

168[L].—NATIONAL PHYSICAL LABORATORY, *Tables of the complex Jacobian zeta function*. 9 foolscap pages. Deposited with the ROYAL SOCIETY (no. 14).

The Jacobian Zeta function Z_n of modulus $k = \sin \alpha$ can be found from the tabulated function f_1 by the relation

$$\begin{aligned} Z_n(K\psi_1 + iK'\phi, k) &= f_1(\psi_1, \phi, \alpha) + if_2(\psi_1, \phi, \alpha) - \frac{1}{2}i\pi\phi/K \\ f_2(\psi_1, \phi, \alpha) &= f_1(1 - \psi_1, 1 - \phi, \frac{1}{2}\pi - \alpha) \end{aligned}$$

where K, K' are the complete elliptic integrals of modulus k . f_1 to 3 significant figures is given for $\psi_1 = 0(.1)1$; $\phi = 0(.1)1$; $\alpha = 5^\circ(5^\circ)85^\circ$. No provision is made for interpolation.

169[L].—NATIONAL PHYSICAL LABORATORY, *Integrals of Bessel Functions*. 2 quarto pages. Deposited with the ROYAL SOCIETY (no. 17).

10D values of $\int_0^x J_0(t)dt$ and $\int_0^x Y_0(t)dt$ for $x = 0(.5)50$. No provision is made for interpolation.

170[L].—NATIONAL PHYSICAL LABORATORY, *Table of*

$$\int_0^{2\pi} J_1^2(2k \sin \frac{1}{2}\theta) \cos^2 \frac{1}{2}\theta d\theta.$$

1 quarto page. Deposited with the ROYAL SOCIETY (no. 18).

4D values are given for $k = 0(.1)10$. The table is interpolable using second differences, but no differences are given.

AUTOMATIC COMPUTING MACHINERY

Edited by the Staff of the Machine Development Laboratory of the National Bureau of Standards. Correspondence regarding the Section should be directed to Dr. E. W. CANNON, 415 South Building, National Bureau of Standards, Washington 25, D. C.

TECHNICAL DEVELOPMENTS

A SPECIAL PURPOSE DIGITAL COMPUTER

1. **Design considerations.** The design considerations of a special purpose computer for the solution of a large number of simultaneous linear, algebraic equations depend not only on the number of equations with which the computer must deal but also upon the properties of the matrix of the equations, the time to be allowed for computation and the required accuracy of the solution. In this particular case, it was estimated that up to 1200 equations might be expected and the arbitrary time of one day was allowed for computation, after the problem had been set up on the computer. An accuracy of one part in 100 was demanded in the solutions.

A set of simultaneous equations can be represented in the matrix notation as

$$(1) \quad AX = C$$

where A is the matrix of coefficients, a_{ij} , X is the column vector of unknowns x_i , and C is the column vector of constant terms on the right hand side of the equations, c_i . The first equation in the set of equations would look like this.

$$(2) \quad a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n = c_1.$$

There are many methods of solving such equations^{1,2} but the most suitable, from the standpoint of machine computation, is that of Gauss-Seidel.² This procedure is an iterative procedure, each successive iteration yielding a better estimate of the desired vector X . Thus at the end of the first iteration one has $X^{(1)}$, at the end of the second, $X^{(2)}$, etc. One is assured that $X^{(n)}$ approaches X as n becomes very large if the equations are normal equations.

The computation associated with the Gauss-Seidel procedure is as follows:

$$(3) \quad x_i^{(p)} = (c_i - a_{i1}x_1^{(p)} - a_{i2}x_2^{(p)} \dots - a_{i, i-1}x_{i-1} - a_{i, i+1}x^{(p-1)} - \dots - a_{in}x_n^{(p-1)})/a_{ii}$$

where $x_i^{(p)}$ is the i^{th} unknown being calculated in the p^{th} iteration. Equation (3) simply states that to compute $x_i^{(p)}$ one takes c_i , subtracts the products indicated, and divides the whole by a_{ii} . The products in eq. (3) consist of two kinds, first products involving $x_j^{(p)}$ and $x_k^{(p-1)}$. That is, as an unknown is calculated in the p^{th} iteration, this new value of the unknown is used in successive calculations in that iteration.

Two different methods of performing the computation indicated in eq. (3) suggest themselves. The difference lies in the method of storage. One may feed the coefficients, a_{ij} , into the arithmetic section of the machine according to rows and the unknowns, $x_i^{(p)}$, in synchronism with the coefficients and perform the desired operation. The diagonal terms, a_{ii} , must be left at the end of each row as they are the divisor of the accumulated sum. This method requires that each coefficient be included in order that proper synchronism be maintained, even though the coefficient be zero. The alternate to this method consists of feeding only non-vanishing matrix coefficients into the arithmetic section, as before, and storing the unknowns in such a fashion that they can be called from storage in an arbitrary order. This allows considerable saving in storing matrix coefficients, if the percentage of non-vanishing terms is small, at the expense of some complexity in the storage of the unknowns. In the problems we expected to deal with, only 1% of the coefficients were of the non-vanishing variety and the second method outlined above was selected. Fig. 1 is a block diagram of the computer using this method.

2. Storage. For a given problem, the order of the matrix coefficients entering the computation is fixed and furthermore is periodic, with period of one iteration. Magnetic tape was selected as the medium for storing these terms, a continuous loop of tape being used. The matrix coefficients are recorded serially along one channel of the multi-channel tape, along with an order that specifies the type of term, i.e., c_i , a_{ij} or a_{ii} . In an adjacent channel of the tape is recorded the column address of the matrix coefficient. It is this address that is used to specify the location of the corresponding unknown, x_i . The coefficient-order, called a word, is stored in 25 binary digits. A front view of the computer is given in the frontispiece. This shows the tape trans-

port mechanism with a continuous loop of tape. The tape is run at 15 in./sec. and the coefficients are read off at 20 words per second.

