Electronic Data-Processing Machines

PRELIMINARY MANUAL OF INFORMATION

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TYPE 702 AND ASSOCIATED EQUIPMENT

ELECTRONIC DATA-PROCESSING MACHINE

Type 702

NEWEST of IBM's contributions to the field of business management are the Electronic Data-Processing Machines. This equipment has developed from IBM's wide experience and practical research in the use of electronics for effective management tools.

The IBM Type 702 is a powerful management and accounting system which incorporates the latest electronic devices—magnetic tapes, magnetic drums, and electrostatic storage. It is designed to fill the need of management for the handling of large amounts of data at electronic speeds, just as the earlier Type 701 Electronic Data-Processing Machine met the scientist's need for performing complex calculating problems.

In designing the 702, IBM has used the most advanced, fully proved technical developments available today. The extremely flexible, unitized construction of the 702 not only insures maximum utility of each component, but also guarantees that any new or improved component available in the future may be readily incorporated into the existing system without affecting the continuity of that system.

Input-Output Devices

Data are introduced into the system from both IBM cards and magnetized plastic tape. Results can be printed, punched into IBM cards, or written on magnetic tape, all in the same procedure. Any practical number of such input or output devices—such as card readers, tape units, card punches, and printers —may be incorporated in the system to provide the desired complete flexibility of entering data into the system and recording the final results.

Input-output devices identical to, and interchangeable with, those described for use as a part of the system, may also be used in separate, independent operations of converting from cards to tape, tape to cards, or tape to printed report.

The 702 handles numerical and alphabetic characters and a variety of symbols with equal facility in reading, recording, or internal processing.

Magnetic Tape

The principal record and file storage medium is magnetic tape, which is physically similar to the plastic tape used in sound recording devices. Information is recorded in the form of magnetized spots, as the tape moves at the rate of 75 inches per second. Recording density is 200 characters to the inch.

The tape may be used for repeated processing, and provides permanent record storage with great savings in space and at minimum cost. Magnetic tape is a very economical medium. It can be used repetitively to store new data, the old information being automatically erased just prior to a new recording.

Individual records on tape may be variable in length and may consist of from one to several thousand characters. Within a unit record there may be several different fields and each field may vary in length.

Storage

Electrostatic memory is the principal storage medium within the machine. It consists of cathode ray tubes which can store up to 10,000 characters of information in the form of electrostatic charges. Characters are stored in, and read from, memory at the rate of twenty-three one-millionths of a second per character. A highly flexible system for locating individual character positions in memory makes possible the rapid selection of any stored record, field, or any individual character within a record.

The 702 has two accumulator storage units, each with a capacity of 512 character positions. An accumulator storage unit serves as a temporary storage for information from electrostatic memory while such information is being acted upon either logically or arithmetically.

Additional storage, as required, may be provided through the use of magnetic drum storage units, each having a capacity of 60,000 characters.

Practically unlimited storage can be obtained on magnetic tape.

Logical Ability

Operation of the 702 is controlled by coded instructions stored in memory. The machine acts upon these instructions in a sequence determined by the programmer. Alternate instructions designed to handle special circumstances may also be pre-arranged in memory, so that the machine will automatically follow them when these special conditions are recognized. In fact, the 702 may be caused to modify its own instructions.

This "stored program" method of procedure opens new areas of mechanization because it brings within the scope of a regular procedure specific instructions for handling many exceptions to the normal processing routine.

Checking

The 702 automatically checks the validity of each character handled. In addition, the stored program principle permits the use of systems checks to prove the consistency of results. The detection of a possible error may be used either to stop the machine or to cause it to take corrective steps, at the discretion of the programmer.

Application

The Type 702 can be used for a wide variety of applications. Its tremendous capacity and operating speed bring data processing to areas which heretofore have been outside the practical limits of mechanization.

INFORMATION STORAGE

A TOTAL of 10,000 characters can be stored at any one time within the main storage unit of the Type 702. A character may be a letter of the alphabet, a decimal number, or any of eleven different punctuation marks or symbols used in report printing.

Characters may be arranged in any sequence to form fields of various sizes to make up records. A record may be of any length within the capacity of the storage unit, from one to several thousand characters. An entire record, a field within a record, or an individual character can be located by referring to its proper location number or "address."

The versatility of this storage unit is made possible by the use of cathode ray tubes which are 3" in diameter. This type of tube is familiar to everyone as the picture tube in the home television receiver. Intensive research by IBM has further developed this type of tube for use as a storage medium in the 702 with exceptionally high standards of performance. In the 702, a character is represented in storage by a particular combination of seven dot and dash charges or bits on the face of the tube.

The bit charges are spaced within a regular grid pattern as shown in Figure 1. Once a character is stored, it will be maintained or "remembered" by a system of automatic regeneration until it is replaced with new information or the power is turned off. Thus the storage unit is referred to as *Electrostatic Memory*, *ESM*, or simply *Memory*.

As a record is read into positions of storage, any information previously placed in those locations will be erased. To read out a character, field, or record, the electron beam is returned to the same location where the information has been previously stored to sense the dots and dashes found there. A record may be read from memory as many times as desired.



FIGURE 1. CATHODE RAY TUBE



FIGURE 2. ORGANIZATION OF DATA TRANSMISSION

The coding of characters within the machine need not concern the operator or programmer during normal operation. Data are read by the input devices directly as punched in standard IBM cards or as recorded on tape. Results can be obtained in the same direct manner without decoding from binary or other forms of notation. The reading and interpretation of an instruction calling for the location of information in memory is performed in .138 milliseconds (thousandths of a second). Characters are read or stored at the rate of .023 milliseconds each. A record of 100 characters can therefore be located and transferred to accumulator storage from memory in 2.438 milliseconds, or in slightly more than 2.4 thousandths of a second, including instruction time.

All data to be processed by the various components of the 702 must pass through electrostatic memory, except when the independent operations of reading from cards to tape, tape to cards, and tape to printer are performed. Figure 2 shows the organization of data transmission. Smaller capacities of storage can be provided when desired, but because operating instructions are also stored in memory, 2,000 positions are considered a minimum. Storage units can be added in multiples of 2,000 up to 10,000 positions. Storage tubes are arranged in drawers in the arithmetic and logical unit for easy access and interchangeability (Figure 3).



FIGURE 3. MEMORY DRAWER



FIGURE 4. MEMORY ADDRESS SYSTEM

Each one of the 10,000 positions of memory is numbered from 0000 to 9999 and each stored character must occupy one of these positions (Figure 4). This serial number of the memory position is known as the "address" of that position. The location of information can thus be specified exactly by the address of the memory positions where it is stored. Since all memory positions are addressable, data need not be handled in uniform record lengths, blocks, or words. Records can be of variable lengths within the same procedure. Other components of the machine are also assigned addresses.

STORED PROGRAM

THE TYPE 702 can perform 32 separate operations, including reading, writing, comparing, arithmetic operations, and others. The machine is completely controlled during these operations by the use of the stored program.

Several stages of preparation are usually necessary to set up a program for data processing:

1. The procedure is analyzed and broken down in terms of the basic operations which the machine can perform. These operations are arranged in the combinations and sequences necessary to produce the desired results. One method is to prepare a detailed procedure outline or flow chart.

2. The operations to be performed in working the procedure are then written in a form which can be "understood" by the machine. For this purpose, each possible operation is designated by a single character (Operation Chart Figure 78), either a letter of the alphabet or a number. To the machine, for example, the letter G means ADD and the number 4 means COMPARE. Each operational step will later be seen to consist of two parts: (a) the operation part, which tells the machine what function to perform, such as add, subtract, compare, or control; (b) the address part, which is the address of data stored in memory to be operated upon or the machine unit to be called into use. The complete operational step, including operation part and address part, is known as an "instruction." A complete series of instructions becomes a program. Preparation of a program for the 702 is analogous to wiring a control panel for other types of IBM accounting machines.

3. The program is read into memory from either punched cards or tape by a loading procedure. The loading of a program corresponds to placing a control panel in an accounting machine before feeding cards.

4. The machine is set to the location of the first instruction of the program in memory by depressing the reset key, by manual instruction, or by the loading procedure. The machine executes the first instruction and can then find and execute succeeding instructions automatically. The sequence in which they are executed is determined by the order in which they are stored or by instructions within the program itself.

The Type 702 operates entirely without the use of control panels. Instructions may be stored on drum, tape, or cards, but at the time they are to be executed by the machine, they must be stored in memory. Each time an operation is performed, the machine looks up the instruction in memory, executes it, and then goes back to memory for the next instruction. The normal sequence of instructions can be altered, however, by means of certain "transfer" operations by which any instruction in memory can be selected, regardless of its position in the program.

The program is stored in memory in exactly the same manner as data. The distinction between the two is the way in which they are interpreted by the machine. An instruction may be caused to enter the arithmetic unit in the same manner as data. Thus, one instruction may call for the modification of another instruction by directing the machine to compute a new address or to substitute a new address. A program may operate on itself and compute one of its own instructions. Or, a program may choose among



FIGURE 5. INSTRUCTION STORAGE

several instructions, depending upon the results obtained in the course of the problem. This ability of the machine to modify and relocate instructions at high speed lends great flexibility to its operation and enlarges the scope of its application.

A single instruction or program step consists of two separate parts:

- 1. the operation part of one character which determines the operation to be performed.
- 2. the address part of four digits which is the address of some position in memory, an inputoutput device, a drum section, or an indicator.

A schematic diagram of an instruction is shown in Figure 5. Note that the instruction occupies five positions of memory.

Component Addresses

All components of the machine, as well as individual positions of memory, are assigned addresses in order that they may be called upon by the operation part of an instruction. The following addresses are assigned:

ADDRESS	COMPONENT
0000-9999	Memory
0100-0199	Card Readers
0200-0299	Tape Units
0300-0399	Card Punches
0400-0499	Printers
0500-0599	Typewriter
1000-9999	Drum Sections
0911-0919	Alteration Switches
0900	Instruction Check Indicator
0901	Machine Check Indicator
0902	Read-Write Check Indicator
0903	Printer-Punch Check Indicator
0904	Overflow Check Indicator
0905	Sign Check Indicator

Select (2-SEL)

These units are called into use during a program by preceding the address part of the instruction by a select operation part. In this manner, the machine differentiates between a memory address and the address of a component. The address 0100, for example, when preceded by an add operation part, instructs the machine to add data stored at memory address 0100. When the address is preceded by a select operation part, the instruction refers to card reader 0100.

Only one unit can be selected at a time and the selected device remains selected until another select instruction is given.

A DATA-PROCESSING procedure may use many or all of the various operations which the machine can perform. These operations are defined in detail in this section, with sample problems of data conversion, arithmetic and alphamerical operations, checking and end-of-file procedures, table look-up, and others.

It should be clearly understood, however, that the following examples are not intended to be complete

procedures or primary applications of an installation, but that they are offered only as illustrations of basic principles of operation. For example, end-of-file routines, checking procedures, and error correction are omitted from the introductory problems. The problems are presented in the sequence best suited for learning machine principles, and not in the order of their importance.



FIGURE 6, FLOW OF DATA FROM CARDS TO TAPE

Each instruction and machine unit is described as it is first introduced. The instruction title is followed by its operation part and abbreviation. For most of the operations, a sample program and explanation are presented.

DATA CONVERSION

TAPE-TO-CARD, card-to-tape, and tape-to-print operations are normally carried out independently. Data conversion through the arithmetic and logical unit is done only as a part of more complex processing involving not only the input-output units but the arithmetic and logical components as well.

Card-to-Tape Conversion through Memory

Figure 6 illustrates the flow of information for the processing of data from cards to magnetic tape. The procedure, when reduced to basic machine steps, requires five operations which may be described as follows:

- 1. Select a card reader.
- 2. Read the card record into memory.
- 3. Select a tape unit.
- 4. Write the record from memory on tape.
- 5. Transfer to repeat the operations until all cards are processed.

Note that two machine units are selected by the programmed instructions, a card reader and a tape unit. Two operations are performed, reading the card record and writing on tape. A transfer operation is inserted to repeat or "loop" the program until all the card records are read.

This section shows the development of the program with a description of the machine units used and an explanation of operations.

Card Reader, Type 712

The Type 702 uses the IBM punched card as a source of input data. Punched cards prepared by other IBM accounting machines can be further processed by the 702 and the results can be recorded either on magnetic tape, other punched cards, or printed records.

For handling card input data, the 702 is equipped with card readers which read cards into electrostatic memory at the rate of 250 cards per minute. The Type 712 Card Reader reads the standard IBM punched hole coding. Figure 7 is a schematic of the feed unit and card stations in the card reader.

Cards are first fed into a control or check station. A second station reads the card into a record storage unit and from there into memory. A check is made with the punching read at the first station to verify the accuracy of reading. A record storage unit is provided for each card reader. After the card has been read into record storage, it is transferred to memory at the high internal speed of the 702. Further instructions can then be executed. Calculations made from the card record may be transmitted to other output units, which in turn may begin writing results while the next card record is being fed.

All 80 card columns, including blank columns, must be read into memory during each read cycle. Rearrangement of fields can be accomplished after the card record has been stored in memory.

A detailed description of the switches, signal lights and other operating features of the card reader will be found under the sections on machine components. The 702 may be equipped with any number of card readers up to 100. Each card reader requires a control unit containing timing, decoding and other circuits used in reading cards into memory.



FIGURE 7. CARD READER FEED

Magnetic Tape Unit, Type 727

A reading or writing operation on magnetic tape is performed by the tape unit. Oxide coated plastic tape is used on reels 10¹/₂ inches in diameter in lengths up to 2400 feet per reel. The speed for reading or writing is the same, 75 inches per second. Rewind time averages 500 inches per second.

Information is recorded on the tape in the form of magnetized spots at a density of 200 characters to the inch. Figure 8 compares the size of an IBM card with a strip of tape containing 80 characters. The end of a record is indicated by a $\frac{3}{4}$ inch inter-record gap or blank space on the tape. The end of recorded information on the tape is indicated by a tape mark which appears after the inter-record gap that follows the last record. The physical ends of the tape are indicated by reflective spots, which are photo-electrically sensed by the tape unit. Records of any length may be stored on tape, limited only by the capacity of memory.

Figure 9 shows schematically the position of the tape reels in relation to the read-write heads and feed rollers. A loop of tape is fed through vacuum columns on both sides of the read-write head to permit constant feeding speed without waiting for the reels to accelerate or decelerate when starting and stopping.

The tape unit, as well as other components of the 702, is called into use by the select operation part of a program instruction. The address part of the instruction determines which unit is selected. A unit may be assigned any one of ten addresses associated with its control unit, from 0200 to 0209, by a dial



FIGURE 8. CARD AND TAPE RECORD

arrangement on the tape unit. Up to three units may be assigned the same address to write duplicate tapes, provided the checking features of the units are not required. (Duplicate recordings can be made only by the tape units.) The unit is told whether to read or write by the program instruction following the select instruction.

Any number of tape units up to 100 may be obtained with the 702. Certain common circuits are contained in the tape control unit which can handle up to ten tape units. Each additional ten units require a separate control unit.

A detailed description of switches and signal lights will be found in the section on machine components.

Read (Y-READ)

1. The read instruction is used to store a record in electrostatic memory from an input unit or a drum. A select instruction is first given to specify the particular unit or drum section from which to read.

2. Information is read into memory successively from *left to right*, starting at the memory position specified by the address part of the instruction. For example, in card reading (Figure 6), the instruction READ 0501 will read column 1 of the card into memory position 0501, column 2 into position 0502, column 3 into 0503, and so on until position 0580 is reached. In tape reading, the number of memory positions used depends upon the length of the unit record. The number of positions read from the drum depends upon the position of the drum mark.

3. All characters from an entire unit record, including blank characters, are stored in memory by the read instruction. All 80 columns of a card will always be entered into memory. Unpunched columns are entered as blank characters. In tape reading, the first character of the record is stored at the memory address specified by the address part of the instruction. The limits of the record being read are defined by the inter-record gap on the tape. In drum reading, the first character in the drum section previously specified by a select instruction will be read into the position of memory specified by the read instruction. A partial record cannot be stored in memory by a read instruction.

4. When the end of a record is sensed while reading, a record mark is automatically emitted into the next higher memory address following the last character of the record. From cards, the record mark will always be placed in the 81st memory position to the



FIGURE 9. TAPE UNIT FEED

right of the position specified by the address part of the read instruction. In Figure 6 this is position 0581. From tape, sensing the inter-record gap causes a record mark to be recorded in memory. In drum reading, sensing the drum mark causes a record mark to be recorded in memory. Consequently, the record in memory occupies one more position than it does on cards or tape.

Write (R-WRITE)

1. The write instruction causes a record to be written from memory to an output unit or to be stored on the drum. The output unit may be a tape unit, a card punch, a printer, or a typewriter. A select instruction is first given to specify the unit to be used for writing or the drum section to be used for storage.

2. Information is written from memory successively from *left to right*, starting at the memory position specified by the address part of the instruction and continuing until a record mark is reached. The record mark is not written or punched. When cards are being punched, the character stored in the memory position specified by the address part of the write instruction will be punched in column 1. The second character from memory will be punched in column 2, the third in column 3, and so on until the record mark is reached. If the length of the record is less than 80 columns, the remaining columns in the card will remain unpunched. Records longer than 80 characters will be punched in successive cards by a single write instruction. The write status will be maintained and subsequent operations delayed until the last card of a single record has been read into record storage. The 81st character of the record in memory will be punched in column 1 of the second card.

When a record is being written on tape, sensing the record mark in memory will automatically cause an inter-record gap to be placed on the tape to define the limits of the record. When a record is written on the drum, the record mark in memory is converted to a drum mark at the end of the record.

On the printer, the first character of the record specified in memory will be printed by print wheel 1, the second by print wheel 2, and so on until 120 characters have been written. If the length of the record is less than 120 characters, the remaining print wheels do not print. Records longer than 120 characters will be printed on successive lines by a single write instruction. The write status will be maintained and subsequent operations will be delayed until the last block of characters has been read into record storage. The write instruction should not be addressed to the memory address of a record mark.

Rearrangement of record fields for writing will be discussed under the store-for-print instruction and in later program examples.

3. The record in memory is unaffected by the write instruction. Note: The carriage switch on the printer may be set to PROGRAM. In this case the first character of the record stored in memory is used for skipping and space control. This will be more fully explained in the section Machine Components.

Transfer (1—TR)

The transfer instruction is used to change the sequence in which instructions of a program are executed. The address part of the instruction specifies the memory address of the right-hand digit of the next instruction to be executed. Program, Card to Tape

The program for processing information from cards to tape, using the instructions and components previously described, may be written as in Figure 10.

Instruction	Instruction			
Number	Operation Abbrev.	Operation Part	Address	
1	SEL	2	0100	
2	READ	Y	0501	
3	SEL	2	0200	
4	WRITE	R	0501	
5	TR	1	(Address of	
			Instruction)	

Figure 10. Program, Card-to-Tape Conversion

To store the program so that the machine may execute it, each instruction is assigned storage space in memory. The address of the right-hand digit is considered the address of the instruction. Thus the location of instruction 1 in memory is 0004, instruction 2 is 0009, and so on. Figure 11 shows the program with memory address locations. The operation abbreviations shown are not stored in memory but are written merely for the convenience of the programmer. Note that the transfer instruction may now be given the address of the first instruction of the program to form a program "loop." The program is repeated until all records have been processed. Figure 12 is a schematic of the card-to-tape program stored in memory. An explanation of the program in Figure 11 follows.

0004. Select card reader 0100.

0009. Read a unit card record into memory, beginning at address 0501. Continue to read the card into successively higher-order memory addresses until all 80 columns are stored. Store a record mark in the next higher memory position, 0581.

0014. Select tape unit 0200.

0019. Write the record stored in memory beginning at address 0501 and continue writing from suc-

Instruction	Instruction				
Location	Operation Abbrev.	Operation Part	Address		
0004	SEL	2	0100		
0009	READ	Y	0501		
0014	SEL	2	0200		
0019	WRITE	R	0501		
0024	TR	1	0004		

Figure 11. Program, Card-to-Tape Conversion



cessively higher-order memory positions until the record mark is reached.

0024. Transfer to the instruction located at memory address 0004 and repeat the program until all records are processed.

Tape-to-Card Conversion through Memory

Information stored on magnetic tapes may be processed as input data by the 702 and the results can be punched in IBM cards. For this purpose, a tape unit is used as an input device and a card punch as an output device. Cards prepared by the card punch may be further processed by IBM accounting machines. Figure 13 shows the flow of data from the tape through memory to the card punch.

Card Punch, Type 722

Cards are punched by the Type 722 at the rate of 100 cards per minute. A record is punched from memory in the same order or arrangement in which it is stored. The record can be rearranged in memory to fit established card fields before it is punched (refer to load and unload instructions). Figure 14 illustrates the feed stations in the card punch.

Punching is checked by reading the card at the brush station after it is punched.

The 702 can be equipped with from 1 to 100 card punches. Each punch requires a control unit containing the necessary decoding, checking and timing circuits.

Program, Tape to Card

The program for tape-to-card operation is also reduced to sequential steps which conform to the various 702 operations, as follows:

- 1. Select a tape unit.
- 2. Read a record from the tape into memory.
- 3. Select a card punch.
- 4. Punch the record from memory into a card.
- 5. Transfer to repeat the operations until all records are processed.



FIGURE 13. FLOW OF DATA FROM TAPE TO CARDS



FIGURE 14. SCHEMATIC, CARD PUNCH FEED

The program steps for these operations are shown in Figure 15. Note that memory addresses have been assigned to each step.

0004. Select tape unit 0201.

0009. Read a unit record from the tape into memory, beginning at address 0501. Continue to read the tape into successively higher memory positions until the inter-record gap is reached. Store a record mark in memory at the end of the record (address 0529).

0014. Select card punch 0300.

0019. Write the record stored in memory beginning at address 0501 and continue to write from successively higher-order memory positions until the record mark is reached.

0029. Transfer to the instruction located at memory address 0004 and repeat the program until all records are processed.

Instruction	Instruction				
Location	Operation Abbrev.	Operation Part	Address		
0004	SEL	2	0201		
0009	READ	Y	0501		
0014	SEL	2	0300		
0019	WRITE	R	0501		
0024	TR	1	0004		

Figure 15. Program, Tape-to-Card Conversion

Converting Tape to Cards and Printing through Memory

Results may be printed in report form directly from the 702 by the use of the Type 717 Printer.

