONTROL,
SA1001
Sectron, Inc.
Salem, Mass.

Accuracies are possible within 0.0001 inches out of 2 inches on machine tools without requiring highly skilled operators. The SA1001 is a decimal controlled pulse generator for positive positioning of machinery through a stepping motor. It has direct setting, automatic indexing, modular components, a self-contained power supply, and direct coupling to existing control circuits.



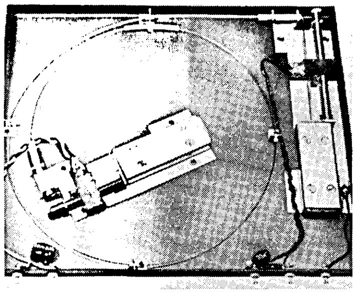
IRIG PRECISION TIME CODE
GENERATOR, MODEL HI-138
Hyperion Industries, Inc.
Digital Products Division
Watertown, Mass.

All of the standard IRIG formats are generated in serial modulated and unmodulated forms and a parallel time of day output is provided. The device can be expanded to accommodate other formats.



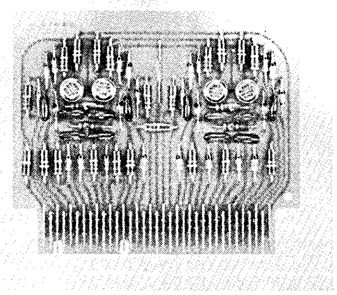
REED-SWITCH RELAYS
General Electric Company
Schenectady 5, N.Y.

The plug-in type reed-switch relay for octal base (left), and the printed circuit type reed-switch relay are capable of operating in 1.0 to 1.5 msec. These hi-speed relays will perform up to 900 cycles per second. They find use in data processing, scanning, counting, instrumentation and similar operations.



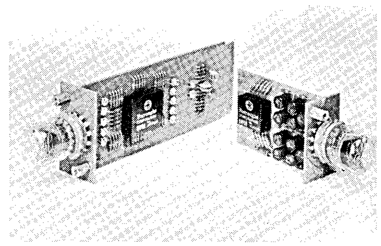
MAGNETOSTRICTIVE DELAY LINE
Andersen Laboratories, Inc.
West Hartford 10, Conn.

This 250 usec., 2 megacycle magnetostrictive delay line is capable of storing 500 bits of information in a return to zero mode of operation or 1000 bits of information in a non-return to zero mode. With a 10 volt drive pulse this line has an output voltage of 12 millivolts into 2000 ohms termination.



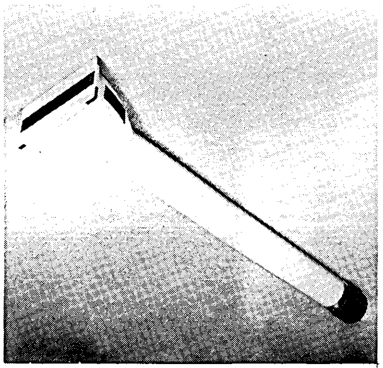
DIGITAL CIRCUIT CARD
Computer Logic Corp.
Los Angeles 64, Calif.

The CS-Series of digital circuit cards designed for counting and shifting operations are manufactured in three frequency ranges: Model CS-1 operates from dc to 300 kilocycles; Model CS-2 operates to 3 megacycles; and Model CS-12 operates to 10 megacycles. Each card has two independent flip-flops with gates for counting either up or down; and shifting, either right or left. Determination of any of the 4 possible operations is made by socket wiring. Selection between the 2 chosen functions is made by a logical control line.



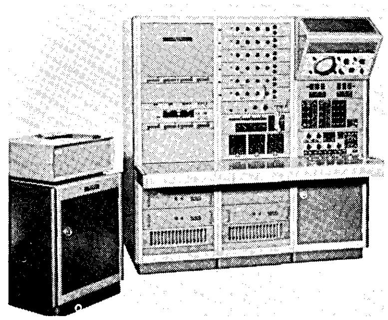
DECIMAL DECADE COUNTER, BIP-8001, and BCD To Decimal Decoder, BTR-58A
Burroughs Corporation
Electronic Components Div.
Plainfield, N.J.

BIP-8001 has 100 Kc frequency capability. BTR-58A is designed to accept 8-4-2-1 binary information. Both use plug-in printed circuit construction and provide visual in-line decimal readout of data with a NIXIE® indicator tube. The units feature a diode matrix which is fabricated from a single piece of silicon. The diodes are then joined to two circuit plates which provide input and output connections to the matrix.



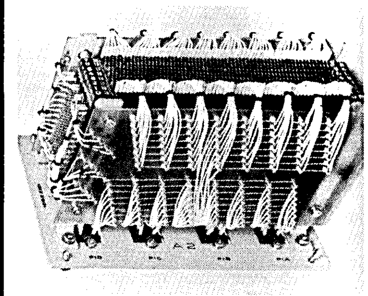
PRINTAPIX® CATHODE RAY TUBE
Litton Industries'
Electron Tube Division
San Carlos, Calif.

This cathode ray tube, the PX-275, has replaced the conventional CRT phosphor screen by a target mosaic composed of a pattern of .001" diameter conductive elements spaced on approximately .004" centers to form a printing area 2-3/4" long by 0.15" high. These conductive elements serve to directly transfer electrons from the electron beam to the printing medium, thereby establishing an electrostatic charge which is made visible by the selective adherence of a precharged pigmented powder.



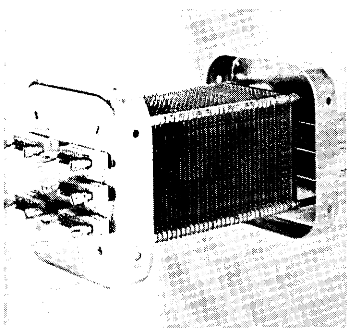
AUTOMATIC MEMORY PLANE TESTER, MODEL 2145
Computer Instrumentation Corp.
Cherry Hill, N.J.

The automatic memory plane and stack tester tests the continuity and directions of access and sense wires and determines the composite sense output characteristic. The system generates standard and experimental programs for all phases of memory test applications. There is a maximum scan capability of 128 x 128 cores in either the coincident-current or word-organized modes, which allows testing of coincident-current memories of up to 16,384 words, and word organized memory arrays holding up to 128 words, each with up to 128 bits per word.



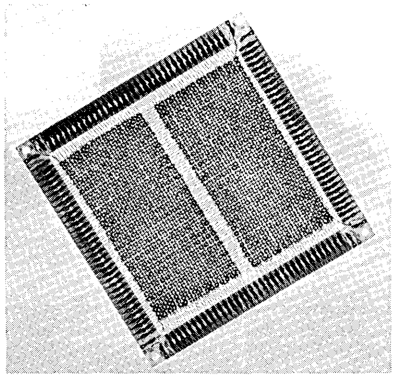
MEMORY STACKS
Ferroxcube Corp. of America
Saugerties, N.Y.

These core memory stacks have planes which are capable of storing up to 1984 information bits per plane. Ferroxcube commercially strings memory planes and stacks with 30 mil cores, and is presently developing units with smaller cores.



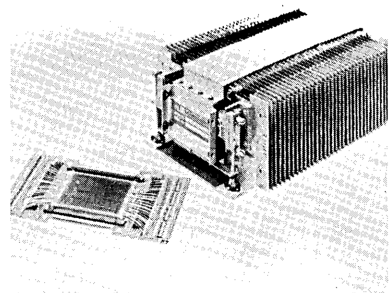
AZTEC 50 ARRAY
Ampex Corporation
Redwood City, Calif.

AZTEC 50 mil coincident current core arrays are available in various sizes as standard products. Complete 4096 word array occupies 10.25 square inches.



AMPEX 30 MIL COINCIDENT CURRENT CORE ARRAYS

Arrays are available in various sizes as standard products. The new stacks are said to deliver improved reliability over previous units on the market as a result of new soldering techniques known as the "Aztec pattern", which increases the amount of solderable area.

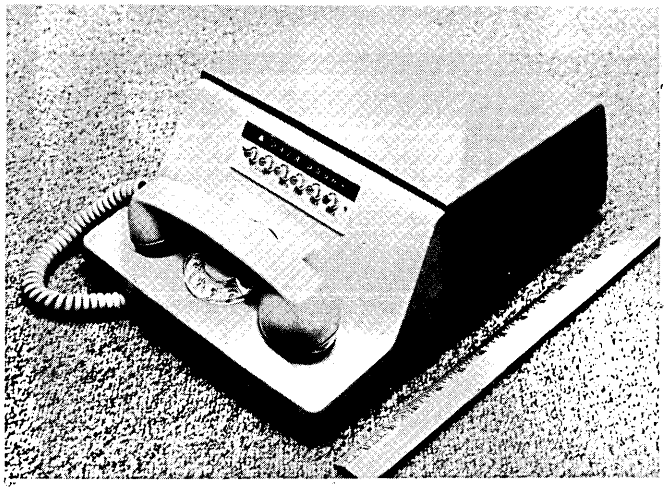


AZTEC 50 MIL COINCIDENT CURRENT CORE MEMORY STACK

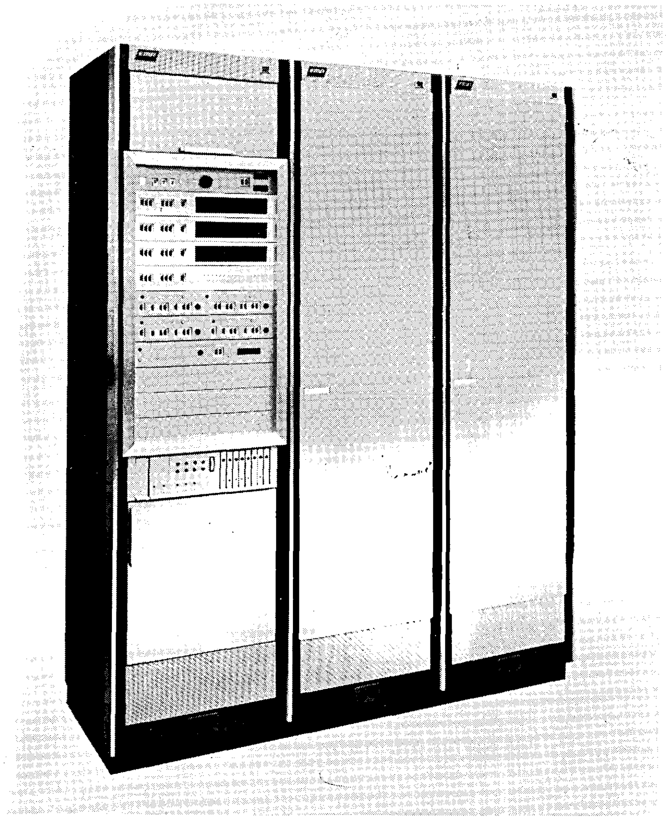
High speed operation is from 2 to 8 microseconds. A complete 4096 word array occupies 10.25 square inches.

