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Student Study Guide
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FOREWORD

This is a service test edition which was prepared and published in a short period of time to meet the needs of the using courses. Because of the short period of time available for preparation and editing, it is possible that the text contains minor errors in organization and information. If any such errors come to your attention, note them and inform your instructor.

The basic operating unit in IBM accounting is the punched card. Punched cards, containing original data in the form of punched holes, actuate the IBM machines to perform automatically the various operations essential to recordkeeping.

Transcribing original data to punched cards is accomplished by any of several types of IBM card punches. This manual explains the operation of two of these machines, the IBM 24 Card Punch and the IBM 26 Printing Card Punch

These two machines are essentially alike in design, features, and operation. The major difference is that the printing mechanism of the IBM 26 prints the characters on the cards as they are punched.

The machines are easy to operate, quiet, and attractive. One of their most important features is the simple means of setting them up quickly for automatic control of skipping, or duplicating operations. Each setup, or program, is made by punching a card and mounting it on a program drum, which is inserted in the machine. The same program card can be used repeatedly for a routine punching operation.

The card punch duplicates common information from any card into the following card in a gangpunch operation. The duplication can be automatic or through the keyboard. This method of duplicating avoids much card handling and consequently increases production.

The duplicating feature greatly facilitates error correction during keypunching. When an error is made, the operator need not re-punch the whole card manually. Instead, without any card handling, the operator duplicates into the next card all correctly punched fields and re-keys only the field in error. The program control permits such duplication, field by field, without concern about column numbers.

Duplication under program control proceeds at a rate of 20 columns per second on the IBM 24, and 18 columns per second on the IBM 26. Skipping and card release proceed at a rate of 80 columns per second. After one card is punched in column 80, the next card feeds into the column-1 position in one-fourth of a second.

Note: Where two speeds are indicated in this publication, the lower speed refers to the IBM 26 and the higher speed to the IBM 24.

The almost complete visibility of the cards in the card bed facilitates the design and punching of dual cards and the identification of prepunched cards into which more data must be punched. Direct access to all parts of the card bed also permits easy manual insertion and removal of cards when necessary.

The keyboards can be moved anywhere on the reading board, for the operator's greatest convenience and comfort. A combined alphabetic and numeric keyboard utilizes a novel principle to facilitate the punching of cards containing both alphabetic and numeric fields. A group of the right-hand typewriter keys serves for punching digits as well as letters, with the shift from one function to the other normally made automatically by the program card. This permits the operator to punch an alphabetic field with both hands and then, without shifting from the *home* position, to punch a numeric field with the right hand only. Use of the right hand alone for numeric punching frees the left hand for document handling.

This publication contains a complete description of the operating features and methods of operation. Under *Operations*, each function is described in detail as it is first used in a typical situation. All functions and the combination keyboard are summarized under *Combination Keyboard Summary*.

Card Punching

Eighty columns on the card can be punched, as shown in Figure 2.

Each column has twelve punching positions; one each for the *digits* 1 to 9, and one each for the *zones* 0, 11, and 12. The 11-zone punch is sometimes referred to as X. As illustrated, digits are recorded by punching a single hole in the corresponding digit or zero position of the desired column.

A letter is a combination of one zone-punch and one digit-punch in the desired column. For example, A is the 12-zone and digit-1 punches, N is the 11-zone (X) and digit-5 punches, and Z is the 0-zone (zero) and digit-9 punches. Some machines have special-character keys.

A special character is one, two, or three holes in the desired column as shown in Figure 2. Punching of two or three holes in one column for a letter or special character is automatic when the corresponding key is pressed.

A maximum of four punches can be duplicated into a single column on the IBM 24 Card Punch. However, duplicating in a single column on the IBM 26 Printing Card Punch must be limited to multiple punches that make up a printable character, regardless of the setting of the print switch. This eliminates possible damage to the printing mechanism.

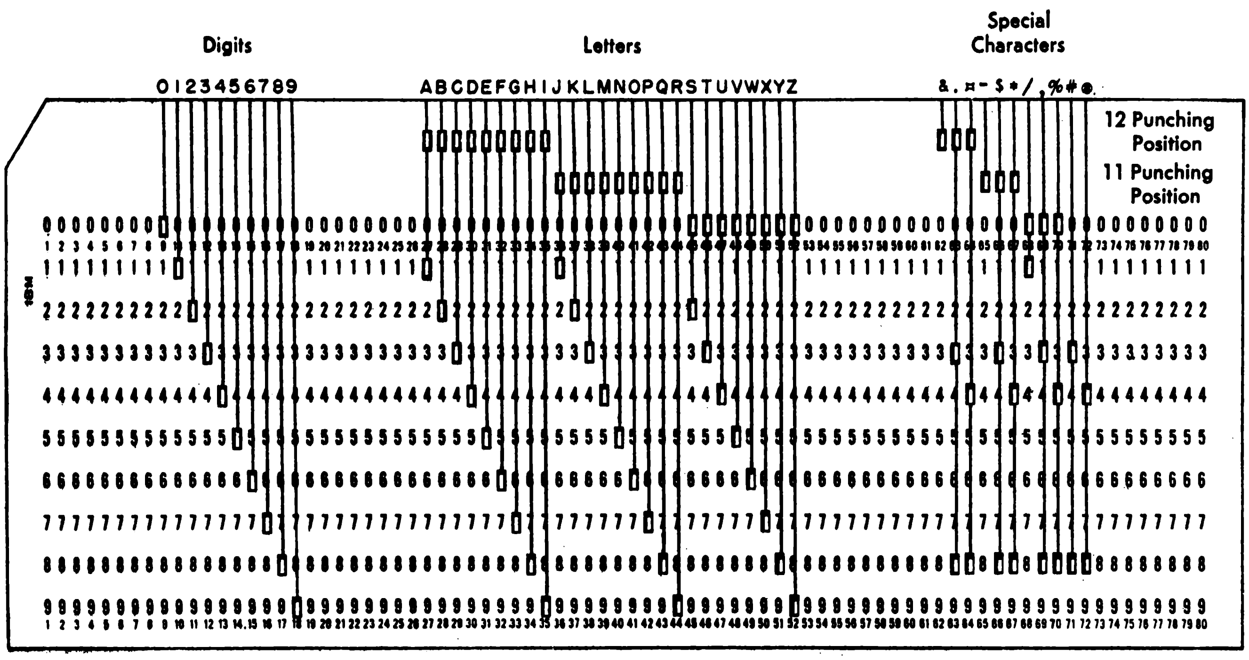


Figure 2 Punching Positions in Card

Operating Features

Figure 4 indicates the operating features described here.

Card Hopper

The card hopper, with a capacity of approximately 500 cards, is on the upper right side of the machine. Place cards in the hopper face forward, 9's down. A sliding pressure plate ensures uniform feeding.

When the cards are in the hopper and the pressure plate is in position, the top portion of the card above the zero row is visible from the left edge of the card through column 9, from column 29 through column 52, and from column 72 to the right edge of the card (Figure 5). Because cards feed from the front of the hopper, any markings in these three sections on the next card to be fed can be seen while the card is still in the hopper. This feature is most advantageous in punching serially numbered cards or cards that are partially punched and interpreted.

A card feeds from the hopper to the card bed automatically or when the operator presses the feed key. The first two cards to be punched must be fed by key, but all other cards in the hopper can be fed automatically, under switch control.

Punching Station

Punching is performed at the first of two stations in the card bed through which the cards pass from right to left. Usually, to start an operation, two cards are fed into the card bed at the right of the punching station. As the second card is fed in, the first card is automatically registered for punching—that is, it is positioned at the punching station. While the first card is being punched, the second card is at the right in the card bed. When column 80 of the first card passes the punching station, the second card is registered at the punching station, and the next card in the hopper is fed into the right of the card bed. This method of card feeding minimizes the time required for feeding and ejecting.

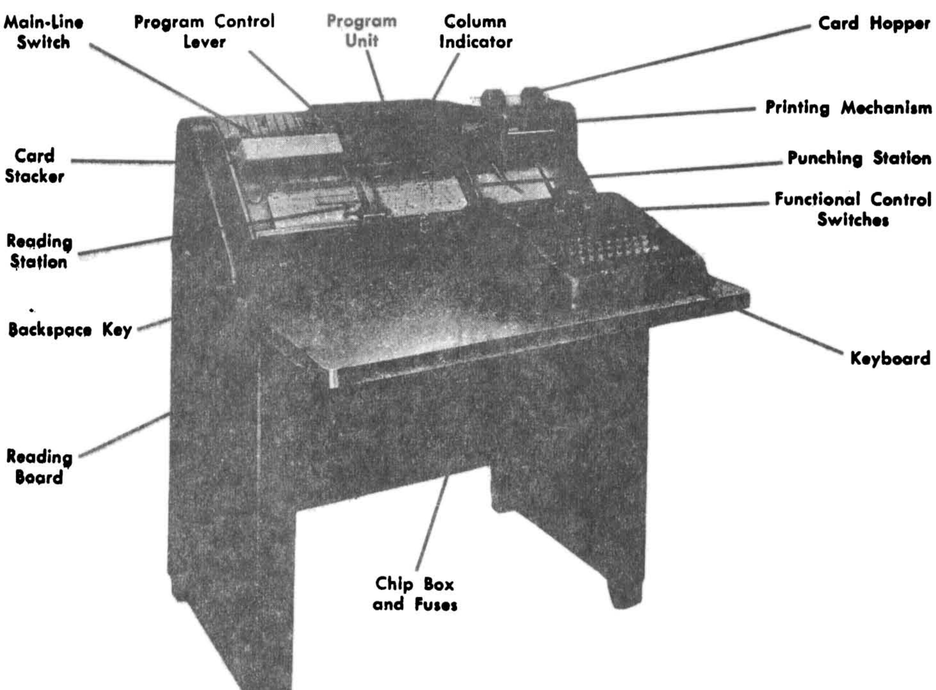


Figure 4. IBM 26 Operating Features

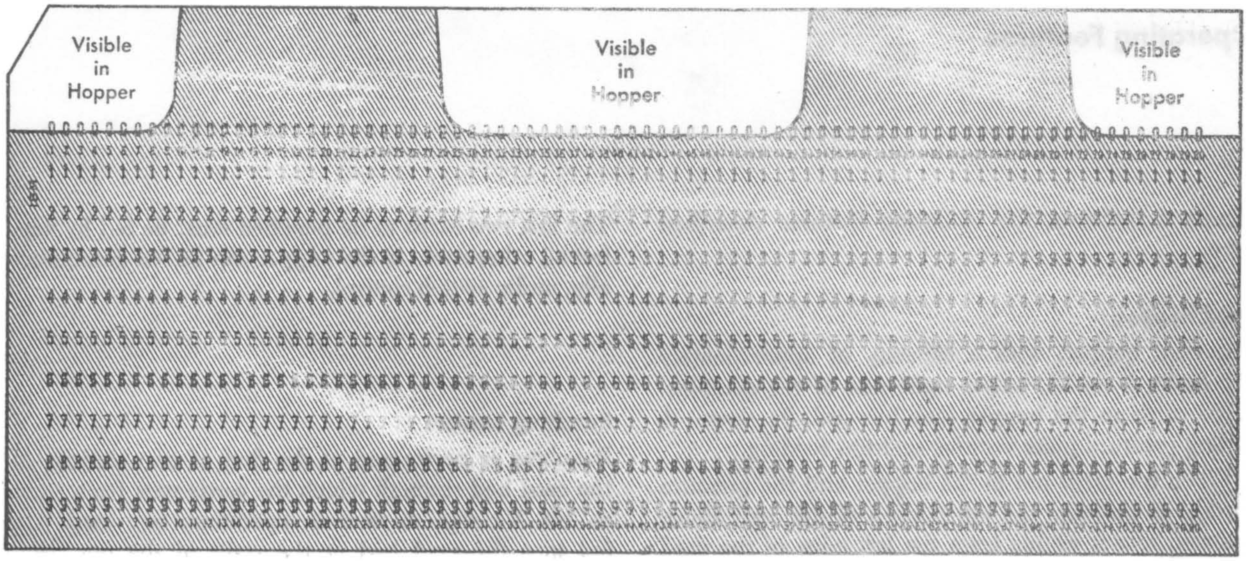


Figure 5. Card Visibility in the Card Hopper

A single card can be placed in the card bed by hand and registered in punching position by key.

The whole card is visible before it is registered, and at least 71 columns are visible after punching has started. For example, when column 15 is to be punched (Figure 6), columns 1-12 and columns 22-80 are visible. This feature simplifies the design of dual cards and facilitates keypunching. Information can be recorded (marked or printed) on a dual card anywhere other than in the two columns to the left or six columns to the right of the column in which the information is to be punched. The narrow pressure arm and the plastic guide in the right of the card bed must be considered, however, when designing dual cards. For most efficient design, test the proposed design through the machine before placing an order for cards. *Cards with certain lower corner cuts cannot be fed satisfactorily through the card bed.* (See *Corner Cuts.*)

Reading Station

The reading station, where the cards are read for duplicating, is about one card length to the left of the punching station. Consequently, each card that has been punched passes through the reading station as the next card is being punched. The two cards move in synchronism, column by column, and information to be duplicated is transferred from the first card to the second. This principle of duplication is the same as gangpunching. Reading from one card to another can be controlled, field by field, so that only the desired information is duplicated.

This feature eliminates card handling for the duplication of information from cards prepared during the punching operation. Card handling is necessary only when an operation requires duplication from prepunched master cards. In this case, insert the prepunched master card manually at the right of the reading station before the next card to be punched is registered. Then, register both the master card and the detail card at their respective stations by pressing the register key.

The whole card is visible before it is registered at the reading station, and at least 68 columns are visible after reading has started. For example, when column 15 is being read, columns 1-8 above the 7-row and columns 21-80 are visible.

Card Stacker

The card stacker, with a capacity of approximately 500 cards, is on the upper left side of the machine on a level with the hopper. After each card passes the reading station, it feeds into the stacker automatically or by key. Cards stack at an angle, 12's down, face back, and are held in position by a card weight. When the cards are removed from the stacker, they are in their original sequence.

Main-Line Switch

The main-line switch is at the rear of the stacker. The machine can be started about one-half minute after the main-line switch is turned on. This allows sufficient time for the electronic tubes to heat. When the stacker becomes full, the switch automatically goes off.

When the main-line switch is turned on, press the release key before starting operation. This ensures that

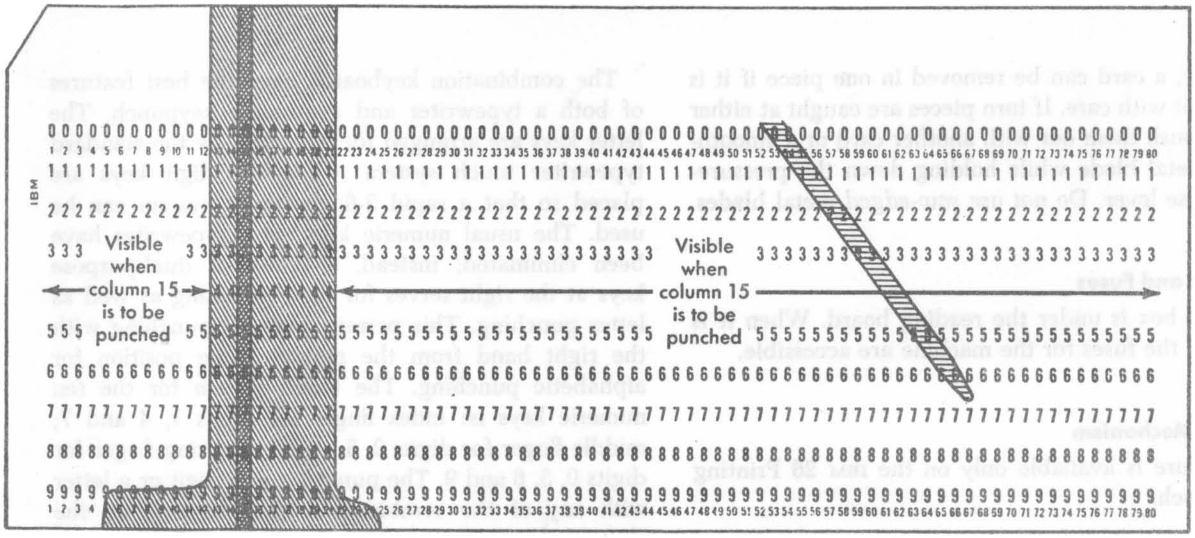


Figure 6. Card Visibility at the Punching Station

the program card is at column 1 and that any card at the punching station is released.

Reading Board

A reading board provides ample space for source documents from which the cards are punched. If extra space is required, a larger reading board extending about ten inches to the left of the standard board is available.

Backspace Key

This key is below the card bed, between the reading and punching stations. As long as it is held down, the cards at the punching and reading stations backspace continuously until column 1 is reached. At the same time the program card, which controls skipping and duplicating, also backspaces. Backspacing should not be attempted after column 78 is passed without first removing the card from the card bed at the right.

The backspace key can also be used to release the keyboard after it has been locked (described in *Keyboard Locking*) on IBM 24 punches with serial numbers higher than 23639 or IBM 26 punches with serial numbers higher than 12260.

Program Unit

The program unit controls automatic skipping, automatic duplicating, and shifting from numeric to alphabetic punching and *vice versa*. Each of these operations is designated by a specific code recorded in a program card. The operator fastens the program card around a program drum and inserts it in the machine, where it is read by a sensing mechanism. The drum revolves in step with the movement of the cards past the punching and reading stations so that the program codes control the operations, column by column. Thus, the program unit affords a highly flexible means of controlling automatic operations.

The program unit also controls printing functions as described under IBM *26 Printing Features*.

Program Control Lever

The program control lever, located below the program unit, controls operation of the program unit. Turn on this lever to lower the program sensing mechanism so that it rests on the program drum, and the codes punched in the program card control the various automatic operations. Turn off the lever to raise the program sensing mechanism so that the program drum can be easily removed or inserted. Turn this lever to the OFF position whenever a program card is not in the machine.

Column Indicator

The indicator, located at the base of the program-drum holder, indicates the next column to be punched. Refer to this indicator as a guide for spacing or backspacing to a particular column.

Pressure-Roll Release Lever

The pressure-roll release lever is next to the column indicator. Press this lever to permit the manual removal of a card from the punching or reading station.

Normally, a card can be removed in one piece if it is pulled out with care. If torn pieces are caught at either station, push them out with another card or a smooth-edged metal blade while holding down the pressure-roll release lever. Do *not* use *saw-edged* metal blades.

Chip Box and Fuses

The chip box is under the reading board. When it is removed, the fuses for the machine are accessible.

Printing Mechanism

This feature is available only on the IBM 26 Printing Card Punch.

Keyboards

Specify any one of two types of cable-connected keyboards: Figure 7 shows the numeric keyboard only (two special characters: — and &).

Figure 8 shows the combination alphabetic and numeric keyboard (four additional special character keys—11 special characters in all).

On all keyboards, the punching keys are gray with blue lettering and the control keys are blue with white lettering. The *home* keys are more concave than the other keys to facilitate accurate touch operation. The keyboards are so interlocked that no two character keys can be completely pressed at the same time, but it is not necessary to wait for one key to rise before pressing another. This design permits *rolling* of keys. To punch multiple digits manually in one column, hold down the MULT PCH (multiple punch) key while pressing the keys one at a time. If the punch is not equipped with a multiple punch key, use the space bar.

The combination keyboards have the best features of both a typewriter and a numeric keypunch. The letter keys are arranged for operation by the standard typewriter touch system, while the digit keys are placed so that a rapid 3-finger touch system can be used. The usual numeric keys on a typewriter have been eliminated; instead, a group of dual-purpose keys at the right serves for digit punching as well as letter punching. This permits numeric punching with the right hand from the normal home position for alphabetic punching. The touch system for the ten numeric keys is: index finger for digits 1, 4 and 7; middle finger for digits 2, 5, and 8; and ring finger for digits 0, 3, 6 and 9. The punching of a digit or a letter with any of the combination keys depends on the shift of the keyboard. For example, pressing the 4-J key punches a 4 when the keyboard is in numeric shift, but a J when in alphabetic shift. This shifting is similar to upper or lower case shifting on a standard typewriter and may be controlled automatically by the program unit or manually by key. The section containing the combination keys is readily distinguishable by the blue area of the key plate. On the combination keyboard, the fourth row of keys contains four special-character keys at the left. These keys punch eight characters as shown on the key tops; four in numeric and four in alphabetic shift.

The blue keys, which control functions of the machine, are explained under *Operations*.

The green correction key is explained under *Special Features*.

Function Control Switches

Two ON-OFF switches, controlling automatic functions, are explained under *Operations*. A third switch, to con-

Figure 7. Numeric Keyboard

Figure 8. Combination Alphabetic and Numeric Keyboard

trol printing, is explained under IBM *26 Printing Features*. These three switches are:

AUTO FEED

AUTO SKIP AND AUTO DUP

PRINT

Program Card

A program card, which is a basic part of the program unit, is prepared for each punching application and can be used repeatedly. Proper punching in this program card controls the automatic operations for the corresponding columns of the cards being punched.

The control punching required in the program card depends on the functions to be controlled, that is, skipping, duplicating, and alphabetic punching. Each row in the program card serves a specific purpose in this respect.

Field Definition (12)

Punch a 12 in every column except the first (left-hand position) of every field to be skipped, duplicated, or manually punched. These 12's serve to continue to the end of a field, any skip or duplication started within that field. Treat as a single field several consecutive fields to be automatically skipped or duplicated as one field. Don't program a single-column field with a 12 code.

The 12's punched in the program card for manually punched fields permit occasional skipping or duplicating. This skipping or duplicating is started by key and is carried across the field by the 12's. This type of skipping is similar to an X-level skip on other IBM card punches; the occasional duplicating may be desired in the case of two or more cards with the same information, or in the duplication of the correct fields of an error card.

Automatic Skip (11)

An 11 punched in the first column of any field automatically starts a skip, which is continued over that field by the 12's punched in the remaining columns of the field. If a single column is to be automatically skipped, punch it with an 11. This coding operates with the automatic-skip-and-duplicate switch, which must be on to start the skipping automatically.

Automatic Duplication (0)

A zero punched in the first column of any field automatically starts duplication, which is continued over that field by the 12's punched in the remaining columns of the field. If a single column is to be automatically duplicated, punch it with a zero. This coding operates with the automatic-skip-and-duplicate switch, which must be on to start the duplicating automatically.

Alphabetic Shift (1)

When the program card is in the machine, the combination keyboard is normally in numeric shift, and pressing any one of the 2-purpose keys causes a figure to be punched. To punch a letter, the combination keyboard must be shifted for alphabetic punching. This shifting is performed automatically by a 1 in the program card in each column of the alphabetic field. During duplication of alphabetic information, the 1's permit automatic spacing over blank columns and prevent X-skipping caused by letters containing X-punches (J through R).

On a numeric machine, the only function of the 1's is to permit automatic spacing over blank columns when duplicating.

Program Card Codes

The four basic program codes are summarized here and are illustrated in Figure 9. Two additional codes, which control printing features of the IBM 26, are also listed here and are explained under IBM *26 Printing Features*.

Code	*Function*
12	Field Definition
11	Start Automatic Skip
0	Start Automatic Duplication
1	Alphabetic Shift
2	Left Zero Print
3	Print Suppression

The other digit rows, in the program card, control functions with the alternate program feature. (See *Special Features.*)

Program Drum

The program card is mounted on a program drum for insertion in the machine. The program drum has a clamping strip to hold the card, and a handle on the top to tighten or release the strip. To fasten a card around the drum (Figure 10):

1. Hold the drum in a horizontal position with the handle to the right. Turn the handle away (counterclockwise direction) as far as it will go. This loosens the smooth edge of the clamping strip.
2. Insert the column-80 edge of the card under the smooth edge of the clamping strip. Two alignment check holes in the clamping strip make it possible to see that the card is flush with the metal edge under the strip. The card should be positioned so that the 9's edge is against the rim of the drum.

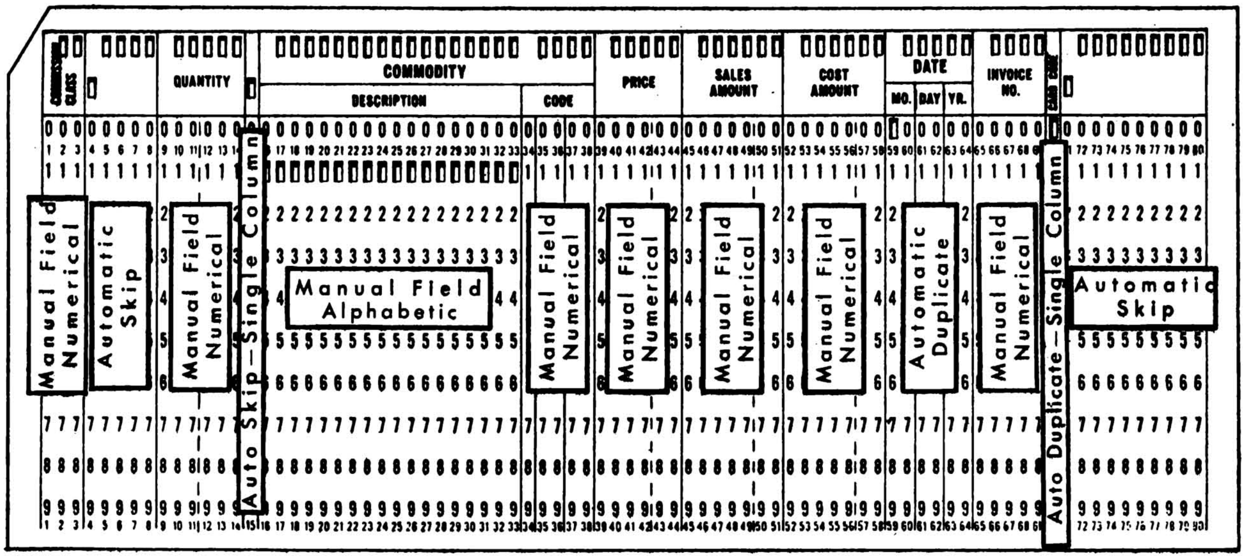


Figure 9. Program Card

3. Turn the handle to the center position. This tightens the smooth edge of the clamping strip and loosens the toothed edge.
4. Wrap the card tightly around the drum and insert the column-1 edge under the toothed edge of the clamping strip.
5. Turn the handle toward you (clockwise direction) as far as it will go. This fastens the toothed edge of the clamping strip. The drum is now ready to be inserted in the machine.

To remove a card from the drum, reverse the procedure.

With the program sensing mechanism raised, place the drum on the spindle under the center cover of the punch, positioned so that the aligning pin falls in the aligning hole in the column-indicator dial. Turn on the program-control lever to lower the reading star wheels onto the program card, and press the release key to engage the reading mechanism fully. Whenever the drum is to be removed, first turn off the program-control lever to raise the star wheels.

To keep the program card for each punching application on a drum ready for insertion in the machine, order extra drums.

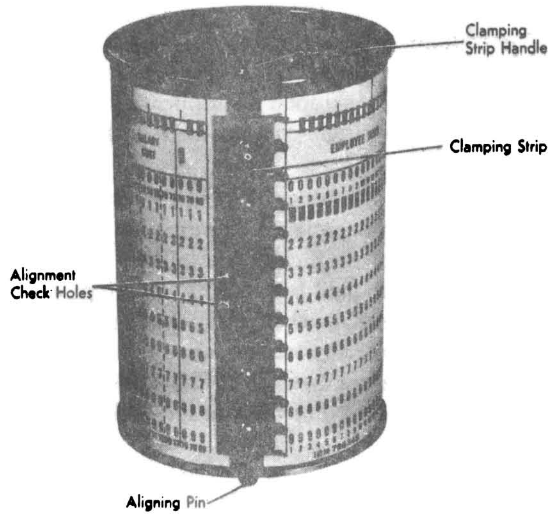


Figure 10. Program Drum

GENERAL.

The Punch Card Reader Set AN/GSQ-72 (punch card reader set) is a one-way, input terminal device that provides for the entering of information, such as operational programs, diagnostic routines, and statistical data, from punch cards into a memory module of the data processing set. The punch card reader set, which is illustrated in figure 4-10, consists of the Punch Card Reader MX-4735/GSQ-72 (card reader) and the Punch Card Reader Control C-4639/GSQ-72 (card reader control). The card reader control furnishes the control signals required for operation with the I/O modules and performs the necessary logic conversion of the card reader codes to the character codes used in the central processing equipment of the data processing set. The information in this section is presented under the following headings:

a. General description.

b. Punch card format.

c. Card reader operation.

d. Card reader status codes.

GENERAL DESCRIPTION.

The card reader is capable of reading standard 12-row, 80-column punch cards at a maximum rate of 200 cards per minute. The cards are loaded into the input hopper face down with column 1 toward the read station. The card reader feeds the cards from the input hopper thru the read station and into the stacker. Information punched in the cards is sensed by solar cells in the read station. Cards are read serially by column and also are read parallel by row, column 1 first. As the information is read, it is transferred one character at a time to the card reader control. The card reader control translates the card reader codes into DPS character codes, inserts a parity bit, and sends the data one character at a time to the I/O module that is controlling the input operation. A validity-check is performed on alphanumeric information sensed at the read station, and a marginal check of the exciter lamps and solar cells is performed prior to and after each card feed cycle. The card reader input hopper and stacker will each hold approximately 500 cards.

The card reader control interprets the punch card information as either binary code or alphanumeric characters. A switch in the card reader control is used to permit the selection of the binary or alphanumeric (alpha) mode of operation. In the alphanumeric mode, all character codes not recognized by the data processing set are invalid codes. The validity-check circuitry in the card reader is automatically enabled in the alphanumeric mode to check for invalid characters. If a character is found to be invalid, the VALIDITY CHECK indicator, on the operator panel of the card reader, lights. This error condition does not terminate the input operation, however, and the card reader continues to read cards. At the beginning of the next card-feed cycle, the VALIDITY CHECK indicator is extinguished; thus, there is only a momentary lighting of the indicator. However, if an invalid character is present in the last card to be read, the VALIDITY CHECK indicator remains lit and must be extinguished by use of the RESET push button.

To place the punch card reader set on line with the central processing equipment of the data processing set, cards must be placed in the input hopper, and the RESET and START push buttons on the card reader panel must be pressed, in that order. Pressing the RESET push button clears any error indicators (READ CHECK, FEED CHECK, or VALIDITY CHECK) that may be lit. When the START push button is pressed, the NOT READY indicator goes out, and the card reader is ready for operation. The end-of-file indicator is lit whenever the input hopper is empty.

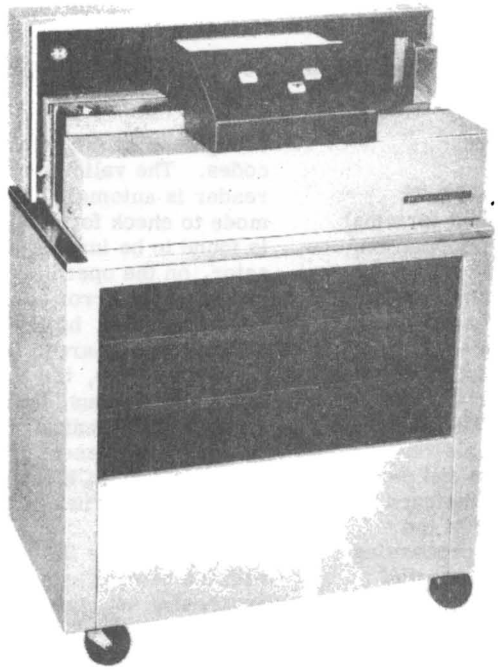
PUNCH CARD FORMAT.

The punch card reader set is capable of reading either binary or alphanumeric information from the punch cards. Separate card formats are used for the two types of information.

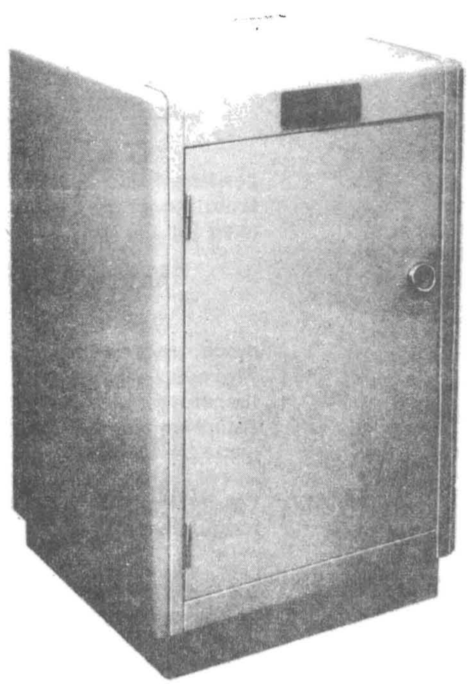
ALPHANUMERIC CARD FORMAT.

When the card reader is operated in the alpha mode, each column of the punch card (A, figure 4-11) represents one six-bit character of a memory word; therefore, each group of eight columns comprises a complete word. The 80-column card in the alphanumeric format thus contains a total of 10 memory words, and the 200-card-per-minute rate of the card reader represents a speed of 2000 words per minute for alphanumeric cards.

Sixty-three different combinations of holes (of the 4096 possible for each column) are translated by the punch card reader set into 63 different six-bit character codes. The remaining 4033 combinations of holes are converted into one remaining six-bit code (111111). Therefore, any invalid six-bit card reader code can be used to purposely enter a delete character into the core memory thru the card reader. The VALIDITY CHECK indicator on the card-reader operator panel lights when this character is read.