Printer, Type 717

The 702 can be equipped with any number of print units from 1 to 100. Each printer has 120 print wheels with 47 characters per wheel (Figure 16). Printing speed is 150 lines per minute. Each printer requires a control unit.

Information within each line is printed in exactly the same order in which it is received from memory. Any arrangement of data to fit report forms must be made by programming in memory before a write instruction is given. Form spacing and skipping may be either under complete control of the program or under control of the carriage control switch.



FIGURE 16. SCHEMATIC OF PRINT WHEEL

Records longer than 120 characters will be printed on successive lines by a single write instruction. The printer receives 120 characters at a time from memory and the write status is maintained until the last block of characters in the record has been sent to the printer as indicated by sensing the record mark in memory.

The accuracy of printing is checked by comparing the position of the print wheels against the information actually sent to the printer from memory. A more detailed explanation is given under *Checking*.

Program, Tape-to-card and Printer

Information from tape may be punched in cards and also written on the printer during the same procedure by the program shown in Figure 15. Two additional instructions are necessary: a select instruction to select the printer and a second write instruction to transfer the record from memory to the printer. The complete program with assigned memory locations for each instruction is shown in Figure 17.

Instruction	Instruction			
Location	Operation Abbrev.	Operation Part	Address	
0004	SEL	2	0200	
0009	READ	Y	0501	
0014	SEL	2	0300	
0019	WRITE	R	0501	
0024	SEL	2	0400	
0029	WRITE	R	0501	
0034	TR	1	0004	

Figure 17. Program, Converting Tape to Cards and Printing

ARITHMETIC INSTRUCTIONS

THE 702 adds, subtracts, multiplies, and divides when it is given arithmetic instructions. These instructions can be applied to data stored either in accumulator storage or in memory. They are normally applied to specific numerical factors or fields, either single factors developed during calculation or fields selected from unit records.

To select a field from memory to be acted upon by an arithmetic instruction, the field is addressed by the memory position of its units digit. The remaining digits of the field are automatically read from *right to left* until a non-numerical character is reached. All characters, including blanks, are considered non-numerical except the digits 0 through 9. Thus, a numerical field in memory can be defined as beginning with the address of its units digit and extending to, but not including, the next left nonnumerical character.

Field A in Figure 19 is defined by an arithmetic instruction as containing the digits between the addresses 0504 and 0501 inclusive, while field B contains the digits between 0507 and 0505 inclusive. The addresses of fields A and B are 0504 and 0507, respectively.

Arithmetic instructions should always be addressed to "signed" fields and both positive and negative fields should be signed. Numerical fields are signed by placing a plus or minus sign indication over the units digit of the field. The sign indication actually converts a numerical digit to a non-numerical character in the same manner that an X or 12 punch over a digit punch in IBM cards forms a letter of the alphabet. On the 702, the equivalent of the 12 zone in punched cards indicates the plus sign, the X zone the minus sign.

The absence of a zone or the presence of a zero zone does not satisfy the requirements of a signed field. When an unsigned field is addressed by an arithmetic instruction, the sign is interpreted as plus. The correct arithmetic will be performed but the machine will indicate an error condition. (Refer to Sign Check Indicator.)

Arithmetic and Logical Unit

An add-subtract unit, controls for effecting multiplication and division, controls for comparing the contents of accumulator storage and memory, and miscellaneous circuits to control accumulator storage are located in the arithmetic and logical unit. These components do not store information, but instead merely operate on the characters as they pass through. Their function is to receive data from memory and operate on it in accordance with the instructions obtained from the stored program. Results are always stored either in accumulator storage or in memory, depending upon the instruction.

Accumulator Storage

Two accumulator storage units are located in the arithmetic and logical unit, each consisting of seven cathode ray tubes of the same type as those used in memory. Each accumulator storage unit is completely independent of the other and operations on data in one will not affect data stored in the other. Both accumulator storage units operate in an identical manner. They are designated as Accumulator Storage A and Accumulator Storage B, as shown in Figure 18.

Instructions which can affect accumulator storage specify accumulator B when a minus sign is placed over the highest order digit of the address part of these instructions. For example, the instruction R ADD 1369 resets accumulator B and adds the amount stored in memory at address 1369. When the highest order digit of the instruction is unsigned, the instruction specifies accumulator A. Only the accumulator positions to be occupied by new data are reset.

Accumulators are used to store information temporarily from memory. Operations may then be performed on this information without changing the original field or record which remains in memory. These operations are not actually performed by the accumulator, however, but are executed in the arithmetic and logical unit.

Each accumulator has a capacity of 512 character positions, either alphabetic, numerical, or special characters. One position is always occupied by a special character called an accumulator mark. This character marks the left-hand limit of the accumulator contents. The mark automatically appears in the proper position next to the highest order character of the stored field. The mark is represented on program charts by the letter *a*. It is peculiar to accumulator storage and cannot appear in memory.

The starting point counter, which contains the location of the right-hand character in the accumulator storage field, sets the right-hand limit to the



FIGURE 18. SCHEMATIC, ACCUMULATOR STORAGE, MEMORY AND ALU

field. All operations involving the field in an accumulator storage, therefore, operate only on those characters located between the accumulator mark and the starting point counter.

The accumulator storage field is extended or shortened on the left by shifting the accumulator mark. It is extended or shortened on the right by shifting the starting point counter.

An internal accumulator address counter determines the position in the accumulator storage field to be operated upon. At the end of executing an instruction, the accumulator address counter is set to the address in the starting point counter. This insures starting the next operation for that accumulator at the right-hand digit.

The number of characters contained in an accumulator is determined by the number of positions from the starting point counter to the accumulator mark (Figure 18).

When arithmetic operations are performed, accumulator storage contains one of two fields to be used in a calculation. The second field is in memory. To calculate A + B = T, the factor A is in accumulator storage while B is in memory. After the operation ADD is completed in the arithmetic and logical unit, the result T replaces A in accumulator storage. The result of a calculation always replaces the original field in accumulator storage, with one exception. A result may be added directly to a field in memory from accumulator storage. In this instance, the result in accumulator storage remains unchanged. (See Add to Memory.) Positive and negative fields are stored as true numbers in accumulator storage by arithmetic instructions. The sign of the field is registered by the accumulator sign indicators (Figure 18). During calculation, signs are automatically set according to the rules of algebra and the sign indication of each accumulator storage may be used to transfer to certain specified instructions when desired. Zero balances in either accumulator storage are registered by zero indicators.

A series of different instructions may be executed, depending upon whether the sign of accumulator storage is plus or minus, or the balance is zero.

Accumulator storage is used to rearrange data in memory. Fields, records, or any portion of either, can be taken from one location in memory to accumulator storage and from there can be relocated in another part of memory to form any desired arrangement. Data cannot be transferred directly from one accumulator storage unit to the other, but must first pass through memory.

A field in accumulator storage may also be compared against a field in memory by a compare instruction. A high or equal condition is registered by the comparison indicators. A low comparison is not registered, and one set of indicators serves both accumulator storage units. The arrangement of indicators is also shown schematically in Figure 18. A series of different instructions may be executed, depending upon whether the factor in accumulator storage is high, low, or equal.

Addition: $A \pm B = T$

Four machine operations permit the addition or subtraction of factors in memory to or from accumulator storage: reset and add, reset and subtract, add, and subtract. The store instruction provides the means of placing the result in memory for recording by an output unit, storage on the drum, or for use later in the program.

Reset and Subtract (Q-R SUB)

1. The reset and subtract instruction enters into accumulator storage the numerical field stored in memory, starting with the digit specified by the address part of the instruction and continuing through the next lower memory addresses until a non-numerical character is reached. The non-numerical character is not entered into the accumulator.

2. The left-hand limit of the field in accumulator storage is located by the accumulator mark (a) which appears in the next position to the left of the last digit entered from memory.

3. The accumulator sign is set to minus when the addressed digit of the memory field has plus zoning, and is set to plus when the addressed digit has minus zoning. When the digit has neither plus nor minus zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

4. The field in memory is not affected by the reset and subtract instruction.

EXAMPLES, RESET AND SUBTRACT

ACCUMULAT	OR BEFORE	ACCUMULAT	OR AFTER	SIGN CHECK
STORAGE	SIGN	STORAGE	SIGN	IND.
a11111	+	a 456	+	
21		a456	_	
a 11	+	a56		
a 1		a0000	+	See note
a111	+	a0	—	On
211		a3		On
a 1	—	a1		On
	storage a11111 a1 a11 a1 a11 a111 a111	all1111 + a1 a11 + a1 a111 + a111 + a11	STORAGE SIGN STORAGE a11111 + a456 a1 - a456 a11 + a56 a1 - a0000 a111 + a0 a11 - a3	STORAGE SIGN STORAGE SIGN a11111 + a456 + a1 - a456 - a11 + a56 - a1 - a0000 + a111 + a0 - a111 - a3 -

Note: Since the resulting accumulator storage field is all zeros, the accumulator sign is set to plus.

Reset and Add (H-R ADD)

1. The reset and add instruction enters into accumulator storage a numerical field from memory. The field is located by the address of its right-hand signed digit. 2. The field in memory is not affected by the reset and add instruction.

3. The left-hand limit of a factor in accumulator storage is defined by an accumulator mark (a) stored next to the last digit entered from memory.

The field A (Figure 19), when entered into the accumulator by the reset and add instruction, would appear as a1256.

4. The accumulator sign is set to plus if the righthand character of the memory field has plus zoning and is set to minus if the character has minus zoning. When the right-hand character addressed in the memory field has neither plus nor minus zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

EXAMPLES, RESET AND ADD

	ACCUMULAT	OR BEFORE	ACCUMULAT	OR AFTER	SIGN CHE CK
MEMORY	STORAGE	SIGN	STORAGE	SIGN	IND.
4456	a23456	+	a 456		
4456	a23456		a456	+	
4b56	a1234	+	256	+	
4 456	a1234	—	a456	+	On
E456	a2345	+	a456		



FIGURE 19. SCHEMATIC, ADDITION

Add (G-ADD)

1. The add instruction adds a field in memory to a factor in accumulator storage. The field in memory is located by the address of its right-hand signed digit.

2. The result in accumulator storage is the sum of the accumulator factor and the memory field.

3. The accumulator sign is set in accordance with the rules of algebra for addition. The sign is always set to plus, however, if the result is zero.

4. When the right-hand character of the field addressed in memory has neither a plus nor minus zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

5. The length of the result is equal to the length of the longer of the two fields being added, unless a carry is effected out of the highest order position of the result. In this case, the result is extended one position to include the carry as the most significant digit, and the overflow check indicator is turned on.

EXAMPLES, ADD

	ACCUMULAT	JR BEFORE	ACCUMULA	FOR AFTER	CHECK
MEMORY	STORAGE	SIGN	STORAGE	SIGN	IND.
6235	a 2 3		a258	+	
6235	a23		a212	+	
6235	a 2 3	+	a212		
6532	a24		a556	+	Sign check on
1234s	a 1 5	+	a2357	-+-	Sign check on
689 -	a20	+	a109	+	Overflow check on

Store (F-STORE)

1. The store instruction is used to transfer numerical information from the accumulator to memory.

2. The units digit of the factor from accumulator storage is stored at the memory address specified by the instruction. The remaining digits to the left are stored in successively lower memory positions until the accumulator mark is read.

3. The size of the field to be stored depends upon the position of the accumulator mark. All digits between the starting point counter and the accumulator mark will be stored.

4. The sign of the accumulator is placed over the units position of the factor stored in memory.

5. When the units position of the next left-hand field in memory is an unsigned numerical character, this character will be signed plus to properly define the stored field. A non-numerical character is not affected.

6. The factor in accumulator storage is left unchanged by the instruction.

Note. The store instruction should not be used on non-numerical fields in accumulator storage. Incorrect characters in memory may result.

EXAMPLES, STORE

JLATOR	MEMORY	MEMORY
SIGN	BEFORE	AFTER
—	1729	1748 ++ +
-+-	1729	1767
	3415	3592
+	3415	3738
	FRAME	F7468
	@16	@35
	ULATOR SIGN + + 	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$

Program, Addition

The program for A + B = T is shown in Figure 20.

0004. Tape unit 0200 is selected.

0009. A tape record is read into memory from left to right, beginning at memory address 0501 and continuing to address 0511. A record mark is stored at address 0512.

0014. The proper positions of accumulator storage A are reset and field A is entered. Field A is defined in memory as beginning with the signed digit $\dot{6}$ in address 0504 and continuing successively to the left until the non-numerical blank character is read.

The accumulator mark is set in the first position to the left of the field placed in the accumulator.

0019. Field B is added to field A. The result is placed in accumulator storage A. The sign of the accumulator is plus.

0024. The result T is stored in memory at address 0511. The sign of the accumulator (plus) is given to the units digit of field T at address 0511. The

INSTR.	INSTRUCTION		ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS	ACCOMULATOR A	š	ACCOMOLATOR B	S
0004	Sel	0200				
0009	Read	0501				
0014	R Add	0504	a1256	+		
0019	Add	0507	a1406	+		
0024	Store	0511				
0029	Sel	0300				
0034	Write	0501				
0039	Tr	0004				
						—

FIGURE 20. PROGRAM, ADDITION

character at address 0507, the units digit of the next left-hand field, is signed. Therefore field T is limited to the characters found at addresses 0508 to 0511, inclusive. The amount in the accumulator is unaffected by the store instruction.

0029. Card punch 0300 is selected.

0034. The unit record stored in memory beginning at address 0501 is read from left to right up to the record mark stored in 0581. The complete record is punched in a card. The record in memory is unaffected by this instruction.

0039. A transfer instruction is given to repeat the program for successive records in the tape unit.

Crossfooting: A + B - C = T

The tape record shown in Figure 21 is stored in memory at addresses 1501 through 1514, inclusive, with a record mark at address 1515. Assume that fields A, B and C are signed plus. The entire record is to be transcribed to tape after calculation.



FIGURE 21. SCHEMATIC, CROSSFOOTING

Subtract (P—SUB)

1. The subtract instruction causes a field stored in memory to be subtracted from a factor stored in the accumulator. The field in memory is located by the address of its right-hand signed digit.

2. The result in the accumulator is the difference between the accumulator factor and field in memory.

3. The accumulator sign is set in accordance with the rules of algebra for subtraction. The sign is always set to plus, however, if the result is zero.

4. When the right-hand character of the field addressed in memory has neither a plus nor minus

zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

5. The length of the result is equal to the length of the longer of the two fields, unless a carry is effected out of the highest order position of the result. In this case, the resulting field is extended one position to include the carry as the most significant digit of the result. The overflow check indicator is turned on.

EXAMPLES, SUBTRACT

A	CCUMULATO	R BEFORE	ACCUMULA	TOR AFTER	CHECK
MEMORY	STORAGE	SIGN	STORAGE	SIGN	IND.
$\frac{1}{6235}$	a23	+	a212	—	
6235	a23		a258		
6235 +	a23	+	a258	+	
6532	a24	+	a508		Sign check turned on
ь89	a20	+	a69	—	

Program, Crossfooting

Figure 22 is the program for A + B - C = T. 0004. Select tape unit 0203.

0009. Read the tape record into memory beginning at address 1501.

0014. Reset and add the factor A into accumulator B.

0019. Add factor B to A and place the result in accumulator B.

0024. Subtract factor C from the result in accumulator B.

0029. Store the result at memory address 1514.

0034. Select tape unit 0202.

0039. Write the record from memory beginning at address 1501.

0044. Transfer to the instruction located at address 0004 to repeat the program.

INSTR.	INST	RUCTION	ACCUMULATOR A			Z
LOCATION	OPER.	ADDRESS	ACCOMULATOR A	SIG	ACCUMULATOR B	SIGN
0004	Se1	0203				Γ
0009	Read	1501				
0014	R Add	<u>1</u> 504			a1256	+
0019	Add	1507			a1406	+
0024	Sub	1510			a1281	+
0029	Store	Ī514				
0034	Sel	0202				
0039	Write	1501				
0044	Tr	0004				

FIGURE 22. PROGRAM, CROSSFOOTING

Multiplication: $A \times B = P$

A record shown in Figure 23 is stored in memory from tape at addresses 0650 through 0663, inclusive, with the record mark in 0664. The field P is blank and is to be calculated. The entire record is to be punched in cards after calculation.



FIGURE 23. SCHEMATIC, MULTIPLICATION

Multiply (V-MPY)

1. The multiply instruction causes a field in memory to be multiplied by a factor in accumulator storage.

2. The multiplicand is the field in memory specified by the address part of the instruction.

3. The multiplier is the accumulator factor.

4. The product is developed in accumulator storage and replaces the multiplier. The number of digits in the product is equal to the sum of the number of digits in the multiplier and multiplicand. A maximum product of 255 digits may be obtained.

5. The accumulator sign is plus if both multiplier and multiplicand have like signs, and minus if they have unlike signs.

6. Only numerical fields may be used in multiplication. The use of a non-numerical field in the accumulator will produce inconsistent results.

7. When the right-hand character of the field addressed in memory has neither plus nor minus zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

	ACCUMULA	TOR BEF	ORE ACCUMUL	ATOR AFTE	CHECK
MEMORY	STORAGE	SIGN	STORAGE	SIGN	IND.
280	a7		a560		
b3	a2	-+-	a06	+	
\$25	a31		a0775	+	
65	a007	+	a0035		
b٢	a007	+	a0035	+	Sign check on

Program, Multiplication

The program for $A \times B = P$ is shown in Figure 24.

INSTR.	INSTRUCTION		ACCUMULATOR A	sign	ACCUMULATOR B	SIGN	ſ
LOCATION	OPER.	ADDRESS	ACCOMULATOR A	š	ACCOMULATOR B	š	L
0004	Sel	0201					
0009	Read	0650					L
0014	R Add	0656	a126	+			L
0019	Mpy	0653	a0625968	+			L
0024	Store	0663					l
0029	Sel	0300					L
0034	Write	0650					L
0039	Tr	0004					l
						1	I

FIGURE 24. PROGRAM, MULTIPLICATION

0004. Select tape unit 0201.

0009. Read tape record.

0014. Reset add field B into accumulator A (multiplier).

0019. Multiply field B by A and place P in accumulator A. The accumulator mark defines P as a seven-digit factor, the sum of the number of digits in the multiplier and multiplicand.

0024. The result, P, is stored at memory address 0663. The accumulator plus sign is placed on the right-hand character of the field.

0029. Select card punch 0300.

0034. Punch the record.

0039. Transfer to the instruction located at address 0004 and repeat the program for successive tape records.

Multiplication with Half Adjustment

The product, P, may be half adjusted at any position by the use of a round instruction. Assume the value of A to be 496.8 and the value of B to be \$1.26 (Figure 23). The result is to be computed to the nearest cent.

Round (E-ROUND)

1. The round instruction drops from the righthand end of the accumulator field the number of digits specified by the address part of the instruction.

2. A five is added to the last digit dropped and any resulting carry-over is added to the units digit of the remaining field.

3. If a carry-over is added out of the highest order position of the original field, the result is extended one position and the overflow check indicator is turned on. (See Overflow Check Indicator.)

4. The instruction ROUND 0000 has no effect.

5. Normally, the sign of accumulator storage is set to plus when the stored result is zero. This rule does not hold, however, if the result has been reduced to zero by a round instruction. For example, assume that the result 00004 is stored with the accumulator sign set to minus. The instruction ROUND 0001 is given. The result remaining in storage is now 0000. The accumulator sign will remain set to minus.

EXAMPLES, R	OUND
-------------	------

		ACC. B	EFORE	ACC.	AFTER	CHECK
INSTRUCTIO	N S1	ORAGE	SIGN	TORAGE	SIGN	IND.
ROUND 00	002 :	15653	+	a\$7	+	
ROUND 00	02 a	15653		a57		
ROUND 00)04 a§	8912	+	a10	+ 0	'flow on
ROUND 00	01	a349	+	a35	+	

Program, Multiplication with Half Adjustment

The round portion of the program is written as shown in Figure 25.

INSTR.	INSTRUCTION		ACCUMULATOR A	Z	ACCUMULATOR B	NO
LOCATION	OPER.	ADDRESS	ACCOMODATOR A	š	ACCOMODATOR B	š
0014	R Add	0656	a126	+		
0019	Mpy	0653	a0625968	+		
0024	Round	0001	a062597	+		
			1			

Figure 25. Program, Multiplication with Half Adjustment

Division: $A \div B = Q$

The fields A and B are stored in memory at addresses 1681 and 1684, respectively, as shown in Figure 26. The quotient, Q, is to be stored at address 1687.

Divide (W-DIV)

1. The divide instruction causes a factor in accumulator storage to be divided by the field in memory specified by the address part of the instruction. The memory field is the divisor; the accumulator factor is the dividend.

2. The quotient is developed in accumulator storage. The remainder is lost, but can be obtained by subtracting the product of the quotient and divisor from the dividend.

3. The number of digits in the quotient is equal to the number of digits in the dividend less the



FIGURE 26. MEMORY STORAGE, DIVISION

number of digits in the divisor. A maximum dividend length of 255 digits can be used.

4. The accumulator sign is plus if the dividend and divisor have like signs, and minus if they have unlike signs.

5. Only numerical fields may be used in division. Non-numerical fields produce inconsistent results.

6. When the right-hand character of the field addressed in memory has neither plus nor minus zoning, an error is indicated and the sign of the field is interpreted as plus. (See Sign Check Indicator.)

7. The dividend must contain a greater number of digits than the divisor. Otherwise, the division is ignored, the zero indicator is turned on, and the machine will proceed to the next instruction.

8. The divisor must have a greater absolute value than an equal number of digits taken from the left end of the dividend. For example, $7 \div 2$ cannot be performed because the divisor, 2, is less than the dividend, 7; $07 \div 2$ can be performed because the divisor, 2, is of greater value than the high-order digit of the dividend, "0"; $12345 \div 13$ can be performed because the divisor, 13, is of greater value than the two high-order digits of the dividend, "12." This rule can be satisfied by inserting zeros in the high-order positions of the dividend as required. If this rule is not satisfied:

a. The overflow check indicator and the zero indicator will be turned on.

b. The division will not be completed.

c. A single zero will replace the accumulator storage contents.

d. The machine will go to the next instruction.

e. The accumulator sign will remain the same as that of the replaced dividend.