DATA TRANSMITTERS AND CONVERTERS

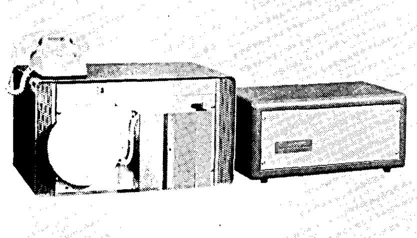
G-E Telemetering System -- General Electric Company, Schenectady 5, N.Y. / A remote meter reading system, developed with the cooperation of Northern Illinois Gas and the Illinois Bell Telephone Company, consists of GE's new Digital Telemetering Encoder (used at unattended locations), a GE Digital Decoder and specially modified DATA-PHONE service. Up-to-date meter readings are automatically obtained from remote un-attended locations by dialing the telephone number of the industrial customer. The identification number of that industrial customer and the up-to-date meter reading is automatically transmitted back to the Northern Illinois Bellwood office, where this information is then printed out on paper tape. The cycle time of this procedure is about 20 seconds.

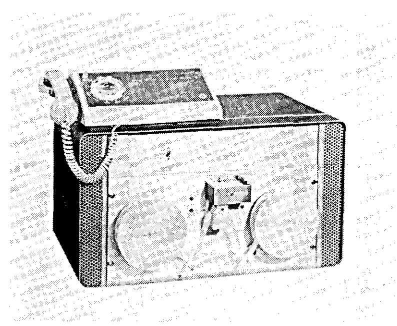


602A Data-Phone data set -- Bell Telephone System, New York, N.Y. / The 602A makes possible the transmission over regular phone facilities, of drawings, maps, charts, printed documents and other visual material, from one facsimile machine to another anywhere in the country. The 602A will probably be in regular production in the third quarter of 1963, with limited numbers of the new Data-Phone data sets available early in 1963.



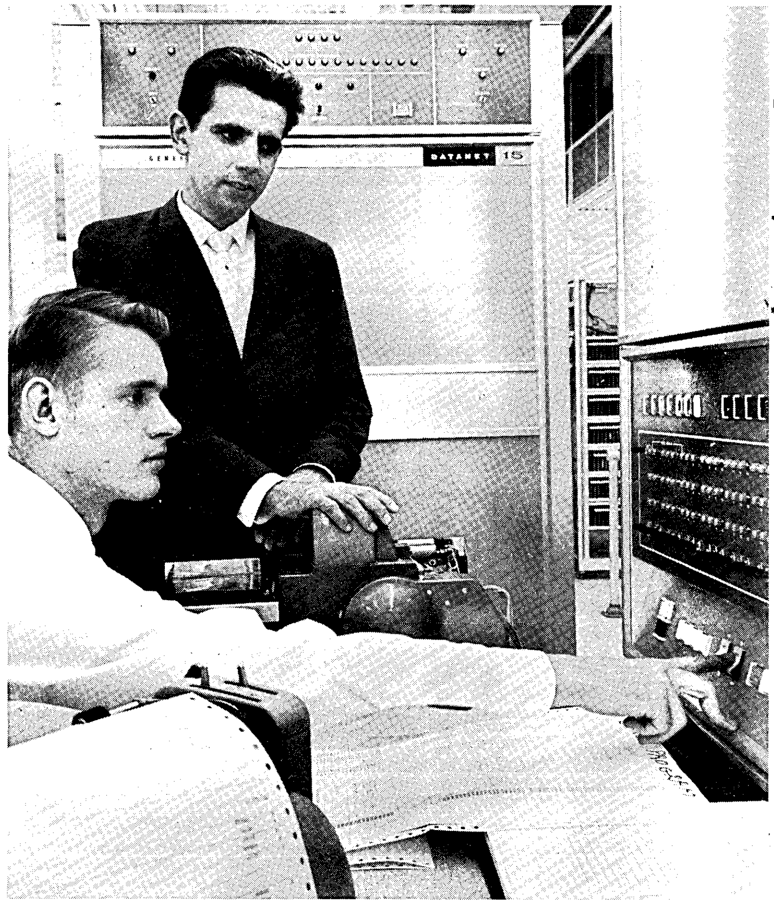
PCM Telemetry Data Processor, EMR Model 285 -- Electro-Mechanical Research, Inc., Sarasota, Fla. / The Model 285 data processor is designed to accept incoming PCM signals and convert them into formats suitable for peripheral devices, such as computers, high speed printers, tape punches, digital-to-analog conversion equipment, analog recorders, etc. Model 285 accepts incoming bit rates up to one million bits per second; data word lengths between 4 and 64 bits, and up to 10 different variable word length formats positioned anywhere in the frame. All word, primary frame, and subframe synchronizers operate automatically at three confidence levels. The system includes two main plug-in patchboards which can be preprogrammed for mission functions.



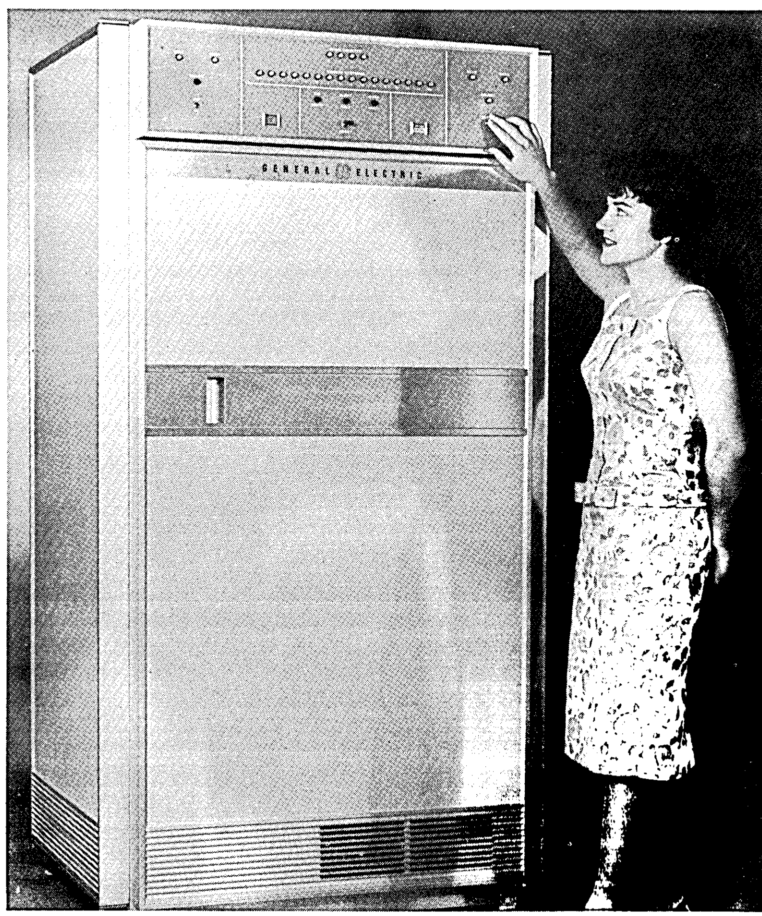


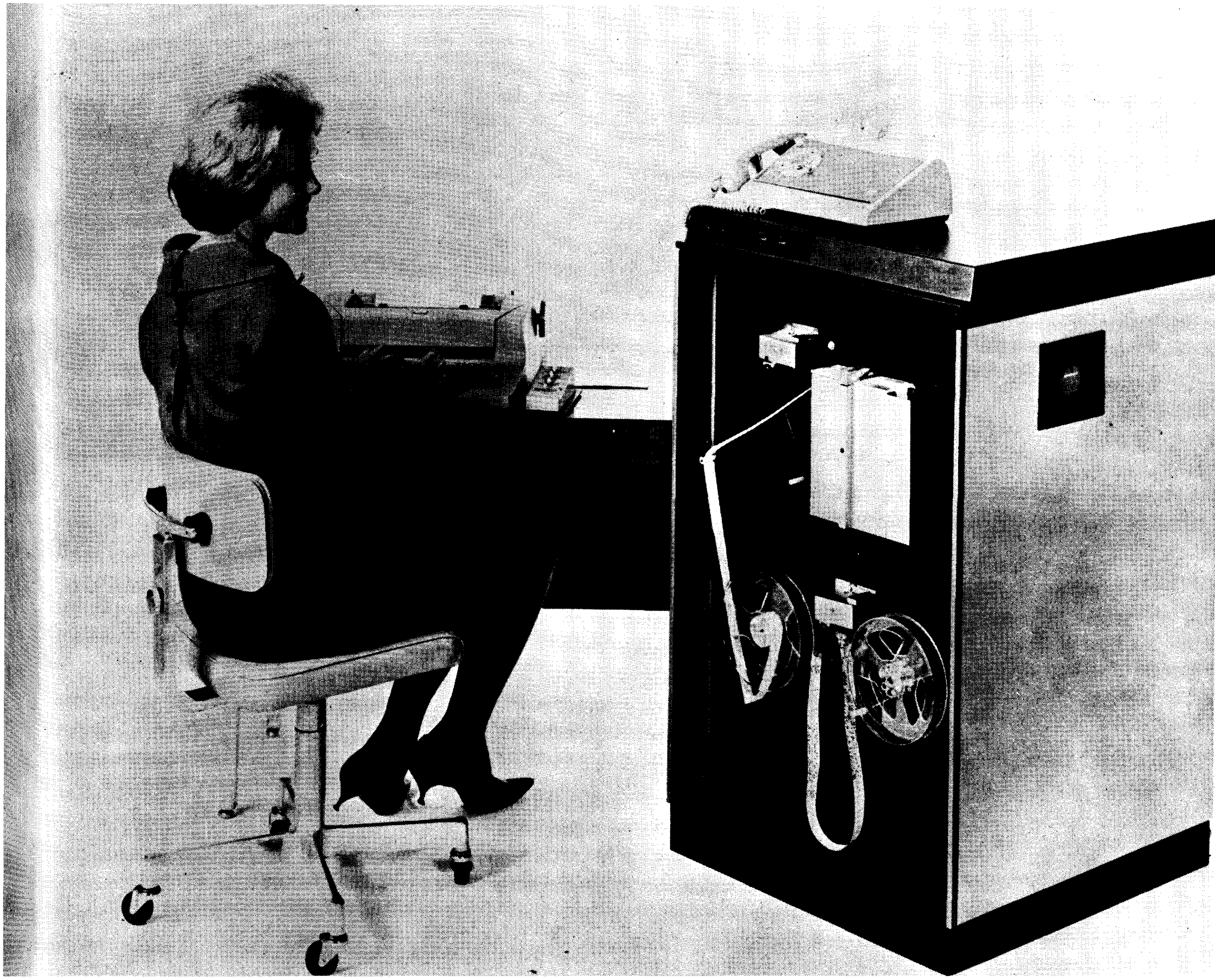
Mark 1 System -- Tally Register Corp., Seattle 9, Wash. / Three series of Mark 1 equipment are available for simple data transmission and reception. They are cable connected to Bell Parallel Data-Phone equipment. The Mark 1A with 402A Data-Phone (shown in the photo at left) is a transmit-only device. The Mark 1B with 402B Data-Phone (photo at right) is a receive-only device. Perforated paper tape is used as the data medium. All Mark 1 systems function with any code of 5, 6, 7 or 8 channels. All data transmitted through the communication line is duplicated on perforated tape with a maximum degree of accuracy at a rate of up to 750 words per minute. The Mark 1C system (not shown) is a bi-direction unit that combines a transmit and a receive device in a common cabinet. It can be equipped with either a Tally combined reader perforator or a separate reader and perforator.