PUNCH CARD READER MX-4735/GSQ-72



PUNCH CARD READER CONTROL C-4639/GSQ-72

Figure 4-10 Punch Card Reader Set AN/GSQ-72

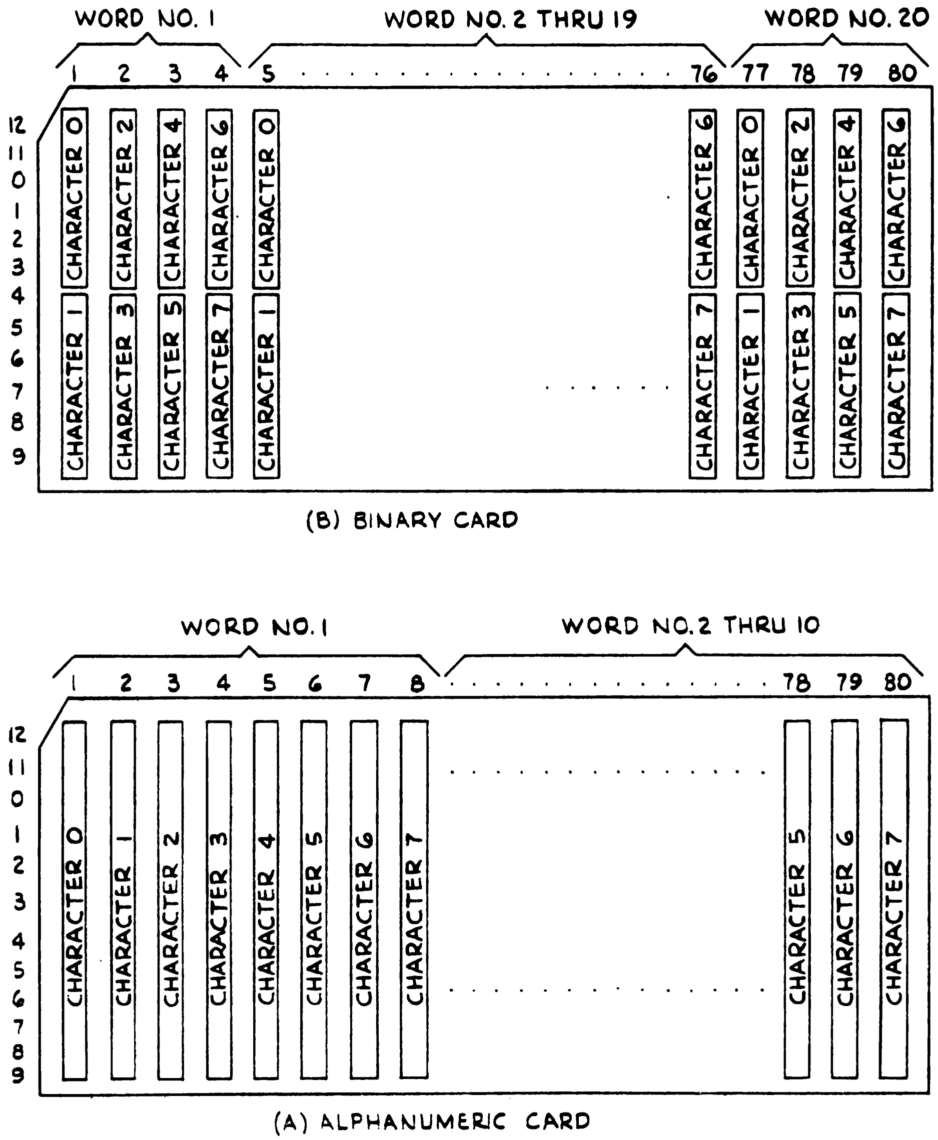


Figure 4-11 . Punch Card Format

The codes produced by the punch card reader set for the different alphanumeric characters are the standard DPS codes. The punch card codes, the DPS codes, and the corresponding "Flexowriter" unit and teleprinter characters are listed in appendix 3. The translation from the punch card code to the DPS code is performed in the card reader control.

BINARY CARD FORMAT.

When the punch card reader set is operated in the binary mode, each of the 960 bit positions (80 columns by 12 rows) on each card represents a bit to be entered into memory. A hole represents a binary 1, and the absence of a hole represents a binary 0. Each column of a binary card (B, figure 4-11) represents one 12-bit syllable (two six-bit characters) of a core memory location. The significance of the bits in a column decreases from the top (row 12) edge to the bottom (row 9) edge. Each group of four columns forms a word in memory; the 80-column card in the binary format thus contains 20 memory words. The 200-card-per-minute rate of the card reader set represents a speed of 4000 words per minute for binary cards.

In the binary read mode, control signals from the card reader control enable the card reader decoding network to first sense the top six rows of a column and then the bottom six rows of the same column. The validity-check circuitry in the card reader is disabled in the binary mode so that all characters are sensed as valid.

4-143. Since there is no parity code punched in the cards, the information read by the punch card reader set is not checked for correct parity. Data verification, such as the inclusion of check-sum, data format, and data reasonableness routines, must be done thru the use of computer programs.

CARD READER OPERATION.

There is only one instruction code for an input operation in which the punch card reader set is used. This instruction code, contained in a command descriptor, is shown in appendix 4. The instruction code, which consists of the value 0162 (octal) in bits 37 thru 48 of the command descriptor, designates the following: Read N cards from the card reader starting at the core memory location specified in the memory address field. Information punched in the cards is interpreted either as binary or alphanumeric, depending on the position of the BINARY ALPHANUMERIC switch in the card reader control. In the alphanumeric mode, each character will be checked for validity as the cards are read. When the BINARY ALPHANUMERIC switch is set to position BINARY, 20 words are read from each card, with the possible exception of the last card read; when the switch is set to position ALPHANUMERIC, 10 words are read from each card, also with the possible exception of the last card read. A binary-mode read operation requires approximately 15 milliseconds per word; an alphanumeric-mode read operation requires approximately 30 milliseconds per word.

If the word count field of the command descriptor is not an integral multiple of 20 for binary cards or of 10 for alphanumeric cards, the last card will not be read completely. In the result descriptor of a card reader operation, there is no indication that only part of the last card was read into memory. After the termination of a card reader operation, the card reader will not be available for use for approximately 200 milliseconds (maximum). If a card reader operation is initiated during this time, a unit-not-available-status occurs in the I/O status field of the in-process descriptor returned following the command descriptor.

CARD READER STATUS CODES.

There are three terminating status codes that can appear in the device status field (bits 20, 37, and 38) of a result descriptor for a card reader operation. These status codes are as follows:

a. 010: end of file.

b. 011: card reader error (malfunction).

c. 110: no access to memory (data too slow).

END-OF-FILE STATUS.

The end-of-file status code (010) will be generated by the card reader control whenever the input hopper becomes empty during a card reader operation. However, this status code is not sent to the I/O module immediately upon detection because the input hopper becomes empty before all the information on the last card has been read. The end-of-file status is not indicated until after the last card cycle is complete; therefore, if the normal completion of a card reader operation occurs on the last card in the input hopper, a normal word-count-equal-to-0 status in the I/O module will terminate the operation before the end-of-file status can do so. The end-of-file status terminates the operation when the word-count field of the command descriptor contains a count that is either greater than 10 times the number of cards read during an alphanumeric-mode operation or greater than 20 times the number of cards read during a binary-mode operation. Whenever the end-of-file condition occurs, the NOT READY and END OF FILE indicators on the operator panel of the card reader light; the END OF FILE indicator remains lit until additional cards are placed in the input hopper.

CARD READER ERROR STATUS.

The card reader error (malfunction) status code (011) is indicated for a read-check error, a feed-check error, or for any other condition that will produce the not-ready state in the card reader. A read-check error is signaled by an out-of-tolerance condition in the exciter lamps, solar cells, or photoamplifiers, all of which are monitored by read-check circuitry in the card reader prior to and after each card read cycle. The READ CHECK and NOT READY indicators on the operator panel of the card reader light when this condition occurs; the READ CHECK indicator is extinguished by pressing the RESET push button. A feed-check error is detected by feed-check circuitry in the card reader whenever a card fails to feed or when a card gets jammed (card is fed but fails to clear the read station). The FEED CHECK and NOT READY indicators on the operator panel of the card reader light when this condition occurs; the FEED CHECK indicator is extinguished by pressing the RESET push button. In addition, the not-ready state in the card reader is indicated when the stacker is full and when the STOP push button is pressed.

NO-ACCESS-TO-MEMORY STATUS.

The no-access-to-memory (data too slow) status code (110) is indicated whenever the I/O module does not respond to a character strobe (from the card reader control) by sending a character request for the next character within approximately 2 or 3 microseconds. The most likely cause for this error condition is that the I/O module did not obtain fast enough access to the desired memory module during the I/O-to-memory input data transfer. A no-access-to-memory condition in an I/O module should never cause the data-too-slow status in the 200-card-per-minute card reader, however, because of its slow speed. The first two characters of the next word must be transferred to the I/O module before a character request to the device can be held up due to a no-access-to-memory condition; during the time it takes to transfer these two characters by use of the 200-card-per-minute card reader, the no-access-to-memory status in the I/O module status field would have terminated the operation.

GENERAL.

The Teleprinter TT-490/GGC-14 (teleprinter) is a high-speed, one-way, output terminal device that is used to furnish a hard-copy printout of program results and/or program instructions to the operator. The teleprinter, which is illustrated in figure 4-36, operates at a rate of 600 lines per minute, with a maximum of 120 characters (including both printable characters and spaces) contained in each line.

GENERAL DESCRIPTION.

For the purposes of this discussion, the core memory, the print drum, and the code wheel can be considered as the major functional areas of the teleprinter. The core memory is used for temporary storage of 15 words of input data (120 characters), which are sufficient to enable one line of information to be printed out. The core memory is divided into two sections: All even-numbered input characters are stored in one section, and all odd-numbered input characters are stored in the other section. The print drum is physically divided into six sections, each of which contains 20 columns of engraved characters. The engraved characters are equally spaced in 64 row positions on the periphery of the print drum. The engraved characters in the columns are physically arranged so that the same character in each column is in the print position at approximately the same time; thus a row of 120 identical characters is created. The rows of characters rotate over a row of print hammers that are actuated by means of solenoids. Each column of characters corresponds to a particular character location in the core memory.

The code wheel, which is mounted on and rotates with the shaft of the print drum, is used to control the character print sequence. The code wheel is divided into 64 equally-spaced segments, which correspond to the 64 print drum characters. Each segment contains a series of holes thru which light is permitted to pass for the purpose of energizing photodiodes; in this way, a binary code that corresponds to the particular character (row) that is in the print position is generated. This character code is compared with the contents of each location in the core memory. Whenever the specified character is found to be contained in a specific core memory location, the print hammer that corresponds to the particular memory location is actuated and the character is printed in that column. In addition, the memory location that contains the specified character is cleared. When the code wheel, together with the print drum, has completed one revolution, a complete line of information (up to 120 characters) will have been printed. Since the wheel rotates at a speed of 600 revolutions per minute (plus or minus five percent), 600 lines (plus or minus five percent) of data can be printed in that time.

TELEPRINTER CHARACTER CODES.

The Teleprinter recognizes 64 different six-bit character codes: 63 printable characters and a space character. However, 16 of the 63 printable character codes cause the same character ("o") to be printed. The teleprinter character codes are listed in appendix 3.

TELEPRINTER OPERATIONS.

The teleprinter has the capability of performing six different types of output operations. All teleprinter output operations are initiated by a command descriptor that contains a device number of 14 (8) in bit positions 39 thru 44. This six teleprinter output operations and the corresponding code (bits 46, 47, and 48 of the command descriptor) for each operation are as follows:

a. 000: Print one line and single space.

b. 001: Print one line and double space.

c. 010: Print one line and advance to top of form.

d. 100: Print one line, single space, and alarm.

e. 101: Print one line, double space, and alarm.

f. 110: Print one line, advance to top of form, and alarm.

In order to print a complete line (120 characters) of data, the word count portion (bits 1 thru 12) of the command descriptor should contain a count of 0017 (8). Approximately 1.6 milliseconds is required to transfer 15 words to the teleprinter; after the 15th word has been transferred the teleprinter is functionally disconnected from the I/O module. If a word count greater than 0017 is specified, the additional words are not accepted by the teleprinter since the core memory of the teleprinter has a capacity of only 15 words. In addition, the print operation does not occur until the I/O module has attempted to transmit the final word to the teleprinter, and the operation is not terminated until the word counter in the I/O module has been counted down to 0. A word count of less than 0017 may be specified if less than a complete line of data is to be printed. In this case, the total number of words specified by the command descriptor is

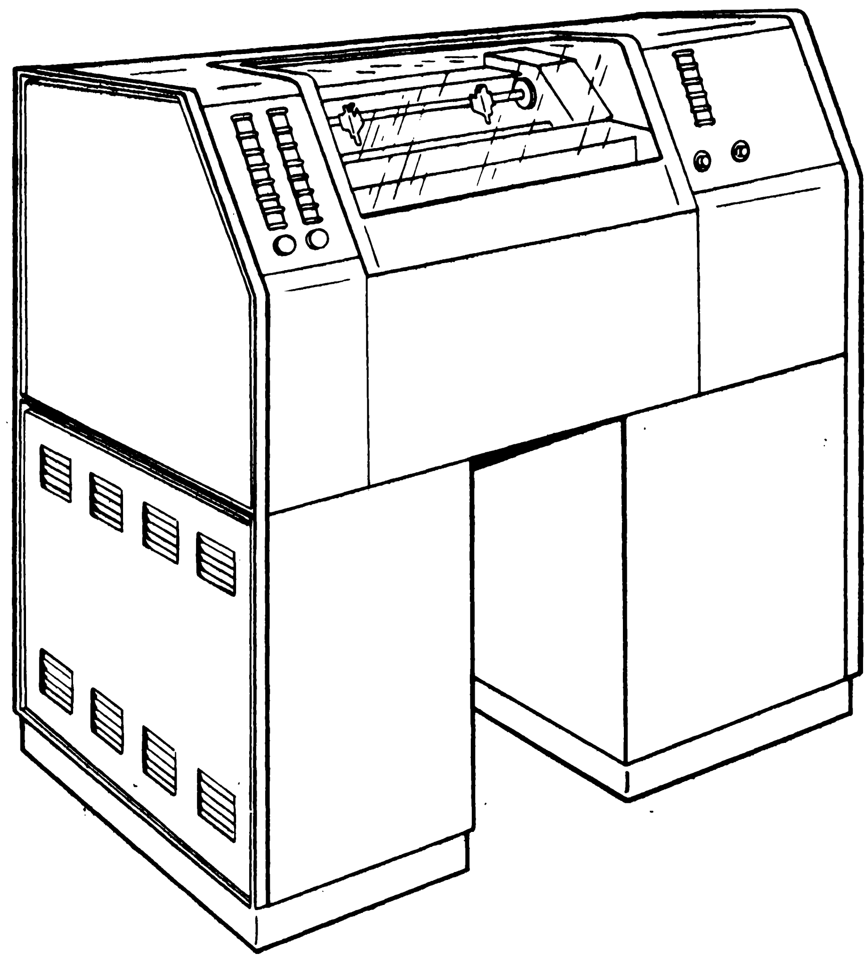


Figure 4-36. Teleprinter TT-490/GGC-14

printed at the left end of the line, and space characters are supplied for the remainder of the line by means of logic circuitry within the teleprinter. It should be noted that after a line has been printed on the teleprinter, it is necessary to advance the form between seven and 11 lines before the printed data can be seen. During each teleprinter output operation, the print operation occurs before the form-advance operation (single space, double space, or advance to top of form). If the form is to be advanced without performing a print operation, the command descriptor should contain a word count of 1 and the memory location specified by the memory address portion of the command descriptor must contain eight space characters (60's). When any one of the alarm commands is transmitted to the teleprinter, the PRINTOUT ALARM indicator on the teleprinter lights and the audible alarm in the teleprinter sounds. The indicator and the alarm must be turned off by the operator, since these functions cannot be reset under program control. After any print operation has been performed, the teleprinter is unavailable for program use for approximately 80 milliseconds. Therefore, in order to maintain the maximum teleprinter print rate (100 lines per minute), the program in control must execute a teleprinter command within 20 milliseconds after the teleprinter becomes available. However, even if the program in control executes a print command immediately after the teleprinter becomes available, the maximum rate of the teleprinter cannot exceed 600 lines per minute (plus or minus five percent) since this rate is determined by the rotation rate of the code wheel (refer to paragraph 4-370). It should be noted that when the form is advanced without a print operation (as described previously), the teleprinter will be unavailable for only approximately 40 milliseconds.

TELEPRINTER STATUS CODES.

The malfunction status code of 010 is the only status code that can be returned in the device status field (bits 20, 37, and 38) of a result descriptor in a teleprinter operation. This status is generated if a parity error is detected in one of the characters received by the teleprinter.

GENERAL.

The Typewriter-Punch-Reader Set AN/GYQ-12 (typewriter-punch-reader set) is a two-way (input-output) terminal device that is used for operator-program communications. As an input device it furnishes a keyboard and a paper tape reader which enable the operator to enter information or instructions for the program. As an output device it can be used to provide a hard copy of program results or instructions to the operator. The typewriter-punch-reader set, which is illustrated in figure 4-8, comprises the Tape Typewriter-Punch-Reader TT-534/GYQ-12 ("Flexowriter" unit) and the Typewriter-Punch-Reader Control CP-7119/GYQ-12 ("Flexowriter" control). The information in this section is presented under the following headings:

a. General description.

b. Keyboard character codes.

c. Paper tape format.

d. "Flexowriter" operations.

e. "Flexowriter" status codes.

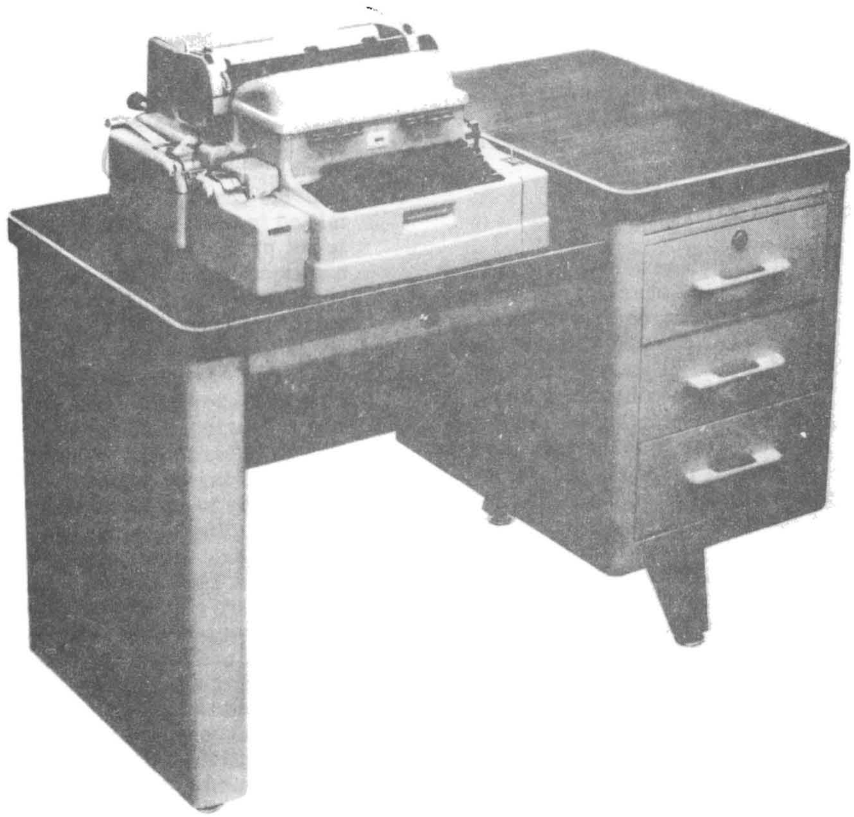
GENERAL DESCRIPTION.

The "Flexowriter" unit is an electromechanical typewriting component that can be used to provide a hard-copy record of information exchanged between the operator and the program. The "Flexowriter" unit is provided with an external request line to the data processing set so that operator requests for entering information can be recognized by the program in operation. The "Flexowriter" unit includes a slow-speed, paper-tape reader and paper-tape punch in addition to the typewriter printer, which is the major assembly of the unit. When either the tape reader or the tape punch (or both) is in use, it operates concurrently with the typewriter printer. However, the tape reader and the tape punch can only be run at the discretion of the operator since their operation cannot be controlled by program. The tape reader can be used during input operations, and the tape punch can be used during both input and output operations. During input operations the tape punch is normally used to duplicate information already contained on paper tape. The operating speed of the "Flexowriter" unit is approximately 10 characters per second when information is being read from the tape reader or is being printed under program control. Carriage return characters and automatic carriage returns take considerably longer and vary between 0.2 and 1.0 second. The operating characteristics of the "Flexowriter" unit are listed in table 4-1.

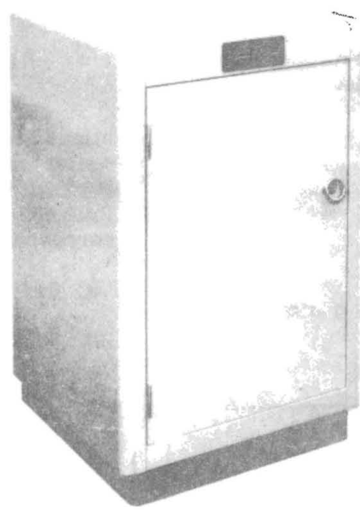
Table 4-1. Operating Characteristics of "Flexowriter" Unit

Feature	Capability or Limitation
Automatic reading or writing speed	10 characters per second
Character codes	61 printable characters plus codes for space, carriage return, delete, and blank
Keyboard	43 printing keys, five non-printing keys, and one space bar
Carriage return time	0.2 second to 1 second
Online operations	a. Generate external request b. Data read from keyboard or I/O module and printed c. Data read from keyboard or I/O module, printed, and punched on tape d. Data read from paper-tape reader and printed e. Data read from paper-tape reader, printed, and punched on tape
Off-line operations	a. Data printed from keyboard b. Data printed and punched from keyboard c. Data printed from paper-tape reader d. Data printed and punched from paper-tape reader
Character code format	Six data bits and one parity bit (P-BA 8421)

The "Flexowriter" control provides the logic conversion and control signals necessary for operating the "Flexowriter" unit with the I/O modules of the data processing set. The "Flexowriter" control receives data from either the I/O module (during



TAPE TYPEWRITER-PUNCH-READER
TT-534/GYQ-12 AND DESK



TYPEWRITER-PUNCH-READER CONTROL
CP-7119/GYQ-12

Figure 4-8. Typewriter-Punch-Reader Set AN/GYQ-12 output operations) or the "Flexowriter" unit (during input operations), converts this information to the operating levels of the unit (either the "Flexowriter" unit or the I/O module) which is to receive the data, and furnishes the proper control and timing necessary to maintain a proper sequence of operation between the two units.

KEYBOARD CHARACTER CODES.

The "Flexowriter" unit provides 64 different character codes: 61 printable characters and space, carriage return, and delete characters, which are used for control purposes. The use of these characters is implemented on the "Flexowriter" keyboard by 43 printing keys, five nonprinting keys, and a space bar. Eighteen of the printing keys contain two characters; one character is selected when the type basket is in the normal position, and one is selected when the type basket is in the shift position. This positioning of the type basket is controlled by the NORM and SHIFT keys. Two other nonprinting keys, CAR RET and DEL, are used to generate the carriage return and the delete characters respectively. The fifth nonprinting key (BLANK) produces a 65th character code used for control purposes, even though it has incorrect parity. The keyboard character codes are listed in appendix 3.

PAPER-TAPE FORMAT.

The paper tape used for the paper-tape punch and reader on the "Flexowriter" unit is a seven-track paper tape with a sprocket hole in each character between the third and fourth track. (See figure 4-9.) The tracks are designated P, B, A, 8, 4, 2, and 1. The character codes punched are those indicated in appendix 3. Figure 4-9 illustrates the paper-tape format. A DELETE CODE lever on the "Flexowriter" unit is used to initiate continuous punching of the delete code in the paper tape; thus, areas of the tape that have been punched incorrectly can be skipped.

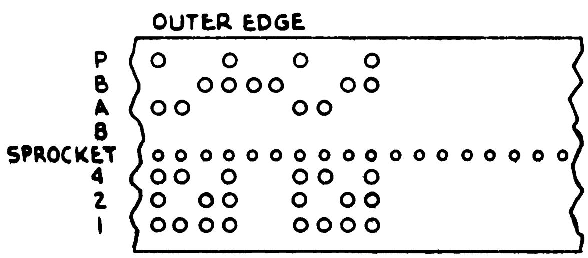


Figure 4-9. "Flexowriter" Paper-Tape Format

"FLEXOWRITER" OPERATING MODES.

The typewriter-punch-reader set can be operated in either of two modes: binary or alphanumeric. The operating mode is selected by means of the ALPHA-BINARY switch, which is located in the "Flexowriter" control. The bit codes that correspond to the 64 "Flexowriter" characters are the same regardless of the operating mode, as is the processing of all 61 printable characters. However, the processing of the three nonprintable characters (blank, delete, and carriage return) varies depending upon the operating mode. During binary mode read operations all valid character codes, except the character code for a blank, can be transmitted to the I/O module (the blank character code is not processed by the "Flexowriter" control). In addition, if two consecutive blank characters are read either from paper tape or from the typewriter printer, the "Flexowriter" control generates end-of-record status code (001) and thus terminates the operation. During binary-mode write operations, all 64 "Flexowriter" character codes are considered valid. During alpha-numeric-mode read operations, all valid character codes except the character code for delete can be transmitted to the I/O module (the delete code is not processed by the "Flexowriter" control). End-of-record status is generated during alphanumeric-mode read operations when either two successive blank characters or two successive carriage return characters are read either from paper tape or from the typewriter-printer. It should be noted that neither of the two consecutive blank characters that create the end-of-record condition are transmitted to the I/O module and that only the first of the two consecutive carriage return characters is transmitted to the I/O module. During alphanumeric-mode write operations, delete characters are processed as valid characters by the "Flexowriter" control but are not typed on the typewriter-printer, nor are they punched on paper tape (if the paper-tape punch is in operation). The delete characters are skipped over at high speed by the "Flexowriter" control; during alphanumeric-mode write operations each delete character is processed in less than 3 microseconds.

READ OPERATIONS.

There are three different types of read operations that can be performed thru use of the "Flexowriter" unit. The instructions that are executed to perform each of these operations and the bit codes (bits 46, 47, and 48 of the command descriptor) that correspond to each operation are as follows:

a. 011: Read words.

b. 001: Read and unlock keyboard.

c. 010: Read and lock keyboard.

The read-and-unlock-keyboard command and read-and-lock-keyboard command are used to implement a read-by-characters function in which only a single character is read from the "Flexowriter" unit (from the typewriter-printer or from paper tape) before the operation is terminated. This method of operation is normally used when it is not feasible to permit the I/O module to remain in the active-busy state for long periods of time. When a read-words command is executed, the I/O module remains active-busy until the entire block of input data has been read from the "Flexowriter" unit. In addition, once the read-words command is executed, the entering of input data is generally under complete control of the operator. However, when the read-by-characters function is employed by the program, the I/O module remains active-busy only for the length of time needed to receive one character from the "Flexowriter" control (approximately 5 microseconds). In addition, the "Flexowriter" operation can be terminated under program control (by the issuance of a read-and-lock keyboard command) at any time without loss of data. The first in a series of read-and-unlock operations need not be performed in response to an external request from the "Flexowriter" unit, although this is generally the case. However, all subsequent read-and-unlock commands that are executed during the read-by-characters operation must be performed only in response to an external request from the "Flexowriter" unit. Any input-output operation can be terminated under program control by a release descriptor; however, if a read-and-unlock keyboard operation is terminated in this manner, a data character may be left in the control buffer of the "Flexowriter" control.

READ WORDS OPERATION.

The "Flexowriter" read words (read) operation is initiated by a command descriptor that contains a device operation code of 0033 (octal) in bit positions 37 thru 48 (see appendix 4). The word count in this descriptor is normally specified in accordance with the size of the memory area in which information is to be written. A word consists of eight keyboard characters, each of which is translated into a six-bit character code. When information is to be read from the typewriter-printer (as opposed to the tape reader), the record count is normally specified as 0001 (octal) so that after the desired message has been entered, the operation can be terminated by the generation of an end-of-record status code (001). However, any number of records (up to a maximum of 16) may be specified for a "Flexowriter" read operation. In any case, the total number of words in all of the records cannot exceed the number of words specified in the word count (up to a maximum of 4096). The read operation is terminated when either the record count or the word count is counted down to 0.

When the read command descriptor is transmitted, the I/O module that receives the command will cause the ENTER indicator on the "Flexowriter" unit to light to inform the operator that data may now be entered into memory. At this point, information to be read into memory may either be typed by use of the keyboard or read from paper tape. If information is to be read from paper tape, the START READ switch on the "Flexowriter" unit is pressed. When information is read into the core memory by either means, the characters are also printed simultaneously on the "Flexowriter" unit. If desired, the information read into memory may also be punched on paper tape, in which case the PUNCH ON switch on the "Flexowriter" unit must be pressed. The read operation is normally terminated by the generation of end-of-record status code (refer to paragraph 4-119).

READ-AND-UNLOCK-KEYBOARD OPERATION.

The read-and-unlock-keyboard operation is initiated by a command descriptor that contains a device operation code of 0031 (octal) in bit locations 37 thru 48 (see appendix 4). This operation is normally performed in response to an external request from the "Flexowriter" unit. The word count in this descriptor is normally specified as 1; the record count must be specified as 1. When the read-and-unlock-keyboard instruction is executed, the ENTER indicator on the "Flexowriter" unit is lit, the typewriter-keyboard is unlocked, and if a character is contained in the output register of the "Flexowriter" control, that character is transferred to the I/O module. The ENTER indicator is lit to signal the operator to type a character, and the keyboard is unlocked to enable the operator to type a character. It should be noted that as soon as the operator types a character, the keyboard is again locked, and an external request is sent to the data processing set (refer to paragraph 4-115).

If a character is read from the "Flexowriter" control when the read-and-unlock-keyboard command is executed, the operation is terminated by the generation of character-read status (010) unless the character is the second of two successive carriage return characters (in the alphanumerical mode) or blank characters (in the alphanumeric mode or binary mode), in which case the operation is terminated by the generation of end-of-record status (001). The character that is transferred to the I/O module is stored in the least significant character position of the memory location specified by the command descriptor. The remaining seven characters of the memory word will contain delete characters (77's), the generation of which is a function of the I/O module. If there is no character contained in the output register of the "Flexowriter" control when the read-and-unlock-keyboard command is executed, the ENTER indicator is lit and the keyboard is unlocked; however, the operation is terminated by the generation of the no-character status code (100). If a series of read-and-unlock-keyboard operations is performed in which the descriptor word count and record count are as specified and if the series of operations is terminated by the generation of end-of-record status, all result descriptors except the final result descriptor will contain a word count of 0 and a record count of 1, and the memory address portion will be increased by 1. The final result descriptor will contain a word count of 1 and a record count of 0, and the memory address portion of the result descriptor will be the same as in the command descriptor. The entire read-and-unlock-keyboard operation, from the execution of the command descriptor to the storing of the result descriptor in core memory, takes approximately 25 microseconds.

READ-AND-LOCK-KEYBOARD OPERATION.

The read-and-lock-keyboard operation is initiated by a command descriptor that contains a device operation code of 0032 (octal) in bit locations 37 thru 48 (see appendix 4). This operation is normally used to terminate a "Flexowriter" read-by-characters operation. The word count in this descriptor is normally specified as 1; the record count must be specified as 1. When the read-and-lock-keyboard command is executed, the keyboard is locked, and if there is a character in the output register of the "Flexowriter" control, that character is transferred to the I/O module. If a character is transferred to the I/O module, the operation is terminated by the generation of a character-read status code (010), unless the character is the second of two successive blanks or carriage returns. In that case, the operation is terminated by the generation of an end-of-record status code (001). If there is no character contained in the output register of the "Flexowriter" control when this command is executed, the operation is terminated by the generation of a no-character status code (04). It should be noted that the execution of a read-and-lock-keyboard command does not cause the ENTER indicator to light.

Since the keyboard does not lock at once when a read-and-lock-keyboard command is executed, it is possible for a character to be typed or read from paper tape after the command has been executed but before the keyboard has been locked. Therefore, it is recommended that a second read-and-lock-keyboard command be executed at least 100 milliseconds after the first command is executed to ensure that all characters have been read. This will also ensure that if a subsequent read-and-unlock-keyboard command is executed in response to an external request from the "Flexowriter" unit, that operation will be terminated by the generation of a no-character status code. The entire read-and-lock-keyboard operation, from the execution of the command descriptor to the storing of the result descriptor in core memory, requires approximately 30 microseconds.

WRITE OPERATION.

