TEC® INCORPORATED

SERIAL, BUFFERED AND CONVERSATIONAL MODE

MODELS 450, 455, 456

PRODUCT DESCRIPTION

#938

SERIES 400 DATA-SCREEN™ TERMINALS

PRODUCT DESCRIPTION

MODELS 450, 455, 456

SERIAL, BUFFERED AND CONVERSATIONAL MODE DATA-SCREEN™ Terminals

Model 450: 1000 Character Display, 50 characters/line, 20 lines
Model 455: 1920 Character Display, 80 characters/line, 24 lines
Model 456: 960 Character Display, 40 characters/line, 24 lines

JULY, 1973

– 938 –

Price $7.50

INCORPORATED

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INTRODUCTION

TEC, Incorporated has been a leader in the display and communications field for over a decade. Hundreds of displays have been operating throughout the United States, Canada, Europe and the Far East for several years. During this time TEC has intensively studied and evaluated numerous forms of user applications and incorporated many important features in the Series 400 DATA–SCREEN Terminals.

The Series 400 Display is a fourth generation family of CRT display manufactured by TEC. The technology and history accrued on the earlier models plus latest state-of-the-art developments, proved reliability, and handsome styling make the Series 400 one of the finest displays available today.

This manual is designed to acquaint operators, programmers and engineers with the features of Models 450, 455, & 456 DATA–SCREEN Terminals.

SYSTEM COMPATIBILITY

A variety of standard interface control features and page formats assures compatibility with most systems and display requirements. The Series 400 provides a versatile, economical input/output station. Sixty-four ASCII graphic characters and four special characters are displayed using a 5 x 7 dot matrix.

Models 450, 455 and 456 DATA–SCREEN Terminals are readily adaptable to any standard computer system and may be connected directly to the computer or located remotely. These units are compatible with, and may replace Teletype® Models KSR 33 or KSR 35.

®Teletype Corp.

FIGURE 1. DESK TOP MODEL

SECTION II

INSTALLATION

UNPACKING

Series 400 Terminals have been carefully packed to insure safety during shipment. Before unpacking, however, the carton should be inspected for external signs of damage incurred during transit or unloading. Note any signs of damage on the bill of lading prior to unpacking. After the equipment is unpacked, inspect for missing parts or signs of damage that may have occured during shipment. If any damage is found, note it on the bill of lading for possible claims at a later date. Also, any equipment that was roughly handled or dropped should be noted on the bill of lading, even though no damage is apparent, so that if damage is discovered later it may be claimed.

INSTALLATION

EQUIPMENT PLACEMENT

DATA–SCREEN Terminals are available in four models:

a. Desk top model with logic, power supplies and TV monitor. See Figures 1 and 42.

b. Desk top model without TV monitor but with logic and power supplies. For use with remote TV monitors. See Figures 2 and 42.

c. Rack mount (for standard 19-inch rack) with 12 1/4" high front panel. Consists of TV monitor, logic and power supplies. See Figures 3 and 43.

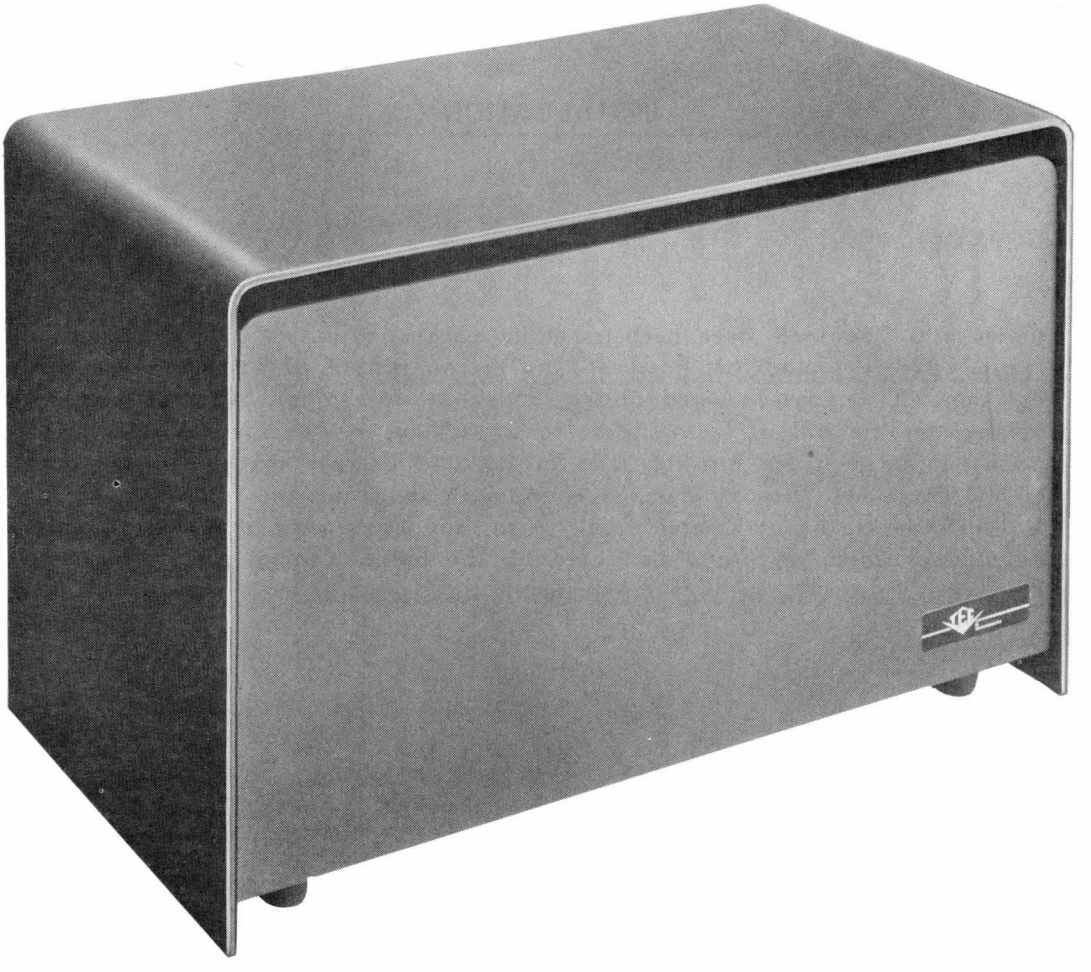


FIGURE 2. DESK TOP MODEL WITHOUT MONITOR

d. Rack mount (for standard 19-inch rack) with 10-1/2" high front panel. Accomodates logic and power supplies only. Designed for use with remote monitors. See Figures 4 and 43.

DESK MOUNTING

Two desk-mount Series 400 Terminals are self-contained and include an attractive enclosure and non-scuffing rubber feet for protection of desk and table tops. Connectors are provided for power (2-wire plus ground), detachable keyboard, video output for remote TV monitor (BNC) and communication line (telephone-modem or direct connection to computer). Clearance is required for convection cooling of electronics.

RACK MOUNTING

Two rack mounting options are available for mounting DATA–SCREEN Terminals in standard RETMA 19-inch racks. When 12-inch TV monitor is included, the rack panel is 12-1/4" high and cutout to accommodate the tube face and DATA·PANEL Display, if provided. When a TV monitor is not provided in the assembly, the rack panel is 10-1/2" high. All power, keyboard and signal connections are made at the rear of the units. Clearance is required for convection cooling of electronics.

POWER AND SIGNAL WIRING

DATA–SCREEN Terminal wiring consists of an AC power cord which is included with the display and signal cables which are provided by the customer. The signal cable requirement is determined by the options included as part of the unit configuration.

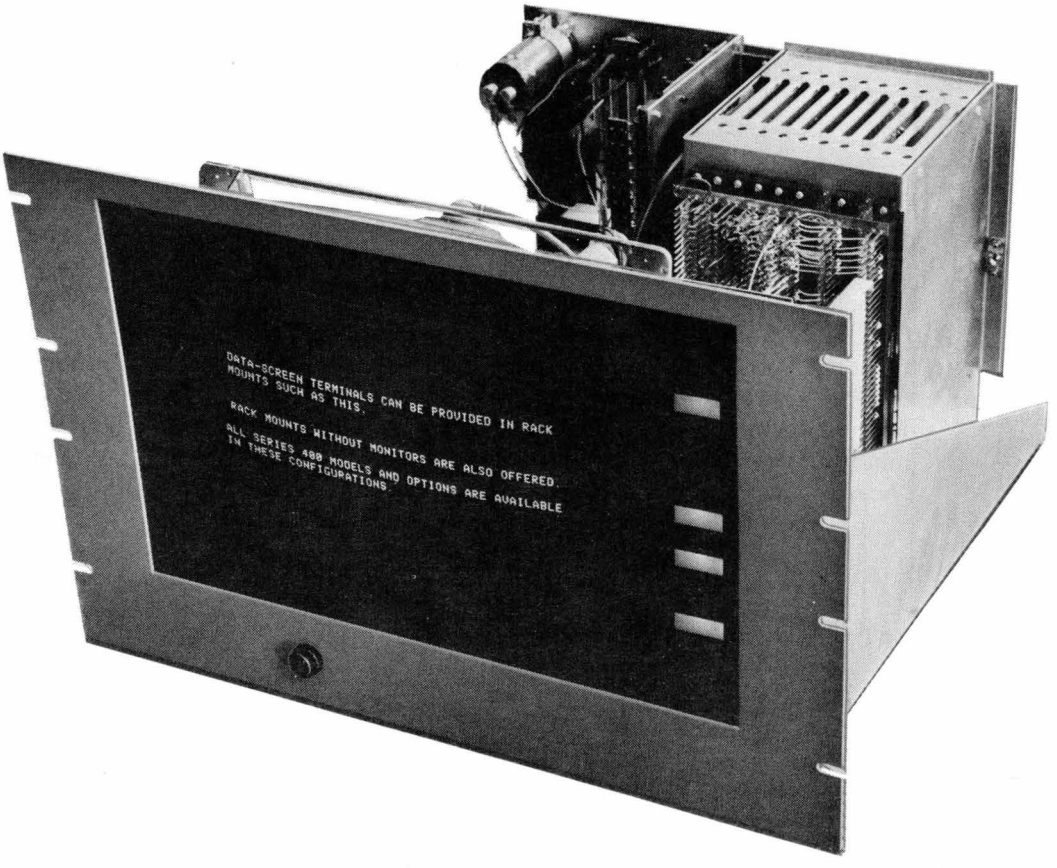


FIGURE 3. RACK MOUNT MODEL WITH MONITOR

INSPECTION/POWER ON

Before connecting power to the display, perform the following checks:

1. Examine the unit for external damage.

2. Check for any remaining packing material, masking tape or any other foreign material within the cover. To raise the enclosure cover on the desk-mount unit with monitor, remove the back panel (secured with three quarter-turn fasteners), pull back the two slide latches at the bottom rear corners and push the shroud forward and rotate up from the bottom front. To remove the cover from the desk-mount unit without monitor, undo the quarter turn fasteners and lift the cover straight up. Both rack mount versions are open-construction and permit easy inspection before mounting in the rack frame. NOTE: Power should not be connected to unit until inspection is complete.

3. Check for loose nuts, bolts, screws, etc.

4. Examine the unit for mechanical damage. Check for broken or pinched wires and for broken or cracked connectors and terminal boards. Also, check for bent pins and shorted connectors.

5. Check to see that all of the power supply connectors are firmly attached to the power supply and that the high-voltage lead is connected into the side of the cathode ray tube.

6. Visually inspect to assure that the unit is properly grounded via the power connector. A standard three-pin wall socket should be used. Where that is not possible, use a two-pin socket with proper ground wire attached and connected to ground.

