Table II gives all the derivatives of the polynomials in Table I as far as $n = 15$.

Table III gives a table of three integer parameters to enable the user to pass easily from the polynomials in Table I to the corresponding polynomials T_r of AITKEN.

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, 225 Far West Building, National Bureau of Standards, Washington 25, D. C.

TECHNICAL DEVELOPMENTS

Report on the Machine of the Institut Blaise Pascal

1. The fundamental characteristics of the machine being built for the Institut Blaise Pascal are as follows.

a) It will be a laboratory machine, of which the elements can be changed or increased in number without upsetting the general structure of the machine.

b) It will be a parallel machine.

This last characteristic has led to the study of calculating devices first, for we assumed from the beginning and still think that the problems of memory and control cannot be solved a priori: their solutions depend upon the characteristics of the calculating devices and upon the nature of the problems to be attacked.

2. Mathematical investigation has led to a method[1] of performing division and square rooting in the binary system, reducing these operations to a series of additions and of subtractions of the same duration as the series which constitutes multiplication—lasting some microseconds only.

In consequence of this result:

a) the arithmetic unit is devised to perform automatically the basic operations of addition, subtraction, multiplication, division, and square rooting, but

b) the only operations actually performed in the calculating organ are addition and subtraction (and repeated sequences of these).

3. The computer built on these principles is composed of:

a) three accumulators, M, X, and P, where are stored or are formed: in M, the multiplicand and the divisor; in X, the multiplier, the quotient, and the square root; and in P, the product, radicand, and the dividend, and

b) of a subroutines program which controls the sequence of additions and subtractions of which are built up the basic arithmetic operations.

Furthermore, the quotient and the square root are transferred to P at the end of these operations, in order that the result of the operation shall always

be read in the same register; the relations of the arithmetic organ to the other parts of the machine are thereby simplified.

4. Each accumulator is formed of standard binary elements of which Figure 1 gives the circuit. The left-hand double triode serves as a register. Carry is effected by the delay line *ES*. The two triodes of the right-hand tube, *L*, act independently; the first, L_c, reshapes the register impulse coming from 7 or from *S* before it enters the register triode, and the second, L_s, transfers the digit held by this binary element to another binary element. Indeed, a positive pulse coming to the grid of this triode from 14 will emerge from 9 to enter a binary element of another accumulator only if the potential of the grid of L_s has already been statically raised, which occurs when the triode F_v holds a 1.

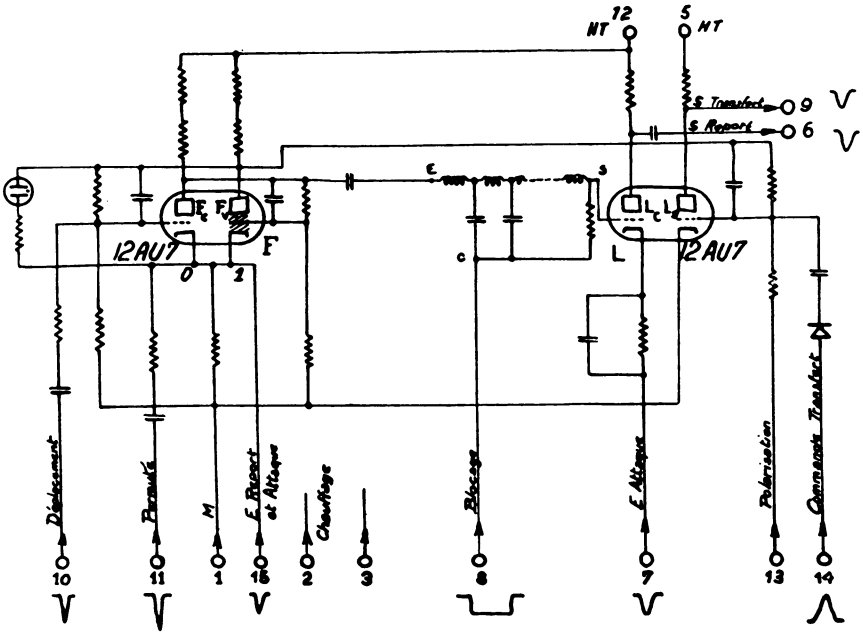

FIG. 1

The shifting of a number one position to the left in an accumulator is performed by introducing a negative pulse at 10. If the triode F_c indicates 0, nothing is changed; if not, it is changed from 1 to 0. This is equivalent to adding the digit to itself, that is to say, multiplying by two which is identical with shifting one position to the left.

Clearing is accomplished by the same means as shifting, except that the carries are simultaneously suppressed.

"Permutation," accomplished by a negative pulse at 11, changes all 1's to 0's and all 0's to 1's. The addition of the number so obtained, combined with an end-around-carry, is equivalent to subtracting the original number. This manner of realizing subtraction is more simple than adding the true complement of the subtrahend.

