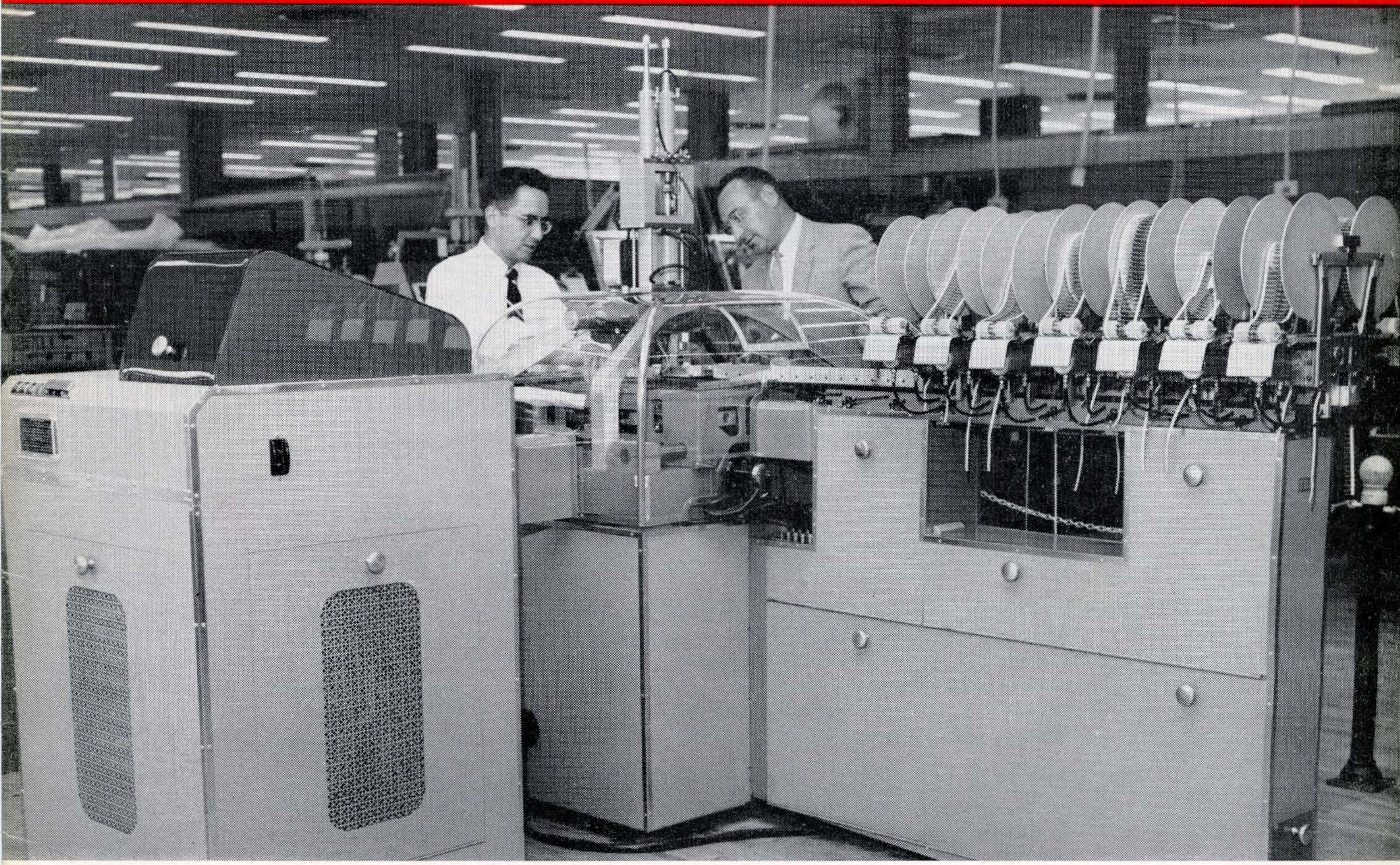
COMPUTERS
and AUTOMATION

DATA PROCESSING • CYBERNETICS • ROBOTS



SEPTEMBER
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IBM PROGRAMMED COMPONENT ASSEMBLY SYSTEM

EXPERIMENTS IN CHESS ON ELECTRONIC COMPUTING MACHINES

THE MARKET FOR COMPUTERS IN BANKING

The Editor's Notes and Readers' Forum

FRONT COVER: PROGRAMMED COMPONENT ASSEMBLY SYSTEM

THE FRONT COVER picture is a photo of the new programmed component assembly system, made by International Business Machines Corp. This machine is operating in the Manufacturing Engineering Division at the company's plant in Poughkeepsie, N. Y.

The new IBM machine automatically inserts components in printed wiring boards according to instructions contained in punched cards. When a change in the layout and components of a printed wiring board is called for, a new set of IBM cards is fed into the system which then automatically adjusts itself for the new job.

The new device was developed and built by manufacturing engineers at IBM's computer manufacturing facilities in Poughkeepsie. It is currently turning out wiring panels for the company's data processing equipment 10 times faster than is possible by manual assembly methods.

For more information, see the article in this issue.

ON LANGUAGE TRANSLATION

I. From the Editor

ONE OF THE most interesting papers given at the meeting of the Association for Computing Machinery in Houston, Tex., in June was "Conclusions on Language Translation" by A. F. R. Brown of Georgetown Univ., Washington, D.C. This paper described a computer method for translating chemical French, which probably can be applied to any language translation problem. The technique used and the amount of progress reported both seemed remarkable. Your editor was fortunate enough to get permission to make a short report on the paper, after it was given and before it is submitted in ampler form to a technical journal. Following is the report, no part of which should be credited in any way to your editor.

"In December and January I tried out my basic ideas with rules expressed in words and written out on filing cards. I found it was possible to arrive, in about 110 hours of work, at a system that would translate 220 consecutive sentences from a French chemical journal into acceptable English. So it seemed reasonable to try to mechanize the system immediately.

"The computer programming needed to handle the system has been completed but not checked out yet, and it appears that the system of translation can be expanded and corrected indefinitely with hardly any more programming. By the end of the summer, I hope to have prepared the dictionary material needed for the system to handle those 220 sentences, and to have tested the material by making the computer go through the motions of translating the sentences. After that it should be possible to develop the system and dictionary quite rapidly into something that will translate say 90% of the sentences in most French chemical literature.

"To start with, it is assumed that the French words have been looked up in a special dictionary and items have been brought out of the dictionary, one for each French word. Each item begins with a fixed number of binary digits that indicate the grammatical characteristics of the French word in fairly conventional terms. Then comes a number indicating what the French word in the item corresponds to; and then the English equivalent which will appear as part of the final translation unless it is changed in the course of working out the sentence. After these essential parts there may follow one or more instructions, then one or more constants that are used in carrying out the instruction, and finally one or more diacritics whose presence or absence may affect the performance of these instructions or instructions in other items.

"The sentence in the form of items found by the dictionary search routine contains instructions that will have to be carried out before a translation is produced. These instructions correspond to the rules which were originally invented in mechanical terms. Some rules are however so general in their application that it is inefficient to represent them by instructions planted in the individual items. For instance, there has to be a rule providing that adjectives, which mostly follow the nouns they modify in French, should be moved around to the English position, before the nouns.

"After each instruction is carried out, it is discarded; and when there are no instructions left, the English words remaining in the items of the sentence are printed out; they compose, one hopes, a translation of the original French sentence.

"The sequence in which instructions are to be carried out has to be controlled very carefully to avoid conflicts. The most important reason for this is that instructions for shuffling the items into English word order must be delayed until all the syntactical questions that depend on the original French word order have been asked and answered. The sequence of execution is fixed by beginning each instruction with a priority number, within a somewhat arbitrary range of one to 126. Whenever the computer has to decide which instruction to follow next, it chooses the one with the lowest priority number.

"As my system is currently set up, an instruction consists of 19 binary digits. When the moment comes for it to be carried out, the computer discards the first

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THE MARKET FOR COMPUTERS IN BANKING: REPORT NO. 2

Ed Burnett and Leland Hewitt
New York, N. Y.

IN the May issue of **Computers and Automation** we published the "Computer Market Survey – Report No. 1", in which the entire U.S.A. market for computers and computer products over the next five years was estimated to total between $4½ and $7 billion. A projection of this survey indicates a market by 1965 of some $2 billion per year.

To indicate at least in part what quantity of computers and what kinds are likely to be sold to which industries, **Computers and Automation** is beginning a series of reviews, industry by industry. The facts reported in this series are based on the original survey findings and are augmented by special research and interviews in each specific field. Here is the first of these reviews, a survey of the market for computers in banking.

The Banking Industry

The permanent functions of banking are to assemble money, invest money, and return money on demand to its owners.

These functions of banking are undertaken by more than 14,000 commercial banks operating some 21,000 banking offices in some 12,000 cities and towns. Total deposits held by all U.S. banks approximate $225 billion, of which 85 percent is held by commercial banks. A few commercial banks are giants – 19 banks, for example, have deposits of $1 billion or more (10 have over $2 billion); the next 30 banks have deposits in the $½ billion to $1 billion range. And at the other end of the scale there are 3500 banks with deposits of less than $2 million; there are 10,000 more banks with deposits from $2 million to $40 million; thus, from a marketing standpoint, banks would seem to fit into four classifications: Very large (with over 5,000 employees) 1 percent; Large (with 501 to 5000 employees) 2 percent; Medium (with 50 to 500 employees) 8 percent; Small (with under 50 employees) 89 percent.

Some 12,500 of these banks operate as individual units from a single location, while 1,700 banks operate 8,000 additional branches or offices. Interestingly enough, more than half of all branch banking operations are in five states – New York, Ohio, Pennsylvania, Michigan, California.

Banking as measured in deposits, items, loans, has grown with the national economy. Business is booming and more business of course means more bookkeeping. Loans and investments of commercial banks now total over $200 billion, a rise of over 50 percent in the last five years. This has resulted in a huge increase in manpower in banking, and a resultant increased attention by banks to all forms of automation. The total number of banking units however has not changed appreciably.

What **has** changed appreciably during this period has been the growth of services offered by banks both to attract new depositors and customers, and to shield current depositor-customers from competitive lures. The banker essentially is a merchandiser of money. The basic competitive merchandising trend is towards a retail operation involving more and more small accounts, and more and more bookkeeping. And to get these retail accounts banks now offer more and more services. Among these services, in addition to conventional banking and loan operations, are:

Special money handling: coins, money orders, traveller's checks, bills of credit, handling of foreign currency, foreign bonds.

Savings: savings bonds, Xmas clubs, school savings programs, savings clubs, banking by mail, night, and outdoor services.

Collect and disburse: coupons, drafts, rent payments, mortgage payments, bills, dividend disbursement, service payrolls, act as escrow agent. (Even merchandising of coupons and stamps!)

Protective services: rent safe deposit boxes, maintain night depository, custody of securities.

Special aids to business and individuals: assist in income tax preparation, financial advice, business assistance, credit information, statistical information, provide customer conference rooms, correspondent bank facilities, operate business-aid library, provide letters of introduction, stock transfer, investment advice, handles securities.

Trust Services: estate planning, management of estates.

From an engineering standpoint, banking operations are usually analyzed into the number of handlings or transactions. For example, for a bank with 100,000 deposit accounts, the maintenance of deposit account records involves some 250,000 daily transactions (for records, account number, branch number, name, address, balance, debits, credits, new balance, service charges, other data). There are over 130 million deposit accounts in banks insured by the Federal Deposit Insurance Corporation.

It has been estimated that each of the 9 billion checks written annually on some 52 million checking accounts (about 36 million per day in the U.S. alone) is handled approximately seven times during the collection process. This is an annual handling of 63 billion pieces of paper. Over 90 percent of the business of the country is transacted through checks drawn against bank deposit accounts. By 1960, if the present growth trend continues, the handling figure will increase by some 50 percent to 98 billion handlings . . . for checks alone. The 1960 figure promises to virtually double by 1970.

One banker notes, "The people involved in handling checks represent one of the largest job classifications, have the highest rate of turnover, and consequently the highest training expense, require the most supervision, use the greatest amount of mechanical equipment investment, and occupy a substantial amount of space." Checks alone thus afford a tremendous potential for electronic machine handlings.

Probably the greatest squeeze in banking operations today is the manpower shortage. Banks are hard put to hang on to those people they now have, much less attract the additional clerical forces they need. Turnover in banking, which has one of the largest ratios of clerical employees to total employees, is reputed to be at the rate of 25 percent per year. This relatively high rate, surveys indicate, is influenced primarily by the heavy monotony of the vast amount of paper work. From a starting salary basis, and long range viewpoint, banking personnel offers are quite comparable to those made by other industries. The banking system now employs some 600,000 persons.

The Economics of Computers

The manpower squeeze, brought on by the spectacular growth in transactions and services, emphasizes the importance of the economics of computers in the banking industry. It is safe to say that the application of electronic data processing occupies the attention of bankers at virtually every conceivable level.

In general, the larger the bank, and the greater the number of transactions, the greater the interest in automation. Yet the average bank is really quite small. And various heads of committees set up by the banking fraternity to consider methods of electronic data processing have recognized and deplored the "general apathy among smaller banks.".

To the banking giants, the multi-million dollar investment in large computers will undoubtedly prove a sound investment in saving in clerical time, increased accuracy, greater speed, and ultimately higher profits. To almost any bank with 50 or more employees, computers, particularly the smaller, lower cost units now coming on the market, offer a good economic choice. The host of small banks, while they are prospects for low-priced specialized bookkeeping machines, are not prospects for computers yet.

Size of the Bank Market

There is some evidence that for every $100,000,000 of deposits, large banks can be expected, **on the average** to expend approximately $200,000 over the next five years for computers and computer-type products. Banks may already be ahead of their own professional association which in a 1957 release indicated that "banks with over $200,000,000 in deposits need to begin gathering accurate information immediately on the subject of automation." From discussion it seems likely that smaller banks will expend less per million of deposits for computers than larger banks. It seems likely that almost all sales will be to the top half of banks by size.

In the following table, which is at best a partly educated guess, no sales are contemplated from some 7,000 of the over 14,000 banks in the country. It must be emphasized that the figures are approximate averages only.

This table suggests that makers of systems in the million-dollar-and-up class are restricted to just 85 institutions — and some of these already have equipment in hand or on order. In the medium-priced computer range, from $100,000 to $500,000, there would seem to be over 1000 prospects. For makers of specialized off-line electronic bookkeeping aids in the $10,000 to $25,000 range some 6000 more banks are prospects. The bulk of the market awaits equipment in the $100,000 class so efficient, so economic that banks cannot afford, due to the competitive situation, not to rent or buy.

TENTATIVE ESTIMATE OF MARKET FOR COMPUTERS IN VALUE OF PRODUCT

Banks, by rank in deposits	Average total installation over next 5 years	Total value for group
Top 10 banks	$3,000,000	$30,000,000
Next 25	2,000,000	50,000,000
" 50	1,000,000	50,000,000
" 100	500,000	50,000,000
" 1000	100,000	100,000,000
" 2000	25,000	50,000,000
" 4000	12,500	50,000,000
7185 banks	approx. $50,000	$380,000,000

The total market for banks alone over the next five years thus appears to be as large as the total computer market was for all applications in 1956 (1956 volume, as measured in value of product, was estimated by Fortune Magazine to be $350,000,000).

