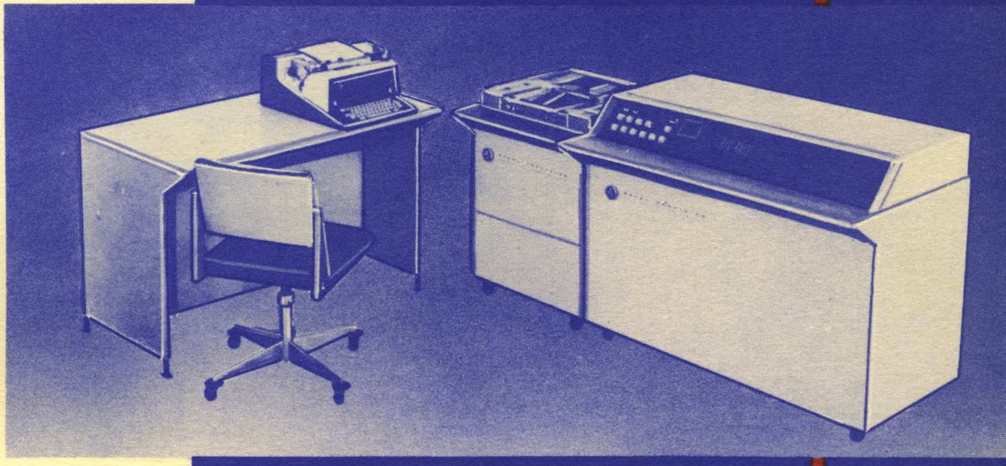
FEATURES MANUAL

4000 ELECTRONIC DATA PROCESSING SYSTEM

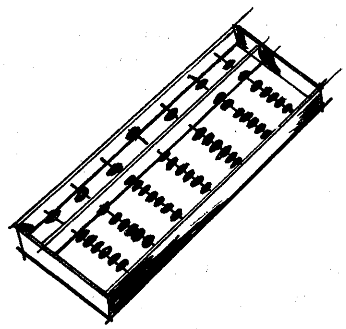


ROYAL McBEE *electronic data processing*

PORT CHESTER • NEW YORK

RPC 4000 FEATURES MANUAL

INTRODUCTION



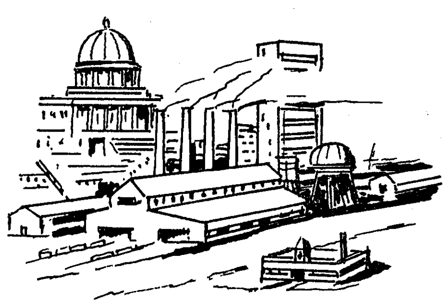
The emergence of the electronic computer as a major tool for Business and Industry is not surprising when it is considered that a very large part of today's total work effort is devoted to the processing of lengthy calculations or vast amounts of statistical data. Much of this computation involves wearisome repetition along with the necessity to utilize effectively a confusing array of interrelated information. It is just this sort of job that can be handled best by an intelligently directed machine. Not only can the computer perform these tasks many times faster, but with much more consistent accuracy than can the human worker.

The growth rate of the computer industry following great pioneer efforts has been truly fantastic. Digital computers are being entrusted with an ever-increasing share of the routine, repetitive functions of business and industry and in the case of highly complex mathematical problems, solutions can be provided swiftly and accurately—with great savings in both time and money.

It has only been in recent years that strides have been made in the area of reducing the physical size and cost of computer hardware. Advanced computer technology has been one answer; another has been the definition of user-requirements, eliminating guess-work on the part of the customer as to the type and size of computer equipment needed. The RPC-4000 embodies advanced computer know-how combined with the features and price-tag that make it both practical and economical to a wide gamut of Government, Business, and Industry applications.

DESIGN PHILOSOPHY

The design and features now available with the RPC-4000 are the result of long-range planning. An automatic digital computer should fulfill certain basic user-requirements. These include:

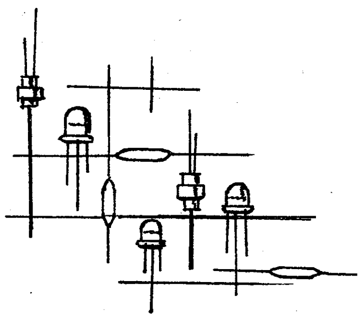


- The ability to perform the full complement of arithmetic functions.
- A memory capacity of sufficient size to handle the lengthy problems of today.
- Electronic Speeds combined with reliability and accuracy.
- Flexibility of application, providing for those users who may require higher speed input-output auxiliaries.
- Sensible pricing to make it not only a tool of the large firm, but a practical reality for the small-to-medium-sized firm.

Careful consideration was given to each of these items in designing the RPC-4000, and each was included in this desk-sized, yet powerful computer.

This manual is offered to discuss and portray many of the features of this new and dynamic computing system. This is not a "computer specialist's" manual, but one to provide generally a greater insight into the design, specifications and user-benefit features of a computer system built for sensible automation.

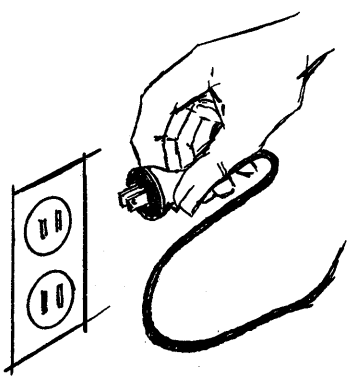
RPC-4000 SYSTEM DESCRIPTION



The RPC-4000 is a general purpose, "solid-state", fully transistorized, internally stored program electronic computer. It is desk-size, yet provides operating speeds, memory capacity and features normally associated with larger and more expensive computing systems. It has been designed to answer the computing needs of scientific, engineering and business data processing functions at a price which is both economically feasible and practical.

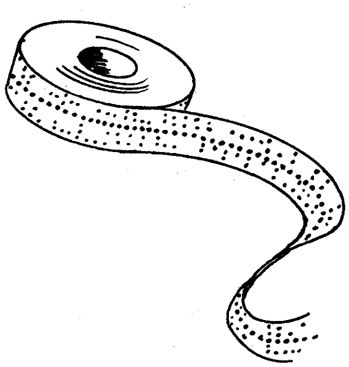
Larger firms can employ the RPC-4000 on a decentralized basis, or, in many cases, on an individual-departmental basis where sufficient volume of repetitive operations are performed or where complex mathematical problem solutions are required at great speed and accuracy.

Smaller or medium-sized companies can use the RPC-4000 on either a single or multiple application basis, depending on the area of application. This allows centralization of computing facility with resulting time and dollar savings as well as increased management control. The utilization of transistors enhances the system's reliability as well as decreases the space needed to house the computer. Floor reinforcement is no problem with a displacement factor of only 60 pounds per square foot.

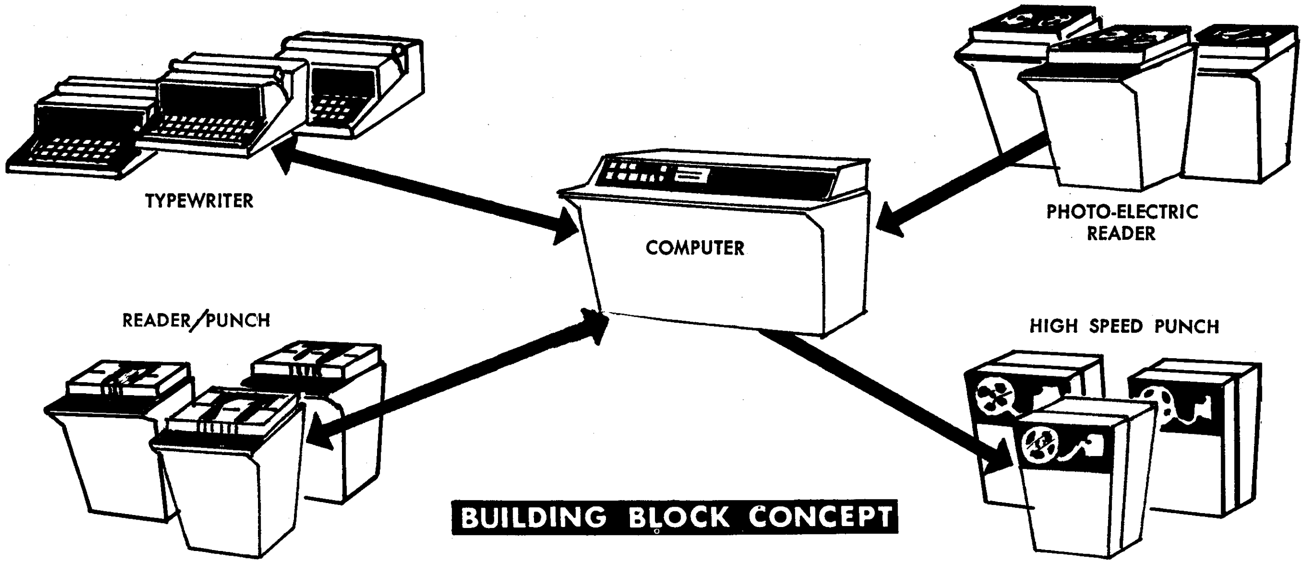


With the RPC-4000, there are no "hidden" site preparation problems; heat dissipation is minimal; standard 110-120 volt outlets provide the required power to operate the system; therefore,no air conditioning or special wiring is required.