Figure 2 shows the group of accumulators M, X, and P, of the reduced model, of which the binary capacity is $8 \times 8 \times 16$ while the capacity of the complete model will be $48 \times 48 \times 96$ which corresponds to $15 \times 15 \times 30$ in the decimal system.[2]

5. Internal programs, e.g., for multiplication, are controlled by permanently-wired arrangements of delay tubes and pulse generators. These, once stimulated, carry out automatically the sequences of addition and shifting required for the operations in question. The permanently-connected arrangements have the advantages of permitting the adjustment of each element separately and of reducing to the indispensable minimum the duration of transmission and execution of the successive orders; this duration is reduced, indeed, for each elementary operation of transfer, permutation, etc., to the excitation time of one tube, that is, to less than a microsecond.

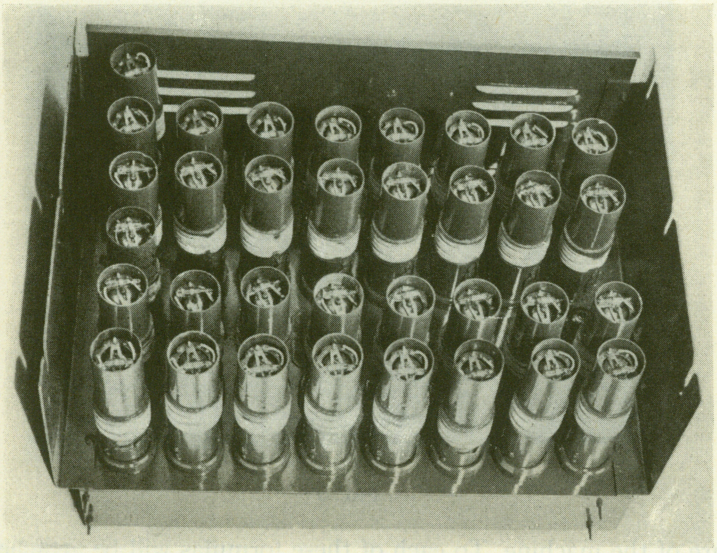

FIG. 2

6. The reduced model of the computer actually constructed has an internal memory composed, for each register, of a single gas diode (neon lamp) in each binary position. Each diode is doubly driven, by a "row" tube which controls the diodes in which are to be written the digits of a particular number to be put in the memory, and by a "column" tube which controls the diodes affected by a particular order of binary numeration. The appearance of the model actually constructed is shown[3] in Figure 3.

This memory device, which already has functioned correctly for more than 300 hours, will be adopted for the large machine, for it has, besides the advantages of ruggedness and simplicity, that of permitting the transfer of a number from the memory to the calculator in less than 2 microseconds; it thus appears to be one of the fastest memories existing.

This internal memory will be limited to the number of registers needed to carry out the usual sequences of intermediate calculations. It will be

built on panels of about twenty registers; new panels will be added if and when the study of particular problems shows their usefulness.

7. A memory for constants, analogous to the diode memory except that the diodes are replaced by resistors, will hold the usual constants: π, M, $180/\pi$, etc., and the coefficients of the formulas for approximating the usual functions $\log x$, $\sin x$, $\tan x$, e^x, etc.

These formulas are, mainly, the expressions of transcendental functions in polynomial form, of which a simple example is a development in series. However the facility with which our machine can perform division and square rooting permits the use of more complicated approximation formulas, which reduces the time required to calculate a function while still retaining simplicity in the internal subprogram. The discovery of the best of these formulas for each given function is a mathematical problem posed by the

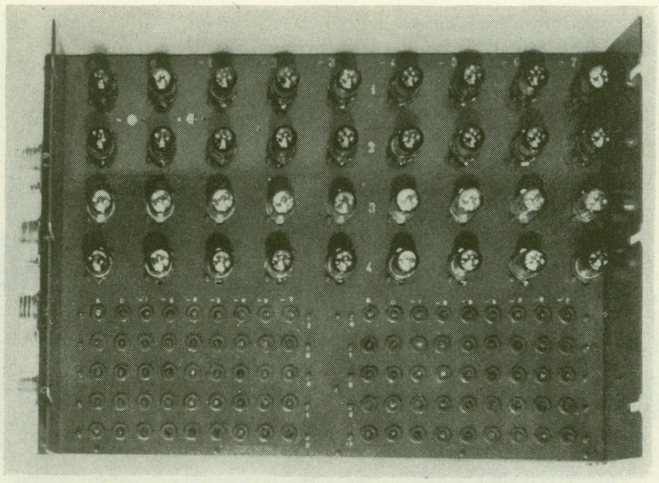

FIG. 3

structure of the machine. To each of these formulas will be attached a subprogram of the same kind as that which has been described in section **5**. For almost all of the functions, even those given by experimental curves, we expect to be able to replace function tables by approximation formulas which will, on the average, give the result more rapidly.

8. The general arrangement is such as to simplify coding as much as possible. To this end we have applied the principle used by Professor AIKEN in Mark I. For each operation the programmer has to write one, two, or three numbers, which designate the operation to be performed, the register to which it is to be applied, and the register which furnishes the operands. For example:

a) division—one number, which indicates the operation of division;

b) clearing—two numbers, that of the operation of clearing and that designating the register to be cleared;

c) transfer—three numbers, that of the operation of transfer, that of the register receiving the number transferred, and that of the register yielding the number.