7. Check the card rack for loose printed circuit boards.

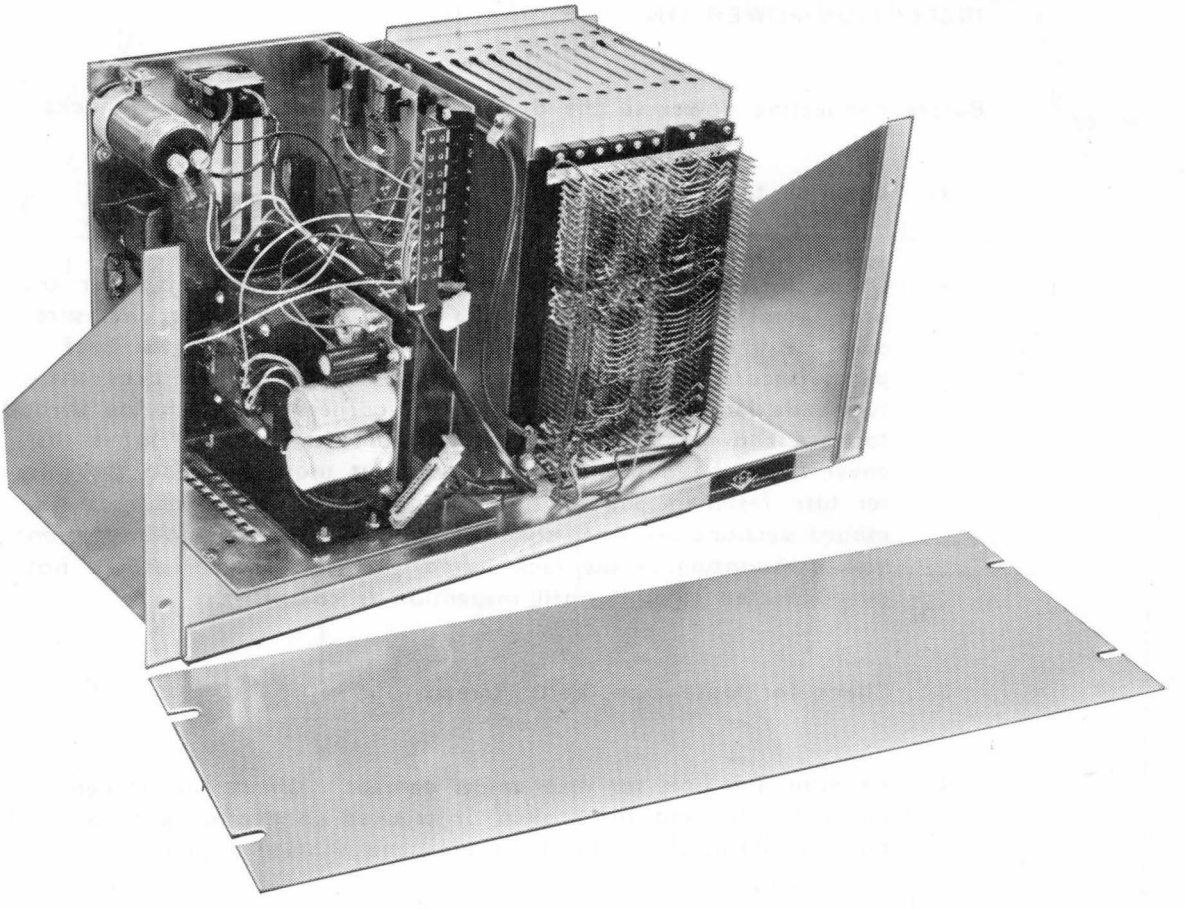


FIGURE 4. RACK MOUNT MODEL WITHOUT MONITOR

INSTALLATION

For initial operation the following steps are required: (See Figure 6 for switch and connector locations).

1. Depress the power switch to the OFF position.

2. Plug the AC line cord into a three wire, 115 volt AC outlet. (or 240 VAC, if so ordered and set up).

3. Connect the signal input cable (25 pin connector).

4. If the unit has a keyboard, plug its connector into the receptacle on the back panel (37 pin connector). The keyboard cable should be routed under the terminal.

5. Depress the power switch to the ON position. The LOCAL indicator is illuminated when the power is applied to the unit along with power on indicator.

6. Set the terminal in the Local condition, via the LOCAL key on the keyboard.

7. Allow approximately one minute for the CRTube filament to warm up. The blinking cursor (location of data entry on screen) should appear in the upper left corner of the screen. If it does not appear, turn up BRIGHTNESS control located under screen. If cursor still does not appear, refer to Section V, Figures 22 and 23 for setting for CURSOR DISPLAY option switch. If cursor does not appear with cursor display switch properly set, a malfunction is indicated.

8. Unit is ready to operate if all of the previous checks are passed satisfactorily. Refer to Section III of this manual for operating information.

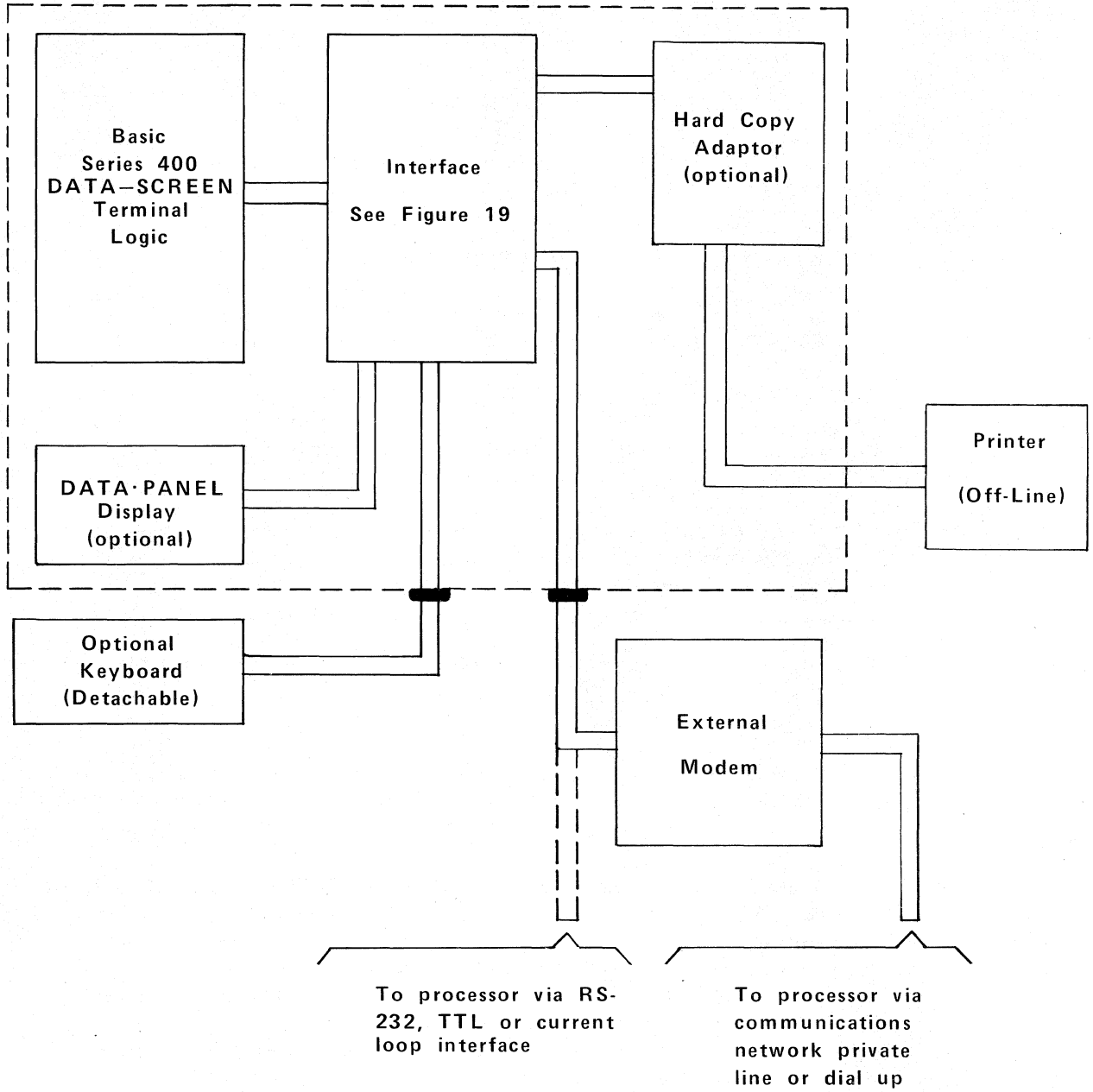
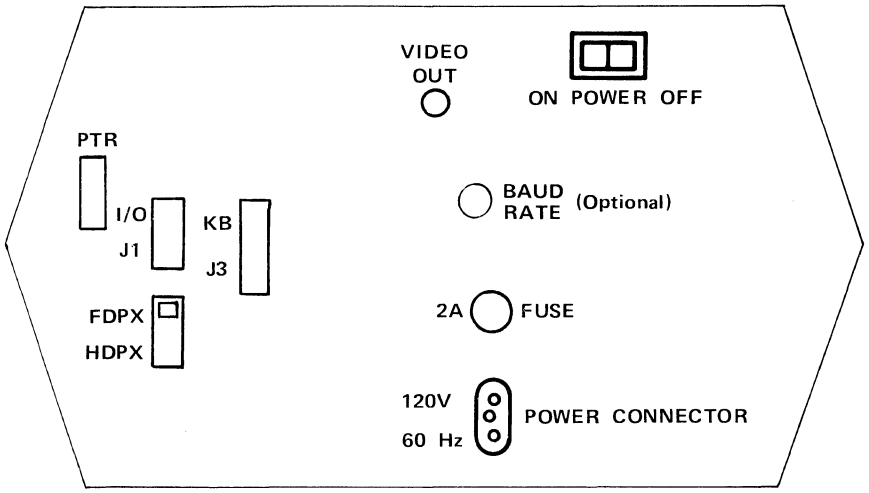
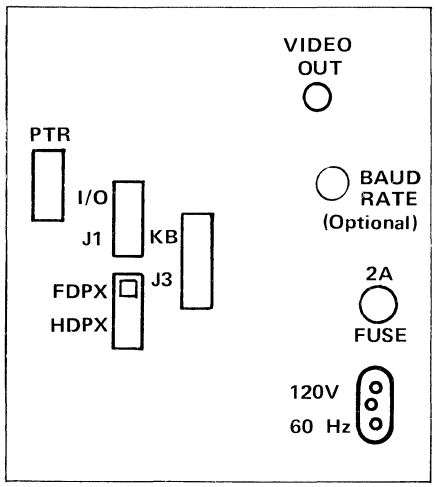


FIGURE 5. BASIC SERIES 400 DATA–SCREEN TERMINAL

DESK TOP
MODEL
With Monitor



DESK TOP
MODEL
Without Monitor



RACK MOUNT
MODELS
With & Without
Monitors

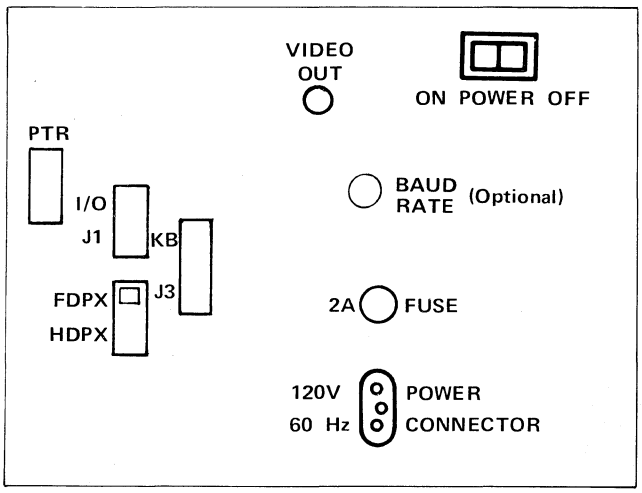


FIGURE 6. BACK PANEL CONNECTOR AND SWITCH LOCATIONS

SECTION III

OPERATING INSTRUCTIONS

KEYBOARD FAMILIARIZATION

Model 450, 455 and 456 DATA–SCREEN Terminals utilize the basic keyboard arrangement of a teletypewriter to simplify operator transition. To practice typing, turn on power, depress the REPEAT key and any displayable character simultaneously. Characters will appear on the screen from left to right. Near the end of a line a bell in the keyboard will ring. (NOTE: Option may disable end of line bell). At the end of the line, the cursor will automatically move to the beginning (left) of the line below. When the cursor moves to the beginning of the bottom line, the bell will ring an extra time (assuming internal bell control enabled.