Datanet-15 -- General Electric Company, Computer Department, Phoenix, Ariz. / During a test of General Electric's new Datanet-15 communications system (background), two computers passed information back and forth via Telstar communications satellite. Messages covered some 13,000 miles from Phoenix, Ariz., reaching Telstar as it orbited over the Pacific Ocean, to Schenectady, N.Y. in a matter of split seconds. Shown during the tests, are William H. Bridge, manager of special systems engineering at GE's Computer Department (standing) and computer programmer Gerald E. Olson.



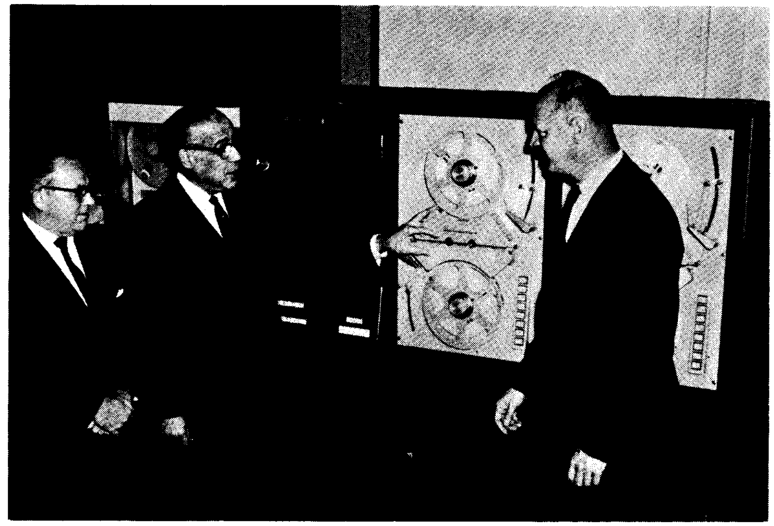
Datanet-15, data-transmission controller -- General Electric Company, Computer Department, Phoenix, Ariz. / The Datanet-15 has two basic channels, with 6- or 15-channel capability for queing. Digital data is sent or received on two-wire cable, telephone or telegraph facilities operating on-line with the GE-225 computer or its peripherals. Finger-tip controls and indicating lights are up out of the way of passing personnel.

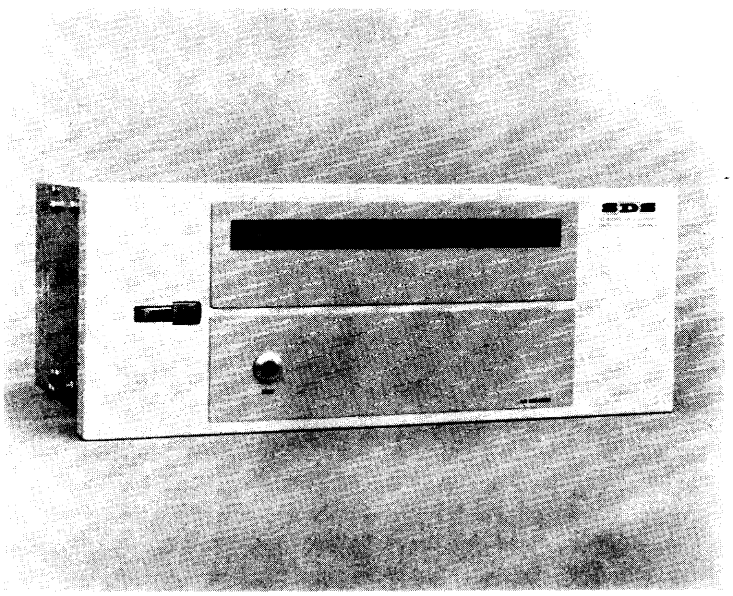




Mark 51P Programmed Paper Tape Systems -- Tally Register Corp.. Seattle 9, Wash. / The Tally Tape Programmer is a control device consisting of a Model 424 Reader and Supporting Logic. The program is stored on the reader in a paper tape loop. The average typist can operate the equipment with a nominal amount of training. Uses of the equipment are: 1) forms writing where a tape for data processing and/or transmission is required; 2) edits a previously punched tape; 3) provides hard copy format while automatically printing out a previously punched tape and 4) any combination of these operations.

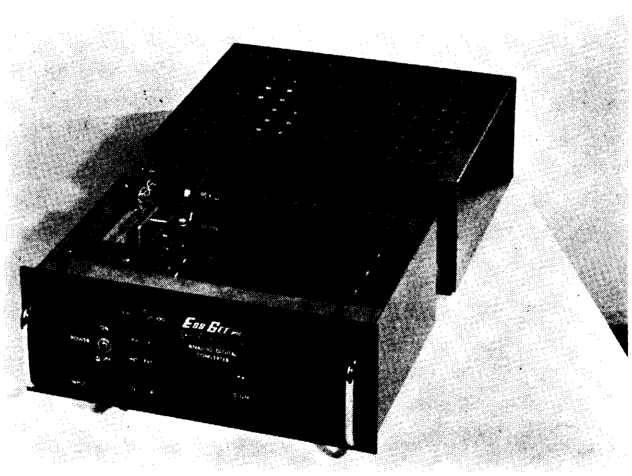
Digitronics D112 Converter — Digitronics Corporation, Albertson, N.Y. / Spiegel Inc., the nation's third largest mail order company, uses this converter to help speed 55,000 catalog orders per day. The D112, operating at 10,000 words per minute, converts paper tape to magnetic tape, detects and records errors in the paper tape, accumulates and prints out daily sales totals by departments, and permits information to be entered into the computer at 150,000 words per minute. Shown at right are (left to right) Charles Faulkner, Spiegel Computing Center Manager, Frederick W. Spiegel, Executive Vice President, and James D. Moe, Digitronics District Manager.





AD Series of analog to digital converters — Scientific Data Systems, Inc., Santa Monica, Calif. / The AD Series of analog to digital converters are high-speed, all silicon semiconductor devices that operate at speeds in excess of 5 microseconds per bit. They operate from 0° to 100°C. Transformer coupling is provided for all digital control and output signals in order to eliminate system grounding problems.

Analog to digital converter — Ess Gee, Inc., Elmsford, N.Y. / This solid state two digit A to D converter, complete with power supplies, is capable of 200 conversions per second. The absolute accuracy of the converter is ±1% of full scale or ±½ the least significant count. Resolution is 1% of full scale.



INTEGRATED AUTOMATIC CONTROL SYSTEMS— APPLICATIONS and FRONTIERS

PART 2

John R. Moore
President
Autonetics, a division of
North American Aviation, Inc.
Downey, Calif.

A skilled and significant analysis of the present science of automatic control, and its application to defense, space, and automation. The frontier problems that challenge its application are thoughtfully reviewed.

(Continued from November Issue)

Non-Defense Space Program Applications of Automatic Control

There are, of course, many other facets of automatic control outside of those directly associated with governmentally-sponsored activities. Many of the techniques and devices which are used in commercial-industrial applications give promise of commanding an increasingly large percentage of the total automatic control effort and represent a great opportunity for increasing man's standard of living and for a smooth transition from an economy geared to cataclysm prevention to one preoccupied with improving man's happiness and well-being.

Industrial and commercial automatic control systems are aimed at making improvements in the performance of tasks which otherwise would have to be done by human operators. Into such categories fall all of the industrial-control activities; the commercial aircraft and ship automatic pilots; and the increasingly complex and competent systems for all types of traffic control. Such applications are becoming widely recognized as part of a major economic and sociological factor termed "automation." We mention here but briefly two classes of industrial automation as indicative of first attempts to use the new science for peaceful purposes.

Automation of Manufacturing. One of the earliest industrial uses of automatic control was in the automatic control of various manufacturing activities. Whereas special purpose automation has long been used successfully in specialized manufacturing operations, the digital control of general-purpose machine tools has had a more discouraging history. This has been the result of both technical and economic factors.

In the technical area there has been the general problem of reliability of electronic equipment and the difficulties of adapting controls to existing machines. However, these technical factors have been of far less significance than the economic aspects of the application. Here the difficulties have included the questionable economic advantage of automating a machining process if resulting "set-up times" are excessive by comparison; the cost of numerical-control systems compared to advantages gained; the small market which results in high development costs per unit; and the high costs of establishing an adequate electronic service and repair capability within the automatic machine tool control industry before complex installations can be accepted for factory automation.

Automation of Plant Operation. The second major industrial application of automatic control is in the control of the operation of various kinds of continuous-process plants. These include chemical process plants, food and drug production, oil refineries, metal producing and processing mills, atomic reactor installations, and all types of public utilities. Here the installations have evolved from man-machine combinations in which the man is the principal controller, toward more and more completely automatic systems. It should be noted that on-line use of digital computers in these applications has long been recognized as having very great potential advantages, not so much from the savings in labor which may result by replacing a few plant operators with robots, as from the increase in plant output which is possible by closer and more accurate control of the process.