As for computing speeds, the RPC-4000 is capable of 230,000 operations per minute. In addition to the basic system, high-speed auxiliary equipment is available for those users whose applications require added input or output speeds; equipment such as a 500-characters-per-second reader and 300-characters-per-second punch (tape). With its extremely large 8,008-word magnetic drum memory, problems of great magnitude and complexity can be processed.



With any computing system, speeds must be combined with accuracy and reliability. To provide accuracy and reliability, the RPC-4000 is equipped with a parity checking device on input which checks the validity of punched paper tape or typewriter input. In the event of error detection, the computer automatically stops, allowing the mistake to be corrected. The basic system consists of a model 4010 computer and model 4500 Tape Typewriter System, which is the primary input-output device. The Tape Typewriter System is comprised of a newly engineered Royal Electric Typewriter with associated electronic circuitry (Model RPC-4480) plus a combination punched paper tape reader and punch (Model RPC-4430).



As many as 45 input and output units may be connected on-line simultaneously and, with minor modifications, up to 60 devices may be connected.

The computer employs a "one-over-one" address system. An instruction consists of an order plus two addresses, whereby the first address contains the location of the operand (an item of information which is to be operated upon or one which enters into an operation); the second address contains the location of the next instruction to be executed. The principle benefit of this system of notation is higher operating speeds owing to more rapid program step execution.

With the RPC-4000, both alphabetic and numeric information may be stored and processed.

Four working registers perform all arithmetic and logical operations:

1. An upper accumulator
2. A lower accumulator
3. A command register
4. An index register

The role of each will be discussed in greater detail in a later section.

MACHINE LANGUAGE

BINARY SYSTEM

In order to facilitate computer efficiency, the language of the RPC-4000 system is binary notation. The binary system of notation consists of only two symbols, zero and one, whereas in the decimal, or "base ten" system, there are ten symbols ranging from zero through nine. Any quantity above nine is formed by combining the symbols 0 through 9. Each digit of a number in the decimal system is multiplied by consecutively higher powers of ten.

Thus the number four hundred and seventy-three is formed:

$$\begin{array}{ccccccc} 4 & & 7 & & 3 & & \\ 4(10^2) & + & 7(10^1) & + & 3(10^0) & = & 473 \end{array}$$

In the binary, or 'base two" system, a similar method is employed to derive quantities greater than one. Moving from right to left, each binary digit, or "bit", is multiplied by consecutively higher powers of two.

The number thirteen in binary form is written

$$\begin{array}{cccccccl} 8 & + & 4 & + & 0 & & 1 & \rightarrow \text{DECIMAL} \\ 1(2^{3}) & + & (1(2^{2}) & + & 0(2^{1}) & + & 1(2^{0}) & = 13 = 1101 \\ 1 & & 1 & & 0 & & 1 & \rightarrow \text{BINARY} \end{array}$$

In other words, the coefficients of the powered numbers are used to represent the binary number.

DECIMAL	BINARY
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010

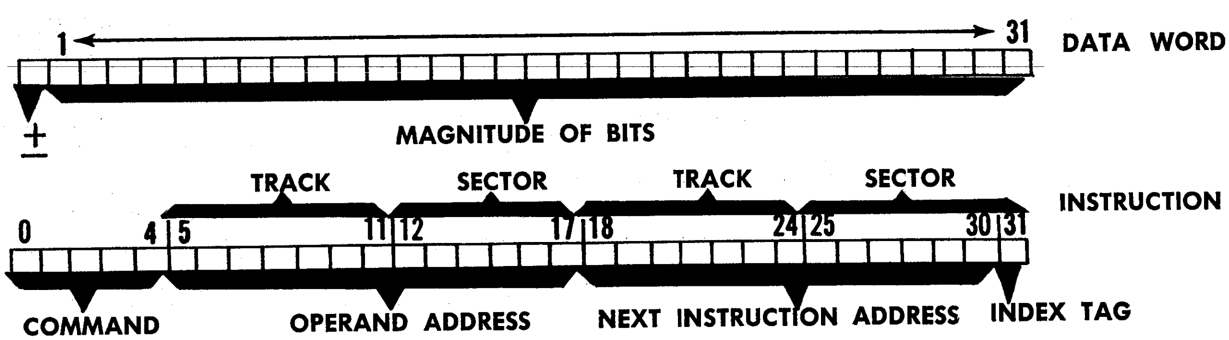
Table of decimal numbers and their conversions to four-place binary numbers.

WORD-STRUCTURE

The basic unit of information is called a "word." The word contains 32 bits (binary digits) and may represent either a "data word" or an "instruction word." When used for data, one bit of the word (furthest to the left) is used to signify an algebraic sign (positve or negative sign). The remaining 31 bits may represent up to 9 significant decimal digits.

When used to represent an instruction, the word may contain one complete basic command(five bits), an operand address (13 bits), a next-instruction address (13 bits), and an index tag (one bit). The command determines what type of operation is to be performed, i.e., addition, subtraction, division, etc. The operand address, as mentioned before, identifies the location within the memory of the quantities related to the operation. The next-instruction address is a word used to identify the location of the next-instruction, and the index tag specifies if the instruction is to be executed as it is recorded in memory, or if there is to be an instruction modification before execution. More clearly, if there is a zero present in the index tag position it means that the index register has no effect on the instruction that is being executed. If a one is present in the index register the operand address of the instruction being executed will be the sum of the operand address of the instruction as recorded in the memory and the contents of the index register. Thus, a programmer may modify an address by merely modifying the contents of the index register.

BASIC WORD STRUCTURE

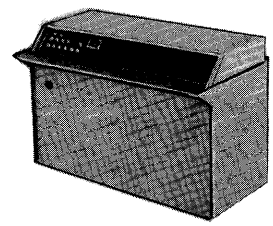


Data transfer is usually accomplished in one-word units. However, part of a word may be extracted and/or operated upon in certain instances at the discretion of the programmer. In addition, multiple words may be transferred in the repeat mode of operation.

WORD-TIME UNIT

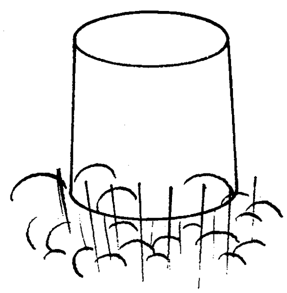
The fundamental unit of time is a "word-time" or the time required for word or sector to pass under a read head. Since the drum rotates at a speed of 3600 revolutions per minute, the duration of a word-time is 0.26 milli-seconds, or 260 micro-seconds.

RPC-4010 COMPUTER



The heart of the system is the advanced design RPC-4010 computer which contains the arithmetic and control registers, and internal memory. The computer operation is under the control of an internally stored program. The operator is provided with means to select any of a wide variety of modes; ascertain internal "states" by means of visual display; interrupt, intervene, and/or produce an alteration in the system program. This is accomplished through an array of indicators and manually operated switches conveniently located on panel controls.

MEMORY



The computer "memory" element is a unique 3600 rpm Magnetic Drum with a total storage of 8008 words. The "main memory" section contains 7872 words with an average access time of 8.5 milli-seconds. Additionally, there are 128 words with "dual-access" facility (described later) and eight words of high-speed memory with an access-time of one milli-second (ms) average, two ms MAXIMUM.