After the bottom line of the screen is filled, the cursor normally will return to the top line of the screen and begin writing over data on this line and the previously entered information will be lost. If however, the "Roll-Up and Auto-Line Feed" options are included, a "Line Feed and Carriage Return" will take place on the bottom line when the "Return" key is depressed. The "page" of data automatically rolls up, erasing the top line and moving line 2 to line 1, etc. The cursor shifts to the extreme left of the bottom line which remains blank, ready for additional data entry. Note that the "Return" code must be received before the end of the line. If the line is ever filled, the cursor will return to the Home position at the top of the screen.

Depress each of the standard alphanumeric keys and verify that the correct character is displayed on the screen. Depress the shift key and verify that all upper case characters are displayed properly.

KEYBOARD KEYS AND CODE FUNCTIONS

NOTE: All ASCII codes referred to in this manual are in hexadecimal notation. See Code charts in Section III, Figures 12 & 13.

GRAPHIC KEYS

Sixty-four graphic characters are provided from 95 ASCII graphics. These characters are those contained in the center four columns of USAS X3.4–1967 USASCII and are shaded in Figure 7. The shift key selects one of two characters on a given key.

CONTROL KEYS

In addition to the alphanumeric characters and symbols located on the keyboard, several control function keys are provided. These keys are illustrated by the shaded areas of Figure 8.

SHIFT KEY - - Causes keyboard circuitry to change the polarity of bit 5 of the outgoing data word if, and only if, the key is designated as a shiftable key. Shiftable keys are all alphanumeric keys that have two alphanumeric symbols on the keytop, plus the blank function key.

In addition, the shift key is used to interlock certain edit functions. The functions generate no strobe unless the shift key is depressed with the desired key. These functions are insert and delete line and character, erase to end of line or page, and clear screen or memory.

RETURN - - When the Return key is pressed, the CR symbol (code ØD in the ASCII code set) is loaded into the page memory at the cursor locations. The cursor then moves back to the beginning of the same line.

Option: The special symbol for Carriage Return (←) will be displayed at the point on the screen where the Return key was depressed. This symbol can be made non-displayable by a switch located on the Line Memory and Character Generator PCB. (See Section V, Figures 22 and 23.

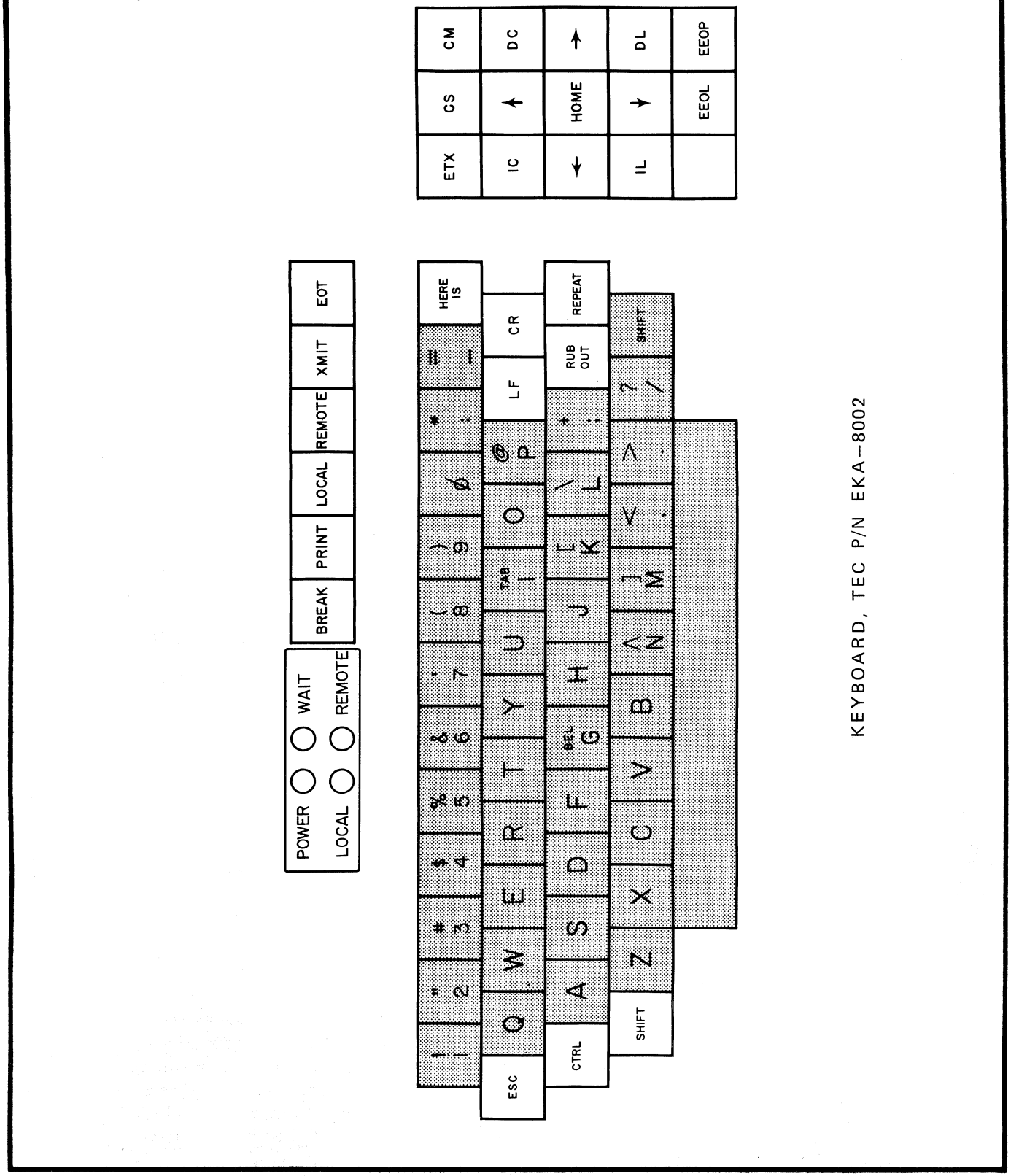


FIGURE 7. MODEL 450, 455, 456 KEYBOARD
(64 Graphic Characters & Space Shaded)

Option: Automatic Line Feed can be enabled by a jumper wire relocation on the Control Board (See Section V, Figure 24. This selectable option, not enabled at time of manufacture, automatically positions the cursor at the beginning of the next line when the Carriage Return key is depressed. NOTE: A "Line Feed" code is not transmitted to the processor, during an automatic line feed.

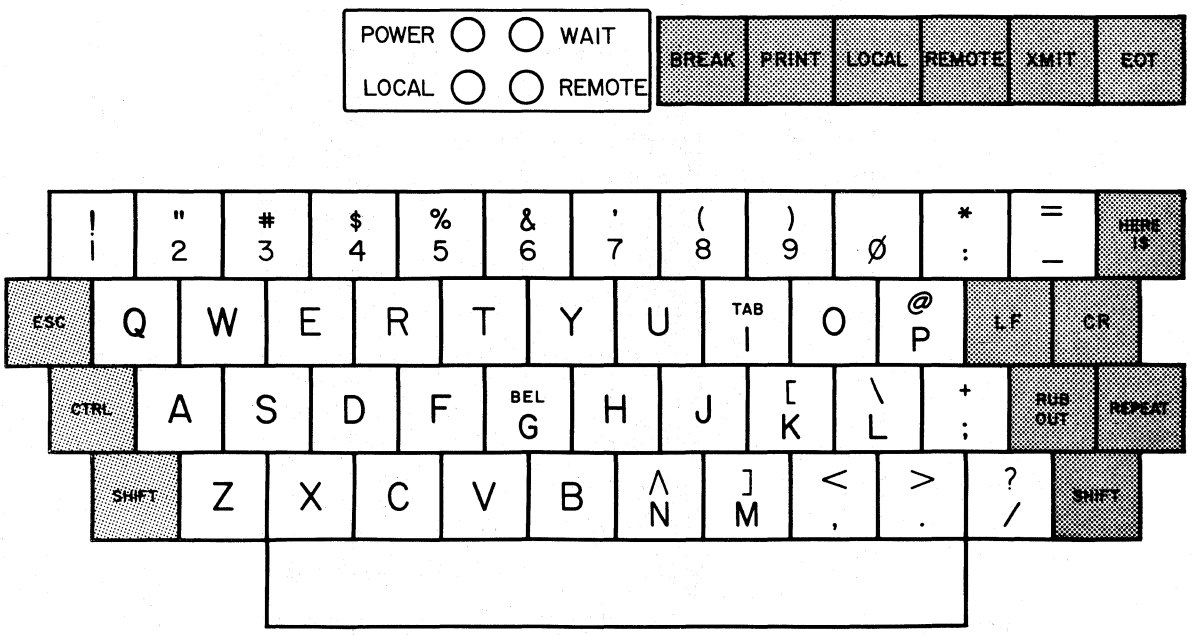


FIGURE 8. CONTROL KEYS

LINE FEED - - Depressing the Line Feed key moves the cursor symbol down one line without affecting its horizontal location on the screen. When the cursor is located on the bottom line, and the Line Feed key depressed, the cursor will move to the top line of the screen, continuing to move down the page with each succeeding Line Feed operation. The Line Feed code (ASCII ØA) is transmitted to the communication line.

Option: "Automatic Roll-Up" is a jumper wire selectable option (not enabled at time of manufacture) located on the Control Board See Section V, Figure 24. When enabled and when the cursor is on the bottom line of the screen, Line Feed actuation will move all displayed information up one line. The top line of data will be lost and the bottom line will have no displayed information. Each additional Line Feed entry will move displayed data up one line until the screen is blank.

If both Auto-Roll-Up and Auto-Line Feed options are enabled, a Carriage Return performed on the last line will cause the cursor to return to the left column and the entire page to roll up one line.

REPEAT KEY - - When used in conjunction with another character or function key, the ASCII code for that character or function will be repeatedly transmitted (and displayed) at a maximum rate of 15 hertz. At transfer rates below 150 baud, the Repeat function will occur as fast as the communication line allows.

RUB OUT - - This key generates the ASCII delete code (code 7F). This code is not recognized by the Terminal but may be used in communicating with the Processor.

ESCAPE - - This key generates the ASCII Escape code (1B). This code is not recognized by the Terminal but may be used in communicating with the Processor.

BREAK - - This key causes the communications lines to go to the spacing level for as long as the key is depressed.

CONTROL (CTRL) - - Used in conjunction with the key or keys that normally generate those codes in columns 4 and 5 of the ASCII Code Set (see Keyboard Code Chart, Section V) and causes the code generated to be changed to those codes shown in columns 0 and 1 of the ASCII Code set. This allows the keyboard to generate many additional codes. Most of the codes generated in this way are not used by the Terminal but may be used in communicating with the Processor. Some of the codes generated in this way are redundant. These codes are the ETX, Here Is (WRU), Line Feed, Return and Escape codes.

STANDARD FIELD TAB (TAB) - - Operation of the letter I with the CONTROL key generates Horizontal Tab code ASCII Ø9 and moves the cursor to the position immediately following the next tab stop. If no tab stops are present, the cursor will stop at the Home position. A tab stop code ("EPS," code ASCII 7A) can only be entered by the CPU.

"HERE IS" FUNCTION (ENQ)

Depressing the HERE IS key generates the ENQ code, sometimes renamed the WRU (who are you) code, ASCII 05, from the terminal.

When the ENQ code is recognized by the terminal's receiver, the terminal will transmit up to a maximum of 64 characters. The characters may be any character on the code chart from columns 0 through 7.

There are three options:

1) 0 characters (no "here is" function - standard)
2) 32 characters (optional)
3) 64 characters (optional)

The information is contained within programmable read-only-memories (PROM's). These PROM's may be programmed by the user to contain any information desired.

In LOCAL or HALF-DUPLEX operation, the transmitted characters are received by the terminal, and will be displayed and/or operated upon. In LOCAL mode, the transmitter line is disabled, so that nothing will be actually transmitted.