EXAMPLES,	DIVISION
-----------	----------

	ACCUMULATO	R BEFORE	ACCUMULA	TOR AFTER	CHECK
MEMORY	STORAGE	SIGN	STORAGE	SIGN	IND.
a\$0+	a2501	+	a50	+	
Ь5 <u>0</u>	a511	+	a0	+	Overflow on
b50	a55	+	a55	+	Zero on
Ь5 <u>0</u>	a12700	+	a254	—	
P20	a12700	+	a254	+	Sign check on

Program, Division

The program for division is shown in Figure 27. 0004. The positions used in accumulator storage A are reset and factor A is added.

0009. A is divided by B; Q is placed in accumulator storage.

0014. The result, Q, is stored at address 1687.

INSTR.	NSTR. INSTRUCTION		ACCUMULATOR A			Z
LOCATION	OPER.	ADDRESS	ACCOMULATOR A	SIG	ACCUMULATOR B	SIGN
0004	R Add	1681	a129521	+		
0009	Div	1684	a981	+		
0014	Store	1687				Γ
						t

FIGURE 27. PROGRAM, DIVISION

Gross Pay Calculation

The combined use of the instructions previously discussed may be further demonstrated by programming a section of a payroll problem.

The payroll data are received on tape and are stored in memory as shown in Figure 28. Fields are: man number, incentive earnings, hourly earnings, overtime allowance hours, and regular hours. The calculations to be performed are:

Average Rate $=$	Incentive Earnings + Regular Earnings		
	(Regular Hours)		

Overtime Amount = Average Rate \times Overtime Allowance Hours

Gross Pay = Regular Earnings + Incentive Earnings + Overtime Amount

Set Left (B-SET L)

1. The set left instruction, by moving the accumulator mark, adjusts the length of the accumulator field to the number of characters specified by the address part of the instruction.

2. The accumulator mark may either delete characters by moving to the right, or add zeros by moving to the left, as required.

3. The instruction SET L 0000 places the accumulator mark at the position of the starting point counter.

EXAMPLES,	SET	LEFT
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INSTRUCTION	ACC. STOR. BEFORE	ACC. STOR. AFTER
SET L 0004	a52	a0052
SET L 0002	a0052	a52
SET L 0001	a52	a2
SET L 0003	a2000	a000

Shorten (C-SHOR)

1. The shorten instruction is used to remove characters from the right end of an accumulator storage field.

2. The number of characters removed is specified by the address part of the instruction.

3. The instruction shor 0000 has no effect.

4. Normally, the sign of accumulator storage is set to plus when the stored result is zero. This rule does not hold, however, if the result has been reduced to zero by a shorten instruction. For example, assume that the result 0004 is stored with the accumulator sign set to minus. The instruction SHOR 0002 is given. The result remaining in storage is now 00. The accumulator sign remains minus.

EXAMPLES, SHORTEN

	ACCUMULATO	R BEFORE	ACCUMULA	TOR AFTER
INSTRUCTION	STORAGE	SIGN	STORAGE	SIGN
SHOR 0002	a1246	+	a12	+
SHOR 0001	a1246		a124	—
SHOR 0000	a1246		a1246	

Lengthen (D-LENG)

1. The lengthen instruction inserts zeros to the right of the field in accumulator storage.

2. The number of zeros inserted is specified by the address part of the instruction.

3. The instruction LEN 0000 has no effect.

EXAMPLES, LENGTHEN

INSTRUCTION	ACCUMULATOR BEFORE	ACCUMULATOR' AFTER
LENG 0002	a5723	a572300
LENG 0005	a1	a100000
leng 0001	a4689	a46890



FIGURE 28. MEMORY STORAGE, GROSS PAYROLL

Program, Gross Payroll

Figure 29 is the program for gross payroll calculation, which illustrates the use of arithmetic instructions.

0004. Select tape unit 0200.

0009. Read record into memory beginning at address 0901.

0014. Reset accumulator A and add regular amount.

0019. Add incentive amount to regular amount. The accumulator storage amount is now the dividend to be divided by the regular hour field.

0024. One zero is added to the left of the accumulator field to insure that the first three digits of the dividend will be less in value than the divisor.

0029. The divisor has one decimal, the quotient two decimals, and the quotient is to be half adjusted, making a total of four places to point off in the dividend. Because the dividend now has two decimals, it must be shifted two positions. The number of positions to the right of the decimal in the dividend must be equal to the number of decimals in the divisor, plus the number of decimals in the quotient, plus one for half adjustment.

0034. Divide:

Average rate $=\frac{\text{regular amount } + \text{ incentive amount}}{\text{regular hours}}$

0039. Half-adjust the average rate to the nearest cent.

INSTR.	INSTRUCTION				ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS	ACCOMODATOR A	SIGN	ACCOMOLATOR B	ŝ
0004	Sel	0200				
0009	Read	0901				
0014	R Add	0929	a55.00	+		
0019	Add	0933	a67.56	+		
0024	Set L	0005	a067.56	+		
0029	Leng	0002	a067,5600	+		
0034	Div	0922	a1.535	+		
0039	Round	0001	a1.54	+		
0044	Store	0936				
0049	Mpy	0925	a03.080	+		
0054	Round	0001	a03.08	+		
0059	Store	0940				
0064	Add	0929	a58.08	+		
0069	Add	0933	a70.64	+		
0074	Store	0944				
0079	Sel	0201				
0084	Write	0901				
0089	Tr	0004				
		1	l			

FIGURE 29. PROGRAM, GROSS PAYROLL

0044. Store average rate.

0049. Multiply: Average rate \times overtime allowance hours = overtime amount.

0054. Half-adjust overtime amount to the nearest cent.

0059. Store overtime amount.

0064. Add regular amount.

0069. Add incentive amount.

0074. Store gross pay.

0079. Select new tape unit.

0084. Write out record.

0089. Transfer to instruction at address 0004.

ALPHAMERICAL INSTRUCTIONS

THE 702 can perform many different collating operations with merging, matching and selection of alphabetic or numerical information from either card or tape records. Factors from these records may be used in calculation and fields may be rearranged during a collating procedure.

Table look-up of such factors as price lists, rate tables, and inventory status can be combined with arithmetic operations. Output may be in the form of printed reports, punched cards or magnetic tape.

All three types of output units may be used in the same data-processing procedure and any number of units of each type can be used in combination. The instructions by which these operations are performed are referred to as alphamerical instructions.

Sequence Checking

A payroll record, to be stored in memory as in Figure 30, is now on tape. The file is to be checked to determine if the records are in ascending numerical sequence by man number. If any out-of-sequence or equal records are discovered, those records are to be written on the typewriter for checking by the operator. When the sequence is correct, the program is repeated for successive records.

Typewriter

The typewriter on the Type 702 can be used to print directly from memory, one character at a time. The speed of typing is approximately 600 characters per minute. All other operations of the machine are held up during the typing operation.



FIGURE 30. MEMORY STORAGE, SEQUENCE CHECKING

Any character not on the code chart prints as a question mark. A plus zero and a minus zero print as a plus sign and a hyphen, respectively. Sensing the record mark causes a carriage return and automatic spacing in accordance with the setting of the space control on the carriage. The record mark does not print.

Load Accumulator Storage (8-LOAD)

1. The load instruction enters a field of alphabetic, numerical or alphamerical information into accumulator storage from memory.

2. The location of the right-hand character of the field in memory is specified by the address part of the instruction.

3. The length of the field loaded into accumulator storage is determined by the position of the accumulator mark. Usually the load instruction is preceded by a set left instruction to adjust accumulator storage to the size of the field to be loaded. Characters are loaded from right to left from memory until the available accumulator storage space is filled.

4. The accumulator sign is always set to plus by a load instruction.

5. The field in memory is unaffected.

EXAMPLES, LOAD

ACCUMULATOR BEFORE			ACCUMULATOR A	FTER
MEMORY	STORAGE	SIGN	STORAGE	SIGN
ABCbbb12345	a7310	+	a2345	+
ABCbbb12345	a12345678901		алвсырр12345	+
ABCbbb12345	a00	+	a45	+
ABCbbb12345	a00000012	+	abbb12345	+

Unload Accumulator Storage (7-UNLOAD)

1. The unload instruction enters a field of alphabetic or numerical data into memory from accumulator storage.

2. The right-hand character of the accumulator field is stored in memory at the location specified by the address part of the instruction. Successive characters are read from right to left into memory until the accumulator mark is read.

3. The length of the field entered into memory is equal to the number of positions in the accumulator storage field.

4. The accumulator sign has no effect upon the information unloaded into memory.

5. The contents of accumulator storage remain the same.

ACCUM	ULATOR	MEMORY	MEMORY
STORAGE	SIGN	BEFORE	AFTER
a3748	—	в0229	в3748
a450	+	1576	1450
aab12	+	134cd	1 AB12
ab\$bb	+	0000	b\$bb

Compare (4—COMP)

1. The compare instruction compares the contents of accumulator storage with the field in memory specified by the address part of the instruction.

2. The comparison begins between the right-hand character in memory specified by the compare instruction and the right-hand character of the accumulator storage field. The comparison proceeds from right to left, character for character, between storage and memory until the accumulator mark is read. The results of the comparison are determined in the usual way; that is, the most significant characters are those on the left. The number of characters compared is equal to the number of positions in the accumulator storage field.

3. All characters that can appear in memory may be compared. The tape mark, drum mark and accumulator mark do not normally appear in memory. The tape inter-record gap and the drum marks, however, are automatically converted to a record mark when read into memory. The record mark can be compared. The ascending sequence of characters is as follows:

Blank & . $\square - \$ * / , \% # @ 0 A through I$

0 J through R ‡ S through Z 0 through 9

4. The results of a comparison are made available in the program by means of two comparison indicators, high and equal. If the accumulator storage field is higher than memory, the high indicator is turned on. If the two fields are equal, the equal indicator is turned on. If the accumulator storage field is lower than memory, neither indicator is turned on.

5. The comparison indicators may be referred to in the program or "interrogated" by a special transfer instruction. For example, if a comparison turns on the high indicator, a following transfer on high instruction effects a transfer to the address of another program step specified by the transfer instruction. In this manner supplementary program routines may be introduced as a result of comparisons.

6. The machine contains only one pair of comparison indicators. They may be turned on by the results of comparisons in either accumulator. Indicators are changed only by execution of a subsequent comparison step in the program. This step may also involve either accumulator. Indicators are not changed by interrogation. They may be interrogated any number of times between comparisons.

7. A signed numerical field in memory should not be compared against an accumulator storage field which has resulted from an arithmetic operation. A calculated result appears in accumulator storage without a sign over the right-hand digit. A numerical field usually appears in memory with a signed righthand digit. A comparison would be unequal, therefore, because of the sign.

Fields are usually entered into accumulator storage for a comparison by a load instruction.

		INDICATORS	
ACCUMULATOR	MEMORY	HIGH	EQUAL
a1234	\$1234		On
a1234	\$1234	On	
a1234	\$2345		
atypeb702	түрев701	On	
asмітнbbb	WARFIELD		
аѕмітньрр	sмітнbbb		On
asмітнbbb	jonesbbb	On	
	•		

Transfer on High (K-TR HI)

1. The transfer on high instruction interrogates the high comparison indicator. When the indicator is on, the machine transfers to the instruction specified by the address part of the transfer on high instruction.

2. If the high indicator is not on, a transfer is not made and the machine proceeds to the next instruction.

3. The instruction can be used during any program step following a comparison.

4. The instruction can be used any number of times between comparisons without turning the indicator off.

Transfer on Equal (L—TR EQ)

1. The transfer on equal instruction interrogates the equal comparison indicator. When the indicator is on, the machine transfers to the instruction specified by the address part of the transfer on equal instruction.

2. If the equal indicator is not on, a transfer is not made and the machine proceeds to the next instruction.

3. The instruction can be used during any program step following a comparison.

4. The instruction can be used any number of times between comparisons without turning the indicator off.

Program, Alphamerical Instructions

The program for sequence checking is shown in Figure 31. It is assumed that a constant 0 has been stored in memory at address 1036 by the loading procedure. The 0 is used to place zeros in memory to compare against the first record only. Memory addresses 1038 through 1043 are reserved for storage of man number from the last record read. Each

INSTR.	INSTRUCTION		ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS	ACCOMULATOR	š	ACCOMULATOR B	S
0004	Set L	0001				
0009	Load	1036	a0	+		
0014	Set L	0006	a000000	+		
0019	Unload	1043				
0024	Sel	0200				
0029	Read	1001				Ľ
0034	Load	1006	a123456	+		
0039	Comp	1043				
0044	Tr Hi	0019				
0049	Sel	0500				
0054	Write	1001				
0059	Tr	0024				

FIGURE 31. PROGRAM, SEQUENCE CHECKING

record is to be compared against the record preceding it for high, low or equal condition.

0004. Accumulator A is set left one position.

0009. The constant 0 is loaded into the accumulator.

0014. The accumulator is expanded to six zeros by the instruction SET L 0006.

0019. Six zeros are unloaded into memory at address 1043.

0024. Tape unit 0200 is selected.

0029. A unit record is read from the tape.

0034. Man number from the first record is loaded into accumulator storage A. The accumulator was previously set left six places.

0039. Man number in the accumulator is compared against the previous number stored at memory address 1043. The first record is compared against zeros.

0044. When the record is higher than the preceding stored record, a high comparison indicator



FIGURE 32. FLOW CHART, BALANCE FORWARD

is turned on. If the record is in sequence, a program transfer is effected to the instruction located at address 0019. The instruction at location 0019 unloads the man number just checked for sequence into address 1043 for comparison against the next record.

0049. When the record is equal to or lower than the preceding record, the high comparison indicator is not on. The transfer on high instruction is ignored and the typewriter is selected.

0054. The record out of sequence is written on the typewriter.

0059. The program is transferred to the instruction located at address 0024 to read a new record.

Balance Forward

The records shown in Figure 32 are processed as part of a stock control procedure. The stock receipt transactions are received in part number sequence on cards with all fields punched. Only one receipt per part number occurs on any one date and it is assumed that all receipts will match part number on the inventory control record. Inventory control records are in part-number sequence on tape. Only one record is kept per part number. All inventory records will not match receipts. The procedure calls for posting of the stock receipts to the inventory control record. A new receipt-to-date balance quantity is calculated and the date and receipt amount are recorded as memorandum amounts.

Add to Memory (6-ADD MEM)

1. The add to memory instruction adds the field in accumulator storage to a field in memory specified by the address part of the instruction.

2. The result replaces the original memory field.

3. The field in accumulator storage is unchanged.

The fields from accumulator storage may be added to memory in two ways depending upon whether the memory field is signed or unsigned.

Signed Memory Field. The addition follows the rules of algebra. The addressed field in memory starts with its right-hand signed digit and continues to the left until a non-numerical character is reached. Any carry-over beyond the left-hand limit of the memory field is ignored. Only numerical portions of the characters from accumulator storage are added.

Unsigned Memory Field. The addition is nonalgebraic and begins with the right-hand digit of accumulator storage and the specifically addressed character in memory and continues from right to left until the accumulator mark is reached. Any carry-over beyond the last position is ignored. The number of characters in the sum of the two fields is equal to the number of characters in the accumulator field. When non-numerical characters, including blanks, occur in the memory or accumulator fields, both zones and digits are added separately. The numerical portions of the characters are added decimally; any carry-over is added only to the numerical portion of the next high-order position. The zone portions of the character are added separately as binary numbers; any carry-over also is added to the next high-order zone position. Zone carries out of the last position are disregarded.

EXAMPLES, ADD TO MEMORY

ACCUMU	ILATOR	MEMORY	MEMORY
STORAGE	SIGN	BEFORE	AFTER
a33	+	5663	5696
a25	<u> </u>	s425	s400
a625	+	4676	4301
a12121	<u> </u>	в456	в335
a3	+	ъ¢	AC
a40	+	w1234	w 1274
a0900	+	R0111	r1011
a9900	+	r0111	r0011
a&	+	26	26
a—-		26	26

Sign (T-SIGN)

1. The sign instruction may be used to remove any zone from a character and place it in accumulator storage as an ampersand or a dash. The character affected is determined by the address part of the instruction.

2. When the zoning of the addressed character in memory is plus (11), zero (01), or no zone (00), an ampersand (plus zone) is stored in the accumulator and the accumulator sign is set to plus.

3. When the zoning of the addressed character in memory is minus (10), a hyphen (minus zone) is stored in the accumulator and the accumulator sign is set to minus.

4. The addressed character will remain in memory with 00 zoning, unless that character is an ampersand (&), a hyphen (-), or a blank. In these cases, the character remaining in memory will be a blank. 5. The sign stored in the accumulator as an ampersand (plus) or a hyphen (minus) may be given to any character in memory that is not already zoned. The add memory instruction is used for this purpose and the character to be signed is specified by the address part of the add memory instruction.

Signing Fields in Memory

Punched card fields are normally signed minus by X punching over the units digit of the field and are signed plus by no-X punching. When read into memory, the minus field is properly signed by reading the X punch as minus zoning over the units digit. The plus field, however, with no zone punching, is considered unsigned. An error is indicated when an unsigned memory field is addressed by an arithmetic instruction.

In Figure 33A, a field in memory positions 1143 through 1148 may be read in from cards as either minus or unsigned, depending upon the X or no-X punching in column 70 of the card. Instructions to sign the field completely are programmed as:

SIGN 1148 ADD MEM 1148

When position 1148 is plus (no X punching) the sign instruction places an ampersand in the accu-

mulator. The add memory instruction places plus zoning over position 1148 and signs the field plus.

When position 1148 is minus, the sign instruction places a hyphen in the accumulator and removes the zoning of the memory position. The add memory instruction restores the minus zoning and signs the field minus.

The sign and add memory instructions may also be used to move the minus zoning in fields from punched cards where X punching is located in columns other than the units digit of the field.

In Figure 33B, the minus X is punched in column 66 of the card field, columns 65 through 70. The field is read into memory positions 1143 through 1148 with the minus zoning in memory position 1144. The instruction to sign the field properly in memory is programmed as:

SIGN 1144 ADD MEM 1148

Program, Balance Forward

The program for the balance forward procedure is shown in Figure 34.

0004. Select card reader 0100.

0009. Read the stock receipt card into memory.



A. SIGNED FIELD FROM CARD TO MEMORY X PUNCHED IN UNITS COLUMN OF THE FIELD



B. SIGNED FIELD FROM CARD TO MEMORY
 X PUNCH IN OTHER THAN UNITS COLUMN OF THE FIELD

FIGURE 33. USE OF THE SIGN INSTRUCTION

INSTR. LOCATION	INSTRUCTION		ACCUMULATOR A	sign		SIGN
	OPER.	ADDRESS	ACCOMODATOR A	š	ACCOMOLATOR B	ž
0004	Sel	0100				
0009	Read	0501				
0014	Sign	0580	a&	+		
0019	Add Mer	<u>1 0580</u>				
0024	Set L	0006	a00000&	+		
0029	Load	0510	a30600A	+		
0034	Sel	0200				
0039	Read	0601				
0044	Comp	0606				
0049	Tr Eq	0069				
0054	Se1	0201				
0059	Write	0601				
0064	Tr	0034				
0069	Set L	0004	a600A	+		L
0074	Load	0504	aJU25			
0079	Unload	0629				_
0084	R Add	0580	a001500	+		
0089	Store	0636				
0094	Add Men	0642				
0099	Sel	0201				L
0104	Write	0601				
0109	Tr	0004				L

FIGURE 34. PROGRAM, INVENTORY CONTROL

0014. Place an & in accumulator A by addressing the units digit of the quantity received field of the card record with the sign instruction.

0019. Sign the quantity received field by adding & to the units digit of the field.

0024. Set left six positions to prepare accumulator A to store part number.

0029. Load part number from the card record. 0034. Select tape unit 0200.

0039. Read the inventory control record into memory.

0044. Compare the receipt part number with the inventory control part number.

0049. When part numbers are equal, transfer to the program for adjusting the inventory record.

0054. When the cards are not equal, select tape unit 0201.

0059. Write out the inventory record on new tape. Receipt balances have not been affected.

0064. Transfer to read in another inventory record from tape unit 0200.

0069. The balance forward program begins with this instruction. Set left four positions to store date received.

0074. Load date received from card.

0079. Unload date into the inventory control record.

0084. Reset and add the quantity received from the card.

0089. Store quantity received in inventory record. 0094. Add quantity to the receipts-to-date field. 0099. Select tape unit 0201.

0104. Write out the adjusted inventory record on new tape.

0109. Transfer to address 0004 and read a new card. Repeat the program.

INTERNAL CHECKING AND END-OF-FILE PROCEDURES

THE INTERNAL checking devices built into the 702 have been designed to insure accuracy of data processing. In order to illustrate the effect of these devices upon machine operation, an explanation of the character coding system is presented in this section together with examples of the use of the check indicators, input-output indicators, and control instructions. Two payroll problems are included, one illustrating end-of-file and error correction and the other illustrating most instructions covered to this point.

Character Code System

Figure 35 illustrates the coding system used for data recording on the IBM punched card. Punching is done in two main areas; the lower numerical section records the digits 0-9 and the upper zone section, used in combination with the numerical section, records alphabetic and special characters. A total of 80 characters may be punched in one card, because each character occupies one of the 80 vertical columns.

The numerical section is further divided into ten horizontal rows, one row for each digit 0-9. The zone section is divided into three horizontal rows, 0, 11, and 12. The zero row is common to both zone and numerical sections.

When punched in their proper rows, the holes can be automatically identified as characters by IBM accounting machines (and the 702); the digits by single punches, the letters and special characters by combinations of zone punching with digits. The 12 zone in combination with the digits 1-9 is recognized as the letters A-I, the 11 zone punch with the digits 1-9 as J-R, and the 0 zone with the digits 2-9 as S-Z.

The same code structure used in punched card accounting is also used by the Type 702. Only the



FIGURE 35. CHARACTER CODING, IBM CARD

digit notation and the form of recording are different.

Figure 36 shows an enlarged section of magnetic tape with character coding represented schematically. Actually, recording on the tape is not visible to the eye. The tape is divided into three sections:

- 1. The zone section, consisting of two horizontal rows or "channels."
- 2. The numerical section, consisting of four channels. Each numerical channel is assigned a value of 8, 4, 2, or 1, respectively.
- 3. The check section, consisting of one channel; used for checking purposes only. A character is defined only by the numerical and zoning sections.