A "Flexowriter" write operation is initiated by a command descriptor which contains an operation code of 0010 (octal) in bit locations 37 thru 48 (see appendix 4). The write operation is initiated by the program to print out the contents of a memory area. This operation begins at the memory starting address contained in the command descriptor and continues for the number of words specified in the word count. The normal completion of the operation occurs when the specified number of words have been printed and the word count has been reduced to 0. However, if a write operation is attempted when the keyboard of the "Flexowriter" unit is unlocked, no data will be written, and the operation will be terminated by the generation of no-character status (100). The information written on the "Flexowriter" unit may also be simultaneously punched on paper tape. To exercise this option the PUNCH ON switch must be pressed before the write operation begins. It should be noted that a write-by-characters function that is similar to the read-by-characters function can be implemented. This function is accomplished by executing a series of one-word write commands in which the word that is sent to the "Flexowriter" unit contains one valid character and seven delete characters. The valid character must be the least significant character in the memory word. The seven delete characters will be passed over rapidly by the "Flexowriter" control, the valid character will be typed, and the operation will be terminated by word-count-equal-to-0 status. This method of operation offers the same advantages as the read-by-characters function; however, one command descriptor is required for each character to be written. A "Flexowriter" write operation requires approximately 100 milliseconds for each character that is transferred to the "Flexowriter" unit, except for delete characters, which require less than 3 microseconds, and carriage return characters, which require between 200 milliseconds and 1 second.

DELAY REQUIREMENTS.

A delay period is needed between the end of a "Flexowriter" read-words or write operation and the transmission of another "Flexowriter" command descriptor (the read-and-unlock-keyboard and read-and-lock-keyboard commands are normally executed only in response to an external request from the "Flexowriter" unit). The delay is necessary because the printing mechanism must complete its cycle before a new operation can begin. After the end of a write operation, the "Flexowriter" unit will not be available for up to 150 milliseconds; after a read-words operation, the "Flexowriter" unit will not be available for up to 100 milliseconds. If a "Flexowriter" operation is initiated during this time, a unit-not-available status will occur in the in-process descriptor that is returned to memory following the command descriptor.

"FLEXOWRITER" OFF-LINE OPERATIONS.

The "Flexowriter" unit may be placed off-line by pressing the OFF-LINE switch on the "Flexowriter" unit. When the unit is off-line, the off-line operations listed in table 4-1 may be performed.

EXTERNAL REQUEST CAPABILITY.

As stated in paragraph 4-87, the "Flexowriter" unit is provided with an external request line to the data processing set. The external request signal is generated (the line goes high) when the "Flexowriter" unit is online and the ENTER REQUEST switch is pressed, unless the "Flexowriter" unit is currently engaged in a read operation. It is in this manner that the operator can signal the program in operation that a message is to be entered via the "Flexowriter" unit. If the external request is generated in this manner, the line remains high until a "Flexowriter" read operation is initiated or until the "Flexowriter" unit is placed off line.

The external request signal is also generated when the operator types a character or when a character is read from paper tape after a read-and-unlock-keyboard command has been executed. When the external request is generated in this manner, the line remains high; however, the keyboard does not lock for 100 milliseconds after the external request is generated. The program in control should respond to the external request within 100 milliseconds in order to reduce excessive wear on the locking mechanism and/or the paper-tape reader.

"FLEXOWRITER" STATUS CODES.

There are six terminating status codes that can appear in the device status field (bits 20, 37, and 38) of a result descriptor in a "Flexowriter" operation. These status codes are as follows:

a. 001: end of record.

b. 010: character read.

c. 100: no character.

d. 110: off line.

e. 111: parity error.

END OF RECORD.

The end-of-record status code (001) is generated under the following conditions:

a. If two successive blank characters are typed or read from paper tape during either binary or alphanumeric-mode read operations.

b. If two successive carriage-return characters are typed or read from paper tape during an alphanumeric-mode read operation.

CHARACTER READ.

The character-read status code (010) is generated if a character is contained in the output register of the "Flexowriter" control when a read-and-unlock-keyboard or read-and-lock-keyboard command is executed.

NO CHARACTER.

The no-character status code (100) is generated under the following conditions:

a. If there is no character contained in the output of the "Flexowriter" control when a read-and-unlock-keyboard or a read-and-lock-keyboard command is executed.

b. If a "Flexowriter" write operation is attempted while a read-by-characters operation is being performed.

OFF LINE.

The off-line status code (110) is generated if the OFF LINE switch is pressed while a "Flexowriter" read or write operation is being performed.

PARITY ERROR.

The parity-error status code (111) is generated if an isolated blank character is detected during a read operation or if a character with even parity is received from the I/O module during a write operation.

GENERAL.

The Magnetic Tape Recorder-Reproducer Set AN/GSH-22 (magnetic tape recorder-reproducer set) is a two-way (input-output) terminal device that is used for bulk storage of large quantities of program information and statistical data. This equipment, which is illustrated in figure 4-12, consists of four Magnetic Tape Recorder-Reproducer RD-300/GSH-22 units (magnetic tape units) and one Recorder-Reproducer Control C-4637/GSH-12 (magnetic tape control). The magnetic tape control is capable of controlling up to six magnetic tape units. The magnetic tape recorder-reproducer set performs 14 different operations: seven variations of the basic read operation and seven variations of the basic write operation. Operating characteristics of this equipment are listed in table 4-2.

The information in this section is presented under the following headings:

a. General description.

b. Magnetic tape format.

c. Magnetic tape operations.

d. Magnetic tape status codes.

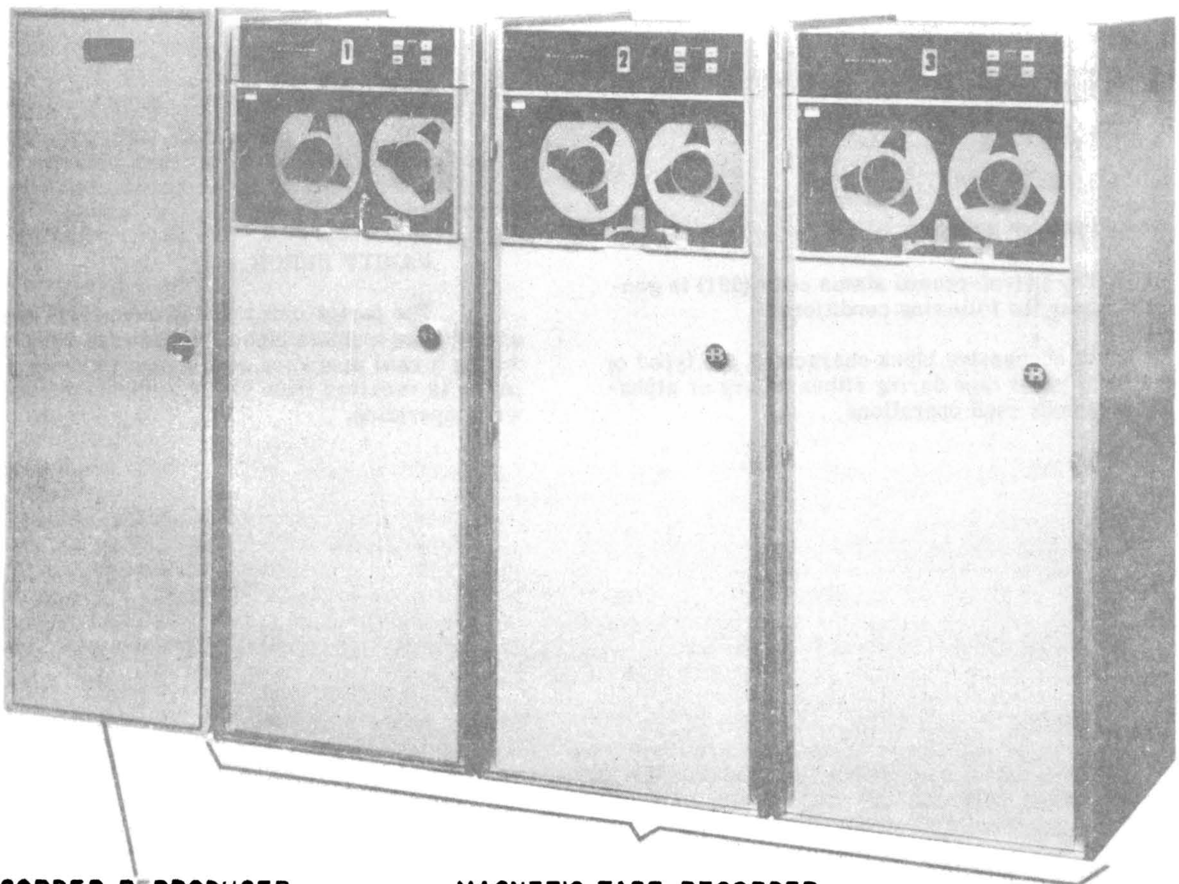


Figure 4-12. Magnetic Tape Recorder-Reproducer Set AN/GSH-22

Table 4-2. Operating Characteristics of Magnetic Tape Recorder-Reproducer Set AN/GSH-22

Feature	Capability or Limitation
Storage capacity	Up to 15,000,000 characters per 2460-foot reel of tape
Speed of tape movement (forward direction)	120 inches per second
Rewind speed (reverse direction)	375 inches per second (80 seconds per 2460-foot reel of tape)
Character transfer rate	66,700 characters per second
Tape packing density	555.5 characters per inch
Types of operations	Read, write, advance, backspace, rewind and erase
Parity checks	Lateral: odd Longitudinal: even
Tape width	0.5 inch
Tape thickness	2.0 mils
Operating environment	The operating environment must be free from excessive radiation and excessive magnetic fields.

GENERAL DESCRIPTION.

The magnetic tape units perform read, write, advance, backspace, rewind, and erase operations under the control of the magnetic tape control. Under local control, the magnetic tape units can perform rewind, backspace, advance, load, and unload operations.

The tape supply (or file) reel is mounted on the right reel-hub assembly, and the tape takeup reel is mounted on the left reel-hub assembly. During a read or write operation, the tape travels over guides and thru vacuum columns from the tape supply reel past the read-write head assembly and onto the tape takeup reel. During a rewind or backspace operation, this motion is reversed. Information is written on the tape or is read from the tape as it passes thru the read-write head assembly. The recording method used is the nonreturn-to-0 method; that is, a 1 bit is represented by a reversal of flux polarity in either direction. Only 1 bits are actually written on the tape. The 0 bits are indicated by the lack of flux change on the tape. The read head is positioned behind the write head so that information that is written on the tape can be read back and checked for parity. Information is written on the tape in groups of characters called records. The length of a record can vary between eight characters (one memory word) and 32,760 characters (4095 memory words); each character is made up of six information bits and one parity bit. Writing information on the tape and erasing information from the tape can only be accomplished by use of tape supply reels equipped with write rings. File protection is also provided by the rewind-and-lockout operation.

The magnetic tape control decodes operating instructions which it receives from an I/O module of the data processing set controls the flow of information to and from the magnetic tape units, and thereby implements the 14 tape operations. The magnetic tape control also provides the control signals required for operation with the I/O modules and performs the necessary conversion of logic signal levels. The magnetic tape control can control only one magnetic tape unit at a time. Therefore, when a tape operation is to be performed, the I/O module sends a tape control word to the magnetic tape control. The tape control word contains the number of the magnetic tape unit to be used and specifies whether a read or write operation is to be performed. The number of the magnetic tape unit can be selected or changed by changing the unit number on the front panel. The magnetic tape control also checks the parity of the data transferred between the magnetic tape unit and the I/O module and inserts the parity bit if necessary.

MAGNETIC TAPE FORMAT.

The information written on the magnetic tape is contained in seven information tracks (figure 4-13) formed on the tape by the seven write heads. The information tracks run longitudinally on the tape, whereas the characters run laterally. Each information track has a read head and a write head associated with it. Six of the tracks (BA8421) contain the six information bits of a character, and the seventh track (P) is used for the parity bit of the character. Odd parity is used for each character. A longitudinal parity character is written approximately four character lengths from the last character in each record. This character is formed by automatically writing a 1 bit on each tape track that has an odd number of bits for the length of the record. The longitudinal-parity character thus maintains an even bit count (even parity) in each track for the length of each record. Both lateral and longitudinal parity checks are made whenever a record is being read from or written on a tape.

The records shown in figure 4-13 are the shortest possible records (one word). The inter-record gap, which is automatically written between the records, consists of approximately 3/4 inch of blank tape that is relatively free from flaws. A flaw exists when a flux change is detected on a tape area that should be blank. An end-of-file record, which consists of an information character followed by a longitudinal-parity character, is written on the tape to separate two groups of records. This one-character record is preceded by a gap of at least 3.7 inches. Both of the characters contain 1 bits in information tracks 1, 2, 4, and 8 and 0 bits in tracks A, B, and P.

Two physical markers are used on the tape. These markers, which are sensed by tape sensors, are coded aluminum strips, approximately 1 inch in length and 3/16 inch in width. They are used to indicate the electrical beginning and end of the tape and to indicate the unload point on the tape. The beginning-of-tape (BOT) marker, which is also referred to as the load point, is positioned between 10 and 11 feet from the physical beginning of the tape. As the tape moves over the read-write head, the BOT marker is placed 1/32 inch from the edge of the tape that is nearest to the door. The end-of-tape (EOT) marker is positioned between 13 and 14 feet from the physical end of the tape. The EOT marker is placed 1/32 inch from the edge of the tape that is nearest to the casting.

Two tape leaders are used with the tape: the female leader and the male leader. The female leader is constructed of magnetic tape and is attached to the tape take-up reel. The length of the female leader is approximately 14 feet, 8 inches. An aluminum marker is attached to the female leader. This marker strip is used for the unload operation and is positioned in a manner which allows it to be sensed by the end-of-tape sensor. This unload marker is positioned 63 inches from the latch end of the leader. The male leader is 6 inches in length and is spliced to the tape. This leader is constructed of nonmagnetic, black, "Mylar" film.

MAGNETIC TAPE OPERATIONS.

Every operation performed by the magnetic tape recorder-reproducer set begins as a write-type of (output) operation. The command descriptor sent to the I/O modules from the memory modules will

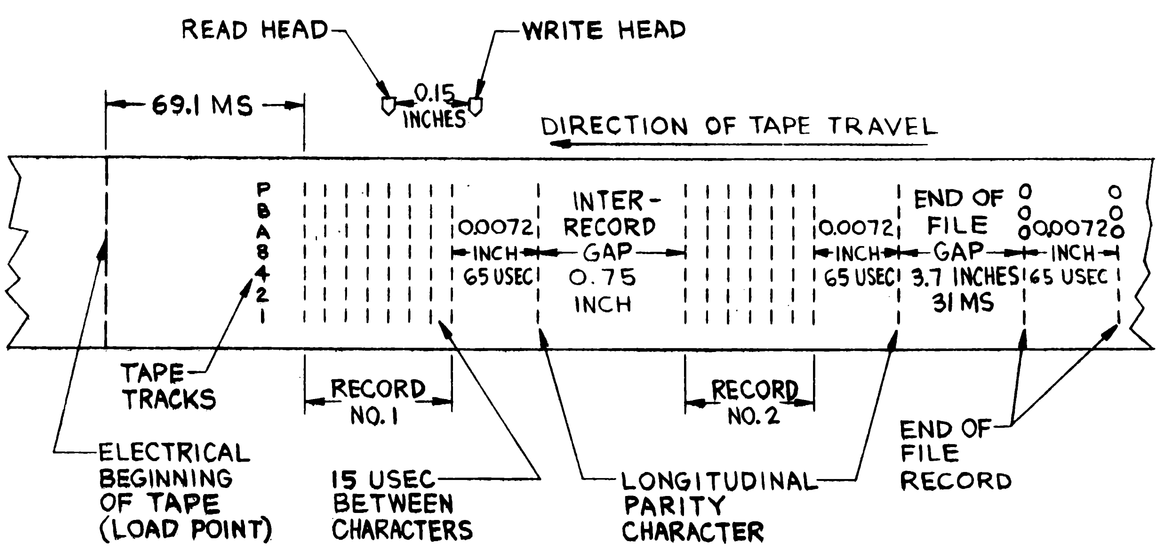


Figure 4-13. Magnetic Tape Format

always be a write type of instruction; that is, bit 44 of the command descriptor will always be a 0. The write operation is necessary to transfer the tape control word to the magnetic tape control. This word designates the magnetic tape unit to be used and the type of operation (read or write) to be performed. The following rules apply to the formation of a command descriptor for a tape operation:

a. The word and record count portions, bits 1 thru 12 and 13 thru 16, will be equal to 0, 1, 2, or a specified count, depending on the tape operation. (Refer to appendix 4.)

b. The memory-starting-address protion, bits 21 thru 36, must contain the address of a tape control word, which is always the first word of the block of memory locations specified by the descriptor.

c. The device number portion, bits 39 thru 43, always contains the number of the magnetic tape control.

d. The operation type portion, bits 44 and 45, is always equal to 01 (write operation with a two-way device).

e. The operation code portion, bits 46 thru 48, contains one of seven three-bit codes. This code indicates the tape operation to be performed.

Only the first character of the tape control word is used. The first three bits of this character specify either a read or write operation, and the other three bits contain the number of the magnetic tape unit. The format of this character (character 0) is shown in figure 4-14.

The three-bit operation code in the command descriptor is transferred as an instruction code to the magnetic tape control along with the tape control word. The seven different bit codes possible in these three bits specify seven instructions for the basic write operation indicated by a write tape control word and seven instructions for the basic read operation indicated by a read tape control word. Each of these 14 tape instructions is discussed. Delay requirements regarding magnetic tape operations are then described.

CHARACTER 0

	1	2	3	4	5	6	
TAPE CONTROL WORD	1	2	3	4	5	6	
WRITE COMMAND	1	1	1	X	X	X	(REMAINDER OF
READ COMMAND	0	0	0	X	X	X	TAPE CONTROL
TAPE UNIT 1	X	X	X	0	0	1	WORD NOT USED)
TAPE UNIT 2	X	X	X	0	1	0	
TAPE UNIT 3	X	X	X	0	1	1	
TAPE UNIT 4	X	X	X	1	0	0	
TAPE UNIT 5	X	X	X	1	0	1	
TAPE UNIT 6	X	X	X	1	1	0	

Figure 4-14. Magnetic Tape Control Word

WRITE TYPE OF INSTRUCTIONS.

The write type of instructions are indicated by a write tape control word; these instructions and the bit codes (bits 46, 47, and 48 of the command descriptor) which correspond to them are as follows:

a. 001: rewind.

b. 010: test.

c. 011: write one record.

d. 100: write end of file.

e. 101: rewind and lockout.

f. 110: erase.

g. 111: write multirecords.

For all write type of operations, a word count of at least 0002 (octal) must be specified in the command descriptor; otherwise, the operation is terminated by the word-count-equal-to-0 I/O status, and the operation is not completed successfully. If an actual write operation (operation codes 010, 011, 100, and 111) is terminated by the end-of-tape device status, the operation was not completed satisfactorily, but some part of the record may have been written on the tape. If information was to be written on the tape during this operation, an attempt should be made to write this information on another tape. Any of the write type of operations are terminated with the parity-error status code (111) in the device status field of the result descriptor if the tape control word is received with incorrect parity by the magnetic tape control.

REWIND. The operation code for the rewind instruction is 001. This instruction causes the tape to rewind at a speed of 375 inches per second. The tape stops when the load-point marker is sensed. As soon as the rewind operation is begun satisfactorily, a result descriptor which contains the end-of-tape status code (101) in the terminal device status field is returned. This status indicates that the rewind operation has begun satisfactorily. The magnetic tape unit remains unavailable until the tape has reached the load point, but the magnetic tape control is available for controlling one of the other magnetic tape units as soon as the end-of-tape status code is transmitted to the I/O module. Therefore, the total time required for initiating the rewind operation, from the execution of the command descriptor to the storing of the result descriptor in core memory, is between approximately 71 microseconds and 136 microseconds. If a magnetic tape unit is addressed while it is rewinding tape, the operation for which the magnetic tape unit was specified is terminated, and the abnormal condition status code (011) is placed in the terminal device status field of the result descriptor; the rewinding of the tape is not interrupted. The actual time required for rewinding the tape depends on the position of the tape when the rewind operation is initiated;

approximately 80 seconds are required for rewinding the full 2460-foot reel. The rewind operation should not be initiated following an actual write operation (operation codes 010, 011, 100, and 111) since, when this is done, only one half of the interrecord gap is produced. Flaws in the tape may be produced when subsequent write operations from this point on the tape are performed, and the new record that was written at this point will not be readable. If the tape must be rewound after an actual write operation, the rewind instruction should be preceded by an erase-one-word operation. If a rewind operation is terminated by the abnormal-condition status, the information on the tape being rewound may be destroyed. None of the other device status conditions can terminate the rewind operation except for the parity-error status code (111), which occurs in the event that the tape control word has incorrect parity when received by the magnetic tape control.

TEST. The operation code for the test instruction is 010. This instruction is only used for maintenance purposes and causes an operation to be performed which is similar to a write operation except that characters "E," "W," and "L" are control characters. The operation begins as a write operation; information is written normally until the first "E" character (010101) is transferred in the data being written. An erase operation now begins, and information on the tape is erased, even though information is still transferred to the magnetic tape control. Likewise, the operation will be changed back to a normal write operation by the first "W" character (110110) occurring thereafter, and the operation can be continually switched back and forth between write and erase by the placement of "E" and "W" characters in the data. If an "L" character (100011) is transferred during an erase operation, a longitudinal-parity check character is written. By use of this instruction, interrecord gaps of any size can be created, the placement of the longitudinal-parity character can be varied, flaws can be created in the tape, and an incorrect longitudinal-parity character can be written (by erasing, writing one character, and erasing).

The test operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. However, any of the device status conditions can result in termination of the test operation. The magnetic tape unit must not be in the erase mode when the word count is counted down to 0 (the last character of the last word must be written on the tape, or the tape transport will run away). In addition, at least the last 15 words must be written in order to check longitudinal parity. A longitudinal-parity character is automatically written at the end of the test instruction. During the erase mode of the test instruction, lateral parity is not checked.

WRITE ONE RECORD. The operation code for the write-one-record instruction is 011. This instruction causes one record of data to be written on the tape. After this record is written, a longitudinal-parity character is formed and written. The length of the record is determined by the word count specified in the command descriptor. A word count of 0000(8) is interpreted as 4096 words. The number of words written on the tape is always one less than the word count because of the transfer of the tape control word; thus the maximum number of words that can be written in one record is 4095. The write-one-record operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. Any of the other device status conditions except the end-of-file status can also terminate the operation. The parameters that must be considered when calculating the time required to perform a write-one-record operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 69.1 milliseconds.

c. Starting time when tape is not positioned at load point (C): 5.385 milliseconds.

d. Time required to write first word (D): 1.347 milliseconds to 1.49 milliseconds.

e. Time required to write each word after first word (E): 96 microseconds to 240 microseconds.

f. Termination time (F): 4.312 milliseconds.

g. Formula: A+(B or C)+D+(E times N-1)+F. (N denotes the number of words in the record.)

WRITE END OF FILE. The operation code for the write-end-of-file instruction is 100. This instruction causes the special end-of-file record to be written on the tape. The end-of-file record, which is used to indicate a separation of data records on the tape, consists of a one-character record followed by a longitudinal-parity character; both characters have a bit configuration of 0001111. The end-of-file operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. Any of the other device status conditions except the end-of-file status can also terminate the operation. The parameters that must be considered when calculating the time required to perform a write-end-of-file operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 69.1 milliseconds.

c. Starting time when tape is not positioned at load point (C): 27.9 milliseconds.

d. Time required to write end-of-file record (D): 1.262 milliseconds to 1.266 milliseconds.

e. Termination time (E): 4.32 milliseconds.

f. Formula: A+(B or C)+D+E.

REWIND AND LOCKOUT. The operation code for the rewind-and-lockout instruction is 101. This instruction causes a rewind operation to be performed; at the end of this operation the magnetic tape unit is placed in the lockout condition. The rewind portion of the rewind-and-lockout operation is the same as for the rewind operation.

When the magnetic tape unit is in the lockout condition, the tape is file protected, and the information on it cannot be altered, though it can be read. If an attempt to write on this magnetic tape unit is now initiated, the file-protect status from the device terminates the operation. If the unit number of the magnetic tape unit is altered at the front panel, however, access for writing on the magnetic tape unit can be obtained, provided the LCK flip-flop for the new unit designated is reset. The lockout condition for any of the magnetic tape units can be reset at the control panel of the magnetic tape control. The rewind-and-lockout operation provides electronic file protection that is separate from the file protection provided by the file-protect write rings. Therefore, this operation is normally used only in magnetic tape units equipped with write rings. The time required to perform the rewind-and-lockout operation is the same as that required for the rewind instruction

ERASE. The operation code for the erase instruction is 110. This instruction causes data to be erased on an area of tape of a length determined by the word count specified in the command descriptor. The erase operation is useful for skipping areas in the tape, such as areas containing flaws. Data are transferred from memory to I/O module and from I/O module to magnetic tape control, but the data are not written on the tape. The parity of the data is checked, however. The erase operation consists basically in writing 0's on the tape. The erase operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. During the erase operation, the tape is read following the actual erase function, and if a valid record is detected, the abnormal-condition status code from the device terminates the operation. This device status in the result descriptor for an erase operation thus indicates the presence of a flaw on the tape. This flaw cannot be erased or rejected (six-character flaw). Any status condition other than end-of-file status can terminate the erase operation. If a word count of greater than 256 is used in an erase operation, information on the tape is erased in records of 256 words, and an end-of-record gap is included in the erased area for each mod 256 count of the word count specified in the command descriptor. For example, if a word count of 4096 is used, information on the tape area for 4095 words (approximately 5 feet) plus the tape area for 15 end-of-record gaps (approximately 12 inches) is erased. The parameters that must be considered when calculating the time required to perform an erase operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 69.1 milliseconds.

c. Starting time when tape is not positioned at load point (C): 5.385 milliseconds.

d. Time required to erase first record (D): 96 microseconds to 240 microseconds per word.

e. Time required to erase each record after first record (E): 24.576 milliseconds to 61.440 milliseconds.

f. Time required to form interrecord gap (F): 5.312 milliseconds.

g. Termination time (G): 4.312.

h. Formula: A+(B or C)+D+[E times (N-1)] + [F times (N-1)] +G. (N denotes the number of records.)

WRITE MULTIRECORDS. The operation code for the write-multirecords instruction is 111. This instruction causes a group of records to be written on the tape; the number of records written is determined by the number of mod 256 counts that occur as the word count specified in the command descriptor is counted down to 0. Each time a mod 256 value is reached, the magnetic tape recorder-reproducer set is signaled by the I/O module, and and end-of-record marker is written on the tape. Therefore, each record will contain 256 words (with the possible exception of the very first record, which will contain the number of words between the original word count specified in the command descriptor and the first mod 256 value). The write-multirecords operation is normally terminated by the end-of-record status code (001) in the device status field of the result descriptor. Any of the other device status conditions except the end-of-file status can also terminate the write multirecords operation. The parameters that must be considered when calculating the time required to perform a write-multirecords operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 69.1 milliseconds.

c. Starting time when tape is not positioned at load point (C): 5.385 milliseconds.

d. Time required to write first record (D): 1.347 milliseconds to 1.49 milliseconds for the first word plus 96 microseconds to 240 microseconds for each word in excess of one word.

e. Time required to write each record after the first record (E): 25.827 milliseconds to 62.690 milliseconds.

f. Time required to form interrecord gap (F): 5.312 milliseconds.

g. Termination time (G): 4.312 milliseconds.

h. Formula: A+(B or C)+D+ [E Times (N-1)] + [F times (N-1)] +G. (N denotes the number of records.)

READ TYPES OF INSTRUCTIONS.

The read types of instructions are indicated by a read tape control word; these instructions and the bit codes (bits 46, 47, and 48) corresponding to them are as follows:

a. 001: backspace one record and read (n) records.

b. 010: backspace (n) records.

c. 011: backspace to end of file.

d. 100: read (n) records.

e. 101: advance (n-1) records and read one record.

f. 110: advance (n) records.

g. 111: advance to end of file.

When the read type of instruction is decoded from the tape control word, a nonterminating status code is transferred to the I/O module from the magnetic tape control to set bit DR44 of the command descriptor and thus change the original write operation to a read operation. The magnetic tape unit is unavailable for approximately 6 milliseconds following any read type of operation even though the magnetic tape control will be available for use with one of the other magnetic tape units. If the same magnetic tape unit is addressed during this time, the operation will be terminated by the abnormal-condition (011) status.

In actual read operations (operation codes 001, 100, and 101), a total of 4096 words can be read from the tape in one operation if the word count is set to 0001. Although this magnetic tape equipment is not capable of writing a 4096-word record, this feature enables the reading of 4096-word records that can be written by certain other magnetic tape sets. In addition, any number of records (16 or less) totaling 4096 words or less (rather than 4095) can also be read in one operation.

The actual read operation does not start until a valid record is sensed on the tape. A valid record consists of six consecutive characters in which a 1 bit is written in at least one of the seven tracks. The magnetic tape unit skips all tape until the first valid record is detected. Therefore, erased areas between records (such as areas containing flaws) are automatically skipped, and flaws of less than six characters in length are rejected automatically. No data transfers take place in any of the read tape control operations. Therefore, the only read types of operations that can be terminated by a parity-error or data-too-slow device status are those with operation codes 001, 100, and 101; these terminations can only occur during the actual read operation. The parity-error status will also occur for any read type of operation if the tape control word has incorrect parity when sent to the magnetic tape control. In this case, DR44 in the result descriptor will not be set.

BACKSPACE ONE RECORD AND READ (n) RECORDS. The operation code for the backspace-one-record-and-read-(n)-records instruction is 001. This instruction causes the tape to be driven backward over one record; then the number records specified by (n) is read. If the previous operation was a write operation, the tape is driven forward for approximately 4.9 milliseconds before it is driven backward. This action causes an interrecord gap to be written at the end of the previous record. The number of records read in this operation is determined by the record count specified in the command descriptor. The operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. This termination will occur whenever the record counter in the I/O module is counted down to 0 by an end-of-record status code from the magnetic tape control (regardless of the count in the word counter). The operation can also be terminated normally, however, by the word-count-equal-to-0 status code (011) in the I/O status field of the result descriptor. This termination will occur whenever the count of word counter is reduced to 0 and the tape is not at the end of a record. If the tape is at the end of a record when the word count is decreased to 0 but the record count is not equal to 0, the end of record status still occurs in the result descriptor. The maximum word count possible is 4096, which includes the tape control word. If the read operation is terminated with word-count-equal-to-0 status, the longitudinal parity of the data read is not checked. If the one record backspaced over in this operation is an end-of-file record, it is ignored as an end-of-file condition during backspace but is recognized as a valid record during the read operation. The operation will thus be terminated by the end-of-file (010) status, and the position of the tape will be the same as when the operation began. During the read portion of this operation, any of the device status conditions except the file-protect (100) status can terminate the operation. However, the only status that can terminate the operation before or during the backspace operation is the abnormal-condition (011) status, the end-of-tape (101) status, or the parity-error (111) status (parity error in tape control word). The parameters that must be considered when calculating the time required to perform a backspace-one-record-and-read-(n)-records operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time following a write type of operation (B): 16.20 milliseconds.

c. Starting time following a read type of operation (C): 6.72 milliseconds.

d. Variable distance factor following a write type of operation (D): 8.33 milliseconds per inch of tape minus the starting time (the combined starting time and variable distance factor is never less than 24.085 milliseconds).

e. Variable distance factor following a read type of operation (E): 8.33 milliseconds per inch of tape minus starting time (the combined starting time and variable distance factor is never less than 6.72 milliseconds).

f. Time required to backspace over one record (F): 96 microsecond to 240 microseconds per word.

g. Tape direction reversal time (G): 3.5 milliseconds.

h. Read time (H): 96 microseconds to 240 microseconds per word.

i. Time required to advance over interrecord gap (I): 8.33 milliseconds per inch of tape.

j. Termination time (J): 181 microseconds.

k. Formula: A+(B or C)+(D or E)+(F times N)+G+(H times X)+[I times (Y-1)]+J. (N denotes the number of words in the record that is backsapced over, X denotes the total number of words in all records read, and Y denotes the total number of records read.)

BACKSPACE (n) RECORDS. The operation code for the backspace (n) records instruction is 010. This instruction causes the tape to be driven backward over a group of records. The number of records to be backspaced over is determined by the record count (n) in the command descriptor. The backspace (n) records operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. If an end-of-file record is sensed during the backspace operation, the end-of-file (010) device status code will terminate the operation. Since there is no transfer of data during this operation, the data-too-slow (110) status condition cannot terminate the operation, and the parity error status can occur only during the transfer of the tape control word. However, any of the other device status conditions except the file-protect status can terminate the operation. Following a backspace (n) records operation, the magnetic tape control will be unavailable for 2.4 milliseconds; a delay of this duration should therefore be accounted for in the program before the magnetic tape control can be used again. The parameters that must be considered when calculating the time required to perform a backspace (n) records operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time following a write type of operation (B): 16.2 milliseconds.

c. Starting time following a read type of operation (C): 6.72 milliseconds.

d. Variable distance factor following a write type of operation (D): 8.33 milliseconds per inch of tape minus the starting time (the combined starting time and variable distance factor is never less than 16.2 milliseconds).

e. Variable distance factor following a read type of operation (E): 8.33 milliseconds per inch of tape minus the starting time (the combined starting time and variable distance factor is never less than 6.72 milliseconds).

f. Time required to backspace over a record (F): 96 microseconds to 240 microseconds per word.

g. Time required to backspace over interrecord gap (G): 8.33 milliseconds per inch of tape.

h. Termination time (H): 1.275 milliseconds.

i. Formula: A+(B or C)+(D or E)+(F times N)+[G times (X-1)] +H. (N denotes the total number of words in all records and X denotes the number of records.)