Why then have digital computers not been applied to many more plants today than they have? The answer is once again both technical and economic. From the technical standpoint, the question of guaranteed reliability of electronic equipment has been a major deterrent. On-line computers must fail safe or their failure could cause a catastrophe—both by ruining the products which were being processed at the time the failure occurred, and also by damage to important plant facilities and injury to personnel. A second technical problem—which is also economic —involves the system engineering required to adapt a plant to digital control. A purely economic factor is the gamble involved in converting an already profitable operation to a more automatic one whose advantages can only be proven by actual experience. Other economic factors are the loss of production during the down time required for the installation; the actual investment in the systems engineering; the cost of digital computers, sensors, and power elements; and the expenses of maintenance and repair of equipment which is unfamiliar to the plant's existing maintenance organization. All of these reasons have combined to make the application of electronic digital computers to on-line control of plant operations a venture whose economic history to date has often been written in red ink.

The New Frontiers of Integrated Automatic Control

Technical Frontiers. It is, perhaps, symbolic of the explosive progress of the science of integrated automatic control that a number of new technical breakthroughs have occurred which, if actively pursued, will produce far more change by 1975 than has transpired since the advent of the transistor. These breakthroughs involve both devices and concepts.

In the area of devices there is the whole field of developments generally lumped under the umbrella of "microminiaturization," energy conversion elements, low-noise amplifiers, MASERS, LASERS, cryogenic devices and plasmas. In the realm of concepts the list must include adaptive control systems, the whole field of logical design and, most important, the concepts of bionics—the electronic simulation of *functions* of the human brain and nervous system in areas of learning, memory and pattern recognition.

1. *Microminiaturization.* It may well be that future historians, cataloguing the accomplishments of the 1960's, will select microminiaturization as the most important technical accomplishment of the decade. This is because the advantages of microminiaturization reach into literally every field of scientific endeavor. By now, almost all technologists involved with automatic control know something about microminiaturization. Suffice it to say here that microminiaturization includes as the principal factor the means for producing complete circuits without the need for handling, soldering, or otherwise risking damage to each of the circuit components. Such circuits involve active and passive elements and are basically solid-state devices after the manner of transistors. These, and other new techniques, make it possible to achieve component densities, even with interconnections, of between 10^6 and 10^7 per cubic foot. With such component densities it is possible to develop control amplifiers and digital computers with tremendous capacity in a very small size, requiring very small amounts of power.

Important as the reduction of size afforded by microminiaturization is, this feature is of much less significance to the new automatic control applications than the potential increase in reliability of the microminiature electronics over conventional "printed" circuits. This expected increase in reliability is intrinsic in the microminiature circuits themselves, because many human operations are eliminated in their manufacture, each of which could cause a failure. These new circuits involve such low levels of power that overheating is not a problem. An important additional means of increasing the reliability of microminiature electronics lies in the use of redundancy of circuits, groups of circuits or complete equipments. This is now feasible because of the great reduction in size.

In addition to the reduction in size and increase in reliability, microminiature electronics can be produced at costs which will represent major reductions below the cost of present equivalent transistor circuits —all of which makes it possible to consider applications of automatic control which were never before feasible.

2. *Low-Noise Amplifiers.* Another important development which is closely akin to the controller-computer type of microminiaturization is the low-noise amplifier. This opens up a whole host of new applications involving tiny sensors with signal outputs which previously would have been too small to amplify by conventional means. It also opens up a new class of applications involving the wireless transmission of information via coded signals inside equipments.

3. *Field-Phenomena Devices.* To date, most electronic controller and computer designs involve the concept of circuits—that is, sets of discrete paths along which power and information are transmitted in the form of electrical signals. Even the concepts of microminiaturization involve new ways to make circuits smaller, cheaper, and more reliable; but they are basically similar to the transistor circuits of today. A most challenging domain for research, however, lies in the use of the phenomena of continuously-distributed fields and the distributed elements which control them. Such distributed devices may ultimately replace many designs using lumped parameters.

4. *LASERS.* An exciting new development is the LASER, a generator of coherent light beams. The LASER will provide a means for the transmission of very large amounts of information on a very narrow beam of light. It also has other interesting properties not directly applicable to automatic control.

5. *Breakthroughs in Concepts—Adaptive Control.* The need for adjusting control parameters to optimize performance of a system with widely varying conditions has led to the concept known as "self-adaptive control." By-product advantages claimed for self-adaptive control include reduction in control-system development and test time, the ability to accommodate wide environmental changes, and the ability to adjust to configuration changes without requiring changes to the basic control system. The use of digital computers greatly increases the potentiality of adaptive control; however, if digital computers are to be used successfully, major improvements must be made in digital sensors and digitally-operated power elements. With digital input signals and digitally-actuated power elements, complete digital systems can be developed which will be the ultimate in adaptive control, using as they will the "learning machine" techniques of the new science of bionics.

6. *Breakthroughs in Concepts—Bionics.* With the tools provided by microminiaturization, we can now attempt to reproduce electronically many of the capabilities of thinking, learning, and reacting which characterize living beings. Such concepts constitute that portion of the automatic control technology known as "bionics." Generally speaking, bionics provides a means for approaching the science fiction concept of the complete robot—capable of accomplishing almost any type of "mental" task. This is a new science, and one which is receiving an increasingly large amount of attention by technologists throughout the world. Its basis is the application of the continually evolving concepts of logical design.

Bionic systems have been conceived that will recognize patterns; "learn," on the basis of "experience," an apparent relation between cause-and-effect in which certain identifiable patterns result in certain optimum "next steps"; memorize with as much abstraction as possible the various-pattern cause-and-effect relationships; and indicate or initiate action.

Conceptually, bionic controllers can ultimately be developed to perform all of the functions of adaptive controllers, including the optimum handling of signal-noise combinations. However, the automatic control system designer should recognize that there will continue to be many "simple" tasks that can be performed more cheaply, more reliably, and with smaller equipment by controllers of more conventional design.

7. *Desirable Technical Breakthroughs.* The discussion of technical frontiers of integrated automatic control would not be complete without mentioning some needed technical breakthroughs. The following are mentioned without any attempt to establish their relative importance.

a. Smaller, higher-capacity energy storage and conversion elements.

b. Smaller, more sensitive, more reliable sensors with digital output: for radiant energy, acceleration, angular velocity, angles, pressure, viscosity, temperature, voltage, current, magneto-motive force, mechanical strain, chemical, and crystalline structure of matter.

c. Smaller, more reliable, more powerful power elements, both electrical and mechanical.

d. Smaller, more sensitive, low-noise electronic signal amplifiers.

e. Smaller, lower-noise power supplies.

f. Smaller, more reliable, power-switching elements.

g. Field-phenomena controllers and computers which can accomplish the same functions as sets of connected elements, without the requirement for connections.

h. Multi-stable (as contrasted with bi-stable) computing elements, and a new logic to increase the computing capacity for a given amount of equipment.

i. Improved means for complex interconnection of system elements, thereby eliminating many reliability problems.

j. Multiple-path systems which can recognize a failure within themselves and "heal" the failure by automatically establishing a best alternate configuration to take over the duties of the faulty element.

k. "Electro-protoplasmic" systems which have within themselves the capacity to repair an "injury" or failure in a manner analogous to living matter, while adopting a substitute configuration during the repair.

Application Frontiers of Integrated Automatic Control

Technical breakthroughs, superimposed upon the present broad spectrum of applications, give promise of an explosive growth of integrated automatic control in nearly all forms of human endeavor. The number of these potential applications is so large and varied that any attempt to classify them into major discrete segments of activity is certain to develop inconsistencies and overlaps. However, it will be expedient to consider here a breakthrough which does not distinguish between military and non-military applications but rather constitutes a classification by general type of problem. In all cases microminiaturization, with its promise of increased reliability and reduced size and cost, will play a key role and will determine the feasibility of the application. We will not attempt to classify these potential applications into major discrete segments of activity, but rather into classifications based upon general types of problems only.

1. *Space System Applications.* Currently, the popularly sensational applications of automatic control systems lie in performing the various tasks required by the space program. All of our satellites presently in orbit, and the great majority of those planned for the future, depend entirely upon automatic control for all of the functions which they must perform. They are placed into orbit by automatic pilot and automatic navigation systems. Their scientific sensors are operated and their data accumulated and processed by automatic means. Communication between the satellites and the earth is effected automatically; and, finally, when recovery of the space capsule is required, this is also an automatic control process.

The principal requirements of automatic control applied to space vehicles involve concentration on reliability, small size, low power requirements, and extreme versatility. The necessity for operating in an environment which includes the acceleration of the boost systems, the high-energy radiation of the Van Allen belts, the weightlessness, and the extreme variations in temperature and pressure of the vehicle's external environment also constitute major technical challenges which must be met by the space vehicle automatic control system designer.

Another way in which integrated automatic control has become an essential partner of the space program is in the various equipments of the ground system. Here automatic control must be applied to very sophisticated automatic checkout, countdown, and monitoring equipment; to the accurate operation of tracking radars and optical sights for orbit determination; to the command and control elements of the space system; and to the retrieval and processing of data gathered by the spacecraft.

Ultimately, it can be expected that bionic automatic-control systems will play an important part in all aspects of the space programs, particularly in activities aboard the space vehicle and other vehicles (such as the "Lunar Prospector") used for exploration of the surface of the moon and planets. Here the flexibility and adaptability of bionic systems will be an invaluable substitute for the relatively frail human astronauts.

2. *Vehicle Control.* Just as the first application of continuous, closed-loop automatic control was to vehicles, so the control of the increased variety of vehicles

constitutes a major frontier of integrated automatic control systems during the next decade. Such vehicle control will involve the automatic mechanization of some or all of the functions normally performed by the pilot, navigator, engineer, communicator, and vehicle commander, which, of course, in many applications are all performed by a single individual. However, it is now feasible to contemplate complete control of all types of aircraft and missiles, from power-on to power-off, including take-off and landing. Schemes already exist and have been experimentally demonstrated for such complete control of aircraft. The fact that they are not being widely used results from limitations presently imposed by equipment reliability, cost, and size. With additional technical breakthroughs in the field of automatic control, we may look for the elimination of these deterrent factors.