REMOTE KEY

Switches the terminal to the REMOTE condition. The transmitter and receiver external connections are enabled. If operational is full-duplex, the internal connection between transmitter and receiver is disabled.

LOCAL KEY

Switches the terminal to the LOCAL condition. The transmitter and receiver external connections are disabled. An internal connection to couple transmitter and receiver is enabled.

PRINT KEY

Depressing the print key generates the PRINT code (ASCII 60). If the PRINT code is received by the terminal, a signal is sent to the HARD COPY ADAPTOR (HCA, optional) to initiate off-line printing. If the HCA board is not able to accept the PRINT code, the code will be "dumped" into the "bit bucket". (ie disregarded)

XMIT KEY

The XMIT key on the keyboard generates the hexadecimal code 6A for use in control of the READ function. The interface may be set to transmit the 6A as is, or modify it to 6B before transmission. Under half-duplex operation, the 6A code will cause the READ mode to start, whereas the 6B code will be ignored by the terminal. With the 6B option setting, the programmer may use the XMIT key to generate an interrupt to the computer, which in turn causes the message to be sent (when it is ready) by returning the 6A code.) (See EOT key, below).

EOT KEY

The EOT key generates the ASCII EOT code (hexadecimal 04) for use as an interrupt to the CPU. Depending on the programmer's preference, it may be used to provide the interrupt for message transmission, instead of the XMIT key, or for any other special purpose requiring an interrupt.

CURSOR CONTROLS

Five keys located on the right hand portion of the keyboard (see Figure 9) control the movement of the cursor on the screen. The arrows on the keys indicate which direction the cursor will move when the key is depressed. The Repeat key can be used in conjunction with cursor control keys to speed cursor positioning.

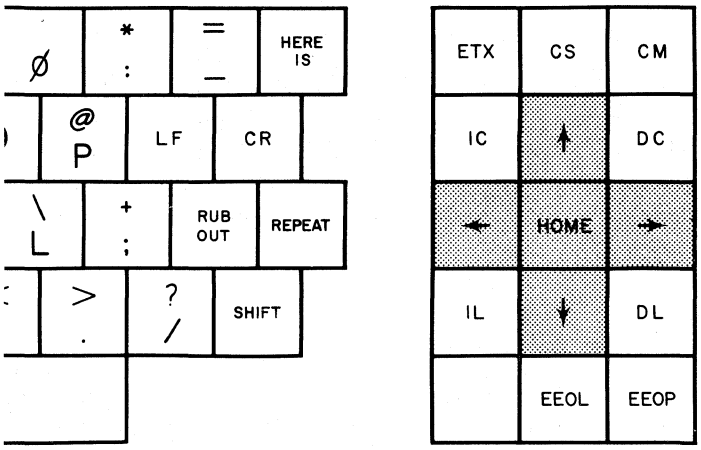


FIGURE 9. CURSOR CONTROL KEYS

HOME CURSOR KEY (HOME)

Moves the cursor from any position on the screen to the top line left column.

UP CURSOR KEY (↑)

Moves the cursor up vertically one line, but remains in the same column. When on the top line, the cursor will move to the bottom line, same column.

DOWN CURSOR KEY (↓)

Moves the cursor down vertically one line, but remains in the same column. When in the bottom line, the cursor will move to the top line, same column.

RIGHT CURSOR KEY (→)

Moves the cursor right one character position. When in the right column the cursor will move to the extreme left column of the line below. When in the bottom line right column, the cursor will move to home position.

LEFT CURSOR KEY (←)

Moves the cursor left one character position. When in the extreme left column, the cursor will move to the extreme right column of the line above. When in home position, the cursor will move to the last position (lower right) on the page.

EDITING CONTROLS

Model 450, 455 & 456 DATA–SCREEN Terminals permit on-line editing, if desired. In Remote Mode, when the various editing keys are depressed, codes are transferred directly to the CPU which performs the editing functions on previously transferred data through its software while the displayed message is edited by the terminal hardware. Editing capability consists of four

erase functions and four repositioning functions. Erase and repositioning functions are interlocked with the SHIFT key to prevent accidental operation of editing keys. Keyboard strobe is not generated for these eight functions unless the shift key is depressed in conjunction with the function key. See Figure 10 for location of editing controls. In addition, the READ mode described later in this manual may be used to transfer operator-edited data to the processor without the need for software editing.

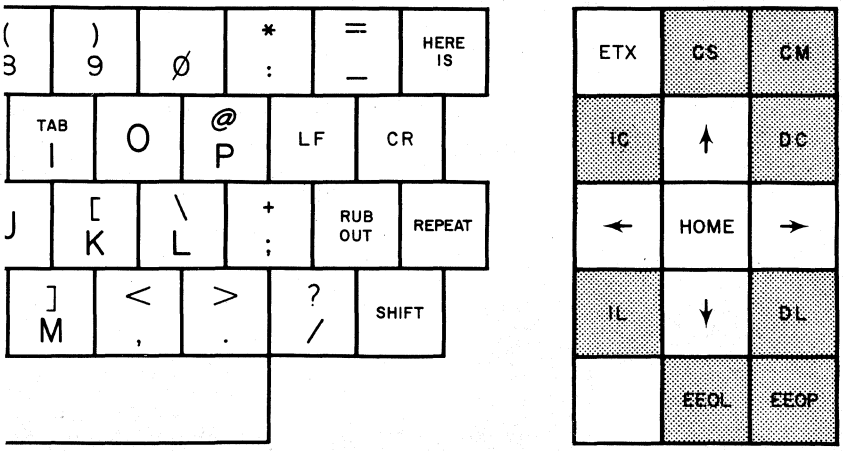


FIGURE 10. EDITING CONTROLS

CLEAR SCREEN KEY (CS) and Function

When the CS key is depressed, with the Shift key, space codes (code 20) are written into all page memory positions except those postiions protected (See PROTECT FUNCTION). Only protected data remains on the screen. Simultaneously, the cursor returns to the beginning of the first line (Home), or the first unprotected location on the page if Home position is protected.

CLEAR MEMORY KEY (CM) and Function

When the CM key is depressed, with the Shift key, space codes (code 2Ø) are written into all page memory positions including protected areas. The screen becomes completely blank and the cursor returns to Home.

ERASE TO END OF LINE KEY (EEOL)

When this edit key is depressed, with the Shift key, the character over the cursor and all characters to its right are erased from the line. The cursor remains in the same position. No other lines on the page are affected. Protected characters will not be erased.

ERASE TO END OF PAGE KEY (EEOP)

When this edit key is depressed, with the Shift key, the character over the cursor and all remaining characters on the page to right of and below the cursor are erased from the page. The cursor remains in the same position. Protected data will not be erased.

DELETE CHARACTER KEY (DC)

When this edit key is depressed, with the Shift key, the character over the cursor is deleted and the space is immediately filled with the character at the right. All remaining characters on the line move one space left. The right end of the line is filled with a SPACE code (code 2Ø). No other lines are affected. This function is inhibited if any protected characters are displayed, anywhere on the screen.

DELETE LINE KEY (DL)

When this edit key is depressed, with the Shift key, all characters in the line are lost and remaining lines below move up one line. The cursor can be in any position on the line to perform this function. After performing this function, the cursor will be located in the left column of the deleted line. The bottom line of the screen will be filled with space codes (code 2Ø). This function is inhibited if any protected characters are displayed, anywhere on the screen.

INSERT CHARACTER KEY (IC)

When this edit key is depressed, with the Shift key, the character over the cursor and all characters to its right are moved one space to the right. The cursor remains in the same position which is filled with a space code, (ASCII 20). The character moved off the end of the line is lost. A new character can be inserted at the cursor position. The cursor remains in the same position. This function is inhibited if any protected characters are displayed, anywhere on the screen.

INSERT LINE KEY (IL)

When this edit key is depressed, with the Shift key, all characters in the line and on the remainder of the page are moved down one line. The new line is filled with space codes (ASCII 20) and the cursor moves to the left column of the new line. New data can be entered on the now blank line. Any characters on the bottom line of the screen are lost. The cursor can be in any postion on the line to perform this edit function. This function is inhibited if any protected characters are displayed, anywhere on the screen.

COMPUTER COMMAND FUNCTIONS

Model 450, 455 and 456 DATA–SCREEN Terminals have the capability of performing a variety of functions under direct computer control. All data, protected or not, can be changed by computer program, made to blink at a rate to attract attention without impairing readability and protected from operator modification with Format Protect or Keyboard Lockout. Also, DATA-PANEL Display indicators can be turned on or off and a bell sounded to gain the operator's attention.

COMPUTER COMMAND FUNCTIONS

BLINK FUNCTION

The Start Blink (SBS code 7B) and End Blink (EBS code 7C) codes are inserted by the processor to control the blink function. When activated, a single character or a group of characters will blink at a frequency of approximately 1/4 second ON and 1/4 second OFF. The complete screen message, multiple characters or groups of character scattered randomly on the screen can be made to blink. Each group of blinking characters must be bracketed by a "Start Blink" and "End Blink" code. All SBS and EBS codes are displayed as spaces and are cleared when Clear Screen or Clear Memory functions are performed, unless they are within a protected sequence on a Clear Screen operation.

FORMAT PROTECT FUNCTION

The format protect function is used to prevent modification of certain areas of the screen by operator intervention (via keyboard input). Two special characters, which can be entered only by a processor, are used. Start Protect Sequence (SPS—code 79) and End Protect Sequence (EPS—code 7A) are used to surround the protected area. Any characters which appear after an SPS code and before the next EPS code cannot be modified by keyboard input. If the cursor enters a "protected area" the cursor will automatically jump over the protected area.

Whenever any area of the screen contains an SPS code, initializing the format protect function, the repositioning edit functions (character/line Insert/delete) are locked out (protect-inhibited).

The Clear Screen (CS) function leaves all protected areas unaffected when performed by either the operator or the processor. The Clear Memory (CM) function clears all of memory, including all SPS and EPS characters.

Each group of protected characters must be bracketed by an SPS code and and EPS code in the page memory. The protect function is not reset at the end of a line, so several lines of information may be protected by a single pair of SPS-EPS codes. The SPS and EPS codes themselves are protected with one exception: if no SPS occurs to begin the protected sequence, an EPS character will not be protected.

The EPS code is also used as a Tab stop code. Whenever the Tab function is used, the cursor seeks the next EPS on the page. If the programmer desires to retain field tabs after a Clear Screen operation, he must "protect" each EPS code with the SPS code immediately preceeding.

LOCK FUNCTION

The Lock Function (LOCK code - ASCII 7D) is entered by the processor to lockout the keyboard to prevent data being entered by the operator. The communications mode becomes full duplex regardless of the position of the half/full duplex switch and the transmitter remains connected to the keyboard. The processor may enter data anywhere on the screen including protected areas and the four edit functions (character or line - insert/delete) are operational. SPS and EPS characters are moved (as if they were alphanumeric characters) if they are within the edit function. Characters moved off the screen are lost.

RELEASE FUNCTION

The Release function (REL code - ASCII 7Ø) releases the keyboard and clears the lock condition by re-enabling the protect sequences and returning the communications mode to half duplex if the switch is set in that position.

The Release code also generates a signal to the printer adaptor to halt any print operation, if the print adaptor is so equipped to accept it. The adaptor equipped to halt printing is labelled HCA (Hard Copy Adaptor) and is numbered TEC P/N [redacted]. The adaptor not so equipped is labelled PRINT ADAPTOR and is numbered TEC P/N 933033.
930071

READ FUNCTION

When the read function code (ASCII 6A) is initiated by the computer or by the operator, the interface boards cause the transmission of data toward the computer beginning with the current cursor location and continuing until either an ETX is encountered within the message of the last position on the screen is reached. The last character transmitted will be an ETX. The unit must be in the REMOTE condition for the READ function to occur. The computer may interrupt the READ mode at any time by transmitting any displayable or non-displayable character. It can then re-issue the READ command and the terminal will begin transmitting data from its current cursor position (The READ-Interrupt may be disabled if desired).

