

This function has been tabulated using SEAC, the computations being planned by H. E. SALZER. Among those who contributed to the preparation were R. B. JASPER, P. J. O'HARA, M. PAULSEN, and W. R. SODERQUIST. The quadratures were checked by comparison with the Bickley-Nayler table. There is now available, on IBM cards, values to 9S of $y(\theta, x)$ for

$$\theta = 0(1^\circ)90^\circ, \quad x = 0(.01)2(.02)5(.05)10.$$

A table to about 5S for $x = 0(.5)10$ and the same values of θ by SIDNEY JOHNSTON is referred to in UMT 103, *MTAC* v. 4, p. 163.

J. T.

¹ W. G. BICKLEY & J. NAYLER, *Phil. Mag.*, s. 7, v. 20, 1935, p. 343-347.

AUTOMATIC COMPUTING MACHINERY

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TECHNICAL DEVELOPMENTS

THE DEVELOPMENT OF A.P.E.(X).C.

1. Historical.—It is the purpose of this paper to give a technical description of the all purpose electronic digital computer developed at the Birkbeck College computation laboratory. Before embarking on this, however, it seems appropriate to mention certain historical details which put the present machine into perspective.

In 1946 the present author was engaged in the development of a special purpose relay digital calculator for the automatic evaluation of three dimensional Fourier sums¹ of the type:

$$\rho(x, y, z) = \sum_{-H}^{+H} \sum_{-K}^{+K} \sum_{-L}^{+L} |F_{hkl}| \cos \left\{ 2\pi \left(\frac{hx}{a} + \frac{ky}{b} + \frac{lz}{c} \right) - \alpha_{hkl} \right\}$$

where the F and α are given in digital form and are available from a punched tape.

The complete design for this machine involved a magnetic *disc* store for 256 words of 16 bits, and also a matrix function table (one-many, many-one) for producing the cosine function.

Although this machine was to be relatively compact (600 relays and 100 vacuum tubes) it did not satisfy aesthetically since the input had to be in binary form and output resulted in a like manner.

Fortunately, at this point, the author was invited to address the American Society for X-ray and Electron Diffraction, and in the course of this visit to the U.S.A. was able to make contact with the pioneer work which was being carried out at several centres.

Through the generosity of the Rockefeller Foundation a period of study at the Institute for Advanced Study followed, during which plans were completed for an all purpose relay computer using roughly the same equipment as was already available for the earlier project.

Thus, by the end of 1947, the A.R.C. (Automatic Relay Computer) was completed. This machine, which is still available for use in this laboratory, employs 800 high-speed relays to form a parallel operation single address code computer.² The storage organ, which was originally on a nickel plated brass drum,³ had a capacity of 256 words each of 21 bit length. This was later (vide infra) replaced by an electro-mechanical store for 50 words of the same length and the control modified to a pluggable unit for 600 instructions.

The reason for this seeming *volta face* lay in the use to which the machine was eventually put, which was essentially the Fourier series evaluation mentioned earlier. It has proved far more efficient to have a pluggable sequence machine when this is used only intermittently (not more than three or four times during a year) and then only by research students.

Input to the A.R.C. is *via* teletype tape or push buttons and the output is by means of a teleprinter. The code² is as follows:

No.	Symbol	Description
0	T to M	Fill memory from input tape.
1	T to T_i	Start tape moving to T_i and proceed with next order.
2	T_{ij} to M	Read material between T_i and T_j into first $(j - i)$ positions in memory.
(0) 3	M_{ij} to T	Punch contents of memory position i to j into tape.
(0) 4	C to $M(x)$	Shift control to order located at $M(x)$.
5	C_c to $M(x)$	If number in accumulator ≥ 0 shift control as in 4.
6	$l(n)$	Shift contents of accumulator and register (A and R) n places to left. $A(0) A(1) - A(20)$; $R(0) R(1) - R(20)$ becomes $A(0), A(2) - A(20), R(0)$; $R(1) - R(20), A(1)$, etc.
7	$r(n)$	Shift contents of A n places to right. $A(0), A(1) - A(20)$ becomes $A(0), A(0), A(1) - A(19)$, etc.
8	$+M$ to cA	Clear A and add contents of $M(x)$ into it.
9	$+ M $ to cA	
10	$-M$ to cA	
11	$- M $ to cA	
12	$+M$ to A	Add contents of $M(x)$ into present contents of A .
13	$+ M $ to A	
14	$-M$ to A	
15	$- M $ to A	
16	MR to cA	Clear A . Multiply $M(x)$ by R , place 1st 20 digits and sign in A after adding unity to 21st. Leave last 20 digits in R .
17	MR to cA (n.r.o.)	As in 16 but without round off.
18	$A \div M$ to cR	Divide A by $M(x)$, place quotient in R with last digit unity. Leave remainder in A .
19	M to cR	
20	R to cA	
21	R to M	
22	A to M	
(0) 23	A_L to M	Substitute digits 1-8 of A in order located at $M(x)$.
24	A to cR	
25	E	Stop and emit end of calculation signal.

Notice that those instructions marked (0) are no longer available since the alteration in control structure, and that the original code-word was constructed as follows:

Digit	1 to 8	9 to 15	16 to 20
	Memory location (x)	Sequence	Order Code

The zeroth digit was always zero in an instruction and the position marked "sequence" was used in orders (2) and (3) to specify $(j - i)$.

The speeds of the various arithmetic operations are:

+, - .	20 m. sec.
×, ÷	1 sec.
$l(n)$ and $r(n)$	$n \times 20$ m. sec.

In its original form (i.e. on the magnetic drum) transfers to and from M required 20 m. sec. (max); in the current electro-mechanical device a maximum of 250 m. sec. is needed, but this can be reduced by optimum programming, to 20 m. sec.