What Computers Can Do

In 1956, the American Banking Association's Bank Management Commission, Technical Subcommittee on Mechanization of Check Handling, published a progress report, which included the following analysis:

"The thing we are all striving for as individual bankers and as the industry as a whole is the ability to substitute a mechanical method for existing bank operating processes performed manually or semi-manually. When we break down elementary clerical facilities, we find only the following:

1. The movement of substance.
2. The reading of data.
3. The recognition of information.
4. The ability to compare.
5. The facility to select.
6. The capacity to adjust.
7. The means to record.

"As outlined in our presentation to the manufacturers, what we are seeking really are replacements for the hands, the eyes, and the more automatic phases of mental activity. We are looking for a method that will relieve monotonous clerical detail, provide greater accuracy in operation, produce greater individual productivity, and perform all of this with either lower cost or no greater cost than what is presently being incurred."

Machines are now available that compute and record interest; sort, select, collate, analyze, and accumulate data; verify results; and print visible records. The day is fast approaching when most checks, as approved by the American Bankers Association, will bear in a band one-

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Note: Some articles on computers in banking previously published in **Computers and Automation** are:

Magnetic Ink Character Recognition — The Common Machine Language for Check Handling, October, 1956.

Automation of Bank Check Processing, August, 1955.

Application of Automatic Computing Equipment to Savings Bank Operations, July, 1955.

Report of American Bankers Association Committee on Electronics (Sept., 1953), January, 1954.

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UNIVAC *pinpoints the weather*

Irving P. Krick
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Denver, Colorado

(Reprinted with permission from Systems Magazine, March-April, 1957, published by Remington Rand Division, Sperry Rand Corporation.)

SINCE the beginning of time, man has had to adjust himself to the elements in order to survive. Weather was of such importance to early peoples that they established gods for the sun, the rain, the wind, and the snow. Regularly they offered sacrifices to these gods to bring about the weather they needed.

Though we have come a long way since the days of the rain gods, our dependence upon weather is as great as ever—perhaps greater. This need cuts across the world's entire economy, since virtually every business has a weather factor to consider in making decisions. It is not whim nor curiosity that causes companies from every part of the world to come to us for long- and short-range weather forecasts. In every case, it is imperative that management know what the weather will be like for stated periods.

That we have been able to provide this information with a continuing degree of success, and to increase through cloud-seeding rainfall when needed, is a testimonial to comparatively recent advances in the science of meteorology. By making use of these advances, and combining them with our own weather theories, we have been able to predict the weather accurately for any spot on the globe—and, if necessary, years ahead of time.

Now another scientific tool has been put to work in our laboratories, one which shortly will enable us to prepare, practically on a moment's notice, exact weather forecasts day by day for any future time in any given city or for the entire globe. And these forecasts can be made on the basis of past records alone. If through some unforeseen circumstance, new weather data became unavailable we could make accurate predictions for the next five years for any part of the world.

Computer Is New Tool

The electronic computer is the tool that makes such accurate long-range weather forecasting possible. The mathematical computations necessary can be done fast enough for practicability because of the Remington Rand Univac 120 punched-card computer we use. Soon, our capacity for handling such work will be vastly increased through the magnetic drum Univac File-Computer we have on order. With this system the extent to which accurate weather forecasting can be accomplished will be limited only by our capacity to utilize the equipment to its best advantages, along with our own years of experience in the field of "rain or shine."

Our most significant recent forecast was for President Eisenhower's inauguration January 21 in Washington, D.C. It was also the first official long-range forecast to be made with Univac, having been worked out two full weeks before inaugural day. The computer was fed data consisting of pertinent pressure patterns for the East Coast ranging over the years 1935 through July 1955. Univac did the mathematical calculations necessary to determine whether an equation from this bloc of material could be projected to January 21, 1957. It came up with three equations which fit the inaugural date.

Our prediction was that January 21 "will mark a one-day break in the storm which will hit the city over the weekend. Cold, brisk, reasonably clear weather will prevail from the time of the inauguration ceremony throughout the rest of the day." The weather behaved on schedule—even to the extent that as the President stepped upon the reviewing dais, the sun broke through for the first time that day.

The theory involved is one we have been working with for over 20 years. It relates to the behavior of atmosphere rather than to behavior of weather. While there is little consistent rhythm in weather itself, there is a definite rhythm in the pressure patterns which produce weather. The atmosphere is not as chaotic as most people think. It is a sort of fluid envelope around the earth, and like the ocean it has systematic oscillations which never exceed certain limits.

Testing the Theory

We tested this theory exhaustively by studying sequences of pressure maps covering long periods of time around the world, and established beyond doubt this systematic behavior pattern. We combined this theory with actual weather records for a period of 40 to 50 years, and were able to develop ways to predict the weather accurately anywhere in the world.

However, the forecasts could seldom be pinpointed and could not be extended beyond a few months except in very general terms. A tremendous number of mathematical calculations are necessary to analyze the mass of data involved, and the analyses must be brought to such a fine point that these calculations would take literally thousands of people more time than is available. By the time the work would be finished, the weather being predicted would long since have passed. Moreover, the inevitable human errors in computations would cause considerable inaccuracy in the final result.

The Univac 120 has provided the answer to this bottleneck. It can do the necessary computations error-free in a matter of minutes or hours, depending on the complexity of the material and the solutions that are sought. Thus, the ability to pin-point a forecast, sought for so long by meteorologists, is now at hand. Dependable, long-range weather forecasting has become an established fact.

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IBM'S PROGRAMMED COMPONENT ASSEMBLY SYSTEM

Neil D. Macdonald
New York, N. Y.

ON AUGUST 22, International Business Machines Corp., New York, announced an automatic machine for the assembly of printed wiring circuit boards. The machine is used to fasten resistors, capacitors, diodes, transistors, and similar components into circuit panels bearing printed wiring, before these panels are made into complete plug-in units for insertion into computers and other electronic equipment.

But the most important and novel thing about this machine is that when a change in layout and insertion of components on a panel is called for, the machine takes its new instructions from a pack of IBM punched cards, and is thereby programmed to reset and work instead on a changed assignment.

The new machine is called the Programmed Component Assembly System. It was developed and built by manufacturing engineers at the IBM plant in Poughkeepsie, N. Y. The first machine is currently hard at work assembling wiring panels for the company's data processing equipment. Assembly speed is more than 10 times faster than by previous manual methods and a more uniform product is obtained.

The system was built for the company's own use, but IBM's new Special Engineering Products Division is considering making similar machines available to industry. The system now in use at Poughkeepsie inserts one component every second and one-half. The proposed market version of the system is a one-a-second machine with a probable price in the $100,000 range. IBM believes the extreme simplicity and economy of the changeover operation makes the new system particularly adaptable to low production runs of a great variety of board assemblies.

Characteristics Standardized

A key to the successful design and operation of the Programmed Component Assembly System was the decision to standardize many characteristics of printed panels as well as dimensions of electronic components. Now, for example, all components are packaged in one of two ranges of size regardless of their individual characteristics. Prior to this, the great variety of shapes and sizes of these components resisted automated assembly methods.

Components are grouped according to their electrical values, mounted on masking tape "belts," and wound on "cut-off" reels, much in the same way that machine gun bullets are loaded in drums. Several thousand components are stored on each reel in this fashion. The system has a capacity of 20 reels, although it can be expanded to accommodate many times that number if necessary. The reels are set in place on the selection "rack" and the taped components are fed into cut-off stations.

In order to attach a component onto a printed panel, three instructions are provided simultaneously by the system's card reader. Two columns of an IBM card contain the three instructions needed to insert any one component. The first tells the device which one of 20 different stored components to select, cut off from its reel, and deliver to the insertion system. The second and third instructions position the panel so that the selected holes are accurately aligned under the insertion mechanism. When all three instructions have been obeyed, the insertion system automatically inserts the selected component and staples it to the panel. This process continues over and over until all instructions have been followed and the printed panel is completely assembled.

The Programmed Component Assembly System will accept a panel of any size up to 10 inches square, and will operate to accuracies of better than 1/500 of an inch. A two-directional servo system performs the positioning operation and can locate the panel to receive a component at any intersection of a grid with 1/20th inch spacing in each direction.

Univac Pinpoints the Weather

(Continued from page 8)

Teamwork Brings Progress

Continued progress in our work, of course, is entirely dependent on teamwork—the combined efforts of our own staff plus government agencies. We get exact details of what the weather is up to—temperatures, atmospheric pressures, wind strengths and direction, cloud heights and visibility—funneled directly to us by the U.S. Weather Bureau. They come to us by way of Civil Aeronautic Authority Teletype circuits, 24 hours a day, seven days a week, through arrangement with the Department of Commerce.

For cloud seeding this constant flow of information is absolutely essential. If we have been asked to "provide rain" in a given area, we must know when conditions will be propitious. No one can create a cloud. All we do is to make use of existing ones. As these "moisture banks" move along they pick up deposits, and they're inclined to be stingy, making us labor to secure a withdrawal.

Usually not more than five percent of a cloud's moisture is given up during a rainstorm. With the use of silver iodide crystals for cloud-seeding, we try to release seven or eight percent. This is no loss to anyone, because a cloud automatically makes up for lost moisture as it moves along. When compiled weather data show that the moment is right, we bombard the target cloud

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MATHEMATICAL SUBROUTINES

For the UNIVAC SCIENTIFIC COMPUTER - a Survey

Werner L. Frank
The Ramo-Wooldridge Corporation
Los Angeles, California

IN THE three-year period since the delivery of the first of the UNIVAC Scientific Computers by the Sperry Rand Corporation, the program libraries of the various installations employing these machines have developed a repertoire of mathematical subroutines which reflect, in a large sense, the basic computational needs of industry and science. In addition, the programs also give indications of the status of the computing art with respect to the mathematical methods and numerical techniques which are employed. Presented here is a survey of such available routines for the UNIVAC Scientific Model 1103 and 1103A computers. As an aid to the reader, some characteristics of these two computers are presented in Table I. Though there are important differences between the computers, programs prepared for the 1103 will operate on the 1103A with minor modifications; the converse is true only if certain instructions of the 1103A are not used.

Elementary Functions

Subroutines for the elementary functions are a necessary building block for all computing centers and have probably been given more attention than any other type of function. While many mathematical methods are available, the popularity of the rational function approximations of Hastings [1] are evident since most subroutines employ these expressions for the determination of trigonometric, exponential and logarithmic functions.

There are, however, applications of Chebyshev polynomial (RR)* and minimax fits (RW) for a few of these functions. An example of the former is a routine which evaluates $\sin\frac{\pi}{2}x$ and $\cos\frac{\pi}{2}x$, while the latter has been applied to finding $\log_e x$ and e^x. The technique of continued fraction expansions (WS) is used for finding e^x and arctan x in one instance, while the Taylor series expansion (AP, CV) has been employed for finding sin x and cos x.

Agreement seems to be universal for finding the n^{th} root of a number by the Newton-Raphson procedure. However, one of the more popular routines (RR) for square root makes an initial rational function approximation to $\sqrt{x}$ and follows this by one cycle of the Newton-Raphson iteration.

Most of these routines are available for the 1103 and 1103A and operate in fixed and floating point real arithmetic. In one instance a square root subroutine has been prepared for operation in double precision, real arithmetic and also for complex arithmetic.

The availability of these routines is given in Table II.

Matrix Algebra

Among the more important mathematical subroutines are those which find solutions to linear systems of equations and inverses of matrices. In most of the available programs these closely associated problems are solved by a single subroutine designed to determine the unknown matrix X in the linear matrix equation $AX = B$. The three direct methods [2] of Gauss, Jordan and Crout and the iterative Gauss-Seidel procedure [2] have been coded and are summarized in Table III.

To find the determinant of a matrix the technique of elimination, to the point of a triangular matrix, is performed. The product of the elements on the diagonal of this reduced matrix is then the desired result. Routines (CV, RW) operating in floating point, real and complex arithmetic are available. Limits on the order of the matrices are $n \leqq 170$ and $n \leqq 115$ respectively for the arithmetics mentioned.

The determination of eigenvalues and eigenvectors of both real symmetric and arbitrary complex matrices has been given considerable attention. Among the methods coded to solve the symmetric case are the well known Jacobi rotational procedure [3, 4] and also the gradient method due to Hestenes and Karush [5]. As a result of an intensive research program a number of codes have been prepared for the non-Hermitian case which employ the power method, root finding techniques and condensation of data by applying symmetry transformations [6]. A description of these routines is presented in Table IV.

In addition to these standard problems many installations possess special abstractions which perform some of the basic matrix operations. Such codes are usually part of an interpretive system. They include computing vector norms, scalar product and matrix multiplication.

Roots and Extrema of Non-Linear Functions

A variety of root finding techniques are available for the 1103 and 1103A computers, including two new methods due to Ward [7] and Muller [8]. Although in most cases such subroutines are prepared to find the zeros of polynomials, there is one program which can also handle arbitrary functions. The characteristics of these codes are given in Table V. In connection with polynomials a number of subroutines have been prepared which evaluate this function, for given argument, by the well known nesting algorithm.

A subroutine has also been prepared to minimize a function of n variables with one constraint by a modified steepest descent technique. This program (RW) is carried out in floating point, real arithmetic and can handle problems of dimension up to order 20.

Differential Equations

The problem of finding the solution to a system of ordinary first order differential equations has been treated by a number of subroutines. The three methods programmed include a modified Euler method, the Runge-Kutta-Gill [9] procedure and the

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*Letter pairs in parentheses identify the computing installation which has prepared the subroutine in question. The identification is according to the following:

- (AP) Applied Physics Laboratory, Johns Hopkins University
- (BO) Boeing Airplane Co., Seattle, Washington
- (CV) Convair, San Diego, California
- (OR) Operations Research Office, Chevy Chase, Maryland
- (RR) Remington Rand Univac, St. Paul, Minnesota
- (RW) The Ramo-Wooldridge Corporation, Los Angeles, California
- (WS) White Sands Proving Grounds, New Mexico
- (NA) National Security Agency, Washington, D. C.

Adams-Moulton predictor corrector method [10]. In all cases equations of order larger than one can also be handled by suitable representation. The characteristics of these routines are summarized in Table VI.

It is noted that no standard library routines are available for solving partial differential equations, although special programs have been prepared for specific problems.

Integration and Differentiation

Definite integral evaluation is performed by a combination of techniques. These include:

(a) Combination of Simpson's rule and Newton's three-eighths rule (RW) for equally spaced points x_n where $2 \leqq n \leqq 16{,}000$.

(b) Combination of Simpson's rule (RW) and formulas of Milne [11] for equally spaced points x_n *where* $8 \leqq n \leqq 4095$.