The same principles and equipments used for the control of aircraft will also be applied, with suitable variations, to the control of helicopters, surface ships, submarines, and hydrofoil vessels. These applications lie in the present or near future, and the frontier of automatic control in this area consists primarily of improvements in reliability, versatility, size, and cost.

There is also another type of vehicle control which is just as possible, but fraught with many more difficult practical and economical problems. This is the control of land vehicles—automobiles, trucks, and ground-effect machines—operating over streets and highways. Here the requirements of reliability are as extreme as those for "every man's aircraft." Furthermore, the cost of the equipment must be substantially reduced. It is theoretically possible to predict a bionic steering and speed control system for wheeled vehicles which applies principles of pattern recognition, through optical or electro-magnetic sensors, to keep a vehicle in the proper lane and to automatically avoid collisions. The combination of technical problems involving absolute reliability and the economic problem of the cost of the equipment makes this application appear to be far off.

3. *Automatic Traffic Control.* A necessary condition for the increase in human mobility is improvement in the means for controlling the motion of large numbers of vehicles in congested areas. Air-traffic-control is a complex systems problem requiring the correlation of large amounts of information and the generation of appropriate instructions, either verbal or automatic, to the aircraft in the controlled area. Not only does air-traffic control require increases in the capacity and reliability of data handling equipment, but more importantly, it demands an increase in the accuracy of information regarding aircraft position and velocity components; and a more rapid and accurate response by these aircraft to ground instructions.

Other applications of automatic control to vehicle traffic involve marine vessels in and near harbors, and road vehicles in congested urban or suburban areas. Both of these applications require improved means for detecting vehicles, for communicating with their occupants, and for processing the data associated with vehicle positions and speeds. It will also be necessary to effect tighter control of vehicle speed and acceleration if the full benefits of such a traffic control system are to be achieved.

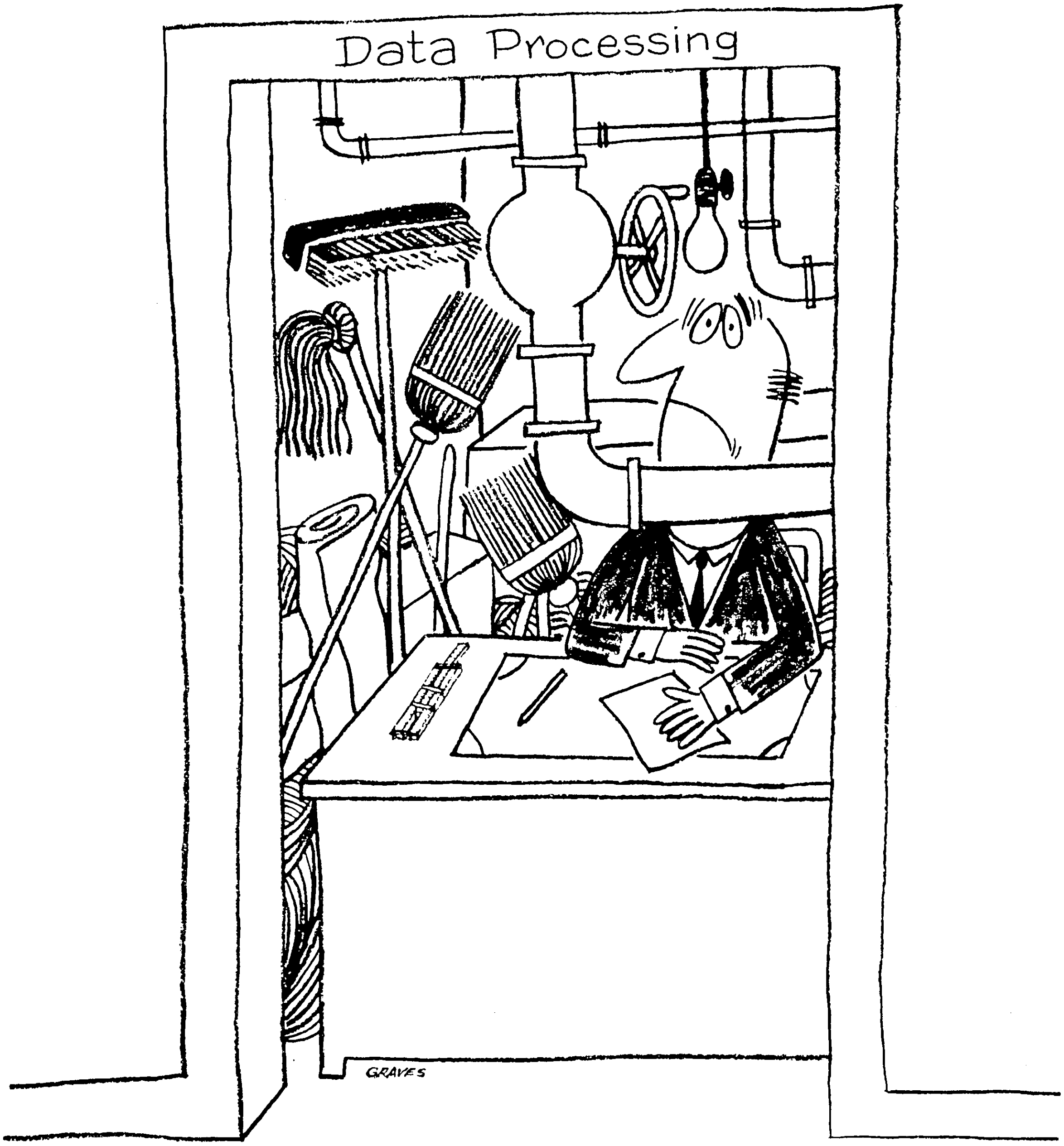
4. *Automatic Production Applications.* The biggest stimulus to the increased automation of machine tools, assembly operations, equipment testing, process control, and plant operation, will be a substantial improvement in the reliability of electronic equipment. Once again, the flexibility and adaptability of bionic control systems should open the door to new applications of automatic control to the various phases of production of goods, power, and services. The consequences of providing automation capability for general purpose production equipment will be far reaching. This is because such automation will greatly reduce the cost of "custom built" devices and make it feasible for a manufacturer to produce, at a reasonable cost, small lots of goods for sale to a temporally and geographically local market.

5. *Automatic Maintenance and Repair.* The same principles and elements of the programmer-comparator and its adapters, as well as more specialized automatic equipments, will have to be applied wherever complex equipment is used. This is true in the maintenance of automatic factory and plant operation systems as well as the preoperational checkout and fault isolation of complicated vehicle systems. It provides another potentially important application for micro-miniaturization and bionic controllers.

6. *Business System Applications.* The application of automatic control to streamline the operation of the "papermills" of business constitutes a major segment of the integrated automatic control potential. Thus far, most attempts in this area have involved man-machine combinations based upon the use of high capacity, fixed installations of large and expensive electronic data processing equipment. This concept has been carried so far that much work is being done on means for communicating between all portions of a complex operation and a central computer into which all data will be fed, and by which it will be analyzed, stored, and redistributed.

This "all or nothing" central concept is less practical and efficient than a concept using much smaller, portable "satellite" centers located at strategic points throughout the business operation. This concept recognizes that the largest amount of essential communication exists completely within relatively small operating entities of an organization. By designing the business systems to serve this series of "inner loops" of the whole system, it is possible to minimize the total amount of data processed, to reduce the reaction time, and to render the system less vulnerable to a failure of the central equipment. Of course, certain outputs of such satellite computing centers will have to be cross-fed to other satellite centers and to a central computer to provide the proper coordination and control of the decentralized operating elements for the maximum benefit of the whole system.

7. *The "Automatic Secretary."* We have all heard of attempts by pattern-recognition scientists to replace


Data Processing
GRAVES

the functions of a secretary (I say functions advisedly because I am sure none of us believes that a machine can ever replace a female secretary). The "automatic secretary" would automatically type out dictated information, based upon analysis of the sound patterns and correlation of these patterns with a dictionary of words. One potential mechanization of the "dictowriter" would again involve a type of bionic learning-machine. Such a device would have an advantage over the "canned dictionary" approach, in that it could actually enlarge the scope of the pattern analyzed to include complete phrases or sentences, upgrading the quality of the grammar as necessary.

8. *The Automatic Linguist.* A similar device is the automatic language translator. Original attempts at the mechanization of language translation involved the use of dictionaries built into the memory of the machine, whereby a literal word-for-word, dictionary-to-dictionary translation would result. A few attempts in this direction have revealed the basic inadequacies of the system because of the different meanings of words and the different rules of grammar and idioms employed by different languages. The flexibility of the learning-machine approach to translate, via pattern recognition involving large and complex patterns and by the ability to synthesize patterns from sub-patterns, offers a potentially superior solution to the automatic language-translator problem.

9. *The Automatic Oracle.* Further application of the principles suggested for the "automatic secretary" and the "automatic linguist" opens up a whole new field of bionic applications. Generally speaking, these might be termed the "automatic oracle." Such a concept involves the use of learning machines to become expert in the answering of certain classes of questions or in the analysis of particular types of problems. Thus it is conceivable to have in an executive office a bionic machine capable of business-situation analysis. Such an aid to decision making would have the advantages of infallible memory and the accurate correlation of existing situations with those which had occurred in the past or which could be synthesized from pertinent past experience.

The concept is applicable to almost any field of human mental activity, limited only by the oracle's internal capability and logic, and by the time available to teach it to become an expert in a particular speciality. Thus, the automatic oracle might become a legal expert, a procedural expert, a medical expert, a scientific specialist, etc., ad infinitum.

10. *Automatic Information Retrieval.* One class of applications for automatic data processing and control equipment is known as "data retrieval." One of the largest operating problems throughout the economy is that of indexing and identifying data in accordance with the various characteristics used to describe it. Many businesses such as libraries, insurance companies, banks, brokerage houses, loan organizations, and title insurance companies continually accumulate vast quantities of data which must be indexed and stored for ready access. All of this has made data retrieval a most important problem to be attacked by the integrated automatic control industry.

11. *Application to Medical Science.* The advent of microminiaturization and low-noise amplifiers, combined with improvements in sensors, makes it possible to expect major benefits to medical science. Miniature sensors attached to or implanted in a human body could broadcast their findings either to a nearby control center or to a microminiature receiver-memory unit carried on the body. This would provide an opportunity for introducing quantitative dynamic measurements into medical science. These techniques could be used both to determine the range of "normal" readings more accurately and to correlate these readings with causal phenomena to diagnose the existence or severity of an ailment. Measurements of this sort, used in combination with a medical "automatic oracle," would be of invaluable assistance in diagnosis.