Each order is therefore represented as a binary number. This number is read by a photocell from a variable-density film. The test model, with the film mounted on a disk, is shown in the frontispiece. The orders are entered in series on the film and are conveyed in parallel to the tubes seen at the top of the device for later transference in parallel to the several parts of the machine. In the final machine the order film may be of great length. Its speed will be of the order of three meters per second.

9. For the external memory and the output mechanism no decisions have yet been made. It is probable that several devices, such as magnetic tapes, photographic films, electroscription, etc., will be used together.

L. COUFFIGNAL

Institut Blaise Pascal
Laboratoire de Calcul Mécanique
Paris, France

[1] L. COUFFIGNAL, "Calcul d'un quotient ou d'une racine carrée dans le systéme de numération binaire," Acad. des Sci. Paris, *Comptes Rendus*, v. 229, 1949, p. 488–489.

[2] In the accumulator assembly the two tubes of each stage, the accompanying circuit elements and the neon light for reading the stored digit are all mounted inside a heavy cardboard tube which serves at the same time to protect the elements and to support the delay line. Each element is supplied with a special nylon mounting.

[3] The figure shows at the bottom of the panel the tips of the neon diodes in 10 rows of 9 each. These correspond to 10 numbers of 8 digits and a sign. At the top are the selection tubes for the numbers and for the binary positions.

The Operating Characteristics of the SEAC

In a previous report [*MTAC*, v. 4, p. 164–168] the logical design of the SEAC was described in detail. The following gives some account of the machine's operating characteristics.

(1) *Basic repetition rate*—1 megacycle per second.
(2) *Type of number representation*—binary system, serial.
(3) *Word length*—number and instruction words consisting of 45 binary digits (44 numerical digits and algebraic sign), equivalent in precision to approximately 13 decimal digits.
(4) *Instruction systems*—two modes of operation are available, namely:

  (a) *4-address system*—typical instruction word specifying 10-digit addresses of (α) first operand, (β) second operand, (γ) result of operation, and (δ) next instruction
  (b) *3-address system*[1]—typical instruction word specifying 12-digit addresses of (α) first operand, (β) second operand, and (γ) result of operation with instructions normally arranged in consecutively-numbered memory locations.

Before starting computation, the computer is set for operation in the particular instruction system desired.

(5) *Types of internal memory*

  (a) *Serial*—512 words stored in 64 mercury acoustic delay lines containing 8 words each with access times as follows: maximum, 336 microseconds; average, 168 microseconds
  (b) *Parallel*[1]—512 words stored in 45 electrostatic (Williams) tubes

holding 512 binary digits each with access time as follows: average for typical operation, 12 microseconds

(c) *Serio-parallel*—32 words stored in 3 electrostatic (Williams) tubes holding 512 binary digits each with access time as follows: average, 1728 microseconds (experimental system).

The serial memory can be used in conjunction with either of the other two types. The experimental serio-parallel type will be replaced by the 45-tube fully-parallel system as soon as construction of the latter is completed. Pending this, the 3-tube system will be used for evaluating comparative performance under practical operating conditions of various types of memory tubes, e.g., Williams tube, selectron tube, etc.

Provision is made for possible increase of the combined memory capacity up to 4096 words.

(6) *Basic operations and performance times*—

Operation[2] (with abbreviation)	Time (in milliseconds) for complete operation (including access time)			
	Serial acoustic memory			Parallel electrostatic memory
	Max.	Min.	Av.	
1. Addition (*A*)	1.5	0.2	0.9	0.2
2. Subtraction (*S*)	1.5	0.2	0.9	0.2
3. Multiplication	3.6	2.3	3.0	2.4
(a) Major part, unrounded (*M*)				
(b) Major part, rounded (*R*)				
(c) Minor part (*N*)				
4. Division (*D*)	3.6	2.3	3.0	2.4
5. Comparison (A conditional transfer of control based on value of arithmetical result)	1.2	0.2	0.7	0.2
(a) Algebraic value (*C*)				
(b) Absolute value (*K*)				
6. Logical Transfer (*L*) (An arbitrary partial word transfer for the purpose of forming composite words)	1.5	0.2	0.9	0.2
7. Input-Output Control			50 (See footnote 3)	
(a) Read-in (*T*)				
(b) Print-out (*P*)				
(c) Reverse motion (*7*)				

(7) *Number of components* (approximate quantities)—

	Tubes	Germanium diodes
Serial memory (512 words)	400	3,500
Parallel memory (512 words)	300	4,500
Computer exclusive of memory	350	7,500
Totals	1,050	15,500

(8) *Power requirements*—15 kw.

(9) *Net floor space*—150 square feet.

ELECTRONIC LABORATORY STAFF

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[1] The 3-address system and the parallel memory are still under construction.

[2] In the initial model, shift effects may be obtained by means of multiplication, division, or addition. Provision is made for the possible later addition of a special shift instruction, as well as other additional instructions.

[3] This is true for the initial single channel magnetic wire with 8-word block. The interim system uses modified teletype equipment. Provision is made for the addition of other types of serial and/or parallel input-output equipment.