(c) Gauss' Quadrature (WS) for up to 16 points and for a selected set to 48 points.

All three programs are prepared for operation in real, fixed point arithmetic. In addition (b) is also available in a real, floating point version. Methods (a) and (b) are fourth and fifth order processes respectively.

One subroutine (CV) is available which evaluates the first and second partial derivatives of a function of up to 48 variables by a central difference scheme.

Interpolation and Curve Fitting

Three basic interpolation subroutines have been prepared. The first program (RW) performs third order interpolation by Neville's method for any tabulated function of one variable. The independent variable may be unequally spaced and up to 4095 points are admissible. Two other programs (CV) are available which perform four point Lagrange interpolation for bivariate and trivariate functions. These subroutines also find interpolated values for the first partial derivatives. The calculations for the above routines are performed in real, fixed point arithmetic.

Curve fitting of discrete data has been given considerable attention. In addition to the usual least squares procedure of solving the associated set of normal equations, a routine has been prepared which makes the fit by orthogonal polynomials generated by a three term recurrence relation [12]. Also programmed is the procedure for polynomial fitting according to the mini-max criterion [13]. A summary of available subroutines which perform this operation is contained in Table VII.

Linear Programming

A linear programming routine (RR) has been prepared to maximize (minimize) a linear form subject to a set of linear restraints. The method of solution adopted is the alternate algorithm of the Revised Simplex Method due to Dantzig [14]. The program takes advantage of zero entries in the coefficients and the computation is performed using floating vector arithmetic. The number of restraints cannot exceed 106 and the number of variables, including slack variables, is restricted to be less than 258. Also, the product of these two dimensions must not exceed 15,000.

Statistical Analysis

The following statistical operations have been programmed and standard subroutines are available.

(1) Analysis of Variance—Performs an analysis of variance on up to 1536 observations of at most 7 variables with associated levels ranging from 2 to 7. There can be as many as 217 effects and interactions but no interaction of more than 2 factors. Each variable can have associated with it an orthogonal polynomial of up to fourth degree. The program (CV) operates in real, floating point arithmetic.

(2) Moments of a Function—Three subroutines (CV) are available which compute the central moments of a function. The first of these finds the average, standard deviation, second through eighth central moment, skewness and kurtosis. Also a histogram is provided. The second routine approximates the first four central moments of a function of up to 15 variables. One also obtains the mean and standard deviation of the function. Knowledge of the first eight central moments of the independent variable is necessary in addition to the first and second partial derivative of the function. Finally, the mean, second, third and fourth central moments of a function of n variables are estimated having given these same quantities for each of the up to 15 independent variables. A modified Edgeworth series, together with a Monte Carlo technique, is used to represent the distribution of each of the variables. These programs all operate in real, floating point arithmetic.

(3) Multiple Regression and Correlation—This program (RR) performs a regression analysis for up to 30 independent and dependent variables with up to 400 observations for each. A number of statistical quantities are computed in addition to the basic regression coefficients. The routine employs both fixed and floating, real arithmetic in an optimum fashion.

(4) Auto-Correlation—Two subroutines (AP, RW) compute an estimate of the autocorrelation function for a given lag m, employing real, fixed point arithmetic. Up to 16,000 points can be admitted and m is restricted to be less than 850 or 2047 depending on the routine.

(5) Power Spectral Density—Two subroutines (AP, RW) estimate the power spectral density function from given values of the autocorrelation function associated with a time series, by the technique due to J. Tukey [15]. The time series must be such that the two functions are related by the Fourier transform. The number of values of the autocorrelation function is limited to 2047 and the computation is performed in real, fixed point arithmetic.

(6) Random Number Generation—The question of pseudo-random numbers has been given attention in at least five different subroutines (CV, OR, RR, RW, WS). All of these operate in fixed point arithmetic and tests have been performed to check the degree of randomness. All programs employ a method described by Lehmer [16] and Juncosa [17]. Included in this repertoire are uniform, normal and negative exponential (e^{-x}) distribution. In addition a routine (AP) for generating normal deviates is also available which employs the Fibonacci Series [18].

Conclusions

The information presented in this article is a summary of responses to inquiries which were made to the various users of the UNIVAC Scientific Computers. While most of these subroutines were designed for operation on the 1103 rather than the more recent 1103A, more activity is currently being devoted to the development of programs for the latter machines. Instrumental in this endeavor is the Mathematics Committee of the USE (UNIVAC Scientific Exchange) organization which promotes and coordinates mathematical subroutines.

TABLES

Table I: CHARACTERISTICS OF THE UNIVAC SCIENTIFIC COMPUTERS (APRIL, 1957)

Each item in the following tabulation shows: Feature / Report for the 1103 machine / Report for the 1103A machine. The slant signs (/) are the equivalent of the vertical separating lines in the usual table.

Number of machines delivered / 11 / 6

Number of machines on order / 0 / 13

Delivery date of first machine / October, 1953 / October, 1956

Word length / 36 bits / 36 bits

High Speed Storage Capacity / 1024 words, electrostatic; 1024 words, magnetic core / 4096, 8192, or 12,288 words, magnetic core

Magnetic Drum Storage Capacity / 16,384 words / 16,384 words (up to 2 such units)

Magnetic Tape Storage Capacity / Four units with 65,386 words each / Up to 10 uniservos with 326,000 words each (384,000 words optional)

Basic Input / Paper tape, punched cards / Magnetic tape, paper tape, punched cards

Basic Output / Paper tape, punched cards, flexowriter, line printer / Magnetic tape, paper tape, punched cards, flexowriter, line printer

Floating point / No / Optional

Operating Speeds in Microseconds / 36-66, addition; 266, multiplication; 490, division / Fixed point: 32-60, addition; 259, multiplication; 486, division. Floating point: 156-308, addition; 182-386, multiplication; 650-660, division.

Table II: SUMMARY OF AVAILABLE ELEMENTARY FUNCTION SUBROUTINES

Each item in the following tabulation shows: Type of function subroutine / Method employed / Fixed point arithmetic employed? Floating point arithmetic employed?

$\sqrt{x}$ / Rational function approximation combined with Newton-Raphson iteration / fixed, floating.

$\sqrt[n]{x}$ / Newton-Raphson / fixed, floating.

$\sin \frac{\pi}{2} x$, $\cos \frac{\pi}{2} x$ / Chebyshev fit / fixed, floating.

$\sin x$, $\cos x$ / Sheet Nos. 14 and 16*; Taylor Series / fixed, floating.

$\sin^{-1} x$, $\cos^{-1} x$ / Sheet No. 39; Taylor Series with refinements / fixed, floating.

$\tan x$ / $\frac{\sin x}{\cos x}$ $(-75° \leq x \leq 75°)$; Modified Taylor Series / fixed, floating.

$\tan^{-1} x$ / Sheet No. 13; Continued fraction expansion; Taylor Series / fixed, floating.

$\log_e x$ / Sheet Nos. 42 and 56; mini-max fit / fixed, floating.

$\log_2 x$ / Sheet No. 42 / fixed, — .

e^x / Sheet No. 20; continued fraction expansion; mini-max fit / fixed, floating.

e^{-x} / Sheet No. 59 / fixed, — .

2^x / Sheet No. 20 / —, floating.

*(*Sheet Numbers refer to the identification made in reference [1].)*

Table III: CHARACTERISTICS OF LINEAR EQUATION AND MATRIX INVERSION SUBROUTINES ($AX = B$, $AX = I$)

Each item in the following tabulation shows: Method and Source / Arithmetic, number of mantissa bits, number of exponent bits / Capacity in solving linear systems / Capacity in inverting matrices / Special devices and limitations.

Gaussian Elimination (RW) / real fixed arithmetic, 35 mantissa bits, — / $n \leq 179$ / $n \leq 104$ / determines pivot by interchanging rows.

Gaussian Elimination (RW) / real floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 179$ / $n \leq 104$ / determines pivot by interchanging rows.

Gaussian Elimination (RW) / real floating arithmetic, 62 mantissa bits, 8 exponent bits / $n \leq 103$ / $n \leq 52$ / determines pivot by interchanging rows.

Gaussian Elimination (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 103$ / $n \leq 52$ / determines pivot by interchanging rows.

Gaussian Elimination (RR) / real floating arithmetic, 27 mantissa bits, 8 exponent bits / — / $n \leq 30$ / Finds inverse of symmetric matrices only. Has option to improve computed inverse X_0 by iterating on $X_{k+1} = X_k(2 - AX_k)$.

Crout (CV) / real floating arithmetic, 35 mantissa bits, 35 exponent bits / $n \leq 51$ / $n \leq 51$ / improves solution x_0 of $Ax = b$ by iterating on $Ax_{k+1} = b - A \sum_{i=0}^{k} x_i$.

Jordan (WS) / real floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 63$ / $n \leq 63$ / — .

Gauss-Seidel (WS) / real fixed arithmetic, 35 mantissa bits, — / $n \leq 23$ / — / Solves linear system, $Ax = b$ where A is a positive definite matrix.

Table IV: AVAILABLE SUBROUTINES FOR FINDING EIGENVALUES AND EIGENVECTORS OF MATRICES

Each item in the following tabulation shows: Method and Source / Arithmetic, number of mantissa bits, number of exponent bits / Capacity / Special devices and limitations.

Jacobi rotational method (RW) / real fixed arithmetic, 35 mantissa bits / — / capacity: for eigenvalues and eigenvectors $n \leq 38$, 75 (1103A); for eigenvalues only, $n \leq 40$, 85 (1103A) / Obtains eigenvalues and eigenvectors of real symmetric matrices only.

Hestenes-Karush near optimum gradient method (CV) / real floating arithmetic, 35 mantissa bits, 35 exponent bits / $n \leq 64$ / Takes advantage of zero entries in storage allocations. Finds eigenvalues and eigenvectors of real symmetric matrices only.

Leppert's Method (CV) / complex floating arithmetic, 35 mantissa bits, 35 exponent bits / $n \leq 10$ / Obtains eigenvalues for arbitrary complex matrices having given good estimates of eigenvalues. Eigenvalues must be distinct.

Leppert's Method (RW) / complex floating arithmetic, 62 mantissa bits, 8 exponent bits / $n \leq 20$ / Obtains eigenvalues for arbitrary complex matrices having given good estimates of eigenvalues. Eigenvalues must be distinct.

Roots by determinant evaluation (RW) / Complex floating arithmetic, 27 mantissa bits, 8 exponent bits / Tri-diagonal matrix $n \leq 219$ (effective only if $n \leq 72$). Full-bodied matrix $n \leq 73$ (effective only if $n \leq 15$) / Finds eigenvalues for arbitrary complex matrices by locating zeros of $|A - \lambda I| = 0$.

Lanczos bi-orthogonalization procedure (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 20$ / Finds eigenvalues for arbitrary complex matrices by producing a tri-diagonal matrix and finding its roots by method of determinant evaluation.

Danilewski method (RW) / real floating arithmetic has either 27 or 62 mantissa bits, 8 exponent bits, with capacity $n \leq 128$ and $n \leq 64$, respectively; complex floating arithmetic has either 27 or 62 mantissa bits, 8 exponent bits, with capacity $n \leq 64$ and $n \leq 32$, respectively / Determines eigenvalues for arbitrary matrices by finding the associated characteristic equation and locating its roots. Choice of arithmetic is governed by nature of the matrix.

Wielandt (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 32$ / Given estimates to an eigenvalue and eigenvector, this program obtains these quantities to an accuracy determined by a preset parameter.

Generalized eigenvalue problem (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $g + 2n \leq 147$ where g = number of roots sought; n = order of the matrix A / Finds zeros of the determinant of a matrix $A(x)$ having elements which are polynomial in x. Determinant evaluation is employed.

Power method (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 50$ / Finds eigenvectors of arbitrary matrices by iterating $Ax_i = x_{i+1}$. Acceleration is incorporated. Estimates eigenvalue from Rayleigh quotient. Successive values and vectors are obtained by employing matrix deflation.

Power method (NA) / real, vector floating arithmetic, 35 mantissa bits, 15 exponent bits / $n \leq 25$ / Finds dominant eigenvalue and eigenvector only.

Table V: SUBROUTINES AVAILABLE FOR FINDING ZEROS OF FUNCTIONS

Each item in the following tabulation shows: Method and Source / Arithmetic, number of bits in each mantissa, number of bits in each exponent / Capacity / Special devices and limitations.

Ward's Downhill Method (WS) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 63$ / Finds roots of polynomials. Deflates polynomial after obtaining each root.

Muller's Method I (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 150$ / Finds roots of polynomials. After convergence has taken place employs one Newton-Raphson step. Deflates polynomial after obtaining each root.

Muller's Method II (RW) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / — / Roots of arbitrary function are obtained. "Deflation" is replaced by the device of considering

$$\frac{f(x)}{\Pi_{i=1}^{r} (x - x_i)}$$

when searching for the $(r + 1)$th root.

Newton-Raphson (CV) / complex floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leq 50$ / The Newton-Raphson procedure is modified to include the second order term of the Taylor series expansion. The polynomial is deflated after obtaining each root.

Table VI: SUBROUTINES AVAILABLE FOR INTEGRATING ORDINARY DIFFERENTIAL EQUATIONS

Each item in the following tabulation shows: Method and Source / Arithmetic, number of bits in each mantissa, number of bits in each exponent / Capacity / Special devices and limitations.

Runge-Kutta (RW) / real fixed arithmetic has 35 mantissa bits; real floating, 27 mantissa bits and 8 exponent bits; complex floating, 27 mantissa bits and 8 exponent bits / Capacity essentially unlimited if magnetic drum is used. Systems up to 84th order have been solved / Employs Gill's modification for storage minimization. Also, a fixed point version adopts Gill's device for control of round-off error.

Modified Euler Method (BO) / Real floating arithmetic, 27 mantissa bits, 8 exponent bits / $n \leqq 10$ / Length of step determined by accuracy required.

Adams Moulton Predictor-Corrector (RW) / real floating arithmetic, 27 mantissa bits, 8 exponent bits / limited only by storage capacity / Program chooses optimum stepping intervals according to the accuracy required. Uses modified Euler method for starting.

Table VII: SUBROUTINES AVAILABLE FOR CURVE FITTING

Each item in the following tabulation shows: Method and Source / Arithmetic, number of mantissa bits, number of exponent bits / Description and limitations.

Mini-Max, one variable (RW) / real fixed arithmetic, 35 mantissa bits, no exponent bits / Finds a polynomial of specified degree ($\leqq 16$) such that the maximum error of the polynomial over the tabular points is minimized. The points must be equally spaced and less than 582 in number.

Least Squares I, one variable (RW) / real fixed arithmetic, 35 mantissa bits, no exponent bits / Fits tabular data by polynomials of degree $\leqq 63$ according to least square criterion. A three term recurrence relation is used employing orthogonal polynomials. The data points may be unequally spaced and are limited to less than 300.

