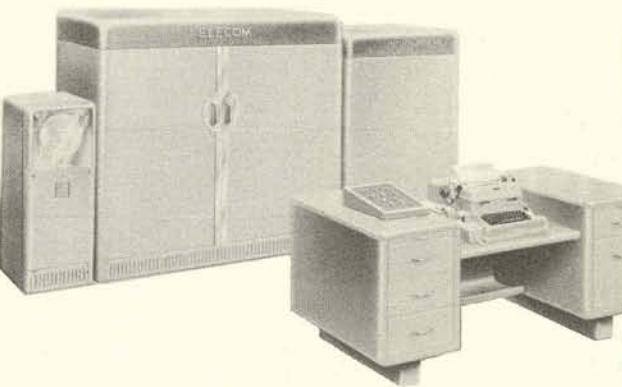


**an electronic  
computing system  
any business can afford**



**ELECOM 120**

**ELECOM 120**

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**AT LAST, A SOLUTION TO THE PROBLEM OF MOUNTING COSTS  
OF PAPER WORK IN BUSINESS.**

A growing threat to profitable business management has been the rise of office costs. While good clerical personnel have become increasingly difficult to recruit, the mountains of paper work have grown higher and higher every year.

There was some promise of relief to this situation when giant-sized electronic "thinking machines" were developed and publicized. Yet these million-dollar "brains" are out of reach to the business world, because of their prohibitive cost and space requirements, and their complexity of operation.

Rather than being satisfied with expensive and glamorous "thinking machines," ELECOM has achieved a compact electronic computer for business and industry which is as versatile as its contemporaries, but which is available at a fraction of their cost: ELECOM 120.

ELECOM 120 works faster, and at less cost, than present punched card equipment, accounting machines, and printing calculators. It handles payroll and inventory computations, accounts payable and receivable, production control, cost distribution, market research, scientific and engineering problems. Performs in *one hour* as much work as six people can do in a *week* on desk calculators!

Compact, easy to install, and simple to operate, ELECOM 120 handles alphabetic as well as numerical data. These pages contain a semi-technical explanation of the operation and specifications of ELECOM 120.

<b>CONTENTS:</b>	Internal memory . . . . .	3	Word structure . . . . .	5	Instruction code . . . . .	6
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## INTERNAL MEMORY

The high-speed memory consists of a magnetic drum  $9\frac{1}{2}$ " in diameter and 5" long rotating at approximately 3600 RPM, and having 21 channels. 20 of these channels comprise the basic memory; each channel is subdivided into 50 equal parts termed 'words,' consisting of 36 pulse positions each, and representing either a numerical quantity or a coded instruction. The basic memory thus consists of 1000 words, any one of which may be chosen and is accessible in, at most, 20 milliseconds.

Another channel carries a fixed magnetization pattern. It is permanently engraved and serves to synchronize the "clock" or master oscillator which controls the timing of all operations.

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## AUXILIARY MEMORY

To supplement this large internal memory, the computer is provided with magnetic tape drives accommodating tapes  $\frac{1}{2}$  inch wide by 1200 feet long. A multiple head serves to read or record in any one of 5 channels across the tape. Another channel carries a fixed magnetization pattern which is pre-recorded by a tape-testing device. Pulses in this channel, called "sprocket pulses", are used to control recording and reading of information and to confine it to portions of tape which have been found to be entirely free of defects. Pulse spacing is approximately 100 per inch and recording is in blocks of 50 words, each occupying about 27 inches along the tape, including space between blocks for starting and stopping the tape. The total tape capacity is over 2500 blocks or approximately 125,000 words. Speed of the tape movement is approximately 20 inches per second corresponding to a pulse rate of 2000 per second or 45 words per second. Automatic checking of the tape operations is performed as described later.

A "tape search" operation enables the tape to be run a specified number of blocks in either direction without reading or writing. Once this operation is started, it proceeds independently of computation, allowing the latter to proceed concurrently with tape search. (If another tape instruction is encountered in the program before a search is completed, its execution is automatically delayed until the completion of the tape search, after which the new operation automatically proceeds.)

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## INPUT-OUTPUT

Data (numbers and /or instructions) are introduced into the computer either by mounting a previously prepared tape containing such data on the tape drive or by use of the typewriter keyboard (either manually operated or controlled by punched paper tape). Reading in of the paper tape to the machine may be programmed as well.