Discussions

Binary—Decimal Conversion on a Desk Calculator

The EDVAC normally employs 43-binary-digit numbers less than one in absolute value. The machine will generally be programmed so as to convert automatically its input data to this form and its numerical results to decimal form.[1] We describe here procedures for performing these conversions upon a 10-place desk calculator. These procedures are designed for the use of problem preparers, coders, and maintenance personnel for the occasional conversion of decimal numbers to 43-binary-digit numbers and conversely.

A 43-binary-digit number furnishes, roughly, the same degree of approximation as a decimal number of 13 digits. This degree of approximation is maintained in the methods here described, even though only a 10-place desk calculator is used, by taking advantage of the fact that $1/8^j$ for $j = 1, 2, \cdots, 15$, can be approximated to 14 decimals by a 10-decimal-digit number multiplied by an appropriate power of 10. The processes may be terminated at any point if full accuracy is not required. The resultant binary or decimal equivalent, as the case may be, is recorded automatically on one of the two dial registers of the desk calculator.

The binary number, $+.c_1c_2 \cdots c_{43}$, ($c_j = 0$ or 1), is an abbreviation for the quantity

$$N = c_1 2^{-1} + c_2 2^{-2} + \cdots + c_{43} 2^{-43}.$$

This quantity may be expressed in the form:

$$\begin{aligned} N &= (4c_1 + 2c_2 + c_3)8^{-1} + (4c_4 + 2c_5 + c_6)8^{-2} + \cdots \\ &\qquad + (4c_{40} + 2c_{41} + c_{42})8^{-14} + 4c_{43}8^{-15} \\ &= d_1 8^{-1} + d_2 8^{-2} + \cdots + d_{14} 8^{-14} + d_{15} 8^{-15}, \end{aligned}$$

(where $d_k = 0, 1, 2, 3, 4, 5, 6, 7$ for $k = 1, 2, \cdots, 14$; and where $d_{15} = 0$ or 4) which we write as $+.d_1d_2 \cdots d_{15}$, an octal number.

We convert from binary to octal by arranging the binary digits in groups of threes starting from the binary point and converting each group to an octal digit according to Table I.

Table I

Binary—Octal Conversion

Binary	000	001	010	011	100	101	110	111
Octal	0	1	2	3	4	5	6	7

We convert the resultant octal number to decimal form by adding the octal digits, $d_1, d_2, d_3, \cdots$, each multiplied by the appropriate negative power of 8. Rounded negative powers of 8 are listed in Table II.

The dial of a desk calculator upon which the product appears will be referred to as the "accumulator." The dial upon which the multiplier is recorded will be called the "counter."

We illustrate the mechanics of our process for binary-decimal conversion by converting to decimal form the 43-binary-digit number

$$N = +\ .110\ 010\ 010\ 000\ 111\ 111\ 011\ 010\ 101\ 000\ 100\ 010\ 000\ 101\ 1.$$

TABLE II

Negative Powers of 8

Unshifted	Shifted
$1/8 = .125$	$1/8 = .125$
$1/8^2 = .01562\ 5$	$10/8^2 = .15625$
$1/8^3 = .00195\ 3125$	$10^2/8^3 = .19531\ 25$
$1/8^4 = .00024\ 41406\ 25$	$10^3/8^4 = .24414\ 0625$
$1/8^5 = .00003\ 05175\ 7812$	$10^4/8^5 = .30517\ 57812$
$1/8^6 = .00000\ 38146\ 9727$	$10^5/8^6 = .38146\ 9727$
$1/8^7 = .00000\ 04768\ 3716$	$10^6/8^7 = .47683\ 716$
$1/8^8 = .00000\ 00596\ 0464$	$10^7/8^8 = .59604\ 64$
$1/8^9 = .00000\ 00074\ 5058$	$10^8/8^9 = .74505\ 8$
$1/8^{10} = .00000\ 00009\ 3132$	$10^9/8^{10} = .93132$
$1/8^{11} = .00000\ 00001\ 1642$	$10^5/8^{11} = .00001\ 1642$
$1/8^{12} = .00000\ 00000\ 1455$	$10^6/8^{12} = .00001\ 455$
$1/8^{13} = .00000\ 00000\ 0182$	$10^7/8^{13} = .00001\ 82$
$1/8^{14} = .00000\ 00000\ 0023$	$10^8/8^{14} = .00002\ 3$
$1/8^{15} = .00000\ 00000\ 0003$	$10^9/8^{15} = .00003$

Convert N to its 15-digit octal equivalent by inspection,

$$N = +\ .62207\ 73250\ 42054.$$

0) Clear the calculator. Enter the 10 most significant digits (.62207 73250) of the octal equivalent in the counter. (On calculators with automatic multiplication this may be done by executing .62207 73250 × .00000 00000; otherwise it must be done digit by digit.) Shift the carriage to the extreme right. Set the counter lever to count subtractions. Set the keyboard lever to hold the number until manually cleared. Assume the keyboard decimal point to be on extreme left. Assume the accumulator decimal point to be immediately above keyboard decimal point. This places the most significant octal digit above the extreme right position of the keyboard.