Normal operation for the READ mode is as follows (See table 1): The operator places the terminal in the LOCAL condition using the Local key on the keyboard. The cursor is positioned to the desired beginning point of the message using the cursor controls. The message is typed and corrected until the operator is satisfied. An ETX is placed at the end of the message and the cursor is repositioned to the beginning of the message (usually HOME). The operator returns to the REMOTE mode, using the REMOTE key and depresses the transmit key. The terminal then transmits the entire message to the computer.

TABLE 1.

	OPERATOR	TERMINAL	COMPUTER
1)	Press Local	Local Light Turns On	
2)	Compose Message	Displays Data On Screen	
3)	Place ETX at End	Displays Data On Screen	
4)	Home Cursor	Displays Data On Screen	
5)	Press Remote	Remote Light Turns On	
6)	Press XMIT Key	XMITS 6A Code	Receives 6A Code
7)		XMITS Message *(Half Duplex)	Receives Message

*For full duplex computer must echo 6A code before transmission of Data occurs.

The READ function may also occur as follows (See table 2: The operator follows the same procedure as described above. The terminal transmits a 6B Code (See Communications Code Chart, Page 33) when the transmit key is depressed or the operator types a programmed instruction to the processor, such as ESC, or any other code or group of codes that the keyboard can generate, at the programmer's option. (The blank function key is available, giving out code 62 unshifted or code 72 shifted - See Communications Code Chart Page 33). The computer receives the 6B code or other prearranged query and reserves a buffer for the incoming data. When the computer is ready it transmits a 6A code to the terminal. The terminal then transmits the message.

TABLE 2.

	OPERATOR	TERMINAL	COMPUTER
1)	Press Local	Local Light Turns On	
2)	Compose Message	Displays Data On Screen	
3)	Place ETX at End	Displays Data On Screen	
4)	Home Cursor	Displays Data On Screen	
5)	Press Remote	Remote Light Turns On	
6)	Press XMIT Key or Prearranged Code	XMITS 6B Code or Prearranged Code	
7)		Receive 6A Code	Reserves Buffer and XMITS 6A code.
8)		XMIT Message	Receive Message

A number of options are available to the programmer in using the READ mode. The computer may send a message to the operator for verification and, if needed, updating, whereupon it is transmitted back to the computer in its latest form using one of the sequences described above. In addition,

the computer may be programmed to handle a portion of the cursor repositioning, if desired. For example, if messages always start at the HOME position, the operator may switch to REMOTE just before entering the ETX character. The ETX is then transmitted to the computer which sends a HOME Code to the terminal, followed by a READ code (if operation is full duplex, it may even echo the ETX to the screen before setting the cursor to the HOME position).

READ CURSOR ADDRESS FUNCTION (RCA)

When the RCA code (ASCII 6D) is transmitted to the terminal by the computer, the terminal responds by sending two characters to the computer. The first character is the one's complement of the horizontal cursor address and the second is the one's complement of the vertical cursor address. The terminal is ready for further data interchange as soon as the second character is completed. The terminal must be in the REMOTE mode for the READ CURSOR ADDRESS function to be recognized and performed.

LOAD CURSOR ADDRESS (LCA) FUNCTION

The computer may move the cursor to any position in memory by sending out a three character sequence consisting of 1) the LCA code (ASCII 6C), 2) the one's complement of the horizontal cursor address (CAH), and 3) the one's complement of the vertical cursor address (CAV). The terminal will respond by moving the cursor to the position selected, and all other functions will be disabled until the two characters are received.

If an invalid address is received (for example, attempting to position the cursor to row 27), the terminal will accept the address, decode it as invalid and inhibit loading of that address. This feature can be used to move only the vertical or horizontal address without affecting the other. If a parity error occurs and the parity check is enabled, the SUB character code (ASCII 1A) will be substituted. The cursor address which will be loaded into the

counter will be as if the SUB character code were originally sent. Note that if only five bits are used in a cursor address (as in the Vertical address), only five bits will be used to determine validity of the address. Similarly with 6 bits, as in the horizontal address on the Model 450 and 456.

BELL FUNCTIONS (BEL)

The computer may signal the operator by sending a BEL code (ASCII 07) to the terminal interface and causing the bell located in the Keyboard to ring. The terminal also generates a bell signal when the cursor approaches the end of each line and, when it enters the bottom line.

In Model 450, six entry positions remain when the bell sounds; In Model 455, when 11 positions remain; in Model 456, when 10 positions remain.

SET DATA·PANEL FUNCTION (SDP)

(See Section V for description of this option)
When the SDP function code (ASCII 6E) is transmitted to the terminal by the computer the DATA·PANEL control is set. The next character recevied is used by the adaptor to illuminate one display module of the DATA·PANEL Display. All other functions are disabled for one character.

The lowest four significant bits are used in setting the DATA·PANEL (see code chart for DATA·PANEL, Section V). While any combination of bits five through seven will be accepted, it is suggested that column three of the ASCII code chart be used - i.e.; bit 7 at "0" and bits 5 and 6 at "1". If a parity error is received on the data bit used to set the DATA·PANEL the SUB code (ASCII 1A) will be substituted if the parity check is enabled. If this occurs, the sixth indicator from the top of the DATA·PANEL Display will light up. If less than 16 legends are used it it suggested that this indicator be labeled PARITY ERROR. If all 16 are used, it is suggested that a relatively unimportant legend be assigned to this position.

CLEAR DATA·PANEL FUNCTION (CDP)

The CDP function code (ASCII 6F) clears all DATA·PANEL indicators. It does not require a second character in sequence. Individual indicators cannot be turned off selectively.

BLANK FUNCTION KEY

A blank function key is included in the keyboard and shown in the shaded area of Figure 11. Blank function key unshifted is ASCII code 62. Blank function key shifted is ASCII code 72. This key is a spare function key to be used only for special processor programs. Codes generated are transmitted to the processor via the communication line, but are not loaded into memory and are not recognized by the terminal in any way.

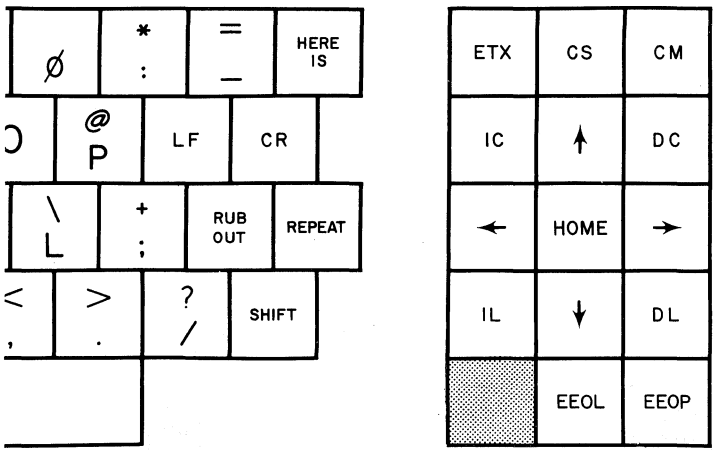


FIGURE 11. BLANK FUNCTION KEY

b7 → / b6 → / b5 → / Bits					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b4 ↓	b3 ↓	b2 ↓	b1 ↓	column → / row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SPACE	0	@	P	PRINT	
0	0	0	1	1	SOH	DC1	!	1	A	Q		
0	0	1	0	2	STX	DC2	"	2	B	R	BFK 1	BFK 2
0	0	1	1	3	ETX	DC3	#	3	C	S	EEOL	EEOP
0	1	0	0	4	EOT	DC4	$	4	D	T	IC	DC
0	1	0	1	5	ENQ	NAK	%	5	E	U	IL	DL
0	1	1	0	6	ACK	SYN	&	6	F	V	CS	CM
0	1	1	1	7	BEL	ETB	'	7	G	W	→	←
1	0	0	0	8	BS	CAN	(	8	H	X	↓	↑
1	0	0	1	9	TAB	EOM	)	9	I	Y	Home	
1	0	1	0	10 (A)	(LF)	SUB	*	:	J	Z	XMIT*	
1	0	1	1	11 (B)	VT	(ESC)	+	;	K	[	XMIT*	
1	1	0	0	12 (C)	FF	FS	,	<	L	\		
1	1	0	1	13 (D)	(CR)	GS	-	=	M	]		
1	1	1	0	14 (E)	SO	RS	.	>	N	^		
1	1	1	1	15 (F)	SI	US	/	?	O	—		RUB OUT

Codes in parentheses in columns 0 and 1 are generated directly on the keyboard. The remaining codes may be generated by use of the control (CTRL) key plus the corresponding code in columns 4 and 5 respectively.

BFK1 is Blank Function Key, unshifted.
BFK2 is Blank Function Key, shifted.

*The keyboard generates the 6A code, but by option, the interface may transmit either a 6A code or a 6B code.

FIGURE 12. KEYBOARD HEXADECIMAL CODE CHART
For Keyboard code summary, see pages 34-36.

b7 / b6 / b5 / Bits: b4	b3	b2	b1	column / row	0 (0 0 0)	1 (0 0 1)	2 (0 1 0)	3 (0 1 1)	4 (1 0 0)	5 (1 0 1)	6 (1 1 0)	7 (1 1 1)
0	0	0	0	0			SPACE	0	@	P	PRINT	REL
0	0	0	1	1			!	1	A	Q		
0	0	1	0	2	STX		"	2	B	R		
0	0	1	1	3	ETX		#	3	C	S	EEOL	EEOP
0	1	0	0	4			$	4	D	T	IC	DC
0	1	0	1	5	ENQ		%	5	E	U	IL	DL
0	1	1	0	6			&	6	F	V	CS	CM
0	1	1	1	7	(BEL)		'	7	G	W	→	←
1	0	0	0	8			(	8	H	X	↓	↑
1	0	0	1	9	TAB		)	9	I	Y	Home	SPS
1	0	1	0	10 (A)	(LF)	SUB	*	:	J	Z	READ	EPS
1	0	1	1	11 (B)			+	;	K	[		SBS
1	1	0	0	12 (C)			,	<	L	\	LCA	EBS
1	1	0	1	13 (D)	(CR)		-	=	M	]	RCA	LOCK
1	1	1	0	14 (E)			.	>	N	^	SDP	HLO
1	1	1	1	15 (F)			/	?	O	—	CDP	RUB OUT

SBS = CHAR(123)
EBS = CHAR(124)

FIGURE 13. COMMUNICATIONS HEXADECIMAL CODE CHART

For interface code summary, see pages 34-36.

EXPLANATION OF SYMBOLS
(Used on Keyboard and Communications Code Charts, Pages 32-33)

SYMBOL	EXPLANATION
XMIT	Causes transmission of contents of page memory from present cursor location to ETX or end of page.
HERE IS	Initiates automatic answer back when option is provided.
STX	Start of Text. Displays STX character (⊥) when received by memory.
ETX	End of Text. Display ETX character (┘) when received by memory.
BEL	Bell Code. Rings bell in Keyboard when received.
TAB	Field Tab Code. When received, causes terminal to advance cursor to next EPS code in memory.
LF	Line Feed. When received, causes cursor to descend one line, or causes Roll-Up from bottom line if option selected.
CR	Carriage Return. When received, causes character to be stored and cursor returned to left column. May have option to give automatic line feed. Displays CR symbol (◄).
SUB	When stored in memory, display full 35 dot matrix (■) to indicate parity error on received character.
ALPHA NUMERIC CHARACTERS	Displayable symbols in columns 2 thru 5 of the ASCII standard code chart.
REL	Release Keyboard. Resets Lock condition. Can be entered only from communications line. (See LOCK)

BFK	Blank functions key. ASCII codes 62 or 72 (respectively) are transmitted to the communications line when this key is pressed unshifted or shifted. No terminal functions or displays are associated with these two codes.
EEOL	Erase to End of Line. When received, causes system to erase from present cursor position to end of same line.
EEOP	Erase to End of Page. When received, causes system to erase from present cursor position to end of page.
IC	Insert Character. When received, causes system to insert a character at present cursor location.
DC	Delete Character. When received, causes system to delete a character at present cursor location.
IL	Insert Line. When received, causes system to insert a line at present cursor row.
DL	Delete Line. When received, causes system to delete a line at present cursor row.
CS	Clear Screen. When received, causes system to erase all non-protected characters on screen.
CM	Clear Memory. When received, causes system to erase entire memory.
← → ↓ and ↑	Cursor Position Controls. When received, system moves cursor one count in direction indicated.
HOME	Home Cursor Control. When received, places cursor at Home position. (top left corner)
LCA	Load Cursor Address. When received, the system accepts the next two characters as cursor addresses, first horizontal, then vertical.