Output printing by the typewriter can be edited through the use of special characters, in addition to numerical digits 0 through 9. The special characters include a space, which

may be used in any position in a word including the sign position. A negative sign and a decimal point can also be printed, although these characters can only be used in the sign position of a word; tab and carriage return symbols can be used in any position except the sign position. Finally, a character is provided which causes no typewriter action; it is used to fill out words of less than 8 digits or to fill the sign position where numbers of more than 8 digits are to be printed without spaces between digits. Positive numbers are ordinarily printed with a space in the sign position.

A selector switch permits "unedited" typing, for the purpose of checking data previously typed into the memory. Under these conditions, tab and carriage return symbols print as TA and CR respectively, without producing their usual effects on typewriter operation, and a "blank" character prints as BL. A space is automatically inserted after each word and an automatic carriage return occurs after every 10 words. Alphabetic characters, if used, print in their usual form during "unedited" typing. Unedited typing may start at any address, but automatically terminates at the end of a memory channel—i.e., after typing any word from an address ending in 49 or 99.

Input from the typewriter is always "unedited"—i.e., tab, carriage return, and blank symbols are introduced into the memory by typing the special symbols TA, CR, and BL respectively; keys are provided on the typewriter keyboard for these symbols. In particular, a space or negative sign must be typed at the beginning of each number. Instructions are always preceded by space, BL, or decimal point, while constants typed in for later use in editing may contain any of the above characters in the sign position.

The space bar and carriage return key on the typewriter do not enter corresponding characters into the memory, but are used to control the typing-in process. A word may be inserted into the memory by first typing it, then operating the space bar, and typing a three-digit number to indicate the address into which the word is to go. Operation of the carriage return causes actual transfer of the word into the specified address. If a program or any group of data is to be typed into sequential addresses, it is necessary to specify only the starting address; after each subsequent word is typed, only the carriage return key is operated and it is automatically placed in the address following that of the word previously typed. Whenever a new sequence of data requires a change in the starting address, it is only necessary to operate the space bar and type the new starting address, following typing of the first word in the new sequence but before operating the carriage return. An error made while typing may be corrected simply by finishing the number and then retyping it. Since all operations connected with the entering of data into the memory are controlled by keys on the typewriter, it is possible to prepare an entire program on punched paper tape, and enter it into the memory at any time or as often as required without manual typing.

When it is desirable to type output data on two separate forms, as in payroll computation where payroll journal and pay checks are to be prepared concurrently, the computer can be made to control an additional typewriter or typewriters—handling up to three typewriters.

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## WORD STRUCTURE

Numbers consist of eight decimal digits representing the absolute value, preceded by another digit representing the sign. A space in the sign position indicates a positive number; negative signs are both typed and printed as such.

Arithmetic processes are based on the assumption that the decimal point is located at the extreme left—thus numbers are assumed to lie in the range  $-1 < n < 1$ .

The decimal digits are represented in the machine by 4 binary digits coded in the excess three system in which a decimal number  $n$  is represented by the binary number  $n + 3$ . This code contains certain advantages discussed later under checking.

In the alphabetic model of the 120, words containing alphabetic or mixed alphabetic and numeric data are represented by pairs of words in the memory. Each character is represented by corresponding digits in the two words of a pair. This arrangement has certain desirable features not found in other systems of alphabetic coding. When data stored in the memory is predominantly numeric, as is usually the case, such data can be stored in single words, requiring only the logical minimum of four binary digits per decimal digit. Thus it is not necessary to waste memory space by always providing enough binary digits in each character to represent any type of data. On the other hand, the segregation of additional characters, needed for alphabetic or mixed data, into a separate word permits the numerical portion of mixed data to have the same form (in one word of the pair) as it would have in purely numeric form. Thus arithmetic operations such as addition can be performed on the numerical portion of mixed data without the carry-over complications which result when different numbers of binary digits are used for such data.

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## CIRCUITRY

The computer is completely serial not only as concerns operations as a whole but as concerns individual digits in words. This reduces equipment to a minimum. In general, non-linear functions such as gating are performed by appropriate combinations of germanium crystal diodes, while vacuum tubes serve to provide the necessary amplification and/or power. Except where very low frequency components must be transmitted, tubes are supplemented by pulse transformers to obtain DC isolation and impedance transformation. Circuits are, in general, of "dynamic" rather than "static" type.