Other applications of automatic control to the science of medicine would involve the treatment of ailments, as well as their diagnosis. Thus, microsensors could be used to detect the effect of drugs well in advance of any gross symptoms detectable by the patient or by conventional medical means. This more precise "error" detection might be used as a part of a feedback loop to determine the quantity of medication optimum for the particular patient under the particular circumstances of the moment. Thus it is reasonable to predict that the application of the developments of automatic control to medical technology constitutes one of its potentially greatest benefits to mankind.

12. *Communication Equipment.* The general field of communication, which first provided the tools for control-system synthesis, now represents one of today's most important scientific frontiers. As in the case of the automatic factory, so much has already been written about the bright future of the communication industry that it will not be profitable to belabor it here, except to forecast the day of the telephone for every automobile, the transoceanic telecon without delay, and the interconnection of remote world areas by video links.

13. *Application of Automatic Control to Governmental Activities.* The same principles and equipments of automatic control which can be applied to business can also be applied to the more complex management and service functions of government. These include the business and data retrieval systems and "automatic oracles," useful as administrative aids to government agencies and departments. They also include the capability to perform the extremely complex economic analyses required to make and implement government policies. Such analyses would be useful, for example, in understanding in advance the probable consequences of such actions as a modification of the prime rate; a change of credit policy; the award or cancellation of major defense contracts; and the build-up or draw-down of business inventories which are so influential in booms and recessions.

Another class of governmental activity lies in the general area of services, such as the handling of mail. Several European countries are working on machines for automatically handling, sorting, and distributing


f = 3wb²/4t²(1+1.61b²/a²)

letters; attempts have also been made in the U.S.A. to automate a post office, but they have not yet been successful.

Automation of the physical handling of mail has much less appeal than the facsimile reproduction of mail for transmission via data links and reproduction at the destination post office. Obviously, this endeavor has many serious technical problems such as the extracting of facsimile data from folded sheets, with writing on both sides and sealed in an envelope. There is also the problem of maintaining the privacy of the information contained therein. However, such problems may be solvable, using a combination of pattern recognition and fluoroscopy. Perhaps, too, the populace can be taught to conform to particular requirements which will simplify the job of facsimile transmission. The Automatic Post Office is only one of many governmental services which can make effective use of the equipment and techniques of one facet of the automatic control industry.

14. *Oceanology*. There is a certain similarity between the problems of exploiting outer space and those of exploiting "inner space"—the oceans and the 70% of the earth's surface which lies beneath them. Both are foreign environments for human beings; both involve their own special technical difficulties; and both have mysteries which challenge the ingenuity of men to explore—although the direct economic payoff from oceanology is certainly more predictable than that from the exploration of outer space.

In the case of exploitation of the earth's oceans and the land which lies beneath them, automatic control has a clear-cut summons. Because the ocean's depths are foreign to man, special precautions must be taken to ensure his survival there. Since these precautions are both expensive and, for many activities, unnecessary, the robots of integrated automatic control are natural volunteers for the assault on the ocean frontier. Manned and unmanned submarines, both requiring automatic controls and automatic equipment, can expore the ocean floor, and accumulate data in the many forms which are desirable for analysis. Problems of policing, prospecting, mining, and extracting of the bountiful quantities of food and minerals in the waters of the oceans, as well as communicating via sonars, cables, or developments as yet unpublished, all provide a challenge to the technologists of automatic control. Such challenge is limited only by the economic means required to undertake the development. When reserves of certain minerals on the surface of the earth are depleted to the point of uneconomic operation, man will turn to the virgin 70% of his planet. Then automatic control will navigate, steer, and operate the auxiliary equipment of the machines needed to open up this vast new frontier.

Conclusion

Scarcely have the gains of the last decade been solidified in the maturity of the present, when the challenge of new frontiers threatens to convulse the automatic control industry far more violently than at any time in the past. Microminiaturization and bionics seem destined to be the principal architects of this convulsion and the explosive growth which it promises for the whole technology of automatic control. Almost all of the accomplishments which seem to lurk just beyond the frontier involve microminiaturization, and most of them are proper candidates for bionic controls.

Yet, while we breathe the intoxicating air of technical possibility, we must not repeat the errors of the past which often saw the pioneers of new technologies lose sight of the less interesting, but just as important, realities so necessary to bring their sensational brain children to a useful function.

In the case of automatic control, we must not become so preoccupied with the excitement of designing new controllers that we neglect the attention properly demanded by the sensors, power supplies, actuators, and the connections required to bind them together. We must also continued to hold fast to our industry's new maturity and emphasize the economic factors of finance, marketing, and management and thereby assure the exploitation of the new wonders of our exploding technology.

And, with all of this, we must never, for a moment, lose sight of the fact that the first requirement—the price of admission to our new frontiers—is increased reliability and reduced cost. We must continue to appreciate that these factors—particularly, increased reliability—are absolutely essential to the increased equipment capability and broadened applications which lie just over the horizon.

If our industry can continue to recognize these facts of its life—if its technologists can keep their feet on the ground while holding their heads in the clouds—and, if an enlightened government can continue to make the funds available for the vast amount of technical work required to pioneer the new frontiers—the technology of integrated automatic control will move forward with confidence in its proper role as the world's mightiest industrial effort and the greatest boon to all mankind.

Computers and the Legal Profession

"It's beginning to sneak in fine print, eh — maybe you should have called a lawyer."

WHO'S WHO IN THE COMPUTER FIELD — CUMULATIVE EDITION, 1962

Computers and Automation will publish this fall a cumulative edition of "Who's Who in the Computer Field."

If you are interested in computers, please fill in the following Who's Who entry form (which may be copied on any piece of paper) and send it to us for your free listing. If you have friends in the computer field, please call their attention to sending us their Who's Who entries. The cumulative edition will include only the entries of persons who send us their Who's Who information.

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Its Address? ....

Your Title? ....

Your Main Computer Interests?
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( ) Business
( ) Construction
( ) Design
( ) Electronics
( ) Logic
( ) Mathematics
( ) Programming
( ) Sales
( ) Other (specify):

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Year of birth? ....
College or last school? ....
Year entered the computer field? ....
Occupation? ....
Anything else? (publications, distinctions, etc.) ....

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When you have filled in this entry form please send it to: Who's Who Editor, **Computers and Automation,** 815 Washington Street, Newtonville 60, Mass.

CALENDAR OF COMING EVENTS

Dec. 3-7, 1962: Course in Mathematics of Information Storage and Retrieval, Georgia Institute of Technology, Atlanta 13, Ga.; contact Director, Department of Short Courses and Conferences, Georgia Institute of Technology, Atlanta 13, Ga.

Dec. 4-6, 1962: FJCC (Fall Joint Computer Conference), Sheraton Hotel, Philadelphia, Pa.; contact E. Gary Clark, Burroughs Research Center, Box 843, Paoli, Pa.

Dec. 6-7, 1962: PGVC (PG on Vehicular Communications) Conference, Disneyland Motel, Los Angeles, Calif.; contact W. J. Weisz, Motorola, Inc., Comm. Div., 4545 West Augusta Blvd., Chicago 51, Ill.

Dec. 12-14, 1962: American Documentation Institute Annual Meeting and Exhibit, Diplomat Hotel, Hollywood, Fla.; contact John L. Whitlock Associates, 253 Waples Mill Rd., Oakton, Va.

Jan. 22-24, 1963: Ninth National Symposium on Reliability and Quality Control, Sheraton-Palace, San Francisco, Calif.; contact A. R. Park, Librascope Division, General Precision, P. O. Box 458, San Marcos, Calif.

Jan. 27-Feb. 1, 1963: 1963 Winter General Meeting of the American Institute of Electrical Engineers, Statler and New Yorker Hotels and Coliseum, New York, N. Y.; contact Dr. D. R. Helman, ITT Federal Laboratories, 500 Washington Ave., Nutley 10, N. J.

Jan. 30-Feb. 1, 1963: 4th Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Calif.; contact IRE L. A. Office, 1435 La Cienega Blvd., Los Angeles, Calif.

Feb. 4-8, 1963: ASTM Committee Week, Queen Elizabeth Hotel, Montreal, Canada

Feb. 20-22, 1963: International Solid State Circuits Conference, Sheraton Hotel and Univ. of Pennsylvania, Philadelphia, Pa.; contact S. K. Ghandi, Philco Scientific Lab., Blue Bell, Pa.

Mar. 15-16, 1963: Pacific Computer Conference, California Institute of Technology, Pasadena, Calif.; contact Dr. E. J. Schubert, Systems Division of Beckman Instruments, Inc., 2400 Harbor Blvd., Fullerton, Calif.

Mar. 19-21, 1963: Symposium on Bionics, sponsored by Aeronautical Systems Div. of the Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, Biltmore Hotel, Dayton, Ohio; contact Commander, Aeronautical Systems Div., Attn.: ASRNEB-3, Lt. Col. L. M. Butsch, Jr., Wright-Patterson Air Force Base, Ohio

Mar. 25-28, 1963: IRE International Convention, Coliseum and Waldorf-Astoria Hotel, New York; contact Dr. D. B. Sinclair, IRE Headquarters, 1 E. 79th St., New York 21, N. Y.

Apr. 17-19, 1963: Southwestern IRE Conference and Elec. Show (SWIRECO), Dallas Memorial Auditorium, Dallas, Tex.; contact Prof. A. E. Salis, E. E. Dept., Arlington State College, Arlington, Tex.

April 23-25, 1963: The Eleventh National Conference on Electromagnetic Relays, Student Union Bldg., Oklahoma State University, Stillwater, Okla.; contact Prof. Charles F. Cameron, Technical Coordinator of the NARM, Oklahoma State University School of Electrical Engineering, Stillwater, Okla.

April 24-26, 1963: Power Industry Computer Application Conference, Hotel Westward Ho, Phoenix 4, Ariz.; contact E. J. Lassen, 453 E. Lamar Rd., Phoenix 12, Ariz.

May 17-18, 1963: Symposium on Artificial Control of Biology Systems, Univ. of Buffalo, School of Medicine, Buffalo, N. Y.; contact D. P. Sante, 4530 Greenbriar Rd., Williamsville 21, N. Y.

May 20-22, 1963: National Telemetering Conference, Hilton Hotel, Albuquerque, N. M.; contact T. J. Hoban, NTC Program Chairman, Sandia Corp., P. O. Box 5800, Albuquerque, N. M.