SDP	Set DATA·PANEL. When received, system accepts the next character to light one of sixteen indicators on the DATA·PANEL option.
CDP	Clear DATA·PANEL. When received, all lights in the DATA·PANEL indicators are extinguished.
SPS	Start Protect Sequence. When received, this code is stored in memory to indicate that one or more characters following are to be "protected".
EPS	End Protect Sequence. When received, this code is stored in memory to indicate the end of a sequence of protected characters. It is also used as a "tab stop" for field tab operations, especially when no SPS is used with it.
SBS	Start Blink Sequence. When received, this code is stored in memory to indicate that one or more characters following are to be "blinked" on and off at an attention-getting rate.
EBS	End Blink Sequence. When received, this code is stored in memory to indicate the end of a group of characters in a blink sequence.
LOCK	When received, this code prevents the keyboard from entering data into its own memory, but does not prevent transmission of characters on the communications line.
HLO	Halt Local Output. Sends signal to Hard Copy Adaptor to stop printing. Printer completes characters in process before stopping.
RUB OUT	Rub Out or Delete Code. When key is pressed, ASCII Delete code is transmitted to communications line. No terminal display or function occurs.

All codes not specifically called out (specifically the remaining codes in columns 0 and 1) do not correspond to terminal functions but may be generated by the use of the CONTROL key with a code from columns 4 and 5 (alphabet, with or without shift as necessary). Blank areas in columns 6 and 7 can neither be generated nor used by the terminal, except for the Rub Out Code (7F) which may be generated but is not used by the terminal.

SECTION IV

THEORY OF OPERATION

NOTE: All ASCII codes referred to in this manual are in hexadecimal notation. See code charts in Section III.

INTRODUCTION

400 Series DATA–SCREEN Terminals are general purpose CRT display terminals for use in data processing, control and communications systems. Interface options allow direct connection to a processor or various types of remote connection.

The basic DATA–SCREEN Terminal consists of three modules: a power supply, a TV-type monitor and a card cage assembly. The card cage accomodates up to 10 printed circuit boards of which five are used for the basic device and one or more additional PCB's used for interface and optional features.

The five basic boards are the Timing Generator, Line Memory & Character Generator, Page Memory, Control, and Counter.

The TIMING GENERATOR board contains a basic oscillator and several counter-type frequency dividers. It provides timing signals to the rest of the display.

The LINE MEMORY & CHARACTER GENERATOR board stores one row of characters and converts from ASCII code to video signals for the monitor. Two switches on the board provide options for display or nondisplay of Cursor and Carriage Return symbols.

The PAGE MEMORY board stores the entire page of data. Its contents can be read and selectively altered through the interface, which includes keyboard and communicatons line inputs.

The COUNTER board consists of three counter circuits. These are, in effect, address registers containing the current addresses of the display (monitor), the Page Memory and the cursor.

The CONTROL board decodes incoming data and loads it into the proper place in the memory or performs the function called for.

Because screen display capacity format affects the functional description of the printed circuit boards, three descriptive sections follow:
one for the 50 X 20 page format (Model 450),
one for the 80 X 24 format (Model 455),
and one for the 40 X 24 format (Model 456).

The SERIAL I/O - 6A board contains the keyboard interface and transmitter circuitry for the serial interface.

The SERIAL I/O - 8B board contains the communications line interface and the receiver circuitry for the serial interface.

PRINTED CIRCUIT BOARD ASSEMBLY FUNCTIONS

Model 450, 1000 Character Display, 50 characters per line, 20 lines

TIMING GENERATOR - Board 1. See Function Diagram, Figure 14.

BASIC OSCILLATOR*

The oscillator frequency is determined as follows:

50	Hz	60	Hz	Refresh rate
x 317		x 264		No. of horizontal scans per frame
15.84	KHz	15.84	KHz	
x 64		x 64		No. of character times per scan
1.01376	MHz	1.01376	MHz	
x 7		x 7		No. of dot times per character
7.09632	MHz	7.09632	MHz	

DOT COUNTER

The Dot Counter divides the oscillator frequency by seven. Dot counts 1 thru 5 are the displayed character and dots 6 and 7 are blanks. The count is octal 1 thru 7. Phase 1 and phase 2 clocks for the Character Generator ROM and clock for the Line Memory are generated from Dot Counter signals.

CHARACTER COUNTER

The 1 MHz (approx.) character rate is divided by 64 by this 6 stage binary counter. Decoded outputs at count 6 and 56 turn the Line Memory clock on and off providing 50 pulses during each scan. The other 14 counts are horizontal retrace time. Horizontal Sync for the TV monitor(s) begins at count 60.

*60 Hz Standard, 50 Hz Optional. Text discusses 60 Hz Operation.

SCAN COUNTER

This 4 stage binary counter is driven by the Horizontal Sync pulse at 15.84 KHz. The counter is reset to zero after the count of ten and therefore divides by eleven. Each scan counter cycle represents one line of displayed characters. The scans are labeled thus:

Count	Binary	Scan	Display
0	0000	C	blank
1-7	0xxx	1-7	characters
8	1000	X	cursor
9	1001	A	blank
10	1010	B	blank

ROW COUNTER

This counter consists of a divide-by-12 counter and a divide by 2 stage. The outputs are vertical sync for the TV monitor at 60 Hz (or 50 Hz) a blanking signal during vertical retrace and a counter reset signal used on the counter board.

BLINK RATE

The 60 Hz is divided by 16 to provide a cursor blink rate of about 4 Hz. This is divided by 2 to provide the character blink rate for use in the blink sequences (SBS, EBS; See Section III).

PAGE MEMORY CLOCK GENERATOR

A 2 MHz (approx.) rate is generated by dividing the oscillator frequency by 4. This is the Page Memory Clock rate except during Scan A. The rate then becomes the Line Memory Clock rate or approximately 1 MHz. Stopping of the Page Memory clock for display and for I/O operations is controlled by the circuits in this section. Also included is a timer which prevents the Page Memory clock from being stopped long enough to lose data in the MOS dynamic shift register.

LINE MEMORY & CHARACTER GENERATOR - Board 2 (50 x 20 format)

See Functional Diagram, Figure 15.

LINE MEMORY

This section consists of seven MOS 50 bit dynamic shift registers operated in a bit parallel, character-serial mode. Also included are input or recirculate gates, output gates, voltage level converters, clock generator and driver circuits and load control circuits. The Line Memory (LM) stores one line of characters (50) while it is being displayed and is also used as a buffer memory during insert and delete edit functions.

During refresh the LM is loaded with a line of characters from the Page Memory during each Scan A. These are then recirculated during the next 10 scans and displayed during scans 1 thru 7. The cursor code (NUL, all "O's"), is forced into the LM when the Cursor compare and Cursor Blink Rate signals are both present. The result is an alternating cursor symbol and displayed character at a 4 Hz rate.

During editing the LM is operated at the Page Memory rate so that data can be transferred between the memories. Two discrete component circuits generate phase 1 and phase 2 clock pulses from the leading and trailing edges respectively of the input clock signal.

CHARACTER GENERATOR

The Character Generator circuits convert the ASCII code stored in the Line Memory to the 5 X 7 dot matrix pattern for display on the CRT. The standard 64 ASCII displayable symbols (upper case alpha, numbers and punctuation marks), hex codes 20 thru 5 F, are converted by a MOS Read only Memory. This ROM has nine address inputs. Six of these are the ASCII code coming from the Line Memory, less bit 7, and the remaining three addresses are the three low order bits of the Scan Counter. The ROM is inhibited if bits 6 and 7 of the incoming code are alike, or if the Scan Counter is not on a displayable scan. The five outputs are the dot patterns for that ASCII character in that Scan. This data is loaded in parallel into a five bit register and shifted serially at the basic oscillator frequency to form the video signal for the monitor.

The five special symbols STX, ETX, Carriage Return, Substitute and the Cursor are generated by TTL circuits. This data is serialized in another five bit register to compensate for the time delay normally taken thru the ROM.

The video is gated off during editing functions to prevent meaningless display on the CRT when the LM is not being used for refresh.

NTSC composite video & sync is provided at a BNC connector (VIDEO OUT) on the rear panel for driving remote TV monitors.

PAGE MEMORY - Board 3 (50 x 20 format) See Functional Diagram, Figure 16.

PAGE MEMORY

The Page Memory consists of seven 1024 bit MOS serial shift registers connected bit-parallel, character-serial, along with input recirculate gates, an output register and clock drivers. The switching of the input gates is controlled by the interface via the control board.

Each 1024 bit shift register is actually two 512 bit registers multiplexed. Thus each clock pulse, phase 1 or phase 2, results in a new character at the output and a new character loaded at the input. The clock rate is therefore divided by two and split into a 2 phase clock. Discrete circuit clock drivers provide the required voltage and power amplification. The output register provides properly timed outputs to the rest of the terminal logic. This register adds one character to the memory making 1025 characters of storage.

PROTECT & BLINK CONTROL

A Protect flip-flop is set when a Start Protect (SPS) character (code 79) is decoded at the Page Memory input. It is cleared when End Protect (EPS-code 7A) is decoded. While this flip-flop is set, the cursor is advanced unless the Keyboard Lock is set. Thus the field between SPS & EPS can not be altered from the keyboard.

The system is prevented from "hanging-up" in the event a programming error results in protecting the entire page, i.e., SPS at Home and no EPS in the memory. Under this condition the cursor remains at Home and the Protect function is inhibited. At least one position must be unprotected.

Insert and delete editing functions are inhibited when there is a protected field in the memory.

A flip-flop in the blink circuit is set when the Start Blink (SBS Code - ASCII 7B) is decoded at the page memory input and the character blink signal is present in the high state. The Page Memory character codes are replaced by space codes in the Line Memory when the LM is loaded during Scan A. This causes the characters following the SBS code to blink on and off at a two Hz rate until an End Blink (EBS Code - ASCII 7C) is decoded causing the blink flip-flop to reset.

CONTROL - Board 4. See Functional Diagram, Figure 17.

All codes received by the terminal from the interface of the keyboard are sent from the I/O to the control board. The code is examined to determine whether it is data or a function code. Data codes are loaded into the Page Memory at the present cursor address and the cursor is advanced one position. Function codes are decoded and the function is performed. Codes which are recognized as neither data nor function for this terminal are "dumped".

INPUT SECTION

Bits 6 & 7 of the codes coming from the I/O are examined to determine if the code is data, columns 2 through 5 or a function, columns 0, 1, 6 & 7 of the ASCII Code Chart. The Load Register pulse from the I/O is then gated to set the Data flip-flop of Function flip-flop. If either flip-flop is set, the terminal is "busy" and no new data can be entered into the Data Bit Register in the interface. CR, SUB, STX and ETX, SPS EPS, SBS, EBS, function cause data to be forced into memory.

FUNCTION DECODER

This decoder is enabled when the Function flip-flop is set. The input of a four bit to 1-of-16 decoder indicates which row, 0 thru F, the code is in and combined with column information, forms a discrete signal for each function. Refer to the ASCII code chart.

ERASE FUNCTIONS - (Clear Memory, Clear Screen, Erase to End of Line and Erase to End of Page)

The CM function sends the cursor to the Home position where the erase begins. Format protect functions are inhibited so that the entire memory is erased. The function flip-flop is cleared and the erase terminated by the End of Memory signal. The CS function sends the cursor to the Home postiion where the erase begins. Format protect functions are not inhibited so that only unprotected characters are erased. The Function flip-flop is cleared and the erase terminated by the End of Memory signal. The EEOL and EEOP functions begin the erase at the present cursor position. Format protect functions are not inhibited so that only unprotected characters are erased. The cursor remains in its position. The Function flip-flop is cleared and the erase terminated at the End of Line signal for EEOL and at the End of Memory signal for EEOP.

