

179[L].—T. H. CROWLEY, *Tables of Integrals of certain Bessel Functions*. Available at the Antenna Laboratory, Ohio State University, Columbus, Ohio.

These tables give values of the integrals

$$\int_0^u J_0(\lambda x) \sin x \, dx \quad \text{and} \quad \int_0^u J_0(\lambda x) \cos x \, dx$$

for

$$u = 0(.02)10, \quad \lambda = 0(.1)10, \quad \lambda u \leq 15.$$

Although the calculations were designed to give 4D accuracy, spot checking indicates an accuracy of 5D.

T. H. CROWLEY

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180[L].—E. W. PIKE, *Table of Parameters for the Summation Analogue of Laguerre Polynomials*. Two typewritten pages on deposit in the UMT FILE.

This table is of use in the design of filters for pulsed information.

E. W. PIKE

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AUTOMATIC COMPUTING MACHINERY

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TECHNICAL DEVELOPMENTS

INPUT AND ORGANIZATION OF SUB-ROUTINES FOR FERUT

1. **Introduction.**—Descriptions of methods for handling sub-routines on other machines have been written for the Manchester Electronic Computer,¹ EDSAC,² SEAC³ and ILLIAC⁴. The purpose of this article is to discuss the input and storage of routines and numerical data and the organization of routines during the solution of a problem on Ferut.

Ferut is the serial, one address, electronic digital computer now in operation in the Computation Centre, University of Toronto, Canada. It was built by Ferranti Ltd., Manchester, England, and is similar to the computer at the University of Manchester, England. Ordinary 5-hole telegraphic punched tape is used for input with a photoelectric reader. The output mechanism is a teleprinter and punch.

Information in the machine is kept in blocks or pages. In each page there are 64 short lines of 20 binary digits each. For convenience these 20 bits are arranged in four groups of five bits. The five-bit group constitutes a digit in the scale of 32 and is represented by one teleprint character. An electronic instruction consists of one short line, two teleprint characters for

the address, and two for the order. Numbers consist of two short lines or 40 bits.

The electronic storage comprises eight pages labelled S_0, S_1, \dots, S_7 . In addition, there is a magnetic storage of 256 tracks on a drum, each track holding two pages of information. The pages may be transferred singly or in pairs to or from a magnetic track. This is accomplished by a magnetic transfer instruction.

2. Routine Changing.—During the operation of a program, space in the electronic store is at a premium and thus the instructions necessary to carry out a problem are divided, as is customary, into a main, or master routine and a number of sub-routines. Only the set of instructions immediately in use is kept in the electronic store; the other routines are in the magnetic store. When it is desired to change from one routine to the next, it is necessary to have a group of orders which will (1) preserve, in a list called the link list, the location in magnetics of the routine being left, (2) record the line at which it is being left, (3) locate the next routine and call it down from magnetics and finally (4) enter the new routine at the appropriate line. This group of instructions is common to all routine changes and thus is kept separate from any one routine in a *Routine Changing Sequence* (R.C.S.) which is permanently down in the electronic store. (This occupies page S_2 along with powers of 2 for shifting and some other constants which are frequently required, and the page is known as PERM.)

There must be, however, in the routine being left a few instructions supplying the required information about the specific routine to be entered and a control transfer to R.C.S. This linking sequence of orders which appears in the routine being left must be kept to a minimum to conserve space, and in the case of the Ferut system it occupies four short lines. One of these lines is, of course, the magnetic transfer which calls down the next routine from the magnetic store to the electronic store.

This transfer is recorded in the link list by R.C.S. so that it can be used at a later date. The list of links grows as the control moves down a chain of sub-routines changing from the master routine (zero-th level) to the first level sub-routine, to the second level sub-routine, etc. The list is consulted by R.C.S. as the control returns back up the chain of sub-routines to the master routine.

3. Directory.—The magnetic tracks are numbered, and in writing a magnetic transfer it is necessary to specify the track number. For several reasons it may be desirable to change tracks after a problem has been coded and the tapes have been punched. You must then seek out and alter all magnetic transfers which, of course, are embedded in the program. This is not only tedious but leads to errors. To overcome this difficulty all magnetic transfers are kept separate from the routines proper in a list called the directory. In the line of the routine where the transfer should appear is placed the address in the directory of the required magnetic transfer. This line is called a false line. During input the false lines are replaced by the appropriate magnetic transfers from the directory.