A partial reason for the removal of the magnetic drum store from A.R.C. was a desire to make this unit a part of a small all-electronic calculator. This machine, later called S.E.C.⁴ (simple electronic calculator) was never brought to a state of useful operation, but served as a test bed for the designs of the A.P.E.(X).C. machines which followed. The interesting point about S.E.C. lies in the small number of vacuum tubes used in its construction (230). The code was rudimentary and the input/output took the form of switches and neon lamps. A major change in logic was the adoption of a two address code⁵ of the type: "Perform operation A on number in position (x) and go to position (y) for the next instruction."

This extension removes the chief speed limitation which is inherent in a magnetic drum store and in favourable cases, increases the speed of operation by a factor of 16-32.

2. The A.P.E.(X).C. [All Purpose Electronic (X -initial of sponsoring agency) Computer].—At a relatively early stage in the actual construction of S.E.C., it was felt that sufficient experience had been gained to justify the development of a full-scale machine. A set of standard circuits had been devised^{6,7,8} and the problems of drum storage were considered solved. Essential details are as follows:

<i>Drum:</i>	Speed 3,800 R.P.M.	
	Digit packing 50 bits/inch.	
	Track packing 32 tracks/inch.	
	Capacity 512 words of 32 bits.	
	Repetition rate 30 K.C./sec.	
<i>Tubes:</i>	Three major types	6.J.6.
		6.A.L.5.
		6.A.G.5. (only 6 of these).
<i>Standard Circuits.</i> ⁸		
	Binary cell.	
	Binary counting cell.	
	Two input gate.	
	Diode buffer.	
	Amplifier inverter.	

No germanium diodes were used, as tests had not shown them to have the reliability which was considered needful (in 1949).

The first machine of A.P.E.(X).C. type was constructed for the British Rayon Research Association; no attempt was made to eliminate redundancies in the design but the resulting machine, shown in Fig. 1, still had less than 500 tubes (no germanium or other semi-conductor diodes). In many

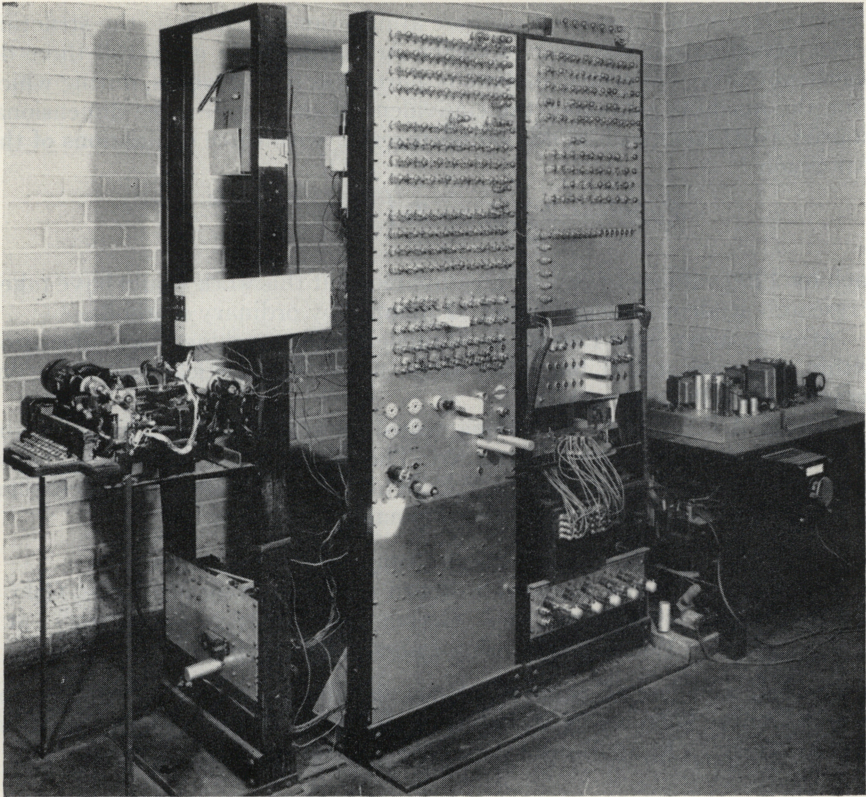


FIG. 1. The A.P.E.(R).C.

ways this machine was still a prototype, the input-output system was not fully decided and certain problems connected with track selection had still to be solved. Nevertheless from its completion in June 1952, with only 64 storage positions and teletype input/output, the machine proved reliable and useful.

By January 1953 the complete storage for 512 words was available and punched card input/output had been incorporated. From that time, until its delivery to the sponsoring agency in July 1953 the machine was in continuous use in this laboratory, and it is interesting to note that in the first 500 hours of operational use only 30 hours of faulty operation were noted (94% good operation). Moreover, no regular maintenance was done during this period:

Amongst the problems solved on the above machine (A.P.E.(R).C.) are:

- Octal-Decimal Conversion table 1000 values and differences.
- Decimal-Octal Conversion table 1000 values and differences.
- Tables of binary sines and cosines to 32b. (For machine use).
- Chebyshev polynomial co-efficient evaluation.
- Solution of sets of simultaneous equations (up to 16×16).
- Determination of a crystal structure.

Perhaps the most interesting of these applications is the last, the structure under investigation was that of Oxalic Acid Dihydrate using full three dimensional data. The whole analysis required less than 2 weeks, during which time the machine evaluated the equivalent of six sets of three dimensional Fourier syntheses (each at 48 points) together with three evaluations of the expression:¹

$$F_c(hkl) = 2 \sum_{v=1}^8 f_v \cos 2\pi \left(\frac{hx_v}{a} + \frac{ky_v}{b} + \frac{lz_v}{c} \right)$$

each for 1200 values of (hkl) . It is estimated that this work would have taken a research student between 6 and 12 months by ordinary methods.

After its move from London to Manchester the machine was in operation within one week and it has lately been in use in statistical problems concerned with mill productivity.