BACKSPACE TO END OF FILE. The operation code for the backspace-to-end-of-file instruction is 011. This instruction causes the tape to be driven backward until an end-of-file record is read. This operation is normally terminated with the end-of-file status code (010) in the device status field of the result descriptor. The abnormal condition (011) and the end-of-tape condition (101) are the only other status conditions that can terminate this operation. After a backspace-to-end-of-file operation has been performed, all end-of-file records are ignored during read operations until a valid record has been passed over by the read heads. Following a backspace-to-end-of-file operation, the magnetic tape control is unavailable for 2.4 milliseconds; a delay of this duration should be accounted for in the program before the magnetic tape control can be used again. The parameters that must be considered when calculating the time required to perform a backspace-to-end-of-file operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time following a write type of operation (B): 24.085 milliseconds.

c. Starting time following a read type of operation (C): 14.5 milliseconds.

d. Backspace time (D): 8.33 milliseconds per inch of tape.

e. Termination time (E): 12 microseconds.

f. Formula: A+(B or C)+D+E.

READ (n) RECORDS. The operation code for the read-(n)-records instruction is 100. This instruction causes a specified number of records to be read from the tape. The number of records read is determined by the record count specified in the command descriptor. The read-(n)-records operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. This termination occurs whenever the record counter in the I/O module is counted down to 0 by an end-of-record status code from the magnetic tape control (regardless of the count in the word counter). The operation can also be terminated normally, however, with the word-count-equal-to-0 status code (011) in the I/O status field of the result descriptor. This termination occurs whenever the word count is decreased to 0 and the tape is not at the end of a record. When a read operation is terminated by word count equal to 0 status, the longitudinal parity of the data read is not checked. If the tape is at the end of a record when the word count is decreased to 0 but the record count is not equal to 0, the end-of-record status still occurs in the result descriptor. The maximum word count possible is 4096; the tape control word is included in this count. Any of the device status conditions except the file-protect status can result in terminating the read (n) records operation. The parameters that must be considered when calculating the time required to perform a read (n) records operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 14.5 milliseconds.

c. Starting time when tape is not positioned at load point (C): 135 microseconds.

d. Variable distance factor when tape is poisitioned at load point (D): 8.33 milliseconds per inch of tape minus 14.5 milliseconds (when tape is positioned at load point, the combined starting time and variable distance factor is never less than 14.5 milliseconds).

e. Variable distance factor when tape is not positioned at load point (E): 8.33 milliseconds per inch of tape minus 135 microseconds (when tape is not positioned at load point, the combined starting time and variable distance factor is never less than 135 microseconds).

f. Time required to advance over interrecord gap (F): 8.33 milliseconds per inch of tape.

g. Termination time (G): 181 microseconds.

h. Formula: A+(B or C)+D+(E times N)+ [F times (X-1)] +G. (N denotes the total number of words in all records and X denotes the number of records.)

ADVANCE (n-1) RECORDS AND READ ONE RECORD. The operation code for the advance-(n-1)-records-and-read-one-record instruction is 101. This instruction causes the tape to be advanced over the number of records specified by (n-1); after the tape is advanced, one record is read. The number of records advanced over is determined by the record count specified in the command descriptor. The tape is advanced for (n-1) records, and then the next record is read. The advance-(n-1)-records-and-read-one-record operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. This termination occurs when the end-of-record status code is sent to the I/O module from the magnetic tape control (when the end of the record being read is reached). The operation can also be terminated with the word-count-equal-to-0 status code (011) in the I/O status field of the result descriptor. This termination occurs if the word count specified in the original command descriptor is less than the number of words in the one record. The maximum word count possible is 4096; the tape control word is included in this count. When the read operation is terminated with word-count-equal-to-0 status, the longitudinal parity of the data read is not checked. Any of the device status conditions except the file-protect status can result in terminating the advance-(n-1)-records-and-read-one-record operation; however, the parity error (111) and data-too-slow (110) status conditions cannot occur during the advance-(n-1)-records part of the operation. The parity-error status can occur during the transfer of the tape control word. The parameters that must be considered when calculating the time required to perform an advance-(n-1)-records-and-read-one-record operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 14.5 milliseconds.

c. Starting time when tape is not positioned at load point (C): 135 microseconds.

d. Variable distance factor when tape is positioned at load point (D): 8.33 milliseconds per inch of tape minus 14.5 milliseconds (when tape is positioned at load point, the combined starting time and variable distance factor is never less than 14.5 milliseconds).

e. Variable distance factor when tape is not positioned at load point (E): 8.33 milliseconds per inch of tape minus 135 microseconds (when tape is not positioned at load point, the combined starting time and variable distance factor is never less than 135 microseconds).

f. Time required to advance over interrecord gap (F): 8.33 milliseconds per inch of tape.

g. Termination time (G): 181 microseconds.

h. Formula: A+(B or C)+D+(E times N)+ [F times (X-1)] +G. (N denotes the total number of words in all records, and X denotes the number of records.)

ADVANCE (n) RECORDS. The operation code for the advance-(n)-records instruction is 110. This instruction causes the tape to be advanced over the number of records specified by (n). The number of records passed over is determined by the record count specified in the command descriptor. The advance-(n)-records operation is normally terminated with the end-of-record status code (001) in the device status field of the result descriptor. Since there is no transfer of data during this operation, the data-too-slow (110) status condition cannot terminate this operation, and the parity-error status occurs only for a parity error in the tape control word. However, any of the other device status conditions except the file-protect status can terminate the operation. The parameters that must be considered when calculating the time required to perform an advance (n) records operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 14.5 milliseconds.

c. Starting time when tape is not positioned at load point (C): 135 microseconds.

d. Variable distance factor when tape is positioned at load point (D): 8.33 milliseconds per inch of tape minus 14.5 milliseconds (when tape is positioned at load point, the combined starting time and variable distance factor is never less than 14.5 milliseconds).

e. Variable distance factor when tape is not positioned at load point (E): 8.33 milliseconds per inch of tape minus 135 microseconds (when tape is not positioned at load point, the combined starting time and variable distance factor is never less than 135 microseconds).

f. Time required to advance over interrecord gap (F): 8.33 milliseconds per inch of tape.

g. Termination time (G): 181 microseconds.

h. Formula: A+(B or C)+D+(E times N)+ [F times (N-1)] +G. (N denotes the number of records.)

ADVANCE TO END OF FILE. The operation code for the advance-to-end-of-file instruction is 111. This instruction causes the tape to be advanced until an end-of-file record is read. The advance-to-end-of-file operation is normally terminated with the end-of-file status code (010) in the device status field of the result descriptor. After an advance-to-end-of-file operation has been performed, all end-of-file records are ignored in a read operation until a valid record has been passed over by the read heads. The parameters that must be considered when calculating the time required to perform an advance-to-end-of-file operation and the formula used for these calculations are as follows (all figures are approximate):

a. Designate time (A): 40 microseconds to 105 microseconds.

b. Starting time when tape is positioned at load point (B): 14.5 milliseconds.

c. Starting time when tape is not positioned at load point (C): 135 microseconds.

d. Tape advance time (D): 8.33 milliseconds per inch of tape.

e. Termination time (E): 12 microseconds.

f. Formula: A+(B or C)+D+E.

DELAY REQUIREMENTS.

After the execution of many of the magnetic tape operations, delays must be accounted for in the program before the magnetic tape control and/or the magnetic tape unit is again available for use. The type of tape operation and the status condition which caused the operation to be terminated determine whether or not a delay in the program needed to allow the magnetic tape control to become available before any of the magnetic tape units can again be used. If the magnetic tape unit that was used in the previous tape operation is to be used again during the next tape operation, an additional time delay may be required after the magnetic tape control has become available. Whether or not this additional delay is required is also dependent upon the type of tape operation and the status condition which caused the operation to be terminated. Tables 4-3 and 4-4 list the approximate periods of time that the programs will be delayed for the magnetic tape control and the magnetic tape units, respectively, to become available after the termination of the different tape operations for various status conditions. The total delay time required is obtained by adding the applicable delay times from each table.

MAGNETIC TAPE STATUS CODES.

There are seven terminating status codes that can appear in the device status field (bits 20, 37, and 38) of a result descriptor for a magnetic tape operation. These codes and the status for each of these codes are as follows:

a. 001: end of record.

b. 010: end of file.

c. 011: abnormal condition.

d. 100: file protect.

e. 101: end of tape.

f. 110: data too slow.

g. 111: parity error.

END OF RECORD.

The code for the end-of-record status is 001. This status code is sent to the I/O module each time a record is passed during any read type of operation except the advance-to-end-of-file and the backspace-to-end-of-file operations. Each time this signal is sent to the I/O module, the record count specified in the command descriptor is decreased by 1. When the record count is decreased from 1 to 0, the operation is terminated. When the end-of-record status is sent during a write type of operation, the operation is terminated. This status code indicates the successful completion of all tape operations except the backspace-to-end-of-file, advance-to-end-of-file, rewind, and rewind-and-lockout operations.

END OF FILE.

The code for the end-of-file status is 010. This status code is sent to the I/O module each time an end of file record is read during a read type of operation. The conditions stated for the backspace-one-record-and-read-(n)-records operation, the backspace-to-end-of-file operation, and the advance-to-end-of-file operation are exceptions to this rule. This status code will not occur for a write type of operation.

ABNORMAL CONDITION.

The code for the abnormal-condition status is 011. This status code is sent to the I/O module and terminates the operation when any one of the following conditions occurs:

a. A write instruction is given, and the magnetic tape unit does not set up the write operation properly.

b. A valid record is read from the tape during an erase operation.

c. A valid record is read from an area of tape that should be blank.

d. A rewind instruction is given, and the magnetic tape unit does not respond properly.

e. A rewind instruction is given, and the magnetic tape unit performs the rewind operation while in the write mode. (Data are destroyed as a result of this malfunction.)

f. The magnetic tape unit is placed in the local mode while an operation is in progress.

g. Signal $\overline{\text{TTOL}}$ to the magnetic tape control goes high during a read type or write type of operation. If this action occurs during a write operation, the movement of the tape is terminated; therefore the longitudinal parity character is not written and the read-write heads are not positioned in an interrecord gap. If this action occurs during a read type of operation, it is possible for the tape to stop in the middle of a record.

h. The magnetic tape unit performs a backspace operation while in the write mode. Valid data on the tape are not destroyed in this case.

i. A read-forward instruction is given, and the magnetic tape unit remains in the write mode. Valid data on the tape are not destroyed in this case.

j. An illegal instruction (order code 000) is given.

k. The I/O module does not respond to the first eight character requests from the magnetic tape control.

l. The I/O module starts an instruction operation as an input operation rather than as an output operation.

m. The first character of the tape control word is invalid.

n. The designated magnetic tape unit is not available.

o. A nonexistent magnetic tape unit (unit numbers 0 and 7) is addressed.

p. The I/O module does not respond to the read character request when the nonterminating status signals are sent.

FILE PROTECT.

The code for the file-protect status is 100. This status code is sent to the I/O module when any write type of instruction except the rewind and rewind-and-lockout instructions is given when the write ring is not on the tape supply reel or when the magnetic tape unit is in the lockout condition.

END OF TAPE.

The code for the end-of-tape status is 101. This status code is sent to the I/O module when any one of the following conditions occurs:

a. The beginning-of-tape (load point) marker on the tape is sensed during an operation that moves the tape backward.

b. The end-of-tape marker is sensed during a read type of operation. The end-of-tape status code is not sent, however, until the reading of the record being read is completed. After this record is read, the end-of-tape status code is sent to the I/O module if the record did not have a parity error and the end-of-file record was not read.

c. A rewind or rewind-and-lockout operation begins satisfactorily.

If the end-of-tape status code appears in the result descriptor for an output (write type) instruction other than the rewind instructions (operation codes 001 and 101), the status indicates that the operation was not completed satisfactorily. If the operation transferred data to the tape, an input (read type) instruction probably will not be able to read this information back into memory; consequently, the write type of operation during which the end-of-tape status was received should be performed again on another tape.

DATA TOO SLOW.

The code for the data-too-slow status is 110. This status code is sent to the I/O module if the I/O module is too slow in accepting data during a read type of operation or if the I/O module is too slow in sending data during a write type of operation. The transfer rate that must be maintained is approximately 67,000 characters per second.

PARITY ERROR.

The code for the parity-error status is 111. This status code is sent to the I/O module whenever a lateral or longitudinal-parity error is detected during read types and write types of operations (when a valid character has been read). A parity check is performed on data read from tape during an input or an output operation and on data received from the I/O module during an output operation. The parity-error status occurs during any tape operation when the tape control word received at the magnetic tape control has incorrect (even) parity.

DATA STORAGE MAGNETIC DRUM MU-529/GYK-10 AND MAGNETIC DRUM CONTROLLER-CONVERTER C-7123/GYK-10 AND DATA STORAGE MAGNETIC DRUM MU-469/GYK-4 AND MAGNETIC DRUM CONTROLLER-CONVERTER C-7124/GYK-10

GENERAL.

The Data Storage Magnetic Drum MU-529/GYK-10 (display/bulk drum unit) and the Magnetic Drum Controller-Converter C-7123/GYK-10 (display/bulk drum control) function as a two-way (input-output) terminal device that provides bulk storage and a means for automatic readout and transfer of display data from the display/bulk magnetic drum units to the data display consoles. There are two display/bulk magnetic drum units and two display/bulk magnetic drum controls contained in the data processing set. The Data Storage Magnetic Drum MU-469/GYK-4 (bulk-only drum unit) and the Magnetic Drum Controller-Converter C-7124/GYK-10 (bulk-only drum control) also function as a two-way (input-output) terminal device that provides bulk storage; however, these units do not have the capability of automatic readout and transfer of data to the data display consoles. Since many of the operating characteristics are identical for both types of units, the information pertaining to both types of units is presented in this section. When information that is applicable to both the display/bulk drum unit and its associated control and the bulk-only drum unit and its associated control is presented, the units are referred to simply as magnetic drum unit and magnetic drum control, respectively.

There are three types of magnetic drum unit operations: read, write, and erase. These operations are initiated and controlled by use of command descriptors which are transmitted to the I/O modules by the operational program. The automatic readout of display information from the display/bulk drum units is also controlled (enabled or inhibited) by means of command descriptors issued by the operational program; however, once enabled, this readout is performed automatically and is thus independent of the operational program. The magnetic drum unit and the magnetic drum control are illustrated in figure 4-20. Operating characteristics of the magnetic drum unit and the magnetic drum control are presented in table 4-6. The information in this section is presented under the following headings:

a. General description.

b. Automatic display operations.

c. Program-controlled operations.

d. Magnetic drum status codes.

Table 4-6. Operating Characteristics of Magnetic Drum Unit and Magnetic Drum Control

Equipment	Feature	Capability or Limitation
Magnetic drum unit	Access time	Program data: 8.33 mx (average) 16.67 ms (max) *Display data: 100 ms (max)
	Data transfer rate	3.35 usec per six-bit character
	Drum speed	3600 rpm
	Storage capacity of bulk-only drum unit	65,536 words: all words for general storage
	Storage capacity of display-bulk drum unit	65,536 words: 6144 words for situation data, 14,336 words for radar data, and 39,936 words for general storage
Magnetic drum control	Rate of data transfer to I/O module	2.035 usec per six-bit character
	Clock-pulse frequency (slave clock)	2.9999 mc when free running and 3.0001 or 3.0000 mc when driven

*applicable to display-bulk drum unit only

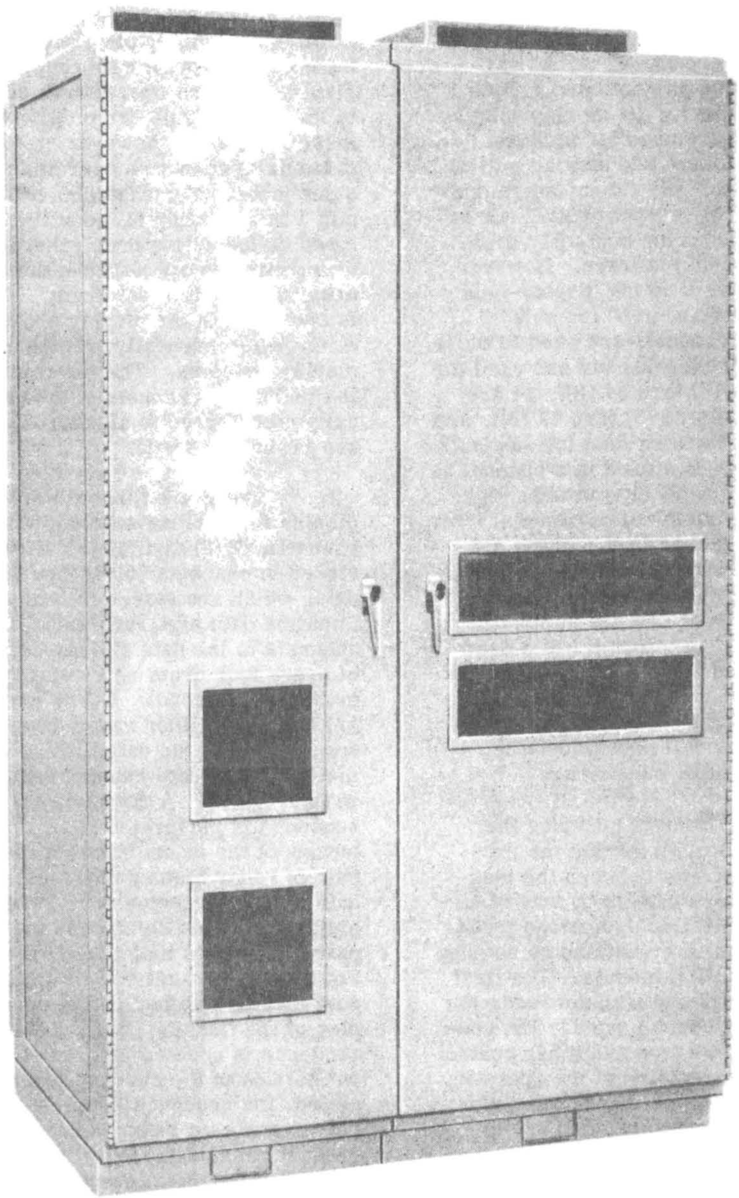


Figure 4-20. Magnetic Drum Unit and Magnetic Drum Control

GENERAL DESCRIPTION.

The magnetic drum unit has space for 448 binary recording tracks. On the display/bulk drum unit, 384 of these tracks are used for data storage, two are used for master timing, three are used for active timing, 27 are used as spares, and 32 are not used. The track allotment on the bulk-only drum unit is the same as that specified for the display/bulk drum unit except that 32 tracks are used as spares and 28 tracks are not used. Each recording track has the capacity for storing 9224 binary bits, of which 9216 are used for storage. The 384 tracks used for storage are divided into 64 channels of six tracks each. The channels are numbered from 00 (8) thru 77 (8), respectively. All 64 of the addressable channels on the bulk-only drum unit are used for general (bulk) storage. However, of the 64 addressable channels on the display-bulk drum unit, only 39 channels are used for bulk storage; the remaining 25 channels are used to store display data. Of these 25 channels, six are used for situation data (channels 47 (8) thru 54 (8)), 14 are used for radar data (channels 55 (8) thru 72 (8)), and five channels are used for flashing data (channels 73 (8) thru 77 (8). Information is stored in a channel as a series of nine parallel, six-bit characters: eight data characters and one longitudinal parity character. Each bit of a character is stored in one of the six tracks which comprise the channel. Consequently, each channel has the capacity to store 1024 information words. The word locations are numbered from 0000 (8) thru 1777 (8). The drum has a dead space between the last word of each channel and the first word of the next channel; no information is written into these dead spaces. The time interval during which the dead space will pass under the read-write heads is about eight bit-times.

The magnetic drum control provides the control functions required for permitting the program-controlled transfer of data between the magnetic drum unit and a memory module by way of an I/O module. Program-controlled operations (read, write, and erase operations) are initiated by sending a command descriptor to an I/O module. The first word extracted from memory and transferred to the magnetic drum control is a control word. The control word contains drum addresses and other control information necessary for execution of the operation. The operation specified in the command descriptor and by the control word then proceeds under the control of the I/O module.

A parity check is performed at the magnetic drum control to check the parity of data read from the magnetic drum unit and received from the I/O module. If an error occurs, an appropriate parity error code is generated, and the operation is terminated. Longitudinal parity bits are also inserted into the ninth character position of each word written into the drum. A parity bit is associated with the eight word bits contained in each of the six tracks in which the word is contained.

AUTOMATIC DISPLAY OPERATIONS.

The automatic transfer of data from the display/bulk drum unit to the data display consoles is accomplished by the display section of the display/bulk drum control. This transfer of data is independent of the normal program-controlled transfer of data between core memory and the display/bulk drum unit. The display/bulk drum unit has two modes of operation with respect to the automatic display read-out operations: active and test. Each of the display/bulk drum units operates in one of these two modes; however, both of the display/bulk drum units cannot be operated concurrently in the same mode. For example, when display/bulk drum unit 1 is operating in the active mode, it is designated as the active drum; therefore display/bulk drum unit 2 is operating in the test mode and is designated as the test drum. The information that is contained in the display channels of the active drum is automatically transferred to all online data display consoles. The information that is contained in the display channels of the test drum is automatically transferred to all data display consoles that are in the test mode.

There are three different categories of display data: situation data, which are stored in channels 47 (8) thru 54 (8); radar data, which are stored in channels 55 (8) thru 72 (8); and flashing data, which are stored in channels 73 (8) thru 77 (8). Situation data are transferred from two display channels to the data display consoles during three out of every four drum revolutions (the drum revolves every 1/60 second). Every fourth revolution (every 1/15 second) either radar data or flashing data are transferred to the data display consoles. The automatic display data readout sequence is illustrated in figure 4-21. A complete display data readout sequence is performed in a minimum of 76 revolutions of the drum. During this sequence, each pair of radar history channels are read out to the data display consoles once, with the oldest radar history channels being read out first. However, the pair of channels that contain the present radar data are read out a total of four times to ensure that these data will be retained on the consoles during the display of the flashing data. If the radar channel sequence is updated before the radar channel readout portion of the current sequence has been completed, the sequence is adjusted in such a way that the most recent radar history data (which were the present radar data) are read out once, and the present radar data (which were the oldest radar data) are then read out four times. Thus, the automatic display readout sequence is lengthened as needed to complete the radar channel readout sequence.

The transfer of data between an I/O module and the display channels is inhibited during the readout of either radar data, flashing data, or the situation data contained in channels 53 (8) and 54 (8). Therefore, access to the display area is possible only during the readout of channels 47 (8) and 50 (8) or channels 51 (8) and 52 (8). In addition, only a single access is allowed during this time. The maximum number of words that can be continuously transferred between an I/O module and the display area is 2048. If a word count greater than 2048 is contained in the command descriptor or if the operation extends to more than two channels, access to the third channel is inhibited until after the next radar-data or flashing-data readout in the sequence has occurred. Thus, there will be a delay of approximately 50 milliseconds (maximum) between the transfer of the last word to the second channel and the transfer of the first word to the third channel.

Radar channel update operations are performed in the following manner. If it is assumed that the present radar information is stored in channels 67 (8) and 70 (8) of the display/bulk drum unit, the next most recent radar history will occupy channels 65 (8) and 66 (8), the next most recent radar history will occupy channels 63 (8) and 64 (8), and so forth, with the oldest radar history occupying channels 71 (8) and 72 (8). When additional radar information is transmitted to the display/bulk drum unit, it will be written into one of the pair of radar channels that currently contain the oldest radar data. The channel selection sequence is then adjusted to permit readout of what is now present radar data, to redesignate the former present radar data as the most recent radar history data, and to redesignate the other radar history channels accordingly. This adjustment of the channel selection sequence will be performed only when the advance readout sequence bit in the drum control word has been set. When the display/bulk drum control is turned on, or if the active-test bit in the drum control word is changed by the program (the active-test status of the display/bulk drum units is changed), the channel selection logic circuitry is reset to the initial condition, in which the contents of channels 55 (8) and 56 (8) are treated as the oldest radar data, the contents of channels 71 (8) and 72 (8) are treated as the present radar data, the contents of channels 67 (8) and 70 (8) are treated as the most recent radar history, and so forth.

PROGRAM-CONTROLLED OPERATIONS.

Every program-controlled operation performed by the magnetic drum units begins as a write type of operation. The command descriptors sent to the I/O modules will always be write type of instructions; that is, bits 44 and 45 of the command descriptor will always be 01. (The command descriptors used in performing drum operations are listed in appendix 4). The write operation is necessary so that a drum control word can be transferred to the magnetic drum control. The drum control word is contained in the location specified by the address in the memory-starting-address portion of the command descriptor. This control word contains control information supplementary to the information contained in the command descriptors. If the operation code in the command descriptor specifies a read operation, bit 44 in the command descriptor will be set after the drum control word is transferred to the magnetic drum control. The time required to perform a magnetic drum unit operation may be determined by adding the channel access time (an average of 8.33 milliseconds for the bulk storage channels and a maximum of 100 milliseconds for the display channels) to the total time required to transfer the data from the I/O module to the magnetic drum control (16.28 microseconds per word). Descriptions of the command descriptors, control words, and the read, write, and erase operations are contained in paragraphs 4-271 thru 4-287.

COMMAND DESCRIPTORS AND DRUM CONTROL WORDS.

COMMAND DESCRIPTORS. The following rules apply to the formation of a command descriptor for a magnetic drum unit operation:

a. The word count portion, bits 1 thru 12, contains the number of words to be written on or read from the magnetic drum unit plus 1. When the erase command is used, a count of 1 is placed in this field.

NOTE

Bits 15 and 16 are applicable only to command descriptors used for display/bulk drum unit operations.

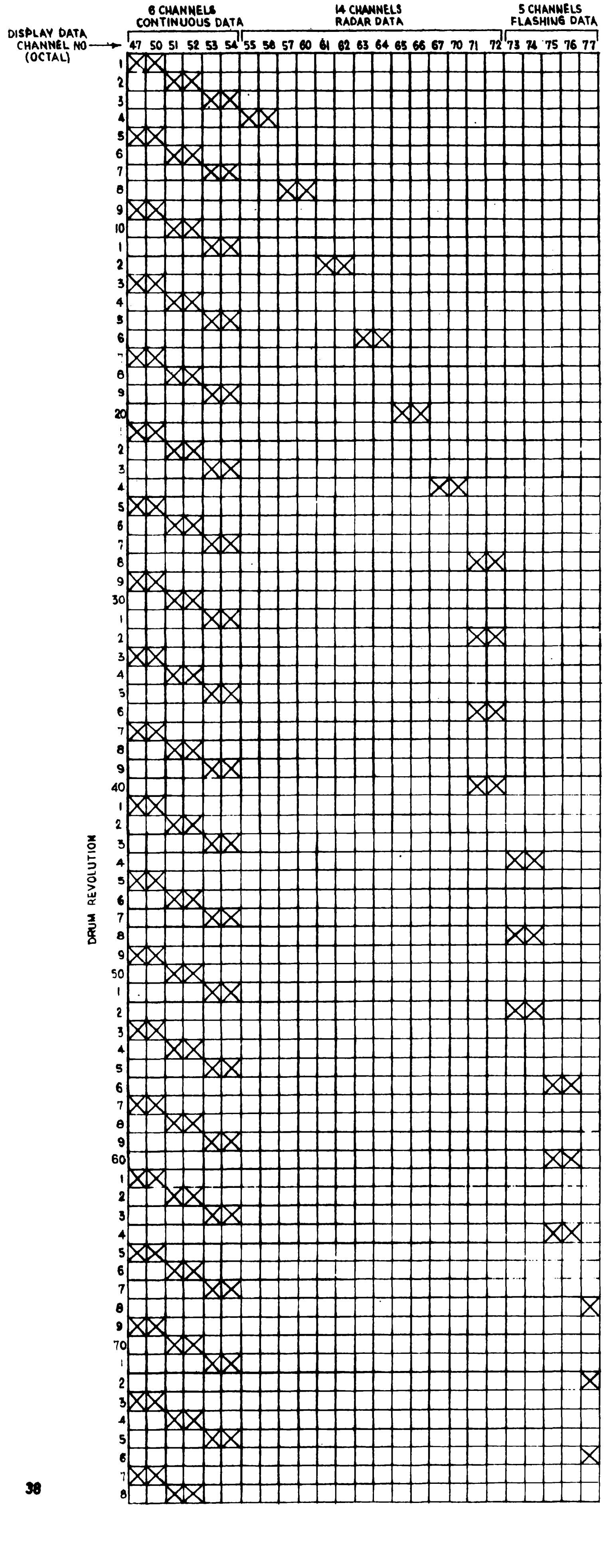
b. Bit 15 is the inhibit display data readout bit; when this bit is set, the automatic display readout function is inhibited. This function remains inhibited until a drum command descriptor in which bit 15 is reset is transmitted.

c. Bit 16 is the display readout parity-error interrogator bit. When this bit is set, the display readout error flip-flop is sampled. This flip-flop will be set if a parity error has been detected in the data transferred from the display/bulk drum control to the data display consoles since the previous drum operation. This flip-flop will then be reset, and the current drum operation will be terminated. If the flip-flop is not set when sampled, the operation indicated by the command descriptor is performed.

d. Bits 21 thru 36 contain the memory address in which the drum control word is located.

e. Bit 38 is the priority bit. This bit should always be set for drum read and write operations. This bit, when set, permits a magnetic drum unit and another type of terminal device to transfer data in or out of any memory module as long as the two I/O modules on the same I/O bus are used to control the data transfers.

f. Bits 39 thru 43 contain the device number. The coding of these bits will cause one of the magnetic drum units to be selected. A code of 00010 causes the selection of display/bulk drum unit 1, a code of 00001 causes the selection of display/bulk drum unit 2, and a code of 00111 causes the bulk-only drum unit to be selected.



NOTES:

1. RADAR DATA READOUT SHOWN FOR PRESENT RADAR ON CHANNELS 71 AND 72, WITH OLDEST RADAR HISTORY ON CHANNELS 55 AND 56. ON SUCCEEDING RADAR SCANS, NEWEST RADAR DATA OVERWRITES OLDEST DATA.
2. LETTER X INDICATES CHANNELS WHICH ARE READ EACH REVOLUTION OF THE DRUM.

Figure 4-21. Display/Bulk Drum Unit Automatic Display Readout Sequence

g. Bits 44 and 45 specify the type of operation. These bits must always initially contain a code of 01, which specifies a write operation. If the operation code in bits 46 thru 48 specifies an operation other than a write operation, bit 44 is set after the control word is transferred to the magnetic drum control.

h. Bits 46 thru 48 specify the specific magnetic drum unit operation. The codes for the operations specified are 001 (read), 011 (write), and 010 (erase).

DRUM CONTROL WORDS. Each drum control word contains the address of a channel, the address of the word within that channel at which a drum operation is to begin, and the address of the last word to be erased plus 1. This word also contains two control bits that are used to indicate that certain display/bulk drum unit operations are to be performed; these bits are not used in control words for bulk-only drum unit operations. The control word is the first word that is transferred to the magnetic drum control during any drum input or output operation. The format of the drum control word is illustrated in figure 4-22.

1	2	3 — 8	9 — 18	19 — 36	37 — 48
		CHANNEL ADDRESS	WORD ADDRESS	NOT USED	STOP ERASE ADDRESS

BIT 1 IS ADVANCE READOUT SEQUENCE FOR DISPLAY AREAS OF DISPLAY/BULK DRUM UNIT
BIT 2 CONTROLS ACTIVE-TEST STATUS OF DISPLAY/BULK DRUM UNITS
BITS 3-8 ARE A CHANNEL ADDRESS
BITS 9-18 ARE THE WORD ADDRESS IN THE CHANNEL
BITS 37-48 ARE THE STOP ERASE ADDRESS (LEAST SIGNIFICANT 12 BITS OF THE STARTING ADDRESS PLUS NO. OF WORDS TO BE ERASED)

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Figure 4-22. Drum Control Word

Specific information must be placed in the drum control word for each type of drum operation. In read or write operations, the drum control word must contain the address of the drum location at which the operation is to begin (the channel number in bits 3 thru 8 and the word address within the channel in bits 9 thru 18). In write operations involving either display/bulk drum unit, the advance readout sequence bit (bit 1) and the active-test bit (bit 2) are also used. In erase operations, the word address of the last word to be erased plus 1 must be contained in bits 37 thru 48 of the control word.

The drum control word is constructed as follows;

a. Bit 1 is the advance readout sequence bit. This bit is set when new information is to be written into one of the pair of channels containing the oldest radar history. When this bit is set, the logic circuitry of the display/bulk drum control that is addressed will be adjusted so that the pair of channels containing oldest radar data will become present radar data channels, and the automatic display readout sequence will be adjusted accordingly. When this bit is set, the drum channel that is addressed must be one of the pair containing the oldest radar information, or the write operation will not be performed.

b. Bit 2 is the active-test bit. This bit is used to control the active-test status of the display/bulk drum units with respect to the data display consoles and to reset the radar-channel-selection logic circuitry of the display/bulk drum unit that is addressed. A change in the active-test status of the display/bulk drum units with respect to the data display consoles can be accomplished only by addressing display/bulk drum unit 1. This action is necessary because the ACTIVE TEST flip-flop that is used to control this status is contained in the control unit for display/bulk drum unit 1. A change in the state of this flip-flop also resets the radar-channel-selection logic circuitry of display/bulk drum unit 1. The ACTIVE TEST flip-flop contained in the control unit for display/bulk drum unit 2 is used only to reset the radar-channel-selection logic circuitry of display/bulk drum unit 2. There is no relationship between the state of the ACTIVE TEST flip-flop contained in the control unit for display/bulk drum unit 2 and the active-test status of that unit with respect to the data display consoles. If the active-test bit in the control word is set and any display channel of display/bulk drum unit 1 is addressed, then display/bulk drum unit 1 is designated as the active unit, and display/bulk drum unit 2 is designated as the test unit. If this bit is reset and if any display channel of display/bulk drum unit 1 is addressed, then display/bulk drum unit 1 is designated as the test unit, and display/bulk drum unit 2 is designated as the active unit. If display/bulk drum unit 1 is off-line, display/bulk drum unit 2 is always in the active state with respect to the data display consoles, and its status cannot be changed; however, the state of the ACTIVE TEST flip-flop in that unit can be changed. If display/bulk drum unit 2 is off-line, there is no effect on the operation of display/bulk drum unit 1. It should be noted that the condition of the active-test bit has no effect when the bulk storage area of either display/bulk drum unit is addressed.

c. Bits 3 thru 8 contain the drum channel address. This address specifies the particular drum channel at which the selected operation will start.

d. Bits 9 thru 18 contain the drum word address. This address specifies the particular word in the specified drum channel at which the selected operation will start.

e. Bits 37 thru 48 contain the stop erase address. This address is used with the erase command only and specifies the last address to be erased plus 1. This address is determined by adding the number of words to be erased (1 thru 4096) to the starting address contained in bits 3 thru 18 and extracting the 12 least-significant bits of the sum. Bits 37 and 38 then contain the two least-significant bits of the drum channel address, and bits 39 and 48 contain the word address within the drum channel. When 4096 words are to be erased, these 12 bits are identical to bits 7 thru 18.

READ OPERATION.

DATA TRANSFER. The read operation is initiated by the transfer of a command descriptor specifying a read operation to the I/O module and by the subsequent transfer of the drum control word to the magnetic drum control specified in the command descriptor. To initiate the transfer of data, a signal is transmitted to the I/O module so that bit 44 in the command descriptor will be set and will thus change the instruction from a write operation to a read operation. The I/O module in turn transmits a start read signal, and the total number of words specified by the word count in the command descriptor minus 1 is read from the magnetic drum unit into core memory. The reading of data from the magnetic drum unit starts at the channel and word address specified in the control word, and the storing of data into memory starts at the memory location following the location which contains the control word.

A word is transferred from the magnetic drum unit to core memory by the sequential transfer of eight six-bit data characters and a six-bit longitudinal parity character from the magnetic drum unit to the magnetic drum control. The eight data characters are transmitted from the magnetic drum control to the I/O module. The word formed is transferred from the I/O module to a memory module by four syllable (12-bit) transfers plus a parity transfer.

PARITY CHECKS. Parity checks are made after the transfer of data from the magnetic drum unit to the magnetic drum control and from the magnetic drum control to an I/O module. At the magnetic drum control the longitudinal parity character associated with each word is checked. If a parity error is detected, the word is transferred to an I/O module and is subsequently stored in a memory module. However, a parity error status is placed in the result descriptor, and the operation terminates. A parity bit is added to each character transferred to the I/O module. At the I/O module, a parity check is made on each character. If a parity error is detected, the operation terminates, and the word containing the error is not stored in core memory. A result descriptor which indicates a parity error from a terminal device (bits 17, 18, and 19 are equal to 110) is returned from the I/O module to core memory.

WRITE OPERATION.

The write operation is initiated by the transfer of a command descriptor which specifies a write operation to the I/O module and by the subsequent transfer of the drum control word to the magnetic drum control specified in the command descriptor. When either of the display/bulk drum units is addressed, bits 1 and 2 of the control word are sampled before the write sequence begins in order to determine whether information is to be written into the oldest radar history channel or whether a change of active-test status of the display/bulk drum units has been specified.

RADAR CHANNEL UPDATE. When a display/bulk drum unit is addressed, the advance readout sequence bit is sampled to determine if new information is to be written into one of the pair of channels that contain the oldest radar data. If this bit is a 1 and the channel address in the control word is a radar channel, the logic circuitry in the magnetic drum control is adjusted to treat this channel and its complementary channel as the new present radar channels and to update the display sequence logic circuitry accordingly.

ACTIVE-TEST STATUS. When display/bulk drum unit 1 is addressed, the active-test status bit (bit 2) in the control word is sampled to determine if the active-test of the display/bulk drum units with respect to the data display consoles is to be switched. If this bit is a 1, the ACTIVE TEST flip-flop in the control unit for display/bulk drum unit 1 is set. Conversely, if this bit is 0, this ACTIVE TEST flip-flop is reset. It should be noted that the active-test status of the display/bulk drum units is not changed if the ACTIVE TEST flip-flop already corresponds to the condition of the active-test status bit in the control word. When display/bulk drum unit 2 is addressed, the state of the ACTIVE TEST flip-flop in the control unit for this drum is controlled in the same manner as described for the ACTIVE TEST flip-flop in the control unit for display/bulk drum unit 1. However, a change in the state of the ACTIVE TEST flip-flop in the control unit for display/bulk drum unit 2 has no effect on the active-test status of the display/bulk drum units with respect to the data display consoles. If a change occurs in the state of either ACTIVE TEST flip-flop, the radar-channel-selection logic circuitry in the corresponding control unit is reset to its initial state.

DATA TRANSFER. During the write sequence, data beginning at the memory location following the location of the drum control word are written into the specified number of magnetic drum unit locations which start at the channel and word address specified in the control word. A longitudinal parity character for each word is developed in the magnetic drum control and is placed in the magnetic drum unit in the ninth character position of the word.

PARITY CHECKS. Parity is checked upon transfer of information from core memory to the I/O module and upon transfer of information from the I/O module to the magnetic drum control. If an error is detected in either check, the operation is automatically terminated. If a core memory-to-I/O parity error is detected, the word containing the error is not transmitted to the magnetic drum control. If an I/O-to-magnetic-drum control parity error is detected, the character containing the parity error and the characters preceding this character (and possibly one additional character) are written on the magnetic drum unit.

ERASE OPERATION.

An erase operation is the same as a write operation except that the erase operation code is placed in the command descriptor and the command descriptor for an erase operation must contain a word count of 1. In this operation all 0's are written in the specified word addresses of the specified channel of the magnetic drum unit. The operation continues until the contents of the location whose address is 1 less than the address specified in bits 37 thru 48 of the drum control word are erased. It should be noted that when an erase operation is performed, the I/O module is functionally disconnected from the magnetic drum unit immediately after the control word has been transmitted (the I/O module generates word-count-equal-to-0 status). The magnetic drum unit then performs the erase operation independently of the I/O module. Although additional operations can be performed by use of that I/O module, the magnetic drum unit remains unavailable for additional operations until the erase operation has been completed.

MAGNETIC DRUM STATUS CODES.

Four terminating status codes are generated by the bulk-only drum control, and six terminating status codes are generated by the display/bulk drum control. Any of these codes can appear in the device status field (bits 20, 37, and 38) of a result descriptor during a magnetic drum unit operation. These status codes are as follows:

a. 010: illegal instruction.

b. 011: drum not ready (abnormal condition).

c. 100: display longitudinal parity error. (This status code is applicable only to the display/bulk drum units.)

d. 101: radar channel update error. (This status code is applicable only to the display/bulk drum units.)

e. 110: no memory access (data too slow).

f. 111: parity error.

ILLEGAL INSTRUCTION.

An illegal instruction status code (010) occurs if one of the following conditions occurs:

a. If during the execution of a read instruction, the write sequence begins before the drum control word has been received by the magnetic drum control. This condition occurs if bit 44 in the read command descriptor is a 1 when the descriptor is transmitted to an I/O module.

b. If an illegal order code is detected by the magnetic drum control.

c. If the word count contained in the command descriptor is greater than 1 at the start of an erase operation.

DRUM NOT READY.

A drum-not-ready (abnormal condition) status code (011) occurs if one of the following conditions occurs:

a. If the power supply voltage of the magnetic drum unit or magnetic drum control is out of tolerance or is not ready.

b. If the OPERATION switch on the magnetic drum control is set to a test mode position while the device is being addressed by an I/O module during a read or write operation.

c. If an address overflow condition occurs. This condition occurs when an attempt to cross the end-of-drum boundary or the boundary between a general storage area and the display data storage area is made during a data transfer.

d. If a counter error occurs. This error occurs when the drum word counter or the read or write character counters do not contain the correct count (0's) at drum marker time.

DISPLAY LONGITUDINAL PARITY ERROR.

The display-longitudinal-parity-error status code (100) is generated when a longitudinal parity error is detected in the automatic display readout subsequent to the previous interrogation. This status is not applicable to bulk-only drum operations.

RADAR CHANNEL UPDATE ERROR.

The radar channel update error status code (101) is generated when a disagreement exists between the address of the display channel that is addressed at the time the advance readout sequence bit is received and the address of the channel containing the oldest radar history at the time. This status is not applicable to bulk-only drum unit operations.

NO MEMORY ACCESS.

The no-memory-access (data too slow) status code (110) is generated if one of the following conditions occurs:

a. If during a write operation the I/O module does not respond to a character request from the magnetic drum control by sending a character strobe within 1.81 microseconds.

b. If during a read operation the I/O module does not respond to a character strobe from the magnetic drum control by sending a character request within 1.81 microseconds.

The no-memory-access condition can occur for reasons other than a hardware failure. For example, this condition may occur if the program in control attempts to gain access to the same memory module that is being used for the magnetic drum unit operation.

PARITY ERROR.

The parity-error status code (111) is generated if during a write operation the magnetic drum control detects a parity error in data received from the I/O module or during a read-from-drum operation the magnetic drum control detects incorrect longitudinal parity.

If a parity error from the terminal device is detected during a write operation, a parity-error-from-terminal-device status code (110 in bits 17, 18, and 19) is placed in the result descriptor. If a parity error from memory is detected by an I/O module, a parity-error-from-memory status code (111 in bits 17, 18, and 19) is placed in the result descriptor. The device which detected the parity error, the storage location of the word, and the memory address of each type of parity error are shown in table 4-7.

Table 4-7. Magnetic Drum Read and Write Parity-Error Operations

Operation	Device Which Detected Parity Error	Word Storage	Memory Address in Result Descriptor
Read	Magnetic drum control (error in data from magnetic drum unit)	Error word stored in core memory	Address of error word plus 1
	I/O module (error in data from magnetic drum control)	Error word not stored in core memory	Address of location in which word was to be stored
Write	I/O module (error in data from core memory)	Error word not stored in magnetic drum unit	Address of error word plus 1
	Magnetic drum control (error in data from I/O module)	Character which has error transferred to magnetic drum unit	Ambiguous. Result descriptor will contain address of error word or address of error word plus 1

GENERAL.

The Data Display Console OJ-5/GSA-51A (data display console) is used to display radar target information that is received from remote installations and is processed by the message processor modules and the central processing modules of the data processing set. This displayed information is used in monitoring and in evaluating tactical air situations. There are either 10 or 11 data display consoles contained in the BUIC NCC, depending on the requirements of the particular installation. However, the capability exists for expanding the display capability of the BUIC NCC to a maximum of 16 data display consoles. The transmission of display data to the data display consoles is controlled by the automatic readout function of the display/bulk drum units (refer to paragraph 4-265). A data display console is illustrated in figure 4-23.

The automatic transfer of display data from the display/bulk drum units to the data display consoles is controlled exclusively by the display/bulk drum controls. However, a means for the operator to generate two-word input messages for transfer to the data processing set is provided in the data display console. These message transfers are accomplished by normal input-output operations in the data processing set. Therefore, from the standpoint of the I/O control programming in the

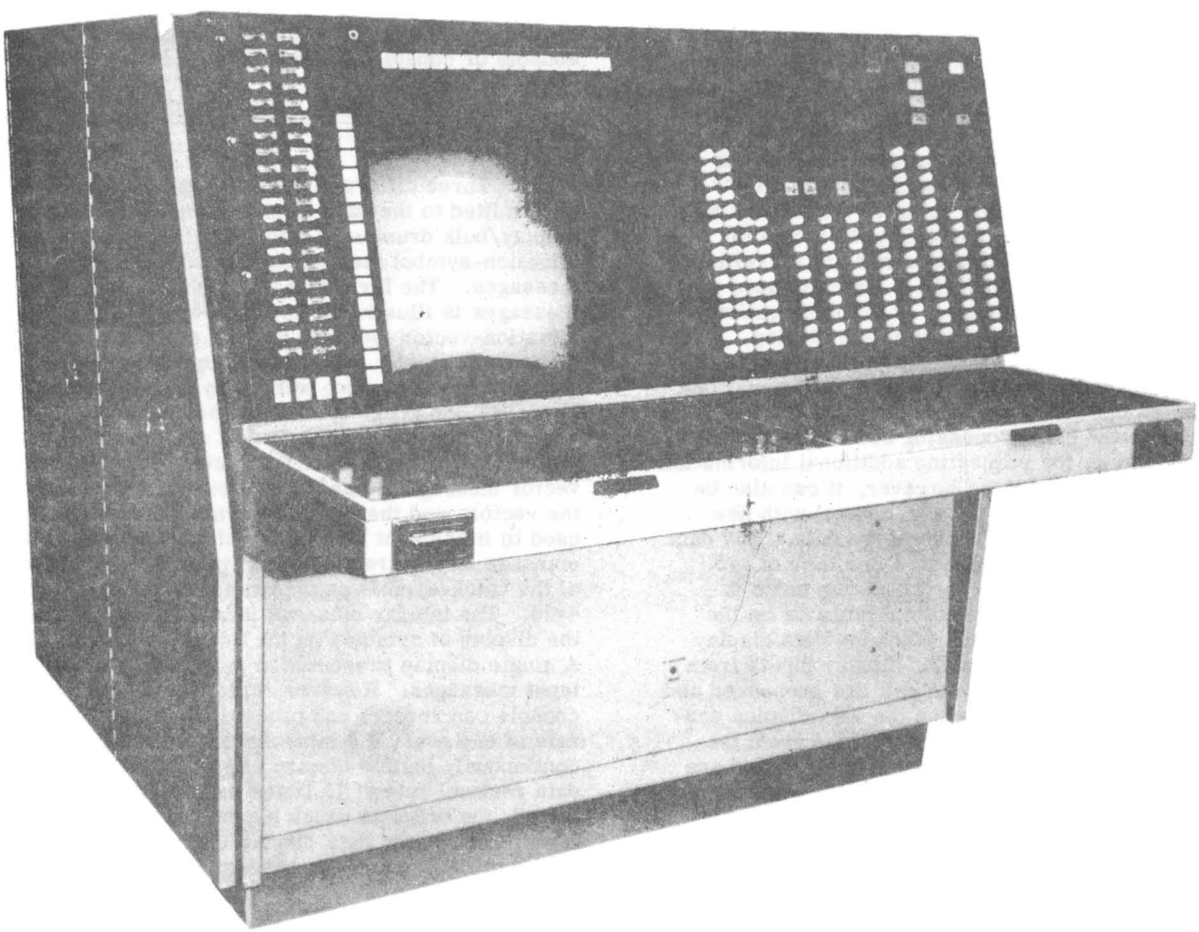


Figure 4-23. Data Display Console OJ-5/GSA-51A

data processing set, the data display consoles are essentially one-way input terminal devices. It should be noted that since the data display consoles are not equipped with an external request capability and therefore cannot communicate directly with the program in control, the program in control must periodically interrogate the data display console (by attempting a read operation) in order to determine whether an input message has been generated by the operator. The information in this section is presented under the following headings:

a. General description.

b. Input message formats.

c. Output message formats.

d. Data display console input operations.

e. Data display console status codes.

GENERAL DESCRIPTION.

The data display console is an operator-controlled, cathode-ray type of display equipment that converts digital input data received from a display/bulk drum control into character stroke data (alphanumeric characters, special symbols, or vectors) for visual display on the face of a CRT. Each data display console contains a 19-inch CRT (the situation display), which is used primarily to display geographic information and air surveillance information, and a 5-inch CRT, which is used primarily to display a summary of the information available for display on the situation display. The data display console is also equipped with a manual keyboard and a light-sensing device (light gun) that enable the operator to generate input messages for transfer to the data processing set. This system is used primarily for requesting additional information regarding displayed data; however, it can also be used to provide the program in control with new information regarding the displayed data. The data display console can be operated in either of two modes; active or test. The operating mode is selected by use of a push-button indicator on the front panel of the console. When the data display console is in the active mode, display inputs from the active display/bulk drum unit are processed and displayed. Conversely, when the data display console is in the test mode, display inputs from the test display/bulk drum unit are processed and are displayed. Active display data normally consists of geographic maps, aircraft tracks and associated track data, weapons locations, and predicted points of intercept. The test function is normally used to display a preselected test pattern.

During the display data readout sequence of the display/bulk drum unit, all messages that are read out are transmitted to all data display consoles. Since it would be impractical to display all messages on all consoles, 40 category-selection switches are mounted on the front panel of the data display consoles; these switches enable the operator to select the information to be displayed on a particular console. The category-selection switches are functionally divided into three classes: primary category switches, secondary category switches, and data category switches. Thus the operator can, at his own discretion, control the routing of all messages that belong in these three categories. In addition to the category-selection switches, three switches mounted on the maintenance panel of the data display console are also used to control message routing. These switches are the CONSOLE ADDRESS switch, the GROUP A switch, and the GROUP B switch. The CONSOLE ADDRESS switches are used to assign a unique number (address) to each data display console and thereby enable messages to be addressed to a particular data display console. The GROUP A and GROUP B switches are used to assign each data display console to two of six groups; therefore, messages can be addressed to a group of data display consoles. When a message is addressed to a particular console or to a group of consoles, the message is referred to as a "forced" message and is unconditionally displayed by the console or consoles addressed.

DATA DISPLAY CONSOLE INPUT MESSAGES.

Three different types of input messages are transmitted to the data display consoles by way of a display/bulk drum unit: situation-vector messages, situation-symbol messages, and tabular symbol messages. The format of the three types of input messages is illustrated in figure 4-24. The situation-vector message and the situation-symbol message normally are used to implement the display of a track-symbol pattern on the situation display CRT. A track-symbol pattern consists of a vector and up to 18 symbols that are used to provide information pertaining to the vector. The situation-vector message is used to implement the display of the vector, and the situation-symbol message is used to implement the display of the symbols (one message is required for each symbol). The format of the track-symbol pattern is illustrated in figure 4-25. The tabular message is used to implement the display of symbols on the tabular display CRT. A single display presentation may require many input messages. However, since the data display console can receive and process messages at the rate of one every 7.3 microseconds and since a continuously legible display can be maintained if a data renewal rate of 15 times per second is maintained, the order in which a group of messages is transmitted to the data display console has no effect on the overall composite presentation.

SITUATION-VECTOR MESSAGE.

The situation-vector message is used to implement the display of a vector on the situation display CRT. This message consists of seven binary-coded groups and a light-sensor control (LSC) bit. The first two groups, which consist of bits 1 thru 12 and bits 13 thru 24, are used to establish the gross position (point of origin) of the vector. This position is defined in terms of X and Y and is with respect to the lower left-hand corner of the CRT. During the normal (times 1) operating mode of the data display console, bits 1 thru 9 are used to define gross position along the horizontal coordinate, and bits 13 thru 21 are used to define gross position along the vertical coordinate. Bits 10 thru 12 and bits 22 thru 24 are used during the three expansion modes (X2, X4, and X8) of the data display console. During the times-2 expansion mode, bit 2 becomes the most significant bit of the horizontal gross position field and bit 10 becomes the least significant bit. In addition, bit 14 becomes the most significant bit of the vertical gross position field, and bit 22 becomes the least significant bit. The bit configurations used during the normal operating mode and during the three expansion modes are illustrated in figure 4-26. There are 512 points on the situation display CRT that can be selected as points of origin by use of the gross position bits. The screen area is subdivided by each of the nine bits in such a manner that the distance between these points becomes smaller and smaller until the least significant bit in each expansion mode moves the point of origin by only 0.025 inch. The manner in which the CRT is subdivided along the horizontal coordinate by bits 1 thru 9 is illustrated in figure 4-27. The CRT is subdivided along the vertical coordinate in the same manner by bits 13 thru 22. It should be noted that the origin of a vector is located to the extreme right of the display when all nine X position bits are 1's and to the extreme left when all nine X bits are 0's. The origin of a vector is designated as the extreme upper section when all nine Y position bits are 1's, and the extreme lower section is designated when all nine Y position bits are 0's. Consequently, the upper right-hand corner of the situation display is designated as the point of origin when the 18 gross-position bits that are used during the normal display mode are 1's.

SITUATION VECTOR MESSAGE

	X	Y	ΔX	ΔY	10 T 11	MRF	LSC	MNRF	P
NO. OF BITS	12	12	6	6	2	4	1	5	1

SITUATION SYMBOL MESSAGE

	X	Y	FORMAT AND FEATURE	SYMBOL	T 01	MRF	LSC	MNRF	P
NO. OF BITS	12	12	6	6	2	4	1	5	1

TABULAR MESSAGE

	ZEROS	FR	FC	SYMBOL	T 01	MRF	LSC	MNRF	P
NO. OF BITS	21	4	5	6	2	4	1	5	1

X: X GROSS POSITION
Y: Y GROSS POSITION
ΔX: VECTOR X (COMPONENT MAGNITUDE PLUS DIRECTION)
ΔY: VECTOR Y (VERTICAL COMPONENT MAGNITUDE PLUS DIRECTION)

T: MESSAGE TYPE
- 00: TABULAR SYMBOL
- 01: SITUATION SYMBOL
- 10: EXPANDABLE VECTOR (GEOGRAPHIC OR STROBE VECTOR
- 11: NONEXPANDABLE VECTOR (TRACK VECTOR)

FR: FORMAT ROW
FC: FORMAT COLUMN
LSC: LIGHT SENSOR CONTROL
MNRF: MINOR ROUTING FIELD
MRF: MAJOR ROUTING FIELD
P: PARITY

Figure 4-24. Data Display Console Input Message Formats

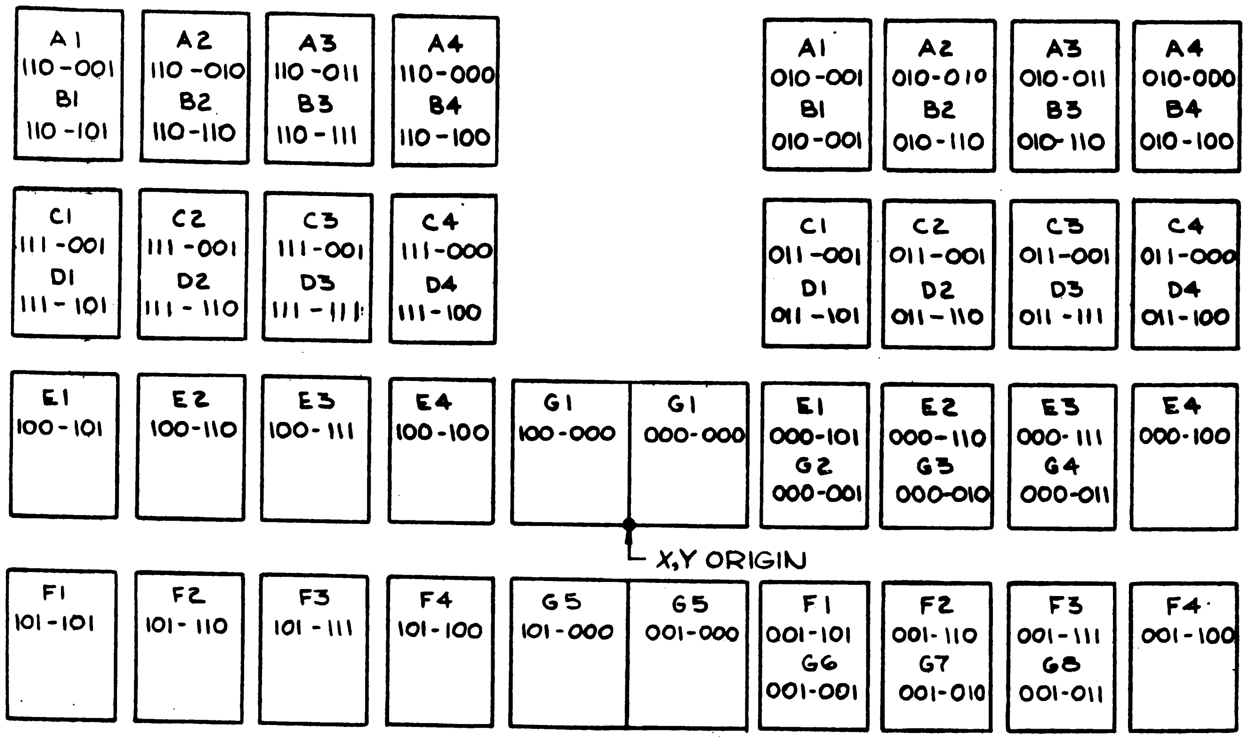


Figure 4-25. Track-Symbol Pattern Format

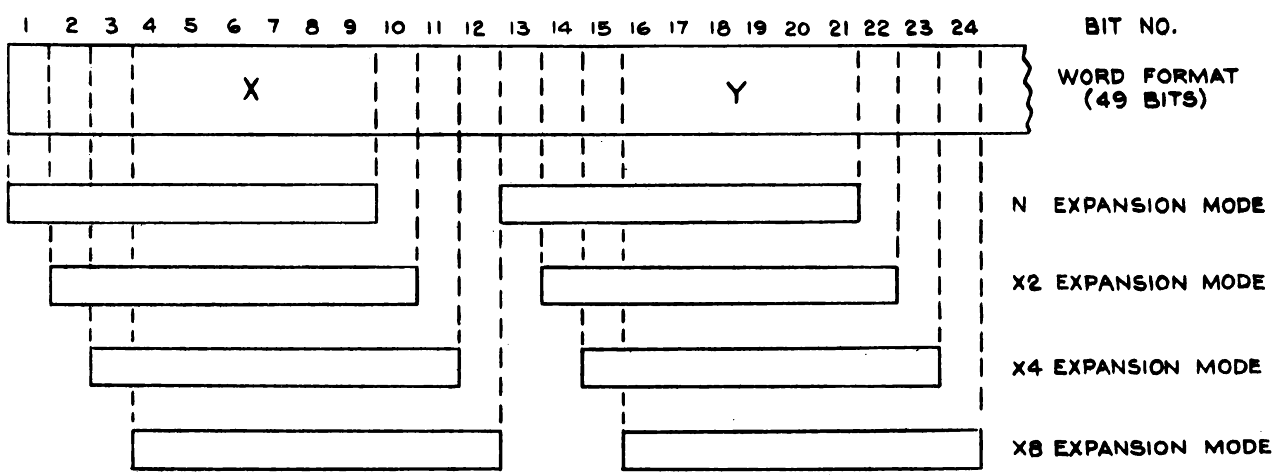


Figure 4-26. Gross-Position Bits of Input Message Used During X and Y Expansion Modes

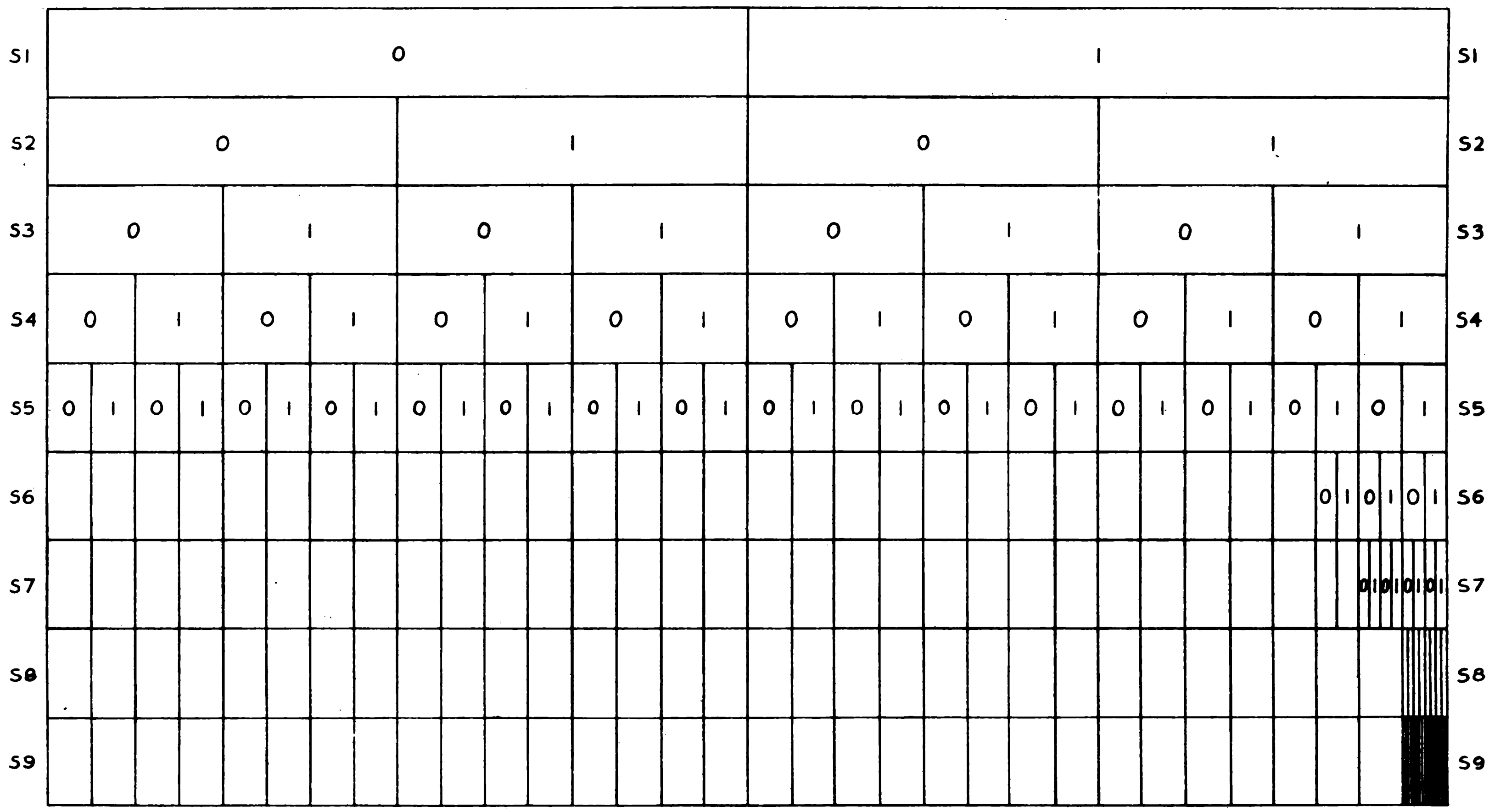


Figure 4-27. Gross-Position Division of Situation Display Screen

The third and fourth groups (bits 25 thru 30 and bits 31 thru 36) of the situation-vector messages are used to establish the horizontal and vertical components of the vector. Bits 25 and 31 are used to establish the direction of the vector and bits 26 thru 30 and bits 32 thru 36 are used to establish the magnitude (ΔX and ΔY components, respectively). When bit 25 is a 1, a right (positive) direction is indicated on the situation display. Conversely, when bit 25 is a 0, a left (negative) direction is indicated. When bit 31 is a 1, an upward (positive) direction is indicated on the situation display. Conversely, when bit 31 is a 0, a downward (negative) direction is indicated. The fifth group (bits 37 and 38) are the type-identification code for the situation display message. These bits are used to specify whether the vector to be displayed is an expandable (geographic or strobe) vector or a nonexpandable (track) vector. A code of 10 denotes an expandable vector, and a code of 11 denotes a nonexpandable vector.

The sixth group (bits 39 thru 42) and the seventh group (bits 44 thru 48) of the situation-vector message are used to control the routing of the message; that is, they are used to enable the message to be displayed on a particular data display console or consoles. The sixth group is the major routing field; this field is used either to define one of the 14 primary message categories or to indicate that one of the 18 data categories is defined by the minor routing field. The seventh group is the minor routing field; this field is used either to define one of the eight secondary message categories or one of the 18 data categories. The minor routine field is also used to denote the address of a particular data display console or the group designation of one or more consoles. When the minor routing field is used in this manner, the message is referred to as a forced message. The binary codes that are used to define each message category and the various types of forced messages are listed in table 4-8. In table 4-8, the data display console is referred to as DDC. It should be noted that a primary category code may be included in the same message that contains either a forced-message code or a secondary-category code. Bit 43 of the situation vector message is the light sensor (light gun) control bit. When this bit is a 1, the corresponding vector can be "hooked" by the operator by use of the light gun. Conversely, when this bit is a 0, the corresponding vector cannot be tagged by use of the light gun.