If the magnetic transfer required to call down a certain routine is stored in line ab of the directory, ab is said to be the *Directory Number* of the routine. This directory number is what is written in a false line. When a routine has been tested and is considered useful, it may be assigned a

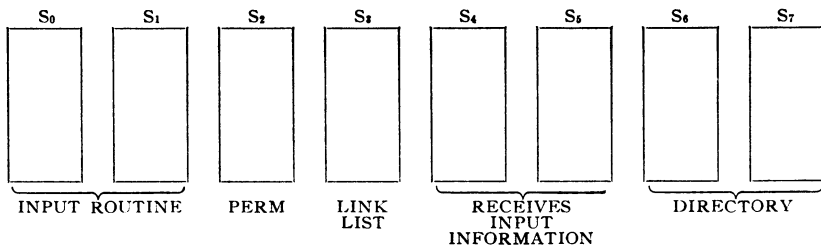
Library Number which will be its permanent directory number. Sixteen lines at the beginning of the directory are kept open for routines of a particular problem. These directory numbers are temporary.

4. Input and Output.—To perform input or output operations it is necessary to combine the simple input or output orders of the machine with other orders in an input or output routine. The function of the Ferut *Input Routine* is to read information from tape, perform certain alterations on routines or numerical data and store the routines or data in assigned locations in the machine.

The input routine reads one character at a time from the tape testing it until it finds a *Warning Character*. There are eleven warning characters. Each of the warning chs. causes control to be taken to a certain section of the input routine where a prescribed group of instructions is obeyed.

An attempt has been made to choose, for warning chs., teleprint characters which are suggestive of the operations which the warning chs. perform. For example—the warning ch. J followed by n/ causes the n chs. following the / to be printed out by the machine. (The ch. J suggests the word JOT.) After the Jn/ the machine reads in n chs. before it begins again to examine the tape for the next warning ch. Since / (zero) is not a warning ch., blank tape is examined rapidly and passed by. Thus between meaningful sequences on the tape (such as the Jn/ followed by n chs.) it does no harm to have spaces, and they are a great assistance when reading the tape by eye.

The use of the electronic pages during input is best described by a diagram.



After input only page S₂ and one half of S₃ are used. Routines normally operate from S₀ and S₁.

The list of warning characters is as follows:

STOP—Stops the tape—control is returned to input to search for the next warning ch. when a prepulse is given manually.

Jn/—Prints out the n chs. on the tape following Jn/—used for titling routines (J suggests JOT).

E ab—Transfers control to line (ab + 1) (E suggests ENTER).

:abcd—Causes abcd to be obeyed as a magnetic instruction (: suggests /; the “obey as a magnetic instruction” order of Ferut).

K ab n—Reads in from the tape n short lines starting the entries in line ab of the store. A maximum of 32 short lines can be read in at a time. (K suggests absolutely nothing but is used for this purpose by all the other input systems.)

U ab—Writes Up
D ab—Reads Down } the routine whose directory number is ab { from } page S₄ (or
pages S₄ and S₅ if it is a 2 page routine) { to } the magnetic track assigned
in the directory. Check of the magnetic transfer is performed, and a warning
signal indicates failure.

@ abcd }—Calls in as an { ad-routine } the routine whose directory number is ab and
 R abcd } { sub-routine } enters it at line (cd + 1). (@ sounds like ad—and R is suggestive of Routine.)

F ab—Replaces the false line ab of a routine by the contents of a line of the directory. (Explanation: In order to incorporate a magnetic transfer within a routine in line ab the directory number of the appropriate magnetic transfer is placed in the routine itself in line ab. This is a false line. The warning ch. F replaces this by the appropriate true line, i.e., the magnetic transfer as it appears in the directory. For example: One line of the linking sequence is such a false line and any routine containing a linking sequence must be followed by the proper F sequence.)

C/(2n)—Adds together the 32 long lines of page n and compares the sum modulo 2^{40} with the known *Check Sum* of this page. If the two differ, a signal occurs. The known check sum must, of course, be planted in a certain line of the store.

A wide variety of routines have been devised for handling the input and output of numerical data depending on the position of decimal or binary point, method of conversion, number of significant figures, layout, etc. These are entered as sub-routines from the input routine by an R warning ch. or from the master routine of the problem by a linking sequence. When numerical data are put in, the pages of information can be given directory numbers and thus stored and brought down in a manner similar to that used in handling sub-routines.

The following checks are a part of this system of input. Each Up or Down transfer is checked; thus the contents of magnetic and electronic storage are known to be identical. The transfer from tape to electronic storage is checked by having a known check sum of a routine or of numerical data read in and compared with the check sum of the contents of the electronic page by means of the C warning ch. Alternately, if the check sum is not known, the tape may be read in twice, once with current on which writes from electronic to magnetic storage, the second time with this write current off. The Up transfer check then effectively compares what was read in the first time from tape with what was read in the second time.