1) $1/8 = .12500\ 00000$ to keyboard; add until 1st counter digit is zero; shift 1 left; and clear keyboard.

2) $10/8^2 = .15625\ 00000$ to keyboard; add until 2nd counter digit is zero; shift 1 left; and clear keyboard.

. . . .

10) $10^9/8^{10} = .93132\ 00000$ to keyboard; add until 10th counter digit is zero. (The accumulator contains .78539 81629 0139 = 10th partial decimal sum.)

10′) Clear keyboard. Enter five least significant digits of 8^5 × (octal equivalent)—i.e., .00000 42054 in counter. Shift carriage four positions to the right.

11) $10^5/8^{11} = .00001\ 16420$ to keyboard; add until 6th counter digit is zero; shift 1 left; and clear keyboard.

. . . .

15) $10^9/8^{15} = .00003\ 00000$ to keyboard, and add until 10th counter digit is zero. (Accumulator contains .78539 81633 9744 = 14-decimal-digit equivalent of given binary number $\cong \pi/4$.)

In the above process, we added to the $(j-1)^{st}$ partial decimal sum a prescribed number of multiples of $1/8^j$. In the inverse process, we subtract from the $(j-1)^{st}$ partial decimal remainder as many positive integral

multiples of $1/8^j$ as possible. Specifically, enter all 14 decimal digits in the left hand end of the accumulator and shift carriage to the extreme right. Now subtract out multiples of $1/8^j$ starting with $j = 1$ and shifting carriage one left after each subtraction. When the 10 most significant octal digits have been obtained in this way, the counter will be filled. Clear counter, shift carriage 4 right. Continue the subtracting and shifting cycle until the 5 least significant octal digits have been obtained.

The process of converting from 43 binary digits to 15 octal digits is exact. In converting from 15 octal digits to 14 decimal digits, an error, $\epsilon_D = \sum_{j=1}^{15} d_j\epsilon_j$, is introduced, where ϵ_D is the error of the resultant decimal equivalent, d_j is the jth octal digit to the right of the octal point, and ϵ_j is the error of the tabular approximation to the quantity $1/8^j$. (All errors are taken in the sense that the true value is equal to the approximate value plus the error.) Comparing the jth entry of Table II with the exact value of $1/8^j$ we find that

$$\epsilon_1 = \epsilon_2 = \epsilon_3 = \epsilon_4 = 0$$

$$\begin{aligned} \epsilon_6 &= -.44 \times 10^{-14} & \epsilon_5 &= +.50 \times 10^{-14} \\ \epsilon_7 &= -.18 \times 10^{-14} & \epsilon_8 &= +.48 \times 10^{-14} \\ \epsilon_{11} &= -.47 \times 10^{-14} & \epsilon_9 &= +.06 \times 10^{-14} \\ \epsilon_{13} &= -.11 \times 10^{-14} & \epsilon_{10} &= +.26 \times 10^{-14} \\ \epsilon_{14} &= -.27 \times 10^{-14} & \epsilon_{12} &= +.20 \times 10^{-14} \\ \epsilon_{15} &= -.16 \times 10^{-14} \end{aligned}$$

Now $d_j = 0, 1, \cdots, 7$ for $j = 1$ to 14 and $d_{15} = 0$ or 4. Therefore, ϵ_D is greatest when $d_6 = d_7 = d_{11} = d_{13} = d_{14} = d_{15} = 0$ and $d_5 = d_8 = d_9 = d_{10} = d_{12} = 7$. On the other hand, ϵ_D is least when $d_6 = d_7 = d_{11} = d_{13} = d_{14} = 7$, $d_{15} = 4$, and $d_5 = d_8 = d_9 = d_{10} = d_{12} = 0$. Thus $-10.93 \times 10^{-14} \leq \epsilon_D \leq 10.50 \times 10^{-14}$.

In converting from 14 decimal digits to 15 octal digits, a remainder, R, is left in the accumulator after the 15 octal digits have been obtained. But R is in error by an excess of $\sum_{j=1}^{15}{}' d_j\epsilon_j$, where the prime after the summation symbol denotes that now d_{15} as well as d_1 through d_{14} may range over all positive integers between 0 and 7, inclusive. Therefore, the error, ϵ_0, of the octal equivalent is given by

$$\epsilon_0 = R - \sum_{j=1}^{15}{}' d_j\epsilon_j$$

or

$$R_{\min} - \left(\sum_{j=1}^{15}{}' d_j\epsilon_j\right)_{\max} \leq \epsilon_0 \leq R_{\max} - \left(\sum_{j=1}^{15}{}' d_j\epsilon_j\right)_{\min}.$$

But, from Table II, $0 \leq R \leq 3 \times 10^{-14}$. Therefore,

$$0 - (10.50 \times 10^{-14}) \leq \epsilon_0 \leq (3 \times 10^{-14}) - (-11.41 \times 10^{-14})$$

or

$$-3.70 \times 8^{-15} \leq \epsilon_0 \leq 5.07 \times 8^{-15}.$$

Conversion of the 15 octal digits to 43 binary digits is exact except for the final rounding of the least significant octal digit. This rounding introduces an error of at most 1×2^{-44} in absolute value. For the total error, ϵ_B, of the binary equivalent of the original decimal number we have then

$$(-3.70 \times 8^{-15}) + (-1 \times 2^{-44}) \leq \epsilon_B \leq (5.07 \times 8^{-15}) + (1 \times 2^{-44})$$

or

$$-1.43 \times 2^{-43} \leq \epsilon_B \leq 1.77 \times 2^{-43}.$$

The error of the binary equivalent might be reduced further by rounding the remainder left in the accumulator instead of neglecting it. The additional accuracy to be gained, however, is insufficient to justify complicating the procedure.