Least Squares II, one variable (CV) / real floating arithmetic, 35 mantissa and 35 exponent bits / Fits tabular data by either a polynomial $f(x)$ of degree $\leqq 6$ or by an exponential curve $e^{f(x)}$ according to least squares criterion. The data points may be equally or unequally spaced. Limit on the number of points is 2500.

Least Squares I, n variables (RW) / real floating arithmetic, either 27 or 62 mantissa bits, 8 exponent bits / Fits tabular data by linear combination of simple analytic expressions in the independent variables according to the least square criterion. The program employs a Gram Schmidt orthogonalization procedure. The number of points N is limited only by the capacity of the drum storage.

Least Squares II, n variables (CV) / real floating arithmetic, 35 mantissa and 35 exponent bits / Fits tabular data by a polynomial in n variables of specific degree p according to the least square criterion, found as a solution to the normal equations. The program is designed to carry out the special problem $n = 4$, $p = 2$ and for 44 points. Other variations can be set up by simple changes.

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The Editor's Notes and Readers' Forum

(Continued from page 3)

seven, which make up the priority number, stores the last three as a parameter, and uses the other nine digits to look up in a table the address of the operation to which the instruction refers. The operation is a series of consecutive computer words carried in permanent storage. An interpretive routine converts the operation into a number of suboperations. An operation, as a program of suboperations, can use loops, logical decisions, and orders for making changes in the sentence where appropriate.

"There are 48 basic suboperations. Some of the basic suboperations are used for choosing which item to look at, or to alter. A suboperation can also look forward or backward from the current item under consideration until it finds an item that satisfied some condition. Other suboperations can insert or delete whole items, or rearrange the order of items in the sentence.

"The method by which the rules, and the dictionary items for them to work on, was arrived at follows. I opened a recent French chemical journal at random, went to the beginning of the article, and copied out the first sentence. Then I wrote a straightforward translation below it and set out to formulate the verbal rules

(Please turn to page 21)

EXPERIMENTS IN CHESS ON ELECTRONIC COMPUTING MACHINES

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(Reprinted with permission from the Chess Review, Jan., 1957. Note: Readers of COMPUTERS and AUTOMATION who are not familiar with the game of chess should omit the middle section, but are still likely to find a number of important and interesting ideas in this thought-provoking article.)

(To the Editor, Chess REVIEW)

COMPLYING with a request of my friend Dr. Claude E. Shannon of M.I.T., I am transmitting to you the appended article which the well known mathematician and mathematical physicist Stan Ulam and a colleague of his, P. Stein, have written on chess-playing machines.

Prof. Ulam has done some very important work in connection with atomic energy and computing machines. He is normally working at Los Alamos Scientific Laboratory where atomic research is carried on, but is currently a visiting professor in the mathematics department at M.I.T. He is also a good chess-player.

The experiments described in the article represent the first instance in which an electronic computer has been made to play essentially a whole game of chess on the basis of operating instructions of strictly general nature.

Previous attempts never concerned themselves with more than either short mating combinations (problems), where a computer would find the solution by running through every legal series of moves, or elementary endings, like King and Rook against King, where comparatively simple instructions would enable the machine to avoid blunders, or where certain routine ways of forcing mate were embodied in the instructions move by move, so that the machine could consult these instructions, similar to a human player who consults Fine's book on end-games when he gets stuck in analyzing an adjourned position.

Previous Literature

Undoubtedly, your readers will remember one or the other of the fantastic pieces which have off and on appeared in the press on the subject of chess-playing machines, ever since Norbert Wiener, in his famous book, "Cybernetics," first speculated on the possibility of constructing a computer which "might be as good a player as the majority of mankind," and Claude Shannon actually enabled a little home-made computer to play a few simple positions with few enough pieces not to overtax the memory of the machine.

Some chess players who discussed the subject with me at the time, and who had not read Shannon's paper on a practical method of handling the problem, flatly refused to believe that a machine could arrive at making a move which had not been previously "put into it" by the operator. It was most amusing how violently they rejected the idea of a machine doing something akin to "thinking," though I ventured to say that it was really a question of definition whether or not we could dignify the machine's performance with that term.

Since we do not as yet understand the mechanism of our own thinking, we can, of course, not design a machine which thinks the way we do. But in operating on given premises in accordance with given instructions, the machine arrives at results which the human mind can discover only by "thinking." Moreover, neurophysiological research has established that the complicated interactions between our nerve cells involved in thinking is partly of an electrical nature and that there is a certain parallelism in the ways in which nerve cells and the electronic elements of a computer behave in transmitting their informatory signals. Thus, when we say that a computer thinks, we are perhaps still within the limits of permissible poetic liberty even though human instructions must guide the thinking to avoid nonsensical results.

Recently, I had occasion to play a game of checkers against one of the most advanced electronic computers hitherto designed at I.B.M. The mathematician, Dr. Arthur Samuels, had worked out checker-playing instructions which permitted the machine to calculate three moves in advance. I play checkers worse than chess, but I felt that I could easily see three moves ahead anyway.

In the early middle game, out of a clear sky, the computer sacrificed one man, and then two more, and I was just about to make a polite remark to Dr. Samuels about the machine's deplorable oversight, when I noticed to my horror that no matter what I played—I had the choice between two continuations—the machine would win back the three men with the better game.

A computer of this type is expected at M.I.T. early this year. It would no doubt lend itself to a considerable elaboration of the chess instructions designed for the Los Alamos machine and thus lead to a tremendous improvement of the quality of the game the machine can play. I do hope that Dr. Shannon and Prof. Ulam will find some spare time to devote to this problem and that I may have occasion to offer a few chess-strategic suggestions.

Edward Lasker

IS CHESS an art or a science? All devotees of the game know that the great player is one who possesses superior "insight"—but what, precisely, is its nature? One view is that chess skill is a divine gift; some players seem to possess an intuitive feeling for the pregnant situation, amounting at times to an almost mystical perception. At the other extreme lies the theory that great chess is the result of consistent application of rational principles. Most writers on the game will be found to have taken their stand somewhere in between. They speak, indeed, of "rational principles," but when it comes to the question of "consistent application" they throw up their hands and, at least by implication, support the intuitionists. One suspects that many authorities regard the "rational principles" of chess as somehow inferior, indispensable but prosaic guides to lead the player through the maze of complications when his intuition is unhappily dormant. Alternatively, one can very well argue in reverse, i.e., that chess is basically an exercise in logic and that intuition is only called upon when the process of calculation becomes too difficult or, at least, too time-consuming.*

Our knowledge of chess to-date tends to support the view of the game as more an art than a science. Only in certain standard situations, e.g., the simplest end-games and mates, can chess be thought of as reduced (some die-hards might prefer the word "elevated") to a science in the sense that a certain well-defined procedure will invariably produce the expected result. Despite many decades of intensive study and analysis, the "correct" handling of the opening remains an art rather than a science. Innovations are constantly appearing as early as the fourth or fifth move in what were previously thought to be the best-established lines.

"Best Play" Theories

As for the middle game, technique in this phase of play can hardly be described logically, except in the most general terms and illustrated, paradoxically, by elucidation of a few very special situations. Yet no one can deny that there must exist, in theory, principles capable of more or less precise formulation that constitute the basis of "best play." The first, and in some ways the most thorough-going, attempt to enunciate such principles is that of Wilhelm Steinitz.

Steinitz's theory is discussed at length in Dr. Emanuel Lasker's famous book "Manual of Chess." Lasker was a mathematician by profession, and one would not be surprised to see him exalt the rational element in chess. Curiously enough, while praising reason in general, and Steinitz's theories in particular, Lasker seems to have felt that the net result was insufficient. That is, while a knowledge of the rational principles laid down by Steinitz is indispensable, it is not enough. One needs imagination and, above all, the ability to act in the face of the unforeseen, both in the chess "struggle" and in life, of which he considered chess to be a sort of purified miniature. (Cf. Reinfeld's excellent introduction to Lasker's book.)

One feels that Dr. Lasker would not have applauded efforts to reduce chess to a set of essentially numerical rules. Steinitz's dicta concerning the attack and the defense, and above all, the principle of the "accumulation of small permanent advantages," have been the basis of all later rational developments. On the practical side, certain concepts such as rapid development, weak squares, open files, etc., have shown themselves to be highly relevant in the majority of situations.

These concepts are certainly basic to the analysis of positions as well as being indispensable guides in actual play.[1] They, at least, have a statistical validity. (We might add that they are the meat and drink of the commentators; without them, the art of annotation would consist solely in the listing of continuations.)

These precepts give rise to criteria by which the relative strengths of certain types of positions may be judged. Do they, then, constitute a set of "principles" for the play of the game? It is permissible to doubt it. There must be some more fundamental ideas involved. The authors are not prepared to say what these are, but at least two obvious postulates must be included. The first and most obvious is the principle of "Material Advantage," i.e., the securing and maintaining of a plus in material. This point needs no discussion; specific tactical considerations apart (and certainly "ceteris paribus," as Lasker would say), it is clearly a good thing to be a piece up.

Secondly, there is the principle of "Superior Mobility," i.e., the securing of more freedom for one's pieces and the restriction of the opponent's field of action. This principle can be seen in operation even in the play of the average chess amateur. No one can doubt the validity of these elementary desiderata: the interesting question is how far method of play can be based on these two principles alone. What then about combinations? What about direct mating attacks?

We think that such tactical points are to some extent taken care of in the application of the two general principles. (A combination can be looked on, roughly, as a device to win material or to gain room for maneuver.) As for mating attacks, the mate is the most extreme case of immobility for the player mated (the case of stalemate, of course, requires special consideration).

Programming the Code

These simple thoughts appeared to merit some sort of test. Accordingly, a group of scientists at Los Alamos, including amateur chess players,[2] decided to construct a method (technically known as a "code") which would enable an electronic computing machine to play chess utilizing just these two criteria of material advantage and mobility. A well known article by C. Shannon, "Programming a Computer for Playing Chess," *Philosophical Magazine*, May, 1950,[3] describes such possibilities in admirable fashion.

Chess-playing "codes" for automatic computers have been successfully constructed in the past—by the late Professor A. Turing in England and, quite recently, by a Russian group. No details are yet available on the Russian effort,[4] but Turing's attempt is fully reported in the book, "Faster Than Thought," edited by Bowden. Without going into details, we need only say that Turing's code allowed his electronic player to see only one move ahead, except in certain particularly vital situations. Needless to say, the machine did not succeed in playing a very good game and was easily beaten by its "trainer."

* It is hardly necessary to mention that, mathematically speaking, chess is in principle completely determined, that is, a well-defined strategy exists which leads to a unique outcome. Practically, of course, the determination of this strategy is not feasible. Cf. von Neumann and Morganstern's "Theory of Games and Economic Behavior" for a short discussion of this point.

Now the restriction of the machine's range of foresight to a single move was necessary in Turing's case in order that the time required per move should not be too long. To readers who are unfamiliar with the workings of automatic computers, this may seem surprising, hence a few remarks on the general problem of coding chess for machine play may not be out of place:

Let it be said once and for all that computing machines do not "think" (the term, "giant brains," notwithstanding!). They add, subtract, multiply and divide, in addition to which they can make elementary decisions: e.g., whether or not a given number is larger, smaller, or equal to a second given number. All more complicated operations must be compounded from these simple ones.

To make a computing machine perform any given task, all the rules must be provided in advance, and these in quite explicit form. The more complicated the problem, the more detailed and elaborate must be the code embodying the rules of calculation. In a game like chess, the computer must proceed in a quite naive fashion, essentially trying all possibilities which are allowed by the rules of the game, and then picking the "best" in accordance with some pre-arranged criterion. Starting from a given chess position, a sequence of moves of prescribed length can very well include millions of possibilities.

64 Million Sequences

For instance, if we consider a sequence four moves long, (two moves by each side), and assume for the sake of argument that there are 20 legal moves possible at each stage, then the number of different possible sequences (in the following we shall call them "chains") is 160,000. If we wish to consider three moves by each player, keeping the number of legal moves available equal to 20, then some 64 million chains can occur!

Lest the reader feel that 20 is too high a figure for the number of possible legal moves at each stage of such a chain, we give a concrete example. Starting from a position reached in a standard line of the King's Indian after seven moves on each side (*M.C.O.* p. 89, col. 46), the average number of legal moves at each stage of the six-move chain (three moves by each side) following the actual column is just over 31. (These are the *legal* moves, not necessarily good or even sensible moves.) There are thus roughly 890 million chains possible.

In human play, all but a very few of these chains are rejected almost instantaneously, and the remaining continuations are subjected to relatively careful scrutiny. How the human brain does this is certainly a great mystery; and, until we know more about the mechanism of thought, we cannot incorporate such features into a machine code. That the machine can achieve any worthwhile result by its naive method of trial and error is due to the great speed with which it performs its elementary operations.

The computers of two or three years hence will be able to perform nearly a million of these elementary operations in a second. Even at that rate, and even if the machine did not have to spend time separating out the legal moves from those forbidden by the rules of chess, it would take well over two hours to make a single move in our above example. Incidentally, it should be mentioned that present-day machines are 50 to 100 times slower.

Thus we see that, even with this great advantage of speed, the length of the chain that can be considered at any stage of a chess game is severely limited by time considerations. In addition, if the machine had to "remember" too much information during the course of the game, it might well run out of space in which to store this information; another way of putting this is to say that its "memory" capacity might be exceeded. In practice, this is usually not so serious a limitation as that imposed by the time required per move, since the amount of information that must be retained from move to move can be reduced by ingenious coding.

On the other hand, if one should wish to incorporate a large set of rules applying to special situations that arise in practice, one might well overtax the memory of even the largest computer. For example, suppose that our main purpose were to make a computing machine play a better-than-average game of chess. In view of the impracticability of extending the "range of foresight" beyond, say, three moves, it might seem a good idea to incorporate into the machine's memory several thousand typical positions (arranged, perhaps, in some thematic order).

The machine could then, by direct comparison, choose that pattern most relevant to the actual position, after which it could consult a library of suggested continuations and tentatively select its move, subjecting the result to some standard evaluation. The machine would then be playing, so to speak, by analogy. To do so properly might require a tremendous amount of storage space. Actually, the authors do not feel that such an approach is fruitful as yet, less because of the technical difficulties involved than because the results would not shed much light on the fundamental structure of the game.

Try "6x6" Chess

With these considerations in mind, we decided to test our ideas, not on the classical game of chess, but rather on a somewhat simplified version which we call "6x6 chess." This is a game in which the Bishops and Bishop Pawns are omitted and the rest of the pieces are arranged in the usual order on a 6x6 board. The rules of the game are identical with those of ordinary chess except that castling is not allowed, and the initial Pawn advance is restricted to one square. (The reason for this last rule becomes obvious on setting up the board.)

It turns out that 6x6 chess is an interesting game in its own right, though vastly simpler than its 8x8 parent. Much of the flavor of chess is retained, though it soon becomes clear that there is little room for maneuver. The reason we chose this game for our initial experiments was to enable a machine to look *two* moves

---

1. An admirably lucid discussion is given by Dr. M. Euwe in his book, "Chess Strategy and Tactics."

2. In addition to the authors, J. Kister, W. Walden, and M. Wells were involved in the planning and preparation of these experiments. Cf. an article to appear in the Proceedings of the Western Joint Computer Conference.