Recording is accomplished by magnetizing spots or "bits" in the iron oxide coating of the tape. The presence of a charge indicates a one, the absence of a charge indicates a zero. The arrangement of these magnetized bits in combinations in the seven channels forms digits, letters and special characters. For example, the zoning bit combination of 11 (one, one) represents the 12 zone of IBM cards, the combination of 10 (one, zero) represents the 11 zone, and 01 (zero, one) represents the 0 zone. A 00 (zero, zero) combination corresponds to no zoning or pure numerical punching.

Because there are only four numerical channels on the tape instead of ten possible numerical positions on the card, bits in the numerical section are also used in combination to represent numerical values. By adding the values of one or more bits any number from 1 to 9 can be represented. In punched card coding the number 7 is represented by a punch in the 7 position of the card (Figure 35). By reference to Figure 36 it may be seen that 7 is represented in bit form by 1's in the 4, 2 and 1 numerical positions. The sum of the bits in the numerical and zone sections of the character is odd. Therefore a 1 is stored in the check position to record an even total number of 1's in the number 7.

The character P (Figure 36) is represented by 1's in the 4, 2 and 1 numerical positions and a 10 zoning. The sum of the zone and numerical 1's is even. Therefore a zero is stored in the check position. The check position is used to store a 1 whenever the sum of the 1's in the numerical and zoning portions of the character is odd, and to store a zero if the sum of the 1's is even. A character code check on the transmission, reading, and recording of all data is made by the machine to insure that each character has an even total number of 1's including zone, numerical and check positions.

The code system shown on tape in Figure 36 is used in all components of the 702, including memory, accumulator storage, and drum storage. The conversion of the 702 code system to or from IBM card code is automatic whenever a card reader, printer, punch, or typewriter is used.



FIGURE 36. CHARACTER CODING, MAGNETIC TAPE

Check Indicators

The 702 is equipped with six check indicators to provide the operator with a check on the accuracy of data being processed by the 702. These indicators are associated with separate switches on the operator's control panel.

In many cases, it is not necessary to interrupt machine operation when an error condition is detected. Special branch programs can be included by the programmer to handle certain types of errors as exceptions. An error in reading a record from tape, for example, may be programmed to back space the tape and re-read the record. If a correct reading is obtained the second time, normal machine operation will continue. If the error persists, machine operation can be interrupted or the incorrect record can be noted and operation continued.

The choice of programming around an error or stopping the machine is given by the indicator switch setting on the operator's console. When a switch is set to AUTOMATIC STOP, the error detected by the corresponding check indicator will cause an automatic machine stop. To resume operation, the indicator may be turned off by depressing the start key on the operator's console. When a switch is set to PROGRAM, the corresponding check indicator may be "interrogated" during the program and an error will not automatically stop the machine. The particular instruction during which the error was detected will be carried out and the machine will proceed to the next instruction.

A check indicator is interrogated by a select instruction with the address of the proper indicator. The select instruction is then followed by a transfer on signal instruction with the address of the first operation of the program branch to be followed if an error is detected. An error transfers the machine to the branch of the program addressed by the transfer on signal instruction. Machine operation is not interrupted when the error is corrected by the branch program. The transfer on signal instruction turns the indicator off.

Check indicators and their assigned addresses are:

Instruction Check Indicator	0900
Machine Check Indicator	0901
Read-Write Check Indicator	0902
Printer-Punch Check Indicator	0903
Overflow Check Indicator	0904
Sign Check Indicator	0905

Instruction Check Indicator

The instruction check indicator is turned on when:

- 1. During instruction time, a character code error is detected.
- 2. An invalid operation part is encountered going to the operation register.
- 3. The operation part is incorrectly interpreted.
- 4. The highest order position of the instruction address carries any zone other than 00 zone or the minus (10) zone to designate accumulator B.
- 5. Any of the remaining positions of the addresses are other than the numerical 0 through 9.

It is recommended that the switch associated with this indicator be turned to AUTOMATIC STOP to cause a machine stop when an error is detected. Programming around this type of error is usually impractical. With the switch set to AUTOMATIC STOP, the machine stops during the character cycle in which the error occurred.

Machine Check Indicator

The machine check indicator is turned on when a character code error is detected during the execution of all instructions (except write, write and erase, read, and read check) in which information is read from accumulator storage or memory.

Instructions to read information from accumulator storage or memory include: sign, add memory, reset and add, reset and subtract, store, store for print, load, unload, lengthen, set left, round, and normalize and transfer.

When the indicator switch is turned to AUTOMATIC STOP, the machine stops during the character cycle in which the error occurred.

Read-Write Check Indicator

The read-write check indicator is turned on when a character code error is detected during the execution of a read, read and check, write, or write and erase instruction. The indicator is also turned on if an error is detected in reading the holes in the card or by the longitudinal check in tape reading. The indicator, therefore, checks the transmission of data from all input units. It also checks the transmission of data from memory to the drum, tape unit, card punch, printer, and typewriter. The indicator is turned on if an attempt is made to read or write beyond the limits of the drum or if an error occurs in recording a tape mark. (See *Control 0001*.)

Errors detected by the echo-check method on the printer and by the brush-compare method on the punch are covered by the printer-punch check indicator.

When the indicator switch is turned to AUTOMATIC STOP, an error stops the machine after the instruction is executed.

Printer-Punch Check Indicator

The printer-punch check indicator is turned on when an error is detected by the echo-check or brushcompare method on the printer or punch. An error in card punching is detected as the card passes the brush station. When an error occurs, the printerpunch indicator is turned on during the execution of the second write or write and erase instruction involving that card punch.

An error in printing is detected by sensing when the print wheels start turning. When an error occurs, the printer-punch indicator is turned on during the execution of the *next* write or write and erase instruction involving that printer.

In both cases, when the switch for this indicator is on AUTOMATIC STOP, an error stops the machine at the end of the punching or printing cycle during which the indicator was turned on. At this time the error card is the last card into the punch stacker. The incorrect line of printing immediately precedes the last printed line.

Overflow Check Indicator

The overflow check indicator is turned on during an add or subtract operation when the number of digits in the result is greater than the number of digits in the longer of the original fields. An overflow is indicated as a result of a round operation if a carryover is made out of the highest order position of the original accumulator storage field.

The indicator is turned on by a divide instruction when the divisor does not have a greater absolute value than an equal number of digits taken from the left end of the dividend.

When the error switch for this indicator is turned to AUTOMATIC STOP, an error stops the machine during the execution of the instruction.

Sign Check Indicator

The sign check indicator is turned on if a field addressed by an arithmetic instruction, except store and store for print, does not have plus or minus zoning over the right-hand digit.

When the switch for this indicator is on AUTOMATIC STOP, an error stops the machine during the character cycle following the one in which the error was detected.

Input-Output Indicators

Card Reader Indicator

Each card reader is provided with an input-output indicator which is turned on when a read or read and check instruction involving that card reader is given after the last card has been read from record storage.

The indicator is turned off by the instruction CTRL 0000 or by the feeding of cards when machine operation is started.

Printer Indicator

Each printer is provided with an input-output indicator which indicates the end of a page. It is turned on by the overflow signal obtained from channel 12 of the carriage control tape as the last write instruction for each page is executed.

The indicator may be turned off by a CTRL 0000 instruction or by depressing the printer stop key.

Tape Unit Indicator

Each tape unit is also provided with an input-output indicator which indicates the end of a tape or file. The indicator can be turned on by any of the following:

1. Reaching the physical end of a tape when writing. This condition is signaled by a reflective spot on the tape itself at a convenient distance from the end of the tape.

2. Reaching the end of information on tape when reading. A tape mark is considered a unit record and is read on the first read instruction after the last record has been read from the tape.

3. When activated by the program by the use of a CTRL 0003 instruction. (See *Control*.) The inputoutput indicator is turned off by the CTRL 0000 instruction and also by depressing the unload key on the tape unit.

Drum Indicator

The input-output indicator of a drum is turned on if an attempt is made either to read or write beyond the limits of the drum.

The indicator is turned off by a CTRL 0000 instruction and also by a subsequent read, read and check, write, or write and erase instruction specifying that drum.

The input-output indicator of any unit is automatically selected by the use of a select instruction specifying the address of that unit. Thus, the instruction SEL 0100 not only selects a specific card reader but also selects the input-output indicator of that unit. The indicator may then be interrogated by a subsequent transfer on signal instruction. When the indicator is on, signaling end of cards, tape, or other conditions, a transfer to a branch program can be made for end-of-file procedure. When the indicator is off, a transfer is not made and the machine continues to the next step of the main program.

Control Instructions

Six control instructions are used to control various features of the input-output units and to turn on and off the input-output indicators. The control instruction applies to the last selected input-output unit. No other select instruction may intervene between the input-output select instruction and the control instruction referring to it.

The address part of the control instruction specifies the feature to be controlled, as follows:

Control 0000 (3-CTRL)

The input-output indicator of the unit previously selected, if on, is turned off. This instruction refers to printers, tape units, drums, and card readers.

Control 0001 (3-CTRL)

A tape mark is recorded on tape in the last selected unit. A check is also made of the echo impulses from the write circuits to insure that the proper character arrived at the tape unit write circuits. If not, the read-write check indicator is turned on. (See Checking.)

Control 0002 (3-CTRL)

The tape on the last unit selected is rewound.

Control 0003 (3-CTRL)

The input-output indicator on the tape unit last selected, if off, will be turned on.

Control 0004 (3—CTRL)

The tape on the unit last selected will be backspaced one unit record. This instruction is intended for use in checking of tape in conjunction with the read and check instruction. A record containing an error can be rewritten after back-spacing over it. A write instruction, however, can be followed by a back-space instruction only if the remainder of the tape contains unwanted information.

Control 0005 (3-CTRL)

This applies to printers and punches only. Information previously read from memory to the printer or punch record storage is prevented from being printed or punched for one cycle. By the use of this control, erroneous information previously written into the printer or punch record storage can be corrected.

For example, assume that a printer or punch is selected by a select instruction and is given a write instruction. The read-write indicator may now be selected by the instruction SEL 0902 and can be interrogated by the transfer on signal instruction. The address of the transfer on signal instruction is the address of the first step of a branch program. If the indicator 0902 is on, a character code error has occurred between memory and record storage, and a transfer to this branch program will be made.

The first step of the branch program contains the control 0005 instruction and prevents the incorrect record from being printed. The record can now be reloaded from memory into printer record storage and a transfer can be made back to the main program. Stop and Transfer Instructions

The use of the control instruction for end-of-file and error procedure may be illustrated by considering a second problem of simple payroll calculation (Figure 37).

Payroll information is received on tape and information read into the 702 is checked for accuracy of reading. If a reading error is discovered, the tape is back-spaced and the record re-read. If the error persists, the tape is back-spaced and read a third time.



FIGURE 37. FLOW CHART, END OF FILE AND ERROR CHECK
The machine is stopped if the error occurs on the third reading. When the end of the input tape is signalled, the tape is rewound.

Net earnings are computed and completed payroll records are written on a new output tape. A tape mark is recorded on the output tape when the end of file is signalled from the input tape and the output tape is rewound. Machine operation is stopped after all instructions have been executed.

Stop (J-STOP)

The stop instruction stops the machine on the program step containing the stop instruction. Depressing the start key will cause the machine to read and execute the next instruction.

Several stops may be indicated in a program at the discretion of the programmer. Incorrect reading or writing, end of file, or various other conditions encountered in a procedure may be programmed to stop the machine. The address part of the stop instruction appears in binary code in lights on the console and may be coded to indicate to the operator why a stop has occurred. In the following problem, STOP 0001 indicates an error condition that persists after a record has been read three times. STOP 0002 indicates end of file. Any four-digit code can be assigned to the address part of a stop instruction.

Transfer on Plus (M-TR PLS)

The transfer on plus instruction causes a program transfer when the sign of the designated accumulator is plus. The transfer will be made to the address specified by the address part of the instruction.

When an accumulator storage field consists of all zeros, the sign of the accumulator is always plus except as a result of a round or shorten instruction. (Refer to *Round* and *Shorten*.) Therefore, if a distinction is to be made between zero and plus in the contents of accumulator storage, the transfer on plus must be preceded by a transfer on zero instruction.

Transfer on Zero (N-TR ZRO)

The transfer on zero instruction causes a program transfer when the designated accumulator contains only characters having numerical portions equal to zero (1010). These characters are zero, plus or minus signed zero, and the record mark. The instruction has no effect when a factor in accumulator storage is reduced to zeros by a shorten or round instruction.

Transfer on Signal (O—TR SIG)

The transfer on signal instruction causes a program transfer when the last previously selected indicator is on. The indicator may be an input-output indicator, an alteration switch or a check indicator. The transfer will be made to the memory address specified by the address part of the instruction.

When the transfer on signal is executed, the instruction turns off a check indicator only. An inputoutput indicator is turned off by a control instruction or by various other means. (Refer to *Input-Output Indicators.*) The alteration switches are manually operated.

Program, End-of-File and Error Correction

Figure 38 is the end-of-file error correction program.

0004. Reset and add the constant $\overline{2}$ into accumulator B.

0009. Select tape unit 0200.

0014. Read a record from tape beginning with memory position 0128.

0019. Transfer on signal. If the input-output indicator is on, the end of the tape has been reached.

INSTR.		JCTION	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS	ACCOMODATOR A	SIC	ACCOMOLATOR B	š
0004	R Add	0153			a2	+
0009	Sel	0200				
0014	Read	0128				
0019	Tr Sig	0089				
0024	Sel	0902				
0029	Tr Sig	0064				
0034	R Add	0139	a012500	+		
0039	Sub	0144	a011500	+		
0044	Store	0150				
0049	Sel	0201				
0054	Write	0128				
0059	Tr	0004				
	ERR	OR COR	RECTION PR	.00	RAM	
0064	Sel	0200				
0069	Ctrl	0004				
0074	Sub	$\bar{0}155$			a1	+
0079	Tr Pls	ō014				
0084	Stop	0001				
	END	OF FU	E PROGRAM	-		_
0089	Ctrl	0002				
0094	Sel	0201				_
0099	Cont	0001				
0104	Cont	0002				
0109	Stop	0002				

FIGURE 38. PROGRAM, END OF FILE AND ERROR CHECK

Transfer to address 0089 for the first step of the end-of-file procedure.

0024. Select the read-write check indicator.

0029. If the read-write indicator is on, signalling a read error, transfer to address 0064 for the error correction procedure.

0034. Reset and add gross pay into accumulator A.

0039. Subtract deductions.

0044. Store net pay in memory.

0049. Select tape unit 0201.

0054. Write out the complete record on output tape.

0059. Repeat the program for succeeding records.

0064. Select tape unit 0200.

0069. Back-space the input tape.

0074. Subtract 1 from accumulator B.

0079. When an error occurs in first reading, accumulator B contains a 1 with the accumulator sign plus. On the second reading the accumulator stands at plus 0. On the third reading the accumulator contains a minus 1.

0084. After the record has been read three times, accumulator B has a minus sign. A transfer on plus is not made and the machine reaches the stop instruction 0002.

0089. Rewind tape unit 0200.

0094. Select output tape unit 0201.

0099. Record the tape mark on the output tape.

0104. Rewind the output tape.

0109. Stop the machine at the end of file.

Payroll, Gross to Net

The payroll record shown in Figure 39 is written on magnetic tape and is used as input data on tape unit 0200. Payroll computation includes:

a. Withholding Tax == Gross Pay — Tax Class \times 13.00 \times 18%. If no tax is to be deducted, zeros are entered into the tax space in the record.

b. Withholding year-to-date = last period taxto-date + current tax.

c. FICA = 2% of gross earnings, provided previous gross does not equal or exceed \$3600.00. If earnings this period make gross equal to or over \$3600.00, then only the difference between old year-to-date gross and \$3600.00 is taxable.

d. Year-to-date FICA = last period tax-to-date + current tax.

e. Year-to-date gross = current gross + previous year-to-date gross.

f. Net Pay == Gross -- Withholding -- FICA. The completed payroll record, after calculation, is written on output tape unit 0201, as follows:

FIELD	NUMBER OF Characters	EXAMPLE	MEMORY Address
Man No.	6	100372	1006
Tax Class	1	6	1007
Yrto-Date Earnings	6	350000	1013
Yrto-Date With. Tax.	6	043061	1019
Yrto-Date FICA	4	2142	1023
Net Pay	5	<u> </u>	1028
FICA	3		1031
Current With. Tax	4	<u> </u>	1035
Gross Pay	5	19279	1040

Constant data are stored in memory as follows:

ITEM	NUMBER OF Characters	MEMORY ADDRESS
1300	4	1045
18	2	1 047
020	3	1050
360000	6	1056
0000	4	1060

Program, Payroll

Figure 40 is the payroll, gross to net, program.

0004. Select input tape unit 0200.

0009. Read the record into memory.

0014. Add tax class into accumulator A.

0019. Multiply tax class by the constant 13.00 from memory address 1045. Note that the constant 13.00 is minus; therefore, a negative result is produced in the accumulator.

0024. Add gross pay into accumulator A. The result is the taxable amount if it is plus.

0029. When the result is a plus amount, tax can be taken and a transfer is made to address 0049 for tax calculation.

0034. When the result is a minus amount, a transfer will not be made. Reset and add 0000 to the accumulator to cancel the negative amount.

0039. Store 0000 in the withholding tax field of memory.

0044. Transfer to compute FICA.

0049. Multiply the taxable amount computed in location 0024 by the tax rate of 18%.

0054. Round two places and half adjust.

0059. Set left accumulator mark to four places.



FIGURE 39. FLOW CHART, PAYROLL (GROSS TO NET)

0064. Store withholding tax in memory.

0069. Add withholding tax to previous year-todate tax amount.

0074. Reset and add the constant 360000.

0079. Subtract previous year-to-date gross earnings. 0084. Subtract current gross earnings.

0089. If the result is plus, transfer to compute FICA on complete gross pay.

0094. If the result is minus, add back gross pay.

0099. If the result is plus, transfer to partial computation of FICA.

0104. If the result is minus, earnings are over \$3600.00 and no FICA is to be taken. Transfer to no-FICA routine.

0109. Multiply the result obtained at location 0094 by 2% for partial or total calculation. 0114. Round three places and half adjust.

0119. Set left accumulator mark to three places. 0124. Add current FICA to previous year-to-date FICA.

						r	Ŧ
INSTR. LOCATION	INSTRU OPER.	ADDRESS	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN	
0004	Sel	0200		l"		100	t
0004	Read	1001			•	1	t
0009	R Add	1001	a6	+		+	t
0014	Mpy	1007	a07800	T_			t
0013	Add	1040	a01800 a11479	+		-	t
0024	Tr Pls	0049		-		\square	t
0029	R Add	1060	a0000	+		1-	t
0034	Store	1035	40000	F		1	t
0044	Tr	0074					t
				1			t
	СОМ	DITTE V	THHOLDING	2 7		1	t
0049	Mpy	1047	a0206622	+			t
0054	Round	0002	a0200022	+		1	t
0059	Set L	0004	a2066	+		1	t
0064	Store	1035		Ľ			t
0069	Add Mer						t
				\mathbf{T}		\mathbf{T}	t
	TRIA	L FOR	FICA			\square	t
0074	R Add	1056	a360000	+			t
0079	Sub	1013	a010000	+			t
0084	Sub	1040	a009279	1-			t
0089	Tr Pls	0139				\square	t
0094	Add	1040	a010000	+		<u> </u>	t
0099	Tr Pls	0109		<u>†</u>			t
0104	Tr	0149					t
	1	0110					t
	PAR	TIAL FI	CA				Ī
0109	Mpy	1050	a000200000	+		Γ	Ī
0114	Round	0003	a000200	+		Γ	ſ
0119	Set L	0003	s200	+			Ι
0124	Add Mer						Γ
0129	Store	1031					Γ
0134	Tr	0164		Γ			ľ
х. Х.							I
	(WH	OLE PA	Y FICA				ĺ
0139	R Add	1040	a19279	+			I
0144	Tr	0109					I
							l
	NO	FICA					l
0149	R. Add	1060	20000	+			l
0154	Set L	0003	a000	+		Ĺ	ļ
0159	Store	1031					l
				1			ļ
	CO		NET PAY	 		_	ļ
0164	R Add	1040	a19279	+			ļ
0169	Add Me	n 1013					ļ
0174	Sub	1035	a17213	+		1	ļ
0179	Sub	1031	a17013	+		1	ļ
0184	Store	1028		 		1	ļ
0189	Sel	0201					ļ
0194	Write	1001		1			ļ
0199	Tr	0004		L		1_	ļ
1	ł	I	1	1	I	I.	I

FIGURE 40. PROGRAM, PAYROLL (GROSS TO NET)

- 0129. Store current FICA in memory.
- 0134. Transfer to net pay computation.
- 0139. Reset and add gross pay.
- 0144. Transfer to compute FICA.
- 0149. Reset and add four zeros.
- 0154. Adjust accumulator storage to three places.
- 0159. Store zeros in the FICA field in memory.
- 0164. Reset and add gross pay.

0169. Add current gross to previous year-to-date gross.

- 0174. Subtract withholding tax.
- 0179. Subtract FICA.
- 0184. Store net pay in memory.
- 0189. Select tape unit 0201.
- 0194. Write out the payroll record.
- 0199. Repeat the program for the next record.

TABLE LOOK-UP

MANY TYPES of procedures include as a basic operation the matching of detail transactions against a previous balance record. Usually the purpose of associating detail with balance records is to revise the balance to include the detail. In IBM accounting practice, three main steps are involved:

- 1. Arranging the detail in sequence by some field common to both detail and balance forward cards.
- 2. Matching and merging the detail with the balance forward records by a common field.
- 3. Summarizing to revise the balance forward and also printing a report to record new balances.

Other preliminary procedures may involve a separate coding operation where, instead of a balance record, a table look-up is required. This may be necessary in order to price, code, classify, or perform calculations on detail transactions before they are associated with balance cards. Three main steps are also involved in this procedure:

- 1. Arranging the detail in sequence by some field common to the detail and the table cards.
- 2. Matching and merging the detail with the table cards.
- 3. Transcribing a factor from the table to the detail card by gang punching or reproducing.