Whilst A.P.E.(R).C. was being tested several other machines of the same general design were constructed. The first group of these were based upon a redundancy analysis of A.P.E.(R).C. which resulted in the elimination of 180 vacuum tubes from the original system, they are:

- A.P.E.(X).C. at Birkbeck College Computation Laboratory.
- A.P.E.(N).C. at the Norwegian Board for Computing Machines, Oslo.
- M.A.G.I.C. (Magnetic and Germanium Integer Calculator) at Wharf Engineering Laboratories, England.

In the first and last of these machines the storage capacity has been increased to over 8000 words of 32 bits, and the repetition frequency doubled (60 K.C./sec.). Input/output are either by teletype or by punched card.

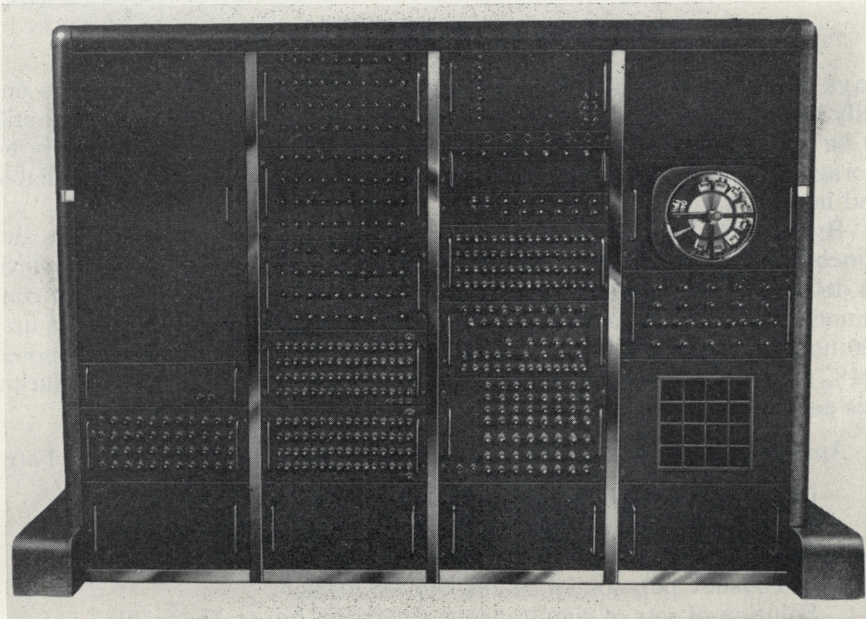


FIG. 2. Hollerith Electronic Computer. 2.

The second group of machines are based upon the original A.P.E.(R).C. design and have been constructed by the British Tabulating Machine Company Ltd., they are noticeable for the provision of a special input conversion device,⁹ which enables them to work efficiently in conjunction with decimally punched cards. H.E.C.1. (Hollerith Electronic Computer 1) has been in use for program investigation for over 12 months and H.E.C.2. was exhibited at the Business Efficiency Exhibition, London, in June 1953, giving fault-free operation for 99 $\frac{3}{4}$ % of the four days of the show.

A photograph of H.E.C.2., which is now available commercially, is shown in Fig. 2.

3. Code and Control Word Layout on A.P.E.(X).C.—Although minor differences both in the actual control word constitution, and in the orders themselves, exist between the various members of the A.P.E.(X).C. and H.E.C. families; the scope of these machines will be evident from the following description which refers to A.P.E.(X).C. and M.A.G.I.C.

		11 to	16 to	21 to	26 to	
Digits	0 to 5	6 to 10	15	20	24	31 32
	X Track	X Loca- tion	Y Track	Y Loca- tion	Code Spare	C6 Spare

Make up of Instruction Word in A.P.E.(X).C.

A.P.E.(X).C. Code

No.	Symbol	Description
0	(y)E	Stop.
1	(y)H	Card feed.
2	(y)P	Print first 5 binary digits of number held in register.
3	(x)(y)Cc	If number in A ≥ 0 select next order from position (y) if A < 0 select instruction from (x).
4	(y)l(n)	Left shift n places. A and R are connected cyclically.
5	(y)r(n)	Right shift n places. A(0).A(1)⋯A(31); R(0), R(1)⋯R(31) becomes A(0).A(0)A(1)⋯A(30); A(31), R(0), R(1)⋯R(30), etc.
6		Spare.
7		Spare.
8	(x)(y)+c	Add contents of (x) into cleared accumulator.
9	(x)(y)-c	Subtract contents of (x) from cleared accumulator.
10	(x)(y)+	Add contents of (x) into accumulator.
11	(x)(y)-	Subtract contents of (x) from accumulator.
12	(x)(y)+R	Transfer contents of (x) to R.
13	(x)(y)×(n)	Multiply number in (x) by last n digits of number in R. First half of product in A last part in R.
14	(x)(y) A(n)	Record first (or last) n digits of A in (x).
15	(x)(y) R(n)	Record first (or last) n digits of R in (x).

Some features of this code require further description. In the first place it will be noticed that each order has both an (x) and a (y) address. The first (x) refers to the location of the number required in the performance of the operation, whilst the second (y) gives the location of the next instruction. The number (n) which specifies shift, precision of multiplication, and numbers of digits to be recorded has to be placed in digits 26–31 (Marked C6).

It is chosen in accord with the following rules:

$l(n)$	C6 contains (n)
$r(n)$	C6 contains $(64-n)$
$\times(n)$	C6 contains $(64-n)$
$A(n)$	C6 contains $(32-n)$ if 1st (least significant) n digits of A are to be recorded, but $(64-n)$ if first n digits are to be recorded.
$R(n)$	C6 as in $A(n)$

The multiplier is based upon the non-restoring method described elsewhere,¹⁰ and operates upon numbers of any sign; it normally short-cuts and the provision of the (n) digit facility is an aid to programming rather than to speed.

The times of the various arithmetic operations (in A.P.E.(X).C.) are:

$+$, $-$,	600μ sec.
\times	$m \times 600\mu$ sec.
$r(n)$	600μ sec.
$l(n)$	$1,200\mu$ sec.