3. Given in essence in "20th Century Chess-Playing Automata" by Edward Lasker, page 104, Chess Review, April, 1950. — Editor.

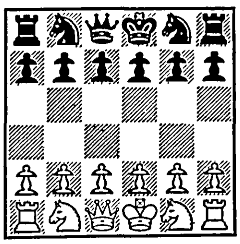
4. A short report appeared in Pravda; apparently, some games were played on a computer in Moscow. According to the article, the machine can not hold its own with a "good" player. Just how "good" is not stated.

ahead, i.e., two by each side, and still make its moves in a reasonable time (the number of legal moves at each stage is roughly half the number for classical chess). Therefore we get a factor of $16 = 2^4$ for chains, and the machine could make a move in about 10 minutes; on the average 8x8 game, it would take over one hour per move.

We did not use the fastest machine available in our laboratory, but rather a slower and older machine known officially as MANIAC I. This computer can perform about 10,000 elementary operations per second and was ideally suited to the simplified problem we wished to study. Omitting technical details, we need only say that the machine examined all legally allowed four-move chains (i.e. two moves by each player), finally selecting that continuation which resulted in the greatest net mobility, coupled with the greatest material advantage. (This description of the procedure is not strictly accurate, but the actual prescription is too involved to be discussed here.)

Mobility was defined for this purpose as the number of legally available squares; certain weightings were applied later in order to avoid a few obviously senseless moves (cf. White's first move in Game I). Material strength was evaluated by assigning to each Pawn the value of eight legal moves and valuing the other pieces accordingly, following the scale generally accepted as applying to the classical game (the correct relative values are undoubtedly different for our game; as yet they are unknown).

THESE CRITERIA are admittedly extremely crude. Nevertheless, the actual games revealed several amusing features. The first game pitted the machine against itself. The very first move indicated that the code needed revising.



GAME I

Maniac I. White — **Maniac I.** Black

1 N-K3 **P-Q3**

White did not "expect" . . . P-Q3.

His shortsightedness results in loss of time. Later, this weakness was corrected.

2 N-N1 **P-QN3**
3 P-K3 **P-K3**
4 Q-K2 **P-Q4**

White continues to waste time.

5 PxP **NPxP**
6 Q-Q1 **Q-R3**

Black gives up his advantage; he is afraid of the check at R3.

7 Q-R3† **QxQ**
8 NxQ **K-Q1**

Black avoids being checked at N5.

Though we give a few diagams to set the visual picture for the reader, we advise him to follow the moves carefully on a properly blocked off board. There are a number of mild surprises for a player used to the conventional board and notation.—Editor.

9 N-R3 **K-Q2**

Black leaves the Pawn **en prise.**

10 R-QN1 **. . . .**

White fails to take it. He feels his Queen Knight is not secure.

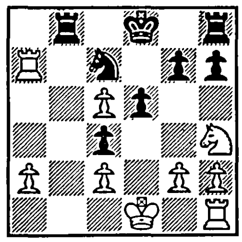
10 . . . . **K-K1** **12 PxN** **R-Q1**
11 N-Q4† **NxN** **13 R-N5** **. . . .**

White wins a Pawn, anyway.

13 . . . . **N-Q2**
14 RxP **R-QN1**

Black threatens mate on the move.

† = check; ‡ = dbl. check; § = dis. ch.



15 R-N5 **R-R1** **17 NxNP** **KxN**
16 P-R3 **P-R3** **18 RxN†** **K-N1**
19 R-K5? **R-K1??**

Here Black failed to see the win: 19 . . . RxP 20 P-N3 (forced), P-R4! 21 any, R-R6 mate.

20 RxR† **KxR**
21 P-Q5† **. . . .**

White's play is hardly precise.

21 . . . . **KxP** **23 P-N3** **KPxP**
22 K-Q1 **R-KN1** **24 PxP** **R-N3?**

Black will not play 24 . . . PxP for fear of the Rook check.

25 RxP **RxR**
26 PxR **K-N2**

And now it's all over.

27 P-R5 **K-R3**
28 P-R6(Q) **KxP**
29 Q-K4 **. . . .**

And mate the next move.

BY MINOR ADJUSTMENTS in the evaluation procedure, we were able to correct some of the more serious weaknesses in the machine's play which the first game exposed. We now felt ready to let MANIAC play against a suitably handicapped human player. Dr. Martin Kruskal, of Princeton, graciously accepted the challenge. Since Dr. Kruskal is a strong (8x8 chess) player, we felt it only fair to have him give the machine odds of a Queen. As a slight compensation, he was allowed to play White. The game follows.

GAME II

(Remove White's Queen)

Dr. M. Kruskal White — **Maniac I** Black

1 P-K3 **N-QR3**
2 P-QN3 **N-N1**

Black's shortsightedness has not yet been cured.

3 P-Q3 **P-K3** **8 P-R3** **P-N4†**
4 P-Q4 **PxP** **9 K-Q2** **PxP†**
5 KPxP **P-QR3** **10 PxP** **N-KR3**
6 N-QR3 **P-KN3** **11 N-K3†** **NxN**
7 K-K2 **K-N2** **12 KxN** **. . . .**

White has succeeded in closing the position so that Black's Queen has no scope. If the Queen ever gets loose, White might as well resign. Black can, of course, free himself by sacrificing his Knight for a Pawn, but such subtlety is well beyond him.

12 . . . . **K-R3**
13 K-Q2 **. . . .**

White wants to make room for his Knight at K3. This plan occurred to him just as he was on the verge of conceding a draw. Note that, if he plays 13 N-Q2, then 13 . . . K-N2! forces the Knight back to R3: e.g., 14 RxR? Q-N3†! 15 PxQ (forced), PxP mate.

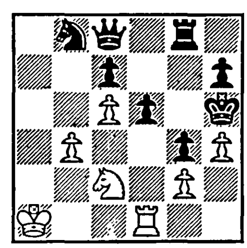
13 . . . . **R-R2**
14 K-N2 **R-N1**
15 KR-K1 **. . . .**

White prevents the dangerous advance, 15 . . . P-K4.

15 . . . . **R-KN2**

This weak move gives White an idea for a mating trap.

16 N-Q2 **RxR**
17 KxR **R-N1**
18 K-N1! **. . . .**



This waiting move is the key to the combination. Kruskal thinks he can predict the Machine's next move.

18 . . . . **R-N2??**

White has guessed correctly. Black now loses his Queen.

19 N-N1! **Q-N3†**

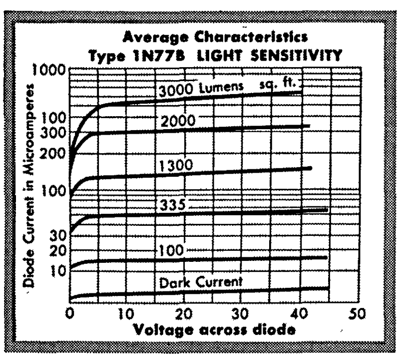
Black's last move is heart-breaking, but necessary. In eminently human fashion, the machine "deliberated" 20 minutes before giving up its Queen. But, otherwise, 20 N-K3 is mate.

(Please turn to page 20)

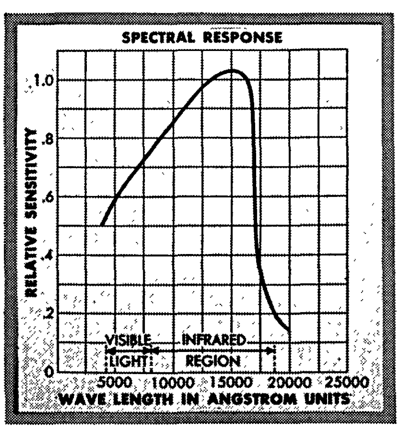
New Sylvania Photodiode

Type IN77B

...puts tinier beams



Light sensitivity of the new Sylvania photodiode, type 1N77B



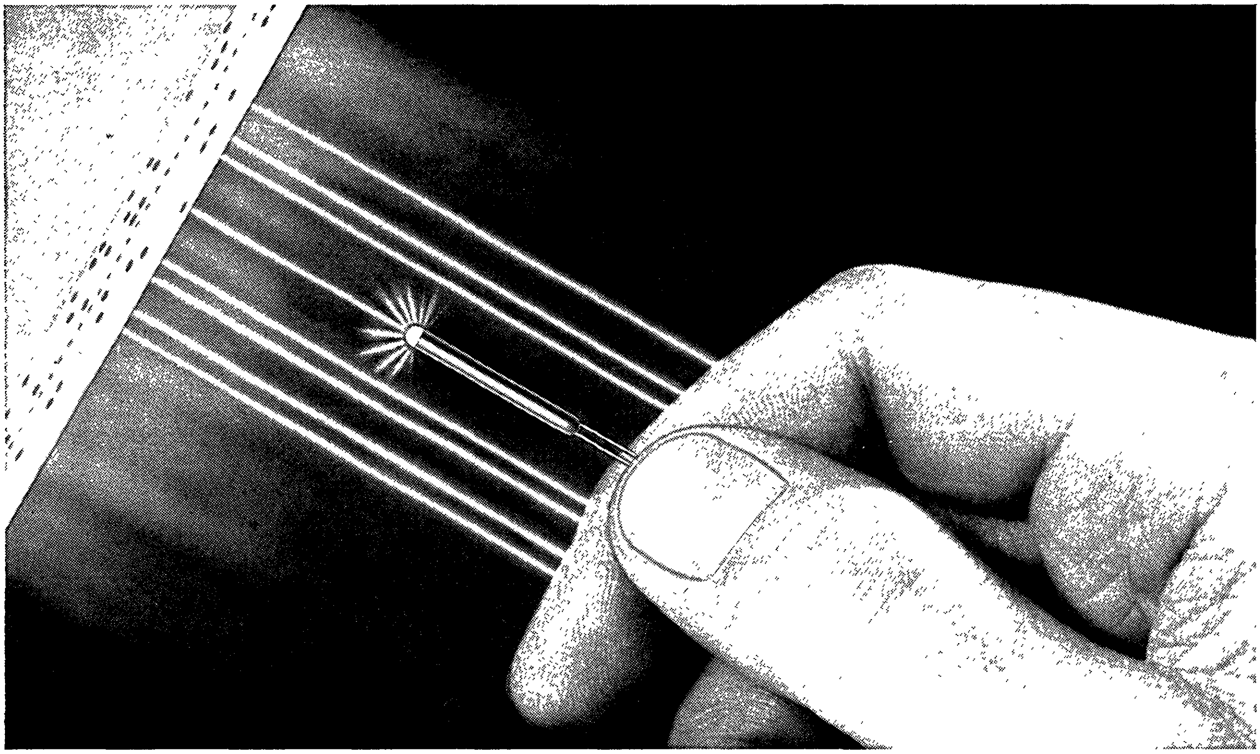
Spectral Response of Sylvania's new 1N77B

Sylvania designs a smaller photodiode with improved capabilities to handle applications where space is limited

Sylvania, leader in diode development, introduces the 1N77B, a new smaller junction photodiode with superior power dissipation and higher temperature capabilities. The improved unit, with a diameter of .077 inch, is ideal for highly compact assemblies and other applications where space is at a premium. The new 1N77B, which replaces type 1N77A, is now available at substantially lower prices in volume quantities.

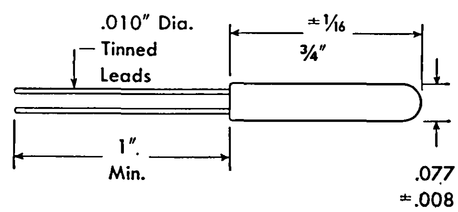
The compact construction and fast response of the Sylvania 1N77B make it ideal for rapid, highly sensitive scanning and reading applications, such as in computer tape or punched cards readout. The new unit is also readily

"Sylvania—synonymous with Semiconductors"



A fraction of an inch in diameter, new Sylvania photodiode, type 1N77B, is ideal for computer tape readout. It operates in the visible and infrared regions

of light to work



Sylvania's new photodiode, type 1N77B, is nearly 20 percent smaller in diameter than type 1N77A which it replaces

adaptable to infrared detection and heat-seeking devices because it is sensitive to light wave lengths extending from near ultraviolet into infrared. Other applications for the new 1N77B include liquid level control, headlight and street light dimmers, intensity controls, photoelectric controls and motion picture sound pickup.

Sylvania's improved photodiode has a higher lumen intensity than other types and a high output impedance. This is especially advantageous when coupling into vacuum tube or grounded collector transistor circuits. The new units are hermetically sealed in glass with a built-in lens that focuses light on the sensitive portion of the junction. The light interruption frequency response of the 1N77B photodiode is flat from 300 cycles to 15 kc at 100 percent with 260 lumens/sq. ft.; R_L = 110,000 ohms, —45 v.

Contact your Sylvania representative for further information on the new 1N77B.

TABLE OF RATINGS & CHARACTERISTICS

Absolute Maximum Ratings (at 25°C):

Operating Voltage	50 volts dc
Ambient Temperature (Maximum)	75°C
Power Dissipation	40 Milliwatts
Forward Current	10 Ma dc

CHARACTERISTICS

Reverse Current—Dark (E_R= −10 volts)	15 ua max.
Reverse Current—Dark (E_R= −50 volts)	100 ua max.
Noise Voltage—Dark (E_R= −45 volts, R_L=100,000 ohms)	15 Millivolts max.
Light Sensitivity	18.7 peak-to-peak volts—min.
Light Sensitivity	37.5 peak-to-peak volts—max.
Typical Minimum Frequency Response	15.0 KC

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LIGHTING • RADIO • TELEVISION • ELECTRONICS

Experiments in Chess

(Continued from page 17)

20	PxQ	PxP
21	K–Q2	P–K4†

Black's inherent limitations afford him no chance in the end-game.

22 PxP	P–N5	30 NxR	K–Q2		
23 R–R1	R–N1	31 K–K3	K–N3		
24 R–R5	PxP†	32 K–K4	NxP		
25 K–K2	R–N3	33 PxN	K–N4		
26 RxP	R–N1	34 P–Q5	K–N3		
27 NxP†	K–N3	35 P–Q6(Q)	K–N4		
28 KxP	K–K3§	36 N–K3	K–R5		
29 R–N5	RxR†	37 Q–Q3	K–N6		
		38 Q–N2 mate			

THE THIRD GAME matched the machine against a beginner with one week's experience, who had, in fact, been taught the game expressly for the purpose of participating in this contest. The play was naturally weak on both sides, but as the ending shows, MANIAC enjoyed a slight advantage in precision.

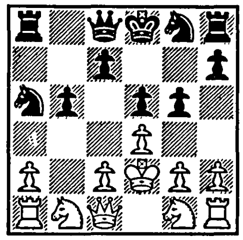
GAME III

Maniac I — **Beginner**
White — Black

1 P–K3 . . . .

An improvement over the opening move of Game I.