J. O. HARRISON, JR.

Ballistic Research Laboratories
Aberdeen Proving Ground
Maryland

[1] FLORENCE KOONS & SAMUEL LUBKIN, "Conversion of numbers from decimal to binary form in the EDVAC," *MTAC*, v. 3, p. 427–431.

BIBLIOGRAPHY Z–XIII

1. W. BARROIS & R. BASILE, "Le calcul matriciel et l'aviation," *Atomes*, v. 5, no. 50, 1950, p. 165–169, figs.

The solution of vibration problems in airplane design is discussed by the authors. A brief statement of the nature and importance of the vibration problem is followed by an elementary treatment of the method of reducing it to a form suitable for solution on punched-card equipment. The economy in presentation of the problem by use of the matrix notation is pointed out. The utility of the matrix calculus in solving the problem is indicated.

Some computational results obtained on punched-card equipment are listed. The solution of a system of six equations in six unknowns required one hour and thirty minutes; that of eight such systems required six hours. Eight systems of eight equations in eight unknowns required nine hours. The product of two eighth-order matrices was computed in one hour and fifty minutes. Two such matrix products were computed in two hours and thirty minutes. In regard to the complete vibration problem, the authors state that the use of punched-card equipment increased the computation rate by a factor of four to eight.

E. W. C.

2. EDMUND C. BERKELEY, *Giant Brains or Machines that Think*, John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London, 1949, 270 + xvi p., 14 × 21.2 cm., bibl., figs., $4.00.

This is an interesting book, which is designed for the general reader. In this essay in scientific journalism the author has been very successful in keeping explanations and language simple.

Chapter 2 deals with "Languages"—systems for handling information, with particular emphasis on numerical information, while Chapter 3 outlines the principles of design of automatic machines by detailing the design of a very simple model using a finite arithmetic of four numbers, with four operations: addition, negation, greater than, and selection.

In Chapters 4 to 9, machines in existence up to the end of 1946 are described, i.e., punched-card machines, the MIT differential analyzer No. 2, the Harvard IBM Automatic Sequence-Controlled Calculator, the ENIAC, the Bell Laboratories General-Purpose Relay Calculator, and the Kalin-Burkhart Logical Truth Calculator. The origin and organization of each machine are described as are the processes which it can carry out. Finally an appraisal of each machine is given.

Chapter 10 describes further developments in progress when the book was written—mercury delay lines, Williams tubes, magnetic tapes, etc., for storage, new operations, and new ideas in programming and reliability. Machines under construction are also described briefly; several have been subsequently put into operation.

Chapter 11 describes possible future developments—some far-reaching—and should stimulate a good deal of thought. Some of these are automatic library, automatic translator, automatic typist and stenographer, automatic recognizer, and so on. Problems possibly suitable for mechanization, such as problems of control, weather, psychological testing and training, business, etc., are suggested and discussed.

In Chapter 12 the problem of social control is discussed, and the difficulties that may be caused by the advent of automatic machines on a large scale are enumerated.

The major criticism of the reviewer concerns the title and subtitle of the book. The phrases, "giant brains" and "machines that think," may stimulate interest in those new to the ideas involved in automatic machinery, but may be dangerous and can only irritate most of those who really study the machines and processes involved. The giantness is a measure of inefficiency, the much better human brain is much more compact. Chapter I in the book, deliberately mentioned last in this review, is a discussion on "Can machines think?" which is answered in the affirmative. This is only because the author defines "thinking" in such a way that the answer *can* be in the affirmative. To be quite fair one must mention that the author lists "the kinds of thinking a mechanical brain can do" (all can be classed as instinctive or "thoughtless" reactions) and the kinds of thinking it cannot do—the important kinds! The objection to these ideas is that the reader will not realize that *all* important kinds of thinking are excluded—only automatic reactions remaining. This could be dangerous.

This criticism is mentioned mainly because the first chapter is involved, and this may prevent many readers from continuing, which could be a pity, for the book is a stimulating account.

J. C. P. MILLER

NBSNAML

3. TUNG CHANG CHEN, "Diode coincidence and mixing circuits in digital computers," I. R. E., *Proc.*, v. 38, 1950, p. 511–514.

Two types of gate circuits, the coincidence and mixing, are derived in terms of germanium diodes. The operation of the coincidence gate is analyzed for transient response with a rectangular pulse input taking into account the "back" resistance and capacity of the coupling and clamper diodes. The operation of a typical mixing gate using germanium diodes is analyzed for transient output for a rectangular pulse input under the conditions stated

above. An equivalent circuit is described of a driving source and one of the inputs of a coincidence gate for positive pulses. The article concludes by illustrating and listing some uses of these gates in digital computer circuits.

