6345
Memorandum M-1020

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Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: CONFERENCE ON AUTOMATIC COMPUTING MACHINERY, RUTGERS UNIVERSITY, MARCH 28-29, 1950

To: 6345 and 6673 Engineers

From: C. W. Adams and D. R. Israel

Date: April 6, 1950

Abstract: Some of the papers and exhibits presented at the Conference on Automatic Computing Machinery at Rutgers University are summarized and discussed. References are given, where possible, to further sources of information.

Introduction

Only 16 of the 27 talks are summarized below, since the papers were presented in concurrent sessions. Of those that were heard, some were either so specialized or so poorly presented as to be hardly worth summarizing. Personal opinion enters into the emphasis and evaluation given. The facts are subject to human errors in reporting.

In the program listed in full below, the papers have been marked with numerals as follows:

(1) a summary of this paper is given in this memorandum
(2) the full text or an abstract is already available in printed form
(3) this paper was not heard and cannot be summarized

Many of the papers marked (3) were attended by K. E. McVicar and interested persons could perhaps contact him for information.

The exhibits are all described briefly or in detail at the end of this memo.

Abstracts of all papers have been promised by the Association for Computing Machinery and anyone interested in more details is referred to these abstracts if the writers of this summary are unable to oblige.

Program:

Tuesday morning, March 28:

"High Speed Computing Machines - A Survey", by Perry Crawford (1)
"Machines of Moderate Cost", by George Stibitz (1)

Tuesday afternoon, March 28:

Section A

"Applications of Computing Machines to the Solution of Management Problems", by Marshall K. Wood, Department of the Air Force (1)

"Engineering Applications of Electronic Analog Computers", by Herbert Zagor, Reeves Instrument Corporation (1)

"Applications of Electronic Computers to Census Bureau Problems", by James L. McPherson, Florence K. Koons, Ralph E. Mullendore, Bureau of the Census (1)

"Applications of the BINAC" by John W. Mauchly, Eckert-Mauchly Computer Corporation (Subsidiary of Remington-Rand Corporation) (1)

Section B

"The BINAC - A Technical Report" by James R. Weiner, Eckert-Mauchly Computer Corporation (Subsidiary of Remington-Rand Corporation) (3)

"An Analog Series Computer", by Max G. Scherberg, Office of Air Research (3)

"Preliminary Design of the Mark IV", by Benjamin L. Moore, Harvard University, (3)

"Design of a Low-Cost Computer" by Paul L. Morton, University of California (1)

Tuesday evening, March 28, banquet speaker:

"Automatic Computing Machinery of Moderate Cost", by Howard H. Aiken, Director, Computation Laboratory, Harvard University (1)

Wednesday morning, March 29:

Section A

"A Digital Computer for Solution of Simultaneous Linear Equations", by Samuel Lubkin, Electronic Computer Corporation (2)

"The ANACOM, A Large-Scale General-Purpose Analog Computer", by D. L. Whitehead, Westinghouse Electric Corporation (3)

"The IBM Card-Programmed Electronic Calculator" by Cuthbert C. Hurd, International Business Machines Corporation (3)

"The MADDIDA, General Features", by Floyd G. Steele, Northrop Aircraft, Inc. (3)

Section B

"Planning and Error Consideration in the Numerical Integration of a Difference Equation", by Francis J. Murray, Columbia University (1)

"Probability Methods in the Solution of Elliptic Partial Differential Equations" by John H. Curtiss, National Bureau of Standards (1)

"A Machine Method for Solution of Systems of Ordinary Differential Equations", by Richard F. Clippinger, Bernard Dimsdale, Aberdeen Proving Ground (1)

"The Theory of Digital Handling of Nonnumerical Information and Its Implications to Machine Economics", by Calvin M. Mooers, Zator Company (1)

Wednesday afternoon, March 29:

Section A

"New Circuits Installed in the Aiken Relay Calculator" by Frederick G. Miller, U. S. Naval Proving Ground (1)

"Digital Computing Machine Components of Universal Application", by William S. Elliott, Research Laboratories of Elliott Brothers, Ltd. (London) (3)