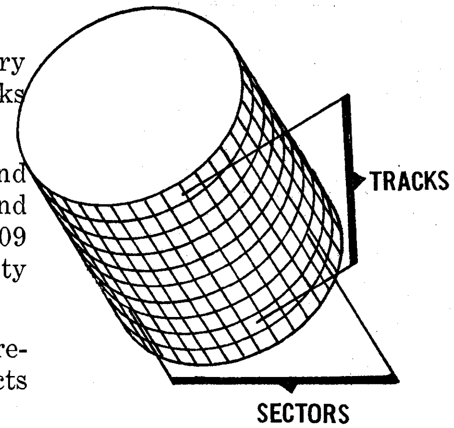
The memory unit is a non-volatile magnetic drum housed in a metal case which protects the unit from dust particles or accidental damage. When the machine is idle the drum rests safely away from the heads so as to prevent damage from physical contact. When the power is turned on, air pressure raises the drum to correct operating position allowing the drum to operate with minimal friction. Physical size has been kept to a minimum by the use of miniaturized heads.

MAIN-MEMORY

The main-memory surface of the drum contains 123 "tracks." Every track is divided into 64 sectors of 32 bits (one-word) each. The 123 tracks are "addressed" as 000 through 122 and the sectors as 00 through 63.

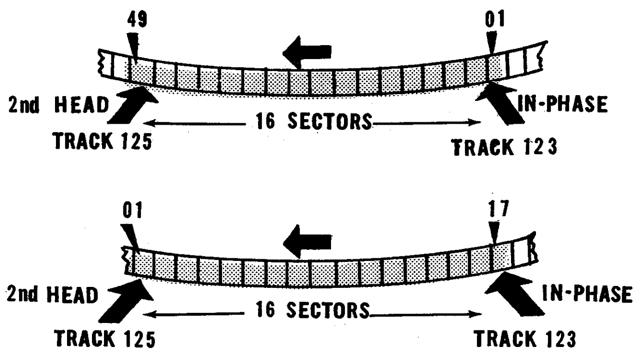
Any word location in main-memory is selected by specifying the track and sector addresses. Thus, word address 01723 designates the word found in track 17 at sector 23. Address 10961 designates the word in track 109 at sector 61. Hence, 123 tracks of 64 sectors (123 x 64) affords a capacity of 7872 words in main-memory.

Each track has one associated read-write head for data recording and retrieval. The track portion of an address (first 3 decimal digits) selects the proper magnetic head.

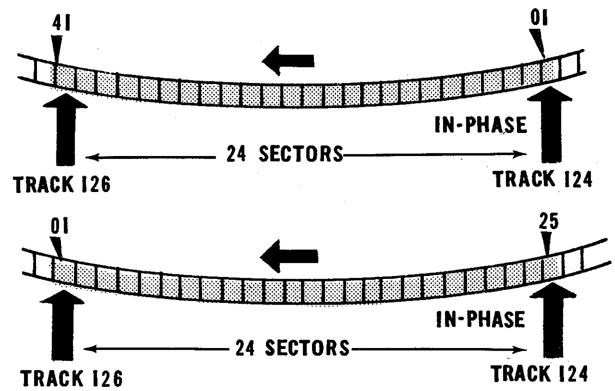


DUAL ACCESS STORAGE

In addition to the main-memory section, the drum contains two tracks with dual access to the data in each track.



One dual-access track has two read-write heads located 16 sectors apart with each separately addressed. Heads 123 and 125 are on this same track, but head 125 is 16 sectors "behind" 123; that is, a word will pass head 123 first then pass head 125 exactly 16 word-times later. Thus, any word on this track may be retrieved by either head. For example, Word in 12300 = 12516. Word in 12301 = 12517.

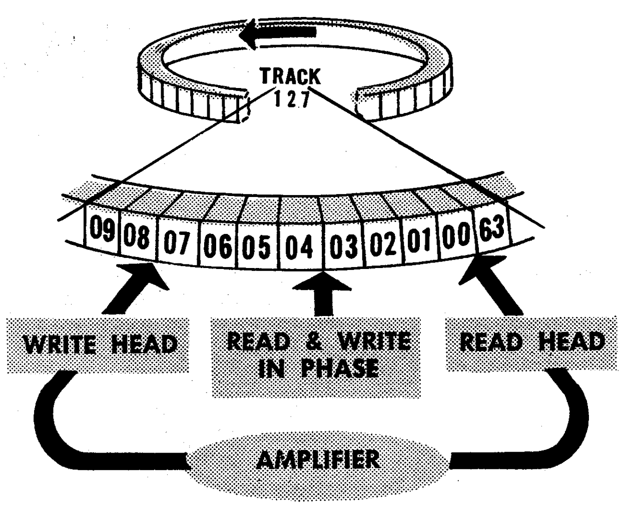


Similar characteristics apply to the second dual-access track which contains read-write heads 124 and 126. They operate on and share the same track, but head 126 is exactly 24 sectors behind 124. For example, Word in 12400 = 12624, Word in 12401 = 12625.

In each case, the lower numbered head is called the "reference" head because it is in phase with main-memory.

These dual-access tracks have an INITIAL access time of 8.5 milli-seconds (average). However, a second access to the same item of information may be effected in four or six milli-seconds.

EIGHT-WORD (HIGH SPEED) STORAGE



There is one track on the drum devoted to HIGH SPEED (access) storage. This is called an "eight-word high speed line," since eight words of information are duplicated eight times, and has a track address of 127. The sector address is modulo 8, thus sector designations 0, 8, 16, 24, . . . 56 all apply to the *same word.*

This high speed storage provides one milli-second (average) access-time to any of the eight words in the track. *Its primary value is for quicker access to data which is referred to many times by a program. The extremely rapid access affords significant advantages in program-execution time.*

Since eight sector addresses will select the same word, the programmer may select that one which affords minimum access time to the data in this line.

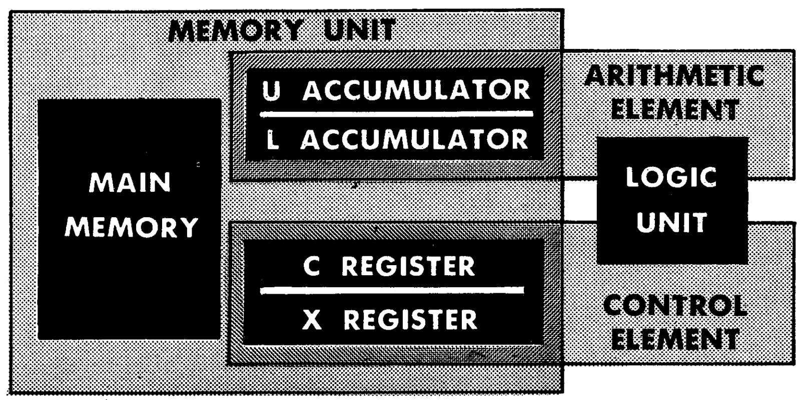
Note: The high speed line may be considered as eight "identical blocks" (utilizing a common drum track) of eight sectors each wherein the same eight words are recorded in all blocks but with non-conflicting, separate addresses. The read-write head is "in phase" with the main-memory and is used for data insertion and retrieval. The individual read-head and write-head are employed for the recirculation process only.

COMPUTING CONTROL

All computer functions are controlled by four registers and associated circuitry which comprise the arithmetic and computing control unit. The registers are recirculating lines physically located on the magnetic drum. Internal calculations are accomplished by directing information from the memory to the arithmetic unit, processing it, and directing it back to the memory or an output device. The control unit is the "nerve center" of the computer.

The four registers are designated as:

U—Upper accumulator L—Lower accumulator	In Arithmetic Unit
C—Command register X—Index register	In Control Unit



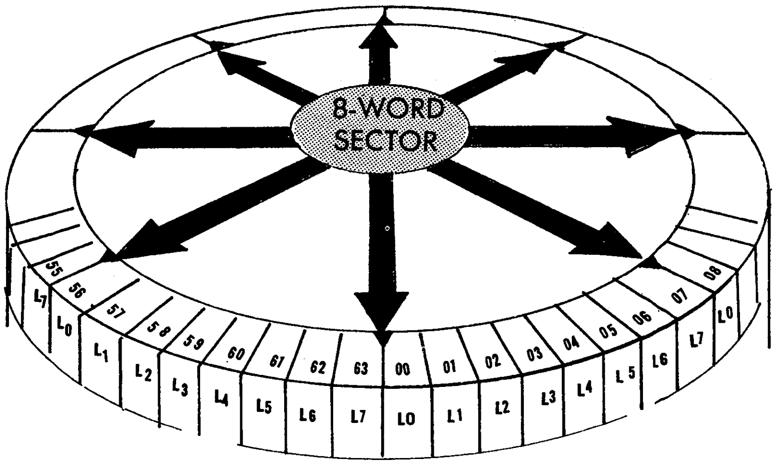
"U" REGISTER

The Upper Accumulator may contain the result of addition or subtraction, the quotient of a division process, or the sign and most significant half of a multiplication product. It is also used in comparisons. Prior to the execution of a command pertaining to this register it will contain one of the operands, the location of the other operand being specified by the instruction.