M. M. ANDREW

NBSMDL

4. J. P. ECKERT, JR., H. LUKOFF, & G. SMOLIAR, "A dynamically regenerated electrostatic memory system," I. R. E., *Proc.*, v. 38, 1950, p. 498–510, bibl.

This comprehensive paper on electrostatic memory systems discusses various techniques of using commercial cathode-ray tubes as electrostatic storage elements. After a brief introductory section on the fundamental theory of the subject, the authors list and describe seven possible methods of storing binary information in cathode-ray tubes. Included among these methods are the dot-line and the dot-circle techniques. After a discussion of these various storage methods, the authors conclude, from the characteristics of the reading voltage, the speed of reading, and the signal stability obtained, that the dot-circle method is the best of those examined. However, other investigators in this field using different methods for utilizing the dot-line method of storage may challenge their conclusion here.

Tests of the commercial phosphors as functions of high output signal at high accelerating voltages, ease of erasure, and cost were made. It was concluded that P1 phosphor is the best of the commercial phosphors for this specialized use.

Using the dot-circle method of storage and P1 phosphor surfaces, the authors carried through a series of tests in which the following factors were among those investigated:

1. Gun structure
2. Tube diameter (3″, 5″, 7″)
3. Accelerating voltage
4. Grid voltage
5. Input circuit design.

Their research on the effect of tube diameter versus the number of storage spaces brings out the interesting point that the increase in number of spots stored on a 7″ tube over the number stored on a 3″ tube is only about 73%, while the increase in area is about a factor of 5.

The remainder of the article is devoted to a discussion of regeneration and deflection circuits and the use of these tubes in memory units of digital computers operated in parallel or serial modes.

M. M. ANDREW

NBSMDL

5. W. B. FLOYD, "Electronic machines for business use," *Electronics*, v. 23, May 1950, p. 66–69.

A businessman expresses his opinion on the applicability of electronic computers to the clerical work of business. In most cases, it is stated, sorting, lookups, posting, and typing far outweigh the arithmetical work in a clerical

procedure. In business applications, a computer would in general perform relatively simple mathematical operations on a vast amount of data.

Special design features which would be necessary in an ideal clerical computer are discussed. The elimination of a manual keyboard, or at least the reduction of manual key depressions to a minimum, is recommended. A step in this direction has already been made by the retail garment trade, in the development of equipment for perforating as well as printing code numbers on marketing tickets. Extremely fast output printers would be necessary; over 1,000 printed lines a minute might be a usable speed. Storage capacity undreamed of in connection with mathematical computers would be needed. Requirements for the storage in readily accessible form of hundreds of thousands of items would not be unusual. An alleviating factor regarding storage is that access times to computer memory would not need to be comparable to those deemed essential for mathematical computations.

The attractive features of electronic digital computers, from the standpoint of business applications, are given as the following. It is unnecessary to perform a series of separate mechanical operations to produce a single result. Interposition of manual operations during a computation is reduced to a minimum. The electronic machines, because of their selective sequencing feature, can recognize and handle all irregularities the possibility of which can be foreseen by the human operator. Whatever rules can be given to a clerk can be included in the programmed machine instructions.

The author states that all of the computer circuits required for a useful clerical computer are at hand and have been well proven. What remains to be done, in his opinion, is industrial engineering—the engineering of electronic computing equipment for particular business applications.

E. W. C.

6. Office of Naval Research, *Digital Computer Newsletter*, v. 2, no. 2, May 1950, 4 p.

This is the fourth release of the Mathematical Sciences Division of the ONR. Previous releases are dated April 1949, Sept. 1949, Jan. 1950. The present status of the following digital computer projects is treated briefly in this number.

1. Naval Proving Ground Calculators
2. Raytheon- Computers
3. UNIVAC
4. Aberdeen Proving Ground Computers
5. The California Digital Computer
6. Institute for Advanced Study Computer
7. Project Whirlwind
8. MADDIDA Computer
9. Institute for Numerical Analysis Computer
10. NBS Computer
11. Computers, Manchester University, England
12. Telecommunications Research Establishment Computer
13. BARK Computer, Sweden.

7. LOUIS N. RIDENOUR, "High-speed digital computers," *Jn. Applied Physics*, v. 21, 1950, p. 263–270.

This is a survey article which discusses current machine design, capabilities, and future trends in the computer field. Of particular interest is the discussion of the application of the Monte Carlo method by these machines.

8. CLAUDE E. SHANNON, "A chess-playing machine," *Scientific American*, v. 182, Feb. 1950, p. 48–51.

A machine is proposed which can play a reasonably good game of chess at speeds comparable to human speeds. The author states that it is impossible to achieve perfection in a machine game as even the high-speed electronic computers cannot calculate all the possible variations to the end of the game. This seemingly trivial investigation is undertaken to develop techniques which can be used for more practical applications.