Table 4-8. Data Display Console Input Message Routing Codes

Message Routing	Category Designation	Message Routing Field Code (Octal)	
		Major	Minor
Forced to DDC 1	Not applicable	*	21
Forced to DDC 2	Not applicable	*	22
Forced to DDC 3	Not applicable	*	23
Forced to DDC 4	Not applicable	*	24
Forced to DDC 5	Not applicable	*	25
Forced to DDC 6	Not applicable	*	26
Forced to DDC 7	Not applicable	*	27
Forced to DDC 8	Not applicable	*	30
Forced to DDC 9	Not applicable	*	31
Forced to DDC 10	Not applicable	*	32
Forced to DDC 11	Not applicable	*	33
Forced to each DDC in group 1	Not applicable	*	11
Forced to each DDC in group 2	Not applicable	*	12
Forced to each DDC in group 3	Not applicable	*	13
Forced to each DDC in group 4	Not applicable	*	14

Table 4-8. Data Display Console Input Message Routing Codes (Cont)

Message Routing	Category Designation	Message Routing Field Code (Octal)	
		Major	Minor
Forced to each DDC in group 5	Not applicable	*	15
Forced to each DDC in group 6	Not applicable	*	16
Primary Cat. 1	TROUBLE + M1 TRACKS	01	*
Primary Cat. 2	SPARE	02	*
Primary Cat. 3	CORRELATED AMD	03	*
Primary Cat. 4	UNCORRELATED AMD	04	*
Primary Cat. 5	UN CORR STROBES	05	*
Primary Cat. 6	CORR CONF STROBES	06	*
Primary Cat. 7	CORR UNCONF STROBES	07	*
Primary Cat. 8	WD #6	10	*
Primary Cat. 9	WD #5	11	*
Primary Cat. 10	WD #4	12	*
Primary Cat. 11	WD #3	13	*
Primary Cat. 12	WD #2	14	*
Primary Cat. 13	WD #1	15	*
Primary Cat. 14	SD + UNASSIGNED	16	*
Secondary Cat. 1	JAMMER HUKP	*	01
Secondary Cat. 2	NONJAMMER HUKP	*	02
Secondary Cat. 3	F, R TRACKS	*	03
Secondary Cat. 4	S, B, Y, W TRACKS	*	04
Secondary Cat. 5	INTCPTS ON INTCPT	*	05
Secondary Cat. 6	INTCPTS ON CAP	*	06
Secondary Cat. 7	INTCPTS ON RTB	*	07
Secondary Cat. 8	POP UP ATTENTION	*	10
Data Cat. 1	SPARE	17	01
Data Cat. 2	PRESENT SEARCH	17	02
Data Cat. 3	PRESENT BEACON	17	03
Data Cat. 4	HIST CORR SEARCH	17	04
Data Cat. 5	HIST UNCORR SEARCH	17	05
Data Cat. 6	HIST CORR BEACON	17	06

Table 4-8. Data Display Console Input Message Routing Codes (Cont)

Message Routing	Category Designation	Message Routing Field Code (Octal)	
		Major	Minor
Data Cat. 7	HIST UNCORR BEACON	17	07
Data Cat. 8	OPS COND + ATTN DISP	17	10
Data Cat. 9	BOUNDARIES ADIZ	17	11
Data Cat. 10	GEO REF	17	12
Data Cat. 11	LRR + GAT SITES	17	13
Data Cat. 12	DIV ADAPT #1	17	14
Data Cat. 13	SPARE	17	15
Data Cat. 14	DIV ADAPT #2	17	16
Data Cat. 15	AADCP + D RING	17	17
Data Cat. 16	BOMARC BASE	17	20
Data Cat. 17	RECOVERY BASES	17	21
Data Cat. 18	BASE + STOPR PNTS	17	22

* A major-category code may be included in the same message that contains either a forced message code or a secondary-category code.

SITUATION-SYMBOL MESSAGE.

The situation-symbol message is used to implement the display of a symbol on the situation display CRT. This message consists of seven binary-coded groups and a light-sensor control bit. As shown in figure 4-24, the format of the situation-symbol message is the same as the format of the situation vector message except for the second and third binary-coded groups. The gross-position fields, major and minor routing fields, and the LSC bit provide the same functions as those explained previously for the situation-vector message. The type-identification code for the situation symbol message is 01. The second group (bits 25 thru 30) of the situation-symbol message is the format-and-feature code. These bits are used to determine where the particular symbol will be displayed within the track symbol pattern and to determine which feature-selection switch (A, B, C, D, E, or F) on the front panel of the data display console must be pressed in order to display the symbol. The format-and-feature code consists of the format locator bit (bit 25), the format-and-feature row code (bits 26 through 28), and the format column code (bits 29 and 30). The format locator bit is used to determine whether the symbol will be displayed to the left or right of the point of origin as defined by the X and Y gross-position fields (bits 1 thru 24). When bit 25 is a 1, the symbol is displayed to the left of the point of origin; when bit 25 is a 0, the symbol is displayed to the right of the point of origin. The format-and-feature row code and the format column code are used to determine where the symbol will be displayed within the track-symbol pattern. As shown in figure 4-25, a complete track-symbol pattern consists of five columns of symbols; the first two rows contain four symbols, and the second two rows contain five symbols. Bits 26 thru 28 contain the row and feature-selection code and bits 29 and 30 contain the column code. The binary configurations that are used for the format-and-feature row code and for the format column code are listed in table 4-9. It should be noted that G feature symbols are forced and will be displayed regardless of the feature switch positions. The fourth binary-coded group (bits 31 thru 36) in the situation symbol message is the symbol code. The binary code that corresponds to each symbol that can be displayed is listed in table 4-10. The symbols that are listed in table 4-10 as special symbols are illustrated in figure 4-28. It should be noted that when an octal code of 77 is placed in the symbol-code portion of the situation-symbol message, no symbol is displayed; instead, the COMPUTER ALARM indicator on the data display console lights, and the audible alarm in the data display console sounds.

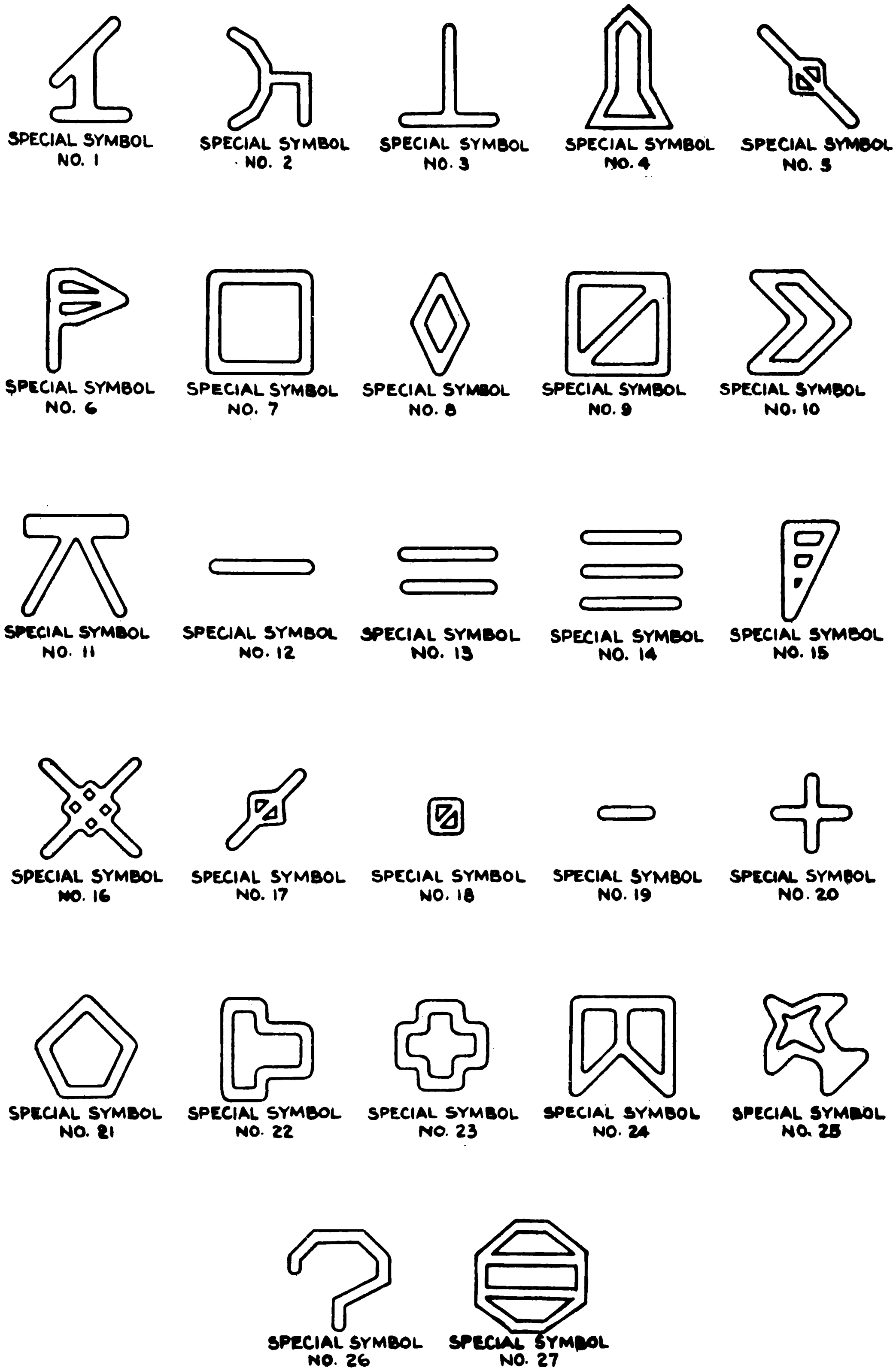


Figure 4-28. Data Display Console Special Symbols

Table 4-9. Situation Symbol Message Format-and-Feature Codes

Row	Feature	Binary Code	Column	Binary Code
1	A	100	1	01
1	B	101	2	10
2	C	110	3	11
2	D	111	4	00
3	E	001		
3	G	000		
4	F	011		
4	G	010		

Table 4-10. Data Display Console Symbol Codes

Octal Code	Symbol
00	0
01	1
02	2
03	3
04	4
05	5
06	6
07	7
10	8
11	9
12	Special symbol No. 1
13	Special symbol No. 2
14	Special symbol No. 3
15	Special symbol No. 4
16	Special symbol No. 5

Table 4-10. Data Display Console Symbol Codes (Cont)

Octal Code	Symbol
17	Special symbol No. 6
20	Special symbol No. 7
21	A
22	B
23	C
24	D
25	E
26	F
27	G
30	H
31	I
32	Special symbol No. 8
33	Special symbol No. 9
34	Special symbol No. 10
35	Special symbol No. 11
36	Special symbol No. 12
37	Special symbol No. 13
40	Special symbol No. 14
41	J
42	K
43	L
44	M
45	N
46	O
47	P
50	Q
51	R
52	Special symbol No. 15

Table 4-10. Data Display Console Symbol Codes (Cont)

Octal Code	Symbol
53	Special symbol No. 16
54	Special symbol No. 17
55	Special symbol No. 18
56	Special symbol No. 19
57	Special symbol No. 20
60	Special symbol No. 21
61	Special symbol No. 22
62	S
63	T
64	U
65	V
66	W
67	X
70	Y
71	Z
72	Special symbol No. 23
73	Special symbol No. 24
74	Special symbol No. 25
75	Special symbol No. 26
76	Special symbol No. 27
77	Alarm

TABULAR-SYMBOL MESSAGE.

The tabular-symbol message is used to implement the display of symbols on the tabular display CRT. The symbol code, major and minor routing fields, and the LSC bit (see figure 4-24) perform the same functions as those of the situation symbol message. The type-identification code for the tabular symbol message is 00. The tabular display is functionally divided into 16 rows and 17 columns; thus, there is a total of 272 positions at which a symbol can be displayed on the tabular display CRT. The format row (FR) code (bits 22 thru 25) of the tabular symbol message is used to specify the row, and the format column (FC) code (bits 26 thru 30) is used to specify the column. The 272 symbol positions and the row codes and column codes that are used to display a symbol at each position are illustrated in figure 4-29. Since the FR and FC codes are used to provide position data for the symbol, X and Y coordinates are not required. Therefore, bits 1 thru 21 of the tabular symbol messare are normally 0's. It should be noted that when an octal code of 77 is placed in the symbol code portion of the tabular-symbol message, no symbol is displayed; instead, the COMPUTER ALARM indicator on the data display console goes out, and the audible alarm in the data display console turns off. The audible alarm can be turned off by the operator, but the COMPUTER ALARM indicator can only be extinguished by means of the tabular-symbol alarm message.

DATA DISPLAY CONSOLE OUTPUT MESSAGES.

There are two types of output messages that can be generated at the data display console for transfer to the data processing set: a keyboard-actuated message and a light-gun actuated message. Each type of message consists of two 48-bit words. The format of the output messages is illustrated in figure 4-30. The transfer of the two-word output message to the I/O module is controlled by the I/O module, which transfers data as a series of six-bit characters. The manner in which the two words are segmented and are transferred is shown by the two lower message formats in figure 4-24. C1 represents the first six-bit character transmitted, C2 represents the second six-bit character, and so forth. The time required to perform a data display console read operation (two words), from the execution of the command descriptor to the storing of the result descriptor in core memory, is approximately 50 microseconds.

KEYBOARD-ACTUATED MESSAGE.

The first word of the keyboard-actuated message contains a five-bit binary code (bits 44 thru 48) that is used to indicate the setting of the rotary heading switch. Bit 43 of this word is a control bit that is used to indicate the operating mode online or test of the particular data display console. If this bit is a 1, it indicates that inputs from the active display/bulk drum unit are being processed; conversely, if this bit is a 0, it indicates that inputs from the test display/bulk drum unit are being processed. Bits 1 thru 42 of the first word of the keyboard-actuated message are not used and are always 0's. The second word of the keyboard-actuated message contains 12 four-bit binary codes that are used to indicate the settings of the keyboard switches. Each data display console operator has at his disposal four groups of 15 vertically-arranged push-button indicators and eight groups of 10 vertically-arranged push-button indicators, which can be used to generate information for inclusion in the second word of the two-word message. The 12

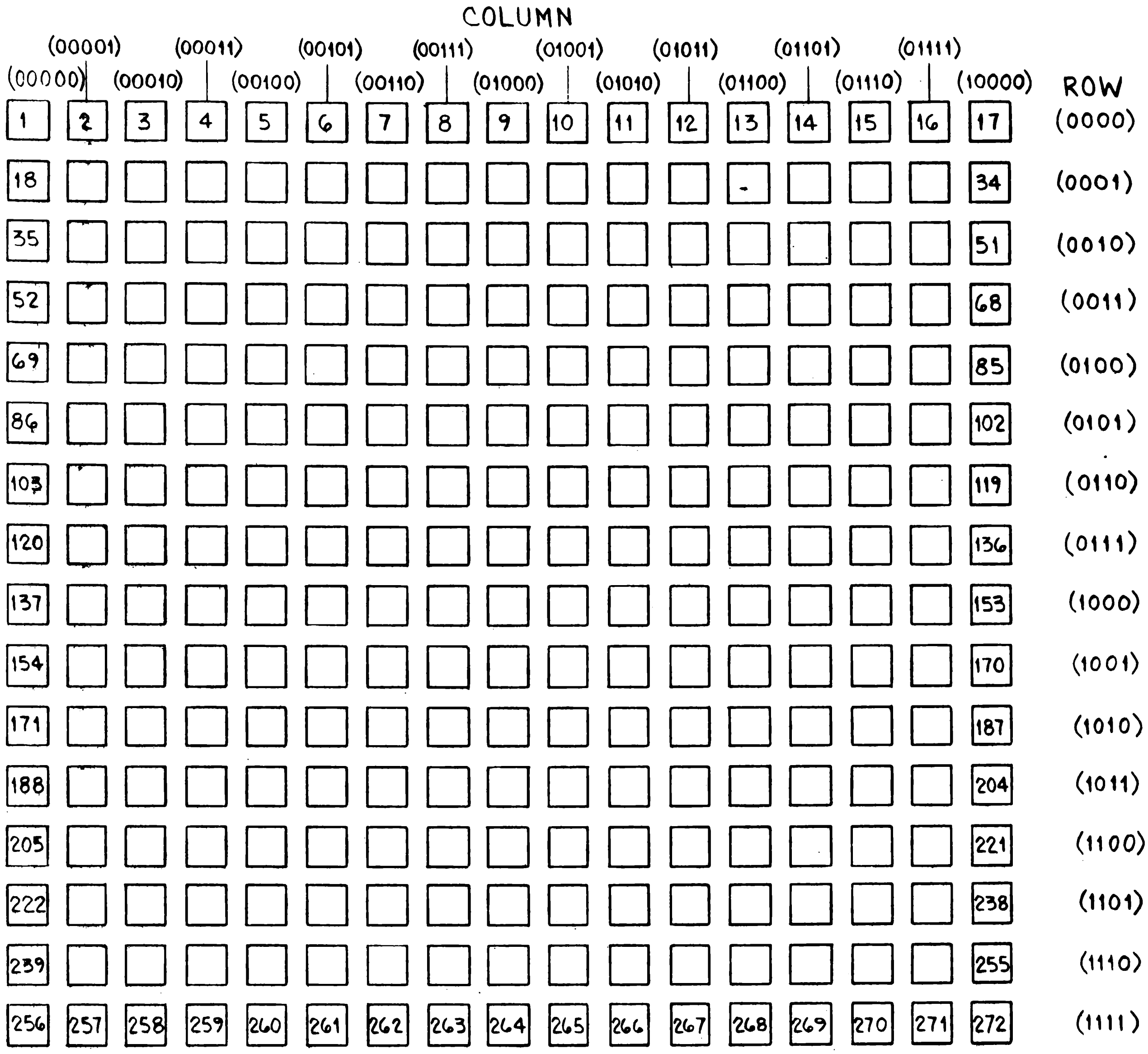


Figure 4-29. Tabular Symbol Display Format

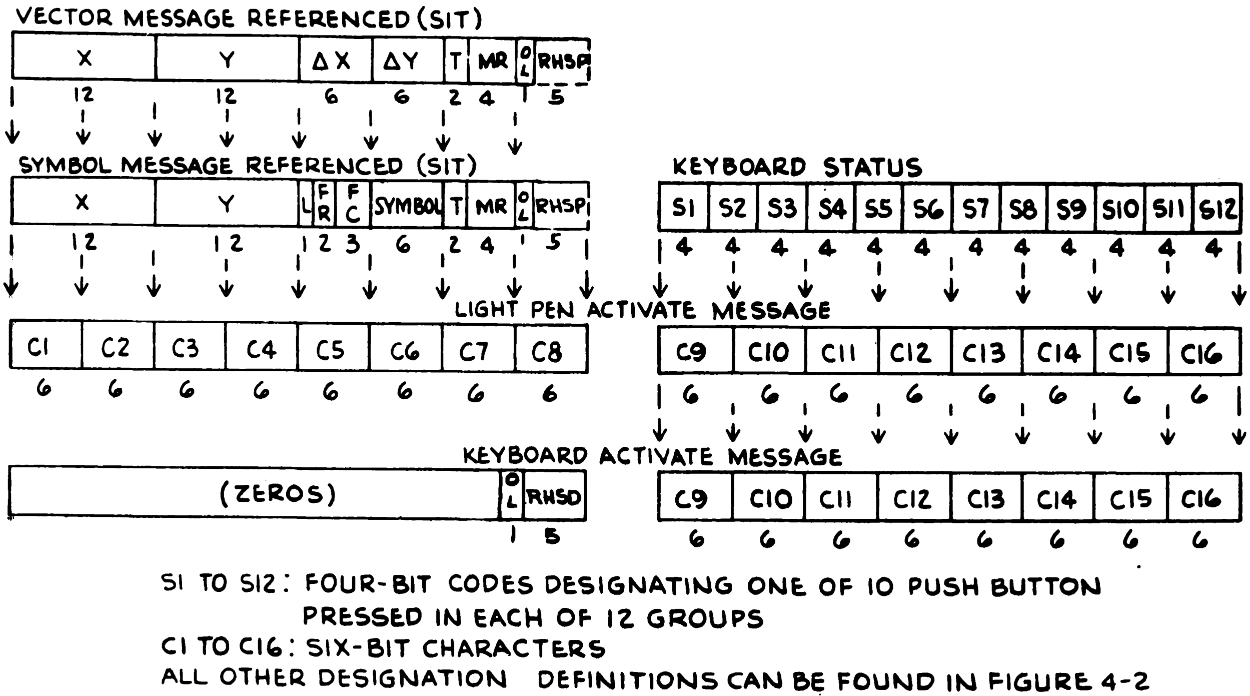


Figure 4-30. Data Display Console Output Message Formats

groups of push-button indicators on the front panel of the data display console are identified by S1 thru S12 from left to right. Each push-button indicator is considered to be a switch position. Each switch position is represented in the output message by a four-bit binary code. The four-bit codes used to represent the 10 push-button indicators in a group are binary 0001 thru 1010 from the bottom push button to the top push button. The four-bit codes used to represent the 15 push-button indicators in a group are binary 0001 thru 1111 from the bottom push button to the top push button. A four-bit binary code of 0000 in the output message indicates that no push-button indicator in the corresponding group has been actuated. When the keyboard message has been generated by the operator, the KEYBOARD ACTIVATE push button must then be pressed; when this push button is pressed, the unit available line to the I/O modules is set high to enable the program in control to read the data display console output message. It should be noted that if the safety interlock switch on the data display console is not actuated (on those data display consoles that have a safety interlock switch), a code of 0000 is generated whenever either of the bottom two push-button indicators in the fifth column from the right is pressed. For those data display consoles that are not equipped with a safety interlock switch, a code of 0000 is always generated whenever either of these two push-button indicators is pressed.

LIGHT-GUN-ACTUATED MESSAGE.

The light-gun-actuated message is generated whenever the light gun is used by the operator to tag a symbol or a vector. The first 42 bits of the first word of this message define the item that has been tagged. These bits are an exact duplicate of the first 42 bits of the input message that was used to implement the display of the vector or symbol that has been hooked. The remaining six bits (bits 43 thru 48) of the first word of this message perform the same function as described for the keyboard-actuated message. The second word of the light-gun activated message is identical to the second word of the keyboard-activated message. When a successful hook is made by the operator thru use of the light gun, the unit available line to the I/O modules is set high to enable the program in control to read the data display console output message.

DATA DISPLAY CONSOLE INPUT OPERATION.

Since there is no direct communication between the data display consoles and the program in control, the program in control must periodically interrogate the data display consoles for input messages by attempting read operations. As stated previously, whenever the KEYBOARD ACTIVATE push button is pressed or whenever a successful tag is made by use of the light gun, the unit-available line from the applicable data display console to the I/O modules is set high, and the read operation can be initiated by the program in control. The following rules apply to the formation of a command descriptor for a data display console input operation (refer to appendix 4).

a. The word-count portion (bits 1 thru 12) contains a count that specifies the total number of words to be read from the data display console. This count must always be equal to 2 since the data display console input message always comprises only two words. If a word count greater than 2 is specified, the operation will not be terminated properly.

b. The record count portion (bits 13 thru 18) should always be made equal to 00 (octal).

c. Bits 21 thru 36 contains the memory starting address, that is, the address of the location into which the first word read from the data display console will be loaded; the second word read from the data display console is loaded into the location immediately following this location.

d. The priority bit (bit 38) is not used.

e. The device number portion (bits 39 thru 43) must contain the device number for the data display console that is to be addressed. The device-number bit codes for the maximum complement of data display consoles that can be contained in an expanded BUIC NCC are as follows:

(1) 01010: data display console No. 1.

(2) 01011: data display console No. 2.

(3) 01100: data display console No. 3.

(4) 01101: data display console No. 4.

(5) 01110: data display console No. 5.

(6) 01111: data display console No. 6.

(7) 10000: data display console No. 7.

(8) 10001: data display console No. 8.

(9) 10010: data display console No. 9.

(10) 10011: data display console No. 10.

(11) 10100: data display console No. 11.

(12) 10101: data display console No. 12.

(13) 10110: data display console No. 13.

(14) 10111: data display console No. 14.

(15) 11000: data display console No. 15.

(16) 11001: data display console No. 16.

f. Bits 44 and 45 define the type of operation. These bits must always contain a code of 10, which specifies a read operation. An I/O-module-to-data-display-console write operation is not possible.

g. Bits 46 thru 48 are not used. These bits may contain any configuration other than 000 or 001 (refer to paragraph 4-32). A code of 010 is normally placed in these bits.

A parity bit is added by the data display console to each character that is transferred to the I/O module. At the I/O module, a parity check is made on each character. If a parity error is detected, the operation is terminated, and the word containing the error is not stored in the memory module. A result descriptor that indicates (a) a parity error from a terminal device (bits 17, 18, and 19 equal to 110) and (b) the address of the location in which the word was to be stored is returned from the I/O module to the descriptor list in memory.

DATA DISPLAY CONSOLE STATUS CODES.

The data display consoles do not have the capability of generating status codes. Therefore, the device status field (bits 20, 37, and 38) in the result descriptor should always be equal to 000.

GENERAL.

The Simulator Group OA-7728/GSA-51 (simulator group) is a one-way input terminal device that is comprised of two simulator manual keyboard components (A and B) and the simulator compatibility unit. The two simulator manual keyboard components are physically and electrically identical. Each of these components is comprised of a simulator manual keyboard, a keyboard stand, and a junction box (see figure 4-34). One of the simulator manual keyboard components, together with the simulator compatibility unit, is illustrated in figure 4-34 (the junction box is not shown).

The primary function of the simulator group is to provide a means of manually composing input messages that can be used to simulate tactical air situations, so that operators can be trained in the use and operation of the data display consoles and in the solving of tactical problems. These messages are composed by means of controls that are provided on the simulator manual keyboards. The simulator compatibility unit provides control signals that are required for operating the simulator group with the I/O modules of the data processing set and performs the logic conversion of the four-bit simulator manual keyboard output characters to the six-bit character code format that is used in the DPS central processing modules. Since the simulator group is capable of providing known inputs to the data processing set, it can also be used as a maintenance device when malfunctions occur in certain equipments of the BUIC NCC.

GENERAL DESCRIPTION.

The simulator group supplies one-word input messages to the central processing modules of the DPS for processing and transfer to the data display consoles via a magnetic drum unit. The simulator group is provided with an external request line to the data processing set so that operator requests for entering messages can be recognized by the program in operation. An external request can be entered from either of the two simulator manual keyboards. A simulator group read operation is initiated by a command descriptor that contains 0327 (octal) in bit locations 37 thru 48. The command descriptor normally contains a word count of 0001 (octal), since if a word count greater than 0001 is specified in the command descriptor, the same word will be read from the simulator group the number of times specified by the word count. Information is transferred from the simulator group to an I/O module at the rate of approximately 1.32 microseconds per six-bit character. The simulator group is normally used in conjunction with a special training program that is capable of converting the contents of each 48-bit word that is received from the simulator group into a series of 48-bit words that are used to simulate tactical inputs to the data display consoles. A simulator group read operation requires approximately 35 microseconds (from the execution of the command descriptor to the storing of the result descriptor in core memory). The operational features of the simulator group are listed in table 4-13.

MESSAGE FORMAT.

The composite output from a simulator manual keyboard is a 32-bit message that consists of eight four-bit groups. This message is used by the simulator compatibility unit to form the nucleus of the final 48-bit word that is sent to the data processing set. The four most significant characters of the 32-bit message are generated by use of the INTERCEPTOR TRACK NUMBER MODULE thumbwheel switches. The three least significant characters are generated by use of the GENERAL INPUT MODULE select push-button indicators. The remaining character is generated by use of the ACTION MODULE select push-button indicators. The various binary codes that are generated by use of the keyboard switches are listed in table 4-14.

The simulator compatibility unit generates the remaining 16 bits that are required to produce the eight six-bit characters necessary for a one-word read operation. Each four-bit group that is transferred from a simulator manual keyboard to the simulator compatibility unit becomes bits 3 thru 6 of a six-bit character that is subsequently transferred to an I/O module. Bit 2 of each six-bit character is not used; the simulator compatibility unit inserts a 0 in this bit position. Bit 1 of the first character that is sent to the I/O module (character 0) during each read operation is used to specify which one of the two simulator manual keyboards is currently being used; that is, from which keyboard the external request has been entered. When keyboard A is used, bit 1 is set to a 1; conversely, if keyboard B is used, bit 1 is set to a 0. Bit 1 in characters 1 thru 7 is not used, and this bit will always be a 0. The character and word format of the message word that is transferred from the simulator group to the I/O module is illustrated in figure 4-35.

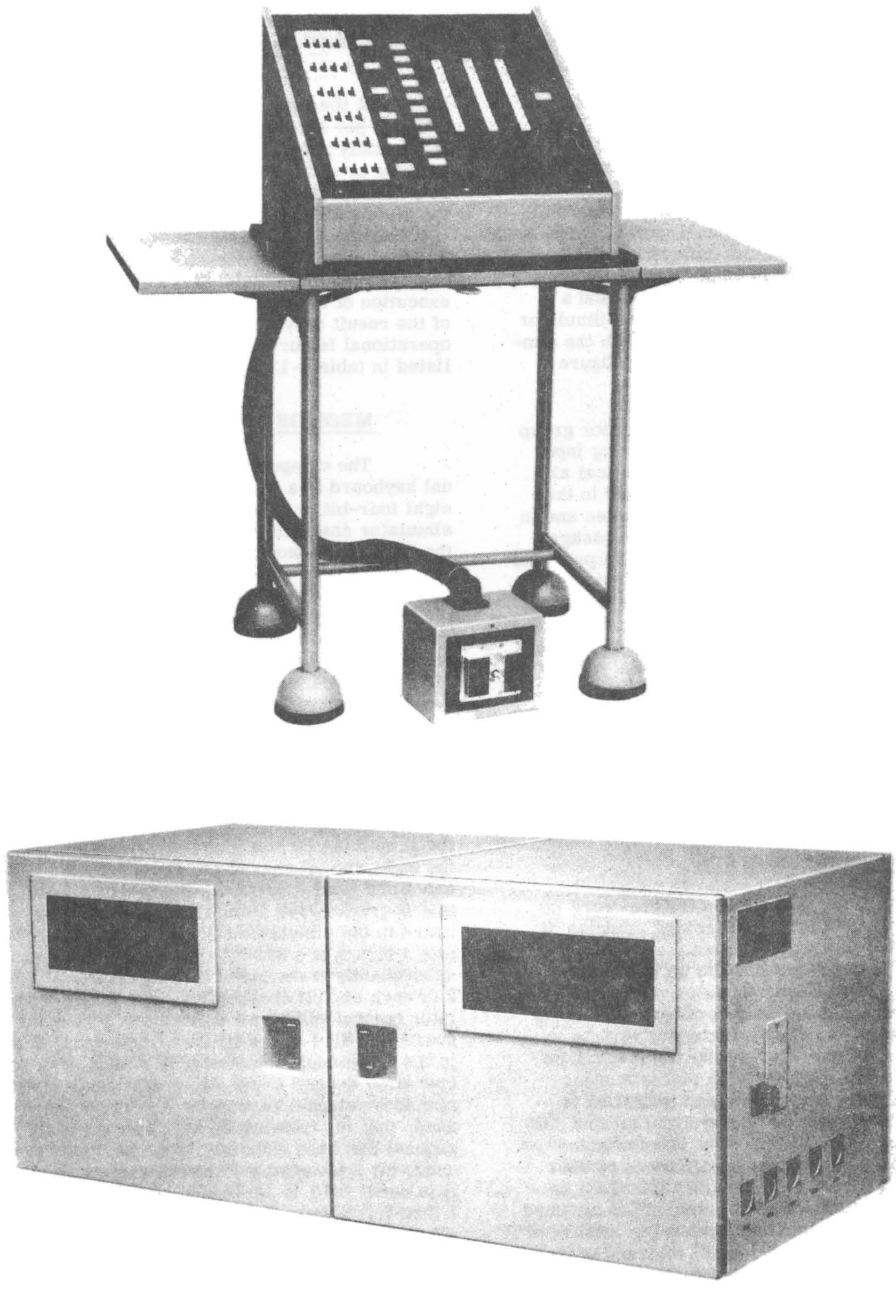


Figure 4-34. Simulator Group OA-7728/GSA-51

SIMULATOR GROUP STATUS CODES.