LOAD CURSOR ADDRESS FUNCTION

When the LCA code is received a control flip-flop is set which steers the one's complement of the next code received to the horizontal section of the cursor counter. At that time, the first control is cleared and a second control is set. The one's complement of the next code goes to the vertical section of the cursor counter and the second control is cleared. When either control flip-flop is set, codes received can not be interpreted as data of functions.

INSERT AND DELETE FUNCTIONS - (Insert Line, Insert Character, Delete Line, Delete Character)

If there is a protected field anywhere in the Page Memory, the Insert and Delete functions are inhibited. The function flip-flop is cleared immediately ending the function before it begins. The following descriptions assume no protected areas:

INSERT AND DELETE LINE SEQUENCE

Insert and Delete Line functions follow a similar sequence. Both functions move the cursor to the beginning of the line by clearing the Cursor Horizontal Address Counter to zero. Then the Line Memory clock and video are disabled and two control flip-flops set.* The first flip-flop activates a signal that forces space codes into the Page Memory and the second controls the gating of the Page Memory clock and output to the Line Memory. At the End of Line signal the first flip-flop is cleared. The combination of the first flip-flop cleared and the second flip-flop set, gates the Line Memory output to the Page Memory input. At this point, the Line Memory and Page Memory are in series and one line of spaces has been loaded into the Page Memory. The memories are clocked together until the function is terminated.**

* A Cursor Compare signal sets the two flip-flops for the Insert Line functions while an End of Memory signal is used for the Delete Line function.

**An End of Memory signal terminates the Insert Line function while a Cursor Compare signal is used for the Delete Line function.

INSERT AND DELETE CHARACTER SEQUENCE

The Insert and Delete Character functions follow a similar sequence. For both functions the Line Memory clock and video are disabled and the Page Memory clock is gated to the Line Memory. The first complete (full line) Cursor Compare Vertical causes the Load Line Memory signal to go active. After the End of Line signal the data in the Line Memory is recirculated. At this point the two functions differ:

Insert Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input. The following Cursor Compare (both vetrical and horizontal) loads the Page Memory with a space at the cursor position and inhibits the Line Memory Clock one character time losing the last character in the line.

Delete Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input and loads the Line Memory with a space at the end of the line. The following Cursor Compare (both vertical and horizontal) inhibits the Page Memory Clock one character time losing the deleted character.

Both functions are terminated by the next End of Line signal.

COUNTER - Board 5. See Functional Diagram, Figure 18.

This board contains 3 binary counters and 2 comparators. All counters are organized by column and line i.e., 50 counts horizontally and 20 counts vertically. A vertical count pulse is generated when the horizontal section rolls over from 49 to 0.

PAGE MEMORY COUNTER

This is a count up only counter which is advanced one count each time the Page Memory is clocked. It therefore contains the address of the character currently being read from and loaded into the Page Memory. Since the PM is 1025 characters long, a master reset pulse is generated at vertical count 20 and horizontal count 24 to reset both sections to 0.

DISPLAY COUNTER

This is a count up only counter which is advanced 50 counts during each Scan A and is reset to 0 during vertical retrace. It therefore contains the address of the next character to be loaded into the Line Memory for display.

CURSOR COUNTER

This is a count up, count down and directly presettable counter. It contains the address of the cursor position on the screen. Count down roll over from 0 to 49 horizontal and 0 to 19 vertical is provided by the borrow outputs which preset 49 into the horizontal counter and 19 into the vertical counter. Invalid addresses are detected and inhibit the Load Cursor Address function. An invalid address is "dumped", allowing the display to continue in sequence.

A "Bell" signal is generated when the horizontal section goes from 43 to 44 or the vertical section goes from 18 to 19. This signal goes to the interface to operate the keyboard bell.

COMPARATORS

The cursor comparator indicates coincidence between the Page Memory Counter and the Cursor Counter for loading the page memory and for displaying the cursor.

The Display comparator indicates coincidence between the Page Memory Counter and Display Counter for entering information into the Line Memory for subsequent display.

PRINTED CIRCUIT BOARD ASSEMBLY FUNCTIONS

Model 455, 1920 Character Display, 80 characters per line, 24 lines

TIMING GENERATOR - Board 1. See Functional Diagram Figure 14.

BASIC OSCILLATOR*

The oscillator frequency is determined as follows:

50	Hz	60	Hz	Refresh rate
x 312		x 260		No. of horizontal scans per frame
15.60	KHz	15.60	KHz	
x 102		x 102		No. of character times per scan
1.5912	MHz	1.5912	MHz	
x 7		x 7		No. of dot times per character
11.1384	MHz	11.1384	MHz	

DOT COUNTER

The Dot Counter divides the oscillator frequency by seven. Dot counts 1 thru 5 are the displayed character and dots 6 and 7 are blanks. The count is octal 1 thru 7. Phase 1 and phase 2 clocks for the Character Generator ROM and clock for the Line Memory are generated from Dot Counter signals.

CHARACTER COUNTER

The 1 MHz (approx.) character rate is divided by 102 by this 7 stage binary counter. Decoded outputs at count 12 and count 92 turn the Line Memory clock on and off providing 80 pulses during each scan. The other 22 counts are horizontal retrace time. Horizontal Sync for the TV monitor(s) begins at count 94.

*60 Hz Standard, 50 Hz Optional. Text discusses 60 Hz Operation.

SCAN COUNTER

This 4 stage decade counter is driven by the Horizontal Sync pulse at 15.6 KHz. Each scan counter cycle represents one line of displayed characters. The scans are labeled thus:

Count	Binary	Scan	Display
0	0000	B	blank
1-7	0xxx	1-7	characters
8	1000	X	cursor
9	1001	A	blank

ROW COUNTER

This counter consists of a divide-by-16 counter and a divide by 2 stage. The outputs are vertical sync for the TV monitor at 60 Hz, a blanking signal during vertical retrace and a counter reset signal used on the counter board. It is reset to 0 at the end of count 25.

BLINK RATE

The 60 Hz is divided by 16 to provide a cursor blink rate of about 4 Hz. This is divided by 2 to provide the character blink rate used in the character blink sequences. (SBS, EBS; See Section III).

PAGE MEMORY CLOCK GENERATOR

A 4 MHz (approx.) rate is generated by dividing the oscillator frequency by 3. This is the Page Memory Clock rate except during Scan A. The rate then becomes the Line Memory Clock rate of approx. 1.6 MHz Stopping of the Page Memory Clock for display and for I/O operations is controlled by the cirucits on this board along with a timer which prevents the Page Memory clock from being stopped long enough to lose data in the MOS dynamic shift register.

LINE MEMORY & CHARACTER GENERATOR - Board 2 (80 x 24 format)

See Functional Diagram, Figure 15.

LINE MEMORY

This section consists of seven MOS 80 bit dynamic shift registers operated in a bit-parallel, character-serial mode. Also included are input or recirculate gates, output gates, voltage level converters, clock generator and driver circuits and load control circuits. The Line Memory (LM) stores one line of characters (80) while it is being displayed and is also used as a buffer memory during insert and delete edit functions.

During refresh the LM is loaded with a line of characters from the Page Memory during each Scan A. These are then recirculated during the next 9 scans and displayed during scans 1 thru 7. The cursor code (NUL, all "O'x"), is forced into the LM when the Cursor compare and Cursor Blink Rate signals are both present. The result is an alternating cursor symbol and displayed character at a 4 Hz rate.

During editing the LM is operated at the Page Memory rate so that data can be transferred between the memories. Two discrete component circuits generate phase 1 and phase 2 clock pulses from the leading and trailing edges respectively of the input clock signal.

CHARACTER GENERATOR

The Character Generator circuits convert the ASCII codes stored in the Line Memory to the 5 x 7 dot matrix pattern for display on the CRT. The standard 64 ASCII displayable symbols (upper case alpha, numbers and punctuation marks), hex codes 20 thru 5F, are converted by an MOS Read only Memory. This ROM has 9 address inputs. Six of these are the ASCII code coming from the Line Memory, less bit 7, and the remaining three addresses are the low order bits of the Scan Counter. The ROM is inhibited if bits 6 and 7 of the incoming code are alike, or if the scan counter is not on a displayable scan. The five outputs are the dot patterns for that ASCII character in that Scan. This data is loaded in parallel into a 5-bit register and shifted serially at the basic oscillator frequency to form the video signal for the monitor.

The special symbols STX, ETX, Carriage Return, Substitute and the Cursor are generated by TTL circuits. This data is serialized in another 5-bit register to compensate for the time delay normally taken thru the ROM.

The video is gated off during editing functions to prevent meaningless display on the CRT when the LM is not being used for refresh.

A switch selectable option allows either normal white-on-black or inverted black-on-white display (See Figure 22). NTSC composite video & sync is provided at the BNC connector on the rear panel for driving remote TV monitors.

PAGE MEMORY - Board 3 (80 x 24 format) See Functional Diagram Figure 16.

PAGE MEMORY

The Page Memory consists of fourteen 1024 bit MOS serial shift registers connected as seven 2048 bit registers in parallel along with input recirculate gates, input and output registers and clock drivers. The switching of the input gates is controlled by the interface via the control board.

Each 1024 bit shift register is actually two 512 bit registers multiplexed. Thus each clock pulse, phase 1 or phase 2, results in a new character at the output and a new character loaded at the input. The clock rate is therefore divided by two and split into a 2 phase clock. Discrete circuit clock drivers provided the required voltage and power amplification. The output register provides properly timed outputs to the rest of the terminal logic. This register adds one character to the memory making 2049 characters of storage.

PROTECT & BLINK CONTROL

A flip-flop in the protect circuit is set when a Start Protect (SPS Code - ASCII 79) is decoded at the page memory input. The cursor will automatically advance, UNLESS the keyboard is locked out, until the End Protect (EPS Code - ASCII 7A) is decoded causing the protect flip-flop to reset. Therefore, the field of data between the SPS and EPS positions can not be altered from the keyboard.

The system is prevented from "hanging-up" in the event a programming error results in protecting the entire page, i.e., SPS at Home and no EPS in the memory. Under the condition the cursor remains at Home and the Protect function is inhibited. At least one position must be unprotected.

Insert and delete editing functions are inhibited when there is a protected field in the memory.

A flip-flop in the blink circuit is set when the Start Blink (SBS Code - ASCII 7B) is decoded at the page memory input and the character blink signal is present in the high state. The Page Memory character codes are replaced by space codes in the Line Memory when the LM is loaded during Scan A. This causes the characters following the SBS code to blink on and off at a two Hz rate until an End Blink (EBS Code - ASCII 7C) is decoded causing the blink flip-flop to reset.

CONTROL - Board 4. See Functional Diagram, Figure 17.

All codes received by the terminals from the interface of the keyboard are sent from the I/O to the control board. The code is examined to determine whether it is data or a function code. Data codes are loaded into the Page Memory at the present cursor address and the cursor is advanced one position. Function codes are decoded and the function is performed. Codes which are recognized neither as data nor function for this terminal are "dumped".

INPUT SECTION

Bits 6 & 7 of the codes coming from the I/O are examined to determine if the code is data, columns 2 through 5, or a function, columns 0, 1, 6 & 7 of the ASCII Code Chart. The Load Register pulse from the I/O is then gated to set the Data flip-flop or Function flip-flop. If either flip-flop is set, the terminal is "busy" and no new data can be entered into the Data Bit Register in the interface. CR, SUB, STX and ETX, & SPS EPS, SBS, EBS, functions cause data to be forced into memory.

FUNCTION DECODER

This decoder is enabled when the Function flip-flop is set. The input of a four bit to 1-of-16 decoder indicates which row, 0 thru F, the code is in and combined with column information, forms a discrete signal for each function. Refer to the ASCII code chart.