In clerical operations, the preliminary step of sorting the detail items is often omitted. Only the table, catalog, ledger or reference material is arranged in sequence. Detail items are compared one at a time against the reference material by looking down the left-hand column of the table until the matching field is discovered.

If the operation is a table look-up, a transcription is made from the table to the detail transaction. When a posting operation is being done, the detail item is posted to the balance record and a new balance is calculated.

Drum Storage

Drum storage may be used in the 702 for both table look-up and balance forward operations. Either the clerical or accounting machine method may be used, depending upon how the records are received, the number of items in the table, and drum capacity.

Magnetic Drum Storage Unit

From one to thirty magnetic drum storage units (Figure 41) are available with the 702, each with a maximum capacity of 60,000 characters. Drum storage of less than 60,000 characters is also available.

While the drum is revolving at high speed, information can be written magnetically on its surface in much the same manner as data are recorded on tape. Also, as on tape, recording is permanent and may be retained after the power is turned off. Writing over a section erases any information previously written.

Each drum is divided into 300 addressable sections and each section can store up to 200 characters. The average time required to locate the first character position of a section by a reading or writing operation is 8.12 milliseconds. Thereafter, characters can be read from or written consecutively on the drum at a rate of .04 milliseconds per character.

The drum is called into use by a select instruction and the address part of the instruction specifies the section to be operated upon. Addresses 1000-1299 specify the sections on the first drum, addresses 1300 to 1599 the sections on the second drum, 1600 to 1899 the third drum, and so on.

The select instruction may be followed by a read, read and check, write, or write and erase operation. Information is read from the drum starting with the first character of the section specified by the select



FIGURE 41. SCHEMATIC, DRUM STORAGE

instruction and is read into memory starting with the memory position specified by the reading instruction. Reading continues until a drum mark is sensed. The reading operation will then stop and a record mark will be emitted into the next higher memory position.

On a read and check operation, sensing the drum mark will cause the machine to check for a record mark in the corresponding memory position. If a record mark is not sensed in this position, the readwrite check indicator is turned on.

Information is written on the drum from memory starting with the memory location specified by the write instruction. The first character from memory will be written in the first position of the drum section specified by the select instruction. Writing continues until a record mark is sensed. The writing operation will then stop and a drum mark will be emitted on the drum in the next higher storage position.

Reading or writing can pass from one drum section to another until a drum or record mark is sensed. An attempt to read or write beyond the limit of the drum will turn on the read-write check indicator and also the drum input-output indicator used especially to detect this error. The input-output indicator will be turned off by a subsequent read, read and check, write, or write and erase instruction for the drum, or it may be turned off by a control 0000 instruction. The read-write indicator is turned off by a select and transfer on signal instruction.

Drum Search (Table Look-up) Problem

The following problem illustrates table look-up combined with balance forward calculations.

The cost of each labor ticket in a cost accounting procedure is to be applied to the corresponding job number. Each labor ticket (Figure 42) has a fourdigit job number and a four-digit suffix. The suffix is the number of the drum section where the total labor cost is stored.

In each section of the drum there are 18 job numbers of four digits arranged in ascending sequence. A seven-digit signed amount field is assigned to each job number to provide storage for a cumulative total for costs applied to that job number. The last job number in each section is 9999.

The program illustrated will read in the card, locate the proper drum section, and read the contents of that section into memory beginning in position 2001 (Figure 42). When the proper drum section is in memory, including all job numbers and amounts stored in that section, a search is made for the proper job number.

After it is found, the total cost is adjusted and the series of job numbers is again stored on the drum. The loading program for putting balance forward records on the drum is not included in this problem. The card record, the constant data and the drum record are shown below.

(CARD REC	ORD	
	NO. OF		
FIELD	DIGITS	EXAMPLE	ADDRESS
Dept. No.	3	168	4003
Man No.	5	07163	4008
Job No.	4	7170	4012
Job No. Suffix	4	1206	4016
Job Cost	5	b0941	4021
COI	NSTANT I	DATA	
Memory address			
of first job no.			
read in from drum	5	b2004	5004
Constant	4	0011	5008
Constant	4	0007	5012
DR	UM RECO	ORD	
Job Number	4	7170	
Total Cost	7	0014683	



DRUM RECORD STORAGE

FIGURE 42. RECORD STORAGE, DRUM SEARCH

INSTR.		ICTION	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS		ŝ	ACCOMODATOR B	š
0004	Sel	0100				
0009	Read	4001				
0014	Set L	0004				
0019	Load	4016	a1206	+		
0024	Unload	0034				
0029	Unload	0109				
0034	Se1	(1206)				
0039	Read	2001				
0044	Load	4012	a7170			
0049	Comp	(2004)				
0054	Tr Eq	0089				
0059	Tr Hi	0069				
0064	Stop	0001				
0069	R Add	5008			a0011	+
0074	Add Mer	n <u>0</u> 049				
_0079	Add Mer	n <u>0104</u>				
0084	Tr	0049				
	EQU	AL CON	DITION			
0089	R Add	4021	a0941	+		
0094	R Add	$\bar{5}012$			a0007	+
0099	Add Mer	n $\overline{0}104$				
0104	Add Mer	n (2004)				
0109	Sel	(1206)				
0114	Write	2001				
0119	R Add	5004	a2004	+		\square
0124	Unload	0049				
0129	Unload	0104				
0134	Tr	0004				

FIGURE 43. PROGRAM, DRUM SEARCH

Program, Drum Search

The steps in the program are as follows:

0004. Select card reader 0100.

0009. Read the card record into memory beginning with position 4001.

0014. Prepare the accumulator to load in four digits.

0019. Load in the job number suffix. This is also the address of the drum section where this job number is stored.

0024. Unload this address into the address part of a select instruction. The instruction can then be used to select the proper drum section for reading.

0029. Unload this address into the address part of a second select instruction. This instruction will later be used to select the proper drum section for writing the completed record back onto the drum.

0034. Select drum section 1206; this address was set up by the unload step in location 0024.

0039. Read the contents of the entire drum section 1206 into memory until the drum mark is sensed. 0044. Load the first job number from the card record into the accumulator.

0049. Compare the job number from the card record with the first job number from drum storage.

0054. When job numbers match, transfer to the balance forward calculation program branch.

0059. If the detail (card) job number is high, transfer to the program to compare against the next job number from the drum.

0064. If the detail job number is lower, an error has occurred; stop the machine.

0069. Reset add 0011 into the accumulator. When the job number is high, the compare instruction at location 0049 must be adjusted to compare with the next number on the drum. Each job number is spaced eleven positions on the drum, four for job number, seven for cost amount.

0074. The constant 0011 is added to the address part of the compare instruction. The 0011 is used because an add to memory instruction is addressed to an unsigned memory location.

0079. The constant 0011 is added to the address of the add to memory instruction to change the balance forward amount. This address now agrees with the compare instruction address which will check for a match between the detail job number and the next balance forward job number.

0084. Transfer to the compare instruction to compare the next highest job number from the drum.

EQUAL CONDITION—BALANCE FORWARD CALCULATION

0089. Job cost from the card record is added into accumulator A.

0094. The constant 0007 is added into accumulator B.

0099. A 7 is added to the address part of the next instruction to calculate the address of the balance-forward amount.

0104. Detail job cost is added to total cost.

0109. The drum section for the series of job numbers now stored in memory is selected.

0114. The job numbers and corresponding costs are read from memory to the drum.

0119. Reset and add the starting address of the first job number in memory.

0124. Replace the starting address in location 0049.

0129. Replace the starting address in location 0104.

0134. Transfer to read the next record.

OTHER INSTRUCTIONS

ADDITIONAL operations of the 702 are detailed in this section. These provide for rearrangement of records in memory for printing, checking of records which have been written on tape, cards, or drum, and elimination of repetitive printing. Also included are illustrations of floating dollar signs, using the normalize and transfer operation and the setting of a program switch using the no operation instruction.

Record Arrangement for Printing

When a write instruction follows the selection of a printer, data are "written out" of memory from left to right beginning with the character specified by the address part of the write instruction. Information is transmitted to printer record storage, character by character, exactly as received from memory until the record mark is reached.

In normal programming, it is therefore necessary to consider the report form and to record fields in memory to fit this particular form before a write instruction is given. One position must be allowed in the record for each type space of the printed line, including special characters, commas, decimals, and blanks. Insignificant zeros to the left of digits in arithmetical fields should also be dropped before printing.

Indicative fields, descriptions, or other portions of a record can be shifted to conform with the printing arrangement in memory by the use of load and unload instructions. Amount fields from accumulator storage are stored in memory for printing by the store for printing instruction.

Store for Printing (5—ST PR)

1. The store for printing instruction normally is used to transfer a numerical field from accumulator storage to memory.

2. When the sign of the accumulator is plus, a blank is stored in the memory position specified by the address part of the instruction.

3. When the sign of the accumulator is minus, a hyphen is stored in the memory position specified by the address part of the instruction.

4. The numerical accumulator field is stored in the memory positions directly to the left of the sign position. The left limit of the field is determined by the accumulator mark.

5. When decimals or commas are encountered in

memory, these memory positions are skipped and the digits are stored in successively lower address positions.

6. All zeros and commas to the left of the highest order significant digit of the resulting field in memory are replaced by blank characters. Zeros to the right of a decimal point will not be replaced.

7. The field in the accumulator remains unchanged by this instruction.

Program, Store for Printing

One method of using the store for printing instruction is to store the printing form on the drum as blanks and special characters during the loading procedure, as shown in Figure 44. The amount field in



FIGURE 44. INSTRUCTION, STORE FOR PRINTING

accumulator A is to be printed from print wheels 1 through 9. Eleven positions in memory are assigned for storage of the field, including the comma and decimal characters to be printed. One position is also allowed for the sign, one for a blank print wheel to the right of the field, and one position for the record mark. Memory addresses are 0614 through 0624. The program is diagrammed in Figure 44.

Additional examples of the store for printing instruction are given below:

ACC.	ACC.	ME	MORY
STORAGE	SIGN	BEFORE	AFTER
a007638	+	2135.146	bb76.38b
a0071834	<u> </u>	bb,bbb.bbb	bbb718.34 —
a00000000	+	bbb,bbb.bbb	bbbbbbb.00b
a0473829		bb,bbb.bbb	b4,738.29 —

Checking Tape Records

Information recorded on tape, drums, or cards may be checked by the use of the read and check instruction.

Read and Check (I—R CHK)

1. During the read and check operation, a record is read from the input-output unit last selected and is compared against a stored record in memory.

2. The address part of the instruction locates the first character of the record in memory to be compared.

3. Comparison between memory and a tape, card or drum record continues from left to right through higher memory address positions, one character at a time, until the end of the record is sensed. A test is then made to determine that a record mark is stored in the next higher memory address.

4. When the comparison results in an inequality, the read-write check indicator is turned on. A progratn transfer can then be made by a transfer on signal instruction.

Program, Read and Check

A program example of the read and check instruction is given in Figure 45. This method of correction assumes that no information is wanted beyond the point where back-spacing occurs.

0004. Select tape unit 0200.

0009. Write the output record.

0014. Back-space the tape unit record.

INSTR. LOCATION		JCTION	ACCUMULATOR A	sign	ACCUMULATOR B	SIGN
LOCATION	OPER.	ADDRESS		S		S
0004	Sel	0200				
0009	Write	0150				
0014	Ctrl	0004				
0019	R Chk	0150				
0024	Sel	0902				
0029	Tr Sig	0059				
0034						
	COF	RECTIC	N ROUTINE			-
0059	Sel	0200				
0064	Ctrl	0004				
0069	Tr	0009				

FIGURE 45. PROGRAM, READ AND CHECK

0019. Read the tape and compare with memory. 0024. Select the read-write check indicator (indicator is on if comparison is not equal).

0029. Transfer to the correction routine when the indicator is on.

0034. Continue the main program if no error is discovered.

Correction Routine

0059. Select the tape unit.

0064. Back-space the tape one record.

0069. Transfer back to the write routine.

Read and Check Sub-Routine

Sub-routines may be included in this program to limit the number of times the machine will attempt to rewrite a record. At the end of the limit, the machine can be instructed to stop and write the record on the typewriter. Operation can then continue at the discretion of the operator, depending upon the nature of the error.

The read and check instruction may also be used after all records have been written on the tape. The tape is rewound, the write instruction of the program is replaced by read and check, and the program is repeated. The records previously written will be checked against the recalculated results in memory. Over-all machine operation can be checked by computing the same records with two different programs.

Information recorded on the drum can be checked by giving a read and check instruction having the same address as the previous write instruction.

Cards can be checked after punching by placing them in a card reader and substituting the select and write instructions that pertained to the card punch with select and read and check instructions for the card reader.

The record illustrated in Figure 46 is on tape. Compute the number of days required to make a certain part. The time required, expressed in days, equals the hours required per part multiplied by the number of parts required, divided by eight (eighthour day), plus a constant five-day contingency. Round days.

Read the input tape and check for end of file and for character code error. If an error is detected, read the tape again. Stop the machine if the error persists after re-reading. When the end of file is sensed:

1. Rewind tape unit 1.

2. Place the tape mark on the new tape.



FIGURE 46. FLOW CHART, READ AND CHECK

- 3. Rewind tape unit 2.
- 4. Write instructions to the operator.
- 5. Stop the machine.

Write the output tape, back-space the output tape and read and check to be certain the record was written correctly. If an output error is detected, stop the machine. Formula:

$$\frac{\text{Hours per part } \times \text{ Parts required}}{8} + 5 =$$
Total Time Required

Note: Hours per part times parts required will never exceed 755.0 hours.

Program, Read and Check Sub-Routine

Figure 47 is the program for the problem.

0004. Select tape unit 0200.

0009. Read in the record.

0014. Transfer to end of file if the input-output indicator is on.

0019. Select the read-write indicator.

0024. Transfer to the error procedure if the readwrite indicator is on.

0029. Transfer to the calculation procedure if no error is indicated.

INPUT ERROR PROCEDURE

0034. Select tape unit 0200 a second time.

0039. Back-space the tape one record.

0044. Read the tape a second time and check.

0049. Select the read-write check indicator.

0054. If an error occurs the second time, transfer to stop the machine.

0059. If the error is corrected, transfer to calculate. 0064. Stop 0001.

CALCULATION PROCEDURE

0069. Reset and add hours per part.

0074. Multiply parts required.

0079. Divide product by 8 hours.

- 0084. Round off the last decimal place.
- 0089. Remove the insignificant zero.
- 0094. Add the 5-day contingency.
- 0099. Store the result in memory at address 0722.

OUTPUT ERROR PROCEDURE

- 0104. Select the output tape unit 0201.
- 0109. Write the record.
- 0114. Back-space the output record.
- 0119. Read the record and check.
- 0124. Select the read-write check indicator.

INSTR.	INSTR	JCTION		z	r	Iz	T
LOCATION	OPER.	ADDRESS	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN	l
0004	Sel	0200					t
0009	Read	0710					ſ
0014	Tr Sig	0144					ſ
0019	Sel	0902					Γ
0024	Tr Sig	0034					Γ
0029	Tr	0069					ſ
							F
	INPU	T ERRO	R PROGRAM	r			ſ
0034	Se1	0200					Γ
0039	Ctrl	0004					
0044	Read	0710					
0049	Sel	0902					
0054	Tr Sig	0064					
0059	Tr	0069					-
0064	Stop	0001				Ì	
	CAL	CULATI	ON PROGRAM	1			
0069	R Add	0717	a17	+			
0074	Mpy	0720	a05423	+			
0079	Div	0725	a0677	+			
0084	Round	0001	a 068	÷			
0089	Set L	0002	a68	+			_
0094	Add	0727	a73	+			
0099	Store	0722					_
	OUT	PUT ER	ROR PROGRA	M			
0104	Sel	0201					
0109	Write	0710					_
0114	Ctrl	0004					
0119	R Chk	0710					
0124	Sel	0902					
0129	Tr Sig	0139					_
0134	Tr	0004					
0139	Stop	0002					_
							-
	END	OF FIL	E PROGRAM				-
0144	Ctrl	0002				$ \rightarrow $	_
0149	Sel	0201					_
0154	Ctrl	0001					_
0159	Ctrl	0002					-
0164	Sel	0500					ŀ
0169	Write	9801		<u> </u>	l		ł
0174	Stop	0003		\vdash			Ļ

FIGURE 47. PROGRAM, READ AND CHECK

0129. Transfer to stop 0002 if an error is detected.

0134. If no error occurs, read the next record and repeat the entire program.

0139. Stop 0002.

END OF FILE PROCEDURE

- 0144. Rewind the input tape unit 0200.
- 0149. Select tape unit 0201.
- 0154. Write a tape mark on the tape.
- 0159. Rewind tape unit 0201.
- 0164. Select the typewriter.
- 0169. Write the instruction to the operator.
- 0174. Stop 0003.

Write and Erase Memory

It is often desirable, when writing a record on tape or when printing reports, to write certain indicative information only once. This information may be common to a group of records. Usually, the common information, such as name, part number, invoice number, or customer number, is written with the first record of the group. In accounting machine practice this operation is referred to as "group indication." The same operation can be performed by the 702 by using the write and erase memory operation.

Write and Erase (Z—WR ER)

1. The write and erase instruction is used to transfer a record stored in memory to an output unit or a drum. A select instruction is first given to specify the address of the tape unit, card punch, printer, or drum section to be used. The address part of the write and erase instruction locates the first left-hand character of the record in memory. 2. A record is written from memory from left to right until a record mark is sensed in the same manner as for the write instruction. The write and erase instruction, however, replaces *each character in memory by a blank*. The entire record is therefore erased from memory when the instruction is executed. The storage of the record mark is unchanged.

3. The instruction is normally used for printing successive lines of different field arrangement or for group indication when detail printing. Fields may also be arranged on the tape for future printing and repetitive information can be eliminated in successive records.

Program, Write and Erase

The report form illustrated in Figure 48 is printed by using the write and erase instruction.

Card input records are stored in memory as shown in Figure 48A. Cards are received in sequence by assembly number and are punched to include the



c.	PRINTED	OUTPUT	RECORD	STORAGE

	Assembly Number	Assembly Name	Quantity Assem's	Part No.	Total Parts
ne 1 ne 2 ne 3 ne 4	104683A	BAIL ARM	150	107843P 107943P 107953P 107963P	300 1,500 900 300
ne 5 ne 6 ne 7	104706A	FEED ROLL	300	107230P 107246P 107257P	600 300 1,200
ne 8	104786 A	PLATEN	1,150	106P 209P	2,300 1,150

FIGURE 48. STORAGE AND REPORT, WRITE AND ERASE MEMORY

fields shown. Card fields are unsigned. The steps in the procedure follow.

- 1. The quantity of assemblies is multiplied by quantity of parts per assembly to calculate the total parts requirements.
- 2. The card record is arranged for printing in memory as shown in Figure 48C.
- 3. A comma, zero and record mark are stored for use as constant factors (Figure 48B).
- 4. The previous card record assembly number is stored in memory for sequence checking and to control group indication of assembly number, name, and quantity (Figure 48B).

The complete program is shown in Figure 49. A detailed explanation follows.

0004. Reset and add plus zero in accumulator A. 0009. Place seven zeros in the accumulator.

0014. Unload seven zeros in memory at address 0588. Zeros are used to compare against the first

card record assembly number to obtain a higher comparison.

0019. Set left accumulator B one position.

0024. Load in the record mark.

0029. Place the record mark at the end of the print record.

0034. Load a constant comma from memory position 0589.

0039. Unload the comma in print record storage position 0639. The comma will be printed on every line when the total quantity of parts is 1000 or more.

0044. Select the card reader.

0049. Read the card record.

0054. Place an ampersand in accumulator A.

0059. Add the sign to the quantity per assembly.

0064. Add the sign to assembly quantity.

0069. Reset and add quantity per assembly.

0074. Multiply result by assembly quantity.

0079. Adjust the accumulator to four positions. 0084. Store the total quantity of parts in the print

record. 0089. Adjust the accumulator to seven positions. 0094. Load in the part number from the card

record. 0099. Unload the part number into the print record.

0104. Load in the assembly number from the card record.

0109. Compare with the previous assembly number, The first card compares with zeros, resulting in a high comparison.

INSTR.	INSTRU	JCTION		Z		NO
LOCATION	OPER.	ADDRESS	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIG
0004	R Add	0590	a0	+		
0009	Set L	0007	a0000000	÷		
0014	Unload	0588		_		
0019	Set L	<u>0001</u>			a 0	+
0024	Load	0591			a∓	+
0029	Unload	$\bar{0}644$				
0034	Load	<u>0</u> 589			<u>a</u> ,	+
0039	Unload	0639				
0044	Sel	Q100				
0049	Read	0501				
0054	Sign	0532	a&	+		
0059	Add Men					
0064	Add Men	0521				
0069	R Add	0532	a0010	+		
0074	Mpy	0521	a00001500	+		
0079	Set L	0004	a1500	+		
0084	St Pr	0643				
0089	Set L	0007	a0001500	+		
0094	Load	0528	a107943P	+		
0099	Unload	0635				
0104	Load	0517	a104683A	+		
0109	Comp	0588				
0114	Unload	0588				
0119	Tr Hi	0134				T
0124	Tr Eq	0169				
0129	Stop	0001				Ī
	СОМ	PLETE	PRINTING			
0134	Unload	0607				
0139	Unload	0623				
0144	R Add	0521	a0150	+		
0149	St Pr	0627				T
0154	Set L	0010_	a0000000150	+		
0159	Load		BAILbARMbb	+		T
0164	Unload	0619		T		T
	PAR	FIAL P	RINTING			
0169	Sel	0400				T
0174	Wr Er	0601				
0179	Tr	0034				

FIGURE 49. PROGRAM, WRITE AND ERASE MEMORY

0114. Unload the assembly number for comparison with the next record.

0119. Transfer on a high comparison to print the entire record.

0124. Transfer on an equal comparison to print a partial record.

0129. Stop on a low comparison; cards out of sequence.

0134. Unload the assembly number into the print record.

0139. Unload a comma from accumulator B into the print record to print when the quantity of assemblies is 1000 or more.

0144. Reset and add the quantity of assemblies from the card record.

0149. Store the quantity of assemblies for printing.

0154. Adjust the accumulator to ten positions.

0159. Load the assembly name from the card record.

0164. Unload the assembly name to print.

0169. Select printer 0400.

0174. Write and erase the print record. All memory positions written are cleared to blanks except the record mark.

0179. Transfer to restore the comma to the print record, read a card, and repeat the program.

Normalizing Accumulator Storage

The normalize and transfer instruction is useful in removing zeros, one at a time, from the left end of accumulator storage. A program routine may then be inserted to count the number of zeros removed, a necessary function in floating decimal or floating dollar sign operations.