May 21-23, 1963: Spring Joint Computer Conference, Cobo Hall, Detroit, Mich.; contact Dr. E. Calvin Johnson, Bendix Aviation Corp., Detroit, Mich.

June 11-13, 1963: National Symp. on Space Electronics and Telemetry, Los Angeles, Calif.; contact John R. Kauke, Kauke & Co., 1632 Euclid St., Santa Monica, Calif.

June 19-21, 1963: Joint Automatic Control Conference, Univ. of Minn., Minneapolis, Minn.; contact Otis L. Updike, Univ. of Va., Charlottesville, Va.

June 23-28, 1963: ASTM 66th Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

July 22-26, 1963: 5th International Conference on Medical Electronics, Liege, Belgium; contact Dr. L. E. Flory, RCA Labs., Princeton, N. J.

Aug. 20-23, 1963: Western Elec. Show and Conference (WESCON), Cow Palace, San Francisco, Calif.; contact WESCON, 1435 La Cienega Blvd., Los Angeles, Calif.

Aug. 27-Sept. 4, 1963: 2nd Congress, International Federation of Automatic Control, Basle, Switzerland; contact Dr. Gerald Weiss, E. E. Dept., Polytechnic Inst., 333 Jay St., Brooklyn 1, N. Y.

Sept. 9-11, 1963: 7th National Convention on Military Electronics (MIL-E-CON 7), Shoreham Hotel, Washington, D. C.; contact L. D. Whitelock, Exhibits Chairman, 5614 Greentree Road, Bethesda 14, Md.

Oct., 1963: 10th Annual Meeting, PGNS 2nd International Symposium on Aerospace Nuclear Prop. and Power

Nov. 4-6, 1963: NEREM (Northeast Research and Eng. Meeting), Boston, Mass.; contact NEREM-IRE Boston Office, 313 Washington St., Newton, Mass.

Nov. 10-14, 1963: 9th Annual Conference on Magnetism and Magnetic Materials, Chalfonte-Haddon Hall, Atlantic City, N. J.

Nov. 12-14, 1963: Fall Joint Computer Conference, Las Vegas Convention Center, Las Vegas, Nev.; contact Mr. J. D. Madden, System Development Corp., Santa Monica, Calif.

Nov. 18-20, 1963: 1963 Radio Fall Meeting, Manger Hotel, Rochester, N. Y.; contact EIA Engineering Dept., Room 2260, 11 W. 42 St., New York 36, N. Y.

Nov. 19-21, 1963: Fifth International Automation Congress and Exposition, Sheraton Hotel, Philadelphia, Pa.; contact International Automation Congress & Exposition, Richard Rimbach Associates, Management, 933 Ridge Ave., Pittsburgh 12, Pa.

Feb. 3-7, 1964: ASTM International Conference on Materials, Sheraton Hotel, Philadelphia, Pa.; contact H. H. Hamilton, American Society for Testing and Materials, 1916 Race St., Philadelphia 3, Pa.

Mar. 23-26, 1964 (Tentat.): IRE International Convention, Coliseum and Waldorf-Astoria, New York, N. Y.; contact E. K. Gannett, IRE Hdqs., 1 E. 79 St., New York 21, N. Y.

Apr. 22-24, 1964: SWIRECO (SW IRE Conf. and Elec. Show), Dallas Memorial Auditorium, Dallas, Texas.

Apr. 28-30, 1964: Spring Joint Computer Conference, Statler Hotel, Boston, Mass.

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 computer and associated equipment from the "Official Gazette of the U. S. 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.

September 11, 1962 (Continued)

3,054,092 / Wilhelm Breitling, Wilhelmshaven, Germany / Olympia Werke AG., Wilhelmshaven, Germany / Magnetic Core Storage Register.
3,054,093 / Munro K. Haynes, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Magnetic Control Device.
3,054,094 / Paul E. Stuckert, Katonah, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Magnetic Shift Register.

September 18, 1962

3,054,989 / Arthur S. Melmed and Robert T. Shevlin, Flushing, and Robert Laupheimer, Westbury, N. Y. / United States of America as represented by the United States Atomic Energy Commission / Diode Steered Magnetic-Core Memory.
3,054,996 / Carl P. Spaulding, San Marino, and Edwin L. Wheeler, West Covina, Calif. / Datex Corp., Monrovia, Calif., a corp. of Calif. / Analog-To-Digital Converter.

September 25, 1962

3,055,586 / Roderic A. Davis, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Digit-By-Digit Decimal Core Matrix Multiplier.
3,055,588 / Alfred G. Ratz, Trenton, N. J. / Electro-Mechanical Research, Inc., Sarasota, Fla., a corp. of Connecticut / Transfer Function Computer.
3,056,038 / Henri Benmussa, Jean Pierre Le Corre, and Camille Weill, Paris, France / International Standard Electric Corp., New York, N. Y., a corp. of Delaware / Magnetic Circuits.
3,056,039 / Lubomyr S. Onyshkevych, Princeton, and Walter F. Kosonocky, Newark, N. J. / Radio Corp. of America, a corp. of Delaware / Multi-State Switching Systems.
3,056,040 / Seymour Markowitz, Los Angeles, Calif. / Ampex Corp., Redwood City, Calif., a corp. of California / Magnetic Current-Steering Switch.
3,056,044 / Friedrich-Karl Kroos, Munich, Germany / Siemens & Halske Aktiengesellschaft, Berlin and Munich, a corp. of Germany / Binary Counter and Shift Register Circuit Employing Different RC Time Constant Input Circuits.
3,056,045 / Friedrich Ulrich, Neustadt, Kreis Waiblingen, Germany / International Standard Electric Corp., New York, N. Y., a corp. of Delaware / Electronic Switching Unit for the Construction of Information Storage De-

vices, Counters and the Like.

3,056,112 / Charles T. Lecher, Jr., Saugerties, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / High Speed Register.

3,056,113 / David S. J. Smith, Rochester, N. Y. / General Dynamics Corp., Rochester, N. Y., a corp. of Delaware / Binary Code Storage System.

3,056,114 / Moe L. Aitel, Haddon Heights, N. J. / Radio Corp. of America, a corp. of Delaware / Magnetic Storage Device.

3,056,115 / Arthur W. Lo, Fords, N. J. / Radio Corp. of America, a corp. of Delaware / Magnetic Core Circuit.

3,056,116 / Hewitt D. Crane, Palo Alto, Calif. / AMP, Inc., Harrisburg, Pa., a corp. of New Jersey / Logical Sequence Detection System.

3,056,117 / Richard R. Booth, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Magnetic Core Device.

3,056,118 / Elvin L. Woods, Tustin, Calif. / Ford Motor Co., Dearborn, Mich., a corp. of Delaware / Magnetic Memory Device.

October 2, 1962

3,056,552 / Eric G. Wagner, New York, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of New York / Asynchronous Parallel Adder Deriving Intermediate Sums and Carries by Repeated Additions and Multiplications.

3,056,947 / Edwin I. Blumenthal, Philadelphia, John Presper Eckert, Jr., Gladwyne, and Herbert F. Welsh, Philadelphia, Pa. / Sperry Rand Corporation, New York, N. Y., a corp. of Delaware / Information Translating Apparatus.

3,056,948 / Robert M. Lee, Los Angeles, Calif. / The Bendix Corp., a corp. of Delaware / Magnetic Memory Circuit.

October 9, 1962

3,057,974 / William D. Cohen, Syosset, N. Y. / Digitronics Corp., Albertson, N. Y., a corp. of Delaware / Information Sensing Apparatus.

3,058,007 / John T. Lynch, Lionville, Pa. / Burroughs Corp., Detroit, Mich., a corp. of Michigan / Logic Diode and Class-A Operated Logic Transistor Gates in Tandem for Rapid Switching and Signal Amplification.

3,058,061 / Raymond B. Smith, Whittier, Calif. / North American Aviation, Inc. / Automatic Checkout Coding System.

3,058,096 / Watts S. Humphrey, Jr., Cochituate, and Albert H. Ashley, Bedford, Mass. / Sylvania Electric Products, Inc., Wilmington, Del., a corp. of Delaware / Memory Drive.

3,058,097 / William L. Poland, Bethel Conn. / Schlumberger Well Surveying Corp., Houston, Tex., a corp. of Texas / Information Handling System.

3,058,098 / Francois Henry Raymond, Saint-Germain-en-Laye, Andre Michel Richard, Paris, Alice Maria Recoque, Sartrouville, and Jean Brodin, Bourg-la-Reine, France / Societe d'Electronique et d'Automatisme, Courbevoie, Fr. / Magnetic Core Circuits for Binary Coded Information Handling.

3,058,099 / Michael Williams, Watford, Eng. / The General Electric Co., Ltd., London, Eng. / Bistable Magnetic Devices.

3,058,100 / Jacob J. Hagopian, Santa Clara County, Calif. / I.B.M. Corp., New York, N. Y., a corp. of New York / Magnetic Recording and Reproducing System.

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3,058,656 / James H. Pomerene, Poughkeepsie, N. Y. / I.B.M. Corp., New

York, N. Y., a corp. of N. Y. / Asynchronous Add-Subtract System.

3,058,658 / Livia C. Schmierer, Neuilly Plaisance, and Jacques H. F. Valin, Pavillion sous Bois, France / Societe Nouvelle d'Electronique, Paris, France / Control Unit for Digital Computing Systems.

3,058,659 / William R. Demmer, Wappingers Falls, Warren C. Foin, Buchanan, and Frank B. Hartmen, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Add address to Memory Instruction.

3,059,125 / Thomas H. Wiancko, Altadena, and Robert K. Bunce, San Gabriel, Calif. / Tamar Electronics, Inc., Gardena, Calif., a corp. of Calif. / Gating System Employing a Diode Bridge Logic Circuit.

3,059,221 / John F. Page, Haddonfield, N. J., and Luis A. Fernandez Rivas, Levittown, Pa. / Radio Corp. of America, a corp. of Delaware / Information Storage and Transfer System.

3,059,223 / Norton W. Bell, Monrovia, Calif. / Consolidated Electrodynamics Corp., Pasadena, Calif., a corp. of Calif / Analog-To-Digital Converter.

3,059,224 / Frederick L. Post, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of New York / Magnetic Memory Element and System.

3,059,225 / Gerald Horace Perry and Eric William Shallow, Malvern, and George Richard Hoffman, Sale, England / I.B.M. Corp., New York, N. Y., a corp. of New York / Electronic Storage and Switching Circuits.

3,059,227 / Way D. Woo, Newton Centre, Mass. / Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., a corp. of Delaware / Data Storage and Transfer Apparatus.

October 23, 1962

3,060,270 / Gabriele F. Cerofolini, Milan, Italy / Automatic Electric Laboratories, Inc., a corp. of Delaware / Pulse Sender and Register.

3,060,322 / John F. Erickson, Woodstock, and Eugene J. Nallin, Pleasant Valley, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of N. Y. / Magnetic Core Gate.

3,060,410 / Cravens L. Wanlass, Van Nuys, Calif. / Ford Motor Company, Dearborn, Mich., a corp. of Delaware / Logic System Gating Circuit.

3,060,411 / James L. Smith, Basking Ridge, N. J. / Bell Telephone Labs., Inc., New York, N. Y., a corp. of New York / Magnetic Memory Circuits.

3,060,414 / Gerhard Dirks, Frankfurt am Main, Germany (12120 Edgecliff Place, Los Altos Hills, Calif.) / ——— / Transfer and Storage of Digital Data Signals.

3,060,418 / Werner Buchholz, Wappingers Falls, and Ernest C. Schuenzel, Poughkeepsie, N. Y. / I.B.M. Corp., New York, N. Y., a corp. of New York / Core Array Temperature Responsive Apparatus.

3,060,431 / Harrison W. Fuller, Boston, and Carl W. Ledin, Islington, Mass. / Laboratory for Electronics, Inc., Boston, Mass., a corp. of Delaware / Magnetic Data Storage Techniques.

3,060,432 / Frederick A. Schwertz, Pittsford, N. Y. / Zerox Corp., a corp. of New York / Electrostatic Recording of Information.

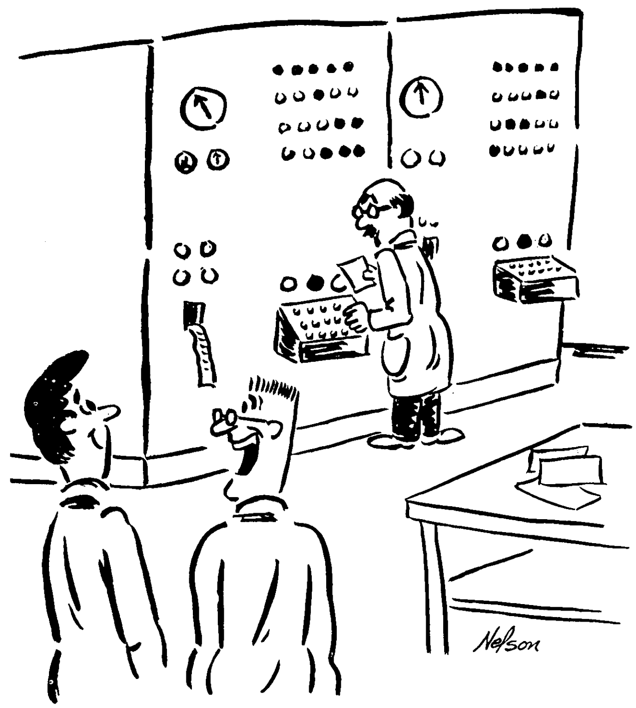
3,060,433 / Roger K. Lee, Jr., Watertown, and William J. Gorman, Swampscott, Mass. / Laboratory for Electronics, Inc., Boston, Mass., a corp. of Delaware / Magnetic Disc Storage Device.

October 30, 1962

3,061,192 / John Terzian, Woburn, Mass. / Sylvania Electric Products, Inc., Wilmington, Del., a corp. of Delaware / Data Processing System.

3,061,193 / Neal D. Newby, Leonia, N. J., and Philip J. Sturiale, Brooklyn, N. Y. / Bell Telephone Labs., Inc., New York, N. Y., a corp. of New York / Magnetic Core Arithmetic Unit.

Computer Rummy



"Instead of playing cards at lunch, we feed the computer all the data and it tells us who lost and how much."

ADVERTISING INDEX

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

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Audio Devices, Inc., 444 Madison Ave., New York 17, N.Y. / Page 51 / Charles W. Hoyt Co., Inc.

Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif. / Pages 23, 89 / John B. Shaw Co., Inc.

Careers, Inc., 770 Lexington Ave., New York 21, N.Y. / Page 98 / Mohr & Eicoff, Inc.

Comcor, Inc., 430 S. Navajo, Denver 4, Colo. / Page 43 / Marshall Robertson Advertising Agency

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General Electric Computer Dept., Phoenix, Ariz. / Page 91 / Foote, Cone & Belding

Honeywell EDP Division, 151 Needham St., Newton Highlands, Mass. / Page 99 / Allied Advertising Agency, Inc.

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National Cash Register Co., Electronics Div., 1401 E. El Segundo Blvd., Hawthorne (Los Angeles), Calif. / Page 96 / Allen, Dorsey & Hatfield, Inc.

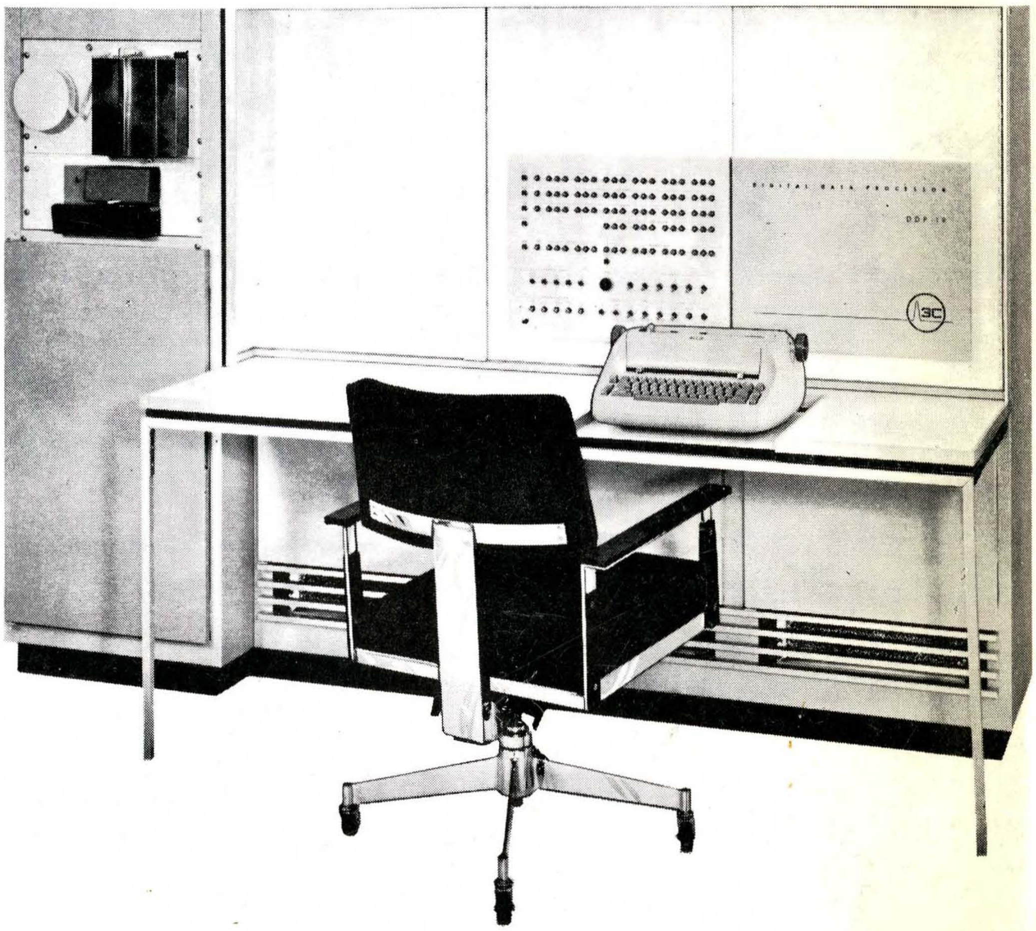
Packard Bell Computer Corp., 1905 Armacost Ave., W. Los Angeles, Calif. / Page 93 / Bertrand Classified Advertising Agency

Rheem Electronics, 5200 W. 104 St., Los Angeles, Calif. / Page 93 / M.R. Crossman Co.

Scientific Data Systems, 1542 Fifteenth St., Santa Monica, Calif. / Page 4 / Faust/Day Advertising

Triton Electronics, Inc., 62-05 30th Ave., Woodside 77, N.Y. / Page 7 / Kameny Associates, Inc.

DDP-19



Fastest real time medium-size computer

The DDP-19 Digital Data Processor handles complex on-line engineering data faster than comparable machines. Off-line too. Typical operation times, including instruction, operand access times:

ADD	10 microseconds
MULTIPLY	39 microseconds
DIVIDE	66 microseconds
DOUBLE PRECISION ADD	60 microseconds
FLOATING POINT — 37 BIT MANTISSA, 10 BIT EXPONENT:	
ADD	220 microseconds
MULTIPLY	347 microseconds
MEMORY CYCLE TIME	5 microseconds
MEMORY ACCESS TIME	3 microseconds

Computation speeds such as these are backed by a strong command structure with multiply, divide, and multiple precision commands, plus easy floating point operation. Indexing, of course.

RELIABLE. DDP-19 modules, 3C's standard S-PACs, have passed 800,000th PAC-hour of life test with no failures.

IN-OUT VARIETY. Program controlled data transfer. Multichannel interrupt with character buffers, word buffers, parallel transfer. Asynchronous full interrupt channels with 200,000 word/sec transfer rate. Fully buffered input-output channels with 200 kc word transfer rate — 3.8 million bits/sec.

EXPANDABLE. A full range of peripheral equipment, including magnetic tape units, is available. DDP-19 modular construction allows internal expansion.

PROGRAMMING AIDS. Algebraic compiler, symbolic assembler, and comprehensive subroutine library.

BASICS. DDP-19 Digital Data Processor is binary, parallel, single address. Core memory (4096 to 16,384 words), indexing, fixed point arithmetic, choice of 19, 22, or 24 bit word. Solid state. Brochure and applications portfolio available.

3C

COMPUTER CONTROL COMPANY, INC.

OLD CONNECTICUT PATH, FRAMINGHAM, MASS. • 2251 BARRY AVENUE, LOS ANGELES 64, CALIF.