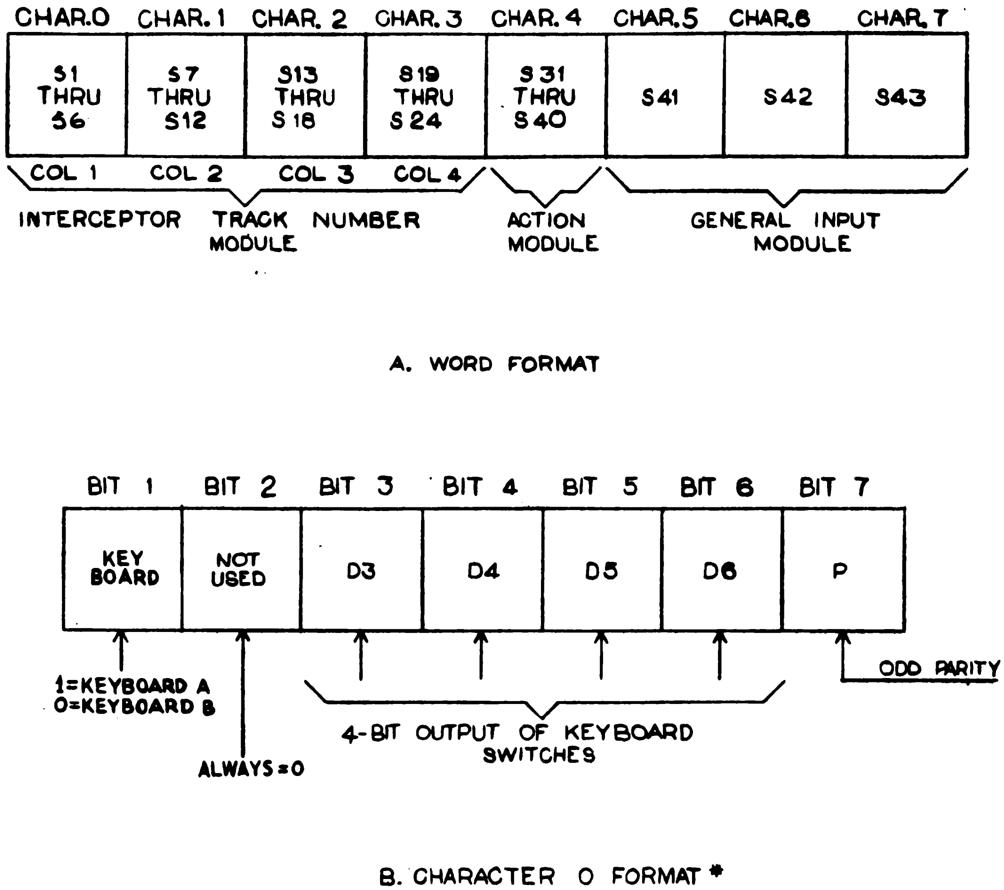
The malfunction status code of 100 is the only status code that can be returned in the device status field (bits 20, 37, and 38) of a result descriptor for a simulator group operation. This status will be generated by the simulator compatibility unit if (1) the unit available line from the simulator group goes low during the transfer of data from the simulator compatibility unit to an I/O module, or if (2) the external request signal that is generated by the simulator group remains high after a read operation has been initiated.

Table 4-13. Operational Features of Simulator Group

Feature	Description
INTERCEPTOR TRACK NUMBER MODULE thumbwheel switches (S1 thru S24)	Six sets of interceptor track code switches are provided (four switches per set). These switches are used to identify the particular track to which the action and general-input portions of the input message pertain.
INTERCEPTOR TRACK NUMBER MODULE select push-button indicators (S25 thru S30)	One push-button is provided for each set of INTERCEPTOR TRACK NUMBER MODULE thumbwheel switches. These push-buttons are used to select one of the six preselected interceptor track numbers.
ACTION MODULE select push-button indicators (S31 thru S40)	Ten ACTION MODULE push-button indicators are provided to enable 10 general tactical conditions to be simulated.
GENERAL INPUT MODULE select push-button indicators (S41, S42, and S43)	Three sets of general input push-button indicators are provided (10 per set). During each simulator group operation, one push-button indicator in each group is used. These push-buttons are used to simulate specific information pertinent to the particular action that has been selected.
ACTIVATE MODULE push-button indicator (S44)	This push-button indicator is used to generate external request signals that are subsequently sent to the data processing set to initiate simulator group operations.

Table 4-14. Simulator Manual Keyboard Output Codes

Binary Code	INTERCEPTOR TRACK NUMBER MODULE Switch Positions				ACTION MODULE Switches	GENERAL INPUT MODULE Switches		
	S1 thru S6	S7 thru S12	S13 thru S18	S19 thru S24	S31 thru S40	S41	S42	S43
0 0 0 1	A	0	0	0	HEADING	0	0	0
0 0 1 0	E	1	1	1	ALTITUDE	1	1	1
0 0 1 1	G	2	2	2	SPEED	2	2	2
0 1 0 0	H	3	3	3	STRTCMD HEADING	3	3	3
0 1 0 1	J	4	4	4	FLIGHT SIZE	4	4	4
0 1 1 0	K	5	5	5	DATA LINK	5	5	5
0 1 1 1	L	6	6	6	(None)	6	6	6
1 0 0 0	M	G	7	7	MARK X DATA	7	7	7
1 0 0 1	N	H	8	8	(None)	8	8	8
1 0 1 0	P	J	9	9	(None)	9	9	9
1 0 1 1	T	K						
1 1 0 0	U	L						
1 1 0 1	V	M						
1 1 1 0	X	N						
1 1 1 1	Y	P						
0 0 0 0	(Blank)	(Blank)						



NOTE:
* FORMAT OF CHARACTERS 1 THRU 7 IS SAME AS CHARACTER 0 FORMAT EXCEPT THAT BIT 1 IS NOT USED AND WILL ALWAYS EQUAL 0.

Figure 4-35. Simulator Group Output Character and Word Format

GENERAL.

The two message processor modules in the BUIC NCC serve as an intercommunication link between remote radar data processing installations and the central processing equipment of the BUIC NCC. The message processor module changes the format of the data received from these remote installations to the 48-bit data word format used in the central processing equipment; it also changes the format of output messages of the central processing equipment to the format used by the remote installations. The message processor module furnishes temporary storage for fully accumulated messages from the remote installations until these messages can be transferred to the memory modules of the data processing set. The message processor module is housed in a standard DPS equipment cabinet along with an I/O module. The message processor module and this I/O module comprise the Controller-Comparator Message Processor C-7122/GYK-10, which is illustrated in figure 4-15 (the message processor module control panel is on the right). The information in this section is presented under the following headings:

a. General description.

b. Input message formats.

c. Output message formats.

d. Message processor module operations.

e. Test loop functions.

f. Message processor module status codes.

GENERAL DESCRIPTION.

The message processor module consists basically of input and output channels thru which the messages to and from the telephone lines are processed, a core memory which is used for temporary storage of the input and output messages, and the circuitry necessary in modifying the format of these messages. The intercommunication link between each message processor module and all remote installations consists of three groups of two-wire telephone lines. All intersystem messages are received by and transmitted from the message processor module in a serial (bit-by-bit) fashion. Concurrent transmission and reception of messages are achieved by multiple inputs to and outputs from the message processor module. Two types of input messages, classified as group I and group II, are received over the telephone lines by the message processor module. Two types of output messages, classified as group I and group III, are transmitted by the message processor module over the telephone lines.

INPUT AND OUTPUT CHANNELS.

The message processor module contains 22 identical input channels for processing input messages and eight output channels for processing output messages. The 22 input channels are divided into two groups; 10 channels are allotted for group I input messages and 12 channels are allotted for group II input messages. The eight output channels are also divided into two groups; seven channels are allotted for group I output messages and one channel is allotted for group III output messages.

Message bits are received from the telephone lines and are processed thru the input channels in a serial fashion. Therefore, the input channels are scanned in sequence for the presence of one data bit at a time. If a bit is detected in a channel, that bit is processed and stored in the message processor memory location assigned to that channel. After the bit is stored, the next channel is sampled. This sampling sequence is continuous for all input channels. When one or more completed messages have been accumulated in the message processor memory, they may then be transferred to a memory module by means of a read operation. Output messages are transferred from the message processor memory to the corresponding output channel at a rate of one bit at a time. A maximum of eight bits is placed on the telephone lines at any one time, one bit from each of the eight output messages (maximum) that are contained in the message processor memory. It should be noted that output messages are transmitted continuously by the message processor module. If valid output messages are not transmitted to the message processor module, null messages are generated by the message processor module and transmitted to the telephone lines (refer to paragraph 4-228).

MESSAGE PROCESSOR MEMORY.

The memory section in the message processor module is functionally divided into three areas: an input storage area, output storage area, and stack storage area. Incoming messages from the telephone lines are accumulated in the input storage area; output messages from the I/O module are stored in the output storage area. When the input messages have been fully accumulated in the input storage area, they are transferred to the stack storage area, and from there they are transferred, upon command, to a specified memory module via an I/O module.

The memory section is a word-organized, random-access, destructive readout, ferrite-core

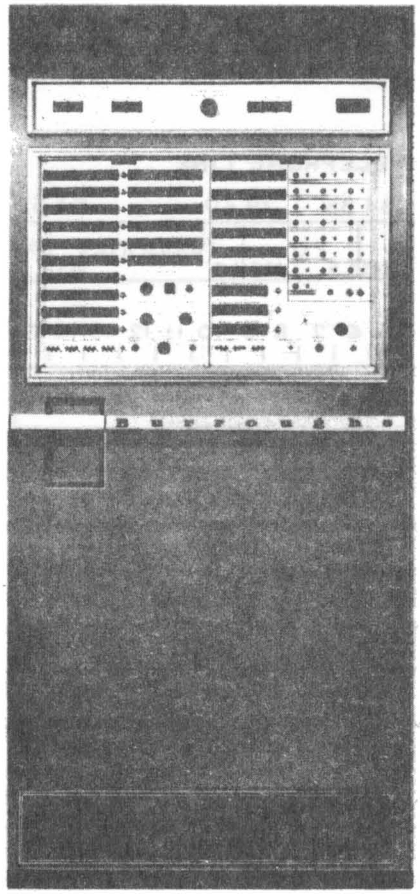


Figure 4-15. Controller-Comparator-Message Processor C-7122/GYK-10 (Message Processor Module On Right Side of Cabinet)

device that is capable of storing 384 18-bit words. The memory section is divided into 64 zones of six 18-bit locations (words) each. Zones 00 thru 27 furnish storage for messages received over the input telephone lines, and zones 30 thru 47 furnish storage for messages to be transmitted to the output channels; zones 50 thru 77 are the stack storage area. The channel assignments are listed in table 4-5. Two memory zones are assigned to each output channel; one zone may be filled with data while the message from the other zone is being placed on the telephone lines. This function ensures that valid (as opposed to null) group I and group III output messages can always be made available for transmission.

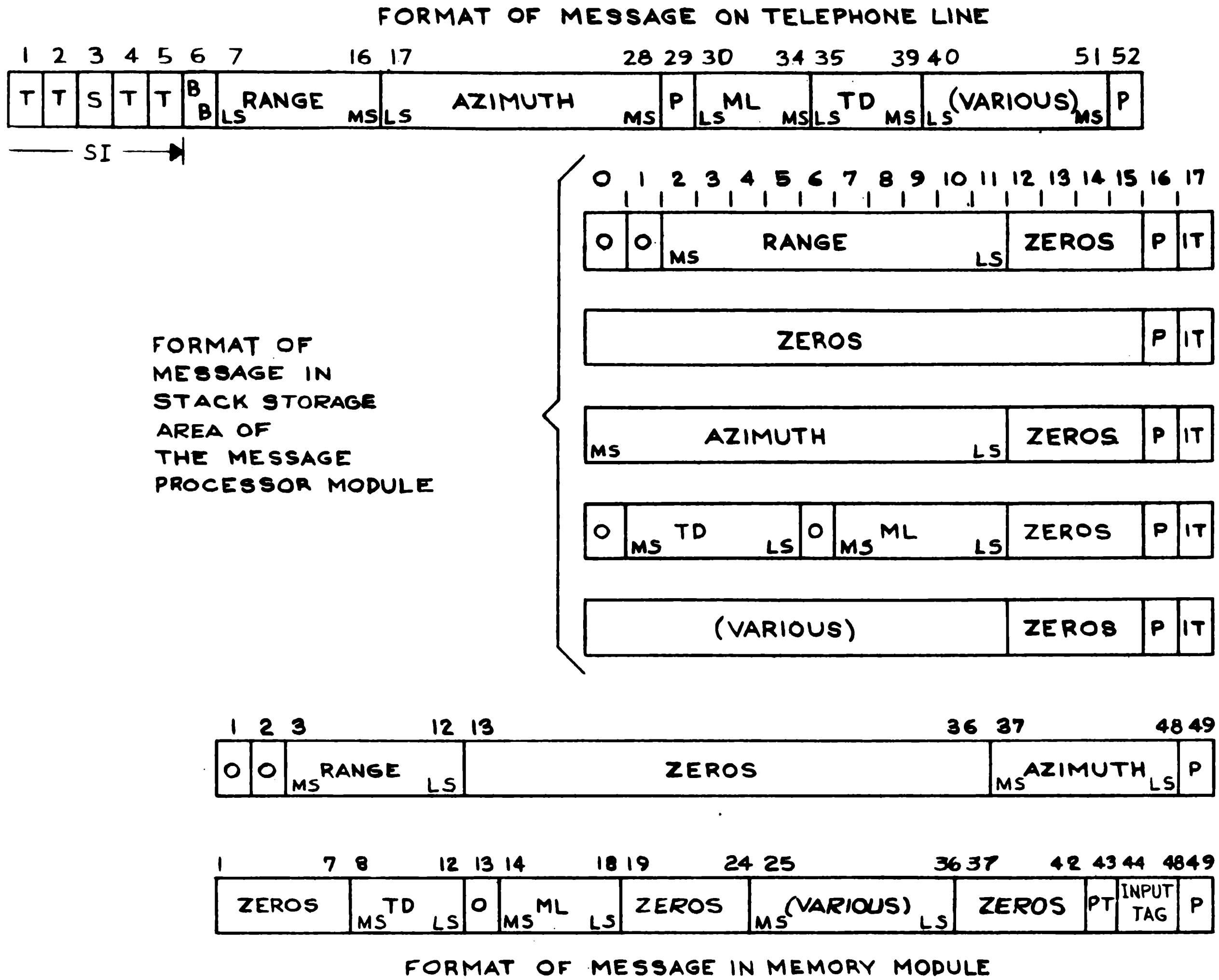
Table 4-5. Message Processor Memory Allocation

Memory Zone (Octal)	Channel (Decimal)	Message Type
00 thru 11	1 thru 10	52-bit radar input
12	--	Unused
13	Test	Internal test (92-bit)
14 thru 27	11 thru 22	92-bit input
30 and 31	1	92-bit output
32 and 33	2	92-bit output
34 and 35	3	92-bit output
36 and 37	4	92-bit output
40 and 41	5	92-bit output
42 and 43	6	92-bit output
44 and 45	7	92-bit output
46 and 47	8	78-bit output
50 thru 77	--	Buffer stack locations

INPUT MESSAGE FORMATS.

The group I and group II messages that are received by the message processor module are 52 bits and 92 bits, respectively, in length. The 52-bit group I input messages (see figure 4-16) contain 10 bits of range information, 12 bits of azimuth information, five bits of message label (ML) information, five bits of time delay (TD) information, 12 bits of various additional target data, and a busy bit (BB). A group I input message will not be accepted and processed by the message processor module unless the busy bit is a 1. The format of the group I input message on the telephone lines, in the stack storage area of the message processor memory, and in a memory module after transfer is illustrated in figure 4-16.

The 92-bit group II message (see figure 4-17) contains five separate information messages, each of which comprises 16 bits. The group II message information received by the message processor module is interleaved in five-bit sequences. The first sequence of five bits received by the message processor module is the first data bit of each of the five messages; the second sequence of five bits is the second most-significant data bit of each of the five messages; and so forth. Group II input messages are not accepted by the message processor module



NOTE:

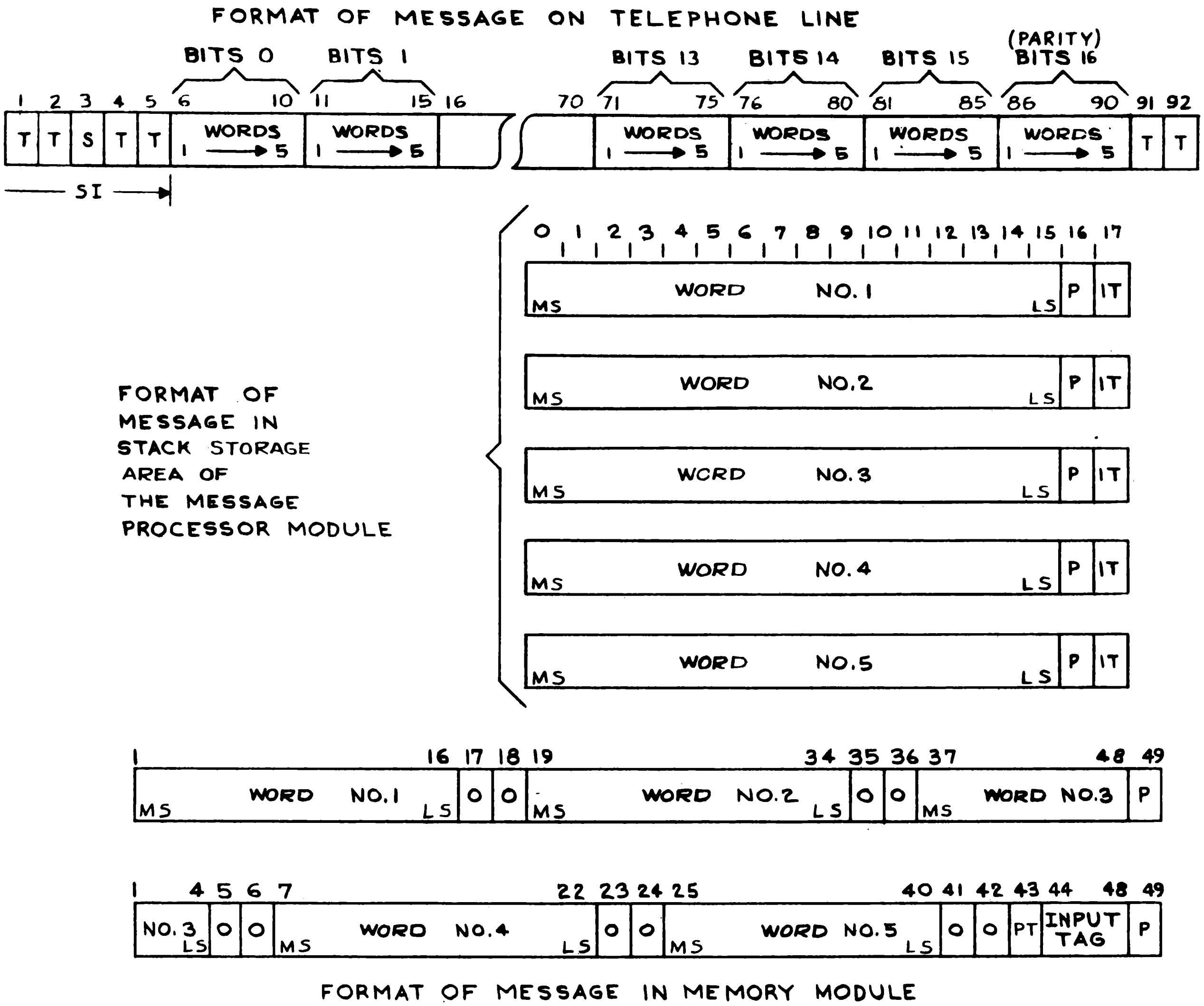
LS = LEAST SIGNIFICANT BIT
MS = MOST SIGNIFICANT BIT
BB = BUSY BIT
ML = MESSAGE LABEL DATA
TD = TIME DELAY DATA
P = PARITY BIT
S = SYNC BIT
T = TIMING BIT
PT = PARITY TAG BIT
SI = SYNC INFORMATION

Figure 4-16. Group I Input Message Formats unless either (a) the site address which is contained in bits 64, 69, 74, and 79 of the input message, corresponds to the prewired site address of the message processor module or (b) the all-parties bit of the input message (bit 84) is a 1. (These five bits are combined to form the address field of the group II input message, and they are stored in core memory as bits 18 thru 22 of the second word of the message.) The format of the group II input message on the telephone lines, in the stack storage area of the message processor memory, and in a memory module after transfer is illustrated in figure 4-17.

Five locations in the stack storage area of the message processor memory are used for each group I or group II input message (see figures 4-16 and 4-17). The first 16 bits of each word are transferred to the I/O module as three six-bit characters; logic circuitry within the message processor module automatically inserts 0's into bit positions 5 and 6 of the third character of each of these three-character groups. The 17th bit of each word in the input message is the parity (P) bit for that word; the parity bits are not transferred to the I/O module. The last bit of each 18-bit word is an identification tag (IT) bit. The five IT bits are generated within the message processor module to identify the memory zone in which the message was received and thereby to identify the message as being either group I or group II. For example, 00 000 specifies zone 00, which receives group I messages from channel 1, and 10 111 specifies zone 27, which receives group II messages from channel 22. The type of message that is received from each channel is listed in table 4-5. As the third character of each 18-bit word is transferred from the stack storage area, the IT bit is extracted from that character and replaced with a 0. The five IT bits are then combined to form the input tag of the message and are transferred to the I/O module with the parity-tag (PT) bit as the last character (bits 43 thru 48 of the second word) of the 96-bit input message (the PT bit becomes bit 43). The generation of the PT bit is a function of the parity-check feature of the message processor module; the parity-check function is controlled by use of the PARITY CHECK and PARITY DISABLE push-button indicators on the status display console. When the PARITY CHECK push-button is pressed, all input messages with incorrect parity are rejected by the message processor module. However, when the PARITY DISABLE push-button is pressed and an input message with incorrect parity is received by the message processor module, bit 43 of the second word of the message is set to a 1. It should be noted that whenever this bit is set to a 1, the appropriate CHANNEL PARITY error indicator on the front panel of the message processor module will be lit; this indicator will remain lit until a valid message (with correct parity) is received on that channel or until the PARITY LIGHTS CLEAR push button on the front panel of the message processor module is pressed.

OUTPUT MESSAGE FORMATS.

The group I and group III messages that are transmitted by the message processor module are 92 bits and 78 bits, respectively, in length. The 92-bit group I output message (see figure 4-18) is the same in content and format as the group II input message except for bits 43 thru 48. The group I output message is transmitted over the telephone lines in the same type of interleaved, five-bit sequence in which the group II message is received. The 78-bit group III output message (see figure 4-19) contains four separate information messages, each of which comprises 16 bits. The message processor module has the capability of transmitting output messages to either the telephone lines or the internal test channel or to both. Bits 44 and 45 of the second word of each group I message are used to control the routing of that message. Bit 44 is the internal test channel (IT) bit; if this bit is a 1, the message is routed to the internal test channel. Bit 45 is the telephone line (validity) bit; if this bit is a 1, the message is routed to the telephone lines. If both of these bits are 1's, the message is routed to both the internal test channel and to the telephone lines. If neither of these bits is a 1, the message is processed as a null message (a null group I output message contains all 0's). Bit 44 of the second word of a group III output message performs the same function as the corresponding bit in a group I output message. However, a validity bit is not required for group III output messages since all group III messages received from the I/O module are transmitted to the telephone lines by the message processor module. If group III output messages are not transmitted to the message processor module, null group III output messages are transmitted to the telephone lines by the message processor module. A null group III output message consists of all 0's except for bits 17, 34, 56, and 73 (these bits are 1's to maintain correct parity). Bits 43, 46, 47, and 48 of the second word of all output messages are always set to 0. It should be noted that the internal test channel of the message processor module is functionally a 92-bit input channel. Therefore, in order for group III (78-bit) output messages to be processed thru this channel, two 78-bit messages in succession must be transmitted to the message processor module. In addition, the first bit of the second 78-bit message must be a 1, since this bit becomes the all-parties bit of the 92-bit input message that is processed thru the internal test channel. The format of the group I and the group III output messages as they are stored in a memory module prior to transfer, as they appear in the stack storage area of the message processor memory after transfer, and as they appear on the output telephone lines is illustrated in figures 4-18 and 4-19.



NOTE:

LS = LEAST SIGNIFICANT BIT
MS = MOST SIGNIFICANT BIT
P = PARITY BIT
S = SYNC BIT
T = TIMING BIT
PT = PARITY TAG
IT = IDENTIFICATION TAG
SI = SYNC INFORMATION

Figure 4-17. Group II Input Message Formats

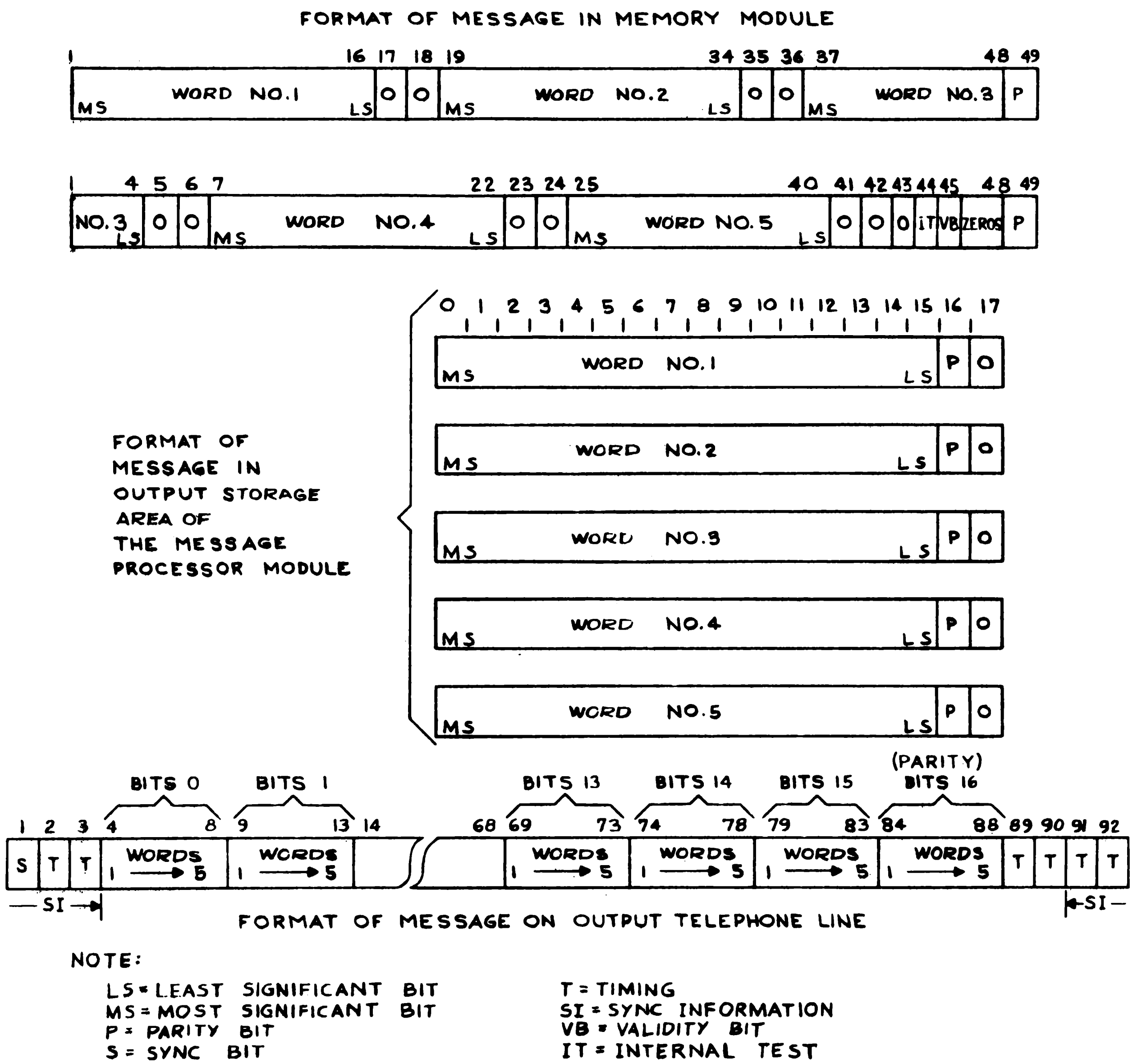


Figure 4-18. Group I Output Message Formats

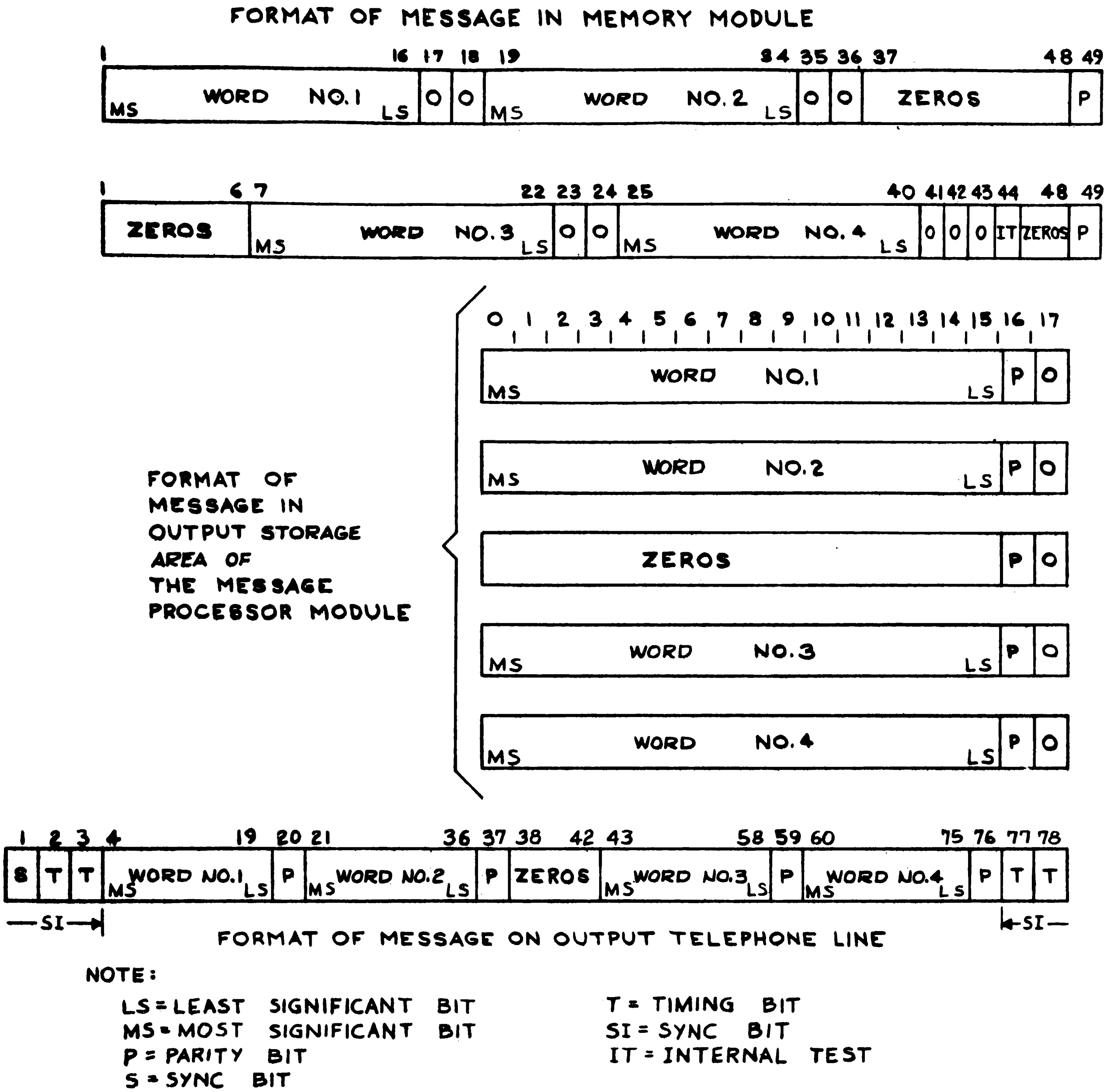


Figure 4-19. Group III Output Message Formats

MESSAGE PROCESSOR MODULE OPERATIONS.

The processing of input and output messages by the message processor module is performed in four major processing operations, as follows:

a. Automatic channel scanning performed by the message processor module. During these scan cycles, input messages are transferred from the telephone lines to the message processor memory and output messages are transferred from the message processor memory to the telephone lines.

b. External requests generated by the message processor module and sent to the computers. These external requests signal the operational program to initiate the input or output message transfers (c and d below) between the message processor memory and the memory modules.

c. Actual input operations (via an I/O module) in which assembled input messages are transferred from the message processor memory to the memory modules.

d. Actual output operations (via an I/O module) in which output messages are transferred from the memory modules to the message processor memory.

The functions performed in a and b above are automatic hardware operations. The response to the external requests and the actual input-output operations, however, are controlled by the operational program.

INPUT-OUTPUT CHANNEL SCANNING.

The automatic message processor module operations are divided into intervals called scan cycles. During a scan cycle, each input and output channel is scanned for the presence of an input or output data bit to be processed. The operations which can occur during a single scan cycle consist of the following:

a. Service of input channels.

b. Service of output channels.

c. Data transfer from an I/O module.

d. Data transfer to an I/O module.

The sequence of input and output channel scanning is as follows: First, the group I and group II input message channels are scanned, and then the group I and group III output message channels are scanned. When the input channels are being scanned, the presence of a completed message in the input storage area will be detected and this message will then be transferred to the stack storage area. During the scanning of the output channels, if a write operation has been initiated, the message transfers from the I/O module are serviced. Message transfers from an I/O module are made directly into the output storage area of the message processor memory. If a read operation has been initiated, the stack storage area is scanned following the output channel scanning to service the message transfers to an I/O module. Since each of these operations includes the transfer of complete messages, they require much more time than the bit transfers between the telephone lines and the input and output sections of the message processor memory. These operations are therefore designated as long operations, only four of which can be performed during a single scan cycle. Since data bits are being received from the telephone lines continually every 770 microseconds, a maximum time is allowed for a complete processing cycle. To allow time for fluctuations of reception time of the input data bits, the complete processing cycle of the message processing operation is limited to a maximum of 600 microseconds.

EXTERNAL REQUESTS.

Message processor module input and output operations are contingent on the recognition (by the program in control of the data processing set) of the five external requests that are generated by each message processor module and sent to the computers. The external request line assignment in the computers for these external requests is as follows:

a. Message processor module 1:

(1) External request line 12: fill output group I (GRIF).

(2) External request line 13: fill output group III (GRIIIF).

(3) External request line 14: computer terminate (CTF).

(4) External request line 15: dump buffer 1 (EI1).