Some of the empirical methods used by chess experts are programmed for the machine, which examines only the important possible variations in the game in sufficient detail to make clear the consequences of a particular move. The machine advantages are listed as: much greater speed, freedom from error (except for those due to programming deficiencies), freedom from laziness, and freedom from "nerves." Human advantages are flexibility, imagination, and learning capacity.

The ability of these machines to think depends upon the definition of thought. The computer follows the strictly behavioristic patterns which, according to some psychologists, characterize thought. However, the author points out the more important fact that the machine is unable to learn by its mistakes and it is wholly dependent upon the programmer who outlines its course of action.

EDITH NORRIS

NBSMDL

NEWS

American Institute of Electrical Engineers.—The Summer and Pacific General Meeting was held June 12 through 16, 1950, at Pasadena, California. One morning section on June 13 was devoted to discussions of large-scale computers and an afternoon section on the same day had as its topic "Applications of computers to aircraft engineering problems."

The program for the morning section was as follows:

"Design features of the National Bureau of Standards Western Automatic Computer," by E. LACEY, D. RUTLAND, H. LARSON, & H. D. HUSKEY, NBSINA.

"Applications of the National Bureau of Standards Western Automatic Computer," by H. D. HUSKEY, NBSINA.

"University of California Digital Computer," by P. A. MORTON, Univ. of Calif.

"A high-speed multiplier for analog computers," by B. N. LOCANTHI, Calif. Inst. of Tech.

"MADDIDA (Magnetic Drum Digital Differential Analyzer), general theory," by F. G. STEELE, Northrop Aircraft.

"MADDIDA, design features," by D. E. ECKDAHL, Northrop Aircraft.

In the afternoon the following talks were presented:

"Automatic data handling techniques, including recording and reduction," by W. D. BELL, Telecomputing Corp.

"Electric analog computing techniques for complex vibration and aeroelastic problems," by G. D. MCCANN & R. H. MACNEAL, Calif. Inst. of Tech.

"Use of analogy computing techniques for aeroelastic problems," by P. A. DENNIS & D. G. DILL, Douglas Aircraft.

"Complex missile control system, design, and analysis with the electric analog computers," by J. P. BROWN, Lear, Inc., & C. H. WILTS, Calif. Inst. of Tech.

"Solution of problems in electrical engineering by means of analog computers," by L. L. GRANDI & D. LEBELL, Univ. of Calif.

National Bureau of Standards.—In June 1950, the NBS Eastern Automatic Computer, called SEAC, was formally dedicated as an operating computer. (See *MTAC*, v. 4, p. 164–168.) Prior to its dedication, SEAC had solved: (1) miscellaneous mathematical exercises such as determination of prime numbers, computation of sine-cosine tables, solution of diophantine equations; (2) a skew-ray problem for the NBS Optics Division; (3) a problem concerning the flow of heat in a chemically reactive material; and (4) an initial problem for Project SCOOP (Scientific Computation of Optimum Programs) for the Office of the Air Comptroller, Department of the Air Force.

SEAC will be used to solve scientific problems for the NBS and production-scheduling problems for the Air Force. It will also serve as an instrument for evaluating the effectiveness and reliability of computer components, and it will increase present knowledge of the maintenance and servicing problems related to computers.

SEAC was completed 14 months after construction of the machine was undertaken. Most of the work on the computer (the design, engineering, fabrication, and assembly) was performed by the NBS staff in its Washington laboratories. The only phase of the work not accomplished by the Bureau staff was the fabrication of the acoustic memory unit of the machine, which was carried out by the Technitrol Engineering Company, Philadelphia, Pennsylvania.

SIMON, a small-scale computing machine.—On Thursday, May 18, 1950, this small computer was unveiled at Columbia University. This tiny machine was conceived by EDMUND C. BERKELEY, actuary and consultant member of Connell, Price and Co., and is described in his book, *Giant Brains, or Machines that Think*, [*MTAC*, v. 4, p. 234.] It is intended to be used primarily for teaching purposes to stimulate thinking and understanding and to produce training and skill. The machine represents the combined efforts of technician WILLIAM A. PORTER and of electrical engineers ROBERT A. JENSEN and ANDREW VALL. This low cost machine is 24 inches long, 15 inches wide, 6 inches thick, and weighs 39 pounds. It will perform the operations of addition, subtraction, greater than, and selection employing an arithmetic of four numbers.

OTHER AIDS TO COMPUTATION

BIBLIOGRAPHY Z–XIII

9. D. P. ADAMS, *An Index of Nomograms*. The Technology Press of MIT and John Wiley & Sons, New York, 1950. v + 174 p. 18.2 × 24.1 cm. $4.00.

This is another example of the recent trend of compiling references in a specialized field thus hoping to cope with the vast extent of present day scientific activity. The present index contains over 1,700 references to nomograms which have appeared since 1923 in 97 selected journals. The references are listed under 21 main headings and are extensively cross referenced by key words. Since the equations are not given, however, there is not much chance of adapting a nomogram from one field to another unless the reader is well acquainted with both.

R. W. HAMMING

Bell Telephone Labs.
Murray Hill, N. J.