In these figures no account has been taken of access; with efficient optimum programming it is found that an increase by a factor of only slightly greater than two is appropriate, but it must be remembered that by "non-optimum" programming all of these figures can be increased by a factor of up to 32! It will be seen that the multiplication time is given as $m \times 600\mu$ sec. The factor m represents the number of changes 0 to 1 or 1 to 0 of the digits in the multiplier.¹⁰

A point worthy of mention is that the correct working of the machine in no way depends upon the accuracy of the optimum programming, if the coder makes a mistake in this it will not cause a machine fault but merely a waste of time. This is a feature which is absent in at least one other machine employing a multi-address code. To complete the description, it must be mentioned that each track on the drum contains 32 words, and it is within these that optimisation is required since inter-track switching is performed between words and causes no delay.

The storage (8×32 tracks each of 32 words) is at present available only in blocks of 32 tracks and the programmer has to select and plug those tracks which he will require in a given problem. This limitation may or may not be temporary, it is in contemplation to have a telephone director type system which will perform the track selection upon instruction either from the machine, or from punched cards; the building of this is, however, awaiting the result of coding studies which are still in progress.

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¹ A. D. BOOTH, *Fourier Technique in X-ray Organic Structure Analysis*. Cambridge, 1948.

² A. D. BOOTH & K. H. V. BRITTEN, *Coding for A.R.C.* Mimeographed. Princeton, 1947.

³ A. D. BOOTH, "A magnetic digital storage system," *Electronic Eng.*, v. 21, 1949, p. 234-238.

- ⁴ N. KITZ, *Thesis for the degree of M.Sc.* University of London, 1951.
- ⁵ A. D. BOOTH & K. H. V. BOOTH, *Automatic Digital Calculators*, London, 1953.
- ⁶ A. D. BOOTH, "The physical realization of an electronic digital computer," *Electronic Eng.*, v. 22, 1950, p. 492-498.
- ⁷ A. D. BOOTH, "The physical realization of electronic digital computer," Part II. *Electronic Eng.*, v. 24, 1952, p. 442-445.
- ⁸ A. D. BOOTH, "On optimum relations between circuit elements and logical symbols in design of electronic calculators." *Brit. I.R.E. Jn.*, v. 12, 1952, p. 587-594.
- ⁹ R. BIRD, "Computing machines—Input and output," *Electronic Eng.*, v. 25, 1953, p. 407-409.
- ¹⁰ A. D. BOOTH, "A signed binary multiplication technique," *Q. Jn. Mech. Appl. Math.*, v. 4, 1941, p. 236-240.

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. A similar 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.

35. UNIVERSITY OF TORONTO, FERUT, *Program Notes, Library Routines*.
This is an expandable library of FERUT routines preceded by chapters from the *Programmers' Handbook for the Manchester Electronic Computer* and notes on the FERUT library.
36. FERRANTI LTD., *Introduction to programming, notes, and routine specifications for the Manchester Electronic Digital Computer*.
This booklet was prepared as an introduction to programming to facilitate the study of the *Programmers' Handbook for the Manchester Computer Mark II*. It is prepared in loose-leaf book form so that *Ferranti Routine Specifications* can be added as they are issued.
37. THE COMPUTING MACHINE LABORATORY, THE UNIVERSITY OF MANCHESTER, *Programmers' Handbook (2nd Edition) for the Manchester Electronic Computer Mark II*.
This contains chapters on the logical design of the machine and the instruction code, coding examples, the preparation of a problem with many programming details, aids to coding (e.g., translation routines, interpretive routines), the calculation of functions of a single variable, numerical solution of ordinary differential equations, fault diagnosis in programmes, measures against machine breakdown, and the console.
38. KLAUS JAMELSON & FREDERICH L. BAUER, "Optimale Rechengenauigkeit bei Rechenanlagen mit gleitendem Komma," *Z. angew. Math. Phys.* v. 4, 1953, p. 312-316.

In most machines with floating decimal (or binary) point a complete "zero-shift" or "normalization" is carried out either immediately after each operation (Mark II, Bell-computer) or before a multiplication (BARK), i.e., the numbers are shifted to the left until the first non-vanishing digit occupies the leftmost position. This method has the drawback that occasionally (e.g., after a subtraction of two nearly equal numbers) insignificant figures, due to round-off etc., are shifted far to the left, where they may spoil subsequent operations. The paper under review proposes to make incomplete shifts in such cases, keeping the

insignificant figures at the right. The allowable amount of shift and how it is determined by the machine itself is discussed. For binary computers, since the first digit of a mantissa is now not necessarily different from zero, a modification of the usual conversion routines becomes necessary, and this is discussed in detail.

PETER HENRICI

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39. T. PEARCY (Commonwealth Scientific and Industrial Research Organization (CSIRO)), *Automatic Computation Part I, The Design of the Mk. I Automatic Computer.*

This is a description including logical block diagrams of the design of the Mk. I computer. It is a 1024 word, mercury delay-line memory machine.

40. T. PEARCEY (C.S.I.R.O.), *Automatic Computation Part II, Programmes for an Automatic Computer.*

This is an introductory programmer's manual for the CSIRO Mk. I computer.

41. T. PEARCEY (C.S.I.R.O.), *Automatic Computation Part III, Programmes for the Mk. I Computer: Pt. I.*

This is an extension of Part II and discusses the preparation of sub-routines for the Mk. I computer.

42. IBM SCIENTIFIC COMPUTING SERVICE, *IBM 701 Speedcoding System.*

The "speedcoding system" refers to the IBM 701 equipment and a method in which the computer aids in the preparation of its own programs. The system permits the programmer to supply the binary machine with input data in decimal form and with a pseudo-code. The pseudo-code is more compact and can be more easily and accurately written than the true machine code. The objective of this method is to shorten the time required in preparing problems for solution with the high speed computer.