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## CODING

Instructions in the Elecom 120 have the same form as numbers—i.e., 8 digits and a sign. The first 2 digits designate the operation to be performed. In most cases, the remaining 6 decimal digits are to be considered as 2 groups of 3 decimal digits each, which represent word locations within the basic internal memory. A group of 3 digits used for this purpose will be called an "address." Most instructions are, therefore, in the form I (b) (a)



where I is a two digit number representing the operation to be performed and (a) and (b) are each 3 digits and represent addresses. Coding is thus of "two address" type. Ordinarily an instruction has a positive sign—i.e., a space in the sign position. If the sign position contains a "blank" (BL), the computer halts after completing the instruction; if the sign position contains a decimal point, the computer halts after completing the instruction, provided the "break point" switch is set to "break."

The available instructions and their code equivalents are listed below. Unless otherwise noted, the machine will, after completing the instruction in memory location m, take the contents of location  $m + 1$  as its next instruction.

In the following description, "A" indicates the accumulator, a one-word register with adding facilities; C represents the control counter, which holds a number indicating the address from which an instruction is taken; X and L are one-word registers. (a) means "contents of address a," etc., and  $(A)_0$  means "contents of A before the indicated operation is performed." Contents of A are retained after completion of any operation. When a new word is entered into the memory or recorded on tape, it replaces whatever data was originally present in that position. Times given are average, and can be reduced in most cases by appropriate choice of addresses.

I	Operation	Time
<b>10 ADD</b>	Add (a) and (b) to $(A)_0$ algebraically and store the result in A.	<b>32 msec.</b>
<b>11 CLEAR-ADD</b>	Same, first clearing A.	
<b>15 SUBTRACT</b>	Subtract (a) from (b) plus $(A)_0$ and store the result in A.	<b>32 msec.</b>
<b>16 CLEAR SUBTRACT</b>	Same, first clearing A.	
	If, on either Add or Subtract, the result is beyond the capacity of the machine, carry out the instruction in address 999; then return to normal sequence unless (999) called for a transfer of control.	
<b>30 MULTIPLY</b>	Double precision—Multiply (a) by (b) and store the most significant 8 digits in A and the least significant digits in X.	<b>46 msec.</b>
<b>35 MULTIPLY</b>	With round-off—Multiply (a) by (b), round off to 8 digits, and store product in A.	<b>46 msec.</b>

I	Operation	Time
60 DIVIDE	With remainder—Divide $(A)_0$ by $(a)$ , and store the unrounded 8 digit quotient in "b" and the remainder in A.	46 msec.
65 DIVIDE	With round-off—Divide $(A)_0$ by $(a)$ , round off to 8 digits and store the quotient in "b." (After this operation, A contains irrelevant data.)	47 msec.
	In either case, if $(A)_0 > (a)$ , indicating an improper division, carry out the instruction in address 998; then return to normal sequence unless (998) called for a transfer of control	
0m SHIFT RIGHT,— EXTRACT	Multiply $(A)_0$ by $10^{-m}$ without round-off. Extract from this number into (b) any digits which correspond to odd digits in (a).	50 msec.
4m SHIFT, LEFT,— EXTRACT	Multiply $(A)_0$ by $10^{+m}$ without round-off. Extract from this number into (b) any digits which correspond to odd digits in (a).	50 msec.
49 NORMALIZE	Shift $(A)_0$ left until no zeros precede first non-zero digit; record number of shifts as last digit of "b" preceded by 7 zeros; take next instruction from "a." [If $(A)_0 = 0$ , only 8 shifts are made.]	25 msec.
70 BRANCH	If $(A)_0$ is positive and $\neq 0$ , transfer control to (a); if $(A)_0$ is negative and $\neq 0$ , transfer control to (b); if $(A)_0 = 0$ , proceed normally.	20 msec.
75 COMPARE	If alphabetic pair $(a, a + 1) > (b, b + 1)$ , make (A) negative; if $(a, a + 1) < (b, b + 1)$ , make (A) positive; if $(a, a + 1) = (b, b + 1)$ , make (A) zero.	32 msec.
50 TALLY	Subtract 1 from "a". If result is positive, transfer control to (b). If result is zero, proceed normally. The tally instruction itself, with "a" modified, is reinserted into the memory in its original position. Here "a" is not interpreted as an address.	20 msec.
20 STORE (A)	Store $(A)_0$ in address "b"; take next instruction from "a."	21 msec.
25 STORE (X)	Store (X) in address "b"; take next instruction from "a."	21 msec.
26 STORE (C + 1)	Extract $(C + 1)$ into last 3 digit positions of "b"; take next instruction from "a."	21 msec.