"L" REGISTER

The Lower Accumulator may contain the result of an addition or subtraction, the remainder in a division process, or the least significant half of a product. It is also used in making comparisons. Prior to execution of a command pertaining to this register it will contain one of the operands, the location of the other being specified by the instruction.

The Lower Accumulator is capable of being extended to eight one-word accumulators under program control. It is converted by means of two control bits which are a part of the command EXC (exchange) instruction word. When the eight-word Lower Accumulator is used the track is divided into eight sections or blocks of eight words each. This means that up to eight words of information may be either stored, transferred, added, subtracted, or multiplied by ten with only one command. For example, eight summations can be carried on with one set of instructions. Block transfer up to eight words at a time also becomes available through this feature, resulting in great savings of access time. The positions of the eight words are referred to as L_0, L_1, L_2, . . . L_7, and are determined by the sector part of the operand address. In other words, the sector address (modulo 8) will determine which one of the eight words will be affected.



Examples:

019*04* 04 (modulo 8) remainder is $4 = L_4$

037*11* 11 (modulo 8) remainder is $3 = L_3$

114*56* 56 (modulo 8) remainder is $0 = L_0$

In other words, an instruction with a data address of 10300 would affect L_0 as would 10308, 10316, 10348, etc. **Likewise, instructions with data** address of 06206, 02714, 11838 would affect L_6.

"C" REGISTER

The Command Register, C, contains the instructions being executed. Any instruction is composed of four parts, all of which must be present in each instruction. As previously indicated, an instruction word of 32 bits includes:

1. Command, five bits (0-4)
2. Operand address, 13 bits (5-17)
3. Next-instruction address, 13 bits (18-30)
4. Index tag, one bit (31)

"X" REGISTER

The Index Register, under program control, performs the following three functions:

1. Modifies addresses in the operand portion of the instruction word.
2. Stores the location of the operand when a successful comparison has been made.
3. Controls the number of times an instruction is to be repeated. (See "repeat execution.")

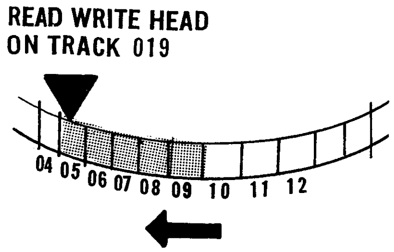
When used for address modification, the Index Register will contain a modifier which is added to any instructions that contain a bit (1) in the Index Tag position of the instruction. Only bits 5-17 (corresponding to the Operand address) are added to the instruction. The sum of the index register X and the tagged instruction is placed in the command register to be executed. The index register X and the instruction (in memory) are not changed by this sequence.

Example:

The computer is to execute the instruction (add upper accumulator) at location 02040, which is ADU 01744 01941 1. The index register contains 000 00203 00000 0. The adjunct instruction that would appear in the command register C is ADU 01947 01941 1, and this would be the actual instruction executed.

REPEAT EXECUTION

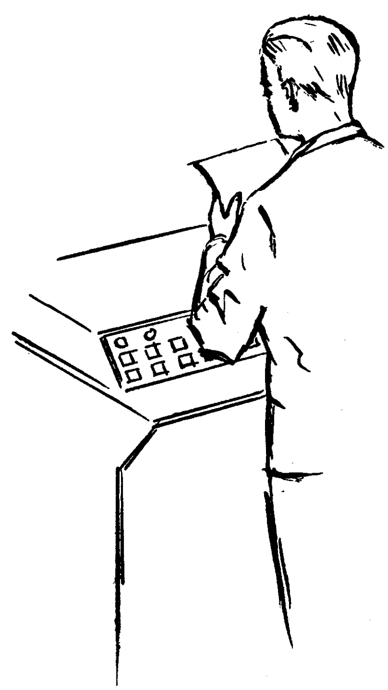
The repeat execution feature is a mode in which the execution phase of an instruction may be extended up to 128 times.



In the illustration, the read-write head on track 19 is typical of all main-memory. Assume it is reading the word at sector 05 which is going through "add" circuits and being added to the upper accumulator. This circuit is normally active only for one-word-time; in this case the time the read-write head is over sector 05. The repeat execution function keeps this circuit active for up to 127 more word-times. If the "add upper accumulator" instruction ADU 01905 XXXXX 0 were repeated four times, the contents of 01905 through 01909 would be added to the upper accumulator.

A seven bit portion of the Index Register is used to control the number of times the instruction is to be repeated. The portion used corresponds to the track position of the "next-instruction address" in the Index Register X, bits 18-24. During a repeat execution, operation is restricted to the same track. If the full number of 128 arithmetic functions is required, for example, this will require two full drum revolutions; i.e., 0-63, or from whatever position on the drum (sector) that repeat execution is commenced.

The repeat control and extension of the lower accumulator to eight words can be used together for eight word block transfer and eight word block arithmetic. Another function of the repeat mode is its use with certain instructions to compare the Upper Accumulator with the contents of given main-memory locations.



When the comparison test begins, the sector location is copied into the six bits (25-30) of the index register (X), and is always *one sector ahead* of the actual sector under the read-write heads.

When a comparison is *true*, the branch control toggle, BC, is turned on and the sector location is no longer copied into the index register. The comparison continues, however, for as many word times as there are left in the repeat control portion of the index register.

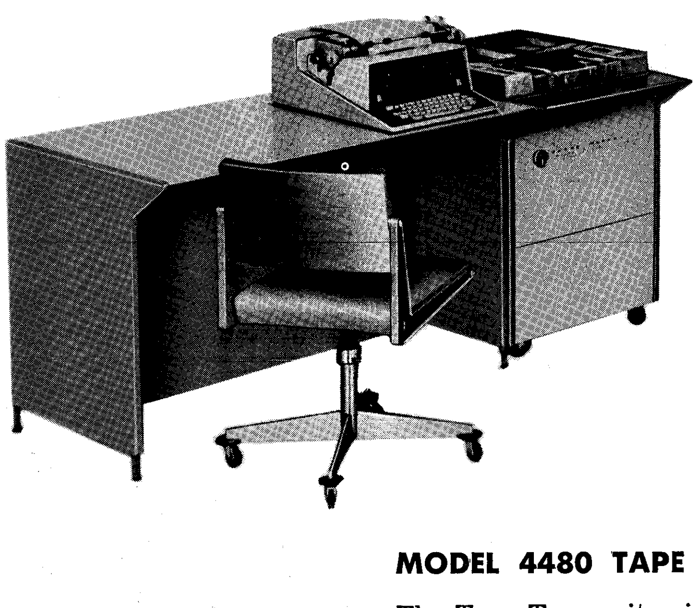
The programmer may determine *if* a comparison was made by testing the branch control toggle, BC, and the location at which it was made, by transferring the contents of the index register to the upper accumulator (by an EXC command) and examining the sector portion. The track portion must be the same as the compare instruction since the repeat command cannot change the track address.

BRANCH CONTROL

The Branch Control, a one bit storage element, is a controlling device used to control normal programming sequence and overflow conditions (the generation, in a computer register, of a quantity beyond the capacity of the register). In reality, the BC is a "flip-flop" switch which is automatically turned on when an overflow condition occurs, or when successful main-memory comparisons have been made according to prescribed instructions. The BC then can be examined and, depending on its state, transfer to one of two alternate paths and execute the specified instructions.

RPC-4500 TAPE TYPEWRITER SYSTEM

The basic input-output unit of the RPC-4000 is the Model RPC-4500 Tape Typewriter System. It is composed of a Model 4430 Punched Paper Tape Reader/Punch and a separately packaged Tape Typewriter, Model 4480. These two units are inter-connected to form a multiple-function system capable of a wide variety of operations, both off-line and on-line.



MODEL 4430 READER/PUNCH

The Reader/Punch unit provides communication both into and out of the computer via punched paper tape. The reader portion is capable of operating up to 60 characters per second, while the punch operates up to 30 characters per second.

The effective speed of any combination is "interlocked" to maintain compatibility. Parity checking is effected through the reader/punch to insure maximum accuracy.

MODEL 4480 TAPE TYPEWRITER

The Tape Typewriter is designed to meet the standards and specifications of the RPC-4000 system. Its maximum typing speed is 10 characters per second, and it is capable of manual or automatic control. At the time of input, paper tapes can be typed for hard copy proof, can be repunched to obtain duplicate tape, or both, under operator or automatic control.

"Single character entry" mode facilitates conversion of tapes for other make machines with proper programming. If code deletion is desired the typewriter is equipped with a special key to be used with the backspacer which allows the operator to backspace both tape and carriage. Keyboard operation is identical to conventional typing practices. Margin control is achieved easily and conveniently at the keyboard as is tab-stop setting and release. The typewriter is installed on a special console which provides adequate workspace to the left of the keyboard. The complete system includes an operator's chair of matching design.

AUXILIARY EQUIPMENT

An RPC-4000 may be augmented with specially designed optional input-output devices as warranted by the need or preference of any application.

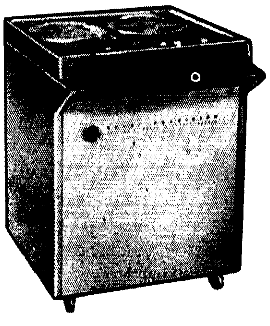
Presently available are:

Model 4410	Photo-Electric Tape Reader
Model 4431	Auxiliary Read-Punch Unit
Model 4440	High Speed Punch
Model 4480	Auxiliary Tape-Typewriter
Model 4600	Auxiliary Tape-Typewriter System

These units may be added to the RPC-4000 as desired up to a total of 22 input and 23 output units on-line concurrently; and, with minor modifications, up to 60 on-line units may be attached. The computer (Model 4010) exercises control, as programmed, over "selection" of input and output devices. Further, the computer may select four or six bit inputs as well as choose either typed copy and/or duplicate tapes to be made from input.

All input data is parity checked for code pattern validation. Output data codes contain proper parity bits in the seventh level for subsequent accuracy control.

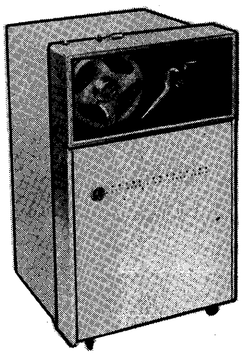
RPC-4410 PHOTO-ELECTRIC READER



The model 4410 Photo-Electric Reader is a high-speed "input" device for the RPC-4000 computer. Capable of reading punched paper tape at 500 characters per second, this unit is separately packaged in a matching cabinet which provides tape-handling facilities. Tape may be sensed in forward or reverse direction with equal ease. Also, tape may be searched for a special code in either direction while the computer accepts input, emits output, or computes.

The RPC-4000 computer ability to handle 45 on-line input-output devices, (60 with minor modifications), plus the Model 4410 speed and bi-directional reading and search, offer an unusual facility for applications wherein paper-tape may be used for unlimited computer "memory" to augment the main-memory of the computer.

RPC-4440 HIGH SPEED PUNCH

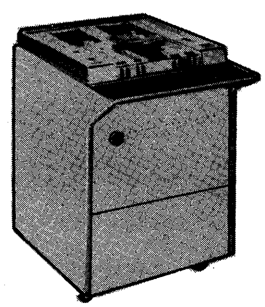


The High Speed Punch is capable of perforating paper tape at the rate of 300 characters per second. It is designed for ON-LINE operation with (and under control of) the 4010 computer.

The Model 4440 is an optional output device which may be added to any 4000 system. In extremely high-volume output applications, one or more of these chad tape punches will obtain easily the results desired.

RPC-4431 AUXILIARY READER-PUNCH

The reader-punch combination unit may be used as a separate optional input-output unit as well as a component of the Model 4600 Tape Typewriter System. This electro-mechanical punched paper tape reader and perforator provides additional computer input of 60 characters per second and output of 30 characters per second. This individually packaged unit includes tape handling and chad collection facilities. Either reeled or strip tapes may be handled with equal ease. Safety inter-locks are provided to assure proper operation of either or both elements.



RPC-4600 AUXILIARY TAPE TYPEWRITER SYSTEM

This is identical to the RPC-4500 unit with the exception that it does not have the Master Input-Output Controls. It consists of a RPC-4431 and a RPC-4480.

The basic character and codes for all input-output devices are shown in the table.

The parity level is not considered in this table. The parity level should be in the left-most channel, and the other channels are represented in sequence.

TABLE OF BASIC CHARACTERS AND CODES

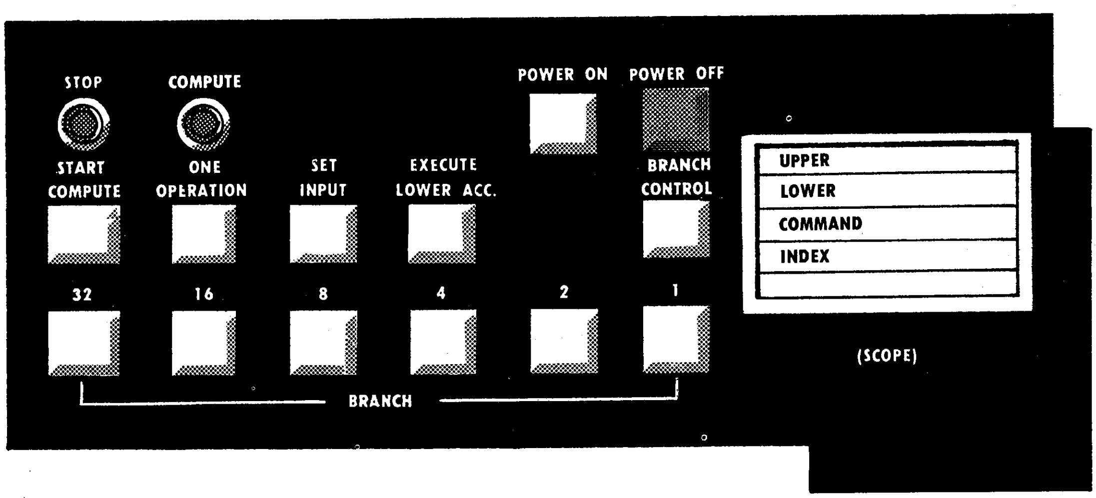
0. Tape Feed	16. 0)	32. g G	48. w W
1. CR	17. 1 °	33. h H	49. x X
2. tab	18. 2 "	34. i I	50. y Y
3. BS	19. 3 #	35. j J	51. z Z
4. CS	20. 4 Σ	36. k K	52. , $
5. UC	21. 5 △	37. l L	53. = :
6. LC	22. 6 @	38. m M	54. [;
7. L.F.	23. 7 &	39. n N	55.] %
8. *Stop Code	24. 8 '	40. o O	56.
9.	25. 9 (	41. p P	57.
10.	26. a A	42. q Q	58. + ?
11.	27. b B	43. r R	59. - —
12.	28. c C	44. s S	60. . .
13.	29. d D	45. t T	61. space
14.	30. e E	46. u U	62. / ÷
15.	31. f F	47. v V	63. Delete

Note: Tape codes "00 through 15" and "63" do not enter the computer in normal mode.

SYSTEM CONTROL

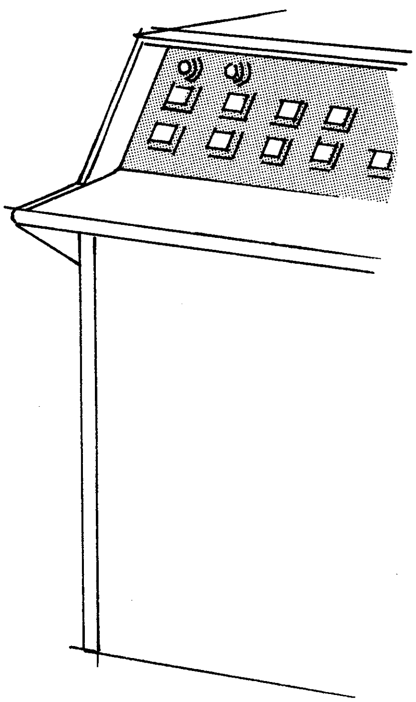
A brief description of all controls and indicators is presented as an elaboration of the "legends" appearing on the panel escutcheon plates. All components of the panel are clearly and accurately identified by title of function or related action.

COMPUTER CONTROL



Operational control of the computer is effected through the control panel of the 4010 computer. The location, arrangement, and components of this panel provide operator convenience in system control and supervision.