Speedcoding utilizes a floating point system. The pseudo-code includes the regular instructions of the true code but also includes single instructions which designate computation of square root, evaluation of trigonometric and exponential functions, certain tape and drum manipulations, and error checking operations.

This booklet is a manual for users of the speedcoding system.

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43. R. R. HARE, *Coding for the Florida Automatic Computer (FLAC)* (revised April 1953).

This report is intended as a reference for the coding of problems for the Florida Automatic Computer at Patrick Air Force Base, Florida. It briefly describes the floating three-address system employed by the FLAC, together with the instructions which may be performed by this computer.

44. MATHEMATICS PANEL, OAK RIDGE NATIONAL LABORATORY, *Manual for the ORACLE.*

This beautifully printed and handsomely bound manual is expandable. It presently contains the following sections: "Electronic Digital Computers" by C. L. PERRY, a general description of digital computers; "Basic Operations of the ORACLE" by A. S. HOUSEHOLDER, which includes a list of the ORACLE operations; "Flow Charts and Coding" by J. MOSHMAN, which explains flow diagramming and gives examples of flow diagrams and their corresponding codes.

45. H. RUTISHAUSER, *Automatische Rechenplanfertigung bei programmgesteuerten Rechenmaschinen*. Mitteilungen aus dem Institut für angewandte Mathematik an der Eidgenössischen Technischen Hochschule in Zürich, No. 3. 45 p., Basel 1952.

A considerable part of the time consumed by the solution of a problem on an automatic computing machine is usually spent for coding. Various attempts have therefore been made to mechanise not only the computation, but also the coding procedure (Coding machine for Mark III, K. ZUSE's "Plankalkül" etc.). All these methods require special equipment, and the computing machine is not used for the coding. Contrary to this, in the report under review H. RUTISHAUSER gives a thorough and complete description of his method to "compute" the code for a given problem on the computing machine itself. Although this method is in principle quite general and could, with some modifications, be carried out on any automatic computing machine, the present exposition is based upon the special properties of the machine to be built at the Institute for Applied Mathematics in Zürich.

The first section of the report is devoted to a short description of this machine, the plans of which have grown out of the experience of its planners with Zuse's and Aiken's machines. It is a one-address machine with an internal drum memory of 1000 cells. Instructions are stored in a separate memory of the same capacity, each cell holding two instructions. Orders can be modified by means of nine index registers. A special order is provided for the punching of an order computed on the machine.

The second section is the heart of the paper. It describes the computation of a code for the evaluation of a given algebraic expression ("bracket expression"). Associated with every symbol E_k of a bracket expression (brackets and operation symbols included) are two integers, a_k and b_k . Roughly speaking, the more in the interior a symbol is located in the bracket expression, the larger is the corresponding number a_k . By an ingenious algorithm the bracket expression is then decomposed step by step, starting from the interior-most elements, and the corresponding orders are computed.

The third section deals with cyclic problems. Here one and the same bracket expression is to be evaluated several times and for several values (and/or addresses) of the numerical parameters. The author proposes to "stretch" the code, i.e., to unfold the cycles and to compute and to store the instructions for each iteration step separately. It is true that some computation time is thus saved by avoiding a decision as to the correct alternative after completion of each cycle. In view of the obvious limitations of memory space, the procedure nevertheless does not seem to be quite convincing.

In the fourth and last section an example is given for the computation of a code for a cyclic problem without unfolding. Here the general method is complicated by a considerable amount of special rules and provisions. Only experience can show if the author's method results in a real gain over straight-forward coding by hand.

In the whole this is a remarkable publication, which should provide a sound basis for further researches in the theory of automatic coding.

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NBSCL

46. National Bureau of Standards *Report*, September 30, 1952. *SEAC Operating and Programming Notes*, V.
 26. Interpretive Subroutine for Operations on Complex Numbers
 27. Subroutine for Square Root of a Single Precision Number with Floating Binary Point
 28. Subroutine for Sinh y , Cosh y , $|y| \leq 2.0634$
 29. Code Checking
 30. Basic Arithmetic Operations for Double Precision Numbers with Fixed Binary Point
 31. Interpretive Subroutine for Operations on Double Precision Numbers
47. National Bureau of Standards *Report*, April 13, 1953. *SEAC Operating and Programming Notes*, VI.
 32. Interpretive Subroutines S36 and S37 for Operations on Single Precision Numbers in Floating Binary Point Form, and Breakpoint Subroutine S38
 33. Subroutine for Double Precision, Floating Decimal Point Operations
 34. Subroutine for $\text{Log}_e N$; Single Precision, Floating Binary Point
 35. Subroutine Assembly Routine (SASS)
 36. Tape Control Subroutines S21 and S22
48. National Bureau of Standards *Report*, April 24, 1953. *SEAC Operating and Programming Notes*, VII.
 37. Basic Arithmetic Operations II, Floating Binary Point, Single Precision Numbers
 38. Interpretive Subroutine for Operations on Double Precision Numbers with Floating Decimal Point
 39. Subroutine for the Square Root of a Double Precision Number with Fixed Binary Point
 40. Subroutine for the Square Root of a Single Precision Number with Floating Binary Point II
 41. Automonitor Processing Routine (BIG BOIE)
49. National Bureau of Standards *Report*, November 13, 1953. *SEAC Operating and Programming Notes*, VIII.
 42. Subroutines S30, S31, S32, and S33 for the step-by-step integration of the first order differential equation $y' = f(x, y)$
 43. Subroutine for 16-point Gaussian quadrature
 44. Subroutine for binary to decimal conversion of a double precision number with fixed binary point

45. Subroutine for binary to decimal conversion of a single precision number with floating binary point
 46. Subroutine for decimal to binary conversion of a single precision number with floating binary point
 47. Subroutine for conversion of decimal degrees to binary radians and vice versa
 48. Subroutine for the evaluation of polynomials, single precision, fixed binary point
 49. Automatic transfer routine
50. NBS INSTITUTE FOR NUMERICAL ANALYSIS. *SWAC Memoranda*.