ERASE FUNCTIONS - (Clear Memory, Clear Screen, Erase to End of Line Erase to End of Page)

The CM function sends the cursor to the Home position where the erase begins. Format protect functions are inhibited so that the entire memory is erased. The function flip-flop is cleared and the erase terminated by the End of Memory signal. The CS function sends the cursor to the Home position where the erase begins. Format protect functions are not inhibited so that only unprotected characters are erased. The Function flip-flop is cleared and the erase terminated by the End of Memory signal. The EEOL and EEOP functions begin the erase at the present cursor position. Format protect functions are not inhibited so that only unprotected character are erased. The cursor remains in its position. The Function flip-flop is cleared and the erase terminated at the End of Line signal for EEOL and at the End of Memory signal for EEOP.

LOAD CURSOR ADDRESS FUNCTION

When the LCA code is received a control flip-flop is set which steers the one's complement of the next code received to the horizontal section of the cursor counter. At that time, the first control is cleared and a second control is set. The one's complement of the next code goes to the vertical section of the cursor counter and the second control is cleared. When either control flip-flop is set, codes received can not be interpreted as data or functions.

INSERT AND DELETE FUNCTIONS - (Insert Line, Insert Character, Delete Line, Delete Character)

If there is a protected field anywhere in the Page Memory, the Insert and Delete functions are inhibited. The function flip-flop is cleared immediately ending the function before it begins. The following descriptions assume no protect areas.

INSERT AND DELETE LINE SEQUENCE

Insert and Delete Line functions follow a similar sequence. Both functions move the cursor to the beginning of the line by clearing the Cursor Horizontal Address Counter to zero. Then the Line Memory clock and video are disabled and two control flip-flops set.* The first flip-flop activates a signal that forces space codes into the Page Memory and the Line Memory. At the End of Line signal the first flip-flop is cleared. The combination of the first flip-flop cleared and the second flip-flop set, gates the Line Memory output to the Page Memory input. At this point, the Line Memory and Page Memory are in series and one line of spaces has been loaded into the Page Memory. The memories are clocked together until the function is terminated.**

* A Cursor Compare signal sets the two flip-flops for the Insert Line function while an End of Memory signal is used for the Delete Line function.

** An End of Memory signal terminates the Insert Line function while a cursor Compare signal is used for the Delete Line function.

INSERT AND DELETE CHARACTER SEQUENCE

The Insert and Delete Character functions follow a similar sequence. For both functions the Line Memory Clock and video are disabled and the Page Memory clock is gated to the Line Memory. The first complete (full line) Cursor Compare Vertical causes the Load Line Memory signal to go active. After the End of Line signal the data in the Line Memory is recirculated. At this point the two functions differ:

Insert Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input. The following Cursor Compare (both vertical and horizontal) loads the Page Memory with a space at the cursor position and inhibits the Line Memory Clock one character time losing the last character in the line.

Delete Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input and loads the Line Memory with a space at the end of the line. The following Cursor Compare (both vertical and horizontal) inhibits the Page Memory Clock one character time losing the deleted character.

Both functions are terminated by the next End of Line signal.

COUNTER - Board 5. See Functional Diagram, Figure 18.

This board contains 3 binary counters and 2 comparators. All counters are organized by column and line i.e., 80 counts horizontally and 24 counts vertically. A vertical count pulse is generated when the horizontal section rolls over from 79 to 0.

PAGE MEMORY COUNTER

This is a count up only counter which is advanced one count each time the Page Memory is clocked. It therfore contains the address of the character currently being read from and being loaded into the Page Memory. Since the PM is 2048 characters long, a master reset pulse is generated at vertical count 25 and horizontal count 48 to reset both sections to 0.

DISPLAY COUNTER

This is also a count up only counter. It is advanced 80 counts during each Scan A and is reset to 0 during vertical retrace. It therefore contains the address of the next character to be loaded into the Line Memory for display.

CURSOR COUNTER

This is a count up, count down and directly presettable counter. It contains the address of the cursor position on the screen. Count down roll over from 0 to 79 horizontal and 0 to 23 vertical is provided by the borrow outputs which preset 79 into the horizontal counter and 23 into the vertical counter. Invalid addresses are detected and inhibit the Load Cursor Address function. An invalid address is "dumped" allowing the display to continue in sequence.

A "Bell" signal is generated when the Horizontal section goes from 68 to 69 or the Vertical section goes from 22 to 23. This signal goes to the interface to operate the keyboard bell.

COMPARATORS

The cursor comparator indicates coincidence between the Page Memory Counter and the Cursor Counter for loading the page memory and for displaying the cursor.

The Display comparator indicates coincidence between the Page Memory Counter and Display Counter for entering information into the Line Memory for subsequent display.

PRINTED CIRCUIT BOARD ASSEMBLY FUNCTIONS

Model 456, 960 Character Display, 40 characters per line, 24 lines

TIMING GENERATOR - Board 1. See Functional Diagram, Figure 14

BASIC OSCILLATOR*

The oscillator frequency is determined as follows:

50	Hz	60	Hz	Refresh rate
x 312		x 260		No. of horizontal scans per frame
15.60	KHz	15.60	KHz	
x 54		x 54		No. of character times per scan
842.4	KHz	842.4	KHz	
x 7		x 7		No. of dot times per character
5.8968	MHz	5.8968	MHz	

DOT COUNTER

The Dot Counter divides the oscillator frequency by seven. Dot counts 1 thru 5 are the displayed character and dots 6 and 7 are blanks. The count is octal 1 thru 7. Phase 1 and phase 2 clocks for the Character Generator ROM and clock for the Line Memory are generated from Dot Counter signals.

CHARACTER COUNTER

The 1 MHz (approx.) character rate is divided by 54 by this 6 stage binary counter. Decoded outputs at count 6 and count 46 turn the Line Memory clock on and off providing 40 pulses during each scan. The other 14 counts are horizontal retrace time. Horizontal Sync for the TV monitor(s) begins at count 50.

*60 Hz Standard, 50 Hz Optional. Text discusses 60 Hz Operation.

SCAN COUNTER

This 4 stage decade counter is driven by the Horizontal Sync pulse at 15.6 KHz. Each scan counter cycle represents one line of displayed characters. The scans are labeled thus:

Count	Binary	Scan	Display
0	0000	B	blank
1-7	0xxx	1-7	characters
8	1000	X	cursor
9	1001	A	blank

ROW COUNTER

This counter consists of a divide-by-16 counter and a divide by 2 stage. The outputs are vertical sync for the TV monitor at 60 Hz, a blanking signal during vertical retrace and a counter reset signal used on the counter board. It is reset to 0 at end of count 25.

BLINK RATE

The 60 Hz is divided by 16 to provide a cursor blink rate of about 4 Hz. This is divided by 2 to provide the character blink rate, used in the character blink sequence (SBS, EBS; See Section III).

PAGE MEMORY CLOCK GENERATOR

A 2 MHz (approx.) rate is generated by dividing the oscillator frequency by 3. This is the Page Memory Clock rate except during Scan A. The rate then becomes the Line Memory Clock rate of approximately 1 MHz. Stopping of the Page Memory clock for display and for I/O operations is controlled by the circuits on this board along with a timer which prevents the Page Memory clock from being stopped long enough to lose data in the MOS dynamic shift register.

LINE MEMORY & CHARACTER GENERATOR - Board 2 (40 x 24 format)

See Functional Diagram Figure 15.

LINE MEMORY

This section consists of seven MOS 40 bit dynamic shift registers operated in bit-parallel, character-serial mode. Also included are input or recirculate gates, output gates, voltage level converters, clock generator and driver circuits and load control circuits. The Line Memory (LM) stores one line of characters (40) while it is being displayed and is also used as a buffer memory during insert and delete edit functions.

During refresh the LM is loaded with a line of characters from the Page Memory during each Scan A. These are then recirculated during the next 9 scans and displayed during scans 1 thru 7. The cursor code (NUL, all "O's), is forced into the LM when the Cursor compare and Cursor blink rate signals are both present. The result is an alternating cursor symbol and displayed character at 4 Hz rate.

During editing the LM is operated at the Page Memory rate so that data can be transferred between the memories. Two discrete component circuits generate phase 1 and phase 2 clock pulses from the leading and trailing edges respectively of the input clock signal.

CHARACTER GENERATOR

The Character Generator circuits convert the ASCII code stored in the Line Memory to the 5 x 7 dot matrix pattern for display on the CRT. The standard 64 ASCII displayable symbols (upper case alpha, numbers and punctuation marks), hex codes 20 thru 5F, are converted by an MOS Read only Memory. This ROM has 9 address inputs. Six of these are the ASCII code coming from the Line Memory, less bit 7, and the remaining three addresses are the three low order bits of the Scan Counter. The ROM is inhibited if bits 6 and 7 of the incoming code are alike, or if the scan counter is not on a displayable scan. The five outputs are the dot patterns for that ASCII character in that Scan. This data is loaded in parallel into a 5 bit register and shifted serially at the basic oscillator frequency to form the video signal for the monitor.

The 5 special symbols STX, ETX, Carriage Return, Substitute and the Cursor are generated by TTL circuits. This data is serialized in another 5 bit register to compensate for the time delay normally taken thru the ROM.

The video is gated off during editing functions to prevent meaningless display on the CRT when the LM is not being used for refresh.

NTSC composite video & sync is provided at the BNC connector on the rear panel for driving remote TV monitors.

PAGE MEMORY - Board 3 (40 x 24 format) See Functional Diagram Figure 16.

PAGE MEMORY

The Page Memory consists of seven 1024 bit MOS serial shift registers connected bit-parallel, character-serial, along with input recirculate gates, an output register and clock drivers. The switching of the input gates is controlled by the interface via the control board.

Each 1024 bit shift register is actually two 512 bit registers multiplexed. Thus each clock pulse, phase 1 or phase 2, results in a new character at the output and a new character loaded at the input. The clock rate is therefore divided by two and split into a 2 phase clock. Discrete circuit clock drivers provide the required voltage and power amplification. The output register provides properly timed outputs to the rest of the terminal logic. This register adds one character to the memory making 1025 characters of storage.

PROTECT & BLINK CONTROL

A Protect flip-flop is set when a Start Protect (SPS) character (code 79) is decoded at the Page Memory input. It is cleared when End Protect (EPS-code 7A) is decoded. While this flip-flop is set, the cursor is advanced unless the Keyboard Lock is set. Thus the field between SPS & EPS can not be altered from the keyboard.

The system is prevented from "hanging-up" in the event a programming error results in protecting the entire page, i.e., SPS at Home and no EPS in the memory. Under this condition, the cursor remains at Home and the Protect function is inhibited. At least one position must be unprotected.

Insert and delete editing functions are inhibited when there is a protected field in the memory.

A flip-flop in the blink circuit is set when the Start Blink (SBS Code ASCII 7B) is decoded at the page memory input and the character blink signal is present in the high state. The Page Memory character codes are replaced by space codes in the Line Memory when the LM is loaded during Scan A. This causes the characters following the SBS code to blink on and off at a two Hz rate until an End Blink (EBS Code ASCII 7C) is decoded causing the blink flip-flop to reset.

CONTROL - Board 4. See Functional Diagram Figure 17.

All codes received by the terminal from the interface of the keyboard are sent from the I/O to the control board. The code is examined to determine whether it is data or a function code. Data codes are loaded into the Page Memory at the present cursor address and the cursor is advanced one position. Function codes are decoded and the function is performed. Codes which are recognized neither as data nor function for this terminal are "dumped".

INPUT SECTION

Bits 6 & 7 of the codes coming from the I/O are examined to determine if the code is data, columns 2 through 5 or a function, columns 0, 1, 6 & 7 of the ASCII Code Chat. The Load Register pulse from the I/O is gated to set the Data flip-flop or Function flip-flop. If either flip-flop is set, the terminal is "busy" and no new data can be entered into the Data Bit Register in the interface. CR,SUB, STX and ETX functions cause data to be forced into memory.

FUNCTION DECODER

This decoder is enabled when the Function flip-flop is set. The input of a four bit to 1-of-16 decoder indicates which row, 0 thru F, the code is in and combined with column information, forms a discrete signal for each function. Refer to the ASCII code chart.

ERASE FUNCTIONS - (Clear Memory, