BENDIX G-15 COMPUTER • PROGRAMMING SYSTEM

intercom 1000

THE INTERCOM 1000 PROGRAMMING SYSTEM FOR THE BENDIX G-15 GENERAL PURPOSE DIGITAL COMPUTER

TO FIND . . . **SEE PAGES**

SOME TERMS DEFINED . . .

A COMMAND is an instruction to the computer to perform specific operations. Intercom commands are listed at the end of the manual.

A PROGRAM is a set of commands which when obeyed by the computer results in the solution to a problem.

An INTERNALLY-PROGRAMMED COMPUTER is an electronic calculating machine with an internal memory in which the program and data may be stored and from which commands may be automatically obeyed.

A DIGIT is any arithmetic integer from 0 to 9.

A WORD is a group of digits which represent either a numerical value or a command to the computer. Both numerical value words and command words may be stored in the internal memory. A command word occupies one memory location; a numerical value word occupies either one or two memory locations.

An ADDRESS is a number which specifies a location in the computer's internal memory.

A SINGLE-PRECISION number is a numerical value which occupies one memory location.

A DOUBLE-PRECISION number is a numerical value which occupies two sequential memory locations.

A FIXED POINT number is a positive or negative numerical value expressed in ordinary notation, such as "-327.65".

A FLOATING POINT number is a positive or negative numerical value expressed in scientific notation, such as "$-.32765 \times 10^{3}$".

INTERCOM 1000 is the name given to a simple programming system for the Bendix G-15 Computer in which data, that is, numerical values, may be read into and out of the computer in either fixed point or floating point notation.

In the INTERCOM 1000 SINGLE-PRECISION system, each numerical value occupies a single address in the memory. Data may be written with five or fewer significant digits.

In the INTERCOM 1000 DOUBLE-PRECISION system, each numerical value occupies two sequential addresses in the memory. Data may be written with twelve or fewer significant digits.

PROGRAMMING WITH INTERCOM 1000

INTRODUCTION

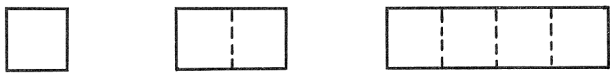
Intercom 1000 is an easy-to-use programming system which does not require specialized knowledge. Completely self-contained, it has facilities for computer control, input, output and program checking as well as program preparation.

A single Intercom command causes execution of a number of internal operations in the computer. Since the programmer need have no knowledge of the varied internal operations performed by each Intercom command, and since decimal points in numbers are handled automatically, the time and skill required for programming is greatly reduced.

command structure

The computer is given its instructions in the form of numerically expressed commands which can be held in the internal memory. Each command is expressed by seven digits.

FORM OF A COMMAND



Index Register | Operation Code | Address

The first digit represents an index register; if no index register is used, the first digit is zero and need not be written. Index registers simplify the programming of automatic address modification and need be considered only when this feature is desired.

The next two digits consist of a code that specifies the operation to be performed. The operation codes are listed at the end of the manual.

The last four digits normally specify the location in the memory to which the operation refers.

internal memory

The Bendix G-15 Computer uses a magnetic drum for its internal memory.

A location in the memory of the computer is specified by a four-digit number called an "address." The first two digits refer to a channel on the magnetic drum; the last two digits refer to the word position in the channel.

In Intercom 1000 Single-Precision, memory locations numbered from 0700 to 1899, inclusive, may be used by the programmer. In Intercom 1000 Double-Precision, memory locations numbered from 0900 to 1899, inclusive, may be used by the programmer. The memory locations not available to the programmer are used by the computer to hold instructions which control the operation of the Intercom system.

A command may be stored at, and executed from, any available address.

A numerical value also may be stored at any address in Intercom 1000 Single-Precision.

A numerical value may be stored at any even-numbered address in Intercom 1000 Double-Precision. The numerical value will occupy the even-numbered location specified by the address and the immediately subsequent odd-numbered one.

Additional data and command storage is provided by punched paper tape. An Intercom command permits any portion of the internal memory to be punched on paper tape at any time during the program; a second command permits punched paper tape to be read into the memory at high speed at any time during the program.

command sequence

Commands are normally obeyed in the numerical sequence of their memory locations. The computer is told the address of the first command to be obeyed. After execution of this command, the computer will automatically obey, in turn, the command in each following address.

Commands are available which transfer control to a command other than the next one in sequence. The computer will then obey commands in the new sequence.

A command to transfer control may be unconditional or may be contingent on the nature of a calculated value.

The address of the transfer of control command may, if desired, be remembered by the computer in order to return control later to the original command sequence. There are two "Mark Place and Transfer Control" commands for this purpose. For each of these two commands there is a "Return" command which transfers control back to the location immediately following the last corresponding "Mark Place and Transfer Control" command.

The two pairs of such commands make it possible to incorporate two levels of sub-program operation; that is, a first "Mark Place and Transfer" command can transfer control to a separate sequence of commands, and while in that subprogram, the second "Mark Place and Transfer" command can transfer control to still another sequence of commands.

form of input data

Fixed point data may be read into the computer with any number of significant digits up to the maximum of either five for the single-precision system, or twelve for the double-precision system. Numbers may be either positive or negative. There may be any number of places in the data up to thirteen, and the decimal point may occur anywhere.

Example: *The number "9 876 543 212 340." has thirteen places and has twelve significant digits. (Zeros before the first non-zero digit, or after the last non-zero digit, are not significant.) The number may be entered into the computer, unmodified, if the Intercom 1000 Double-Precision system is used.*

If the Intercom 1000 Single-Precision system is used, it would be necessary to reduce the number of significant digits to five and the number "9 876 500 000 000." would be entered into the computer.

If floating point notation is used, the decimal fraction may be expressed with any number of digits up to the maximum of either five for the single-precision system, or twelve for the double-precision system.

The multiplier of the decimal fraction may range in value from 10^{-37} to 10^{37}. The exponent of 10 is expressed as an excess-fifty number preceding the decimal point.

Example: *The fixed point number -12.345 may be expressed in scientific form as $-.12345 \times 10^{2}$.*

If fixed point notation is used, there is no change in the form of the number during input.

If scientific notation is used, 2 (the exponent of 10) is added to 50 and the number is written -52.12345.

Example: *The fixed point number .00012 may be expressed in scientific form as $.12 \times 10^{-3}$.*

If fixed point notation is used, there is no change in the form of the number during input.

If scientific notation is used, -3 (the exponent of 10) is added to 50 and the number is written 47.12.

form of output data

Data may be typed out by the computer as positive or negative decimal numbers in either fixed point or floating point notation. Up to five significant digits in the single-precision system, and up to twelve significant digits in the double-precision system, may be typed out.

If type-out is in floating point notation, its form and range are the same as during input.

A number typed out in fixed point notation may have as many as fourteen places. The number of these places to the right of the decimal point may be selected by the programmer. A number, the magnitude of which exceeds the fixed point limit, will be typed out in floating point notation.

Decimal points in columns of data will be automatically lined up in a straight vertical line during type-out.

numbers too large and too small

As a result of an arithmetic operation, a number may become too large to be handled by the computer. In that situation, an "overflow" is said to have occurred and computation automatically halts. The program must then be rewritten so that the capacity of the computer is not exceeded.

An overflow is unlikely to occur in the Intercom 1000 programming systems because all numerical values are handled internally in floating point form; there is no overflow unless the result of computation exceeds 10^{38}.

The significance of small numbers is not lost during computation since the internal exponent may become as small as 10^{-38}. Values with exponents smaller than 10^{-38} are considered to be equal to zero.

the accumulator

A special location in the internal memory is called the accumulator. An arithmetic command causes a numerical value stored in the memory, to be added to, be subtracted from, be multiplied by, be divided by, or be divided into, the number in the accumulator. The result of such an arithmetic operation becomes the new contents of the accumulator.

The accumulator has an address which may be used in commands. The address of the accumulator in Intercom 1000 Single-Precision is 2101. The address of the accumulator in Intercom 1000 Double-Precision is 2100.

constants

The numerical constants zero and one are often needed in a program. They may be obtained without first storing them in the memory of the computer. A value of zero may be placed in the accumulator by executing the "Subtract" command with the address of the accumulator in the address portion of the command. If the accumulator does not contain zero, a value of one may be placed in it by executing the "Divide" command with the address of the accumulator in the address portion of the command.

A PROGRAMMING EXAMPLE

The portion of an Intercom 1000 Double-Precision program which follows is for the calculation of $\frac{a^2 - bc}{d}$ where a, b, c and d are stored at addresses 1100, 1102, 1104 and 1106, respectively.

	Command Location	*Operation Code*	*Address*
Clear accumulator and add b	0900	42	1102
Multiply b, in accumulator, by c	0901	44	1104
Store bc	0902	49	1108
Clear accumulator and add a	0903	42	1100
Multiply a, in accumulator, by a	0904	44	2100
Subtract bc from a^2	0905	41	1108
Divide $a^2 - bc$, in accumulator, by d	0906	48	1106
Type out contents of accumulator in fixed point form	0907	33	2100

The Intercom 1000 Single-Precision system could be used for this program if the addresses in the fifth and last steps were changed from 2100 to 2101.

DESCRIPTION OF COMMANDS

In the descriptions following, the letter K stands for the index register number, if any; the letters ADDR stand for the four digits of the address.

Remember, if Intercom 1000 Double-Precision is used, ADDR must be even-numbered in all commands in the two groups "Arithmetic Commands" and "Input-Output Commands." In other commands ADDR need not be even-numbered.

arithmetic commands

CLEAR AND SUBTRACT . . . . . .K 40 ADDR

The contents of the accumulator are replaced by the contents of address ADDR, with the sign reversed.

Example: *Address 1014 contains the number 23.456. After the command 40 1014 is obeyed, the accumulator contains −23.456. The contents of address 1014 are unchanged.*

SUBTRACT . . . . . .K 41 ADDR

The contents of address ADDR are subtracted from the contents of the accumulator. The difference replaces the previous contents of the accumulator.

Example: *Address 1126 contains the number .0222 and the accumulator contains the number .0666. After the command 41 1126 is obeyed, the accumulator contains the number .0444. The contents of address 1126 are unchanged.*

CLEAR AND ADD . . . . . .K 42 ADDR

The contents of the accumulator are replaced by the contents of address ADDR.

Example: *Address 1212 contains the number 321.5. After the command 42 1212 is obeyed, the accumulator contains 321.5 also.*

ADD . . . . . .K 43 ADDR

The contents of address ADDR are added to the contents of the accumulator. The sum replaces the previous contents of the accumulator.

Example: *Address 1322 contains the number 321.5 and the accumulator contains the number 210.3. After the command 43 1322 is obeyed, the accumulator contains the number 531.8. The contents of address 1322 are unchanged.*

MULTIPLY . . . . . .K 44 ADDR

The contents of the accumulator are multiplied by the contents of address ADDR. The product replaces the previous contents of the accumulator.

Example: *Address 1416 contains the number 20.3. The accumulator contains the number 4. After the command 44 1416 is obeyed, the accumulator contains the number 81.2. The contents of address 1416 are unchanged.*

CLEAR AND ADD ABSOLUTE VALUE . . . . . .K 45 ADDR

The contents of the accumulator are replaced by the absolute value of the contents of address ADDR.

Example: *Address 1544 contains the number −321.5. After the command 45 1544 is obeyed, the accumulator contains the number 321.5. The contents of address 1544 are unchanged.*

INVERSE DIVIDE . . . . . .K 47 ADDR

The contents of address ADDR are divided by the contents of the accumulator. The quotient replaces the previous contents of the accumulator.

Example: *Address 1518 contains the number 126.6 and the accumulator contains the number 42.2. After the command 47 1518 is obeyed, the accumulator contains the number 3. The contents of address 1518 are unchanged.*

DIVIDE . . . . . .K 48 ADDR

The contents of the accumulator are divided by the contents of address ADDR. The quotient replaces the previous contents of the accumulator.

Example: *Address 1518 contains the number 42.2 and the accumulator contains the number 126.6. After the command 48 1518 is obeyed, the accumulator contains the number 3. The contents of address 1518 are unchanged.*

STORE . . . . . .K 49 ADDR

The contents of the accumulator are stored at location ADDR, replacing the previous contents of ADDR.

Example: *Address 1610 contains the number 6705 and the accumulator contains the number 833.3. After the command 49 1610 is obeyed, location 1610 contains the number 833.3 also.*

transfer of control commands

TRANSFER CONTROL IF ACCUMULATOR POSITIVE OR ZERO . . . . . K 20 ADDR

Control is transferred to the command located in address ADDR only if the contents of the accumulator are either zero or positive. If the contents of the accumulator are negative, the next command obeyed will be the one in normal sequence.

Examples: *The command 20 1526 is stored in location 1318. The accumulator contains the number .0365. After execution of this command, the next command obeyed is from location 1526.*

The command 20 1738 is stored in location 1210. The accumulator contains the number −.0365. After execution of this command, the next command obeyed is from location 1211.

TRANSFER CONTROL IF ACCUMULATOR NEGATIVE . . . . . K 22 ADDR

Control is transferred to the command located in address ADDR only if the contents of the accumulator are negative. If the contents of the accumulator are zero or positive, the next command obeyed will be the one in normal sequence.

Examples: *The command 22 1442 is stored in location 1132. The accumulator contains the number −.0365. After execution of this command, the next command obeyed is from location 1442.*

The command 22 1642 is stored in location 1144. The accumulator contains the number .0365. After execution of this command, the next command obeyed is from location 1145.

TRANSFER CONTROL IF ACCUMULATOR ZERO . . . . . K 23 ADDR

Control is transferred to the command in ADDR only if the contents of the accumulator are zero. If the accumulator contains a non-zero quantity, the next command obeyed will be the one in normal sequence.

Example: *The command 23 1746 is stored in location 1161. The accumulator contains zero. After execution of this command the next command obeyed is from location 1746.*

MARK PLACE AND TRANSFER I . . . . . K 26 ADDR

Control is transferred to the command in location ADDR. The address of the "Mark Place and Transfer" command is stored in a special register.

Example: *The command 26 1877 is stored in location 1113. Upon execution of this command, the address 1113 is stored in a special register and the next command obeyed is from location 1877.*

MARK PLACE AND TRANSFER II . . . . . K 28 ADDR

Control is transferred to the command in location ADDR. The address of the "Mark Place and Transfer" command is stored in a special register.

RETURN TO MARKED PLACE I 16 0000

Control is transferred to the command located immediately subsequent to the last "Mark Place and Transfer I" command. This command has no meaning unless it is preceded in the program by a "Mark Place and Transfer I" command.

Example: *In the preceding example, the command 16 0000, situated at a later point in the program than the command 26 1877, would return control to the command located in address 1114.*

RETURN TO MARKED PLACE II 18 0000

Control is transferred to the command located immediately subsequent to the last "Mark Place and Transfer II" command. This command is meaningless unless it is preceded in the program by a "Mark Place and Transfer II" command.

TRANSFER CONTROL, UNCONDITIONALLY . . K 29 ADDR

Control is transferred to the command located in address ADDR.

Example: *The command 29 1623 is stored in location 1234. After execution of this command, the next command obeyed is from location 1623.*

input-output commands

PERMIT COMMAND TYPE-IN . . . . . K 50 ADDR

Computation will halt. If a command, followed by (tab)Ⓢ, is now typed by the operator, the command will be stored in location ADDR and computation will be continued.

PERMIT TYPE-IN OF FIXED POINT DATA . . . . K 51 ADDR

Computation will halt. If a fixed point number, followed by (tab)Ⓢ, is now typed by the operator, the number will be stored in location ADDR and computation will be continued.

PERMIT TYPE-IN OF FLOATING POINT DATA . . . . . K 52 ADDR

Computation will halt. If a floating point number, followed by (tab)Ⓢ, is now typed by the operator, the number will be stored in location ADDR and computation will be continued.

TYPE FIXED POINT NUMBER AND TAB . . . . . K 33 ADDR

The contents of location ADDR are typed out in fixed point notation with the decimal point properly positioned. The typewriter carriage moves to the next tab stop.

TYPE FIXED POINT NUMBER AND RETURN CARRIAGE . . . . . K 38 ADDR

The contents of location ADDR are typed out in fixed point notation with the decimal point properly positioned. The typewriter carriage moves to the beginning of the next line.

TYPE FLOATING POINT NUMBER AND TAB . . . . . K 32 ADDR

The contents of location ADDR are typed out in floating decimal point notation; the typewriter carriage moves to the next tab stop.

TYPE FLOATING POINT NUMBER AND RETURN CARRIAGE . . . . . K 34 ADDR

The contents of location ADDR are typed out in floating decimal point notation; the typewriter carriage moves to the beginning of the next line.

READ PUNCHED TAPE PREPARED BY COMPUTER . . . . . K 55 ADDR

Punched tape, previously punched by the computer, is photo-electrically read and entered into the channel in the memory specified by the first two digits of ADDR. Information is entered in the channel beginning at word position 00 and ending with location ADDR-1.

Up to 100 words (one channel) can be entered into the computer each time this command is executed. If u0 is put in the last two digit positions in ADDR, 100 words will be read.

PUNCH PAPER TAPE . . . . . K 39 ADDR

Information is punched from the channel specified by the first two digits of ADDR, beginning at word position 00 and ending with location ADDR-1. In single precision, zeros are punched for the remaining word positions in the channel.

POSITION TYPEWRITER PAPER . . . . . K 30 TB CR

Paper in the typewriter carriage is automatically positioned by the execution of CR carriage returns followed by TB tabs. CR is a two-digit number ranging from 00 to 99. TB is a two-digit number ranging from 00 to 31.

TYPE TABULATING NUMBER AND TAB . . . . . K 31 TABL

The number TABL is typed out without leading or following zeros. After the type-out the typewriter carriage will move to the next tab stop. TABL is a four-digit number ranging from 0000 to 3000.

The command is useful for the automatic numbering of rows of data since the numbers 1 to 3000 may be typed out.

special commands

RING BELL 63 0000

The bell chimes once.

HALT AND PERMIT MANUAL OPERATION 67 0000

Computation is halted and the computer is put in the manual operating mode. (See page 15.)

BREAKPOINT HALT 68 0000

Computation is halted. Automatic computation may be resumed by moving the Compute switch on the typewriter base from GO to the center position and back to GO.

COMPUTE AUTOMATICALLY . . . . . 69 ADDR

Computation is begun with the command in location ADDR, and proceeds automatically until the command "Halt and Permit Manual Operation" is obeyed.

PERFORM SUBROUTINE . . . . . K 08 ADDR

The machine language subroutine, which begins at location ADDR, is executed.

INDEX REGISTERS

By use of an index register the computer can be instructed to obey the same group of commands a number of times, each time using data from a different set of addresses. Convenient means is also provided for tallying repetitive execution of a group of commands.

Each command which is used with an index register operates on the contents of an address, determined by adding a selected value to the address specified in the command. The command itself is left unchanged in the memory of the computer.

The same index register may be used with any number of commands. Intercom 1000 provides nine index registers numbered from 1 to 9 in order that separate groups of commands in a program may have their effective addresses modified in different ways. The number of the index register is put in the K position of each command in which the address is to be modified by that index register.

Each index register contains a "Word Base" which may range in value from 00 to 99. When an index register number is held in the "K" position of a command, the command will operate on the contents of an address determined by adding the word base to the address in the command.

Example: *Consider that in Index Register 8 the word base is equal to 15 and that the type-out command 8 33 1112 is obeyed by the computer.*

The computer will add 15 to 1112 and type out the contents of address 1127. The command itself will still read 8 33 1112 in the computer's memory.

By repetitively changing the word base during computation the same command may be made to operate on the contents of many different addresses. For use in changing the word base each index register contains also a "Word Difference" and a "Word Limit." Each is a two-digit number from 00 to 99.

The command for changing the word base is:

INCREMENT WORD BASE . . . . . K 76 ADDR

In Index Register K the word difference is added to the word base and the result is made the new value of the word base.

If the new value of the word base is less than or equal to the word limit in Index Register K, control is transferred to the command in address ADDR.

If the new value of the word base is greater than the word limit, the next command in sequence is obeyed.

Example: *Consider that in Index Register 1 the word base is 00; the word difference is 02, the word limit is 10. Location 1320 contains the command 1 76 1434.*

After this command is obeyed, the word base is equal to 02. Since this is less than 10 which is the word limit, control is transferred to the command in location 1434.

Example: *Consider that the word base is equal to 10 but other conditions are the same as in the above example.*

After the command 1 76 1434 in location 1320 is obeyed, the word base is equal to 12 which is greater than the word limit; therefore, the next command obeyed is taken from location 1321.

The commands to initially assign values to the parts of an index register are shown below. WB, WD and WL are abbreviations for Word Base, Word Difference and Word Limit, respectively. Each part of the index register is assigned the two digits written in place of those letters in the command. K is the number of the index register in which the numerical values are being put.

ASSIGN WORD BASE . . . . . K 70 00WB

ASSIGN WORD DIFFERENCE . . . . . K 71 00WD

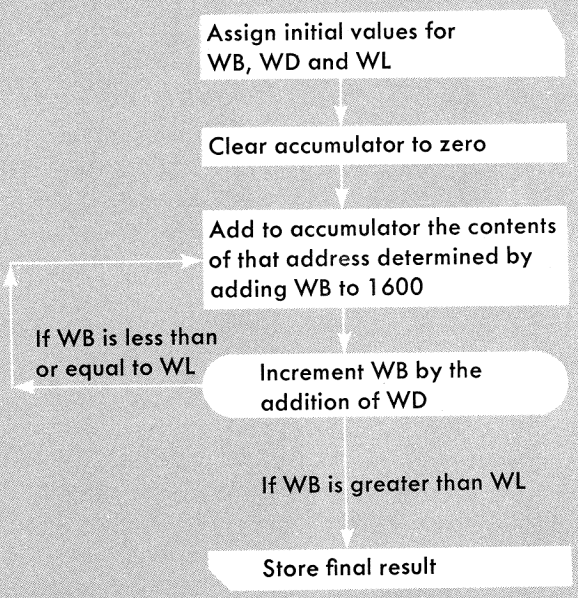
ASSIGN WORD LIMIT . . . . . K 72 00WL

Example: *To assign the Word Difference in Index Register 5 to be equal to 02, write the command "5 71 0002."*

AN EXAMPLE OF A PROGRAM WHICH USES AN INDEX REGISTER

A program is written below to find the sum of, and store, the contents of addresses 1600 to 1699. Notice that Index Register 1 will cause the command in location 1404 to add to the accumulator in turn the contents of addresses 1600 to 1699. The value zero is previously placed at address 1500.

A flow diagram of the problem is:



Notes	*Location*	*K*	*Operation Code*	*Address*
Assign WB equal to 00	1400	1	70	0000
Assign WD equal to 01	1401	1	71	0001
Assign WL equal to 99	1402	1	72	0099
Clear accumulator	1403		42	1500
Add contents of address to accumulator	1404	1	43	1600
Increment word base	1405	1	76	1404
Store accumulator	1406		49	1502

This program is written for the Intercom 1000 Single-Precision system. The program may be used in the Intercom 1000 Double-Precision system by changing the word difference (WD) from 01 to 02.

modification of the channel portion of an address

The index register commands which have been explained can change only the last two digits of an address. A corresponding set of index register commands are available to change the first two digits, or channel portion of an address. These commands, listed below, operate in the same manner as the ones already described.

ASSIGN CHANNEL BASE . . . . . K 73 CB00
ASSIGN CHANNEL DIFFERENCE . . . . . K 74 CD00
ASSIGN CHANNEL LIMIT . . . . . K 75 CL00
INCREMENT CHANNEL BASE . . . . . K 77 ADDR

Example: *Index Register 8 contains a word base of 15 and a channel base of 02; the type-out command 8 33 1112 is obeyed by the computer. The contents of what address will be typed out? The computer will add 02 to 11 and obtain 13 for the first two digits of the address. It will add 15 to 12 and obtain 27 for the last two digits of the address. Therefore, the contents of address 1327 will be typed out.*

If an index register is to modify the word portion of an address, but not the channel portion, the channel base must be assigned a value of zero. Similarly, if an index register is to modify the channel portion of an address, but not the word portion, the word base must be assigned a value of zero. It is not always necessary to use commands to assign the values of zero since all index registers can be automatically cleared to zero when the Intercom 1000 system is entered in the computer.

USE OF SUBROUTINES

A subroutine is a previously programmed sequence of commands which performs an often-used operation. Subroutines may be read into the computer from punched paper tape and stored in a channel in the memory.

Subroutines may be prepared from Intercom commands or may be prepared in basic machine language. The "Mark Place and Transfer" and "Return to Marked Place" commands permit subroutines written in Intercom form to be incorporated into Intercom programs. The "Perform Subroutine" command permits machine language subroutines to be incorporated into an Intercom program.

Many subroutines have been prepared in machine language for use with Intercom 1000. In general, each permits a complex operation to be included in an Intercom program by writing a single command. These machine language subroutines may be considered to be optional extensions of the command list.

mathematical subroutines

A number of mathematical subroutines have been prepared in machine language for use with Intercom 1000. Five commonly used groups are listed below. Each group requires one channel for internal storage. In the tables that list Mathematical Subroutines the groups are separated by horizontal lines.

In each subroutine, the value "x" must be first placed in the accumulator and the result appears in the accumulator.

The trigonometric, logarithmic and exponential subroutines are accurate to eleven decimal places.

Subroutine	Word Position to be Used in "Perform Subroutine" Command
Square Root of x	97
Log_{10} x	71
Log_e x	17
Log_2 x	08
10^x	72
e^x	22
2^x	08
Sine x (radians)	42
Sine x (degrees)	39
Cosine x (radians)	26
Cosine x (degrees)	23
Arctan x (radians)	24

EXAMPLE OF MATHEMATICAL SUBROUTINES

Consider that the sine-cosine subroutine has been stored in channel 16. The program steps to find the sine of an angle in degrees, and store the result in the memory, would be:

1. Transfer angle, in degrees, from ADDR to accumulator — 42 ADDR
2. Perform subroutine — 08 1639
3. Store sine of angle from accumulator to ADDR — 49 ADDR

The three commands are programmed in sequential memory positions.

subroutine to internally control size of decimal fraction during fixed point type-out

When the command "Type Fixed Point Number" is executed, a number of places specified by the programmer will be typed after the decimal point. For example, if the programmer has specified four places, and the numbers to be typed out have values in the memory of 12.3 and 12.3456789, the type-out will be "12.3000" and "12.3456."

The number of type-out places specified can be changed during computation under program control. In order to do so, the "Fraction Selector" subroutine must be read into the memory of the computer. The subroutine may be placed in any available channel.

After the subroutine has been read into the memory, the command "Perform Subroutine" may be executed to specify a new number of type-out places after the decimal point. The first two digits of the address portion of the "Perform Subroutine" command would be the channel in which the "Fraction Selector" subroutine has been placed. The latter two digits of the address specify the number of places to be typed after the decimal point, according to the following table:

Type-out Places After Decimal Point	Word Position to be Used in "Perform Fraction Selector Subroutine" Command
0	08
1	01
2	02
3	03
4	04
5	05
6	06
7	07

Example: *The "Fraction Selector" subroutine has been read into channel 16. For subsequent fixed point type-outs to have three places typed after the decimal point, the command "08 1603" would be executed.*

AN EXAMPLE OF A PROGRAM WHICH USES MATHEMATICAL SUBROUTINES

In this program, each time the operator types in a positive number, x, followed by "(tab)Ⓢ",* the computer calculates $\sqrt{1 - e^{-x}}$. The computer types out the result and rings the bell to indicate that it is ready for type-in of the next value of x.

The square root subroutine has been previously entered in channel 16. The subroutine for the calculation of e^x has been previously entered in channel 17.

	Location	*Operation Code*	*Address*
Ring bell	1100	63	0000
Permit type-in of x in fixed point notation	1101	51	1200
Clear and subtract x	1102	40	1200
Find e^{-x}	1103	08	1722
Store e^{-x}	1104	49	1202
Divide accumulator by itself to obtain 1	1105	48	2100
Subtract e^{-x} from 1	1106	41	1202
Find square root of $1 - e^{-x}$	1107	08	1697
Type out answer in fixed point notation	1108	38	2100
Transfer control, unconditionally	1109	29	1100

This program is written for the Intercom 1000 Double-Precision system. The program may be used in the Intercom 1000 Single-Precision system by changing the address of the accumulator, in the sixth and ninth steps, from 2100 to 2101.

*The earlier model typewriter has no Ⓢ key; wherever the Ⓢ key is indicated, use the s key on the alphabetical keyboard.

OPERATING THE G-15 COMPUTER WITH INTERCOM 1000

operating modes

Intercom 1000 has two operating modes: manual and automatic. The desired mode may be selected from the typewriter keyboard.

In the manual mode, individual commands may be typed and executed one at a time as on a desk calculator, or data and commands may be typed on the keyboard and stored in the computer's memory.

In the automatic mode, computation proceeds in the normal manner. Commands stored in the computer's memory are executed in the order specified by the program.

Any command, including input-output commands, may be executed in either operating mode. Additional data, for example, may be read into the computer from punched tape and stored in the memory by execution of the command "Read Punched Tape," in either the manual or automatic mode.

intercom 1000 tapes

Intercom 1000 and its subroutines are provided on different sets of punched tapes. The basic Intercom 1000 routine, which is called the "Master" magazine in this manual, is contained on one tape. Mathematical subroutines are held on both the Appendix I and Appendix II tapes. Subroutines for use of auxiliary equipment (see page 19) are held on the Appendix I tape. Separate tapes are provided for single-precision and double-precision operation.

TO ENTER AND EXECUTE A PROGRAM FROM THE TYPEWRITER

to prepare the computer for operation

The computer is assumed to be on. If the computer is off, see page 17 for the turn-on procedure.

1. Place either the Intercom 1000 Single-Precision or Double-Precision Master magazine on the photo-reader. Be sure the tape is rewound.

2. Put the Punch and Compute switches on the typewriter base to the center (off) positions.

3. Hold the Enable switch on the typewriter base to the ON position and type "p." Put the Enable switch off.
   Wait until the photo-reader light remains off.

4. Move the Compute switch on the typewriter base to GO.
   Wait for the photo-reader light to remain off. When the bell rings, the computer is in the manual operating mode ready for operation.

to clear memory

The computer must be in the manual operating mode.

1. Put the Compute switch in the center (off) position. Hold the Enable switch ON and type "p." Put the Enable switch off.
   Wait for the photo-reader light to remain off.

2. Put the Compute switch to GO.
   Wait for the neon indicator lights to remain steady.

3. If the Intercom 1000 memory, including index registers, is to be cleared to zero, type "3 (tab) Ⓢ". If the index registers are to be cleared to zero, but the remainder of the Intercom 1000 memory retained, type "2 (tab) Ⓢ".

4. Type "(tab) Ⓢ".
   Wait for the photo-reader light to remain off and the bell to ring. The computer is returned to the manual operating mode.

to select fixed point fraction length

During the type-out of data in fixed point notation, four decimal places will be printed to the right of the decimal point in single-precision data and seven decimal places to the right of the decimal point in double-precision data, unless the following instructions are used.

The computer must be in the manual operating mode.

1. Put the Compute switch in the center (off) position. Hold the Enable switch ON and type "p." Put the Enable switch off.
   Wait for the photo-reader light to remain off.

2. Put the Compute switch to GO.
   Wait for the neon indicator lights to remain steady.

3. Type "-D (tab) Ⓢ" where D indicates the number of decimal places to be printed after the decimal point according to the following table:

D	*Number of Places*
8	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7

   Wait for the photo-reader light to remain off. The computer is returned to the manual mode.

to load subroutines

The computer must be in the manual operating mode.

1. Place the Single or Double-Precision Appendix I or Appendix II tape magazine on the photo-reader. Be sure the tape is rewound.

2. Put the Compute switch off and the Enable switch ON. Type "p". Put the Enable switch off.

   Wait until the photo-reader light remains off.

3. Put the Compute switch to GO.

   Wait for the bell to ring.

4. If one subroutine only is to be read into the memory, go to step 5. If more than one subroutine is to be loaded into the memory, type "N (tab) ⓢ" where N specifies the subroutine and the channel in which it is to be stored. (See "Values of N for Subroutine Input".)

   Wait for the bell to ring after typing "(tab) ⓢ".

   Repeat Step 4 for each subroutine except the last one.

5. For the last subroutine to be read in, type "N − (tab) ⓢ".

   Wait for the photo-reader light to remain off and the bell to ring. The tape is completely rewound.

   The computer is returned to the manual operating mode.

Example: *If in Step 4 or 5, under "To Load Subroutines", it is desired to read the square root subroutine into channel 14 in the memory, "2 14 u0 (tab) ⓢ" would be typed.*

If the N value of a subroutine ends with 00, when the subroutine is:

Placed in Channel	Do not use Index Register
09	1
10	2
11	3
12	4
13	5
14	6
15	7
16	8
17	9

Any index register may be used if the N value of the subroutine ends with u0.

VALUES OF N FOR SUBROUTINE INPUT

The values of N tabulated below are for use in Steps 4 and 5 of the section "To Load Subroutines". The letters "CH" represent the number of the channel in memory in which the subroutine is to be stored. The subroutines may be loaded in any order.

Subroutine	*N Single-Precision*	*N Double-Precision*
Fraction Selector	1 CH u0	1 CH u0
Square Root of x	2 CH u0	2 CH u0
Log_e x Log_2 x Log_{10} x	3 CH u0	3 CH u0
e^x 2^x 10^x	4 CH u0	4 CH 00
Sin x (degrees) Sin x (radians) Cos x (degrees) Cos x (radians)	5 CH u0	5 CH 00
Arctan x (radians)	6 CH u0	6 CH 00

to type data into desired memory locations

The computer must be in the manual operating mode.

1. If data is expressed in fixed point notation, type "51 ADDR (tab) ⓢ", where ADDR is the first memory location to be used for data storage. If data is expressed in floating point notation, type "52 ADDR (tab) ⓢ".

   Location ADDR will be typed out followed by a tab.

2. Type data which is to be entered into consecutive addresses in the memory. Numbers must continue to be expressed in the form selected, either fixed point or floating point. Type "(tab) ⓢ" at the end of each number.

   The decimal point* must always be typed if fixed point notation is used.

   To enter a zero in fixed point notation, type ".(tab) ⓢ".* To enter a zero in floating point notation type "(tab) ⓢ".

The first number typed will be stored at location ADDR. The computer will retype the number in floating point notation, in order to verify proper entry of the number. The carriage will return.

If Intercom 1000 Single-Precision is used, location ADDR + 1 will be typed out. The second number typed will be entered into location ADDR + 1. Following numbers will similarly be entered into consecutive word locations.

If Intercom 1000 Double-Precision is used, only even-numbered locations will be typed out. Numerical values will be stored at consecutive even-numbered locations.

3. Type "0 67 0000 / / (tab) ⓢ".

   The computer is returned to the manual operating mode.

*On the typewriter keyboard, the decimal point for fixed point input is entered by pressing the fixed decimal point key; this key has imprinted on it a hollow decimal point for lower case and a / (slash) for upper case. Either may be typed without change in effect.

to type commands into desired memory locations

The computer must be in the manual operating mode.

1. Type "50 ADDR (tab) ⓢ" where ADDR is the first of a consecutive group of memory locations to be used for command storage.

   Location ADDR will be typed out followed by a tab.

2. Type commands to be stored in consecutive memory locations. Type "(tab) ⓢ" after each command.

   After (tab) ⓢ is typed, the computer will retype the command. The carriage will return to the left and the next consecutive address will be typed out. Another command may now be typed.

3. Type "0 67 0000 / / (tab) ⓢ".

   The computer is returned to the manual operating mode.

to change from the manual to the automatic operating mode

After the program has been fully loaded into the memory, the computer may be instructed to compute automatically, obeying each command in sequence. To do so:

Type "69 ADDR (tab) ⓢ" where ADDR is the location of the command at which computation is to begin.

TO CHECK OUT A PROGRAM

Additional commands and facilities are provided by Intercom 1000 to control and to interrogate the computer during execution of a program. They are useful in the location and correction of errors made in writing the program.

to put the computer in the manual mode

The computer may be put in the manual operating mode at any time by the procedure below.

1. Move the Compute switch on the typewriter base to BP. When the neon indicator lights become steady, return the switch to the center position.
2. Hold the Enable switch on the typewriter base in the ON position and type "ⓢ cf".
3. Release the Enable switch back to the center position and move the Compute switch to GO.

to execute commands in the manual mode

The computer must be in the manual operating mode.

Individual commands may be executed directly from the typewriter keyboard. The result of an arithmetic command will remain in the accumulator after execution. The command itself is not stored in the memory. The procedure is:

1. Type the command followed by (tab) ⓢ.

   The computer will execute the command and halt in the manual operating mode.

2. Repeat Step 1 as often as desired.

to execute stored commands, one at a time

A stored program may be executed one command at a time for check-out purposes. The computer must initially be in the manual operating mode.

1. Put the Compute switch on the typewriter base to BP.
2. Type "69 ADDR (tab) ⓢ" where ADDR is the location of the first command to be executed.

3. Put the Compute switch to the center position and back to BP.

4. Repeat Step 3 for each command in the program. Each time the switch is moved back and forth one command will be executed.

   The computer is in the automatic operating mode.

To execute the remainder of the program without halting between commands, put the Compute switch to GO.

To revert to the manual mode, follow the procedure "To Put the Computer in the Manual Mode."

to inspect a program

Put the computer in the manual mode.

Two additional commands, useful in checking a program, are:

TYPE COMMAND FROM MEMORY . . . . . 35 ADDR

The command in location ADDR will be typed out in the form:

"K Word Position Operation Code Channel."

TYPE LOCATION OF LAST COMMAND EXECUTED 06 0000

The memory location of the last command executed will be typed out. The typewriter carriage will move to the next tab stop.

to list selected commands during computation

Information concerning selected commands can be automatically typed out during computation. The information typed will be the location of the command, the command itself, and the result of its execution. In the type-out of a command with an index register, the address of the command will be incremented by the word base and channel base of the index register.

Any portion of a command may serve as the basis of selection. The computer is notified which commands to type out by two "selectors," each consisting of seven characters.

The first selector holds the digital values which, if found in a corresponding portion of a command in the program, will cause the command to be listed. Z's are placed in the second selector in digit positions corresponding to the digit positions which are to be examined in commands.

Examples: *If the first selector is 0 49 0000 and the second selector is 0 zz 0000, all commands which have the operation code 49 will be listed during computation.*

If the first selector is 2 000 000 and the second selector is z 000 000, all commands with index register 2 will be listed during computation.

The operating procedure is:

The computer must be in the manual operating mode. The Intercom 1000 Master magazine must be in position on the photo-reader.

1. Put the Compute switch in the center (off) position. Hold the Enable switch ON and type "p." Put the Enable switch off.

   Wait for the photo-reader light to remain off.

2. Put the Compute switch to GO.

   Wait for the neon indicator lights to remain steady.

3. Type "1 (tab) Ⓢ".

   Wait for the photo-reader light to remain off.

4. Type " (tab) Ⓢ".

   Wait for bell to ring. The computer is now returned to the manual operating mode.

5. Type "61 0000 (tab) Ⓢ".

   Wait for the input-output neons to be in the configuration 0●●00.

6. To list every command, type "(tab) Ⓢ". To list selected commands, type "FIRST SELECTOR (tab) SECOND SELECTOR (tab) Ⓢ".

   The bell will ring.

7. Type "69 ADDR (tab) Ⓢ" where ADDR is the location of the command at which computation is to begin.

   The computation, with listing of selected commands, will proceed.

To terminate listing:

1. Put the computer in the manual mode.

2. Type "620000 (tab) Ⓢ". This command terminates listing.

   The computer is now in the manual operating mode.

During, or subsequent to, the listing of selected commands the computer is not able to accept input data written in fixed point notation. If it is desired to enter data written in fixed point notation at this time, it is necessary to repeat the procedure "To Prepare the Computer for Operation" on page 13.

breakpoint operation

A program may be executed a portion at a time by placing a "Breakpoint Halt" command (page 8) in the program in each place where computation is to be interrupted.

When later desired, computation can be made to be continuous by replacing each "Breakpoint Halt" command with a "Transfer Control, Unconditionally" command.

to alter a program

Automatic computation may be halted and the computer put in the manual operating mode in order to type in new commands or data. After the program is modified, the computer may be instructed to return to the point in the program at which operation was interrupted and resume computation in the automatic mode. The procedure is:

1. Put the computer in the manual operating mode.
2. Type the command "060000 (tab) Ⓢ" to determine location of last command executed.
3. Type the command "49 ADDR (tab) Ⓢ" in order to store the contents of the accumulator in any empty location ADDR.
4. Make program alterations.
5. Type the command "42 ADDR (tab) Ⓢ" in order to return the contents of ADDR to the accumulator.
6. Type "69 ADDR (tab) Ⓢ" where ADDR is the location of the next command to be executed. (See step 2.)

   The computer returns to the point at which computation was interrupted and resumes computation.

automatic error detection

The computer automatically checks the accuracy of the information read from the Intercom 1000 Tape Magazine. If a reading error occurs, the tape is reversed automatically and the block of information in which the error was detected is read again.

In Intercom 1000 Single-Precision, the computer will halt when the following programming errors occur:

Any internal computation in which the result exceeds 10^{38}.

Square root of a negative number.

Division by zero.

Log of zero or log of a negative number.

In Intercom 1000 Double-Precision, the computer will halt when the four programming errors listed above and the following ones occur:

An arithmetic or data input command with an odd-numbered address.

Incrementing a command until the word position of an address exceeds 99.

After the computer halts, put the Compute switch to the center (off) position and then to BP. The computer will type the address of the command that caused the error to occur. Computation may be resumed with the next command in sequence by putting the Compute switch to GO; or the computer may be returned to the manual operating mode by the method described on page 15.

to recover operating control

If the computer does not respond to a command or to a typed instruction in the proper manner, control may have been lost due to an operator error.

Control may be recovered by one of the two methods indicated below.

1. Move the Compute switch on the typewriter base to the center position.

   Hold the Enable switch ON and type "Ⓢ cf".

   Release the Enable switch back to the center position and move the Compute switch to GO.

   The bell will ring once to indicate return to the manual mode.

   If the computer does not return to the manual mode, use Method 2.

2. Put the "rewind" toggle switch, next to the photo-reader, down in the rewind position until the tape in the Intercom 1000 Master magazine is fully rewound.

   Follow the procedure "To Prepare the Computer for Operation" on page 13, beginning with the second step.

to turn on the computer

When the computer is turned on, it may be checked for proper operation by the use of a test routine which is provided in a punched tape magazine.

The procedure to turn on and check the computer is:

1. Place the "Test Routine" magazine on the photo-reader. Be sure the tape in the magazine is rewound.
2. Put the Enable, Punch and Compute switches on the

typewriter base in the center (off) positions.

3. Turn on the Start switch.

   Wait for the AC meter to read 6.3 volts and the amber AC light to become bright.

4. Press the Reset button until the red DC lamp lights.

   Wait until the photo-reader light remains off and the green "Ready" lamp lights.

5. Move the Compute switch to GO.

   The number "1" will be typed out. Wait for the display panel neons to remain steady.

6. Type "0 0 0 0 0 0 5 (tab) ®".

   Wait for the photo-reader light to remain off and the display panel neons to remain steady.

7. Type "0 0 0 0 0 0 6 (tab) ®".

   Bells ring at repeated intervals to signify successful procedure of each test in the routine.

   Proper computer operation is indicated if no type-out occurs before the following is typed out:

   - 1 1 2 2 3 3 4 · 4 4 5 5 6 6.7 7 7 8 8 9 9
   - u u v v w w x x x y y z z.0 2 3 4 5

8. At completion of the type-out put the Compute switch to the center position and remove the "Test Routine" magazine.

USING AUXILIARY EQUIPMENT WITH INTERCOM 1000

The Intercom 1000 programming system includes input-output facilities for Flexowriter tape, magnetic tape and punched cards.

Magnetic tape input-output is provided by Accessory MTA-2. By its use the effective working memory of the computer is greatly increased in size. One to four magnetic tape units may be connected to, and controlled by, the computer.

Punched card input-output is provided by Accessory CA-1 with the IBM-026 card-handling unit.

Punched tape may be processed independently of the computer by a Flexowriter.

The auxiliary equipment is controlled by subroutines which are available on punched tape labeled "Appendix I". Separate tapes are provided for single-precision and double-precision operation.

When the Appendix I tape magazine is mounted on the photo-electric reader the subroutines may be entered into the computer under keyboard control; or they may be entered into the computer under program control, during computation, by use of the command "Read Punched Tape Prepared by Computer". A channel in the memory which holds a subroutine can not be used at that time to hold data or other commands.

The additional input-output commands permitted by each subroutine are listed in the table below. The table specifies the order in which the subroutines are punched on the Appendix I tape and the memory channel in which each subroutine must be entered.

Note in the following pages that a command for auxiliary equipment input-output usually requires the coding of a pair of command words. When this is true, the two command words must be programmed consecutively.

TO LOAD AUXILIARY EQUIPMENT SUBROUTINES

The procedure for loading auxiliary equipment subroutines into the computer from the Appendix I tape is the same as entering mathematical subroutines. (See "To Load Subroutines", page 14.) If desired, the mathematical and auxiliary equipment subroutines required for a program may be entered in the same loading operation.

The table below lists the auxiliary equipment subroutines on the Appendix I tape and the value of N for each. Note that these subroutines must be stored in specific memory channels.

AUXILIARY EQUIPMENT SUBROUTINES

Accessory	*Subroutine Commands*	*N Single-Precision*	*N Double-Precision*
Flexowriter	Read Data Tape Prepared by Flexowriter Read Command Tape Prepared by Flexowriter	7 17 u0	7 17 u0
Flexowriter	Punch Data Tape to be Tabulated by Flexowriter	8 16 u0	8 16 u0
MTA-2	Write on Magnetic Tape Read Magnetic Tape Write File Number on Magnetic Tape Reverse Magnetic Tape One Block Search Magnetic Tape for File Number	9 18 00	9 18 00
CA-1	Read Data Card Punch Data Card	10 16 u0	10 16 u0
CA-1	Read Command Card	11 17 u0	11 17 u0

TO USE THE FLEXOWRITER

Information may be entered into the internal memory from paper tape which was punched by a Flexowriter Model 35-4. The subroutine for reading Flexowriter tape must first be read into channel 17 in the memory; the following commands are then available:

READ DATA TAPE PREPARED 08 1717
BY FLEXOWRITER . . . . . .K 57 ADDR

Numbers written in floating point notation on punched tape are read into consecutive addresses in the memory beginning with location ADDR. Tape will be read until a Stop code occurs on the tape. K may refer to any register except Index Register number 9 in double precision operation.

READ COMMAND TAPE PREPARED 08 1717
BY FLEXOWRITER . . . . . .K 56 ADDR

Commands on punched tape are read into consecutive addresses in the memory beginning with location ADDR. Tape will be read until a Stop code occurs on the tape. K may refer to any index register except Index Register number 9 in double precision operation.

The computer can be instructed to punch a tape to be later tabulated by a Flexowriter. The subroutine for punching a Flexowriter tape must first be read into channel 16 in the memory. The following command is then available:

PUNCH DATA TAPE TO BE TABULATED 08 1675
BY FLEXOWRITER . . . . . .K N ADDR

The contents of N memory locations are punched on tape in floating decimal point form beginning with location ADDR. N is a two-digit number from 01 to 99. K may refer to any index register except Index Register number 8 in double precision operation.

One hundred word positions may be punched out, if desired, by writing u0 in the N position of the command.

operating instructions for input from punched tape prepared on flexowriter

The tape may be punched on a Flexowriter Model 35-4. After punching, the tape is read into the computer via the photo-reader. Data and commands are punched on separate sections of tape. Data is punched in the floating decimal point form described on page 4.

Prepare the tape in the following manner:

1. Run out seven inches or more of blank, sprocketed tape.

2. If data is being punched, each single-precision word must contain seven digits and each double-precision word fourteen digits. If a number is negative, the minus sign precedes the first digit. A zero in the single-precision system is punched in the form "50.00000". A zero in the double-precision system is punched in the form "50.000000000000".

   If commands are being punched, each word must contain seven digits. If no index register is used in a command, zero is punched in the K position.

3. **For Single-Precision Data or Commands**

   Punch the first four words which are to be entered in consecutive memory locations in the following form:

   word (tab) word (tab) word (tab) word (carriage return)
   /
   Continue to punch in the same form consecutively located groups of four words. Do not mix data and commands. After a section with a maximum of 100 words has been punched, punch "w w w w w w w (tab)" or "z z z z z z z (tab)", repeated a sufficient number of times to complete the last four word group; that is, "w w w w w w w (tab)" or "z z z z z z z (tab)" must be written one, two, three or four times. Then punch "stop 2".

   For Double-Precision Data

   Punch the first two double-precision words to be entered into consecutive memory locations in the form:

   (tab) dbl. word (tab) (tab) dbl. word (carriage ret.)
   /
   Continue to punch in the same form consecutively located groups of two double-precision words. After a section with a maximum of fifty double-precision words has been punched:

   If the section has an odd number of words, after the last word punch
   "(tab) (tab) w w w w w w w w w w w w w w w (tab) (stop 2)" or "tab) (tab) z z z z z z z z z z z z z z z (tab) (stop 2)".

   If the section has an even number of words, punch "(tab) w w w w w w w w w w w w w w w (tab) (tab) w w w w w w w w w w w w w w w (tab) (stop 2)" or "(tab) z z z z z z z z z z z z z z z (tab) (tab) z z z z z z z z z z z z z z z (tab) (stop 2)".

   The "w" codes are used when additional consecutive

input of the same type already entered follows immediately on the tape. The "z" codes are used when input is ended; control will be restored to normal Intercom computation.

4. If a punching error is detected in a group of four words before the following "/" or "stop 2" has been typed, the error may be corrected by retyping the four-word group involved. If the error is detected after the corresponding "/" or "stop 2" has been typed, it is necessary to either retype the entire section or reproduce the tape on the Flexowriter up to the error.

5. After "stop 2" is punched, run out seven or more inches of blank, sprocketed tape.

Note that double-precision data and single-precision data can not be processed in the same program.

Addresses in which the commands or numbers are to be stored are not punched. The information from tape is put in a set of consecutive addresses specified by the "Read Flexowriter Tape" command.

The "w" codes and the "z" codes are not stored in the memory of the computer.

EXAMPLES

Copy for ten words of command input with no additional input following:

```
        0421102 (tab) 0441104 (tab) 0441106 (tab) 0491108 (carriage return)
/ 1700000 (tab) 1710001 (tab) 1720099 (tab) 0421100 (carriage return)
/ 1431600 (tab) 1761404 (tab) zzzzzzz (tab) zzzzzzz (tab) (stop 2)
```

Copy for six words of double-precision data input with additional input following:

```
  (tab)    51.123456000000 (tab) (tab) −53.234567898000 (carriage return)
/ (tab)    55.345678987654 (tab) (tab)   51.100000000000 (carriage return)
/ (tab) −49.876543212345 (tab) (tab) −47.654386212345 (carriage return)
/ (tab)    wwwwwwwwwwwwww (tab) (tab) wwwwwwwwwwwwww (tab) (stop 2)
```

TO USE MAGNETIC TAPE.

Accessory MTA-2 provides magnetic tape input-output facilities. Tape is searched at a rate of 2600 characters per second. Information is written on tape or read from tape at a rate of 430 characters per second. 300,000 words may be stored on a single tape reel.

One to four magnetic tape units may be connected to, and controlled by, the computer. The letter M in a magnetic tape command refers to the number of the magnetic tape unit on which the command operates. M may be 0, 1, 2 or 3.

When the magnetic tape subroutine is in channel 18 in the memory, the following additional commands are available:

08 1870
WRITE ON MAGNETIC TAPE . . . . . .K M2 ADDR

The contents of the memory channel determined by the first two digits of ADDR are recorded on tape in tape unit M. The last two digits of ADDR must be 00. The group of words recorded by a single command is called a block. New information must not be written on top of earlier-recorded information.

08 1870
READ MAGNETIC TAPE . . . . . .K M1 ADDR

A block of information is read from tape in tape unit M and is entered into the internal memory. Information is entered in the channel specified by the first two digits of ADDR, beginning at word position 00 and ending with word position ADDR-1.

08 1870
WRITE FILE NUMBER ON MAGNETIC TAPE. . .K M3 FILE

The number FILE is written on tape in tape unit M. FILE is an arbitrary number from 0000 to 3000.

File numbers need not be sequential but must be recorded in order of increasing magnitude. A file number may be written after any number of blocks.

The file number 0000 must be recorded at the beginning of every tape reel; the file number 3000 is usually recorded at the end of the reel to prevent the tape from running off the reel.

08 1870
REVERSE MAGNETIC TAPE ONE BLOCK. . . .K M4 0000

Tape in tape unit M is moved one block in the reverse direction.

SEARCH MAGNETIC TAPE FOR 08 1870
FILE NUMBER . . . . . .K M5 FILE

Tape in tape unit M will search for, and will stop at, file number FILE.

AN EXAMPLE OF A PROGRAM WHICH USES MAGNETIC TAPE

The contents of channel 16 in the memory will be written on magnetic tape in tape unit 1, and then the first fifty words, recorded on the tape after file number 0036, will be read into channel 16.

08 1870 12 1600	The contents of channel 16 are written on tape.
08 1870 15 0036	The tape searches at high speed and halts at file number 0036.
08 1870 11 1650	Information is read from tape and stored in memory positions 1600 to 1649.

operating instructions for magnetic tape

One to four MTA-2 units may be connected to the computer. Each has a switch labeled "Tape Unit" with positions numbered from one to four. The switch setting is used to identify the tape unit addressed in commands. The number in the M position of a magnetic tape command determines the tape unit in which the command operates. Tape unit switch settings one to four correspond to M numbers of 1, 2, 3 and 0 respectively. For example, a command with 2 in the M position will control the unit or units that have their unit switches set at 2. Thus, information may be recorded simultaneously on more than one tape. However, only one tape at a time may be read during input.

Recording information on a section of tape does not automatically erase old information on that section of tape. Therefore, new information cannot be written on top of old information; to re-use a tape reel, it must first be demagnetized.

Tape motion may be manually initiated and stopped from the tape unit. The rotary selector switch for doing so has five positions:

A	Automatic
S	Stop
F	Forward Motion
S	Stop
R	Reverse Motion

The "Hi-Lo" toggle switch permits selection of one of two speeds for manual tape motion, either 7½ or 45 inches per second.

Before turning on the computer make sure that, on all tape units, the on-off switch is off, the run-standby switch is in standby, and the rotary selector switch is at S.

To Turn on the Magnetic Tape Unit

1. Put the computer in the manual operating mode.
2. On the typewriter base, put the Enable switch ON, the Compute switch off, type "Ⓢ", and put the Enable switch off.
3. On the tape unit, put the on-off switch to the on position. After about two minutes, put the run-standby switch in the run position. Put the rotary selector switch in the A position.
4. Put the Enable switch ON, type "Ⓢ cf", put the Enable switch off and the Compute switch to GO.

   The computer is returned to the manual mode.

To Turn Off the Magnetic Tape Unit

If the tape unit is not required by the computer for a considerable length of time, it may be turned off. The tape unit should always be turned off before the computer is turned off. The procedure is:

1. On the typewriter base, put the Enable switch ON, the Compute switch off, type "Ⓢ", and put the Enable switch off.
2. On the tape unit, put the rotary selector switch in the S position, the run-standby toggle switch in the standby position, and the on-off toggle switch in the off position.
3. Put the Enable switch ON, type "Ⓢ cf", put the Enable switch off and the Compute switch to GO.

   The computer is returned to the manual mode.

Self-Checking Error Detection

Each block of information read from magnetic tape is automatically checked for accuracy by the computer. If the information read is not the same as that originally written on the tape, the tape will be automatically reversed one block and the information read into the computer over again. If the second reading is also incorrect, the tape will continue to be reversed and to be read again until reading is correct or until the operator halts the process. The halting procedure is:

1. Put the Compute switch to BP.
2. When the neon indicator lights remain steady, put the Compute switch to the center position, the Enable switch ON, and type "i". Put the Enable switch off.
3. Put the Compute switch to BP.
4. Follow the procedure on page 15 to return to the manual mode.

TO USE PUNCHED CARDS

Accessory CA-1, with the IBM-026 card-handling unit, provides punched card input-output facilities. Standard eighty-column cards may be read or punched under control of Intercom commands.

Cards being read may contain either data or commands, but not both.

Data cards are both read and punched in floating decimal point notation. In Intercom 1000 Single-Precision, a card may contain from one to eight words of data or commands. In Intercom 1000 Double-Precision, a card may contain from one to four words of data or one to eight commands.

After the data card subroutine has been entered into channel 16 in the memory, the following commands may be programmed:

```
                                        08 1605
READ DATA CARD . . . . . .K ON ADDR
```

Data from one card in the IBM-026 is read into the memory of the computer in consecutive locations beginning at location ADDR. The digit N specifies the number of words held on the card. K may refer to any index register except Index Register number 8 in double precision operation.

```
PUNCH DATA CARD . . . . . .08 1610
```

The contents of the accumulator are punched on a card by the IBM-026 unit.

The number of words punched on a single card is determined by the program card in the IBM-026.

After the command card subroutine has been read into channel 17 in the memory, the following command may be programmed:

```
                                        08 1775
READ COMMAND CARDS . . . . . .K ON ADDR
```

Commands from cards in the IBM-026 are read into the memory of the computer in consecutive word locations beginning at location ADDR. The digit N specifies the number of commands held on each card. K may refer to any index register except Index Register number 9 in double precision operation.

operating instructions for punched card input-output

If the computer is on, prior to using any control on the 026 unit, put the Compute switch off, the Enable switch ON, type "Ⓢ", and put the Enable switch off. After making any change on the 026, put the Enable switch ON, type "Ⓢ cf", put the Enable switch off and move the Compute switch to GO. The computer will then be in the manual operating mode.

IBM-026 Operation

Controls on the IBM-026 unit should be set in the following positions:

The "on-off" switch on the left of the unit in the ON position.

Toggle switches on the keyboard in the upper position.

The Column 1 switch on the back of the accessory in the "SKIP" position.

The program control lever with the right side depressed.

For input, press the "REL" key three times and press the program control lever to the left, to put the first card in position to be read.

For output, press the "REL" key once, the program control lever to the left and the "REL" key once again, to put the first card in position to be punched.

Put a few blank cards at the end of a set of cards to be used.

Information Cards

Data is both read and punched in floating point notation.

On data cards for Intercom 1000 Single-Precision, each word consists of ten columns. The first two are blank; the third column holds the sign; the next two, the exponent in excess-fifty form; and the last five the decimal fraction. One to eight words may be punched on a single card.

On data cards for Intercom 1000 Double-Precision, each word consists of eighteen columns. The first three are blank; the next column holds the sign; the next two columns hold the exponent; and the last twelve hold the decimal fraction. One to four words may be punched on a single card.

On command cards, in both the single-precision and double-precision systems, each command consists of ten columns. The first three columns are blank; the fourth column contains the index register number or the number "zero", if no index register is used; the next two columns hold the operation code; and the last four columns the address. One to eight commands may be held on a single card.

The last command card processed must contain one word or more of "z punches" to signify end of input. The last input card processed is made consistent in form with the earlier-processed cards by placing "z punches" after the last command in all columns corresponding to columns normally read.

Program Control Cards

A program control card must be mounted in the IBM-026 for either input or output. The control card specifies which columns on information cards are to be processed. Instructions for preparing program control cards are listed below. Note that it is possible to use the same control card for input of single-precision data, single-precision commands and double-precision commands.

Input or output program control cards are mounted on the drum in the program unit of the IBM-026 in the manner described in the 026 Operating Manual.

To Prepare an Output Program Control Card

Columns on the output data card which are not to be punched are said to be "skipped". On the program control card, for each set of consecutive columns to be skipped, put an "eleven-punch" in the first column and "twelve-punches" in each following column.

To Prepare an Input Program Control Card

1. Place a "zero-punch" in each column on the control card that corresponds to the first digit of a word being read on the information card. Place "hold" or "twelve-punches" in each of the remaining, consecutive columns of the word to be read.
2. Place a "two-punch" in each column on the control card that corresponds to the last digit of a word on the information card.
   For double-precision data input only, place both a "two-punch" and a "zero-punch" in that column on the control card that corresponds to the second column before the sign column on the data card.
3. The control card may specify that certain columns on the information cards are not to be read. When columns are not read they are said to be "skipped." For each set of consecutive columns to be skipped, put an "eleven-punch" on the control card in the column corresponding to the first column to be skipped. In each remaining consecutive column to be skipped, put a "hold" or "twelve-punch."

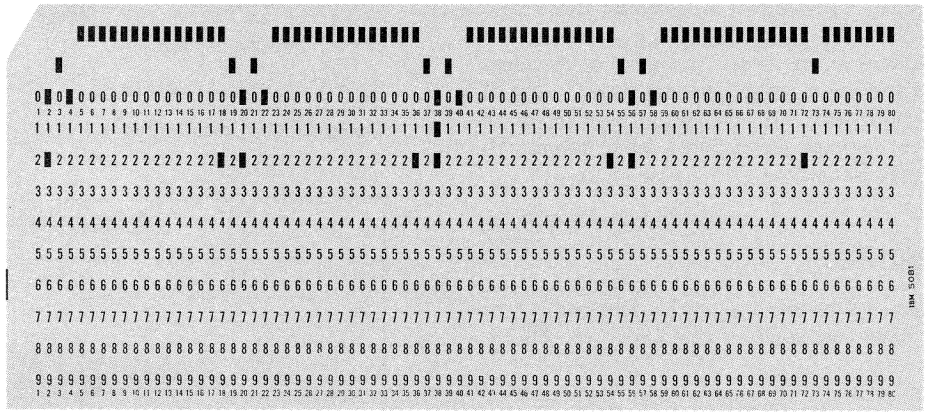
4. Put a "one-punch" on the program control card, if specified in the table below.

If number of words read from the Information Card is:	Put a "one-punch" in the second column after that "two-punch" which indicates the end of the:
Commands or Single-Precision Data	
5	1st word
6	2nd word
7	3rd word
8	4th word
Double-Precision Data	
3	1st word
4	2nd word

Sample Input Cards

The control card shown below will read in the information from the sample data card. The four numbers are read from columns 4 through 18, 22 through 36, 40 through 54, and 58 through 72. The first three columns of each double-precision word are blank: Columns 1-3, 19-21, 37-39, and 55-57. The two-punch in columns 18, 36, 54, and 72 indicates the end of each number. Both a two-punch and a zero-punch are placed two columns before the sign of each number, in columns 2, 20, 38, and 56. A one-punch is put in column 38, after the second word of input, since there are 4 double-precision words on the data card. An eleven-punch follows each two-punch, in columns 3, 19, 21, 37, 39, 55, 57, and 73. The remainder of the card, columns 74 through 80, contains twelve-punches since these columns are skipped.

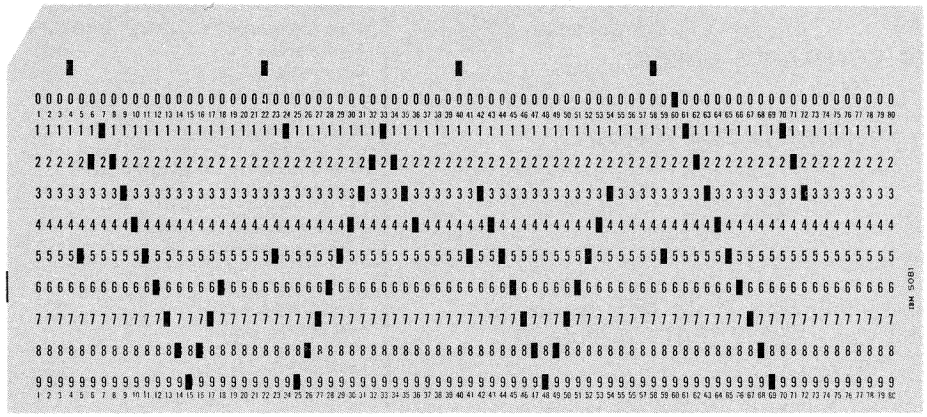
control card



The four double-precision numbers, in floating point form, punched in this card are:

−52.123456789876 −51.987654321234 −53.456789876543 −50.123456789123

data card



OPERATING SUMMARY

TO PREPARE FOR INTERCOM 1000 OPERATION

1. Intercom 1000 Master magazine, rewound, in photo-reader. Punch and Compute switches off, Enable switch ON.
2. Type "p".
3. Enable switch off, Compute switch to GO. When bell rings computer is in manual operating mode.

TO CLEAR MEMORY

1. Computer in manual operating mode. Compute switch off, Enable switch ON.
2. Type "p".
3. Enable switch off, Compute switch to GO.
4. To clear entire memory, including index registers, type "3 (tab) Ⓢ". To clear index registers, type "2 (tab) Ⓢ".
5. To return to manual mode, type "(tab)Ⓢ" or to select fraction length for fixed point type-out, type "-D(tab) Ⓢ" where D indicates the number of places to be typed after the decimal point. (Computer returns to manual code automatically.)

TO LOAD SUBROUTINES

1. Computer in manual operating mode. Appendix I or Appendix II tape magazine, rewound, in photo-reader.
2. Compute switch off, Enable switch ON, type "p".
3. Enable switch off, Compute switch to GO.
4. To read subroutine into memory, type "N(tab)Ⓢ". To read last subroutine into memory type "N-(tab)Ⓢ". When bell rings computer is in manual operating mode.

TO LIST SELECTED COMMANDS DURING COMPUTATION

1. Follow first three steps of "To Clear Memory".
2. Type "1 (tab) Ⓢ".
3. Type "(tab) Ⓢ".
4. Type "61 0000 (tab) Ⓢ".
5. To list every command, type "(tab) Ⓢ". To list selected commands, type "FIRST SELECTOR (tab) SECOND SELECTOR tab Ⓢ".

To terminate listing, put computer in manual mode and type "62 0000 (tab) Ⓢ".

TO CHANGE FROM AUTOMATIC TO MANUAL OPERATING MODE

1. Compute switch to BP, Compute switch off, Enable switch ON.
2. Type "Ⓢ cf".
3. Enable switch off, Compute switch to GO.

TO EXECUTE COMMANDS FROM KEYBOARD

In Manual Operating Mode: execute any command by typing command followed by "(tab) Ⓢ".

During Fixed Point Data Type-In, Floating Point Data Type-In or Command Type-In: execute any command by typing command in manner listed below:

Permit Fixed Point Data Type-In . . 0 51 ADDR / /(tab) Ⓢ

Permit Floating Point Data Type-In . . 0 52 ADDR / /(tab) Ⓢ

Permit Command Type-In . . . . . 0 50 ADDR / /(tab) Ⓢ

Permit Manual Operation . . . . . 0 67 0000 / /(tab) Ⓢ

Compute Automatically . . . . . 0 69 ADDR / /(tab) Ⓢ

SUBROUTINES

	TO CODE	TO LOAD	
Function	*Word Position*	*N Single-Precision*	*N Double-Precision*
Fraction Selector	08, 01-07	1 CH u0	1 CH u0
$\sqrt{x}$	97	2 CH u0	2 CH u0
$\log_e x$ $\log_2 x$ $\log_{10} x$	17 08 71	3 CH u0	3 CH u0
e^x 2^x 10^x	22 08 72	4 CH u0	4 CH 00
Sin x (degrees) Sin x (radians) Cos x (degrees) Cos x (radians)	39 42 23 26	5 CH u0	5 CH 00
Arctan x (radians)	24	6 CH u0	6 CH 00
Read Flexowriter command or data tape	17	7 17 u0	7 17 u0
Punch data tape for Flexowriter tabulation	75	8 16 u0	8 16 u0
Mag. tape input-output Reverse mag. tape Search mag. tape	70	9 18 00	9 18 00
Read data card Punch data card	05 10	10 16 u0	10 16 u0
Read command card	75	11 17 u0	11 17 u0

COMMAND LIST

Offices

Boston 16
607 Boylston Street
COngress 2-9110

Chicago 11
919 N. Michigan Avenue
MIchigan 2-6692

Cleveland 13
55 Public Square
CHerry 1-7789

Dallas 1
1511 Bryan Street
RIverside 7-8805

Denver 3
655 Broadway
Suite 910
ALpine 5-1403

Detroit 37
12950 West Eight Mile Road
JOrdan 6-8789

Kansas City 11, Mo.
3430 Broadway
VAlentine 1-8681

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291 S. La Cienega Blvd.
Beverly Hills, California
OLeander 5-9610

New York 17
205 East 42nd Street
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ORegon 9-6990

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GLencourt 2-3664

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