1	P–QN3	
2 N–KR3	P–K3	
3 P–QN3	P–N3	
4 N–N1	P–QR3	
5 PxRP	NxP	
6 K–K2?	. . . .	
6	N–Q4?	



Analysis indicates that 6 . . . P–Q3 wins. If 7 PxP, QxP, most of the winning lines start with . . . N–KR3 or, when that fails (as on 8 K–K1), with . . . N–Q4†, etc. If White doesn't take the Pawn, then . . . P–Q4 decides quickly. White's sixth move is certainly very weak; but Black lets him get away with it.

7 NxN — NPxN†

7 . . . KPxN† is much better.

8 K–K1	P–R3	12 Q–R3	Q–N2
9 P–QR3	R–N1	13 Q–R2†	K–N2
10 P–R4	R–R1	14 R–N1	RxP
11 P–R5	K–K2	15 RxQ	RxQ
		16 R–N1	R–QR2

White's Queen-side demonstration has resulted in the loss of a Pawn; but his general play conveys at least as good an impression as does Black's aimless wandering. Now White starts action in earnest on the King-side.

17 P–R3 — R–R3?

Black is oblivious to the danger. 17 . . . P–N4 is necessary.

18 RPxP	P–Q3	21 PxR(Q)	N–Q2
19 N–R3†	K–K1	22 QxP†	K–Q1
20 P–N5†	K–K2	23 N–N5 mate	

All things considered, the machine handled the final attack most impressively.

WE MUST NOW ASK, what do these simple experiments indicate for the future attempts? It appears that these games, though weak, tend to confirm the over-ruling importance of our two simple criteria. One must remember that our code had absolutely no "experience," tactical or strategic, built into it. One might think that many of the elementary blunders could be corrected by allowing the computer to explore certain special chains of, for example, exchanges farther than our standard two moves.[5] We definitely plan to do so, in the near future.

One result of this procedure should be to make almost three of four-move mating combinations trivial, even in the 8x8 game. We feel confident, for instance, that the machine will find Marshall's famous "golden move" (Marshall-Levitsky, Breslau, 1912), starting from the same position (and without any coaching from the sidelines!). To be sure, when we do experiment with real chess (as we hope to this winter), we shall have to include as a general principle something equivalent to "King safety."

In defining mobility, we shall also not merely count available moves but weight them differently, e.g., moving a Knight closer to the enemy's camp should count more than retracting it, etc. Whether or not other criteria will be required cannot be answered in advance of the experiment. The authors feel strongly that, perhaps in contrast to the popular view, it is not the "brilliancies," i.e. on the whole, forced tactical combinations, but their preparation—the general feeling for strategy—which constitutes the deepest part of the game and the most difficult to incorporate in any future machine code.

This factor manifests itself with the greatest clarity in the games of Alekhine. Cf. the comment of Spielmann on Alekhine games: "I see well enough the combinations themselves, but where he gets the positions enabling him to start the combinations is beyond me."

A second look at our 6x6 games, however, reveals a truly shocking weakness. In our comments on Game III, we have mentioned that White's sixth move leads to a lost game. It is quite likely that the exchange on the rook file initiated by White's fifth move is already sufficient to doom him—the unnecessary freeing of Black's King Knight is fatal.

It seems that in 6x6 chess, control of the center plus the slightest freedom to maneuver is decisive, mainly because the adversary is almost necessarily in "Zugzwang" on the crowded board. While it is easy enough to correct the particular fault of White's fifth move by a slight adjustment, it is by no means clear how to avoid the evil via the invocation of a precise and general rule. (Of course, the principle of mobility would be sufficient if coupled with an extended range of foresight.) We hope that further experiments will shed light on this problem.

Finally, we must state our feeling, very likely, that no machine will be coded to play *master* chess within the next 10 or perhaps even 20 years. Nevertheless, we feel that experimentation along the lines we have discussed is useful in helping to fix the balance between foresight and rule in chess. It is also our hope that such studies, if pursued sufficiently far, may be suggestive in regard to learning about the functioning of the brain itself—certainly the most efficient chess-playing machine yet imaginable.

5. This device was extensively employed by Turing, who divided all positions into two categories, "dead" and "considerable." Turing's code followed only the "considerable" positions in any detail, i.e., farther than one move by each player.

Note on Computer-Chess

The significance to chess of these experiments, related in the foregoing article, is tremendous.

This machine able to play under the guidance of general principles permits the testing of such principles. The faster, newer machines can work on our orthodox game. And the vast power of their "memory banks" makes the tests permanently applicable.

True, the testing reported in this article is so elementary as to be even crude—to the expert, laughable. But, in time and as each "proved" principle is made a part of a machine's guiding directions, the play of the machine will improve, at an accelerated pace!

As devotees to chess, and so possibly biased, we feel that the game cannot be reduced to any mathematical formula—not even

(Please turn to page 30)

(Continued from page 13)

that would convert the French into English. This sentence had about 40 words in it, and it took some 10 hours to work out the rules from scratch.

"Turning to the second sentence, I added new items to the dictionary, invented new rules, and modified existing rules until the system would handle both sentences. The third sentence was attacked in the same way, and so on up to 220. By the 200th sentence, the time for adding each new sentence to the repertory was about 15 minutes per sentence.

"To my own satisfaction at least, this showed that by the time 200 sentences of running French text had been processed in this way, most of the major difficulties had been encountered, and given solutions that could be called good first approximations. Further progress, once the computer version of the system is working properly, should be very rapid."

II. From A. F. R. Brown

Institute of Language and Linguistics
Georgetown University
Washington 6, D. C.

THE ILLIAC program that I mentioned in my paper on machine translation is now working; not flawlessly I find, but the interpretive routines work properly and show up the faults in the "macro-programming" of constants and suboperations into linguistic operations. So I now have the first crumb of concrete success.

COUNCIL FORMED BY SCHOOLS AND INDUSTRY FOR IMPROVING SCIENCE INSTRUCTION

Hughes Aircraft Co.
Culver City, Calif.

NEARLY 100 national leaders in science, education and industry gathered on July 7 for a week-long national industry-education conference at the new University of California extension conference center at Lake Arrowhead, Calif., 5000 feet above Los Angeles. Their purpose was to take a calm look at the nation's scientific manpower shortage, and decide how industry and education could best cooperate to end it. The sponsors of the conference included the National Academy of Sciences, a key scientific advisory body to the federal government, and Hughes Aircraft Co. of Culver City, Calif., one of the West's biggest developers and manufacturers of electronic equipment.

For five days the conference delegates listened to national authorities outline the dimensions of the manpower problem. Robert L. Clark, executive secretary of the President's Committee on Scientists and Engineers, warned that "the scientific manpower shortage can be ended only in the local classroom" by improved teaching of science courses from grade school through junior college. A science specialist of the U. S. Office of Education, Ellsworth S. Obourn, pointed out that the number of new science and mathematics high school teachers had dropped more than 50 percent between 1950 and 1954, and only now is beginning to climb slowly toward 1950 levels.

Finally teachers, businessmen and scientists from eight different states described local teamwork between industry and education that had improved science instruction in the nation's schools.

By Thursday afternoon, the delegates had begun to process the facts, data, and ideas through discussion groups. By Friday evening they were evolving a plan for organized industry-education cooperation that could be used first in the Southern California area and then extended to other areas and communities.

By Saturday noon, when the conference adjourned, the delegates had:

– Established a permanent Southern California Industry-Education Council, with a full time paid executive secretary and a five-man steering committee representing both industry and education. The Committee members were Dr. Joseph B. Platt, chairman, president of Harvey Mudd College in Claremont, Calif.; Dr. Lester C. Van Atta, associate research director, Hughes Aircraft Co.; Everett Chaffee, associate superintendent, Los Angeles city schools; Adm. C. F. Horne, vice president of Convair and manager of the company's Pomona, Calif. division; and T. Stanley Warburton, superintendent of Fullerton, Calif., high school and junior college districts.
– Appointed five area "salesmen" within the Southern California area, each with the responsibility of getting together more industries and schools to improve science teaching programs.
– Approved a drive to raise funds from industry for running the new Council, and received informal assurances from industrial delegates that the needed money would be forthcoming. Both the National Academy of Sciences and the National Science Foundation also promised financial backing if necessary.
– Agreed to publish a manual, with the backing of the National Academy of Sciences, to show other areas how to start their own industry-education cooperative programs.
– Employed as the Council's first executive secretary James T. Robinson, 34, a brilliant high school science teacher from Whittier, Calif., with a knack of distilling complex scientific principles into simple language.

Robinson is to serve the Council until the middle of September, when he will leave to study at Stanford on a National Science Foundation scholarship. When Robinson's successor takes over, the Council steering committee expects the industry-education cooperative program to be well under way.

"Industry and education delegates to the Arrowhead conference quickly discovered that they had the same goals," said Dr. Van Atta. "Industrialists discovered that educators want industry's help in making science teaching come alive through demonstrations of the practical applications of scientific theory. Educators found that industrialists want their future scientists to get plenty of English and other non-scientific courses as well as technical training, to help them 'think big' and then communicate their ideas to others.

(Please turn to page 26)

INDUSTRY NEWS NOTES

Ed Burnett

New York, N. Y.

SIZE OF COMPUTER MARKET

FORTUNE MAGAZINE has estimated that the current market for computers (about zero as late as 1952) is now about $350,000,000 (or some 3 times the figure published by Forbes). The Fortune estimate for 1960 is $1 billion, $2 billion annually by 1965. These last compare favorably with the results of a nationwide survey by *Computers and Automation* published in the May 1957 issue which indicates the computer market in the next five years "will be between four billion and seven and one-half billion dollars." Fortune reports that there are now over 1200 computers in use, more than 200 in the $1 million-plus class, more than 800 in the $100,000 to $500,000 class, and about 250 in the under $100,000 class.

GRADUATE EDUCATION

WESTERN ELECTRIC CO., New York, has launched a program of graduate education for its engineers on six college campuses (New York University, Northwestern, Illinois Inst. of Tech., Cornell, Duke, North Carolina State) and in three specially equipped centers in New York, Chicago, and Winston-Salem. About 2000 students each year are planned for. The new centers will give courses in communications systems, planning for manufacture, product design principles, communicating ideas, operations research, industrial control devices, engineering statistics, planning of manufacturing facilities, advanced tool design, computer theory, and other subjects. Completely supported by the company, the new program is designed to ease the critical shortage of engineers by making recruits more quickly effective, and by increasing the capabilities of experienced engineers. The scope of the program is equal to the establishment of a new engineering school of 1000 full-time students.

NEUTRON FLIGHT ANALYZER GRAPHS REACTOR ENERGY

A NEW electronic computer at General Electric's Knolls Atomic Power Laboratory now measures, counts, and classifies the flight of neutrons from a nuclear reactor. A counter at the end of an established flight path detects the neutrons, and relays the data to the analyzer, which then produces a graph showing the energy characteristics of the reactor. Formerly, it took a full month of laborious recording to determine the energy distribution from different reactor setups. With the new tool, developed by scientists Elmer J. Wage and Donald S. Davidson, an analysis in graphic form requires only one hour.

THIRD ANALOG COMPUTING CENTER OPENED

ELECTRONIC ASSOCIATES, INC., Long Branch, N. J., has opened its third analog computing center, in Brussels, Belgium. The Electronic Associates computer there is equipped with 100 amplifiers, comparable to the EA computing center in Los Angeles and about half the size of the EA computing center in Princeton, N. J. The three centers represent a total investment of about $1 million.

The company has found that Brussels is the hub of the European market they want to reach. It has helicopter service to Paris and Rome, excellent rail facilities, and a cluster of industrial research around it; Belgium has a sound currency, a stable government, an excellent location, and a favorable attitude towards American business.

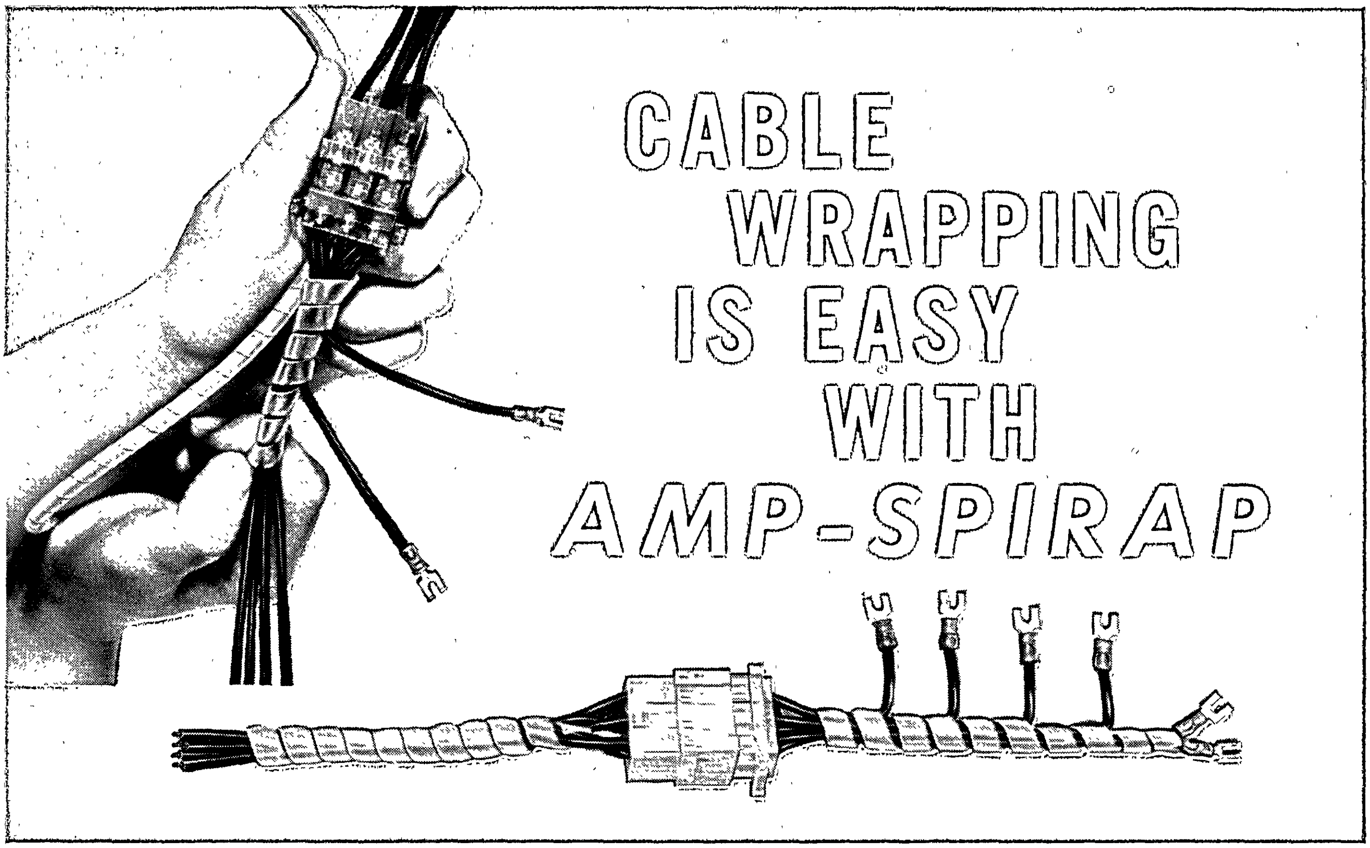
The Brussels computing center will make computations for aircraft and missiles, petroleum, and nuclear energy. (While the United States plans 1½ billion kilowatts of nuclear electrical capacity by 1962, Euratom plans for ten times that by 1967.) It is expected that the new computing center will add 70 percent to the company's income from foreign sales during 1957, as compared with 1956.