Normalize and Transfer (X-NORM TR)

1. The normalize and transfer instruction is used to remove the left-hand character of the accumulator storage field *if the numerical portion of that character is a zero*.

2. A transfer is made to the location specified by the address part of the instruction when a character is deleted.

3. If the numerical portion of the left-hand character is not a zero, the accumulator storage field is not changed, a transfer is not made, and the machine will proceed to the next instruction.

4. When the accumulator storage field consists of a single zero, the zero will not be deleted and a transfer will not be made.

Program, Normalize and Transfer

The problem of printing a dollar sign next to the left-hand digit of a variable-length field is illustrated in Figure 50. The following are assumed:

1. Accumulator A contains a calculated result (a003456) which is to be printed as \$34.56.

2. The location in memory for storing the result for printing is given as 0200 through 0207, with the dollar sign to be stored initially at address 0200. In this example, the dollar sign must be shifted to the right to address 0202 to replace the zeros removed from the accumulator field. The number of positions shifted will be equal to the number of zeros deleted.



Figure 50. Memory Storage, Normalize and Transfer

3. Constant data needed in the program are stored in memory at addresses 0710 through 0721.

Figure 51 is the program for properly placing the dollar sign.

0634. The normalize and transfer instruction removes the left-hand zero of the amount in accumulator A and transfers to a routine to shift the address of the dollar sign. When no insignificant zeros are found in the field, a transfer is not effected and the next instruction will be executed.

0639. Adjust accumulator B one position.

0644. Load the dollar sign.

0649. Unload the dollar sign into the adjusted address calculated by the program steps at locations 0694 and 0699.

0654. Store the normalized amount in memory for printing.

0659. Adjust accumulator B to four positions.

0664. Load the original address of the dollar sign.

0669. Restore the original address of the sign to 0200.

0674. Transfer to other sections of the program for additional operations.

0679. Load the original address of the dollar sign into accumulator B.

0684. Compare to the constant 0204. If the accumulator field should contain five insignificant zeros or should be a zero balance, the dollar sign would be shifted to the right of the decimal point. To prevent this condition, the adjusted address at location 0649 should not be higher than 0205.

0689. A high condition transfers to location 0639, preventing any further normalizing of the accumulator field.

0694. Load 0001 into the accumulator B.

0699. Shift the address of the dollar sign by adding 0001 to the instruction address at location 0649.

INSTR. LOCATION	INSTRUCTION			Z		Z
	OPER.	ADDRESS	ACCUMULATOR A	SIGN	ACCUMULATOR B	SIGN
			a003456	+		
0634	Norm Tr	0679	a03456	+		Γ
0639	Set L	<u> </u>			a0	+
0644	Load	ō710			a\$	+
0649	Unload	(0200)				
0654	St Pr	0208				
0659	Set L	$\overline{0}004$			a000\$	+
0664	Load	$\bar{0}714$			a0200	+
0669	Unload	0649				
0674	Tr					
0679	Load	<u>0</u> 649			a(0200)	+
0684	Comp	0721				
0689	Tr Hi	0639				
0694	Load	ō717		_	a0001	+
0699	Add Men	0649				
0704	Tr	0634				

FIGURE 51. PROGRAM, NORMALIZE AND TRANSFER

0704. Transfer to normalize and repeat the program.

Note that the normalize and transfer instruction may be used to remove zeros from an accumulator storage field without a transfer. The address part may specify the location in memory of the instruction itself. For example: 0964 NORM TR 0964. The address part transfers the program back to the location of the instruction at 0964 and repeats the normalizing of the accumulator field until all zeros are deleted. The machine will then proceed to the next instruction in memory in the normal manner.

Omitting Program Steps

One of the decisions the 702 may make is to omit a program step when the result of a preceding step has made this instruction unnecessary. This can be done by changing the operation part of the instruction to A, no operation.

No Operation (A–NO OP)

1. The no operation instruction causes the machine to proceed to the next instruction of a program.

2. The address part has no effect.

3. The instruction may also be used to set up changes within a program by changing the operation part 1 of a transfer instruction to the operation part A of the no operation instruction. The program can then be made to perform the same function as a pilot selector in an IBM accounting machine. For example, a change can be made to an alternate routine when certain conditions, such as the end of a file or other exceptions to normal routine, are encountered during the program.

The change of the operation part is effected by a sign instruction to remove the 12 zoning from the A code or an add memory instruction to place a 12 zone over the 1 code.

A block diagram for a portion of a balance forward procedure is illustrated in Figure 52. The program switch is set to read out the input tape when there are unmatched balance forward records remaining after all detail transactions have been processed. The switch is set to NO OP as long as there are detail cards to be processed. The posting of the balance forward records continues in the main program. Separate routines are indicated to change reels when the end of the tape is reached, check sequence of input records, and so on.



FIGURE 52. USE OF THE NO-OPERATION INSTRUCTION

Execution of Instructions

The operation of the machine, while executing an instruction, is divided into two parts:

- 1. The reading and interpreting of the instruction, called instruction time.
- 2. The actual execution of the instruction, called execution time.

An instruction counter and a memory address counter are both involved in the reading of an instruction (Figure 53). At the beginning of instruction time, the instruction counter is already set to the memory address of the right-hand digit of the instruction. At the end of the execution of the preceding instruction, the memory address counter is set to the same address. The instruction counter is then stepped four addresses higher while the memory address counter is stepped four addresses lower. As this occurs, the memory address counter reads the address part of the instruction it is passing over in memory into the memory address register, one digit at a time. The operation part of the instruction is read into the operation register.

At the end of instruction time, the instruction counter is stepped one address higher to the address of the right-hand digit of the next instruction in the program. It remains in this position during execution time.

During the normal preparation for executing an entire program, the reset key is depressed, setting the instruction counter to memory address 0004. When the start key is depressed, the sequence of operations just described occurs in reading the instruction.

The instruction counter may be manually transferred to the address of any instruction in memory. When this is done, the reading operations are the same except that they begin at the address of the right hand digit of the instruction transferred to.



FIGURE 53. SCHEMATIC, EXECUTION OF INSTRUCTIONS

The machine automatically executes the instruction during execution time, performing different series of actions for different instructions. During execution time, the memory address counter is changed to the different addresses in memory as necessary to control the information which is read out of or stored in memory.

At the end of execution time, the memory address counter resets to the address position of the instruction counter, which has been positioned at the next instruction. The same operations described for instruction time are repeated for that instruction. The counter continues to count, instruction by instruction, to successively higher memory addresses until it reaches the end of the program or a transfer to a different series of instructions.

MACHINE COMPONENTS

A detailed description of each of the Type 702 components will be found in this section. The use of the various operating lights and keys associated with each unit is also explained.

OPERATOR'S CONSOLE

THE OPERATOR'S console is furnished as a separate unit of the 702 (Figure 54). It may be placed at any convenient location in the installation. The console is used to:

- 1. Control the machine manually.
- 2. Correct errors.
- 3. Determine the status of machine circuits, registers and counters.
- 4. Determine the contents of memory and accumulator storage.
- 5. Revise the contents of memory.

Keys and Lights

The lights and keys on the console are explained under the numbers indicated on the console panel diagram (Figure 55).

1. Operation Decoder

There are 36 neon lights in this section. Thirtytwo of the lights represent the 32 machine instructions and are turned on as each instruction is executed. Four lights are reserved for possible additional instructions.

Both the instruction abbreviation and the operation part are printed beside each light. The binary code decimal notation on the left side represents the digits 1 through 9. The binary codes across the top represent the zones. For example: The operation part for NO OP is A. The binary code for A is zone 11 (12) and numerical 0001 (1).



FIGURE 54. OPERATOR'S CONSOLE



FIGURE 55. SCHEMATIC, OPERATOR'S CONSOLE

2. Operation Register

The operation part of an instruction being executed is displayed in the 702 character code by neon lights in the operation register.

3. Memory Address Register

The four-digit address part of the instruction is displayed in the memory address register. Sixteen neon lights are used to display the 702 character code. The numbers at the top of the section represent the units, tens, hundreds, and thousands positions of the address of the instruction being executed.

4. Instruction Counter

The sixteen neons in this section show the address contained in the instruction counter.

5. Memory Address Counter

The memory address counter neons display the location of the next character position to be operated upon in memory. At the end of execution time, the memory address counter is set to the same address contained in the instruction counter.

6. Accumulator SPC (Starting Point Counter) A

The nine lights indicate in straight binary form (256, 128, 64, 32, 16, 8, 4, 2, 1) the position of the starting point counter for accumulator storage A. This starting point varies according to the program.

7. AAC (Accumulator Address Counter)

The nine lights indicate in straight binary form which of the accumulator field positions is being operated upon at any given time. Either accumulator A or B is selected by the accumulator storage selector switch. This switch affects only manual operations, such as display. (See 23.)

8. Accumulator SPC (Starting Point Counter) B

The nine lights indicate in straight binary form the position of the starting point counter for accumulator storage B. This starting point varies according to the program being worked.

9. Clear Memory

Depressing this key, when the machine is stopped, restores all memory positions to blank characters.

The clear memory key has no effect while the machine is in automatic operation.

10. Power On (Key and Red Light)

Depressing the power-on key turns on the AC and DC voltages sequentially in the machine and turns on the red power-on light. When the voltages are properly stabilized, the machine is automatically reset. The instruction counter is set to address 0004, all positions of both accumulators are reset to accumulator marks, all memory positions are reset to blanks, and all checking circuits are reset to normal. The manual light is then turned on, indicating that the machine is ready for operation.

11. DC On-Off (Keys and Light)

Depressing the DC-on key supplies DC power to the machine and lights the DC-on light. It also accomplishes a reset in the same manner as the power-on key. Pressing the DC-off key cuts off DC power to the machine.

12. Master Off

Depressing this key immediately cuts off all power to the entire machine, including the cooling system.

13. Normal Off

Depressing this key turns off the AC-DC voltages sequentially in the machine. The cooling system continues to operate for several minutes.

14. Check Stops

The check stop lights indicate the exact cause of a stop determined by the machine's checking circuits. The lights are in two columns, instruction check lights and machine check lights.

INSTRUCTION CHECK LIGHTS

Non-Numerical Instruction Character Cycle 1-2-3. This light turns on when the units, tens, or hundreds position of the address is anything but 0-9.

Improper Character Instruction Character Cycle 4. This light turns on when the thousands position of the address is anything but 0 through 9, or 0 through 9 with a minus sign (accumulator B).

Operation Check. This light turns on when the operation part of an instruction is any letter or number other than what has been set up for the 32 instructions or when the operation decoder does not function properly. (This unit translates the coded operation part into the actual operation.) Character Register 1 Code Check. This light turns on when there is a character code.error in the interpretation of an instruction (i. e., during instruction time).

MACHINE CHECK STOP LIGHTS

Character Register 1 Code Check. This light turns on when there is a character code error in the character last used from memory.

Character Register 2 Code Check. This light turns on where there is a character code error in the character last read from accumulator storage.

15. Memory Display CR (Character Register) 1

The seven lights in this unit indicate in 702 code form the character most recently read from memory. The address of the next character to be read is displayed in the memory address counter.

16. Accumulator Display CR (Character Register) 2

The seven lights in this unit indicate in 702 code form the character most recently read from accumulator storage. Either accumulator A or B is selected by the accumulator storage selector switch.

17. Accumulator Sign (--) A, B

These two lights are turned on when the sign of accumulator storage A or B is turned to minus.

18. Accumulator B

This light is turned on when either a manual or program instruction designates accumulator storage B. It remains on until that instruction is completely executed.

19. Select Register

The sixteen lights on the select register display the number of the device last selected in 702 code form. The number will be shown for that device until another device is selected.

20. I/O (Input-Output) No Response

The machine stops and this signal turns on when the selected unit does not exist or when an addressed unit is not in "ready" status. The signal also turns on for conflicting instructions such as select 0100 and write, or select 0400 and read.

21. Alteration Switches

Each alteration switch has a specific address. If a switch is on when interrogated by the program, a transfer is effected. If the switch is off, no action takes place.

22. Check Indicator Switches

Six switches are provided, one for each of the check indicators. When a switch is turned to automatic stop, the machine will stop when the corresponding error occurs. When the switch is turned to program, the error condition will be indicated, but the course of action is determined by the program (see Check Indicator).

Each switch is associated with a light above it to indicate when the indicator is on.

23. Accumulator Storage Selector Switch

This switch selects the accumulator storage from which a character is to be displayed in a manual display operation by the CR 2 lights, or selects the accumulator to be used in a manual instruction operation.

24. Machine Stop

When an internal operation is being performed, depressing the machine stop key stops the machine immediately. When an input-output operation is being performed, both the reset and machine stop keys must be depressed simultaneously to stop operation immediately. The operator must manually transfer to the desired instruction before depressing the start button.

25. Half Multiple Step

Depressing this key causes the machine to operate in half steps. One depression causes an instruction cycle. A second depression causes an execution cycle. If the key is held depressed for more than two seconds, the machine goes through alternate instruction and execution cycles at about ten per second as long as the key is held.

If the machine is running when the key is depressed, it will stop after executing the current instruction.

Depressing the half multiple step key also resets the checking circuits.

26. Instruction (Key and Yellow Light)

To instruct the machine manually, the procedure is:

1. Depress the instruction key. This puts the machine in instruction status. If the machine is in automatic operation, it will stop after the current instruction is executed.

2. Key the address in the address selector (either before or after depressing the instruction key).

3. Key the operation part on the keyboard. This executes the instruction.

Subsequent instructions may be keyed in without any re-depression of the instruction key.

27. Store (Key and Yellow Light)

The store key is depressed to manually key information into memory. When the key is depressed:

- The machine stops after the current instruction is executed.
- The yellow store light and the manual light turn on.
- The first character keyed on the keyboard enters the memory position specified by the address selector. Subsequent characters are entered into successively higher memory addresses.
- During a manual store operation, the next memory address to receive a character is indicated by the memory address counter lights.

28. Automatic-Start (Key and Green Light)

Depressing the start key begins machine operation at the normal high-speed rate. Operations continue until a programmed or error stop occurs, or until the stop, store, display, or half multiple-step key is depressed. Depressing the start key after a manual or programmed stop has occurred turns on the automatic light and causes the machine to begin operation.

If the machine stop is caused by an error during the execution of an instruction, the machine will resume with the instruction following the one in error. If the error occurred during instruction time, a manual transfer to the next instruction must be made before depressing the start key.

To start elsewhere in the program at any time, a manual transfer may be made to any instruction in the program.

Depressing the start key resets all the check circuits.

29. Manual—Stop (Key and Red Light)

Depressing the stop key causes the machine to stop after executing the current instruction and turns on the manual light.

30. Display-Display Step (Keys and Yellow Light)

Depressing the display key stops the machine and puts it in display status as indicated by the display light. Subsequently depressing the display step key causes the character at the memory address specified by the address selector to be shown in the CR 1 section. The right-hand character of accumulator storage is shown in the CR 2 neons. Either accumulator A or B may be shown, depending upon the position of the accumulator storage selector switch.

Successive depressions of the display step key will

The position of the next memory character to be shown in the CR 1 neons is indicated by the memory address counter neons.

31. Reset

The reset key restores all checking circuits to normal, sets the instruction counter to 0004, and restores all accumulator storage positions to accumulator marks.

32. Address Selector

Forty keys in the address selector are arranged in four columns of ten keys each. Each column of keys is numbered 0 through 9, starting at the bottom, and represents one digit of a four-digit address. By depressing the proper key in each column, the operator may set up any four-digit address which will be maintained until other keys are depressed.

The address selector is used in manual store, instruction, and display operations.

When the machine is in automatic operation, depressing the address selector keys has no effect. An address can be set up while the machine is operating, before the store, instruction or display key is depressed.

Keyboard

A keyboard similar to that on the Type 24 Card Punch is provided to allow manual insertion of instructions and data into the machine.

CARD READER, TYPE 712

IBM CARDS may be read at a rate of 250 cards per minute. Because the Card Reader (Figure 56) is provided with record storage, however, it is possible to read the contents of one card at a speed closely approaching the high internal speed of the 702. When the read instruction is given to a card reader, the record is read serially from its record storage to memory. The storage then refills with the contents of the next card, so that this record will also be available at high speed when required.

As soon as a record has been read into memory from record storage, the 702 is free to continue its program while the record storage unit is being refilled.

All eighty columns of the card are read into record storage. Blank columns are read in as blank characters. When the record is read into memory from record storage, all eighty characters are read in and a record mark is stored in the memory position following the last character.

No provision is made for rearrangement of fields within the card record in the process of reading it into the 702. The ability of the 702 to rearrange fields in memory by programming makes such a provision in the card reader unnecessary.

The 702 can be equipped with any reasonable number of card readers with their control units.

Checking

The information entered into the 702 from a card is checked in two distinct ways:

1. The card is read at two different brush stations and the results are checked against each other. A difference causes the read-write check indicator to be turned on.

2. The information read from record storage into the 702 is given a character code check. If this check indicates an error, the read-write check indicator is turned on.

Note that the read-write check indicator is turned on after the record containing the error has been read from record storage into memory.

Operating Keys and Lights

Start Key

The start key has two distinct functions:

1. When the hopper is first filled, depressing the start key feeds the first three cards. The first card is read into record storage.

Depressing the start key a second time turns on the calculator interlock, making the card reader available for operation under 702 control. Depressing this key has no effect if the calculator interlock is already turned on. When the card reader is first prepared for operation, it is necessary to depress the start key twice, once for feeding and once to turn on the calculator interlock.

2. When the last card has been fed from the hopper (before its contents are stored in record storage) the machine stops. The calculator interlock is turned off, and it is necessary for the operator to depress the start key before operation can proceed under 702 control. If the card file is not at an end, the operator will replenish the supply of cards in the hopper before depressing the start key. If the card file is at an end, depressing the start key will allow the 702 to resume operation and the two remaining cards will be read. The input-output indicator for the card reader is turned on when the 702 executes the read instruction following the one which read the last card in the file from record storage to the 702.

The input-output indicator can be turned off by the instruction CTRL 0000, or by running in the cards when starting an operation.

Stop Key

Depressing this key turns off the calculator interlock and causes the card reader to stop operating. After a feed error it can be used to turn off the feed check light after all the cards have been removed from the feed and hopper.

Feed Key

This key provides a manual feed without reading the cards in the machine and is operative only when the calculator interlock is not turned on.

Power On Light

This light indicates that all voltages in the card reader have reached the required level.

Ready Light

The ready light is on whenever the calculator interlock is turned on. It indicates that the card reader is ready for operation under control of the 702.

Select Light

This light goes on when the card reader is selected by the 702, and remains on until another input-output unit, check indicator, or alteration switch is selected.

Feed Check Light

A card jam or failure to feed will turn on this light and turn off the calculator interlock. The light will go off after all the cards have been removed from the feed and hopper and the stop key has been depressed.



FIGURE 56. CARD READER

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CARD PUNCH, TYPE 722

THE CARD punch (Figure 57) punches cards at a rate of 100 cards per minute.

When a write or write and erase instruction is given, the record from memory is sent to the record storage unit of the card punch at the high internal speed of the 702. The machine then continues with its program while the card is being punched. Information is punched in the same order in which it is sent from memory.

The maximum record that can be punched is 80 characters per card. Records longer than 80 characters will be punched in successive cards with a single write or write and erase instruction. The write status will be maintained and subsequent operations will be delayed until the last block of characters in the record has been entered into record storage, as indicated by the sensing of a record mark in memory.

The card punch has no signal device corresponding to the input-output indicator of other input-output units. If the punch runs out of cards, it will stop the 702.

Checking

The card punch contains checking circuits which depend for their operation on reading the card at a brush station just after it is punched. This method of checking imposes a two-card delay so that, if a card is improperly punched, the printer-punch check indicator is *not* turned on until after the execution of the write or write and erase instruction for the second card following the one in error. Any reasonable number of card punches can be supplied.



FIGURE 57. CARD PUNCH

Operating Keys and Lights

Start Key

This key is provided for the run-in of cards. When the hopper is first filled, depressing the start key once causes one card to be fed to the punching station. A second depression turns on the calculator interlock, making the card punch available for operation under 702 control. If the hopper becomes empty during the program, the calculator interlock is turned off and the card punch will not operate under 702 control until the hopper has been refilled and the start key has been depressed.

Stop Key

Depressing this key causes the calculator interlock to be turned off and the card punch to stop operating. After a feed error, it can also be used to turn off the feed check light *after* all the cards have been removed from the feed and hopper.

Feed Key

This key provides a manual feed without punching the cards in the machine and is operative only when the calculator interlock is turned off.

Power On Light

This light indicates that all voltages in the card punch have reached the required level.

Ready Light

The ready light is on whenever the calculator interlock is turned on. It indicates that the card punch is ready for operation under control of the 702.

Select Light

This light is on whenever the card punch is selected and remains on until another input-output unit, check indicator, or alteration switch is selected.

Feed Check Light

A card jam or failure to feed will turn on this light and turn off the calculator interlock. The light will go off after all the cards have been removed from the feed and hopper and the stop key has been depressed.

PRINTER, TYPE 717

THE 702 can be equipped with any reasonable number of Printers (Figure 58) for report printing. Each printer, a modified IBM Type 407, has 120 print wheels with 47 characters each. The maximum printing speed is 150 lines per minute. Because each printer is supplied with a record storage unit, however, a record can be sent from memory to printer record storage at a speed closely approximating the high internal speed of the 702. When a printer is selected and a write or write and erase instruction is given, a record is sent from memory to record storage. The machine continues with its program as soon as record storage is filled and while the record is being printed.

Information within each line is printed in exactly the same order in which it is received from memory. Therefore, all the necessary arranging of data must be done in memory.

Records longer than 120 characters will be printed on successive lines by a single write or write and erase instruction. The machine will send 120 characters at a time to the printer record storage unit to be printed. The write status will be maintained and subsequent operations will be delayed until the last block of characters in the record has been entered into record storage as indicated by the sensing of a record mark in memory.