Since the unknowns do not appear in the computation in a systematic fashion, it is necessary to provide random access to this storage, with the access time commensurate with the speed at which matrix coefficients are produced. A magnetic drum was selected for this storage. The drum revolves at approximately 59 rps and thus maximum access time to any word on the drum is roughly 17 milliseconds. The capacity of the drum storage is dictated by the maximum number of equations to be handled; in this case one must allow for storage of 1200 words. Fig. 2 is a photograph of the magnetic drum.

Words on the drum are stored serially, 64 words of 25 binary digits in each of the 19 tracks around the periphery of the drum. A "return to zero" system of pulse recording is used and pulses are recorded at a density of about 60 pulses per inch. The desired track on the drum is obtained by switching a matrix of gates. This switching is done by inserting the track address into an address register, AR. The desired angular position on the

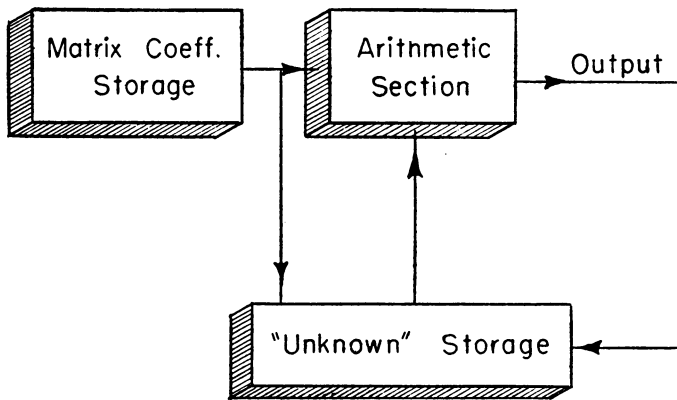


FIG. 1. Block Diagram of Computer

drum is obtained by counting the number of words that have passed under a head, and noting coincidence between this count and the angular position as specified by the AR. When coincidence occurs, the operation (read or write) may proceed. This BOW (Beginning of Word) counter is set to zero once every revolution by an origin pulse.

3. Arithmetic section. All computation is performed in the arithmetic section of the computer. The following operations and the time required for each are indicated below.

Addition	200 microseconds
Subtraction	200 microseconds
Multiplication	8 milliseconds
Division	8 milliseconds

The operation times listed above obviously do not include 17 milliseconds (maximum) required to secure one of the operands from the drum storage.

All computation is performed in parallel,³ that is the four operations

above are performed as parallel transfers from register to register. Carries proceed by means of delay circuits between digits. Thus for an n digit register, nd seconds must be allowed for carries to occur, where d is the delay time between digits. No time advantage over serial operation is obtained but it is possible to modify this method of operation to include a simultaneous carry³ when faster storage becomes practical.

There are three registers in the arithmetic section, a multiplier register, MR, multiplicand register, MD, and a product accumulator, PA. The following transfers are possible: \pm MR to PA, \pm MD to PA. Of the 25 binary digits in the MR, MD registers, 20 digits are occupied by numbers and 5 digits by order. The binary point may be located either to the right of the least significant digit, or to the left of the most significant digit. The PA

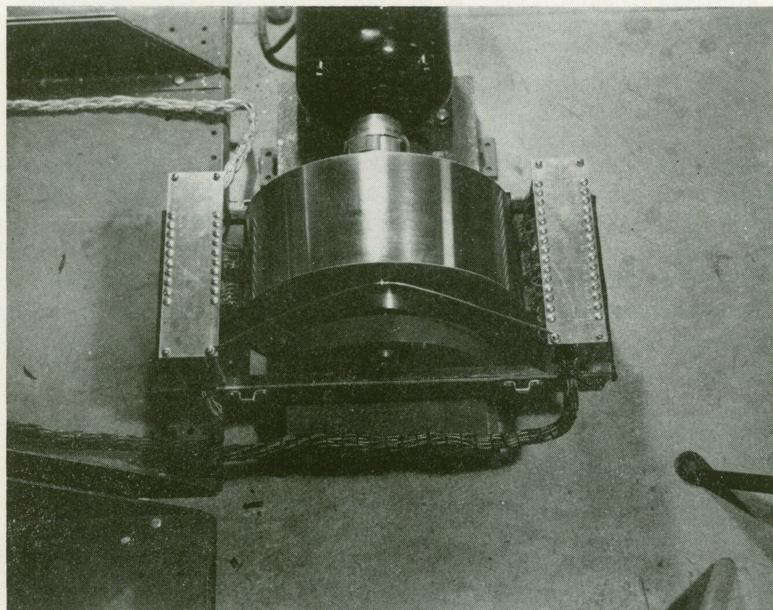


FIG. 2. Magnetic Drum Storage Unit

register contains 40 binary digits and the binary point is located at the center of the register. Each register may be used as an accumulator or as a shifting register.

In normal computation the matrix coefficients are read from the magnetic tape into the MR register, the address of the coefficient into AR, the corresponding unknown is read into the MD and the indicated operation is performed. In the case of division, the quotient $x_i^{(p)}$ is formed in the MD and is compared, digit by digit, with the number previously in the MD, i.e. $x_i^{(p-1)}$. Thus too great a difference in the two values indicates an error in computation (and the new value of the unknown is rejected) and very minor differences for all the unknowns may serve as a criterion for convergence of the solutions.

The frontispiece is a photograph of the complete computer. The rack on the left contains the power supply. The two racks adjacent to the power

supply carry the three registers of the arithmetic section and associated controls. The next rack from the left carries the address register, AR, and drum controls. The tape rack on the right has already been discussed.

4. Logical design. The computer is a purely binary machine. Numbers are represented in the binary notation in order to take advantage of the simplicity of arithmetic operations with this notation.⁴ Negative numbers are represented as the "one's" complement of the absolute value of the number. That is, if the number 10 is written as 0000001010, the number -10 is written as 111110101. In other words, the complement of the absolute value of the number has been taken with respect to the modulus of the register minus one, $M - 1$. With this representation of negative numbers, the product of two numbers may be formed without taking cognizance of the signs of the numbers as such. Let $-A$ be represented as $C(A)$, the complement of A . Then

$$C(A) \cdot B = C(AB)$$

and

$$C(A) \cdot C(B) = AB$$

if the partial products are accumulated modulo $M - 1$. The modulus of an accumulator may be reduced by 1 by the addition of "end around carry." It consists of feeding a carry from the last digit of the register back to the first digit. It is easy to show that the modulus of a n digit register, modulus 2^n , is reduced to a modulus of $2^n - 1$, with the addition of end around carry.

5. Logical elements. The logical elements or components of the computer were designed on the basis of obtaining reliable operation over wide variations of supply voltages and tube characteristics. The components were built

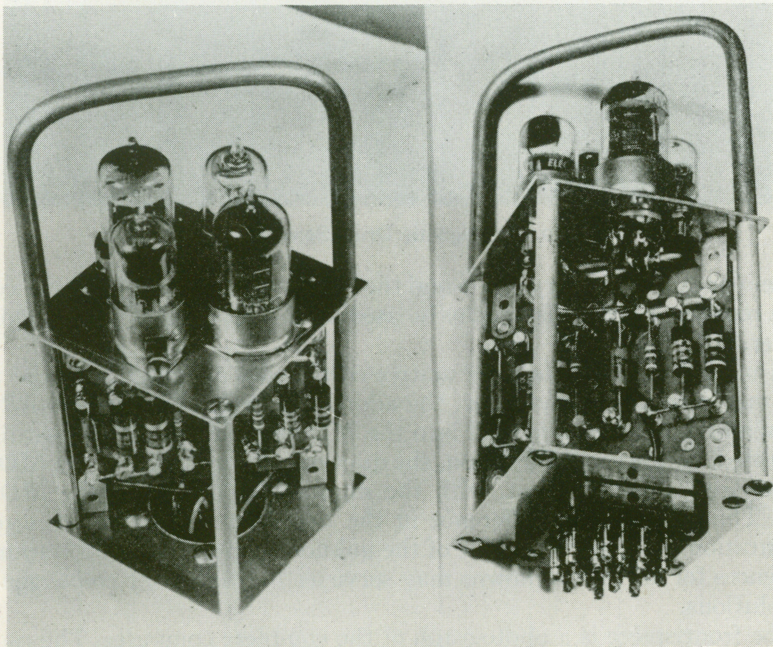


FIG. 3. Typical Plug-in Unit

up on plug-in chassis, as shown in Fig. 3, for ease of maintenance of the computer. The components include flip-flops, delay circuits, gates, and cathode followers. Each element requires a 15–20 volt positive pulse input and its output may be of either polarity. The elements are insensitive to negative pulse inputs. Around 400 of these elements are used in the computer.

6. Operation. The computer has been in operation about 3 months and two problems have been set up and solved. One consisted of 73 equations with a computation time of 3 minutes per iteration. The other consisted of 793 equations and 20 minutes of computing time were required per iteration. In both cases, 15 iterations were sufficient to yield solutions of the desired precision.

J. P. WALKER, JR.

Haller, Raymond and Brown, Inc.
State College, Pa.

¹ FRAZER, DUNCAN & COLLAR, *Elementary Matrices*. Cambridge, 1946.

² WHITTAKER & ROBINSON, *The Calculus of Observations*. London, 1924.

³ ENGINEERING RESEARCH ASSOCIATES, *High Speed Computing Devices*. McGraw Hill, 1950.

⁴ INSTITUTE FOR ADVANCED STUDY, *Preliminary Discussion of the Logical Design of an Electronic Computing Instrument*. Princeton, 1947.

BIBLIOGRAPHY OF CODING PROCEDURE

The material described below is among that which has been added to the collection at the National Bureau of Standards Computation Laboratory. An equivalent collection is available at the National Bureau of Standards Institute for Numerical Analysis.

Material for inclusion in these collections should be sent to the Computation Laboratory, National Bureau of Standards, Washington 25, D. C., for the attention of J. H. WEGSTEIN.

16. Remington Rand, *Prefab Tab*. A routine is described which generates a routine for turning UNIVAC into the logical equivalent of a fictitious punch card tabulator.
17. Remington Rand, *Preliminary Exposition, UNIVAC Short Code*.
18. Willow Run Research Center, University of Michigan, *Willow Run Research Center Memoranda*. The following subjects are included:
 - MIDAC characteristics
 - A list of problems and machines with which they were solved
 - Programming on the Whirlwind Computer
 - Indoctrination of potential coders
 - A suggested method of processing problems on MIDAC
 - MIDAC Logic: word composition
 - MIDAC magnetic drum control equipment
 - Preliminary coding manual for MIDAC
19. Analysis Laboratory, Calif. Inst. of Technology, Bibliography of articles on computing machines published prior to June, 1949.
20. Digital Computer Laboratory, Mass. Inst. of Technology, *A Short Guide to Coding*, May, 1951.
21. Digital Computer Laboratory, Mass. Inst. of Technology, *Short Guide to Coding and Whirlwind I Operation Code*.