Section B

"Optical Ray Tracing", by Donald P. Feder, Benjamin Hardy, National Bureau of Standards (1)

"Solution of Matrix Equations of High Order by an Automatic Computer", by Herbert F. Mitchell, Jr., Eckert-Mauchly Computer Corporation (Subsidiary of Remington-Rand Corporation) (1, 2)

Wednesday afternoon, March 29 (continued):

Section A

"Design Features of a Magnetic Drum Information Storage System", by John L. Hill, Engineering Research Associates, Inc. (3)

"The SB-256 Electrostatic Selective Storage Tube" by Jan A. Rajchman, RCA Laboratories (3)

Section B

"Theodolite Reductions on the IBM Relay Calculators" by Mark Lotkin, C. E. Johnson, Aberdeen Proving Ground (1)

"The MADDIDA, Design Features" by Donald E. Eckdahl, Northrop Aircraft, Inc. (2)

Exhibits

"The REAC", Reeves Instrument Corporation
"The RCA Linear Simultaneous Equation Solver", RCA Laboratories
"The IBM Card-Programmed Electronic Calculator", International Business Machines Corporation
"A Small Binary-Octal Calculator", Raytheon Manufacturing Company
"The MADDIDA, Magnetic Drum Digital Differential Analyzer", Northrop Aircraft, Inc.
"The Oscillograph in the Computer Field", Allen B. DuMont Company
"Zator Card Equipment", Zator Company

Summary

High Speed Computing Machines - A Survey: Perry Crawford

"The basic capability of a computer is the representation of a complex physical system," claimed Mr. Crawford as the theme of his excellent general discussion. A computer, when programmed for a particular problem, responds to any given stimulus in exactly (or nearly) the fashion in which the physical system in question would respond, whether that system be an electrical network or a national economy. People who are computer-minded usually have no money; people who have money must therefore be converted to being computer-minded.

The problem which really brought about the development of analysis and of computing is the trajectory problem, and the cost of a single solution to the problem has been reduced from $10.00 in 1940 to less than a cent in the foreseeable future.

CMR

Machines of Moderate Cost: George Stibitz

The definition of cost might be made on a logarithmic basis:

$10 to $1,000:	low cost
$1,000 to $100,000:	moderate cost
$100,000 to $10,000,000:	high cost

All things considered, a girl computer costs as much per year to obtain and maintain as a $10,000 machine, so a company hiring from 1 to 100 girl computers can afford to buy a computer of moderate cost.

Two major choices must be made between

(1) analog or digital
(2) fixed formula (special purpose) or variable formula (general purpose)

The decision depends on the type of problem, the number of different problems, and the likelihood of obsolescence, among other things. CWA

Applications of Computing Machines to the Solution of Management Problems: Marshall K. Wood

The term "management problem" is presently understood to encompass planning in many fields, especially those with economic backgrounds, in which it is desired to select and carry out an optimum plan to reach one or more alternative goals or achievements. Mr. Wood spoke in particular reference to problems of planning for future operations of the Air Force. This work is discussed in "Programming of Interdependent Activities" by Marshall K. Wood and George B. Dantzig, available in the WWI library (475). Material of a similar nature was discussed at the Harvard Symposium by Wassily W. Leontiff, and associated literature is available in the WWI library, numbers 649 and 650 ("A Proof of the Equivalence of the Programming Problem and the Game Problem" and "Simplex Solution of the Hitchcock-Koopmans Transportation Problem", by George W. Dantzig). JRJ

Engineering Applications of Electronic Analog Computers: Herbert Zagor

The REAC, an electronic differential analyzer built by the Reeves Instrument Corporation, was discussed. (The machine was on exhibit at the conference.) REAC uses, as does the differential analyzer built by the Goodyear Aircraft Corporation, feedback amplifiers for both summing and integrating. Since there is only one independent variable -- time -- multiplication cannot be carried out by the familiar equation $xy = \int xdy + \int ydx$. Multiplication is therefore carried out from the $E = IR$ equation with servo circuits used for varying the R.