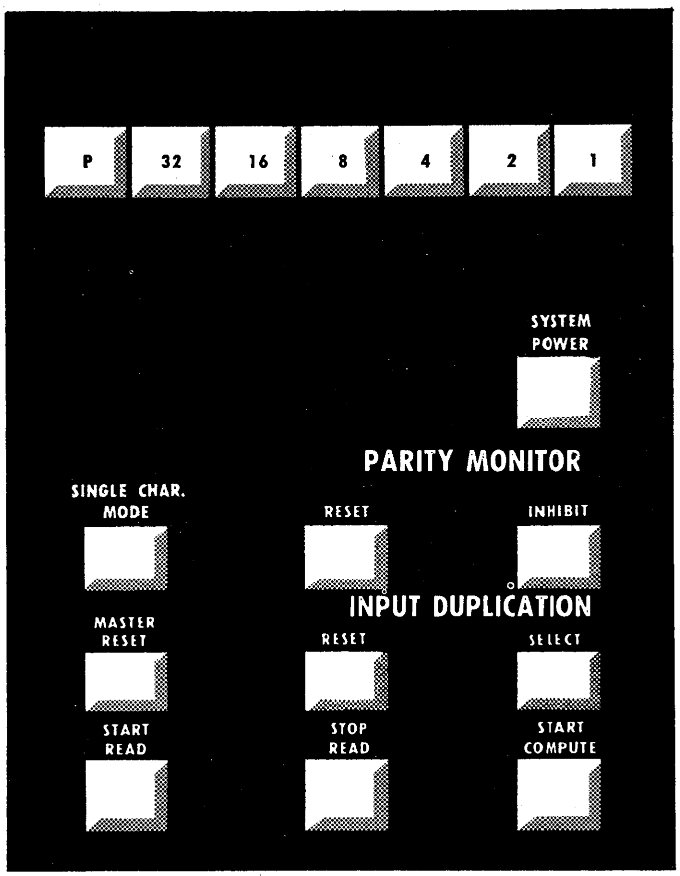
CONTROL OR INDICATOR	FUNCTION
Power On	A momentary switch which turns "on" the electrical power.
Power Off	Momentary switch turns the power "off".
Stop	This light glows when the computer is NOT executing instructions.
Start	Momentary switch initiating program execution.
Compute	Light glows to indicate the computer IS executing instructions.
One Operation	A two-position selector switch, when depressed, will cause the computer to stop after execution of one instruction. When raised, it permits the computer to operate at high speeds in the normal instruction-execution mode. This switch is illuminated in the depressed position.
Set-Input Mode	A momentary switch used in conjunction with a depressed "one-operation" switch to cause the following actions: 1. Zeroize the track portion of the command register. 2. A four-bit input order given. 3. Set lower accumulator to one-word length.
Execute Lower (two positions)	A two-position switch used in conjunction with the one-operation switch depressed. It causes the word contained in the Lower Accumulator to be transferred into the Command Register and to execute when a start signal is received.
Branch Control	Momentary switch used to reset (turn off) the Branch Control, provided the one-operation switch is in the depressed position. This switch is illuminated when the Branch Control toggle BC is ON.
Branch Switches 32-16-8-4-2-1	Two-position switches used in conjunction with the sense instruction. Each switch is lit when depressed.
Oscilloscope	Displays a visual representation of the contents of the registers in the computer, in the form of square waves.
L-Display	A rotary (eight-position) switch used to alter the oscilloscope display of the lower register. If the Lower Accumulator is set to eight-word state, any of those eight words may be selected for (scope) display by rotating this switch to the related position.

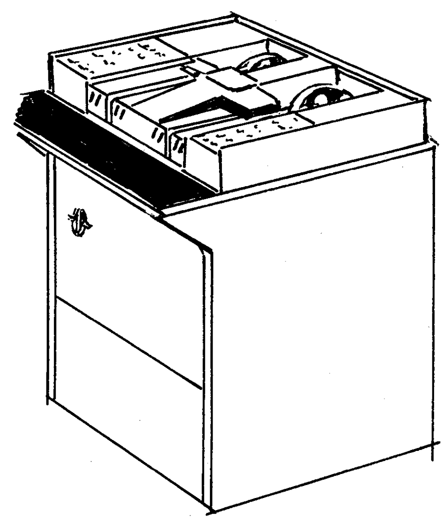


MASTER INPUT-OUTPUT CONTROL

The RPC-4000 provides the facility of either: computer-program control of the several input-output devices (RPC-4500/4410/ and 4440) or manual-control of such units.

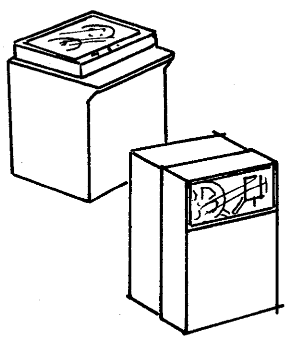
Program control of the input-output is exercised through a "master input-output control" unit contained within the basic RPC 4500 Tape Typewriter system. The control panel is located on the system and is described as follows:





CONTROL OR INDICATOR	FUNCTION
System Power	A two- position switch used to turn ON or OFF electrical power to all input and output devices connected to the system. Individual power ON-OFF switches of each device are "in-series" with this system power switch so that both must be in the ON position to make a unit operable. This switch is illuminated in the ON (depressed) position.
Single Character Mode	A two-position switch, when depressed, causes the input to halt and the computer to start after each character is read. When in the raised position it permits normal operation.
Parity Monitor RESET	Momentary switch used to RESET a "parity-error-stop" toggle which halts the computer in case a parity-error was detected. Indication of a parity-error is provided by a light (in the reset switch) which glows when the computer stops for this reason.

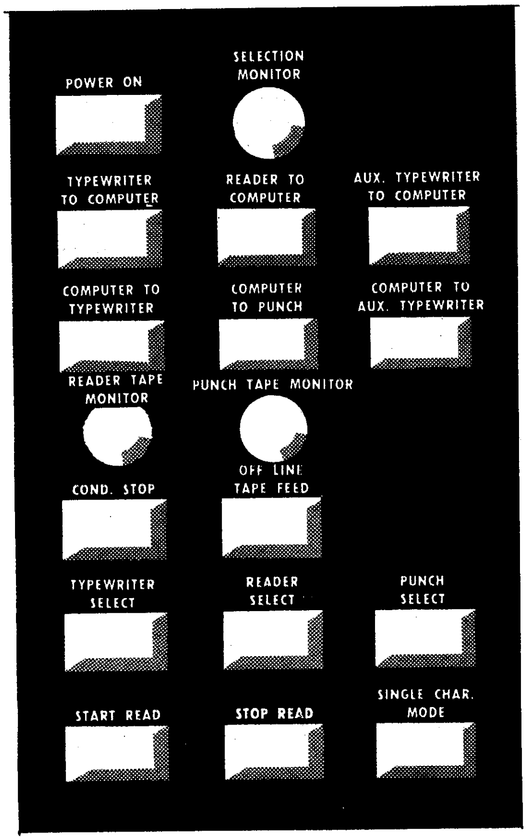
CONTROL OR INDICATOR	FUNCTION
Parity Monitor INHIBIT	This two-position switch is used to (A) inhibit parity-error-detection, or (B) enable parity checking. A. When depressed, parity checking is inhibited and the self-contained lamp will be lit. B. In raised position, parity-checking is enabled.
Master RESET	A momentary switch used to "disconnect" all input-output units from the computer.
Input Duplication SELECT	The momentary switch is used to turn ON the feature of Input-duplication whereby selected output devices "duplicate" (make an exact copy of) the input data as it enters the system. Note: This feature of ON-LINE regeneration of input data concurrent with system-entry provides an extremely valuable and unique verification benefit.
Input Duplication RESET	This momentary switch is used to turn OFF the feature of Input-Duplication.
Start Read	This is a momentary switch by which the selected reader-operation may be initiated.
Stop Read	Momentary switch used to halt operation of the selected reader.
Start Compute	Momentary switch initiating program-execution by the computer.
Character Indicator Lights	These lights represent the bit-pattern of the character code. They are illuminated to show the NEXT character-code to be read into the system by the reader of the RPC-4500.