22. Digital Computer Laboratory, Mass. Inst. of Technology, *Programming for Whirlwind I*. This report tells what Whirlwind I is and what it can do. It presents essentials and examples of Whirlwind I programming and suggests various programming techniques. It contains an appendix which discusses handling numbers in the machine and the operation code.
23. National Bureau of Standards Report 1612, April 21, 1952. SEAC Operating and Programming Notes, I.
1. Operation of SEAC Control Panel as of October, 1951
 2. Non-mathematical Routines
 3. Conversion Subroutines for Integers
 4. Decimal to Binary and Binary to Decimal Subroutines
 5. Subroutine for 2^x and e^x
 6. Subroutines for \sqrt{N} , $\sqrt[3]{N}$, $\sqrt[4]{N}$
 7. Subroutine for Sin X and Cos X
24. National Bureau of Standards Report 1807, July 22, 1952. SEAC Operating and Programming Notes, II.
8. Subroutine for $\tan^{-1} a/b$
 9. Hexadecimal-decimal Converter Table
 10. Four-Hexi Converter Table
 12. Subroutine for Decimal to Binary Conversion of a Double Precision Number with Fixed Binary Point
 13. Subroutine for i -th Differences, $i=1, 2, \dots, 6$
 14. Three-address System and Base Order
 15. Preparation of Pure Hexadecimal Coding for Punched-Card Composition
25. National Bureau of Standards Report 1873, August 22, 1952. SEAC Operating and Programming Notes, III.
16. Magnetic Tape to Wire Transfer and Check Routine
 17. Subroutines for Basic Arithmetic Operations and Square Root in Floating Decimal Form
 18. General Dump Routine (512 or 1024 Word Memory)
 19. Memory Decomposition Routine (512 or 1024 Words)
 20. Flow Charts for Magnetic Tape Checking Routines
26. National Bureau of Standards Report 1917, September 12, 1952. SEAC Operating and Programming Notes, IV.
21. Composition Routine (SEBBE)
 22. Basic Arithmetic Operations I, Floating Binary Point, Single Precision Numbers
 23. Subroutine for Cube Root: Single Precision, Floating Binary Point
 24. Subroutine for $\sin z$, $\cos z$, $z = x + iy$.
 25. Corrections and Changes to Technical Memoranda Nos. 1-24.
27. RUTH B. HORGAN, *SWAC Coding Manual*, National Bureau of Standards Report 2047, November 4, 1952, 37 p.

This coding guide gives a good introduction to the art of coding for the SWAC, although it is incomplete in certain respects. For example, the relative time to obey each command is not given so it is not possible to minimize or even estimate the time required to do a calculation with the SWAC. The number of binary digits in a word is not stated explicitly, nor whether the modulus or complement convention is used.

In Chapters 2 and 3 the input-output procedures and possibilities are described in detail. Chapter 4 is devoted to a method of verifying the correctness of the store and the coding precautions which have to be taken to enable this to be done readily. The following two chapters describe how commands can be modified and tallies kept.

The last chapter describes the use of sub-routines and the necessary conventions although it is not actually stated how a sub-routine is entered from a program.

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BIBLIOGRAPHY Z

- 1038.** ALBERT A. GIRLACH, "Test pulse generator for digital computers," *Electronics*, v. 25, Nov. 1952, p. 158-160.

This paper gives a description of a pulse generator which was built using multivibrator and gate circuits. It can be triggered either internally or externally. The outputs are a clock output plus two pulse outputs and their complements. The width and amplitude of each output can be varied independently. A block diagram and complete circuit diagrams are given.

ERNEST F. AINSWORTH

NBSEC

- 1039.** S. E. GLUCK, "The Electronic Discrete Variable Computer," *Electrical Engineering*, v. 72, Feb. 1953, p. 159-162.

A careful description of the EDVAC is given by the author. This machine has been operating successfully since the Spring of 1952 at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

The reader familiar with the SEAC will find much similarity between the two machines.

IDA RHODES

NBS

- 1040.** INTERNATIONAL BUSINESS MACHINES CORPORATION, *Industrial Computation Seminar*, edited by Cuthbert C. Hurd, Dec. 1949, 173 pages. 22 × 28.5 cm.

This is one of a series of seminars that was held for research engineers and scientists who have active interests in the mathematical solution of physical problems by the application of punched card techniques to the computing art. The following articles were discussed:

1. "The future of high-speed computing," by JOHN VON NEUMANN.
2. "Some methods of solving hyperbolic and parabolic partial differential equations," by RICHARD W. HAMMING.
3. "Numerical solution of partial differential equations," by EVERETT C. YOWELL.
4. "An eigenvalue problem of the Laplace operator," by HARRY H. HUMMEL.

5. "A numerical solution for systems of linear differential equations occurring in problems of structures," by PAUL E. BISCH.
6. "Matrix methods," by KAISER S. KUNZ.
7. "Inversion of an alternant matrix," by BONALYN A. LUCKEY.
8. "Matrix multiplication on the IBM card-programmed electronic calculator," by JOHN P. KELLY.
9. "Machine methods for finding characteristic roots of a matrix," by FRANZ L. ALT.
10. "Solution of simultaneous linear algebraic equations using the IBM Type 604 Electronic Calculating Punch," by JOHN LOWE.
11. "Rational approximation in high-speed computing," by CECIL HASTINGS, JR.
12. "The construction of tables," by PAUL HERGET.
13. "A description of several optimum interval tables," by STUART L. CROSSMAN.
14. "Table interpolation employing the IBM Type 604 Electronic Calculating Punch," by EVERETT KIMBALL, JR.
15. "An algorithm for fitting a polynomial through n given points," by F. N. FRENKIEL and H. POLACHEK.
16. "The Monte Carlo Method and its application," by MARK KAC and M. D. DONSKER.
17. "A punched card application of the Monte Carlo Method," by P. C. JOHNSON and F. C. UFFELMAN.
18. "A Monte Carlo Method of solving Laplace's equation," by EVERETT C. YOWELL.
19. "Further remarks on stochastic methods in quantum mechanics," by GILBERT W. KING.
20. "Standard methods of analyzing data," by JOHN W. TUKEY.
21. "The application of machine methods to analysis of variance and multiple regression," by ROBERT J. MONROE.
2. "Examples of enumeration statistics," by W. WAYNE COULTER.
23. "Transforming theodolite data," by HENRY SCHUTZBERGER.
24. "Minimum volume calculations with many operations on the IBM Type 604 Electronic Calculating Punch," by WILLIAM D. BELL.
25. "Transition from problem to card program," by GREGORY J. TOBEN.
26. "Best starting values for an iterative process of taking roots," by PRESTON C. HAMMER.
27. "Improvement in the convergence of methods of successive approximations," by L. RICHARD TURNER.
28. "Single order reduction of a complex matrix," by RANDALL E. PORTER.
29. "Simplification of statistical computations as adapted to a punched card service bureau," by W. T. SOUTHWORTH and J. E. BACHELDER.
30. "Forms of analysis for either measurement or enumeration data amenable to machine methods," by A. E. BRANDT.
31. "Remarks on the IBM Relay Calculator," by M. LOTKIN.
32. "An improved punched card method for crystal structure factor calculations," by M. D. GREMS.

33. "The calculation of complex hypergeometric functions with the IBM Type 602-A Calculating Punch," by HARVEY GELLMAN.
34. "The calculation of roots of complex polynomials using the IBM Type 602-A Calculating Punch," by JOHN LOWE.
35. "Practical inversion of matrices of high order," by WILLIAM D. GUTSHALL.

Several of the papers that were discussed dealt with specific problems as encountered in actual practice and their particular solution and are useful only in that they illustrate the type of approach that the authors used. Some of the other articles, such as no. 3 by E. C. Yowell, describe methods which are rather general in approach and could be applied to a large number of problems involving solution of partial differential equations. The article by Donsker and Kac wherein they discuss the Monte Carlo Method and its application is also rather general and so could be applied to numerous problems. Finally the articles by Kunz on matrix methods and Tukey on the standard methods of analyzing data are more theoretical and are excellent summaries but contain no mention of any direct application to punch card methods.

H. BREMER

NBSCL

1041. HERBERT KOPPEL, "Digital computer plays NIM," *Electronics*, v. 25, Nov. 1952, p. 155-157.

Engineers of the W. L. Maxon Corporation have constructed an automatic machine for playing NIM with a human opponent. It can be adjusted so that the human can win if he plays a perfect game or so that he can never win. Digital computer techniques such as gates, binary counters, etc., were used in its construction. The method of operation and a block diagram are given but no circuitry details are shown.

ERNEST F. AINSWORTH

NBSEC

1042. W. H. MACWILLIAMS, JR., "Computers—past, present, and future," *Electrical Engineering*, v. 72, Feb. 1953, p. 116-121.

The author gives an exceedingly clear, yet non-technical, exposition of many computing devices, both analogue and digital, which humanity has been utilizing for the past three centuries. This informative article should appeal to every member of that rapidly growing circle of engineers and mathematicians, who—either as constructors or users—are closely connected with the art of computation.

The reviewer is disappointed that the author's glimpse into the future failed to perceive a much needed system of electronic sorter-collators, whose lack is felt by agencies handling huge masses of data.

IDA RHODES

NBSCL

1043. OFFICE OF NAVAL RESEARCH, *Digital Computer Newsletter*, v. 5, January 1953, 8 p.

The contents are as follows :

1. Naval Proving Ground Calculators
2. Whirlwind I
3. Moore School Automatic Computer
4. The SWAC
5. Aberdeen Proving Ground Computers:
 - The ORDVAC
 - The EDVAC
 - The ENIAC
 - The BELL
 - IBM-CPC
6. The Circle Computer
7. The Jacobs Instrument Company Computer (JAINCOMP)
8. The ELECOM Computers
9. University of Illinois Computer (ILLIAC)
10. Hughes Aircraft Company Computer
 - Data Processing and Conversion Equipment
 1. Flying Typewriter
 2. The Charactron
- List of Computing Services

1044. OFFICE OF NAVAL RESEARCH, *Digital Computer Newsletter*, v. 5, April 1953, 12 p.

The contents are as follows :

1. Naval Proving Ground Calculators
2. Whirlwind I
3. Computer Research Corporation Computers
 - CADAC 102-A
 - CRC 105
 - CRC 107
4. Moore School Automatic Computer (MSAC)
5. Air Force Missile Test Center Computer (FLAC)
6. The SEAC
7. The IAS Computer
8. The SWAC
9. The MONROBOT
10. The Circle Computer
11. The Jacobs Instrument Company Computers (JAINCOMPS)
12. Consolidated Electronic Digital Computer Model 30-201
13. The ERA 1103 Computer
14. The Rand Corporation Computer
15. Aberdeen Proving Grounds Computers
 - Data Processing and Conversion Equipment
 1. TELEDUCER
 2. SADIC

3. Benson-Lehner Incremental Plotter
4. Coleman Digitizer
5. Ferro-Resonant Flip-Flop
6. Logrinc Automatic Graph Followers

List of Computing Services

Computer and Numerical Analysis Courses

1. Massachusetts Institute of Technology
2. Computer Research Corporation

1045. L. PACKER & W. J. WRAY, JR., "Germanium photo-diodes read computer tapes," *Electronics*, v. 25, Nov. 1952, p. 150-151.

This article describes a system for reading Teletype paper tapes using 1N77 photo-diodes. Complete circuit details are given for the amplifier and shaper. It operates over a range from one to 35,000 pulses per second. Mechanical details of the tape transport are not discussed.

ERNEST F. AINSWORTH

NBSEC

1046. UNIVERSITY OF SIDNEY, *Proceedings of Conference on Automatic Computing Machines*, held in the Department of Electrical Engineering, University of Sidney, Australia, in conjunction with the Commonwealth Scientific and Industrial Research Organization, Aug. 1951, 220 pages. 20 × 24.8 cm.

The first of two sessions contained "An introduction to automatic calculating machines" and a paper entitled "Automatic digital calculating machines" both by D. R. HARTREE. Two other papers discussed the C.S.I.R.O. (Commonwealth Scientific and Industrial Research Organization) Differential Analyser and the C.S.I.R.O. Radiophysics MK. I Automatic Computer. The latter is an acoustic-delay-line-memory digital computer with magnetic drum and punched card input-output. In the discussion of the use of superfluous binary digits for error-detecting which followed, Hartree considered that "the use of error detecting procedures at each operation of the machine was a counsel of despair." He felt that experience has shown that computers do not go wrong often enough to warrant this.

In the second session, Hartree gave an introduction to programming using the EDSAC for illustration; also he presented a paper on numerical methods used with automatic calculating machines. The latter included a summary of various methods of determining roots of polynomial equations with automatic machines. T. PEARCEY presented papers on programming for the C.S.I.R.O. digital machine and for punched-card machines and on the functional design of an automatic computer. Some of the other papers presented were: (1) "Some analogue computing devices," (2) "Digital-analogue conversions," (3) "An analogue computer to solve polynomial equations with real coefficients," and (4) "Some new developments in equipment for high-speed digital machines." The last paper dealt with a high-speed magnetic switching device, a single electron tube scale-of-ten numeral-displaying counter, a single tube which combines the functional operations

of a bi-stable element and gate, giving several applications and details of a magnetic-drum digital storage system.

J. H. WEGSTEIN

NBSCL

1047. B. G. WELBY, "Intermittent-feed computer tape reader," *Electronics*, v. 26, Feb. 1953, p. 115-117.

A tape reader is described which will operate at speeds up to 200 characters per second with teletype tape. Each character consists of as many as seven holes punched in the paper tape. Reading is accomplished by a photoelectric system, and no reading pins or contacts are required. The tape is friction driven by rollers which can be controlled intermittently. The maximum reading speed under intermittent control is not stated but appears to be about 100 characters per second. Reading causes no visible wear to the tape after 10,000 passes.

J. L. PIKE

NBSCL

NEWS

AIEE-IRE-ACM.—The joint AIEE-IRE-ACM Computer Conference Committee sponsored a Western Computer Conference at Los Angeles, California, on February 4, 5, and 6. The program for the meeting was as follows:

Feb. 4, 1953, 8:30 a.m.

Registration

Ballroom Floor

10:30-11:30 a.m.

Opening ceremonies

P. L. MORTON, *Chairman*, Univ. of Calif., Berkeley

Keynote addresses:

The impact of computer development on the training and utilization of engineers
Factors influencing the effective use of computers

S. RAMO, Vice-President for Operations, Hughes Aircraft Co., Culver City, Calif.
R. D. HUNTOON, Chief, Corona Laboratories, NBS Corona, Calif.

Lunch

G. D. McCANN, *Toastmaster*, Calif. Inst. of Tech., Pasadena

The scientific manpower problem

L. A. DuBRIDGE, Pres., Calif. Inst. of Tech., Pasadena

2:00-4:30 p.m.

Session I, Commercial applications

E. C. NELSON, *Chairman*, Hughes Aircraft Co., Culver City, Calif.

Commercial applications—The implications of Census experience
Payroll accounting with ELECOM 120

J. L. McPHERSON, Bureau of the Census

R. F. SHAW, Electronic Computer Division, Underwood Corp.

Automatic data-processing in larger manufacturing plants

M. W. SALVESON and R. G. CANNING, Univ. of Calif., Los Angeles

The data-processing requirements of the Social Security problem

E. E. STICKELL, Bureau of Old-Age and Survivors Insurance

The processing of information-containing documents

G. W. BROWN and L. N. RIDENOUR, International Telemeter Corp.

Feb. 5, 1953, 9:00-11:30 a.m.

- | | |
|---|---|
| Session II, Applications to aircraft and missile design | C. STRANG, <i>Chairman</i> , Douglas Aircraft Co., Santa Monica, Calif. |
| Landing gear simulation using a differential analyzer | D. W. DRAKE, Lockheed Aircraft Corp. |
| The equivalent circuits of shells used in airframe construction | R. H. MACNEAL, Calif. Inst. of Tech. |
| Analog-digital techniques in autopilot design | R. L. JOHNSON and W. T. HUNTER, Douglas Aircraft Co. |
| Applications of computers to aircraft dynamics problems | D. DILL, B. HALL, R. RUTHRAUFF, Douglas Aircraft Co. |

12:00-1:30 p.m.