DC amplifiers are used on the REAC, with special balancing circuits used to prevent drift. The machine is set up by patch cord connection on the front panel. A six channel Brush ink recorder is used for the output. Scale factors are variable while the machine is in operation, affording a control of the overflow. Non-linear cams and special cylinders can be used for non-linear functions.

It seems that a number of these machines have been built, have been sold, and are now in use. The price is around $34,000. The Reeves Corporation itself has done a good deal of simulation work with the REAC, especially in connection with auto pilot problems and design problems in aircraft structures. A number of these applications are described in reports available in the Whirlwind confidential file.

JCRJ

Applications of Electronic Computers to Census Bureau Problems: J. L. McPherson

The problem of reducing data ("information processing") led to the development of punched cards by Hollerith of the Census Bureau in the 1880's. The development of computers, though not pioneered by the Census Bureau, will be of great help. Among the many problems which face the Bureau in the reduction of the 1950 enumeration data will be a large one caused by an attempt to cross-correlate two of the three censuses (population, housing, and agriculture). For each of the 46 million housing cards, they must select the head of the household from among the 150 million population cards. (Why this data cannot be cross tabulated while it is being taken is not made clear.)

In any case, the Bureau of Standards' computer which is to be used by the Census Bureau is expected to permit the work to progress from 40 to 1000 times as fast, depending on the problems -- largely through use of magnetic tape instead of punched cards, although punched cards (200 million of them) will be prepared to start with, until the computer is delivered.

CWA

Applications of BINAC: John W. Mauchly

BINAC was delivered to Northrop Aircraft Corporation in August 1949 shortly after it was built, and hence only a few problems were carried out on it by the Eckert-Mauchly Corporation while it was undergoing final tests. The computer employs a mercury delay line and a magnetic tape input and output. The machine stores instructions as data, and has a capacity of 512 thirty binary digit words.

Among the problems run on the computer before delivery were binary-decimal, decimal-binary conversions; collation and sorting problems; finding roots of numbers; numerical solutions of the LaPlace and Poisson equations; and the generation of "random" numbers with associated statistical studies (this last is described in a report to the Statistical Society, December 1949). In connection with the solution of the LaPlace and Poisson equations, a 16 x 16 network was used and it was found that with the ordinary finite difference formulae 203 iterations were necessary at one point before a precision of one part in 2^{24} was achieved. By using formulae employing "acceleration" or prediction this was cut down to about 43 iterations. JCRD

Design of a Low Cost Computer; Paul L. Morton, read by C. V. L. Smith

CALDIC, the California Digital Computer built under contract with the ONR, was discussed. The basic aim of CALDIC, in addition to its low cost, is to be ease in programming. Towards this end a large memory is planned. The machine will store 10,000 ten decimal digit numbers in a magnetic drum storage. The magnetic drum is to operate at 60 rps, and the machine is to be capable of 30 operations per second. Punched tape input and output is to be used, although input and output equipment cannot be used while computation is in progress. The tube complement is to be 2000, the cost about $25000, and the date of completion January 1951. Since the machine exists chiefly on paper, the fulfillment of these three design figures would seem to be in the nature of wishful thinking. JCRD

Automatic Computing Machinery of Moderate Cost: Howard H. Aiken

Professor Aiken questionned the present program of the computing machinery industry. Fearful that the present builders were little more than "gadgeteers" who were striving for speed regardless of other considerations, Professor Aiken expressed doubt as to the advisability of concentrating on speed and complexity of machinery. The chief trouble, as he saw it, was that those in charge of our computer program are more interested in building machines than in doing computing. As evidence of this Aiken declared that a moderate-cost reasonable-speed machine could be built today employing magnetic tape and magnetic drum storage, yet there seemed to be no inclination to build such a machine. It was his opinion that greater impetus would be given to the computing field and more interest would be raised among representatives of business and industry if computers actually started to produce useful results.

Professor Aiken expressed concern over our present educational facilities as regards computation and the use of computing machinery. He predicted a dire shortage of trained personnel unless universities provided courses of study and degrees in the computational field. Further research in the physics of the solid and liquid state as applied to computing components was also stressed. The use and development of liquid relays was suggested, as was the use of germanium rectifiers and static magnetic delay lines as discussed by Way Dong Woo at the Harvard Symposium.

Houston Peterson, toastmaster of the evening, discussed the effects and results of the bad publicity that "mechanical brains" have been receiving.

JORS

Planning and Error Consideration in the Numerical Integration of a Difference Equation: Francis J. Murray

Professor Murray has recently done much work on a particular 14^{th} order system of ordinary differential equations

$$Z_i' = f_i(Z_1, Z_2, \text{--}\ Z_{14}, t) \qquad i = 1, \text{--}, 14$$

in which the f_i were fairly straightforward, involving square root, sine, arc sin, and so forth. He carried out an actual solution for t = 0 to t = 68 on the IBM SSEC. With this very large range of values for t and with a definite budget in mind, his interval of extrapolation was practically chosen for him at h = .04, even though various theoretical considerations showed that .02 would be the most satisfactory value. He used a third order extrapolation and integration, developing two different formulas. The first formula was based on an open-ended extrapolation from t-h to t, using four past values to find the new value

$$\Delta Z_j = \frac{h}{24}\left[55f_j(t-h) - 59f_j(t-2h) + 37f_j(t-3h) - 9f_j(t-4h)\right]$$

and this formula yielded a single-step error of .349 $h^5 f_i^{iv}$. By using the values thus obtained as a first step to evaluate $f_j(t)$, he was able to obtain a better approximation by a second step involving integration over the now-closed region from t-3h to t. This formula was

$$\Delta z_j = \frac{h}{24}\left[9f_j(t) + 19f_j(t-h) - 5f_j(t-2h) + f_j(t-3h)\right]$$

with a resultant error of $-.0264h^5 f_i^{iv}$.

Notice that the error terms are one positive and one negative, so that the two different values can be expected to box in the actual solution. Notice also that the error term is heavily dependent on the value of h. Therefore if two overlapping solutions are run, one with h = .02 and one with h = .04, the accuracy of the .04 run will be easily determined. Such runs were actually made, and these turned out to justify the use of the .04 interval being used in the major part of the work.

This work is to be published, I believe, in MTAC. CWA

Probability Methods in the Solution of Elliptic Partial Differential Equations: John H. Curtiss

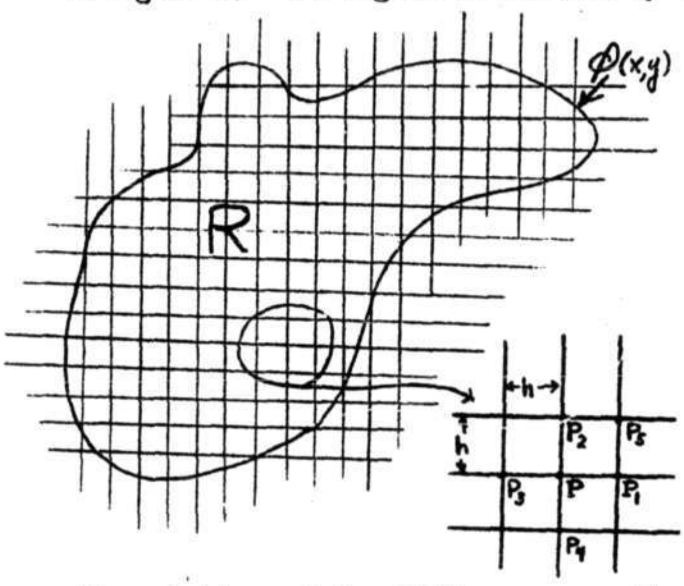
This paper, despite its high-sounding name, is actually oi the Monte Carlo method, said Dr. Curtiss. It was given at the IBM symposium last November and will be published in the Journal of that meeting.

Monte Carlo method is more usually applied to parabolic partial differential equations, but here it has been applied to the fairly general elliptic equation

$$L(u) = \beta_{11}\frac{\partial^2 u}{\partial x^2} + 2\beta_{12}\frac{\partial^2 u}{\partial x\,\partial y} + \beta_{22}\frac{\partial^2 u}{\partial y^2} + 2\alpha_1\frac{\partial u}{\partial x} + 2\alpha_2\frac{\partial u}{\partial y} = F(x,y)$$

under the condition $\beta_{11}\beta_{22} - \beta_{12}^2 > 0$

with boundary conditions given as $\phi(x,y)$ on a Jordan curve enclosing a region R. The region is covered by a mesh and the equation is replaced by a homogeneous difference equation:



$$\beta_{11}\Delta_{xx}(v) + 2\beta_{12}\Delta_{xy}(v) + \beta_{22}\Delta_{yy}(v)$$

$$+ 2\alpha_1\Delta_x(v) + 2\alpha_2\Delta_y(v) = 0$$

in which all of the differences can be found at point p by use of the values at p_1, p_2, p_3, p_4, p_5. Note that the non-symmetrical point p_5 is used to evaluate $\Delta_{xy}(v)$, the cross-difference term. The solution of the difference equation can be carried out by taking a "random walk", using the probability equation

$$v(p) = P_1(p)v(p_1) + P_2(p)v(p_2) + --- + P_5(p)v(p_5)$$

in which $P_1(p) = \dfrac{\beta_{11} - 2\beta_{12} + 2h\alpha_1}{D}$, etc.

where $D = 2\beta_{11} + 2\beta_{22} - 2\beta_{12} + 2h(\alpha_1 + \alpha_2)$.

The random walk can continue on until the boundary is reached. The value of v at the boundary is known and can be taken as a "score" for that walk. The mean value of the score for a large number of walks is the value of v(p).

The paper includes consideration of the mean path length and a discussion which apparently shows the impossibility of a walk becoming infinite in length. The standard error is considered. These considerations are not discussed in this summary because they were not fully understood.

The principal use of this method is for the case in which the value at one point only is needed, or for higher dimensional cases. The usual procedure of proceeding along the grid from boundary to boundary in the conventional numerical method is more practical for the complete two-dimensional case.

cwa

A Machine Method for Solution of Systems of Ordinary Differential Equations: Richard F. Clippinger

This paper presented a fourth-order numerical method intended to reduce the intermediate memory capacity required at the cost of decreased computing time. According to Clippinger, his scheme requires intermediate storage of 3n quantities for an n^{th} order system (in addition to the program and the function evaluations) while the Runge-Kutta method requires 4n and the method used by Murray requires 5n. However the Clippinger method requires that functions be evaluated more often (his is an iterative process), thereby using more computing time. The Clippinger scheme, like the Runge-Kutta, is easy to make changes of grid size in, and if a discontinuity is placed at a grid point no error occurs (these features being advantages compared to methods such as Murray's which are based on past values).

The formula is derived by working with the midpoint $y(x_0 + \frac{h}{2})$. He writes four Taylor series up to y^{iv} about $(x + \frac{h}{2})$ to find $y(x_0)$, $y'(x_0)$, $y(x_0 + h)$, and $y'(x_0 + h)$, and he writes an expression for $y(x_0 + h)$ using Simpson's rule with values of $y'(x_0)$, $y'(x_0 + \frac{h}{2})$, and $y'(x_0 + h)$. These five equations can then be reduced and can be used with a trapezoidal formula to iterate to find $y(x_0 + h)$.

The Theory of Digital Handling of Nonnumerical Information and Its Implications to Machine Economics: Calvin M. Mooers

Mr. Mooers was chiefly concerned with what he has termed "the information retrieval problem". He characterized a piece of information as being composed of a complex of attributes or descriptors. For example, the complex mercury delay line might be considered to be composed of the attributes or descriptors: transmission line, acoustic, and mercury. The problem is to create a system where it is easy and convenient to find all the complexes which include certain desired attributes.

A number of different systems were discussed by Mr. Mooers, among them the alphabetical index, the Dewey Decimal index, the rapid selectors built for the Department of Agriculture and the Atomic Energy Commission, and the Zator Coding System. Examples of Zator Coding were exhibited by Mr. Mooers at the conference, and descriptive literature is available from R. Nelson.

Briefly, one form of Zator Coding is as follows: A card upon which an abstract of an article is attached is provided with space for 40 punched holes along the bottom edge. Attributes are assigned four random integers between 1 and 40 as a code, and the appropriate holes are punched out on the bottom of the complex card for each of the attributes which it possesses. As a result each card has 20 or so punchings. To select a complex from among a number of cards one merely specifies the attributes and selects all those cards having the corresponding punchings.

The principal feature by which this system (Zator Coding) differs from most other systems is in the finite "noise level". Thus, when several attributes are specified, their code numbers looked up, and cards selected which are punched in at least the spaces corresponding to the combined codes of the desired attributes, the selected cards may contain a small percentage of totally irrelevant material. This noise is a small price to pay. The system looks good. JRI

New Circuits Installed in the Aiken Relay Calculator: F. G. Miller

The considerations involved in adding new circuits to the Mark II are threefold:

(1) is it necessary for correct operation?

(2) will it increase the speed of the machine?

(3) will it improve the convenience in coding?

If the answer to the first question is yes, the circuit must be added; only one such case has arisen. Several additions have been made on the basis of the other criteria: six frequently-used constants (not universal constants, just ones that happen to be used in Mark II) have been wired in permanently; orders roughly equivalent to our shift and td operations have been added; and eight registers have been paired and can be used for identity checks, to save the time and trouble of adding and subtracting to detect identities. None of the added circuits have invalidated any previously-written codes. Suggestions, ranging from the ridiculous to the sublime, made by everybody (biggest wheel to smallest cog) are evaluated and added, if worthwhile.

Optical Ray Tracing: Donald P. Feder and Benjamin Hardy
Theodolite Reductions on the IBM Relay Calculator: Mark Lotkin and C. E. Johnson

These papers dealt with rather simple numerical problems, each of which required numerous solutions of simple linear algebraic equations. The first application, which was solved with the IBM 604, dealt with determining the ray vectors for spherical lenses. The second application was concerned with determining from ground observations the speed and position of high-flying missiles.

Solution of Matrix Equations of High Order by an Automatic Computer: Herbert F. Mitchell, Jr.

This paper presented a general program for the solution of equations involving the inversion, multiplication, and addition of matrices of arbitrary order. The program has been coded for UNIVAC and can be used for matrix orders up to 300 (up to 200 if elements are complex rather than real). The basis of the system is the inversion of a partitioned matrix. Mitchell claims that his method is quite applicable and useful when the determinant is about to vanish and is approximately singular.

A complete description of this work is to be published (MTAC, July, 1950). A summary, including examples, is available from D. R. Israel.

Exhibits

Raytheon Manufacturing Company

Raytheon exhibited a Marchant Desk Calculator which had been converted to use the binary (or octal) system. It is claimed that this machine is of value in the programming of complex problems where trial hand runs should be made to determine if the scale factor is satisfactory, and also in checking the actual arithmetic operations of a digital computer. Neither of the arguments advanced seem to override the cost of the machine (about $4000) as compared with the unaltered Marchant (about $700). It should be noted that as far as scale-factor checking is concerned, it is probably easier to do it in the decimal system. Literature is available from D. R. Israel.

Allen B. DuMont Company

This firm exhibited a device for automatically plotting the electrode characteristics of a vacuum tube. The characteristics are plotted on a DuMont Scope and are provided with quick calibration.

RCA Laboratories

An analog equipment for the solution of simultaneous equations was exhibited. Details are available in literature in possession of D. R. Israel.

REAC

The Reeves Computer is mentioned in connection with the paper by Herbert Zagor.

Zator Card Equipment

This equipment is mentioned in connection with the paper by Calvin Mooers.

IBM Card-Programmed Electronic Calculator

This equipment is a card-programmed modification of the 604, the original having been plug-board programmed. At the exhibit they had the machine finding and printing prime numbers (big or small) found by trying all uneven divisors into all uneven numbers. cwa

The MADDIDA

The device which attracted the most attention at the show was the MADDIDA (măd dī´da) or MAgnetic Drum DIgital Differential Analyzer displayed by Northrop Aircraft, Inc., of Hawthorne, California (who, incidentally, are the recipients of the BINAC). The claims, explicit or implicit, for this machine were as follows: high-speed, one part in a million accuracy, compact, reliable, large capacity, easy to program. Actually, the claim of compactness is the only one that I feel confident about. The device as displayed was not as large as an office desk. It contained about 60 vacuum tubes, 1000 crystal diodes and a magnetic drum (10" diameter, 6" high approximately). The drum stores three channels, providing for 22 groups of three words, each word 22 binary digits long. A group of three words (2 numbers and an instruction) is called an "integrator". The machine also has a circulating memory which provides the ability to supply information from the "output" register of one "integrator" to the input of another "integrator". The whole machine is serial and each of the 22 integrators is dealt with in turn once each revolution (.011 seconds).

The principle of operation appears to be as follows:

(1) the first one of the two registers (Y) of each integrator contains some desired function and once each revolution this function is changed as necessary (the code word tells where to look in the circulating memory to see if a change is necessary).

(2) the second register (R) contains the "integral" of the function which is in Y. The integral is formed by straightforward rectangular integration, with the value of Δ (+1, -1, or 0) being determined once each revolution (again the code word tells where in the circulating memory to look for the value of Δ). The actual integration is just addition, where $\Delta = +1$ implies that the contents of Y is to be added to R, $\Delta = -1$ implies subtraction, $\Delta = 0$ implies do nothing. The overflow, if any, from the addition or subtraction is the output of the "integrator" and this output is stored in the circulating memory for use as an input to other "integrators" (it can be used as a Y or a Δ input to one or more "integrators").

The similarity of this process to that of a differential analyzer will be obvious to anyone familiar with such a machine.

The rectangular integration used is ludicrously crude and very small intervals Δ must be used to justify it (a scale factor of 2^{-15} to 2^{-18} is usually attached to the increment of the independent variable, so that 1,000,000 steps (3 hours) may be used to give one period of a sine wave in solving $\frac{d^2y}{dt^2} + y = 0$.) The roundoff error would appear to be enormous for any extended calculation of high-order equations. Functions may be generated and multiplications and divisions carried out using "integrators". The machine has no real input or output devices and no function tables. The claim of accuracy is based on the precision of 1 part in 2^{21} (the 22 digits being used as 20 digits, a sign digit, and a marker pulse). For some reason, the magnetic drum storage is volatile (lost if power fails). There are no facilities for checking of any kind. There are no block diagrams, all the planning having been done by the Boolean algebra approach to switching circuits. Nonetheless, the approach is interesting and has some hopeful aspects, especially since programming really could be quite simple for a machine of this sort.

cwa

Northrop Gas Tubes

The Northrop Aircraft Corporation had a small display of miniature and subminiature gas duo-diode tubes intended for use as free-running multivibrators or as flip-flops. The tube consisted of three metal wires, lying parallel in one plane, sealed through a small glass envelope. The miniature envelope was about 3/8" in outside diameter and 1 1/4" long. The subminiature envelope was about 3/8" in all dimensions. The spacing between elements was about 1/16", the center element being a common plate, the two outside elements being cathodes (it may have been a common cathode and separate plates). The tube and associated circuitry is so designed that only one of the two diodes can support an arc (the arc itself is blue) at any one time, but the other diode is always ready to fire because of the presence of ionized gas in the vicinity of the common plate. By thus switching the arc from one cathode to the other, the designers claim to have improved speed and especially reliability. They had on display a variable-frequency pulse generator about 1 1/2" cube in size, with a range of perhaps 10 cps to 10 kc, and a 12-digit (approximately) binary counter complete with neon indicators, the whole counter being a little smaller than a double deck of playing cards. Both of these units were powered by perhaps 500 V from a small hearing aid battery pack. One important application, to Geiger counters, was mentioned. The designers claim reliable operation at 10 kc and think the units can be pushed to perhaps 60 kc.

Signed C W Adams
C. W. Adams

D. R. Israel
D. R. Israel

Approved R R Everett
R. R. Everett

CWA/DRI/aec