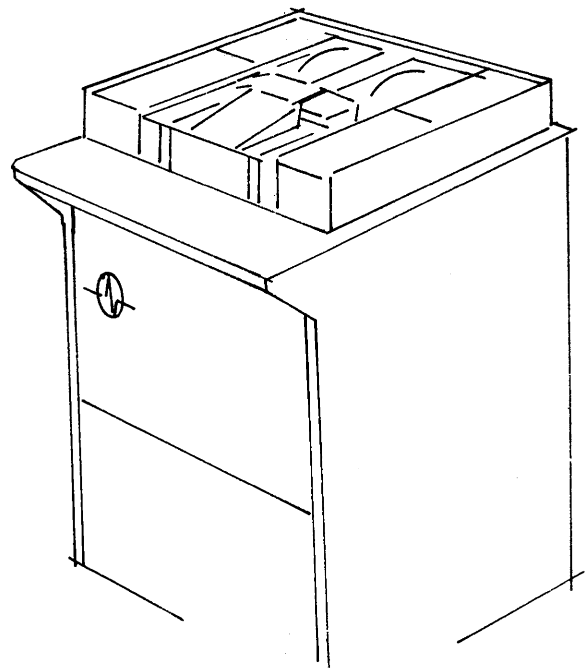


TAPE TYPEWRITER CONTROL (RPC-4500/4600)

In addition to its role as the basic input-output unit for the RPC-4000, the Tape Typewriter System may be used Off-Line as a tape-controlled, tape-producing, manual and/or automatic electric typewriter. The control panel for the tape typewriter is located on the top left-hand side of the Reader Punch cabinet, and is described as follows:

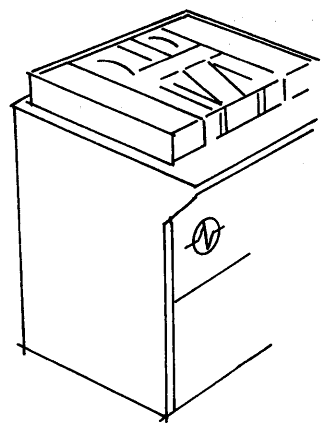
CONTROL OR INDICATOR	FUNCTION
Power	Two-position switch used to turn ON or OFF the electrical power to the RPC-4500. It is illuminated in the ON (depressed) position.
Selection Monitor	This light is illuminated to indicate the improper OFF-LINE condition of a "selected" component (of the RPC-4500). Only an ON-LINE device may be selected; the conditional state is monitored by this indicator.



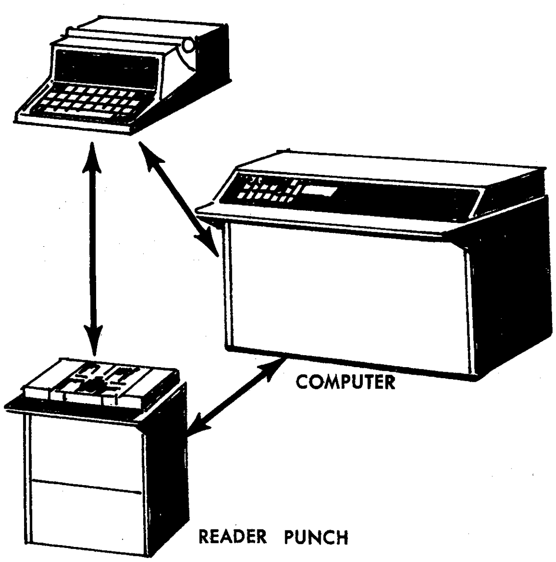


CONTROL OR INDICATOR	FUNCTION
Typewriter to Computer	A momentary switch used to establish the typewriter-to-computer inter-connection. It is illuminated to indicate the typewriter has been "selected" for computer-input.
Reader to Computer	This momentary switch establishes the reader-to-computer inter-connection. It is illuminated to indicate the reader has been selected for computer-input.
Auxiliary Typewriter to Computer	Identical to "typewriter to computer" except that it relates to the auxiliary (secondary) typewriter if included in the system.
Computer to Typewriter	This momentary switch establishes a computer-to-typewriter inter-connection. Illuminated, it indicates the typewriter is "selected" for computer output.
Computer to Punch	A momentary switch establishing computer-to-punch inter-connection. When lit it indicates the punch is "selected" for computer output.
Computer to Auxiliary Typewriter	Identical to "computer to typewriter" except that it relates to the auxiliary (secondary) typewriter if included in the system.
Reader Tape Monitor	An error light which indicates: A. Reader out of tape, or B. Reader tape jammed.

CONTROL OR INDICATOR	FUNCTION
Punch Tape Monitor	Same as above except concerns punch.
Conditional Stop	A two-position switch that conditions the reader to: A. Halt operation upon sensing a "STOP-CODE", or B. Ignore such codes. It is illuminated in the depressed position.
Tape Feed	This momentary switch will cause punching of guide (sprocket-feed) holes ONLY in the paper tape for as long as it is held down.
Typewriter Select	A two-position switch used to place the typewriter "OFF-LINE" when depressed.
Punch Select	Same as above except for punch.
Reader Select	Same as above except for reader.
Start Read	A momentary switch used to start operation of the reader when it is in the "OFF-LINE" state.
Stop Read	A momentary switch used to stop reader operation when in the "OFF-LINE" state.
Single Character Mode	A two-position switch used to: A. Stop the OFF-LINE reader after one-character is read. (When this is depressed each depression of the start-read switch will cause reading of only one character.) B. Permit normal reading in OFF-LINE state.



ON-LINE OFF-LINE



All units switched to OFF-LINE state are automatically interconnected, for example:

Typewriter to punch if both OFF-LINE.
Reader to typewriter if both OFF-LINE.
Reader to punch if both OFF-LINE.
Reader to typewriter to punch if all OFF-LINE.

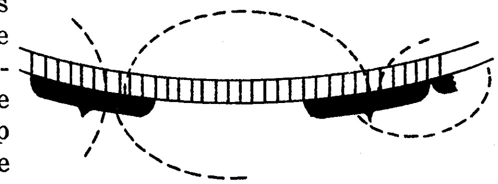
Any unit can be switched OFF-LINE while others are operating ON-LINE.

COMPUTER INSTRUCTION

A typical instruction-cycle proceeds in the following manner:

1. The word contained in the location shown by bits 18-30 ("next-instruction address") of the command register is transferred *into* the command register, replacing the previous contents of that register.
2. The instruction in the command register (as a result of 1 above) is executed. Information is transmitted according to the particular operations demanded by the instruction.

This completes an INSTRUCTION CYCLE, whereupon the computer looks for the next-instruction word and begins the next cycle (step 1). This sequence is followed by the computer for all instructions except when the next-instruction being transferred from memory contains a bit in position 31, the "index tag". In this case the operand-address is added to the corresponding $(X)_{5\,17}$ (operand-address) in the command register (step 2). The addition is performed as the word is being transferred *into* the command register.

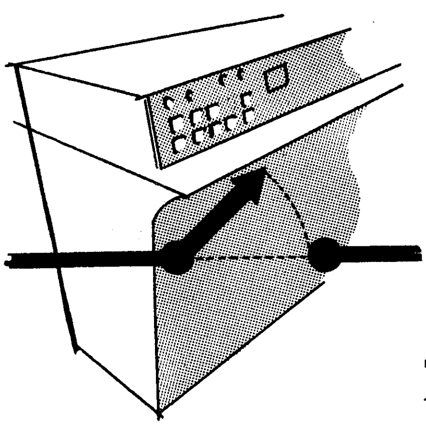


COMMANDS

Listed are the various computer commands, showing:

- **Decimal Code**
- **Binary Code**
- **Mnemonic Code**
- **Brief Description**

00 00000 SNS (Sense)
The 00 command with an operand track number of zero halts the computer in Phase 3 Blocked State. The 00 command with a non-zero operand track number does not stop but may turn on the branch control. BC is turned on with a track number of 64 or greater if no input device is selected or if any input or output device is not ready, but for a track number of 63 or less, at least one sense switch corresponding to a "1" bit in the track number must be on.



01 00001 CXE (Compare Index Equal)
The 01 command tests for equality between its operand address and the operand address portion of the index register, X. If there is equality, the branch control, BC, is turned on or left on. If there is any difference, BC is turned off or left off. If this instruction is given a zero operand address and is address modified, (i. e.,there is a 1 in the least significant bit of the instruction), it becomes an unconditional set sense toggle on.

02 00010 RAU (Reset and Add Upper)
The 02 command replaces the contents of the upper accumulator, U, with the addressed word from memory.

03 00011 RAL (Reset and Add Lower)
The 03 command replaces the contents of the lower accumulator, L, with the addressed word from memory.

04 00100 SAU (Store Address Upper)
The 04 command records, in the addressed word in memory, the content of the upper accumulator, U, in the operand address portion. The rest of the word in memory is unaffected.

05 00101 MST (Masked Store)

The 05 command records, in the addressed word in memory, the content of the lower accumulator, L, in those bit positions occupied by a mask in the upper accumulator, U. Where there are ones in U, recording takes place, and where there are zeros in U, the memory word is unaffected.