Most problem tapes consist of sequences of characters which (i) print the title, (ii) read in and store the directory, (iii) read in, alter and store routines and (iv) start the problem. Titling (see i) is useful for identifying tapes. Process (ii) consists of reading the magnetic transfers for the routines being used into the appropriate lines of the directory. The directory is stored by means of the : warning ch. All routines are read (see iii) by K-sequences into S_4 (or S_4 and S_5 in the case of two-page routines). They are checked if desired by the C ch., altered if necessary, i.e., false lines are replaced by F-sequences, and then stored by the appropriate Up order. The problem is started (see iv) by entering the master routine as an ad-routine by means of an @ sequence on the tape.

Routines may be altered during input by bringing them down with a D-sequence, altering the desired lines by K-sequences and then sending them back up to magnetics by a U-sequence.

Library tapes may be used without alteration in a problem tape. They consist of a titling sequence, K-sequences reading the routine into S_4 or S_4 and S_5 and then the Up order using the library number of the routine. Library tapes have a check sum taken by means of the Down order followed

by the C warning ch. After this false lines are replaced by F-sequences, and the routine is stored again by the U-sequence.

5. **Example.**—Consider the organization of the routines for the two-dimensional Fourier synthesis

$$\rho(y, z) = \sum_{k=0}^{\infty} \sum_{l=0}^{\infty} F_{kl} \cos 2\pi(ky + lz)$$

where the coefficients F_{kl} are tabulated. The program for this problem will consist of four routines and the data. Three of the routines to be used are library routines, namely, Decimal Input, Decimal Output, and Cosine. The fourth is the Master routine. The latter must call in Cosine and Decimal Output as sub-routines and thus has a false line in each of the linking sequences calling in these two routines. These false lines have addresses a_1b_1 and a_2b_2 . Transfers calling down the data require false lines in a_3b_3 , a_4b_4 , etc.

The coefficients F_{kl} are taken in and converted from decimal to binary form by the Decimal Input routine before they are stored in the magnetics. This is accomplished during input by entering Decimal Input as a sub-routine from the tape by means of the R warning ch. Details for the routines and data are given in Table I.

The magnetic transfer calling down the Master will be $(t_1) \delta_2 S_0$, where (t_1) represents the two teletype character track address, S_0 indicates the electronic storage from which the routine operates, and δ_2 denotes that it is a two-page routine. This magnetic transfer must be recorded in line /N of the directory.

TABLE I

Description	Directory Number	Magnetic Storage	Electronic Storage
Master	/N	t_1	S_0, S_1
Decimal Input	SF	t_2	S_0, S_1
Decimal Output	ON	t_3	S_0, S_1
Cosine	XN	t_4 (left half)	S_0
Data 1 (two pages)	EN	t_5	S_4, S_5
Data 2 (two pages)	@N	t_6	S_6, S_7
Data 3 (two pages)	AN	t_7	S_4, S_5
etc.			

The tape is organized in the following way:

<i>Punching</i>	<i>Description</i>
T T T T T	T is a letter which is not a warning ch. but indicates the beginning of the tape to the operator.
spaces
JZ / FOURIER: SYNTHESIS	Title (Z is the teletype character for 17.)
spaces
K / N E $(t_1) \delta_2 S_0$	The K-warning ch. reads into the directory the magnetic transfer for bringing down: the Master
K S F E $(t_2) \delta_2 S_0$	Decimal Input
K O N E $(t_3) \delta_2 S_0$	Decimal Output
K X N E $(t_4) \delta_1 S_0$	Cosine

<i>Punching</i>	<i>Description</i>
K E N E (t ₅) δ ₂ S ₄	Data 1
K @ N E (t ₆) δ ₂ S ₆	Data 2
K A N E (t ₇) δ ₂ S ₄	Data 3
etc.	(E is teleprint for 1.)
: I / R N	I / R N is the magnetic transfer instruction which stores the directory on track.
STOP	
Library tape for Decimal Input	} these routines all have check sums
Library tape for Decimal Output	
Library tape for Cosine	
Master routine punched with the K-sequences which read it into S ₄ and S ₅ .	
Fa ₁ b ₁ Fa ₂ b ₂ Fa ₃ b ₃ Fa ₄ b ₄ , etc.	Replaces false lines in Master by the magnetic transfers from the directory.
U / N	Stores Master on track t ₁ .
STOP	
R S F c d	Enters Decimal Input as a sub-routine at line
Data 1	cd + 1 whereupon Data 1 punched in the appropriate form are read in and converted.
U E N	Stores Data 1 on track t ₅ .
R S F c d	Reads in and converts Data 2.
Data 2	
U @ N	Stores Data 2.
R S F c d	Reads in and converts Data 3.
Data 3	
U A N	Stores Data 3.
etc.	
STOP	
@ / N c d	Enters the Master as an ad-routine at line cd + 1.
\$\$\$ \$	A non-warning ch. indicating the end of the tape.