Planning New Series

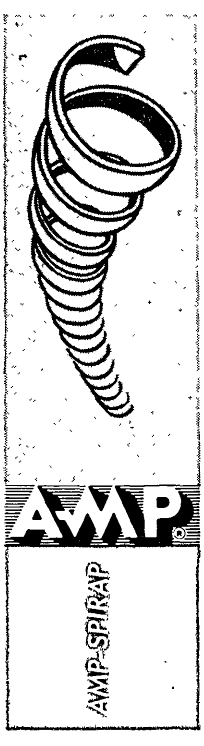
The company is planning to bring out a new series of computers called Operations Control Computers. These will give optimum solutions to linear programming problems such as gas blending, rate of recovery, economic scheduling, feed mixing, and metal alloys. While this type of problem can be solved by a digital computer, the analog computer generally solves this kind of problem in a very short time, so quickly in fact that one can solve the problem over and over as conditions change, and "keep riding the optimum."

The company has noticed that an engineer familiar with vectors and ratios becomes a competent analog computer user in a short time, as for example in problems of automotive computations, on engines, pistons, electrical and mechanical systems, heat transfer problems, stability, vibration. To accomplish the same with a digital computer, the engineer usually finds he needs a middleman, the mathematician, in between him and the machine. An engineer quickly learns to master the analog computer, and make it his own tool. Because it is a "model" of his conditions, he gets a "feel" for his problem, and he can "imagine" the piece of equipment he is working on and how it behaves, because there is almost no time-lag between the information in the mind of the engineer and the information provided by the analog computer; the relationship is close and intimate.

(Please turn to page 24)



The development and production of the finest quality solderless terminals for your electrical circuitry requirements is AMP's primary objective. We also constantly search for allied products and application techniques that will speed, simplify, and obsolete present time-consuming sub-assembly operations. *AMP-SPIRAP* and its application technique stems from such constant searching activity.



AMP-SPIRAP is a unique, spirally-cut plastic wrapping that . . .

- eliminates tedious cable lacing, insulation damage, and pulling of wires through spaghetti tubing
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Distributor in Japan: Oriental Terminal Products Co., Ltd., Tokyo, Japan

THE SECOND UNIVAC-LARC

THE SECOND Univac-Larc has been contracted for by the U.S. Navy Bureau of Ships with Remington Rand, Division of Sperry Rand. It will cost about $3.5 million, will be able to perform more than 100,000 multiplications per second, and is expected to be delivered at the end of 1958 to the Applied Mathematics Laboratory at the David Taylor Model Basin near Washington.

The first LARC (Livermore Automatic Research Computer) was designed for the Radiation Laboratory of the University of California at Livermore, Calif.

A major use of the Navy's LARC will be to solve problems associated with nuclear reactors and their incorporation into shipboard power plants. The Bureau of Ships, in designing the Navy's vessels using nuclear reactors, has used tens of thousands of hours of electronic computer time. The speeds of the computers used, fast as they have been, have still been slow enough to force undesired limitations upon scientists and engineers responsible for designing reactor power plants. In order to complete their designs within the specified time limits, the mathematics used has had to include certain gross approximations.

With the new LARC, it will be possible to obtain solutions to reactor problems which more closely approach reality than has previously been possible.

Work in other fields of interest to the Navy, such as hydrodynamics, ship-hull design, sonar and radar propagation, and logistics planning can be processed with increased savings over present computer costs.

LARC uses transistors—numbering in the tens of thousands—almost to the exclusion of vacuum tubes. This increases the reliability of the computer, while decreasing the electrical power and air conditioning needed.

The computer is divided both mechanically and functionally into separate cabinets, so that the capacity of the computer can be increased in many ways by adding different types of these cabinets. This will enable the computer to handle still larger problems that are expected to occur in the future.

Another feature of the LARC is the use of two separate computers to make one integral computer system. One of the computing units is used exclusively for performing the arithmetic (additions, multiplications, etc.) used in the solution of a problem, while a second computer simultaneously controls the flow of data required by the first computing unit. Each unit has been designed to perform its function with maximum efficiency. The use of the second computing unit, the "input-output processor" that controls the flow of data, greatly expands the capacity and speed of the Univac-Larc system.

For the LARC, the Bureau of Ships has also contracted for a very high speed computer readout, a Charactron readout, from Stromberg Carlson, Division of General Dynamics Corp.

The computer readout will be able to display and record on film split-second "thoughts" of the LARC computer at the rate of 15,000 characters per second, 50 percent faster than any computer readout previously built by the company. The speed compares with about 1,200 characters per second achieved by the fastest mechanical printers in general use with computers.

Dual cameras for recording the data on 35 mm. film will be the only moving parts in the readout. Two complete recording systems will be provided so that one can be loaded with film while the other is operating, to give continuous service. The film will be taken from the machine for normal darkroom photographic processing and later study.

LONG RANGE MISSILES REPORT TO TAPE RECORDERS

TAPE RECORDERS to receive information directly from missiles passing in flight nearby are being installed at more than 100 points, both on the ground and on ships over the South Atlantic, throughout the test range of the intercontinental ballistic missile of the Air Research Development Command. This range to test guided missiles extends from the missile launching site near Patrick Air Force Base in Florida across the Atlantic to Ascension Island off the coast of Africa.

The recording equipment, valued at over $1,000,000, collects the data broadcast by the missile on temperatures, pressure, and thrust and then plays it back to give an "in-flight" pattern of operation. Designed and built by Consolidated Electrodynamics Corp., Pasadena, Calif., the units simultaneously can record up to 14 tape tracks or information channels on a single tape reel. The data is so recorded that it can be automatically translated and transferred to punch cards or coded tape for computer analysis.

VALUE LINE INVESTMENT SURVEY OF OFFICE EQUIPMENT STOCKS

A TEN-PAGE section of a recent issue of The Value Line Investment Survey, New York City, appraises the investment opportunities in the stocks of Addressograph-Multigraph (AIN), Burroughs (BGH), International Business Machines (IBM), Marchant Calculators (MRC), National Cash Register (NC), Pitney Bowes (PBI), Royal McBee (RMB), Smith-Corona (SCT), Sperry Rand (SY); and Underwood (UNX).

While formerly highly cyclical and thus regarded as a sensitive business barometer, the office machine business "through diligent research . . . has created new revolutionary products . . . has thus created new markets . . . and has changed into a growth industry."

But the Survey warns that investors, looking at the phenomenal prospects of the office equipment companies, have bid up their stocks to ". . . levels which ignore current values and discount earnings too far into the future." The Survey predicts "Competition in the electronic computer field has become progressively keener, a situation that is likely to result in lower rental fees or sale prices for these machines."

(Please turn to page 26)

MANUSCRIPTS

WE ARE interested in articles, papers, reference information, and discussion relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the first of the preceding month.

ARTICLES: We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it.

Consequently, a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions.

We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 3000 words. A suggestion for an article should be submitted to us before too much work is done.

TECHNICAL PAPERS: Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable.

REFERENCE INFORMATION: We desire to print or reprint reference information: lists, rosters, abstracts, bibliographies, etc., of use to computer people. We are interested in making arrangements for systematic publication from time to time of such information, with other people besides our own staff. Anyone who would like to take the responsibility for a type of reference information should write us.

NEWS AND DISCUSSION: We desire to print news, brief discussions, arguments, announcements, letters, etc., anything, in fact, if it is not advertising and is likely to be of substantial interest to computer people.

PAYMENTS: In many cases, we make small token payments for articles and papers, if the author wishes to be paid. The rate is ordinarily ½¢ a word, the maximum is $15, and both depend on length in words, whether printed before, whether article or paper, etc.

All suggestions, manuscripts, and inquiries about editorial material should be addressed to: *The Editor,* COMPUTERS AND AUTOMATION, *815 Washington Street, Newtonville 60, Mass.*

Industry News Notes

(Continued from page 24)

These new machines, particularly "the fabulous electronic computers, do not replace or displace standard office equipment. Rather, each of them presents a brand new concept of mechanizing office routine. For that reason, instead of depending on the replacement market, the sales growth of the office equipment makers is now keyed principally to the widening acceptance by businessmen of new products designed to mechanize business procedures and speed the flow of paper work. In today's extremely competitive economic environment, it has become highly necessary for management to obtain complete and significant company information far more rapidly than is possible with conventional methods."

DIGITAL TRANSCRIBER

MINNEAPOLIS HONEYWELL Industrial Division, Philadelphia, has purchased a license to make and sell a new electronic test data computer from ROCKETDYNE division of North American Aviation, Inc. Called the IDIOT II, the new instrumentation digital on-line transcriber reportedly can handle 128 pieces of information at one time, in measuring such conditions as temperatures, pressures, strains. Rocketdyne has been using the computer to analyze data from test runs of engines for guided and ballistic missiles. Production of the computer, tentatively priced in the $200,000 class, has been assigned to the Honeywell Beltsville, Md., plant now making high speed data recording systems using magnetic tape.

The Editor's Notes and Readers' Forum

(Continued from page 21)

"With this kind of mutual understanding, the new Council can serve as a catalyst for increased industry-education cooperation, and also as a clearing house where industry and education can make contact with one another to plan new joint projects."

Hughes has one of the broadest industry education programs in the country. The company sponsors college-level courses and scholarships for more than 1000 of its own employees, and has a cooperative program with the Los Angeles high schools that was cited at the Arrowhead meeting as a good example of an industry-education project. The Hughes high school program has three parts:

1. A summer employment program for high school science and math teachers that enables them to work side by side with top-level Hughes scientists, gaining first-hand knowledge of practical applications of the classroom theory that they teach during the school year.

2. Lectures to high school science classes by Hughes scientists, bring students up-to-date on the latest scientific developments and stimulating their interest in scientific careers.

3. A summer research project in the Hughes laboratories for outstanding high school students, giving them first-hand experience in scientific work as it is carried on by industry.

The Southern California Industry-Education Council (SCIEC) plans to encourage more industries and communities to adopt programs such as this and other programs cited in reports at the conference, such as:

- Programs for math teachers, to help them help one another in reviewing advanced courses in summer sessions (Arlington, Va.).
- Television instruction for science classes, with a top-notch teacher-scientist and with dramatic laboratory experiments (Pittsburgh, Pa.).
- Scholarships paid by industry, to help poorly-prepared teachers get more training in science instruction (Atlanta, Ga.).
- Teamwork among industry and professional scientific societies, providing each school with a single liaison scientist to coordinate outside aid to science teaching in the schools (St. Louis, Mo., Charleston, W. Va., and southeastern New York).
- Statewide efforts by interested citizens to build more public awareness of the importance of science education (Oklahoma).

EXCHANGES OF INFORMATION

I. From V. Barashenkov, Director
Saltykov-Schedrin State Public Library
Exchange Section, Sadovaya 18,
Leningrad-Centre, USSR

OUR LIBRARY is very much interested in the establishment of friendly exchange relations with your institution.

We have available for exchange periodicals and monographs issued in the USSR on any branch of science. Further details about them you will find in "Handbook on the International Exchange of Publications," Paris, UNESCO, 1956, pp. 442–448, or in other catalogs and handbooks.

In return we should like to receive your publication, *Computers and Automation*. We shall be very grateful to you if you find the possibility of sending it to our library on the exchange basis. Please note that we propose to begin exchanging with current issues.

We sincerely hope that the establishment of such relations will be of mutual benefit.

II. From the Editor to Mr. V. Barashenkov

WE THANK YOU for your friendly letter of July 23. We are entering an exchange subscription for your library for *Computers and Automation*.

In return we would appreciate it very much if you would send us, from time to time, copies of reports written in English (we have no one in our organization who can translate from Russian) on activity relating to computers and data processing in the USSR, as you may be able to obtain them.

Bulk Subscriptions

These rates apply to prepaid subscriptions to "Computers and Automation" coming in together direct to the publisher. For example, if 7 subscriptions come in together, the saving on each one-year subscription will be 24 percent, and on each two-year subscription will be 31 percent. The bulk subscription rates, and savings to subscribers depending on the number of simultaneous subscriptions received, follow:

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7 or more	$4.20, 24%	$7.25, 31%
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3	5.00, 9	8.80, 16
2	5.25, 5	9.55, 9

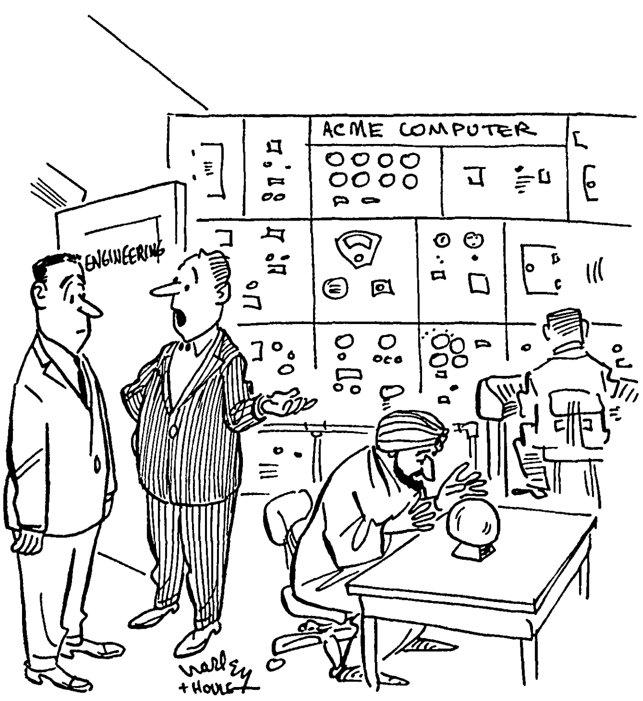
For Canada, add 50 cents for each year; outside of the United States and Canada, add $1.00 for each year.

Special Issues

The June issue of COMPUTERS AND AUTOMATION in each year commencing with 1955 is a special issue, "The Computer Directory and Buyers' Guide" containing a cumulative "Roster of Organizations" and a cumulative "Roster of Products and Services in the Computer Field", and other reference information.

From time to time we publish a cumulative "Who's Who in the Computer Field", as an extra number of COMPUTERS AND AUTOMATION. The last one published, "Who's Who in the Computer Field, 1956-57", was issued in March 1957, and contained over 12,000 entries.