Carriage Control

Spacing and skipping for form control in the printer may be performed either under complete control of the program or under control of the carriage control switch. When the 702 is under program control, the carriage control switch is set to PROGRAM and the first character of each record dictates the type of spacing or skipping for that record. That character is not printed and 120 significant characters can still be printed. The following list indicates the character necessary in the first position of a record to perform various carriage functions:

FUNCTION	CHARACTER
Suppress space Single space Double space	& Blank 0
Skip to channels 1 to 9 of carriage tape. Printing is de- layed until the skip is completed.	1 to 9
Short skip to channels 1 to 9. Skip must be "2" or less. Skip- ping does not delay printing under this condition	1 to 9 with minus zoning (J through R)

If program control is not desired, the carriage control switch is set to single or double space. Under this condition single or double spacing will be per-

formed automatically on each printed line depending on the setting of the switch. The first character of the record does not in any way affect carriage operations under these conditions. It is now an integral part of the record and will be printed from print wheel 1. Furthermore, under single or double space control, the sensing of channel 12 of the carriage tape will automatically cause a skip to channel 1 before printing the first line of the next page. Channel 12 must be punched one line above the last desired printing position on a page in order that the input-output indicator may be turned on by the next write instruction. Sensing channel 12 always leads to turning on the input-output indicator on a subsequent write or write and erase instruction, but causes an automatic skip to channel 1 only when the carriage control switch is set to single or double space.

Otherwise, the action to be taken after turning on the input-output indicator is left entirely to the discretion of the programmer. The programmer can interrogate this indicator by a transfer on signal instruction and subsequently insert a character in the first position of the next record to be printed to cause skipping to any desired channel. The inputoutput indicator is turned off by a control 0000 instruction and also by the clearing cycle occurring on depression of the start key.

Form Control Key and Stop Light

Reaching the end of paper in the printer closes the form stop and provides one of two modes of operation depending on whether or not a tape is used in the carriage.

When a tape is not used in the carriage, the printer stops when the form stop contact is closed and the form stop light goes on. Depressing the form control key once allows the printer to operate for one print cycle. As long as the form control key is held down, the printer remains available and continues to print.

When a tape is used in the carriage, channel 1 must be punched as the first printing line. The printer does not stop when the form stop contact closes. After the form stop has closed and channel 1 is sensed, the printer stops before printing on the next form and



FIGURE 58. PRINTER

the form stop light goes on. This indicates that the carriage has moved from one form to another. The operator now has two options:

- 1. Manually feed new forms of paper into the carriage, thereby opening the form stop contact. Depress the form control key to turn off the form stop light and allow the printer to continue.
- 2. Depress the form control key and thereby turn off the form stop light and allow the printer to continue until the closed form stop contact and channel 1 condition again stops the printer.

This arrangement allows the operator to complete the printing of a form or several forms before finally stopping the printer and inserting additional paper.

Checking

The printing of information is checked by comparing the print wheel echo impulse count against the information sent to the printer from the record storage unit. This is a count check of the numerical portion of all characters. A discrepancy will cause the printer-punch check indicator to be turned on during the execution of the next write or write and erase instruction involving that printer. Figure 59 is a schematic showing the sequence of operations during the printing cycle.

By selecting the printer-punch check indicator and transferring on a transfer on signal instruction, the program may be made to stop the machine after printing the line following the line in which the error occurred.

If a character code error occurs in loading a record from memory into record storage, the read-write check indicator is turned on. By selecting this indicator and transferring on a transfer on signal instruction, the printing of the line in error may be stopped by a control 0005 instruction. Control 0005 suppresses printing and carriage operations. The program may be written to allow the record to be loaded again into record storage without printing the erroneous record.

Operating Keys and Lights

The operating keys and lights for the printer are shown in Figure 60. The remaining keys and switches described are for carriage control.

Start Key

Depressing the start key once causes the printer to go through a clearing cycle. The input-output indicator is turned off during the clearing cycle. Depressing this key again turns on the calculator interlock which makes the printer available for operation under control of the 702. When the calculator interlock is turned on, the start key is no longer operative.

Stop Key

This key causes the calculator interlock to be turned off and the printer to stop operating. It also turns off the input-output indicator.

Form Control Key

This key controls the operation of the printer when the form stop closes.

Select Light

This light goes on when the printer is selected by the select instruction and remains on until another input-output unit, check indicator, or alteration switch is selected.

Ready Light

The ready light indicates that the calculator interlock is turned on and the printer is ready for operation under control of the 702.



FIGURE 59. SEQUENCE OF OPERATION, PRINTER



Figure 60. Printer Operating Keys and Lights

Fuse

The fuse light is turned on when a fuse is burned out in the printer.

Form Stop Light

This light indicates that the printer is running out of paper.

Power-On Key and Light

The key is depressed to supply power to the machine. The light indicates that all voltages in the printer are at the required level.

Power-Off Key

The power-off key cuts off all power to the printer.

Platen Clutch

When the arrow on the knob is pointing upward, the platen clutch is engaged and the platen can be turned only by the vernier knob. When the clutch knob is turned to the right, the platen clutch is disengaged and the platen then can be turned manually by the platen knob.

Restore Key

When this key is depressed, the carriage is restored to channel 1 or home position. On the first print cycle thereafter, skipping may take place only to channels 2 through 9 of the carriage tape. Any attempt to skip to channel 1 or to single or double space will be ignored on this printing line. If the platen is engaged, the platen itself moves with the carriage. If the platen is disengaged, it will not be restored with the carriage.

Stop Key

Depression of this key stops the carriage operation instantly and the printer at the end of the cycle.

Space Key

When the printer is stopped, a form can be advanced one space at a time by depressing this kev.

Carriage Control Switch

The carriage control switch has three positions: single space, double space, and program.

In the single or double position, the spacing of the form is automatic and will be single or double depending on the setting of the switch. Either of these two positions causes the first character of a record to be printed. In program position the spacing of the form will be under the control of the first character of the record which in this case will not be printed. For automatic overflow, channels 1 and 12 of the carriage tape must be punched so that sensing of the channel 12 punch will initiate the overflow to the channel 1 punch.

TYPEWRITER

A TYPEWRITER is supplied for the 702 and can be used to print a portion of memory one character at a time. The speed of typing is approximately 600 characters per minute. The typewriter has no record storage unit and prints directly from memory. All other operations of the machine are held up during the use of the typewriter.

Special instructions to the operator, control totals, exception records, and so on, may be programmed by way of the typewriter, or the contents of any portion of memory may be examined by manually selecting the typewriter and using the write or write and erase instruction in the usual way.

Sensing the right-hand margin or the record mark causes a carriage return and automatic spacing according to the setting of the space control on the carriage. The record mark does not print.

Any character not on the code chart will print as a question mark on the typewriter. A plus zero and a minus zero will print as a plus sign (+) and hyphen (-), respectively. A record may be arranged in memory, before printing, to fit a report form.

MAGNETIC DRUM STORAGE UNIT, TYPE 732

DRUM storage on the 702 consists of one or more 60,000-character drums (Figure 61), each divided into 300 addressable sections. Each section can store 200 characters. The addresses 1000 and over have been reserved for drum section selection. The present four-digit addressing system of the 702 can accommodate thirty drums with a total of 9000 sections with a total drum capacity of 1,800,000 characters. Drum storage of less than 60,000 characters is also available. The average time required to locate the first character position of a drum section for subsequent reading or writing is 8.12 milliseconds. This is termed access time. Thereafter, characters can be read from or written consecutively on the drum at at a rate of one character in .040 milliseconds.

Drum operation is initiated by a select instruction. The address part of the instruction specifies the drum section desired. Assuming a 702 had several drums, the following system would exist: addresses 1000-1299 would pertain to the sections on the first drum; addresses 1300-1599 would pertain to the sections on the second drum; addresses 1600-1899 would pertain to the sections on the third drum; and so on.

After a select instruction has been given, specifying the drum section desired, a read, read and check, write, or write and erase operation may then be called for.

Reading from the Drum

During a read operation, information read from the drum starts with the first character of the section previously selected. This character is read into the memory location specified by the address part of the read instruction. Reading continues from successively higher drum locations into successively higher memory addresses until the drum mark is sensed. The drum mark is read into memory as a record mark.



Figure 61. Magnetic Drum Storage Unit

During a read and check operation, information read from the drum is only compared against information previously stored in memory. Comparison is made, character by character, from successively higher memory addresses until the drum mark is sensed. A check is then made to determine if the drum mark location corresponds to the record mark location in memory. Failure to find a record mark in the proper memory location turns on the readwrite check indicator.

Writing on the Drum

During a write or write and erase operation, information is written from memory starting at the address specified by the write or write and erase instruction and continues to higher memory addresses until a record mark is sensed. Sensing the record mark terminates the operation and causes a drum mark to be emitted on to the drum after the last written character.

Transferring Drum Operations

Operation will not proceed automatically from one drum to the next, and any attempt either to read or write off the end of a drum will cause the read-write check indicator and the input-output indicator to be turned on. A subsequent read, read and check, write, or write and erase instruction specifying this drum will turn off the input-output indicator. The inputoutput indicator also may be turned off by the control 0000 instruction.

Both reading and writing operations associated with drum storage are terminated by a drum or record mark. Operations can therefore pass from one drum section to the next on the same drum until a drum or record mark is sensed.

MAGNETIC TAPE UNIT, TYPE 727

THE 702 can be equipped with any reasonable number of Tape Units (Figure 62). Information is recorded on the oxide coated plastic tape in the form of magnetized spots. A character is represented transversely across the width of the tape by seven bit positions, including the check bit. Information is recorded at a longitudinal density of 200 characters to the inch.

The end of the record is indicated by a $\frac{3}{4}$ inch inter-record gap. Records of any length may be

stored on magnetic tape, limited only by the memory facilities of the 702.

The end of recorded information on tape is indicated by a tape mark which appears *after* the interrecord gap that follows the last record.

Records are recorded on reels of tape $10\frac{1}{2}$ inches in diameter and 2400 feet long. Tape may be read in a forward direction or back-spaced at a rate of 75 inches per second. Tape can be rewound at an average rate of 500 inches per second. It takes an estimated 1.2 minutes to rewind a complete reel, allowing for acceleration and deceleration time.

Changing tape reels on the unit takes approximately 1.5 minutes for loading and unloading. Re-



FIGURE 62. MAGNETIC TAPE UNIT

flective spots are photo-electrically sensed to indicate the physical end of a tape and the load point.

Certain common tape unit circuits are contained in a tape control unit which can handle up to ten tape units; the 11th to 20th tape units require a second control unit; and so on.

Checking

Information read from tape is given a characterby-character code check. A failure detected by this check turns on the read-write check indicator which may either stop the machine at the end of the record or be interrogated by a subsequent instruction. (See *Check Indicators.*)

In addition, a horizontal check is made for an even number of 1 bits in each of the seven tape tracks for each record. This determines whether a single bit has been changed in reading that record.

Seven neon indicators are provided to indicate in which of the seven tracks a reading failure occurred. A failure of this type will also turn on the readwrite check indicator. A cross reference is provided with these two checks that permits single error correction and double error detection.

It should be noted that an error detected in reading a tape can cause one of two corrective measures determined by the programmer. First, the machine can be programmed to stop upon detecting an error. The operator may then intervene and make a manual correction. Second, the program can be written to cause the record in error to be re-read from the tape after back-spacing, with the excellent probability that the record will read accurately the second time.

Information written on tape will be given a character-by-character code check at the writing head. A failure detected by the check will turn on the read-write check indicator which may be interrogated by subsequent instructions.

Operating Keys and Lights

Operating keys and lights are shown in Figure 63.

Select Light

This light is on when a select instruction specifies the address of the corresponding tape unit. It remains on until some other input-output unit, a check indicator, or an alteration switch is selected.

Reset Key

Depressing this key removes 702 control of the tape unit, resets all controls (except the input-output indicator) to their normal position, and, in general, will stop any tape operation which has been initiated.

Start Key

Depressing the start key places the tape unit under the control of the 702 and causes the ready light to be turned on provided (1) tape has previously been loaded into the columns, (2) the reel door interlock is closed, and (3) the tape unit is not in the process of finding the load point (rewind or load operation).

Ready Light

Control of a tape unit by the 702 is indicated when this light is on. The light is on provided the tape has been loaded into the vacuum columns, the reel door interlock is closed, and the tape unit is not in the process of finding the load point (rewind or load operation). Manual control is indicated when the ready light is off, provided the tape unit is not rewinding or loading and the reel door is shut.

Address Selection Switch

A rotary switch is provided to permit the operator to set a tape unit to any of the ten addresses associated with a control unit.

File Protection Light

This light is automatically turned on by loading a protected reel onto the unit. The reel protective



FIGURE 63. TAPE UNIT OPERATING KEYS AND LIGHTS

device prevents the file from being written on by making it impossible to execute write or write and erase instructions. File protection is eliminated by removing the protective device from the reel.

Load/Rewind Key

If the reel door is closed, depression of this key will cause loading of the tape into the columns and searching for the load point in a reverse direction. If the tape has been manually unloaded in the fast rewind section of the tape, depressing this key will execute a high-speed rewind before the above operation takes place. (See *Unload* below.) Operation of the start key *after* the load/rewind key has been depressed will set up the conditions necessary for automatic reversion to 702 control as soon as the load point is reached. The load/rewind key is inoperative unless the tape unit is under manual control.

Unload Key

Operation of this key will remove the tape from the columns and raise the head cover regardless of the distribution of tape on the two reels. If the tape is not at load point when the operator wishes to change it, a load point search should be first initiated by depression of the load/rewind key. Depression of the unload key will also reset the input-output indicator. This key is inoperative unless the tape unit is under manual control and tape is in the vacuum columns.

Tape Indicator On

The input-output indicator light is turned on when its corresponding indicator is turned on (on the tape unit last selected), by a control (0003) instruction, by reaching a tape mark while reading, or by reaching the physical end of tape while writing. It will be turned off by a control (0000) instruction or by depression of the unload key.

Reel Door Interlock

When the door is open, this interlock contact will prevent operation of the reel drive motors.

Operation

Type 702 operation of a tape unit is initiated by a select instruction specifying the address of the particular tape unit desired. A subsequent read, read and check, write, write and erase, or control instruction will cause that tape unit to perform the required operation. The sensing of a tape mark while reading the tape will turn on the input-output indicator which will remain turned on until turned off by a CTRL 0000 instruction, or until the unload key is depressed. Sensing the tape mark will not cause an automatic rewind of the tape. A tape mark can be recorded on a selected tape unit only by a CTRL 0001 instruction. A rewind operation can be called for with a CTRL 0002 instruction after a select instruction. In writing on a tape, sensing the end of tape by the reflective spot will cause the input-output indicator to be turned on.

The input-output indicator may be turned on by a select instruction specifying the tape unit, followed by a CTRL 0003 instruction. The tape can be backspaced one unit record by a similar select instruction followed by a CTRL 0004 instruction. It is not permissible, however, to write over a record within a file without also modifying the remainder of the file.

A write instruction may be followed by a backspace (CTRL 0004) or a rewind (CTRL 0002) operation only if the remainder of the tape contains unwanted information.

CHECKING

ACCURACY is an essential requirement of the dataprocessing system. To meet this requirement, various checking devices are provided in the 702. These devices can be used entirely at the discretion of the programmer. Two types of checks may be made:

1. Checks upon the handling of data within the machine, including the check for legitimate instructions, overflow checks, sign checks and character code checks. These devices have been previously explained in detail in the section *Check Indicators*.

2. Checks made upon the reading and writing of data by input-output units. These have been mentioned in the section *Machine Components*.

A more detailed explanation of input-output checks is given in this section, together with schematic diagrams of operation.

INPUT DATA

Card Reader

All information read from IBM cards is checked automatically by the 702 in two ways (Figure 64).

1. At the first read station, the number of holes in each horizontal row of the card is determined to be odd or even. This information is stored, one row at a time, in a temporary storage device consisting of 12 binary triggers. Each trigger can indicate only one of two possible conditions, odd or even. When the card has passed the first station, the odd-even count for all 12 rows is transferred to a second set of triggers where it is retained during the next card cycle. The first set of triggers is then free to accept the row count for the following card. The information obtained at the first station is used only for checking.

At the second read station, the entire card is stored in an 80-column record storage unit. When a read instruction is given, the card record is converted from record storage to the 702 character code and is sent to memory. The 702 code is also reconverted to the IBM card code and an odd-even count is again made of each row. This information is stored in a third set of 12 triggers and is compared with the count obtained and stored when the card was read at the first read station. A difference in comparison turns on the read-write check indicator.

2. The card record read from record storage into memory is given the same character-by-character check as that given all data handled within the machine. An error will also turn on the read-write check



FIGURE 64. SCHEMATIC, CARD INPUT CHECK

indicator. Note that if the indicator is turned on, it will be after the complete card record has been read from record storage into memory.

Tape Unit (Read)

All information read from tape is automatically checked by the machine in two ways (Figure 65).

1. A character code check is made on each character of information entering memory from the tape unit. This is a vertical check, character by character, to insure that all magnetic bits on the tape have been sensed and transmitted correctly by the read head. An error turns on the read-write check indicator.

2. An even count check is made on each of the seven tape channels at the end of every record. This is a horizontal check to insure that the entire record has been correctly sensed and transmitted by the read head. A failure turns on the read-write check indicator. Seven neon indicators are provided on the tape unit to show in which of the seven channels a reading failure occurs. Note that the read-write indicator is always turned on after the complete tape record has been read into memory.

OUTPUT DATA

Card Punch

All punching of IBM cards by the 702 is automatically checked in two ways (Figure 66).

1. A card record to be punched from memory

when a write instruction is given is first converted from the 702 character code to the IBM card code. The entire record is stored in an 80-column record storage unit. During this operation the machine determines whether the number of holes in each horizontal row of the card record is odd or even. The row count information is temporarily stored by an arrangement of 12 binary triggers. Each trigger can indicate one of the two conditions, odd or even. Trigger storage is identical with the storage described for the card reader. The row count is transferred to a second set of triggers where it is retained until the next write instruction is given. The first set of triggers is then free to accept a row count for the next record from memory. The card is punched at the punch station.

When the next write instruction is given, the card passes the punch brushes. Again the machine determines whether the number of holes in each horizontal row is odd or even. This row count of the punched card is also stored in the record storage unit from which it is transferred, one row at a time, to a third set of 12 triggers. The row count is compared with the count obtained and stored when the record was read from memory. An error turns on the printerpunch check indicator.

2. The record to be punched is also given a character-by-character check when transmitted to record storage in the same manner as for all data handled within the machine. An error turns on the read-



FIGURE 65. SCHEMATIC, TAPE INPUT CHECK



FIGURE 66. SCHEMATIC, CARD OUTPUT CHECK

write check indicator. It is important to note that the read-write check indicator is turned on before the card record is punched. If the indicator is interrogated by a transfer on signal instruction immediately following the write instruction, punching can be prevented by a control 0005 instruction. Record storage can then be reloaded with the same record and another trial for error can be carried out. Punching can be prevented until record storage is correctly loaded.

The printer-punch check indicator is turned on after the card in error has passed the brush station.

Printer

All printing of information from the 702 is checked in two ways (Figure 67).

1. The record to be printed from memory is converted from the 702 character code to IBM card code and is stored in a 120-character record storage unit. A horizontal row count is taken for the numerical portion of the entire record. The result is stored by 11 binary triggers. Each trigger indicates one of two conditions, odd or even, for each row of impulses making up the characters for the entire record. Nine triggers store the count for the rows one through



FIGURE 67. SCHEMATIC, PRINTING CHECK

nine; two store the count for special characters. The record is then printed from record storage as one line of characters on the report form.

The characters printed are read back from the printer by sensing the position of each print wheel during the print cycle. A row count of the impulses from the numerical characters in the printed record is determined and the result is stored as odd or even by 11 triggers. A comparison is made with the count obtained and stored when the record was read from memory. A difference in comparison turns on the printer-punch check indicator.

2. The record to be printed is also given a character-by-character code check when it is transmitted to record storage in the same manner as for all data handled within the machine. An error in this transmission turns on the read-write check indicator.

It should be noted that the read-write check indicator turns on when an error is detected from memory to record storage. If the indicator is interrogated by a transfer on signal instruction immediately following the write instruction, printing can be delayed by a control 0005 instruction. Record storage can then be reloaded for a second trial for printing. This corresponds to a printing delay when a write instruction is given to the card punch. Printing can be prevented until record storage is correctly loaded. The printer-punch check indicator is turned on by a printing error during the execution of the next write instruction involving that printer.

Tape Unit (Write)

All information written on tape is also automatically checked by the 702 (Figure 68).

Records read from memory to tape are transmitted directly through the tape control unit to the write head. The records are written as magnetized spots in the 702 character code in the seven tape channels (Figure 36). While a record is being written, an odd-even check is made of the total number of magnetized bits in each separate channel. At the end of every record an extra bit is inserted where necessary to make the total count in each channel even. The even-bit notation is used in checking whenever the tape record is read.

The impulses to the write heads from memory are returned to a register in the control unit in the same pattern in which they were received. From there they are transmitted back to the 702. The same characterby-character check is given these "echo" impulses as is given all data handled within the machine.

An error turns on the read-write check indicator after the execution of the write instruction.



FIGURE 68. SCHEMATIC, TAPE OUTPUT CHECK

THE TIME that the 702 requires to process information depends on the length of the fields involved and the number and types of instruction used in the program.

The instructions are classified below into six categories. The timing for each classification is given in milliseconds (1 millisecond = 1/1000 second).

Class 1

Each instruction in this class takes 0.138 milliseconds, the time to read and interpret the instruction. It should be noted that the time required for the transfer instructions is the same whether or not the transfer is effected. The instructions included are:

TR	TR SIG
TR PLS	STOP
TR ZERO	NO OP
TR HI	SEL
TR EO	

Class 2

Each instruction in this class takes 0.138 + .023N milliseconds. The instructions are:

R ADD	ADD
R SUB	SUB
сомр	ADD MEM
LOAD	ST PR
UNLOAD	SIGN
STORE	

In the case of R ADD, R SUB, COMP, LOAD, UNLOAD, STORE, ADD, and SUB, N refers to the number of characters in the accumulator storage after the instruction has been completed. For the instruction ADD MEM, N is the number of characters in the result. For the instruction ST PR, N is equal to the number of characters in accumulator storage plus the number of punctuation marks in the result, plus the number of zeros blanked, plus one. For the instruction SIGN, N is equal to two.