6. Summary.—The Ferut System has the following features :

- (1) No reference to fixed magnetic tracks is made except in a special list called the directory.
- (2) Minimum time and mental effort are consumed in changing from one routine to another during the operation of a problem.
- (3) The details of the input are easy to remember.
- (4) Alterations may be made to routines or pages of data with a minimum of effort.
- (5) Certain automatic checks are built into the system.
- (6) Library tapes may be used without alteration in a problem tape.

This system of input and routine organization was adopted after studying the various systems in use at the University of Manchester.¹ The details were devised by the author in cooperation with C. STRACHEY, National Research Development Corporation, London, England, and H. GELLMAN, Chalk River, Canada, with the advice and criticism of C. C. GOTLIEB and the staff of the Computation Centre, University of Toronto.

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¹ *The Programmers Handbook for the Manchester Electronic Computer (Mark II)*. mimeographed, Univ. of Manchester, England, Aug. 1952, 9 chapters.

² M. V. WILKES, D. J. WHEELER & S. GILL, *The Preparation of Programs for an Electronic Digital Computer*. Addison-Wesley Press, Inc., Cambridge, Mass., 1951.

D. R. HARTREE, *Numerical Analysis*. Chapter XII, Oxford University Press, 1952.

³ Anon., "The incorporation of subroutines into a complete problem on the NBS Eastern Automatic Computer," *MTAC*, v. 4, 1950, p. 164-168.

⁴ D. J. WHEELER, *Program Organization for the University of Illinois Digital Computer*. Internal Report No. 33, University of Illinois, May 16, 1952.

DISCUSSIONS

Programs for Computing the Hypergeometric Series

The hypergeometric series

$$F(a, b; c; z) = 1 + \frac{ab}{c} \frac{z}{1!} + \frac{a(a+1)b(b+1)}{c(c+1)} \frac{z^2}{2!} + \dots$$

appears in the solution of various problems in applied mathematics and it is therefore desirable to have efficient methods for evaluating this series. To meet these needs a program of investigating available methods for computing the hypergeometric series is being conducted. The present note discusses two computations on SEAC.

A code for real values of parameters and argument has been checked out with a, b, c equal to various combinations of 1, 2, 3 and $-.9 \leq x \leq .9$ where many of the answers are known functions. The results were accurate to nine and more often ten significant figures. For each set of parameters it took approximately twenty-five minutes to tabulate the series for $x = -.9(.1).9$.

A code for complex values of parameters and argument has been checked with one of the real cases above giving the same accuracy, and with $a = 1 + i.2, b = -2, c = 2 + i, z = .5 - i.8$ where the hypergeometric series is a polynomial. The agreement in this case was exact.

A previous hand computation of $F(a, b; c; z)$ for

$$a = -11.753 + i12.204, \quad b = 12.753 - i12.204, \quad c = 2, \quad z = .5$$

gave the result

$$F(a, b; c; z) = 832,109 - i827,535$$

where the result was accurate to four figures. Using these same parameters and argument and carrying all computations to at least five decimal places and computing until the truncation error was less than 10^{-2} (54 terms) SEAC gave

$$F(a, b; c; z) = 832,103.8 - i827,536.8.$$

Repeating the computations to at least seven decimal places and computing first until the truncation error was less than 10^{-3} (57 terms) and then until the truncation error was less than 10^{-5} (65 terms) SEAC gave the identical results

$$F(a, b; c; z) = 832,108.0985 - i827,540.7310.$$

As a check on this result $F(a-1, b; c; z)$ and $F(a, b+1; c+1; z)$ were computed and the following recursion formula yielded the results

$$F(a, b; c; z) = F(a - 1, b; c; z) + bzF(a, b + 1; c + 1; z)/c$$

$$F(a, b; c; z) = 827,563.5390 - i46,025.5154 \\ + bz(123,187.2697 - i127,239.3492)/c$$

$$F(a, b; c; z) = 832,108.0972 - i827,540.7303$$

which agrees with the previous computation to the second decimal place. Each of the above computations took four minutes time on SEAC, including reading in and out.