NEW PRODUCTS *and* IDEAS



"So far it's a draw — they both come up with the same answers, in exactly the same time."

THE RELIABILITY OF A SAGE SYSTEM PROTOTYPE

A PROTOTYPE digital computer for the SageSystem has reached a reliability of 87% – according to information in a report by W. J. Canty, Lincoln Laboratory, M. I. T., Lexington, Mass., even though this type of information-handling system is significantly larger and more complex than any other. The Sage System (SAGE: initial letters of "Semi-Automatic Ground Environment") is a large real-time information-processing system for air defense including a great digital computer as its chief control element.

The system being tested contains a prototype digital computer (called the XD-1) and an experimental air defense system. The purpose of the prototype system is to gain experience in solving problems of great size and complexity that occur in air defense situations.

In tests over a five-month period, the reliability of the XD-1 has averaged 87.8% during 17 hours per day used for programmed machine operation. The mean free time between machine failures during such operation has averaged 2.4 hours – a shorter time than desired or expected but now lengthening. More than 5/6 of the pluggable units removed from the XD-1 computer in one month period because they were defective, were removed because they were discoverd during periods of preventive maintenance and marginal checking.

The philosophy of performance which has been guiding testing and development is that (1) factors affecting reliability should be found out and controlled early in the design of the equipment, and that (2) deteriorating components should be identified and removed before they fail.

DISTRIBUTION OF EMPTY BOX CARS

AFTER THREE YEARS of study of car movements and application of operations research, the Southern Pacific Railroad, in cooperation with the Stanford Research Institute, now helps govern the movement of empty box cars with an IBM 650 Computer.

Control and movement of empty cars is one of the major problems of all large railroads. It involves seasonal changes, weather, grading of cars according to needs of shippers, divisional movement, switching points, "gateways" to connecting railroads, in-transit operations, and "foreign" cars (those owned by other railroads). The net result is often a total supply of empties in excess of actual need, but not distributed in the right places. The expense of maintaining non-revenue-producing rolling stock is costly. Every car-day lost is irretrievable; and, in addition, each "host" railroad must pay to the foreign road rent of $2.75 per day for every foreign car on its lines.

By processing some 70,000 to 100,000 car movement cards daily, the new data automation system will evaluate car-handling efficiency, forecast traffic trends, and provide the basic intelligence needed to move empties to maintain optimum car supply.

On the basis of early test operation, it seems certain that the new system will result in a significant reduction in the number of empty box cars required by the railroad for its own operation, and the release of more cars to obtain loan-out income from other roads. This will increase the service of the line to its shippers, and result in a substantial saving in operation expense.

The Southern Pacific inaugurated this system July 1 on 11 geographical divisions, covering over 8000 miles of track from Portland, Ore., to El Paso, Tex. The new system measures car needs, car supply, and car handling efficiency for each of these divisions. These data are then fed into the IBM 650, which once each week solves a complex equation in a matter of hours. The computation could be performed by conventional methods, but only weeks after the daily data had any useful application.

ELECTRONIC COMPUTERS AID THE SEARCH FOR OIL

THE GROWING DEMAND for oil has fostered the design of a number of electronic brains with simulated degrees in geophysics. In seismic prospecting, small explosives are utilized to send sound waves through the various rock layers—and the returning echoes vibrate a sensitive recording pen. Until recently, the translation of these wavy lines into cross-section

(Please turn to page 30)

New Products and Ideas

(Continued from page 28)

charts partially showing depth, thickness, type and position of rock layers has been a long time-consuming task, carried out by clerks known as "computers."

"seisMAC," made by Texas Instrument, and recently shipped to Europe to help probe for oil there, performs many of the computational tasks involved in getting seismic records in shape for interpretation.

A new aid developed by engineers of GULF OIL CORP. transforms returning sound waves from seismic probing directly into cross-section pictures of the underground area. The result according to Gulf is one of the most detailed and accurate pictures of underground features yet available from surface observations.

Computers in Banking

(Continued from page 7)

quarter-inch wide, located one-quarter-inch from the bottom edge, a "common machine language code" in magnetic ink which can be "read" by the machines of all of the makers. A list of some of the kinds of banking jobs these machines are now doing or will be doing in the near future includes:

Deposit Account Records (Including Interest and Statements).

Check Processing Accounting (Coding, Sorting, Listing, Bookkeeping).

Signature Verification.

Stockholder Records.

Installment Loan Accounting.

Personal Trust Accounting.

Real Estate Loan Accounting (Mortgages).

Factoring Accounts.

Payroll Accounting.

Club Deposit Accounting.

Inter-Office Record Transmission, Filing and Recall.

Electronic Index Filing.

Central Processing Centers for Groups of Smaller Banks.

Among the banks which have already publicized their planned computer installations are the bank of America (which purchased 30 General Electric ERMA computers); Chase-Manhattan, which is readying a complete computer service based on Laboratory for Electronics equipment; and over 100 small and medium-sized banks which have ordered National Cash Register Post-Tronic units.

The Post-Tronic operates by reading information recorded on a magnetic film on the back of each account card. Two manual operations are required — selecting the card, and punching in the figure to be posted. ERMA (Electronic Recording Machine Accounting) is a larger, costlier, and more sophisticated posting system which can do all of the following automatically: identify preprinted account numbers on checks and deposit slips, select the proper account card, refile the card after posting.

Univac Pinpoints the Weather

(Continued from page 9)

system. The crystals act as freezing nuclei in the warmer cloud regions, where natural agents would fail to cause precipitation. Long range forecasts help us to determine the overall effectiveness of a cloud-seeding program. In marginal farm lands during drought years we may be compelled to recommend against such operations if rainfall will fall short of crop requirements.

Obviously, we do no more than take advantage of what the elements provide. But the knowledge which permits us to do so is the fulcrum; unless we know a cloud system will be over the target area, we can't take advantage of it. Similarly, unless a construction company can be sure that a building site will be free of heavy rainfall for a stated period, it may make a heavy investment in time and money only to have work crews stand around idle.

Predicted Current Drought

This is the great significance of accurate, pinpointed weather forecasting. There is little we can do to head off a drought, but the knowledge that it is coming can enable us to greatly minimize its effects and plan relief measures realistically.

For example, we predicted the current serious drought in the southwest back in 1946. With this knowledge, we could have relieved conditions in many areas. Our warning went unheeded at that time. Our views were considered merely as another "professional opinion." Now with the completely objective approach provided by Univac to produce dependable weather projections these "opinions" are lifted from this intangible category to a completely realistic and fundamental framework within which all interests affected by the drought can plan remedial action.

An accurate weather prediction that a given three-month period, for example, will be unusually cold—or wet—can be of great importance to business, especially those companies which produce for public consumption.

Many other examples could be cited. Their significance is obvious, the potential for human welfare all but limitless. We are no longer dealing with trinkets invented by medicine men to appease recalcitrant gods. Our tools are powerful beyond belief just 10 short years ago. With them, using data we are constantly documenting, the accurate long range weather forecast will soon become a common management report.

Experiments in Chess

(Continued from page 20)

as complicated and extensive as Einstein's tensor equations. Yet, by batting back and forth the augmented total of all "proved principles" under the rapid play of a computer, even that point may be put to the final test!

Some such set of principles, too, as Weaver Adams gives in his "White to Play and Win": attacking power, mobility, options, king safety, much enlarged, can come close to selecting a move with quite limited calculations.

At the very least, principles of good chess play will be the more quickly set. Testing old and trying new in hundreds of games, a computer can give a statistical verdict, as its play shows improvement, with or without each.

Editors, CHESS REVIEW

NEW PATENTS

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

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

June 4, 1957: 2,794,593 / Hendrik Alkema, Baltimore, Md. / – / A "Great Circle" disk computer.
2,794,594 / William K. Ergen, Oak Ridge, Tenn., and Albert H. Palya, Haddon Heights, and Alfred W. Frick, Camden, N. J. / U.S.A. / A heading computer for radio navigation systems.
2,794,595 / Grant C. Ellerbeck, San Leandro, Calif. / Friden Calculating Machine Co., Inc., Calif. / A calculating machine.
2,794,851 / George V. Morris, Chicago, Ill. / Zenith Radio Corp., Ill. / An apparatus for supplying a plurality of individual control signals to an encoding device.
2,794,910 / Jacobus Ludovicus Arends, Hilversum, Netherlands / North American Philips Company, Inc., New York, N. Y. / An automatic frequency stabilizing circuit.
2,794,914 / Peter Daniel Van Der Knaap and Antonius Bockhorst, Eindhoven, Netherlands / North American Philips Co., Inc., New York, N. Y. / A circuit for separating pulsatory signals.
2,794,937 / Frederic Calland Williams, Timperly, and Tom Kilburn, Davyhulme, Manchester, Eng. / National Research Development Corp., London, Eng. / An electronic information storing device.
2,794,970 / John J. Yostpille, Livingston, N. J. / Bell Telephone Lab., Inc., New York, N. Y. / An identification system of serial stored information.
June 11, 1957: 2,795,226 / Allan L. Bralove, Wash., D. C., and Clarence F. Rogier, Chicago, Ill. / The Electrofile Corp., Chicago, Ill. / A card selection apparatus.
2,795,376 / Robert R. Williamson, Hoboken, N. J. / Stevens Research Foundation, Hoboken, N. J. / A computing unit for addition and multiplication.
2,795,377 / Robert J. Loofbourrow, Roland B. Stelzer, and Clarence B. Scotty, Bellair, Tex. / The Texas Co., New York, N. Y. / An electrical analogue.
2,795,378 / Raymond H. Beranger, Paris, France / Compagnie des Machines Bull (Societe Anonyme), Paris, France / An apparatus for subtracting numbers represented by coded pulses.
2,795,696 / David C. Evans, Los Angeles, Calif. / Bendix Aviation Corp., Detroit, Mich. / A flip-flop circuit.
2,795,776 / Herman Epstein, West Chester, Pa. / Burroughs Corp., Detroit, Mich. / A binary counter.
June 18, 1957: 2,795,840 / Anton Salecker, Poughkeepsie, N. Y. / International Business Machines Corp., N. Y. / A memory tube.
2,795,862 / Tomas J. Poole, Seattle, Wash. / – / An adding and subtracting device.
2,795,957 / Benjamin C. Muzzey, Mercer Island, Wash. / Boeing Airplane Co., Seattle, Wash. / A multiple derivative instrument.
2,796,218 / Geoffrey C. Tootill, Shrivenham, Frederic C. Timperley, and Tom Kilburn, Manchester, Eng., and Gordon E. Thomas, Port Talbot, and David B. Edwards, Tonteg, Wales / National Research Development Corp., London, Eng. / An Electronic computing device with subsidiary storage.
2,796,219 / Charles M. Hill, Alameda County, Calif. / Marchant Research, Inc., Calif. / A word counter.
2,796,314 / Robert P. Bishop, George Bruck, Parker Painter, Jr., and George S. Shaw, Melbourne, Fla. / Radiation, Inc., Melbourne, Fla. / A quantizing recorder.
2,796,521 / John J. Lentz, Pasadena, Calif. / International Business Machines Corp., New York, N. Y. / A storage

(Please turn to page 34)

use it on the job!

1. DIGITAL COMPUTER PROGRAMMING

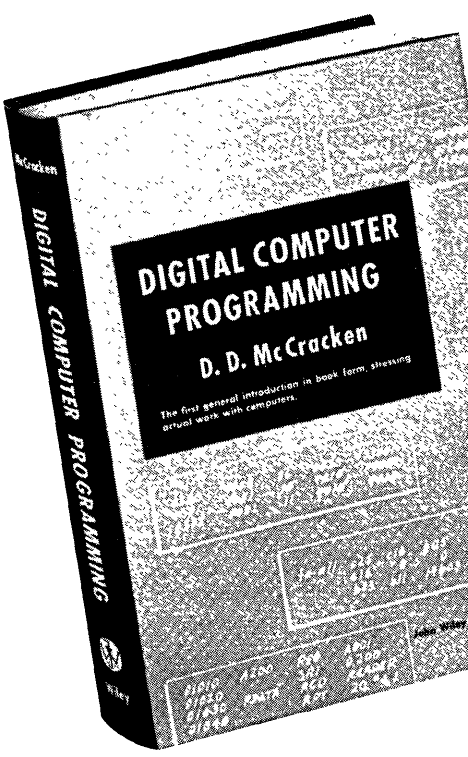
By D. D. McCRACKEN, General Electric Co., Phoenix, Arizona

A lucid, down-to-earth presentation of the practical aspects involved in actually working with automatic digital computers, plus a clear-cut picture of the basic fundamentals underlying this fast-growing field.

A key feature of this readable new book is TYDAC (Typical Digital Automatic Computer), the mythical computer devised by the author to illustrate principles and techniques of operation. Because it combines elements from all models currently on the market, the use of TYDAC makes the book especially valuable where there is no computer available for practice.

Digital Computer Programming can also be used for specific machines, and much of the material is applicable to all digital computers. Thus you gain a better understanding of your own machine, and a wider knowledge of programming in general.

Check these chapter headings: Computing Fundamentals. Coding Fundamentals. Binary and Octal Number Systems. Decimal Point Location Methods. Address Computation. Loops in Computing. Flow Charting. Index Registers. Subroutines. Floating Decimal Method. Input-Output Methods. Magnetic Tape Programming. Program Check-out. Relative Programming Methods. Interpretive Programming Methods. Double Precision Arithmetic. Miscellaneous Programming Techniques. Automatic Coding.



1957
253 pages
Illus.
$7.75

2. INTRODUCTION TO OPERATIONS RESEARCH

By C. WEST CHURCHMAN, RUSSELL L. ACKOFF, and E. LEONARD ARNOFF, all of the Case Institute of Technology. In collaboration with 11 other experts.

Answers your questions about operations research — what it is, what it can do, and what new tools it offers you. Convincing discussions of linear programming, inventory, waiting line, replacement, sampling, etc., help you evaluate and understand its potentialities and procedures. 1957. 645 pages. 136 illus. $12.00.

3. ON HUMAN COMMUNICATION A Review, a Survey, and a Criticism

By COLIN CHERRY, Imperial College, University of London

Reviews recent trends in the study of human communication and the relationships existing between such communication sciences as: linguistics, cybernetics, psychology, semantics, and phonetics. A valuable source book of references, citations, and definitions. A Technology Press book, M.I.T. 1957. 333 pages. 53 illus. $6.75.

4. AUTOMATIC DIGITAL COMPUTERS

By M. V. WILKES, Cambridge University

Furnishes a general introduction to the principles underlying both the design and use of digital computers. Covers logical design, programs, and methods by which the machine itself can assist the programmer in his task. Written by a pioneer in the field. 1956. 305 pages. Illus. $7.75.

5. TRANSISTOR CIRCUIT ENGINEERING

Edited by RICHARD F. SHEA. Eight co-authors, all of the General Electric Company.

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