When it is necessary to recomplement the result of the instructions ADD, SUB, and ADD MEM, the time for the execution of these instructions is increased by .023 (n+1), where *n* is the number of characters in the result. Therefore, the total time, if recomplementation is necessary, is given by 0.138 + .023 (2n+1).

Recomplementation is necessary when the operation is addition with unlike signs or subtraction with like signs and when the factor in the accumulator storage is greater in absolute value than the factor in memory.

Figure 69 is a chart which may be used as an aid to calculating operating time for the instructions in Class 2.

Class 3

This classification includes MPY and DIV.

The time required for a multiplication is given by the expression

$$\left[N_p(N_c+4)+1\right]$$
.023 + .115 milliseconds



FIGURE 69. TIME REQUIRED TO EXECUTE R ADD, R SUB, COMP, LOAD, UNLOAD, STORE, ADD, SUB, SET L

N is the number of characters in accumulator storage after the instruction is completed.
TIME IN MILLISECONDS

there N is the number of divite in the multiplic

FIGURE 70. TIME REQUIRED TO EXECUTE

MULTIPLY INSTRUCTION

Nc is the number of characters in the multiplicand (memory field).

where N_p is the number of digits in the multiplier (accumulator storage field) and N_c is the number of digits in the multiplicand (memory field).

The time required for a division depends upon the number and numerical value of the digits involved. The following expression for computing division time is based on an average digit value of 4.5.

$$.023\left[10 + N_D + (N_D - N_R) (7.5K + 15)\right] + .115$$

where

 N_D = Number of digits in the dividend N_R = Number of digits in the divisor $K = N_R$ if $N_R \ge 8$ $= N_R + .005 (8 - N_R)$ if $N_R < 8$

Figures 70 and 71 may be used to simplify the estimating of multiplying time. Figures 72 and 73 may be used for division.





Figure 72. Time Required to Execute Divide Instruction

Nq is the number of digits in the quotient (number of digits in the dividend minus number of digits in the divisor).

Class 4

The time required to perform the shift instructions is determined as follows:

The SET L instruction takes .138 + .023N milliseconds to perform, where N is the number of characters in the final field. The SHOR instruction takes .161 + .023N milliseconds, where N is the number of characters to be dropped. The LENG instruction takes .161 + .023N milliseconds, where N is the number of zeros to be added.

The ROUND instruction takes .207 + .023N milliseconds, where N is the number of characters to be dropped.

The NORM TR instruction takes .161 + .023N milliseconds, where N is the number of digits in the original field.

Class 5

The time required for the CTRL instruction depends on the feature being controlled.

CTRL 0000—.184 milliseconds. Turn off input-output indicator.





Nq is the number of digits in the quotient (number of digits in the dividend minus number of digits in the divisor).

- CTRL 0001—10.14 milliseconds. Record the tape mark.
- CTRL 0002—.151 milliseconds. Rewind the tape. (This does not include the rewind time.)
- CTRL 0003—.151 milliseconds. Turn on the inputoutput indicator.
- CTRL 0004—60 + .067N milliseconds, where N is the number of characters in the record being back-spaced.
- CTRL 0005—.184 milliseconds. Stop printing or punching.

Class 6

The time required to perform the instructions READ, R CHK, WRITE and WR ER from and to the various input-output units is indicated below.

For card record storage, READ, R CHK, WRITE or WR ER requires .171 + .0335N milliseconds. For the instructions READ and R CHK, N is the number of characters read and should always equal 80. There-



Figure 74. Time Required to Execute WRITE and WR ER to Card Record Storage

fore, the time for these two instructions is equal to 2.85 milliseconds. For the instructions WRITE and WR ER, N is the number of characters written plus one. Figure 74 shows the time required to execute these instructions for card record storage.

For magnetic drum storage, READ, R CHK, WRITE OR WR ER requires 8.12 + .040N milliseconds, where N is the number of characters read or written. Figure 75 shows the time required to execute these instructions for drum storage.

For magnetic tape storage, READ, R CHK, WRITE OR WR ER requires 10.14 + .067N milliseconds, where N is the number of characters read or written. Figure 76 shows the time required to execute these instructions for tape storage.

Input-Output Units

The maximum repetition rates for successive records for the card reader, card punch, and printer are as follows:

Card Reader—250 cards per minute; 240 milliseconds.

Card Punch—100 cards per minute; 600 milliseconds.

Printer—150 lines per minute; 400 milliseconds.

The typewriter will print successive characters at a rate of about 600 characters per minute.



Figure 75. Time Required to Execute READ, R CHK, WRITE, WR ER on Magnetic Drum



FIGURE 76. TIME REQUIRED TO EXECUTE READ, R CHK, WRITE, WR ER ON MAGNETIC TAPE

INDEPENDENT OPERATION

THIS SECTION of the manual describes the various auxiliary machines that are readily available using standard 702 input-output units. Tape units, card punches, card readers, and printers can be so connected as to provide independent machines that can perform many operations not requiring the logical ability of the 702.

CARD-TO-TAPE CONVERTER

THE CARD reader and its associated control unit may be attached directly to a tape unit to record data punched in IBM cards on magnetic tape. The speed of recording is 250 cards per minute.

The punched card information is recorded on tape in 80-character records regardless of the number of card columns punched. Unpunched columns of the card are recorded as blank characters on tape. Information is recorded on tape in the same order in which it is read from the cards.

Operation

To accomplish a card-to-tape conversion, a tape unit is connected by cable to a card reader and its associated control unit. The tape is put in the tape unit and the door closed. Depression of the tape unit load-rewind key will feed the tape into the vacuum columns and take it to the load point. Depressing the start key will then turn on the ready light.

Once the ready status has been established in the tape unit, the card reader may be operated. Cards are placed in the hopper and the start key is depressed once to run in the cards. A second depression of the start key causes the card-to-tape conversion to begin.

When the end of the tape is reached, the operation is stopped. The cards should be removed from the hopper and the start key depressed to record the last two cards in the feed on tape. A tape mark is automatically recorded after the last card. The tape can be rewound by depressing the load-rewind key. The tape can be removed from the columns by depressing the unload key and taking off the reel. The operation should be resumed by repeating the normal starting procedure.

When the end of the card file is reached, the operation is concluded by depressing the start key and recording the last two cards in the feed. A tape mark is automatically recorded after the last record.

Recording

All standard punched card characters will be recorded on tape as indicated by the character code chart (Figure 77). The following card punches will be recorded as indicated:

CARD	TAPE
Zone 11, numerical 0	ō
Zone 12, numerical 0	0
Zone 0, numerical 2 and 8	Record Mark

Checking

Information read from the cards is checked by comparing an odd-even row count of the holes made at the first reading station against a similar count of the twelve bit-coded characters coming from record storage. If a discrepancy is detected by this check the machine is stopped after recording the erroneous record on tape, and the read-check light is turned on.

A check of the echo impulses of the write head is made to detect errors in the writing circuits. A discrepancy revealed by this check stops the machine after the record has been recorded on tape and turns on the write check light.

In either of the above cases, the reset key on the control unit must be depressed to restore the checking circuits to normal. To re-read the card in question and rewrite the record on tape, the tape must be backspaced one unit record by depressing the back-space key on the control unit. The cards must be removed from the hopper and the feed key must be depressed to run out the cards in the feed. The last four cards out must be inserted in the hopper with the remaining hopper cards on top of them. The operation can then be resumed by depressing the start key.

Controls

The standard card reader and tape unit controls are available on these units. In addition, the following controls are available on the Card Reader control unit for use principally on a card-to-tape operation.

Back-Space Key

The back-space key, when depressed, back-spaces the tape one record for each depression. Records which have been recorded incorrectly may be backspaced and rewritten.

Reset Key

Depressing the reset key resets the check circuits and allows normal operation.

Read-Check Light

The read-check light is turned on when a card reading error is detected.

Write-Check Light

The write-check light is turned on when a writing circuit error is detected.

Prepare to Read Light

This light, when on, indicates that the reader has received a read instruction from the arithmetic and logical unit and has not yet executed it.

TAPE-TO-CARD CONVERTER

THE CARD punch and its associated control unit may be attached directly to a tape unit to convert magnetic tape records into punched card records.

Records of 80 characters or less may be punched at a speed of 100 cards per minute. Records longer than 80 characters may cause an error indication and should not be used. Informaton is punched in the cards in the same order in which it is read from tape.

Operation

The tape unit is prepared for the operation first by putting in the proper reel of tape and closing the cover. Depressing the load-rewind key brings the tape automatically to the starting point. Subsequently depressing the tape unit start key turns on the ready light.

When the ready status has been established in the tape unit, the cards are placed in the card punch hopper and the start key is depressed twice to begin the operation.

When a tape mark is sensed, the operation is stopped. Normally, the reel should be rewound at this time by depressing the load-rewind key. The tape is removed from the vacuum columns by depressing the unload key and the reel may then be removed from the unit. Another reel can be loaded onto the unit and fed to the starting point by depressing the load-rewind key. The tape unit start key is depressed and operation is resumed by depressing the card punch start key twice.

After the last reel of tape has been recorded, the cards are removed from the card punch hopper and the remaining cards are run out of the feed by depressing the feed key on the card punch.

Checking of Reading

Information read from tape is given a characterby-character code check. In addition, a horizontal check for an even number of 1 bits in each of the seven tape tracks is made for each record to determine whether a single bit has been changed in any track in reading a record. A failure detected by either of these two methods stops the machine before punching the erroneous record and turns on the read-check light on the control unit.

To re-read the record in question after detecting a reading error, the tape may be back-spaced one record by depressing the back-space key on the control unit. The reset key must then be depressed to turn off the error indication. Depressing the restart key on the control unit now causes the card punch to execute a clearing cycle. On the clearing cycle a card is fed but not punched and record storage is cleared. The operation is then automatically resumed with the same tape record being re-read into record storage.

If, upon detecting a reading error, the record is not to be read, the reset key must be depressed to turn off the error indication. The restart key must then be depressed to resume operation. In this event no clearing cycle occurs and the record in record storage is punched.

Checking of Punching

The punched cards are checked at a brush station, located one card width from the punching station. The check is an odd-even row count of the holes which is matched against a similar count of the 12 bit-coded characters going into record storage.

A discrepancy in a card is indicated by the turning on of the punch-check light after the following card has already been punched and the second record following has already been read into record storage. Therefore, to re-read the record in error, it is necessary to back-space the tape three records by depressing the control unit back-space key three times. The reset key on the control unit should then be depressed to turn off the error indication. Depressing the restart key on the control unit causes a card to be fed but not punched, the record storage to clear, and the operation to resume. Therefore, a blank card is fed and two cards are repunched. The blank card and the two cards preceding it should be removed by the operator.

Punching

The numerical, alphabetic and symbol characters are punched in the standard IBM card code. The following characters are punched as indicated.

TAPE CHARACTER	Card Punching
ō	Zone 11, numerical 0
i	Zone 12, numerical 0
Record Mark	Zone 0, numericals 2 and 8
Character Code Error	Blank

Controls

The standard card punch and tape unit controls are available on these units. The following controls are available on the card punch control unit principally for use in a tape-to-card operation.

Back-Space Key

The back-space key, when depressed, back-spaces the tape one record for each depression. Records that have been read erroneously may be back-spaced and re-read.

Reset Key

The reset key is used to reset the check circuits and permit normal operation.

Punch-Check Light

The punch-check light is turned on when a discrepancy is revealed by the check performed on punching.

Read-Check Light

The read-check light is turned on when a character code error is detected in reading a tape record.

Restart Key

Depressing the restart key resumes the punching operation after an error has been detected and the error indication has been turned off. If the tape has been back-spaced to re-read the records in question, depressing the restart key causes the card punch to execute a clearing cycle, after which the operation is automatically resumed.

Write Condition Light

This light indicates that characters are being stored in record storage during either a regular or independent operation.

TAPE-CONTROLLED PRINTER

THE PRINTER and its associated control unit may be attached directly to a tape unit to provide an additional means of printing information recorded on magnetic tape. Information will be printed in the same order in which it is read from tape at a speed of 150 lines per minute.

Records of 120 characters or less may be printed. Records of 121 characters may be read with the carriage control switch at PROGRAM. Tape records in excess of 121 characters may cause a machine stop or an error indication and therefore should not be used.

The automatic carriage is provided with completely flexible control for form spacing through the carriage control switch and the first character of the tape record. If the carriage control switch is set to PROGRAM, the spacing and skipping operations will be governed by the first character of each tape record. With the switch set to SINGLE or DOUBLE, carriage spacing for each line will automatically be single or double and the first character of each tape record will be printed.

Operation

The tape unit is prepared for the operation first by putting in the proper reel and closing the cover. Depressing the tape load-rewind key brings the tape automatically to the starting point. Depressing the tape unit start key then turns on the ready light on the tape unit.

The printer is then made ready by inserting the proper paper form, by inserting a carriage tape if any is required, by restoring the carriage to channel 1, and by setting the carriage control switch. Depressing the printer start key once will cause a clearing cycle. A second depression will turn on the calculator interlock and start the printing operation.

Checking of Reading

Information read from tape is given a characterby-character even count character code check. In addition, a horizontal check for an even number of 1 bits is made for each of the seven tape tracks for each record. This determines whether a single bit has been changed in any track in reading a record. A failure detected by either of these two methods will stop the machine before printing the erroneous record and turn on the read-check light on the control unit.

To re-read a record found to be in error, the tape may be back-spaced one record by depressing the back-space key on the control unit. The reset key must then be depressed to reset the error indication. Depressing the restart key on the control unit will now cause the printer to execute a clearing cycle. On the clearing cycle the erroneous record is removed from record storage and no printing or carriage spacing occurs. The operation is then automatically resumed with the same tape record being re-read into record storage.

If it is not necessary to re-read the record when a reading error is detected, the reset key is depressed to resume operation. In this event, no clearing cycle occurs and the record in record storage will be printed.

Checking of Printing

The printing of information is checked by comparing the print wheel echo impulse count against the information sent to the printer record storage. This is a row count check of the numerical portions of all characters. A discrepancy revealed by this check will stop the machine after printing the record in error and will turn on the printer check light on the control unit.

Should a printing error be detected, the erroneous record will have been printed and the next record will be in record storage at the time the machine stops. Therefore, to reprint the erroneous record, the tape must be back-spaced two records by two depressions of the back-space key. The reset key must then be depressed to reset the error indication. Depressing the restart key will cause a clearing cycle, after which the two tape records will be re-read and normal operation will be resumed. If the record in error is not to be reprinted, depressing the reset key and the restart key will resume operation.

Printing

All the characters in the character code chart will be printed as indicated except for the following:

Character	How Printed
$\overset{+}{0}$	&
ō	-
Record Mark	Z
Tape Mark	Not printed
Character Code Errors	Blank

Controls

The standard tape unit and printer controls are available on these units. In addition, the following controls on the printer control unit are used principally for the tape-controlled printer operation.

Back-Space Key

Depression of the back-space key causes the tape involved in the tape-controlled printer operation to be back-spaced one unit record. Successive depressions of this key will cause the tape to be back-spaced one record for each depression.

Reset Key

Depressing the reset key turns off any check indicators and the associated lights that were turned on by the detection of an error. The reset key must be depressed after an error has been detected before operation can be resumed. To re-read a record in question, the reset key should be depressed after the back-space operation has been performed.

Restart Key

Depressing the restart key resumes the printing operation after an error has been detected and the error indication has been turned off.

If the tape has been back-spaced to re-read the record in question, depression of the restart key will cause a printer clearing cycle, after which operation will be continued.

Write-Check Light

If a discrepancy is detected by the printer echo check, the machine is stopped after printing the record and the write check light is turned on.

Read-Check Light

If a character code error is detected in reading a tape record, the machine is stopped after reading that entire record and the read check light is turned on.

Write Condition Light

This light indicates that characters are being stored in record storage during either a regular or auxiliary operation.

	CHAR. &	с 0	ва 1]	8421 0000	CHAR.	с 1	ва 10	8421 0000	сная. Blank	с 1	ва 01	8421 0000		um	and Mai 00		
	Α	1	11	0001	J	0	10	0001	1	0	01	0001	сн. 1	c 1	ва 00	8421 0001	
	В	1	11	0010	к	0	10	0010	S	0	01	0010	2	1	00	0010	
	с	0	11	0011	L	1	10	0011	т	1	01	0011	3	0	00	0011	
ETIC	D	1	11	0100	м	0	10	0100	U	0	01	0100	4	1	00	0100	AL
HAB	E	0	11	0101	N	1	10	0101	v	1	01	0101	5	0	00	0101	S I C
ALPI	F	0	11	0110	0	1	10	0110	w	1	01	0110	6	0	00	0110	ÚM EI
	G	1	11	0111	Р	0	10	0111	х	0	01	0111	7	1	00	0111	Z
	Н	1	11	1000	Q	0	10	1000	Y	0	01	1000	8	1	00	1000	-
	1	0	11	1001	R	1	10	1001	Z	1	01	1001	9	0	00	1001	-
	Piu O		ero 11	1010	Mir 0			° 1010	Reco		-	(1010	N 0			al Zero 1010	-
IAL	AR	1	11	1011	\$	0	10	1011	,	0	01	1011	#	1	00	1011	
SPEC	снаг 	0	11	1100	*	1	10	1100	%	1	01	1100	@	0	00	1100	-
														Ta 0	pe /\ 00	Mark 1111	

FIGURE 77. CHARACTER CODE CHART

Instruction	Oper. Part	From	To	Remarks	Limiting Factor	Time in Milliseconds	Pag
ADD	G	Mem.	Acc.	Result in accumulator	Non-num. char. in mem.	.138 + .023N	20
ADD MEM	6	Acc.	Mem.	Signed memory field - algebraic addition	Non-num. char. in mem.	.138+.023N	
				Unsigned mem. field - non-algebraic and zone addition	Accumulator mark	.138 + .023N	29
COMP	4			Accumulator with memory	Accumulator mark	.138+.023N	26
CTRL 0000	3			Turn off input-output indicator		.184	35
CTRL 0001	3			Record tape mark		10.14	35
CTRL 0002	3			Rewind tape unit		.151 + rewind time	35
CTRL 0003	8			Turn on input-output indicator		.151	35
CTRL 0004	3			Back space tape one record		60.00 +.067N	35
CTRL 0005	3			Prevent printing or punching erroneous information		.184	35
DIV	W			Dividend in acc.; divisor in mem.; Quotient in acc.	Non-num. char. in mem.	Refer to chart	23
LENG				Add zeros to right		.161+.023N	24
LOAD	8	Mem.	Acc.	Loads zones as well as numbers	Accumulator mark	.138 + .023N	26
MPY	v			Multiplier acc.; multiplicand mem.; product acc.	Non-num. char. in mem.	Refer to chart	22
NO OP	A			No operation		.138	51
NORM TR	x			Left-hand zero in accum. causes transfer. Zero deleted		.161 + .023N	50
READ	Y	Input	Mem.	From tape to memory	³ / ₄ " inter-record gap	10.14 +.067N	
		-		From card read to memory	80 columns	.171 + .0335 N	12
				From drum to memory	Drum mark	8.12 +.040N	
	I	Input	Mem.	Compare card record with memory	80 columns	.171+.0335N	
B CHK	1	-					
		Output	Mem.	Compare tape with memory	¾" inter-record gap	10.14 +.067N	45
		Output	Mem.	Compare drum with memory	Drum mark	8.12 +.040N	
R ADD	H	Mem.	Acc.	Resets accum., adds from memory	Non-num. char. in mem.	.138 + .023N	19
R SUB	Q	Mem.	Acc.	Resets accum., subtracts from memory	Non-num. char. in mem.	.138 + .023N	19
ROUND	Е			Drop positions from right and ½ adjust		.207 + .023N	22
SEL	2			Select input, output, alter sw. or check indicator	- Marine	.138	9
SET L	В			Place accumlator mark as indicated by address		.138 + .023N	24
SHOR	C			Drop positions from right		.161+.023N	24
SIGN	т			Remove zone 11, 10, or 01 from memory, place & or — in accumulator		.138+.023N	29
STOP	J			Stop machine		.138	37
STORE	F	Acc.	Mem.	Store numerical field in memory	Accumulator mark	.138 + .023 N	20
ST PR	5	Acc.	Mem.	Store field for printing. Consider decimals, commas.	Accumulator mark	$.138 \pm .023N$	44
SUB	Р	Mem.	Acc.	Result in accumulator	Non-num. char. in mem.	.138 + .023N	21
TR	1			Unconditional transfer		.138	13
TR EQ	L			Transfer if accum, is equal to memory		.138	27
TR HI	K			Transfer if accum, is higher than memory		.138	27
TR PLS	M			Transfer if accumulator is plus	······································	.138	37
TR SIG	0			Transfer if indicator is on		.138	37
TR ZRO	N			Transfer if accumulator is zero		.138	37
UNLOAD	7	Acc.	Mem.	Unload zones and numbers	Accumulator mark	.138 + .023N	26
WRITE	R	Mem.	Output	From memory to tape	Record mark	10.14 +.067N	
				From memory to card punch or printer	Record mark	.171+.0335(N+1)	13
				From memory to drum	Record mark	8.12 +.040N	
VR ER	Z	Mem.	Output	Replace each char. in mem. with blank			
				To card punch or printer	Record mark	.171 + .0335 (N + 1)	
				To tape	Record mark	10.14 +.067N	48

ADDRESS DATA	
Memory	0000 - 99
Card Readers	0100 - 01
Tape Units	0200 - 02
Card Punches	0300 - 03
Printers	0400 - 04
Typewriter	0500 - 05
Drum Section	1000 - 99
Alteration Switches	0911 - 09
Instruction Check Indicator	09
Machine Check Indicator	09
Read-Write Check Indicator	09
Printer-Punch Check Indicator	09
Overflow Check Indicator	09
Sign Check Indicator	09

CARRIAGE CONTROL CHARACTERS

Suppress Space	å
Single Space	Blank
Double Space	0
Skip to Channels 1-9	1-9
Short Skip to Channels 1-9	J-R

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FIGURE 78. OPERATION CHART

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