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	Operation	Time
80 TRANSFER	Move (a) to "b."	32 msec.
90 READ PAPER TAPE, WITHOUT TYPING	Read from paper tape associated with typewriter specified by the second digit of "b," interpreting data numerically if the last digit of "b" is zero and alphabetically if this digit is one. Place data in addresses as specified by the tape, continuing until a "stop" character is encountered on the tape. Address "a" is not significant.	0.95 sec. per word
91 READ PAPER TAPE, WITH TYPING	Same as instruction 90, but the information is typed out as it is read.	0.95 sec. per word
92 TYPE OUT, WITHOUT PUNCHING TAPE	Type out from sequential addresses starting with "a" without punching tape, and continuing until a "printer stop" character is encountered. Interpret "b" as in 90 instruction.	0.95 sec. per word
93 PUNCH TAPE	Without typing, punch paper tape following procedure outlined for the 92 instruction.	0.95 sec. per word
94 TYPE OUT AND PUNCH	Perform both the operations 92 and 93.	0.95 sec. per word
	In operations 92-94 inclusive, if switch is set for "unedited" typing, start with address "a" and continue to end of memory channel—i.e., to next word whose address ends in 49 or 99.	
95 TAPE SEARCH, BACKWARD	Move that tape specified by the second digit of address "b" backward the number of blocks specified by address "a."	1.6 sec. per block
96 TAPE SEARCH, FORWARD	Move that tape specified by the second digit of address "b" forward the number of blocks specified by address "a."	1.6 sec. per block
	Either of the tape search operations, once started, can proceed in parallel with any other computer operation not involving tapes.	

I	Operation	Time
97 TAPE READ	Read one block (50 words) from that tape specified by the second digit of address "b," using the channel specified by the remaining digit of "b." Place data in consecutive addresses starting with "a," which must be an integral multiple of 50.	1.6 sec.
98 TAPE WRITE	Record one block on tape specifying tape, tape channel, and memory address as in "tape read."	1.6 sec.

#### MANUAL CONTROL

In addition to the usual power switches, controls are provided to initiate automatic computation, and to cause the computer to take its next instruction from address 000. There is also a "break point" switch which, if set, will cause the computer to stop after any instruction containing a decimal point in the sign position. If this instruction is a branch, the selected branch is indicated visually, and may be altered manually if desired.

Controls are also provided for insertion of data from the keyboard as described under "Input-Output," and for causing the computer to stop after each instruction and wait for the operator to press a "proceed" button—a most useful feature in checking programs. Computation may be suspended at any time by operation of a "halt" button, leaving circuits in condition to resume computation when the "proceed" button is operated.

It is possible to shut down the computer without the loss of information stored in the memory. Information concerning the address from which the next instruction is to be taken and the contents of the accumulator may be typed out, so upon restarting, computation may be resumed at the correct point in the program.

In addition, the number in any memory position may be typed out by typing in a space and the address in which the desired number lies, and then pressing a button labeled "Read Out."

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## TEST FACILITIES

Several features have been included to simplify testing and maintenance. Two pulse signals, one occurring once every 50 words and the other occurring just before the beginning of each word, are brought out to terminals for synchronizing an oscilloscope (not furnished with the equipment). Test switches are provided which allow a selected instruction to be carried out repeatedly at normal computing speed; another control causes the computer to stop before each transfer into or out of the memory and wait until the "proceed" button is pressed. Any instruction may be typed into the computer and a button control causes the computer to carry it out and to proceed.

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## CHECKING

Detection of errors in tape reading is facilitated by recording, in addition to the four information pulses in each digit, a fifth or "check" pulse, which contains a pulse in any position where there are no pulses or two pulses in the corresponding digit, but contains no pulse if the corresponding digit contains one or three pulses. By examining for an odd number of pulses in each digit, therefore, any tape error which results in loss of a pulse (for example, an error caused by a speck of foreign matter on the tape) will be detected.

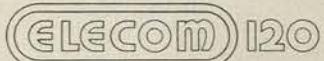
An error which results in the loss or gain of a sprocket pulse is detected by counting the number of sprocket pulses in each block during both tape reading and recording.

When a tape reading error is detected, the tape is automatically backed up one block and the block is read over. If for any reason during normal operation any instruction (except type out) is repeated for longer than 12 seconds, the machine is halted. This prevents continued re-reading of a block of information on the tape in case of a systematic, rather than a transient, error.

Use of the "excess 3" code for binary representation of each digit facilitates checking (in all digits but the sign) against failures in memory or computing circuits. The combinations 0000 and 1111 are not used in this code. Because picking up a whole series of pulses, or dropping a whole series of pulses (which are the commonest types of error) results in the appearance of these combinations, failure may be detected by examination for these "forbidden" combinations. This is done for all numbers entering the decimal adder in the arithmetic circuits.

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