This code uses double precision operations and begins by reading in a, b, c, z and the size of the term where the series is truncated, where all are twenty-two digit decimal numbers. After computing and printing the result the SEAC calls for a new z and will compute using the previous parameters, or may be made to read in new parameters by sending the Control to address zero. In general the result will be accurate to 10^{11-8} significant figures where $F(a, b; c; z)$ and its largest term are both less than 10^8 .

This last code has been modified to compute the confluent hypergeometric function for complex parameters and argument. Using the modified code $w = 1.35218\ 220994$ has been found as a zero of the function¹

$$F\left(\frac{1-w}{2}; 1; 2w\right).$$

W. F. CAHILL

NBSCL

¹H. A. LAUWERIER, "The use of confluent hypergeometric functions in mathematical physics and the solution of the eigenvalue problem," *Applied Scientific Research*, 1951, A, z, p. 184-204.

BIBLIOGRAPHY Z

1091. ANON., "Analog-to-Digital Converter simplifies data reduction," *Product Engineering*, v. 24, May 1953, p. 234-235.

Principles of the SADIC analog-to-digital converter built by Consolidated Engineering Corp. are briefly described.

R. D. ELBOURN

NBSCML

1092. ANON., "Computer assembly line," *Electronics*, v. 26, July 1953, p. 200.

This is a short expository paragraph about the IBM electronic data-processor Model 701.

1093. ANON., "Converters put data into useful form," *Aviation Week*, v. 58, May 18, 1953, p. 68.

Analog-to-digital converters having three decimal digit precision and a cycle slightly less than one second have been announced by two companies, the SADIC by Consolidated Engineering Corp. and the Teleducer by Telecomputing Corp.

R. D. ELBOURN

NBSCML

1094. ANON., "Mathematicians needed to help 'brain,'" *Machine Design*, May 1953, v. 25, p. 236.

ANON., "Armour Research Foundation to get electronic super-brain," *Midwest Engineer*, 5, Feb. 1953, p. 28.

Both articles deal with the IBM electronic computer 701. The first gives a brief description of this card-programmed calculator with its magnificent equipment of electrostatic memory, magnetic drum, and magnetic tapes. The second announces the prospective rental of this model by the ARF of the Illinois Institute of Technology.

The pleasure we find in reading of any advancement in the field of electronic computation is considerably dampened by the persistent occurrence in print of such epithets as "super-brain," "thinking machine," and the like—as applied to computers. Nor is it a pleasure for the hard-working mathematician to be told that "fantastically hard problems are easily solved by the electronic computers."

It should be realized that man-made machines cannot solve problems, any more than telephones can carry on conversations, or telescopes can make celestial observations. None but the *human* mind is capable of initiating and solving mathematical problems, as well as of utilizing various types of equipment for the computation of the results.

Our ruffled feathers were smoothed somewhat by the timely warning voiced in the first article that "there may not be enough top quality mathematicians to prepare problems for . . . these machines. . . ." Prophetic and true words!

I. RHODES

NBS

1095. ANON., "NBS designs 'building block' computer," *Product Engineering*, v. 24, March 1953, p. 205.

A new computer, under development at the National Bureau of Standards for the Defense Department, is composed largely of approximately 800 standardized circuit packages. These are expected to take care of 90 percent of the total circuitry, exclusive of memory units. Two general types of standardized packages have been developed; the first contains an amplifier tube, pulse transformer and germanium diodes; and the second, delay lines. These basic types are made in several versions as dictated by circuit requirements.

The assemblies, now being manufactured commercially, appear to be about two inches wide, five inches high and 10 inches deep. Connection is through a 60-contact pin assembly at the rear. To facilitate checking and fault-localization, a test jack is located on the front of each unit.

M. L. GREENOUGH

NBS Electronic Instrumentation

1096. AN WANG, "High-speed number generator uses magnetic memory matrices," *Electronics*, v. 26, May 1953, p. 200-204.

Numbers are displayed in an 8×8 dot pattern on a cathode ray tube by using conventional raster-scan deflection and pulsing the beam on

according to character shapes stored in 8×8 magnetic core matrices. The device has been tested at 8,000 characters per second, but the builder believes 100,000 per second is achievable.

R. D. ELBOURN

NBSCML

1097. W. COCHRAN & A. S. DOUGLAS, "A new application of EDSAC to crystal structure analysis," *Nature*, v. 171, June 20, 1953, p. 1112-1113.

Determination of the structure of centro-symmetric crystals by evaluating the electron density for each of the 2^N possible sign combinations on N structure factors can be made after the correct signs of about twenty of the largest structure factors have been found (for crystals of moderate complexity).

The EDSAC surveys this large number of alternative answers and selects from them a few which fulfill certain criteria. In the case of salicylic acid, it completed in less than three hours the calculation for $2^{16} = 65,536$ independent possibilities. The number of sign combinations corresponding to each such possibility is listed in an accompanying table in this article. This method is considered valuable when used in conjunction with PEPINSKY'S X.R.A.C. for rapid testing of the most plausible sign combinations.

Mention is made of another method using EDSAC which requires only a few minutes of machine time for determining rapidly the structures of crystals of moderate complexity.

E. MARDEN

NBSCL

1098. P. KLASS, "Giant brains could aid air defense," *Aviation Week*, v. 58, May 11, 1953, p. 67-68+.

This article is a description of two new computing machines, Remington Rand's 1103 and International Business Machines Corporation's 701; it stresses their possible uses in the aviation field. The two uses mentioned were both "real time" control uses, i.e., air defense operations and airport traffic control. No mention was made of their main use so far, that of solving complex problems and simulating flight conditions. "Real time" control can consist of either giving fast answers pictorially and numerically to human beings or of actually controlling aircraft and guided missiles by remote control. Aside from the vast amount of pre-stored information, information as to changing conditions can be fed into the computer directly from radar and other equipment, thus enabling the machine to make its lightning computations.

The bulk of the article contrasts the specifications for the two machines, giving a good summary of their technical points. The machines are roughly comparable but quite different in some details.

C. J. SWIFT

NBSCL

NEWS

Symposium on Monte Carlo Methods.—A Symposium on this subject is being sponsored by the Aeronautical Research Laboratory, WADC. It will be held at the University of Florida at Gainesville, on March 16 and 17. Those interested in Monte Carlo methods

are invited to attend. Further information may be obtained from H. A. MEYER, University of Florida, Gainesville.

Association for Computing Machinery.—A general meeting of the Association was held at the Massachusetts Institute of Technology on September 9, 10, and 11, 1953. Many new ideas and developments in the applications of computing machinery were reported in parallel sessions. In addition the Whirlwind I Computer located at MIT was demonstrated for those attending. The program for the meeting was as follows:

September 9, 1953, Morning Session

Punched card techniques

Solution of simultaneous linear equations by the Crout method on the IBM card programmed calculator

Remington Rand 409 Electronic Computer as applied to scientific and commercial problems

Matrix multiplication on standard punched-card machines

A calculation system for the IBM CPC Model 1A

The EIP—An external and internal program setup for IBM's Model II CPC

A three factor floating decimal panel for the IBM CPC

A high-speed multi-purpose board for the IBM card-programmed electronic calculator

Planned "work flow" in an engineering computing installation

F. M. VERZUH, MIT, *Chairman*

K. J. BERG, United Aircraft Corp., East Hartford, Conn.

R. T. BRUCE, Remington Rand, Inc., South Norwalk, Conn.

JAMES MORISON, Douglas Aircraft Co., Inc., Santa Monica, Calif.

J. C. REA, Engineering Calculations Group, Allison Division, General Motors Corp., Indianapolis, Indiana

J. C. SHAW, The Rand Corp., Santa Monica, Calif.

D. S. BYRON, Bell Aircraft Corp., Buffalo, N. Y.

J. A. POSTLEY, Hughes Research and Development Laboratories, Culver City, Calif.

REX RICE, JR., Northrup Aircraft, Inc., Hawthorne, Calif.

September 9, 1953, Morning Session

Digital computer techniques

Single vs. triple address computing machines

A method of radix conversion

Interim and comprehensive systems of computation on MIDAC

Matrix multiplication on the ERA 1103

Digital computer mathematics

A new method of determination of all roots of an algebraic equation

A comparison of machine methods for evaluating certain mathematical functions

The numerical solution of semilinear parabolic equations by difference methods

C. W. ADAMS, MIT, *Chairman*

C. C. ELGOT, Naval Ordnance Laboratory, White Oak, Md.

WALTER SODEN, Analysis Division, U. S. Naval Air Missile Test Center, Point Mugu, Calif.

J. H. BROWN and J. W. CARR, Univ. of Mich., Willow Run Research Center, Ypsilanti, Mich.

A. E. ROBERTS, Engineering Research Associates, Division of Remington Rand, Inc., Arlington, Virginia

J. W. MAUCHLY, Remington Rand, Inc., *Chairman*

J. W. CARR, Univ. of Mich., Willow Run Research Center, Ypsilanti, Mich.

W. B. FRITZ, Ballistic Research Laboratories, Aberdeen Proving Ground, Aberdeen, Md.

A. J. PERLIS, Purdue Univ., Statistical Laboratory, Lafayette, Indiana

The continued-fraction algorithm for computing machines

G. W. KING, International Telemeter Corp., Los Angeles, Calif., and L. J. EDSON, Arthur D. Little, Inc., Cambridge, Mass.

September 9, 1953, Afternoon Session

Numerical analysis

A survey of methods of solving systems of linear algebraic equations
A survey of methods for dealing with eigenvalue problems
Problems on partial differential equations

F. B. HILDEBRAND, MIT, *Chairman*
J. H. CURTISS, New York Univ., New York City
H. H. GOLDSTINE, The Institute for Advanced Study, Princeton, N. J.
F. J. MURRAY, Department of Mathematics, Columbia Univ., New York City

September 9, 1953, Afternoon Session

Recent systems developments

MIDAC—The Michigan Digital Automatic Computer

The IBM Magnetic Drum Calculator Type 650

Storage class control in the ERA 1103

The problems of preparing acceptance tests for digital computers

Automatic strain-gage and thermocouple recording on punched cards

The analyzing reader

Computation for numerical control

Large-scale computer output through the electronically controlled typewriter

C. C. HURD, IBM Corp., *Chairman*
J. E. DETURK, R. HOCK, J. KAUFMAN, & H. BETHEL, Univ. of Michigan, Ann Arbor, Mich.
F. E. HAMILTON and E. C. KUBIE, IBM Corp., Endicott, N. Y.
W. G. WELCHMAN, Engineering Research Associates, Div. of Remington Rand, Inc., Arlington, Va.
P. BROCK & S. M. ROCK, Consolidated Engineering Corp., Pasadena, Calif.
R. PERLEY, United Aircraft Corp., East Hartford, Conn.
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September 10, 1953, Morning Session

Digital computer programming

An interpretive routine for the manipulation of expansions in Boolean algebra
The IBM 701 speedcoding system

The editing generator

Analytical differentiation by a digital computer

Digital computer programming

Résumé of automatic coding techniques being developed for digital computers

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J. M. BENNETT, Ferranti Ltd., Manchester, England
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 S. GILL, University Mathematical Laboratory, Cambridge, England
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 J. W. CARR, III, Univ. of Michigan, Ypsilanti, Mich.

September 10, 1953, Morning Session

Punched card mathematics

A method for solving boundary value problems of mathematical physics on punch card machines

A method of determining plate bending by use of a punched card machine

Computing supersonic flow around axial symmetric bodies using method of characteristics

Control panels for a card programmed 604 computing system

Logical algorithms

Derivation of a prediction function for complex system performance

Extension of the Veitch chart method in computer design

Automatic series-parallel circuit simplification

Automatic analytic geometry in machine design

C. C. LIN, MIT, *Chairman*

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L. P. CROSMAN, Laboratory of Advanced Research, Remington Rand, Inc., Norwalk, Conn.

September 11, 1953, Morning Session

Numerical solution of partial differential equations

Finite-difference approximations to the fundamental frequency of a vibrating membrane

Boundary conditions in random walks

Numerical treatment of a fourth order parabolic partial differential equation

Numerical solutions of some nonlinear heat-transfer problems

Operation of a computation center

Operation of a technical computing facility

United Aircraft Corporation—Trinity College, Computation Course

The educational aspects of operating a computing service

R. F. CLIPPINGER, Raytheon Manufacturing Co., Waltham, Mass., *Chairman*

G. E. FORSYTHE and B. F. HANDY, NBS, Los Angeles, Calif.

W. F. BAUER, Univ. of Michigan, Ypsilanti, Mich.

S. H. CRANDALL, Dept. of Mechanical Engineering, MIT, Cambridge, Mass.

F. ALT, NBS, Washington, D. C.

W. J. ECKERT, IBM, *Chairman*

W. D. BELL, Telecomputing Corp., Burbank, Calif.

W. RAMSHAW, United Aircraft Corp., Machine Computation Laboratory, East Hartford, Conn.

G. T. HUNTER and D. R. MASON, IBM Corp., N. Y.

Installation of an IBM 701

H. R. J. GROSCH, General Electric Co.,
Evendale, Ohio

September 11, 1953, Morning Session

Analog computation

Automatic computation by analogue computers of certain errors in flight simulation problems

G. A. PHILBRICK, Philbrick Research Associates, *Chairman*

Solution of certain partial differential equations by analogue computers

G. L. LANDSMAN, NBS, Corona, Calif.

Analog computer solution of partial differential equations

O. L. BOWIE, Watertown Arsenal, Watertown, Mass.

Analog computer approach to heat transfer problem

H. B. BELCK, Rensselaer Polytechnic Institute, Computer Laboratory, Troy, N. Y.

A method of approximating the real roots of a polynomial using an analogue computer

C. F. KAYAN and V. PASCHKIS, Columbia Univ., N. Y.

Analog computation

Equipment reliability as applied to analogue computers

R. E. CARROLL, Bell Aircraft Corp., Buffalo, N. Y.

Generation of a function of two variables

W. W. SEIFERT, MIT, *Chairman*

Generator for functions of two variables

H. JACOBS, Jr., MIT, Dynamic Analysis and Control Laboratory, Cambridge, Mass.

Survey of analogue multiplication

R. P. JERRARD and G. T. JACOBI, General Electric Co., Schenectady, N. Y.

An operational digital divider

G. R. WELTI, MIT, Dynamic Analysis and Control Laboratory, Cambridge, Mass.

C. M. EDWARDS, Bendix Research Laboratory, Detroit, Mich.

M. A. MEYER, B. M. GORDON, and R. N. NICOLA, Laboratory of Electronics, Inc., Boston, Mass.

September 11, 1953, Afternoon Session

Operation of a computation center

The University Computing Laboratory

C. V. L. SMITH, ONR

Operation of the Office of Statistical Services

A. J. PERLIS, Purdue Univ., The University Computing Laboratory, Lafayette, Ind.

Operating a computer efficiently

F. M. VERZUH, MIT, Office of Statistical Services, Cambridge, Mass.

Operating and administrative procedures for MIDAC

C. C. GOTLIEB, Computation Centre, Univ. of Toronto, Toronto, Canada

Problems arising in the administration of a multi-machine digital computing service

D. NEEB, Univ. of Michigan, Ypsilanti, Mich.

An integrated data processing facility

J. W. FISCHBACH, Ballistic Research Laboratories, Aberdeen, Md.

E. M. McCORMICK and H. H. ROSEN, Missile Evaluation Laboratory, National Bureau of Standards, Corona, Calif.

September 11, 1953, Afternoon Session

Business data handling	R. A. MANGINI, John Hancock Life Insurance Co.
Premium billing performed by large-scale computers	R. T. WISEMAN, Sun Life Assurance Co. of Canada, Montreal, Canada
Periodic billing and accounting	E. F. COOLEY, Prudential Insurance Co. of America, Newark, N. J.
The development and application of electronic equipment in Monsanto's accounting department	E. J. CUNNINGHAM, Monsanto Chemical Co., St. Louis, Mo.
Experience with the Census UNIVAC	D. H. HEISER & J. L. MCPHERSON, Bureau of the Census, Department of Commerce, Washington, D. C.
Budget computation on IBM 701	Lt. R. E. UTMAN, Navy Aviation Supply Office, Philadelphia, Pa.

OTHER AIDS TO COMPUTATION

BIBLIOGRAPHY Z

1099. ANON., "Chart for the resolution of angles," *Product Engineering*, v. 22, no. 6, 1951, p. 187.

To be used for representing spatial figures on a plane.

1100. ANON., "High speed response in electromechanical integrator," *Product Engineering*, v. 24, no. 6, 1953, p. 240.

A combination of variable speed drive and d.c. feed back integrator constitutes an integrator whose input is a voltage regarded as a function of the time and with mechanical counter output.

1101. E. BROMBERG & R. D. MCCOY, "Calculating machines—new tools for the designer," *Product Engineering*, v. 22, no. 3, 1951, p. 85–88.

This article contains brief descriptions and photographs of REAC equipment and components including the servo multiplier and resolver and function generator. Also various applications to engineering problems are described.

1102. F. W. BUBB & W. L. MORRIS, "How analogical computing devices can serve process industries," *Chem. Engineering*, v. 57, no. 7, 1950, p. 142–144.

1103. W. H. BURROWS, "Methods of calculating with graph papers," *Product Engineering*, v. 22, no. 4, 1951, p. 140–145; also no. 6, p. 168–171.

1104. F. P. COZZONE, "Organizing a computer center in the engineering department," *Product Engineering*, v. 23, no. 1, 1952, p. 136–141.

Various types of digital and analogue computers are described. A chart is given, showing the relative suitability of these types for aircraft design