SWAC Memoranda are prepared in order to maintain a record of current developments in SWAC operating and programming. These memoranda include routines of general interest and applicability, facts of interest to programmers concerning modifications or newly installed facilities of the SWAC, and other information of general importance. The information incorporated in these memoranda represent the efforts being made in the Institute to develop techniques (a) for reducing the amount of time that goes into code preparation and checking, (b) for checking machine and auxiliary equipment operations, (c) for mechanizing as much as possible the code preparation process, and (d) for making optimum use of SWAC equipment.

Memoranda in this series will in general be reviewed by title only.

2. Interpretation Routine
 3. General Test Routine
 4. The Magnetic Drum
 5. Break Point Digit
 6. Relative (Symbolic) Coding
 7. Diagnostic Extract Routine
 8. Memory Test Series 00000 to 00099
51. L. J. PAIGE & C. B. TOMPKINS, *Systematic generation of permutations on an automatic computer and an application to a problem concerning finite groups*. NBS working paper, January 30, 1953.

The authors give a method for generating permutations on n marks which they have coded for SWAC for $n = 7, 9$. The method is as follows: Suppose that all permutations on $n - 1$ marks are known. If $(i_1, i_2, \dots, i_{n-1})$ is such a permutation, then $(i_1, i_2, \dots, i_{n-1}, n - 1)$ and all its cyclic permutations will generate all permutations on n marks. The method is applied to the problem of determining all "complete" mappings of a certain group of order 8 onto itself. An alternative method of generating permutations due to MARSHALL HALL is discussed. A detailed code is included.

MORRIS NEWMAN

NBSCL

52. ACM, *Proceedings of the meeting at Pittsburgh, Pa., May 2-3, 1952*.
 Of the 41 papers in these proceedings the following are noted under this bibliography:
 "Construction and Use of Subroutines for the SEAC," J. H. LEVIN.
 "The Use of Subroutines on SWAC," ROSELYN LIPKIS.

"The Use of Subroutines in Programmes," DAVID J. WHEELER.

"Progress of the Whirlwind Computer Towards an Automatic Programming Procedure," JOHN W. CARR.

"The Education of a Computer," GRACE M. HOPPER.

53. ACM, *Proceedings of the meeting at Toronto, Ontario*, September 8-10, 1952.

Of the 35 papers in these proceedings the following are noted under this bibliography:

"Compiling Routines," R. K. RIDGWAY.

"Machine Aids to Coding," E. J. ISAAC.

"Computer Aids to Code Checking," I. C. DIEHM.

"Input Scaling and Output Scaling for a Binary Calculator," E. F. CODD, H. L. HERRICK.

"Logical or Non-Mathematical Programmes," C. S. STRACHEY.

"A Simplified Universal Turing Machine," E. F. MOORE.

"Simple Learning by a Digital Computer," The COMPUTATION LABORATORY, Harvard University.

"Use of Continued Fractions in High-Speed Computing," D. TEICHROEW.

"Interpretive Sub-Routines," J. M. BENNETT, D. G. PRINZ, M. L. WOODS.

"The Use of Sub-Routines on SEAC for Numerical Integrations of Differential Equations and for Gaussian Quadrature," P. RABINOWITZ.

"Pure and Applied Programming," M. V. WILKES.

54. NATIONAL PHYSICAL LABORATORY, Teddington, England. *Automatic Digital Computation Symposium*, March 25-28, 1953.

This is a collection of copies of most of the 37 papers presented. The following are noted under this bibliography:

"Optimum Coding," G. G. ALWAY.

"Micro Programming and the Choice of Order Code," J. G. STRINGER.

"Conversion Routines," E. N. MUTCH.

"Getting Programmes Right," S. GILL.

"Diagnostic Programmes," R. L. GRIMSDALE.

55. OSBORNE, E. E., *Solution of the Matrix Equation $(M - \Omega D)X = 0$* . NBS report, October 16, 1953.

The author gives a solution by the power method (successive matrix-vector multiplication and vector normalization) of the equation of the title, M being a 6×6 matrix having complex elements and D a non-singular real diagonal matrix. Setting $A = D^{-1}M$, the equation becomes the more familiar one

$$(A - \Omega I)X = 0,$$

and this is the one the author actually solves.

The preliminary multiplication $D^{-1}M$ was performed on IBM equipment. The computation of the eigenvalues Ω and eigenvectors X was programmed for SWAC. Detailed flow charts and codes are given for two such programs, one which can be stored in the high speed memory, the other requiring external storage capacity such as a magnetic drum.

MORRIS NEWMAN

BIBLIOGRAPHY Z

1114. ANON., "New knowledge—computers are busy these days," *Westinghouse Engineer*, Jan. 1954, p. 62-63.

Industry is finding computers economical as well as efficient. An Eastern utility is using one to establish power-system loss formulas and data for load dispatching on large interconnected systems at a saving of \$60,000 yearly.

They are being used for the automatic solution of problems involved in the routine application of electrical machinery; problems in connection with blades of compressors and steam turbines; reduction of data on all effects of inner-cooled generators and stress-analysis problems on rigid steam piping.

A. R. COCK

NBSCL

1115. ANON., "New digital computer speeds math solution at Oak Ridge," *Industrial Laboratories*, Nov. 1953, p. 128-129.

The Oak Ridge Automatic Computer Logical Engine, ORACLE, is described in 9 paragraphs and 3 pictures. It is a descendent of the Institute for Advanced Studies Computer, is fully parallel, and has cathode-ray tubes storage for 2048 words. Net addition time is 5 microseconds and multiplication time 500 microseconds.

R. D. ELBOURN

NBSCML

1116. ANON., "Utilization of digital computing machines," *Nature*, v. 172, 1953, p. 649-651.

This is a report of a meeting of the Engineering Section of the British Association in September 1953. The speakers were F. C. WILLIAMS, R. K. LIVESLEY and G. G. ALWAY. It is interesting to note British experience and opinions in this field: for instance, that at present the need is for more programmers and programs rather than for more machines, that it takes about three months to train a programmer and about the same time to prepare a significant problem, and that the speed factor is 150:1 over hand computing. The desirability of making the machine carry out as much as possible of the preparation of data, no matter how trivial it is, is stressed. It is also noted that the knowledge of the capabilities of computers gained during the solution of one problem has often led to customers realization of the feasibility of attacking other problems in their field.

Among the problems which have been handled (on the machines at University of Manchester and at the National Physical Laboratory) are: torsional and lateral oscillations of systems of shafts, design of cams, analysis of rigid-frame structures, flutter analysis.

J. T.

1117. P. R. BAGLEY, *Electronic Digital Machines for High-speed Information Searching*. Master's Dissertation, Mass. Inst. of Tech., Cambridge, 1951, ix + 133 p.

The author's objective is the examination of the suitability of methods and machines for the high-speed location of related items in a large body of

indexed information. His study is a timely one because of the mountainous volume of information, growing at an ever-increasing rate, which exists in the scientific and engineering fields. For example, a search of *Chemical Abstracts* today involves over a million abstracts, with the present trend of publication indicating that the total abstracts published in this field by 1960 will be almost 1,800,000. In another representative field, Electrical Engineering, it has been estimated that by 1960 the total of published papers of interest may reach 700,000.

Since the effective planning of research requires a knowledge of previous activity in the field, it is apparent that the increasing size of our "storehouse" of information makes it imperative that we attempt to increase the speed of our information searching facility. A notable stride in this direction has been taken in the development of the Rapid Selector, designed by DR. VANNEVAR BUSH, which is in use and being developed further, by the U. S. Department of Agriculture Library. In respect to the problem of information searching, methods and techniques for searching inventory records are interesting. For example, in the October 1953, *Proceedings* of the I.R.E., there was reported an investigation of photographic techniques for information storage underway by the International Telemeter Corporation, which could result in further alleviation of the information searching problem.

The thesis is divided into three parts: Part One, Introduction to the Information Searching Problem; Part Two, Investigation of Electronic Digital Methods for High-Speed Scanning and Selection; Part Three, Conclusions and Recommendations. Four Appendixes are added: Appendix 1, Derivation of Superposed Coding Formulas; Appendix 2, Description of Major Electronic Computer Components; Appendix 3, Guide to Coding for the Whirlwind I Computer; Appendix 4, Searching with the Whirlwind I Computer. A thorough analysis of the problem prefaces an attempt at solving it by use of a high-speed electronic digital computer.

The conclusion of the author is that the general-purpose digital computer is virtually disqualified as a selection device because of its sequential operation and the fact that, in the application, substantial time is required for the transfer of numbers back and forth between the storage element and the arithmetic element of the machine. He considers it feasible to develop an electronic computer more suitable for information searching than the general-purpose digital computer, and presents a block diagram for such a device.

E. W. C.

1118. H. BÜCKNER, F. J. WEYL, L. BIERMANN & K. ZUSE, *Probleme der Entwicklung programmgesteuerter Rechengерäte und Integrieranlagen*. Rhein.-Westf. Technische Hochschule Aachen, Mathematisches Institut, H. CREMER, ed., Aachen, 1953, xiii + 75 p.

This book contains the essential contents of four speeches given at a colloquium in Aachen in July 1952, under the sponsorship of the Institute for Mathematics, Mechanics, Physics and Theoretical Physics of the Rheinisch-Westfälischen Technischen Hochschule.

The four chapters of the book, based upon the speeches of the authors in the order above, are the following: Über die Entwicklung des Integromat; Aufbauprinzip, Arbeitsweise und Leistungsfähigkeit elektronischer pro-

grammgesteuerter Rechenautomaten und ihre Bedeutung für die naturwissenschaftliche Forschung; Die Gottinger Entwicklungen elektronischer Rechenautomaten; Über programmgesteuerte Rechengeräte für industrielle Verwendung.

In the first chapter, BÜCKNER gives a functional description of the Integromat, a differential analyzer. In the second chapter, by F. J. WEYL, the characteristics of electronic digital computers now in use in the United States are compared and some of their uses are discussed. Included in the comparison of machines is the primary motivation of their construction—ballistics computations, the development of improved components and more flexible computational systems, or commercial and industrial applications. In the third chapter, L. BIERMANN discusses the features of a new digital computer in operation at the Max-Planck Institute of Physics. The computer is a moderate-speed, tape-fed, magnetic drum machine, operating on 32 binary-digit numbers, with a 3 binary-digit integral part. Some of the problems being solved on the computer are described. The last chapter, by ZUSE, is an exposition of his development of relay computers, prefaced by a review of the difficulties he encountered up to the time of the installation of a Zuse computer in the Eidgenössische Technische Hochschule at Zürich in 1950. He presents an interesting explanation of the reasoning underlying many of his design decisions, and states a case for moderate speed, simple-to-operate computers, particularly for application to engineering problems.

The book closes with a recording of the discussion which ensued after the presentation of the papers.

E. W. C.

1119. OFFICE OF NAVAL RESEARCH, *A Survey of Automatic Digital Computers*. Washington, 1953, vi + 109 p. Available as PB111293, U. S. Dept. of Commerce. Office of Technical Services, Washington 25, D. C. Price \$2.00.

This compendium of data on automatic digital computers incorporates the results of surveys by the Flight Research Laboratory, Wright-Patterson Air Force Base, and the Mathematical Sciences Division, Office of Naval Research.

Included in the survey is one page of information on each of ninety-eight computers, among which are included machines in use, or under development, in Australia, Belgium, Canada, England, France, Germany, Holland, Japan, Norway, Sweden, Switzerland and the United States.

A partial listing of the information given on the computers included in the survey is the builder, location of installations, availability of programming service and computing time, operating schedule, number base, word length, instruction type, sequence control, built-in operations and time required for their execution, description of internal storage and listing of input-output devices.

The Office of Naval Research survey is a useful reference for workers in the automatic digital computer field and also for those who, though not concerned with their development, are interested in the application of high-speed digital computers to their problems.

E. W. C.

1120. MINA REES, "Applying Computers to Machine Control," *Machine Design*, v. 25, 1953, p. 324-334.

An abstract of an address entitled "The Future Use of Digital Computers" given at Eighteenth National Applied Mechanics Conference of the American Society of Mechanical Engineers, Minneapolis, June 1953.

NEWS

Eastern Joint Computer Conference and Exhibition.—The Joint Computer Conference on Information Processing Systems—Reliability and Requirements was held at the Statler Hotel in Washington, D. C., December 8-10, 1953, under the joint sponsorship of the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Association for Computing Machinery.

Session I Tuesday, December 8, 10:15 AM

Chairman—F. J. MAGINNISS, Secretary, AIEE Committee on Computing Devices

Address of Welcome

JOHN H. HOWARD, *Chairman*, IRE Professional Group, Electronic Computers

Keynote Address

HOWARD T. ENGSTROM, Remington Rand, Inc.

The RTMA Support of the 1950 Computer Conference—A Progress Report

THOMAS H. BRIGGS, Burroughs Corporation

The Use of Electronic Data Processing Systems in the Life Insurance Business

M. E. DAVIS, Metropolitan Life Insurance Company

Computer Applications in Air Traffic Control

VERNON I. WEIHE, Air Transport Association of America

Discussion of papers

Session II Tuesday, December 8, 2:00 PM

Chairman—HOWARD T. ENGSTROM, Remington Rand, Inc.

Data Processing Requirements for the Purposes of Numerical Weather Prediction

JOSEPH SMAGORINSKY, U. S. WEATHER Bureau

Methods Used to Improve Reliability in Military Electronics Equipment

L. D. WHITELOCK, Bureau of Ships

Digital Computers for Linear, Real-Time Control Systems

RALPH B. CONN, Jet Prop. Lab., California Institute of Technology

The MIT Magnetic-Core Memory

WILLIAM T. PAPIAN, Massachusetts Institute of Technology

Discussion of papers

Session III Wednesday, December 9, 9:00 AM

Chairman—C. V. L. SMITH, Office of Naval Research

Reliability Experience on the OARAC

ROBERT W. HOUSE, Wright-Patterson Air Force Base

Operating Experience with the Los Alamos 701

WILLIAM G. BOURICIUS, Los Alamos Scientific Laboratory

Acceptance Tests for the Raytheon Hurricane Computer

FRANCIS J. MURRAY, Columbia University

Reliability of a Large REAC(R) Installation

BERNARD D. LOVEMAN, Reeves Instrument Corporation

National Bureau of Standards Performance Tests

S. N. ALEXANDER & R. D. ELBOURN, National Bureau of Standards

Experience on the Air Force UNIVAC

ROBERT KOPP, Headquarters, U. S. Air Force

Discussion of papers

Session IV Wednesday, December 9, 2:00 PM

Chairman—C. C. BRAMBLE, U. S. Naval Proving Ground, Dahlgren

- Electron Tube and Crystal Diode Experience in Computing Equipment
 Reliability and Characteristics of the ILLIAC Electrostatic Memory
 Electron Tube Performance in Some Typical Military Environments
 Discussion of papers
Session V Thursday, December 10, 9:00 AM
Chairman—R. F. CLIPPINGER, Raytheon Manufacturing Company
 SEAC—Review of Three Years of Operation
 A Review of ORDVAC Operating Experience
 Some Remarks on Logical Design and Programming Checks
 The Advantages of Built-in Checking
 Recent Progress in the Production of Error Free Magnetic Computer Tape
 Discussion of papers
Session VI Thursday, December 10, 2:00 PM
Chairman—S. B. Williams, President, ACM
 Reliability of Electrolytic Capacitors in Computers
 Reliability and its Relation to Suitability and Predictability
 Case Histories in Resistor Stability
 Discussion of papers
 Summary
- Group discussions were held each day at 4 PM which included the following topics:
- Wednesday, December 9
 Applications—Technical
 Applications—Commercial and Industrial
 Diagnostic Checks
 Magnetic Tape Standards
 Crystal Diodes (design for reliability)
- J. A. GOETZ & H. J. GEISLER, IBM Corporation
 JOSEPH M. WIER, University of Illinois
 D. W. SHARP, Aeronautical Radio, Inc.
 P. D. SHUPE, JR., & R. A. KIRSCH, National Bureau of Standards
 CHARLES R. WILLIAMS, Ballistic Research Laboratory
 HERMAN H. GOLDSTINE, The Institute for Advanced Study
 JOHN W. MAUCHLY, Remington Rand, Inc.
 J. C. CHAPMAN & W. W. WETZEL, Minnesota Mining and Manufacturing Company
 MARK VAN BUSKIRK, P. R. MALLORY and Company, Inc.
 E. B. FERRELL, Bell Telephone Laboratories
 JESSE MARSTEN, International Resistance Company
 ALLEN V. ASTIN, Director, National Bureau of Standards
 GEORGE PETRIE, *Chairman*, International Business Machines Corp.
 WALTER FRESE, *Chairman*, General Accounting Office
 J. J. EACHUS, *Chairman*, Dept. of Defense
 ALLEN SHOUP, *Chairman*, Shoup Engineering Co.
 RALPH J. SLUTZ, *Chairman*, National Bureau of Standards

OTHER AIDS TO COMPUTATION

1121. W. G. ANDERSON & E. H. FRITZE, "Instrument approach system steering computer," I. R. E., *Proc.*, v. 41, 1953, p. 219-228.

This paper is mainly devoted to a theoretical discussion of a computer to be used in providing steering indications to an aircraft pilot during a blind landing using the Instrument Landing Approach System. The purpose of the computer considered is to combine signals from three sources used by a pilot in flying such an approach. These sources are the vertical gyro (bank