(5) External request line 16: dump buffer 2 (EI2).

b. Message processor module 2:

(1) External request line 7: fill output group I (GRIF).

(2) External request line 8: fill output group III (GRIIIF).

(3) External request line 9: computer terminate (CTF).

(4) External request line 10: dump buffer 1 (EI1).

(5) External request line 11: dump buffer 2 (EI2).

When a computer senses an external request interrupt condition, the external request interrupt routine of the program in control will store and then sample the contents of the external request lines to determine which of the external request lines is high. The program in control can then provide an appropriate response for the requesting condition. Since the external request interrupts can be masked from recognition by a computer, the program in control has the alternative of inhibiting the interrupt and servicing the external requests by periodically storing and sampling the contents of the external request lines.

READ OPERATIONS.

The EI1, EI2, and CTF external requests and the buffer empty status are used for control purposes during the processing of input messages between the message processor module and the memory modules of the data processing set. The EI1 and EI2 external requests are used to notify the program in control that a check should be made to determine whether a message processor module read operation is required. The EI1 external request line is set high when the first bit of a group III output message is processed by the message processor module. The EI2 external request is set high when the 40th bit of a group III output message is processed by the message processor module. Since group III output messages are processed continuously by the message processor module (if valid group III output messages are not transmitted to the message processor module, null group III output messages are processed), the time during which neither the EI1 external request nor the EI2 external request line is high will not exceed 30 milliseconds. The CTF external request is used to indicate to the program that no input messages are available for transfer to the memory modules (the buffer is empty). The CTF external request line goes high when an attempt is made to read a message from the buffer and the buffer is empty (the buffer empty status code is also generated at that time). The CTF external request line goes low when the transfer of an input message from the input area to the stack storage area is initiated by the message processor module.

The program in control should respond to either the EI1 or the EI2 external request (whichever occurs first) as soon as possible (within a maximum of 2 milliseconds) by checking the state of the CTF external request. If the CTF external request line is low when checked, a read operation should be initiated as soon as possible to ensure that new input messages will not be garbled. The EI1 and/or EI2 external request goes low when the read start-stop signal from the I/O module occurs. One of these two external requests will then be generated within 30 milliseconds (since group III output messages are processed continuously, it cannot be predicted which of the two external requests lines will be generated first). Since the number of input messages that are contained in the stack storage area at any given time cannot normally be determined, a read command should be used which contains a word count equal to or greater than the maximum number of words that can be contained in the stack storage area. If such a command descriptor is used for the read operation, the operation is normally terminated by the generation of buffer empty status (refer to paragraph 4-250). When the message processor module is receiving and processing input messages from the telephone lines, a read operation that empties the buffer may require up to 10 milliseconds. The time required to read messages from the message processor module when live input messages are not being received (the loop tester is connected) is as follows (all times are approximate):

a. One message: between 245 microseconds and 408 microseconds.

b. Two messages: between 281 microseconds and 408 microseconds.

c. Three messages: between 318 microseconds and 408 microseconds.

d. Four messages: between 355 microseconds and 408 microseconds.

e. Eight messages: 709 microseconds.

f. Twelve messages: 1.211 milliseconds.

g. Sixteen messages: 2.0 milliseconds.

h. Twenty messages: 3.387 milliseconds.

i. Twenty-four messages: 5.942 milliseconds.

WRITE OPERATIONS.

The fill output group I and fill output group III external requests are used for control purposes during the transmission of output messages to the message processor module from the memory modules. Two memory zones are assigned to each group I and group III output channel to enable the message processor module to accept group I or group III output messages from an I/O module concurrent with the transmission of the same type of messages to the telephone lines. The GRIF and GRIIIF external requests are generated by the message processor module to notify the program in control that additional messages of the specified type will be accepted by the message processor module. The GRIF external request remains high until all message processor memory zones for group I output messages have been loaded. The external request line will then go low and remain low until the 92nd bit of a message group is processed by the message processor module. The GRIIIF external request remains high until both memory zones for group III output messages have been loaded. The external request line then goes low and remains low until the 78th bit of one of the group III messages is processed by the message processor module. It should be noted that a group I or a group III write operation can be initiated successfully only when the corresponding external request line is high (refer to paragraph 4-252).

A group I write operation is initiated by a command descriptor that contains a configuration of 0211 (8) (for message processor module 1) or 0451 (8) (for message processor module 2) in the device and operation code area (bits 37 thru 48). A group III write operation is initiated by a command descriptor that contains a configuration of 0213 (8) (for message processor module 1) or 0453 (8) (for message processor module 2) in bit positions 37 thru 48. Group I output messages are transmitted to the message processor module in seven-message groups; therefore, the word count portion (bits 1 thru 12) of the group I write command descriptor should contain a configuration of 0016 (8). Group III output messages are transmitted to the message processor module a message (two words) at a time; therefore, this command descriptor should contain a word count of 2. If the word count in any command descriptor for a message processor write operation is less than that specified, an incomplete message group is transmitted to the message processor module. The incomplete message group is accepted by the message processor module; however, during the following scan cycle the validity bit in each message of the incomplete group is reset so that all of these messages are processed as null messages by the message processor module. If the word count in any command descriptor for a message processor module write operation is greater than that specified, the message processor module rejects all messages that are in excess of the specified number of messages (seven for group I and one for group III). In addition, the message processor module generates the not-available status when the first word of the first excess message is received, and the operation is thus terminated.

Valid group I output messages are identified as such in core memory by setting bits 43 thru 48 (character seven) of the second word of the message equal to 001000. This bit configuration is known as the validity tag. If bit 44 of the validity tag is also a 1, the message will be transmitted to the internal test channel of the message processor module. If bits 44 and 45 are both set to a 1, the message is transmitted to both the telephone lines and to the internal test channel. If neither bit 44 nor 45 is set to a 1, the message is not processed as a valid message by the message processor module but is instead processed as a null message. This feature enables less than seven valid group I messages to be transmitted to the message processor module during a single group I write operation. It should be noted that all group III output messages that are transmitted to the message processor module from the I/O modules are transmitted to the telephone lines. However, if bit 44 of the second word of a group III output message is set to a 1, that message will also be transmitted to the internal test channel of the message processor module. A group I write operation requires between 787 microseconds and 995 microseconds (approximate). In addition, after both sets of group I output zones have been filled, the message processor module remains unavailable for additional group I write operations for up to 70.84 milliseconds. A group III write operation requires between 251 microseconds and 459 microseconds (approximate). In addition, after both group III output zones have been filled, the message processor module remains unavailable for additional group III write operations for up to 60 milliseconds.

TEST LOOP FUNCTIONS.

All messages that are transmitted from the message processor modules to the telephone lines are routed thru the Test Adapter MX-7362/GSA-51A (loop test adapter). However, the loop test adapter contains switching circuitry that enables this unit to function as a test loop in which the output channels of a message processor module are routed to the input channels of that message processor module instead of to the telephone lines. This test loop function can be implemented for both message processor modules simultaneously; in this case no input messages are received by either message processor module from the telephone lines nor are any messages transmitted to the telephone lines. When the loop test adapter is functioning as a test loop, the input and output channels of the message processor module are connected as follows:

Output Channels	to	Input Channels
1		1, 11, 18
2		2, 12, 19
3		3, 13, 20
4		4, 14, 21
5		5, 15, 22
6		6, 16
7		7, 17
8		8, 9, 10

4-247. MESSAGE PROCESSOR MODULE STATUS CODES.

4-248. There are four terminating status codes that can appear in the device status field (bits 20, 37, and 38) of a result descriptor after a message processor module input-output operation. These codes and their corresponding status conditions are as follows:

a. 010: buffer empty.

b. 011: not available.

c. 110: time elapsed.

d. 111: parity error.

4-249. BUFFER EMPTY.

4-250. A buffer-empty status code (010) is generated when the last input message has been read from the stack storage area. This status is the normal terminating status for all message processor module read operations.

NOT AVAILABLE.

There are two conditions which will cause the generation of the not-available status (011): (1) when an attempt is made to transmit messages of a particular group to the message processor module and the corresponding external request line is low and (2) when the I/O module has received a message processor module write command that contains all illegal order code, that is, an order code whose last two bits are equal to 00 or 10, (which specifies a nonexistent type of message)

TIME ELAPSED.

The time-elapsed status condition (code 110) occurs during a message processor module input or output operation if the I/O module does not respond to a character strobe from the message processor module with a character request within 32 to 64 microseconds.

PARITY ERROR.

A parity-error status code (111) is generated if a parity error is detected during the transfer of an output message from an I/O module to the message processor module.

GENERAL.

The Status Display Console OJ-6/GSA-51A (status display console) is a two-way (input-output) terminal device that provides at one central location the means of controlling and monitoring the operational and maintenance status of all equipments of the BUIC NCC (including all components of the data processing set but excluding the printing card punch). The status display console, which is illustrated in figure 4-31, also provides a means of controlling equipment availability, ownership, and the diagnostic test function in the BUIC NCC (refer to paragraph 4-338). In addition, the status display console provides for remote control of the application and removal of primary power to the data processing set, monitors the status of the central clock system and the drum clock system in the data processing set, monitors system primary power, and provides an audible monitor of the operation of the two computers in the data processing set. The information in this section is discussed under the following headings:

a. General description.

b. Status display console operation.

c. Status display console status codes.

GENERAL DESCRIPTION.

The status display console contains push-button indicators necessary to control and monitor the operational and maintenance status of the equipments and components of the BUIC NCC. Push-button controls are furnished to apply power to the status console itself and to apply primary power to and remove primary power from the data processing set. The status display console also furnishes the automatic removal of primary power from the data processing set when a primary power failure occurs. When the established primary power tolerances are exceeded, the status display console generates a control signal that causes the initiation of a storage cycle of dynamic control data and an orderly shutdown of power (to prevent loss of data) in the data processing set. When the data processing set is set up for automatic restarting and the power failure has been caused by an under voltage condition, the status display console automatically restores primary power to the data processing set when the fault has been eliminated. Additional push-button indicators are furnished on the status display console for the purpose of initiating and displaying certain program-controlled functions, such as changes in equipment availability and ownership, as well as for controlling the input and output connections to the message processor modules. The operational features of the status display console are listed in table 4-11.

The indicators on the status display console are lit by one of three methods: by direct signals received from the various units of the BUIC NCC, by program-controlled signals received from the data processing set, or by control signals generated within the status display console itself. In general, power status, online, and failure indicators are lit by direct signals. The indicators that are lit by program-controlled signals are indicated by an asterisk in table 4-11.

Direct signals that are used to control the message processor module input and output connections are received by the status display console from the control circuits in the loop test adapter. These signals are routed directly to the appropriate indicators on the status display console. Except for the simulator group, direct signals are also received from each BUIC NCC equipment and component that contains its own power supply. These power supplies are equipped with an error-detection circuit which is used to sense power failures and to apply power-ready signals to and remove power-ready signals from the appropriate indicators on the status display console. The components of the data processing set that contain duplexed master clocks have error-detection circuits which detect either clock failure or loss of clock synchronization. Indicators are provided to give a visual indication that a clock failure or loss of synchronization has occurred.

The status display console supplies one-word input messages to and receives one-word output messages from the central processing modules of the data processing set. The status display console is provided with an external request line to the data processing set so that the operator can inform the program in control that a message is to be read from the status display console. The external request signal is generated whenever any of the push-button indicators denoted by an asterisk in table 4-11 is pressed.

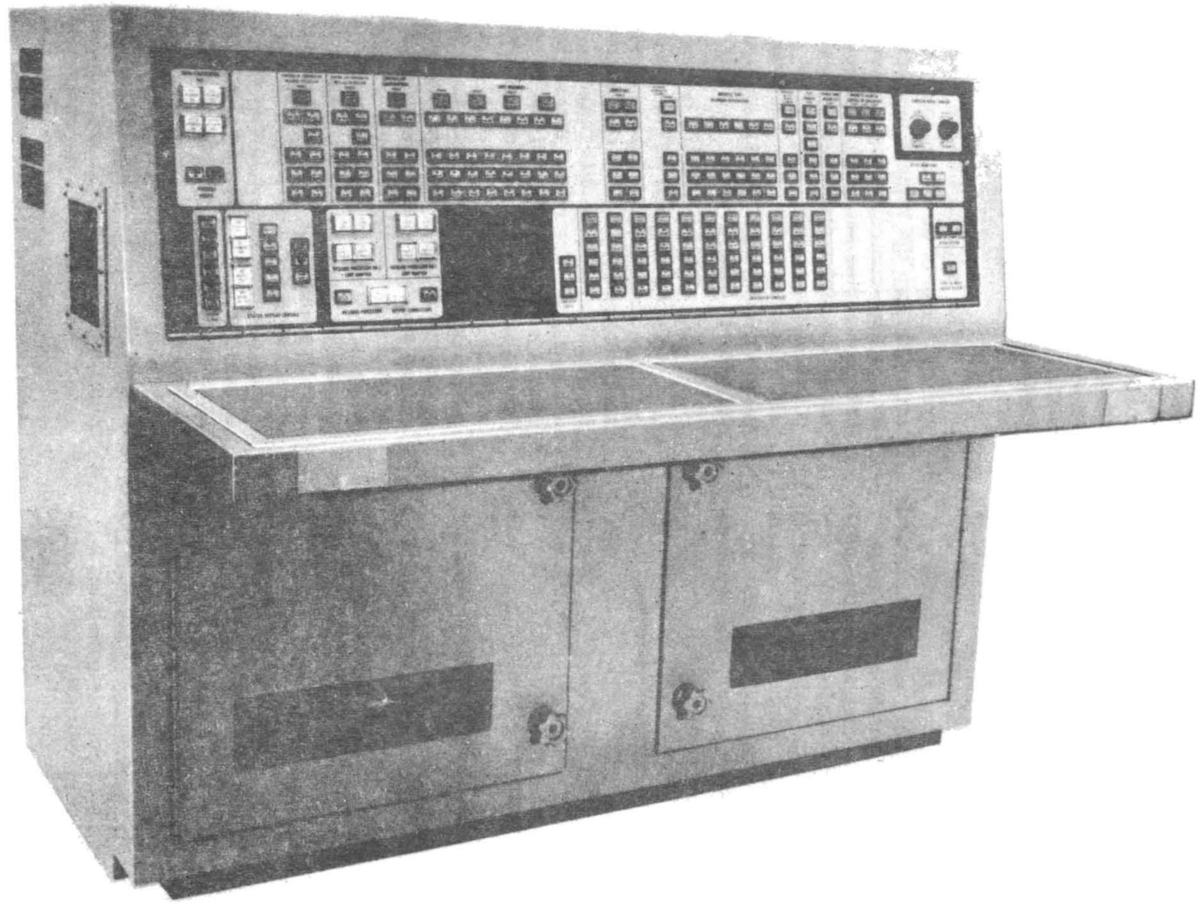


Figure 4-31. Status Display Console OJ-6/GSA-51A

Table 4-11. Operational Features of Status Display Console (cont)

Feature	Description
FAILURE indicators	An indicator is provided for each data display console, the status display console, the teleprinter, and each message processor module. When any one of these indicators is lit, it indicates that a malfunction has been detected in the corresponding unit.
CLOCK FAILURE indicators	Six clock-failure indicators are provided to indicate, when lit, that a failure or malfunction has occurred in the duplexed master-clock system used in the data processing set. Of these indicators, one indicates that the clock in the computer has failed, another indicates that the clock in the memory has failed, a third indicates that the computer and memory-clock system is not in proper phase synchronization, a fourth indicates that the clock in magnetic drum control No. 1 has failed, the fifth indicates that the clock in magnetic drum control No. 2 has failed, and the sixth indicates that the clock system of magnetic drum unit 1 and magnetic drum unit 2 is not in proper phase synchronization.
Audible alarm	An audible alarm in the status display console sounds whenever either a unit-failure indicator or a clock-failure indicator is lit or when an equipment is made unavailable for program use.
AUDIBLE ALARM RESET push-button indicator	A push-button indicator is provided to de-energize the audible alarm circuit; this indicator will light when pressed.
AUDIBLE ALARM TEST push-button indicator	A push-button indicator is provided to manually energize the audible alarm circuit; this indicator lights when pressed.
COMPUTER AUDIBLE MONITOR	Two speaker units are provided to give an audible indication of the operation of the two computers of the data processing set. Each speaker unit is driven by the most significant (sign) bit of the A register of the respective computer. The volume of each audible indicator can be controlled by the corresponding VOLUME control.
LAMP TEST push-button indicator	A push-button indicator is provided to test all lamps on the front panel of the status diaplay console. When the push-button is pressed, all lamps (including the LAMP TEST lamp) will light.
LOOP ON push-button indicators	A push-button indicator is provided for each message processor module of the data processing set. When the push button is pressed, a corresponding relay in the loop test adapter is energized with the result that the corresponding message processor module is disconnected from the telephone and its output channels are connected to its own input channels. The indicator lights when pressed.
LOOP OFF push-button indicators	A push-button indicator is provided for each message processor module of the data processing set. When the push button is pressed, the relay that was energized in the loop test adapter when the corresponding LOOP ON push button was pressed is de-energized, with the result that the corresponding message processor module is reconnected to the telephone lines and its output channels are disconnected from its input channels. The indicator lights when pressed.

Table 4-11. Operational Features of Status Display Console

Feature	Description
PRIMARY POWER ON indicator	An indicator is provided to indicate, when lit, that primary input power is available to the equipments and components of the BUIC NCC.
SC POWER ON push-button indicator	A push-button indicator is provided to apply power to the status display console; this indicator lights when pressed.
SC POWER OFF push-button indicator	A push-button indicator is provided to remove power from the status display console; this indicator lights when pressed.
SC MODE ON-LINE push-button indicator	A push-button indicator is provided to place the status display console in the online mode of operation; this indicator lights when pressed.
SC MODE TEST push-button indicator	A push-button indicator is provided to place the status display console in the test mode of operation; this indicator lights when pressed.
D. P. POWER ON push-button indicator	A push-button indicator is provided to apply power to those components of the data processing set that have their power-control selector switch set to position CONSOLE; this indicator lights when pressed.
D. P. POWER OFF push-button indicator	A push-button indicator is provided to remove power from those those components of the data processing set that have their power-control selector switch set to position CONSOLE; this indicator lights when pressed.
AUTO POWER ON push-button indicator	A push-button indicator is provided to implement an automatic restoration of power following a primary power interruption to each component of the data processing set that has its power-control switch set to position CONSOLE: this indicator lights when pressed.
AUTO POWER OFF push-button indicator	A push-button indicator is provided to inhibit the automatic restoration of power following a power-interrupt condition; this indicator lights when pressed.
Ac-fault sensing circuit	The status display console contains a control circuit that detects a primary input power failure. When a primary power failure is detected, an orderly power turnoff cycle is initiated for all components of the data processing set that have their power-control switches set to position CONSOLE (if the AUTO POWER ON push-button has been pressed).
POWER CONSOLE indicators	An indicator is provided for each component of the data processing set to indicate, when lit, that the application and removal of power to the corresponding component is controlled by use of the status display console.
POWER READY indicators	An indicator is provided for each unit of the BUIC NCC except the simulator group and the teleprinter. When any one of these indicators is lit, it indicates that the power is ready for use in the associated unit. The teleprinter is a special case; separate indicators are provided to indicate, when lit, that both the ac power and dc power in that unit are ready for use. An indicator is not provided for the simulator group.
ON-LINE indicators	An indicator is provided for each unit of the BUIC NCC except the simulator group. When any of these indicators is lit, it indicates that the corresponding unit is in the online mode of operation.

Table 4-11. Operational Features of Status Display Console (cont)

Feature	Description
PARITY CHECK push-button indicators	A push-button indicator is provided for each message processor module of the data processing set. When the push button is pressed, the messages received at the input channels of the corresponding message processor module are checked for correct parity. The indicator lights when pressed.
PARITY DISABLE push-button indicators	A push-button indicator is provided for each message processor module of the data processing set. When the push button is pressed, the message received at the input channels of the corresponding message processor module are not checked for correct parity. The indicator lights when pressed.
TEL. CO. push-button indicators*	A push-button indicator is furnished for each message processor module of the data processing set. When the push button is pressed, the output telephone lines are connected to the output channels of the corresponding message processor module by means of a selector switch contained in the loop test adapter. The indicator is lit, when pressed, by a control signal generated in the loop test adapter.
ACTIVE OUTPUT push-button indicators*	An indicator is provided for each message processor module to indicate, when lit, that the output channels of the corresponding message processor module are connected to the telephone lines.
Equipment availability (AVAIL.) push-button indicators*	A push-button indicator is provided for each unit of the BUIC NCC to make the various units available for use by the program or programs in operation. When any one of these indicators is lit, it indicates that the corresponding unit is available for use.
Equipment ownership (ACTIVE) push-button indicators*	A push-button indicator is provided for each unit of the BUIC NCC for the purpose of assigning ownership of the various units to one of the two program systems that are normally operated in the data processing set. When any one of these indicators is lit, it indicates that the corresponding unit is owned by the active system program (as opposed to the backup system program). If any one of these indicators is not lit, it indicates that the corresponding unit is owned by the backup system program.
Equipment diagnostic (DIAG.) push-button indicators*	A push-button indicator is provided for each unit of the BUIC NCC for the purpose of initiating the diagnostic test program for each unit. When any one of these indicators is lit, it indicates that the diagnostic test program for that unit is currently being executed.
STRT CC push-button indicator*	A push-button indicator is provided to load and initiate the operation of the backup system program in the confidence mode, or to initiate the confidence mode of the backup system program if that program is already in operation in some other mode. This indicator, when lit, indicates either that the active system program is attempting to load the backup system program, or that the backup system program is operating in the confidence mode.
STRT AC push-button indicator*	A push-button indicator is provided to load and initiate the operation of the active system program. This indicator, when lit, indicates either that the backup system program is attempting to load the active system program or that the active system program is operating.

Table 4-11. Operational Features of Status Display Console (cont)

Feature	Description
STR push-button indicator*	A push-button indicator is provided to initiate the start-over function of the active system program. This indicator, when lit, indicates that the start-over function is being performed.
ACTIVE DRUM USAGE indicators*	Five indicators are provided to indicate the usage of the magnetic drum units that are owned by the active system program. When display data are contained in the display channels of a display/bulk drum unit owned by the active system program, the corresponding DISPLAY indicator is illuminated yellow. When the display channels of a display/bulk drum unit owned by the active system program contains data other than display data, the corresponding DISPLAY indicator is illuminated clear. When the bulk-only drum unit is being used by the active system program, the D3 BULK indicator is lit.

* The lighting of this indicator (or push-button indicator) is program controlled. When any push-button indicator denoted by an asterisk is pressed, an external request signal is generated by the status display console and sent to the computers of the data processing set.

STATUS DISPLAY CONSOLE OPERATION.

When the status display console is used in conjunction with the operational and maintenance programs that are normally run in the central processing modules of the BUIC NCC, the operator, by use of the external request and input-output capabilities of the status display console, may request that certain functions be performed by the program and then receive recognition from the program that the request has been acknowledged. The program functions that can be initiated by use of the push-buttons contained on the status display console include changing equipment availability or ownership, running at any one of the diagnostic test programs, and initiating either the backup or active system program. In addition, the operator can indicate to the program whether either or both of the message processor modules should be used for the processing of operational output messages. The program can inform the operator that the request has been recognized by means of the indicators provided on the status display console. In addition, the program can indicate to the operator whether either or both of the message processor modules are currently being used to process operational output messages, whether the display/bulk drum units owned by the active system program are being used to store display data or bulk storage data or both, and whether the bulk-only drum unit is being used by the active system program. Thus, the status display console functions as an integral part of the overall BUIC NCC maintenance plan, which is described in detail in Technical Manual, Facility, Norad Automated Control Center Facility, C-E Facility 178, Service, Circuit Diagrams, and Illustrated Parts Breakdown and Technical Manual, Service, Confidence Diagnostic Program, Radar Course Directing Group AN/GSA-51A. The terms "active," "back-up," "availability," and "ownership" are defined in these technical manuals.

READ OPERATIONS.

A status display console read operation is initiated by a command descriptor that contains a device operation code of 0430 (octal) in bit positions 37 thru 48 (see appendix 4). The read operation is normally performed in response to an external request from the status display console. The read operation is normally terminated by the status display console, which generates end-of-message status (010) after the eighth character has been transferred to the I/O module; therefore, the word count in the command descriptor is normally specified as 1. However, it should be noted that when a word count of 1 is specified, a status of word-count-equal-to-0 is also generated by the I/O module, with the result that a double status of 32(8) appears in the status code portion of the result descriptor. If a word count greater than 1 is specified, the operation is still terminated in the manner described. It should be noted that the external requiest line from the status display console to the computers goes low when the end-of-message status signal is generated. Therefore, if the read operation is not terminated in the normal manner, the external request line will remain high. A status display console read operation requires approximately 35 microseconds (from the execution of the command descriptor to the storing of the result descriptor in core memory).

INPUT MESSAGE FORMAT. The combined octal configuration contained in characters six and

and 7 of the input message specifies the particular push-button indicator on the status display console that was used to generate the external request signal (characters 0 thru 5 of the input message are not used and are always equal to 0's). The status display console codes for characters 6 and 7 are listed in table 4-12 along with the particular push-button indicator that is used to generate each code.

Table 4-12. Status Display Console Output Codes

Character 6	Character 7	Push-button indicator
00	00	P1 TEL Co
	01	P2 TEL Co
	02	STRT/CC
	03	STRT/AC
	04	STR
01	00	C1 AVAIL
	01	C2 AVAIL
	14	D1 AVAIL
	15	D2 AVAIL
	16	D3 AVAIL
	22	M1 AVAIL
	23	M2 AVAIL
	24	M3 AVAIL
	25	M4 AVAIL
	26	M5 AVAIL
	27	M6 AVAIL
	30	M7 AVAIL
	31	M8 AVAIL
02	00	C1 ACTIVE
	01	C2 ACTIVE
	14	D1 ACTIVE
	15	D2 ACTIVE
	16	D3 ACTIVE
	22	M1 ACTIVE
	23	M2 ACTIVE
	24	M3 ACTIVE
	25	M4 ACTIVE
	26	M5 ACTIVE
	27	M6 ACTIVE
	30	M7 ACTIVE
	31	M8 ACTIVE
03	00	C1 DIAG
	01	C2 DIAG
	14	D1 DIAG
	15	D2 DIAG
	16	D3 DIAG
	22	M1 DIAG
	23	M2 DIAG
	24	M3 DIAG
	25	M4 DIAG
	26	M5 DIAG
	27	M6 DIAG
	30	M7 DIAG
	31	M8 DIAG
05	00	P1 AVAIL
	01	P2 AVAIL

Table 4-12. Status Display Console Output Codes (cont)

Character 6	Character 7	Push-button indicator
05 (cont)	06	CR AVAIL
	07	FL AVAIL
	10	TP AVAIL
	11	SD AVAIL
	14	T1 AVAIL
	15	T2 AVAIL
	16	T3 AVAIL
	17	T4 AVAIL
	20	T5 AVAIL
	21	T6 AVAIL
	22	TC AVAIL
	30	K1 AVAIL
	31	K2 AVAIL
	32	K3 AVAIL
	33	K4 AVAIL
	34	K5 AVAIL
	35	K6 AVAIL
	36	K7 AVAIL
	37	K8 AVAIL
	40	K9 AVAIL
	41	K10 AVAIL
	42	K11 AVAIL
	51	SG AVAIL
06	00	P1 ACTIVE
	01	P2 ACTIVE
	06	CR ACTIVE
	07	FL ACTIVE
	10	TP ACTIVE
	11	SD ACTIVE
	14	T1 ACTIVE
	15	T2 ACTIVE
	16	T3 ACTIVE
	17	T4 ACTIVE
	20	T5 ACTIVE
	21	T6 ACTIVE
	22	TC ACTIVE
	30	K1 ACTIVE
	31	K2 ACTIVE
	32	K3 ACTIVE
	33	K4 ACTIVE
	34	K5 ACTIVE
	35	K6 ACTIVE
	36	K7 ACTIVE
	37	K8 ACTIVE
	40	K9 ACTIVE
	41	K10 ACTIVE
	42	K11 ACTIVE
	51	SG ACTIVE
07	00	P1 DIAG
	01	P2 DIAG
	06	CR DIAG
	07	FL DIAG
	10	TP DIAG
	11	SD DIAG
	14	T1 DIAG
	15	T2 DIAG
	16	T3 DIAG

Table 4-12. Status Display Console Output Codes (cont)

Character 6	Character 7	Push-button indicator
07 (cont)	17	T4 DIAG
	20	T5 DIAG
	21	T6 DIAG
	22	TC DIAG
	30	K1 DIAG
	31	K2 DIAG
	32	K3 DIAG
	33	K4 DIAG
	34	K5 DIAG
	35	K6 DIAG
	36	K7 DIAG
	37	K8 DIAG
	40	K9 DIAG
	41	K10 DIAG
	42	K11 DIAG
	51	SG DIAG

WRITE OPERATIONS.

A status display console write operation is initiated by a command descriptor that contains a device operation code of 0410 (octal) in bit positions 37 thru 48 (see appendix 4). The word count in this descriptor is normally specified as 1; however, more than one word can be transferred to the status display console during a single write operation. The write operation is normally performed to give a visual indication of a change in the operational or maintenance status of one or more units of the BUIC NCC. A status display console write operation in which one word is transferred to the status display console requires approximately 35 microseconds (from the execution of the command descriptor to the storing of the result descriptor in core memory).

OUTPUT MESSAGE FORMAT. There are seven different types of valid one-word messages that can be sent to the status display console. Bits 1 thru 3 of each message are used to specify the particular type of message. Bits 4 thru 6 of each message are not used, and these bits are not decoded by the logic circuitry of the status display console. The seven different types of messages, along with the corresponding bit codes in bits 1 thru 3, are as follows:

a. 000: message processor module and magnetic drum unit usage word.

b. 001: primary equipment availability word.

c. 010: primary equipment ownership word.

d. 011: primary equipment diagnostic word.

e. 101: secondary equipment availability word.

f. 110: secondary equipment ownership word.

g. 111: secondary equipment diagnostic word.

The format of the primary and secondary availability, ownership, and diagnostic words is illustrated in figures 4-32 and 4-33. A 1 in any bit position specified in figures 4-32 and 4-33 causes the corresponding indicator on the status display console to be lit. The same applies to the bits in the message processor module and magnetic drum unit usage word, the format of which is as follows:

Bit Number	Indicator
7 thru 37	Spare
38	P2 ACTIVE OUTPUT
39	P1 ACTIVE OUTPUT
40 and 41	Spare
42	D3 BULK
43	D2 DISPLAY (clear)
44	D2 DISPLAY (yellow)
45	D2 BULK
46	D1 DISPLAY (clear)
47	D1 DISPLAY (yellow)
48	D1 BULK

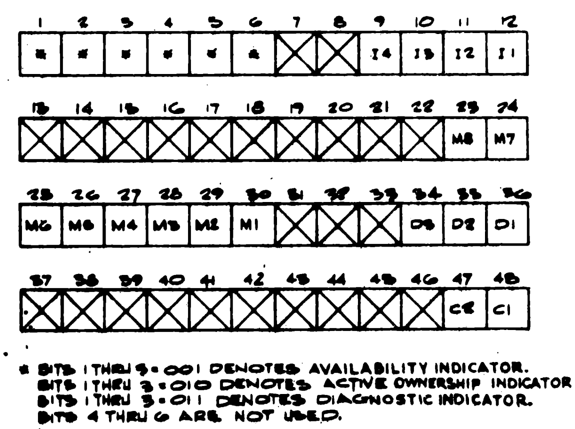


Figure 4-32. Primary Availability, Ownership, and Diagnostic Word Format

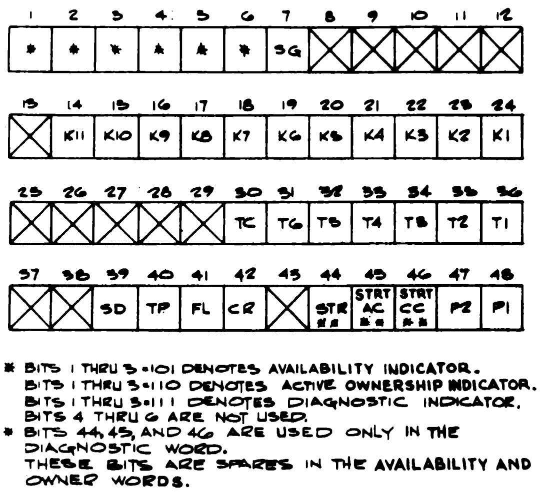


Figure 4-33. Secondary Availability, Ownership and Diagnostic Word Format

STATUS DISPLAY CONSOLE STATUS CODES.

There are four terminating status codes that can appear in the device status field (bits 20, 37, and 38) of a result descriptor for a status display console operation. These status codes are as follows:

a. 010: end of message.

b. 011: malfunction.

c. 110: off line.

d. 111: parity error.

END OF MESSAGE.

The end-of-message status code (010) is generated at the completion of the transfer of the two message-characters from the status display console to the I/O; module. This status is the normal terminating status for all status display console read operation.

MALFUNCTION.

The malfunction status code (011) is generated when an error condition other than parity error is detected by the status display console during a status display console write operation.

OFF LINE.

The off-line status code (110) is generated if the SC POWER OFF push-button indicator is pressed while a read or write operation is in progress.

PARITY ERROR.

The parity-error status code (111) is generated if a character is received from the I/O module with even parity during a write operation.