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| Lunch | R. G. CANNING, <i>Toastmaster</i> , Univ. of Calif., Los Angeles |
| Luncheon Address:
New equations for management | J. E. HOBSON, Director, Stanford Research Institute, Palo Alto |

2:00-4:30 p.m.

Session III, Panel discussion

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| An evaluation of analog and digital computers | G. D. McCANN, <i>Moderator</i> , Calif. Inst. of Tech. |
| Panel: J. L. BARNES, Assoc. Director of Electro-Mechanical Engineering Dept., North American Aviation, Inc. | |
| L. RIDENOUR, Vice-President, International Telemeter Corp. | |
| F. STEELE, Vice-President in charge of Engineering Digital Control Systems, La Jolla, Calif. | |
| A. W. VANCE, Research Section Head, RCA Laboratory, Princeton, N. J. | |

Feb. 6, 1953, 9:00-11:30 a.m.

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| Session IV, New developments in digital computer equipment | H. D. HUSKEY, <i>Chairman</i> , Wayne Univ. |
| The snapping dipoles of ferro-electrics as a memory element for digital computers | C. F. PULVARI, The Catholic Univ. of America |
| Magnetic reproducer and printer | J. C. SIMS, JR., Eckert-Mauchly Div., Remington Rand, Inc. |
| An improved cathode ray tube storage system | R. THORENSEN, NBSINA |
| Nonlinear resistors in logical switching circuits | F. A. SCHWERTZ, and R. T. STEINBACK, Mellon Institute |

1:30-4:00 p.m.

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| Session V, New developments in analog computing equipment | C. H. WILTS, <i>Chairman</i> , Calif., Inst. of Tech., Pasadena |
| New laboratory for a three dimensional guided missile analysis | L. BAUER, Head, Project Cyclone, Reeves Instrument Corp. |
| A new concept in analog computers | L. CAHN, Chief Computer Engineer, Special Products Dept., Beckman Instruments, Inc. |

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| A magnetically coupled low-cost high-speed shaft position digitizer | A. J. WINTER, Research Lab., Supervisor, Telecomputing Corp. |
| Solution of partial differential equations by difference methods using the electronic differential analyzer | R. M. HOWE, Univ. of Michigan |
| A syncro-operated differential analyzer | A. NORDSIECK, Univ. of Illinois |

Following is a brief description of some of the main points brought out in the session on commercial applications. Mr. McPherson's talk outlined conclusions drawn from Census experience with the UNIVAC concerning the commercial applicability of the electronic digital computers. It is possible for them to exceed in efficiency any other available tool for many commercial purposes. They are not commercially ideal because their arithmetic power exceeds their input-output power. It is hoped that these machines will evolve into a powerful aid to business problems similar to the evolution of punched card equipment. The ELECOM 120 described by Mr. Shaw, can process the weekly payroll for 4,000 to 5,000 employees at the rate of about 30 seconds per employee including typing of checks and statements. It is a moderately priced decimal computer. In the discussion by Messrs. Salveson and Canning, it is mentioned that the ONR is sponsoring a project on "Production planning and scheduling" which includes the systems design specifications. Mr. Stickell discusses the possibilities and limitations of card-to-tape and tape-to-card equipment for sorting data in electronic media and the present lack of equipment for high-speed random access to data stored outside of a machine. In the last talk of Session I, Messrs. Brown and Ridenour state that more than 10,000 documents of all sorts can be processed per hour by a single machine which makes no demands on the size, shape, thickness, flatness, or degree of preservation of the documents being handled.

In Session II, "Applications to aircraft and missile design," Mr. Drake states that the computer simulation includes velocity square orifice damping, a nonlinear oleo air spring, wheel spin-up, slop in gear joints, and a broad range of airplane weights, effective wing lift, and landing speeds. The study suggests that this method of investigating actual landing gears is practical. Mr. MacNeal describes the development of analog computer techniques that should be helpful in solving practical problems in connection with aircraft fuselage and wing design. In the third paper of this session the roles assigned to digital and analog computation connected with autopilot design at Douglas are discussed and the associated reasons for such assignment are given. Messrs. Dill, Hall, and Ruthrauff discuss the basic methods for the solution of aircraft dynamics problems on both analog and digital computers; in this connection actual problems successfully solved on the computing equipment used by the Douglas Aircraft Company are outlined.

Mr. Pulvari begins Session IV with a discussion of "The snapping dipoles of ferroelectrics as a memory element of digital computers." The following description of his talk is quoted from the program: A sensitive pulse method has been developed for obtaining static remanent polarization data for ferroelectric materials. This method has been applied to study the effect of pulse length and amplitude, and decay of polarization on ferroelectric ceramic materials with fairly large crystalline orientation. Attempts have been made to develop electrostatically-induced memory devices using ferroelectric substances as a medium for storing information, particularly delay line, matrix, and tape type of memory devices; also a simple counting circuit using ferroelectric condensers as a bistable element has been designed. The paper by J. C. Sims, Jr., describes a new process for producing printed copy by magnetic fields which can be adapted to computer output printing. After the data are recorded on a magnetized surface, the latent magnet image is developed with a magnetic ink and transferred to paper and fixed. In the paper by R. Thorensen, it is shown that by altering somewhat the mode of operation of the cathode ray tube and by changing the associated gating circuitry, a system is obtained which operates successfully even under severe spillover signal distortion. Messrs. Schwertz and Steinback show how nonlinear resistors which are made by applying printed circuit techniques to such materials as standard plastic may be used to replace whole arrays of crystal rectifiers in certain logical switching circuits.

Some new developments in analog computing equipment were described in Session V. A new simulation laboratory constructed at Project Cyclone was planned to be large enough to permit the solution of complex three-dimensional guided missile problems. Mr. Bauer stated that it may also be used for other types of problems. In the paper "A new concept in analog computers" circuits of a coordinated low-cost analog computer are described and evaluated in terms of computing ability.

Symposium on automatic digital computation.—A symposium on Automatic Digital Computation was held at the National Physical Laboratory, Teddington, England on the 25th, 26th, 27th and 28th of March, 1953.

About 200 delegates attended the Symposium and of these about twenty came from other European countries and five from the U.S.A. The United States delegates were GERTRUDE BLANCH and R. J. SLUTZ, NBS; R. HULSIZER, University of Illinois; J. C. MCPHERSON, I.B.M. World Headquarters, New York; and S. KAUFMAN, Shell Development Company.

The computing machine developed at the National Physical Laboratory, the ACE Pilot Model, was demonstrated at various times while the Symposium was in progress.

The programme for the Symposium was as follows:

March 25, 1953, 11:30 a. m.—1:00 p.m.

Session 1	E. T. GOODWIN, <i>Chairman</i> , NPL
Opening remarks	E. C. BULLARD, Director, NPL
Address	D. R. HARTREE, Cambridge Univ.

2:00 p.m. to 5:00 p.m.

Session 2, British Machines	F. M. COLEBROOK, <i>Chairman</i> , NPL
ACE Pilot Model	J. H. WILKINSON, NPL
EDSAC	M. V. WILKES, Cambridge Univ.
Operating and engineering experience gained with LEO	J. M. M. PINKERTON, Messrs. J. LYONS and Co.
MADAM	F. C. WILLIAMS, Manchester Univ.
MOSAIC, the Ministry of Supply Automatic Computer	A. W. M. COOMBS, Post Office Research Station
NICHOLAS	N. D. HILL, ELLIOTT Bros.
Advance notes on RASCAL	E. J. PETHERICK, RAE
The T. R. E. High-Speed Digital Computer	A. M. UTTLEY, TRE

March 26, 1953, 9:30 a.m.—1:00 p.m.

Session 3, Programming	E. T. GOODWIN, <i>Chairman</i> , NPL
Optimum coding	G. G. ALWAY, NPL
Micro-programming and the choice of order code	J. G. STRINGER, Cambridge Univ.
Conversion routines	E. N. MUTCH and S. GILL, Cambridge Univ.
Getting programmes right	S. GILL, Cambridge Univ.

2:00—5:00 p. m.

Session 4, Design	J. H. WILKINSON, <i>Chairman</i> , NPL
Special requirements for commercial or administrative applications	T. R. THOMPSON, Messrs. J. LYONS and Co.
Input and output	D. W. DAVIES, NPL
Echelon storage systems	D. O. CLAYDEN, NPL
Serial digital adders for a variable radix of notation	R. TOWNSEND, British Tabulating Machine Co.

March 27, 1953, 9:30 a.m.-1:00 p.m.

- Session 5A, The Utilization of Computing Machines—I
 Mathematics and computing E. T. GOODWIN, *Chairman*, NPL
 A. VAN WIJNGAARDEN, *Mathematical Centre*, Amsterdam
 Linear algebra on the Pilot ACE J. H. WILKINSON, NPL
 The numerical solution of ordinary differential equations L. FOX and H. H. ROBERTSON, NPL
 The solution of partial differential equations by automatic calculating machines N. E. HOSKIN, *Manchester University*

2:00 p.m.-5:00 p.m.

- Session 6A, The Utilization of Computing Machines—II. Mathematical tables L. FOX, *Chairman*, NPL
 E. T. GOODWIN, NPL
 Applications of electronic machines in pure mathematics J. C. P. MILLER, *Cambridge University*
 'Monte Carlo' methods for the iteration of linear operators J. H. CURTISS, NBS (presented by G. Blanch)

9:30 a.m.-1.00 p.m.

- Session 5B, Circuitry and Hardware E. A. NEWMAN, *Chairman*, NPL
 Gates and trigger circuits W. W. CHANDLER, *Post Office Research Station*
 M. WRIGHT, NPL
 Mercury delay line storage R. C. ROBBINS and R. MILLERSHIP, *Messrs. Elliott Bros.*
 Applications of magnetostriction delay lines T. KILBURN, *Manchester Univ.*
 Cathode ray tube storage R. J. SLUTZ, NBS
 Memory studies at the National Bureau of Standards, Washington, D. C., U.S.A.

2:00 p.m.-5:00 p.m.

- Session 6B, Servicing and Maintenance F. M. COLEBROOK, *Chairman*, NPL
 Preventive or curative maintenance E. A. NEWMAN, NPL
 Experience with marginal checking and automatic routing of the EDSAC M. V. WILKES, M. PHISTER, JR. and S. A. BARTEN, *Cambridge Univ.*
 Diagnostic programmes R. L. GRIMSDALE, *Ferranti Ltd.*
 Component reliability in the computing machine at Manchester University A. A. ROBINSON, *Ferranti Ltd.*

March 28, 1953, 9:30 a.m.-11:00 a.m.

- Session 7, Medium-Size Digital Computing Machines J. R. WOMERSLEY, NPL
 The Harwell Computer E. H. COOKE-YARBOROUGH, AERE
 The A.P.E.(X)C. A low cost electronic calculator A. D. BOOTH, *Birkbeck College*
 The Elliott-N.R.D.C. Computer 401—A demonstration of computer engineering by packaged unit construction W. S. ELLIOTT, H. G. CARPENTER and A. ST. JOHNSTON, *Elliott Bros.*