06 00110 LDC (Load Counter)

The 06 command loads the repeat count from the addressed word of memory into the index register, X, and causes Repeat Mode to be entered for the next instruction executed. The repeat count is held in the next instruction track number part of X, and comes from the corresponding portion of the word in memory.

07 00111 LDX (Load Index)

The 07 command loads its operand address in the operand address portion of the index register, X. The remaining portion of X is unaffected. If this command is index modified, its effect is to add its operand address to X.

08 01000 INP (Input)

The 08 command sends a start read signal to the input-output unit and prepares the computer to load incoming characters into the double-length accumulator, composed of U and L. When given an operand track number of 63 or less, *four* bits are entered from each character read. These are the four least significant bits of each character. When given an operand track number of 64 or more, all six bits are entered from each character.

09 01001 EXC (Exchange)

The 09 command effects full word transfers and exchanges among the upper accumulator, U, the lower accumulator, L, and the index register X. It also controls lengthened mode. The less significant 6 bits of the operand track number control these functions separately, but may be combined when the combination is meaningful.

MEANING OF THE BITS

BIT	FUNCTION
1	Copy U into L
2	Copy L into U
4	Copy U into X
8	Copy X into U
16	Go into lengthened mode
32	Go out of lengthened mode
(64)	No effect

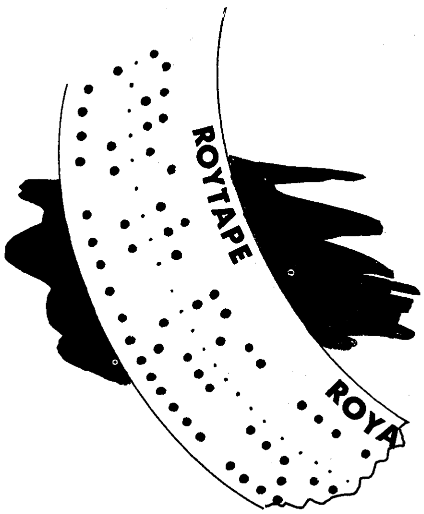
10 01010 DVU (Divide Upper)

The 10 command divides the content of the upper accumulator, U, by the addressed word in memory. The unrounded quotient appears in U and the remainder, positive, and less than the magnitude of the denominator, appears in L, in normal numeric form. Any previous content of L is discarded.

11 01011 DIV (Divide)

The 11 command divides the double length content of the combined upper and lower accumulator by the addressed word in memory. The numerator must be in double length format, the lower half containing no sign bit, but a non-significant bit on the least significant bit position. The unrounded quotient appears in the upper accumulator and the remainder appears in the lower accumulator in normal numeric form.

$$N=DQ+2^{-31}R$$



12 01100 SRT, SLT (Shift Right, Shift Left)

The 12 command effects a right or left shift on the double length content of the upper and lower accumulator. The lower accumulator content is assumed to be in double length form with no sign bit. The operand sector number controls the number of places shifted. The least significant bit of the operand track number controls right or left shifting, a "0" shifting right and a "1" shifting left.

13 01101 SLC (Shift Left and Count)

The 13 command normalizes the double length content of the upper and lower accumulator. The lower accumulator content is assumed to be in double length form with no sign bit. Only the more significant half of the normalized number is retained, appearing in the upper accumulator. The lower accumulator contains the normalize count (the number of places shifted) as an operand sector number.

14 01110 MPY (Multiply)

The 14 command multiplies the upper accumulator (content) by the addressed word in memory. The double length product is left in the upper and lower accumulator, with the lower accumulator content in double length form. Previous content of the lower accumulator is discarded.

15 01111 MPT (Multiply by ten)

The 15 command multiplies the upper or lower accumulator content by 10. The most significant bit of the operand track number controls which; a "0" applying to the upper and a "1" to the lower.

16 10000 PRD (Print from Data Address)

The 16 command presents its operand track number as an output to the input-output section. Normally, track numbers of 0 to 63 are regarded as characters to be printed or punched and track numbers of 64 to 127 are control functions.

17 10001 PRU (Print from Upper)

The 17 command presents the most significant 4 or 6 bits of the upper accumulator, U, as an output to the input-output section. A 64-bit of "1" in the operand address results in the 6 bit form. A 64-bit of "0" results in the 4 bit form.

18 10010 EXT (Extract)

The 18 command extracts the upper accumulator with the word adressed from memory (i.e., 1's are kept in U only where both words have 1's).

19 10011 MML (Masked, Merge, Lower)

The 19 command collates the lower accumulator with the addressed word from memory under control of a mask in the upper accumulator. The content of L is kept where U has 0's and is replaced by memory where U has 1's.

20 10100 CME (Compare Memory Equal)

The 20 command compares the upper accumulator with the addressed word in memory through a mask in the lower accumulator. If the two words are equal in bit positions where L has 1's, the branch control is turned on.

21 10101 CMG (Compare Memory Greater)

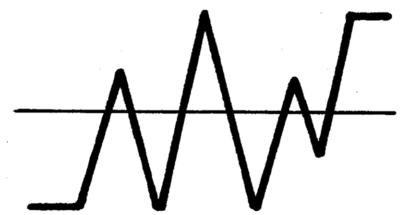
The 21 command compares the upper accumulator with the addressed word in memory through a mask in the lower accumulator. If the word from memory is equal to or greater than the upper accumulator in bit positions where L has 1's, the branch control is turned on. The sector number following the last sector compared, or one after the first successful comparison (when the command is repeated) is put into the index register in the next instruction sector position.

22 10110 TMI (Transfer on Minus)

The 22 command tests the sign of the upper accumulator. If negative, the operand address is used to locate the next instruction.

23 10111 TBC (Test Branch Control)

The 23 command tests the Branch Control, BC. If on, the operand address is used to locate the next instruction.



24 11000 STU (Store Upper)

The 24 command stores the content of the upper accumulator in the addressed location in memory. The accumulator content is undisturbed.

25 11001 STL (Store Lower)

The 25 command stores the content of the lower accumulator in the addressed location in memory. The accumulator content is undisturbed.

26 11010 CLU (Clear Upper)

The 26 command stores the upper accumulator content in the addressed location in memory, setting the upper accumulator to zero. The lower accumulator is undisturbed.

27 11011 CLL (Clear Lower)

The 27 command stores the lower accumulator content in the addressed location in memory, setting the lower accumulator to zero. The upper accumulator is undisturbed.

28 11100 ADU (Add to Upper)

The 28 command adds the addressed word in memory to the upper accumulator. If the result is less than -1 or greater than $1\text{-}2^{-31}$, overflow occurs and the branch control, BC, is turned on.

29 11101 ADL (Add to Lower)

The 29 command adds the addressed word in memory to the lower accumulator. If the result is less than -1 or greater than $1\text{-}2^{-31}$, overflow occurs and the branch control, BC, is turned on.

30 11110 SBU (Subtract from Upper)

The 30 command subtracts the addressed word in memory from the upper accumulator. If the result is less than -1 or greater than $1\text{-}2^{-31}$, overflow occurs and the branch control, BC, is turned on.

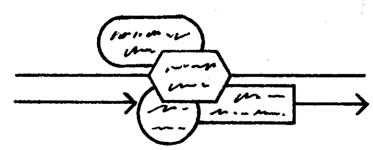
31 11111 SBL (Subtract from Lower)

The 31 command subtracts the addressed word in memory from the lower accumulator. If the result is less than -1 or greater than $1\text{-}2^{-31}$, overflow occurs and the branch control, BC, is turned on.

OPTIMUM PROGRAMMING

Optimum programming is the technique by which data and instructions are placed on the drum of the computer so as to minimize non-productive search time. With optimizing goes the task of keeping track of data and instruction word locations.

With these considerations in mind, it was decided that the first major program should be a symbolic assembler and optimizer. This resulted in ROAR (Royal Optimizing and Assembly Routine). The approach is as follows:



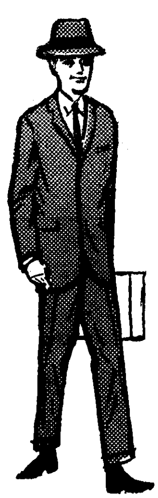
The programmer codes his program in either symbolic language or a combination of symbolic and machine language and enters it into the computer.

The computer then converts the program into machine-instructions and automatically assigns "optimum" locations for the data and/or instructions.

The output of ROAR consists of a machine language tape of the assembled program, and a printed copy of the assembled program along with a reproduction of the input. These provide the programmer with a ready means of loading this program as well as a complete record for error correction and program checkout.

ROYAL McBEE

SERVICES AND BENEFITS



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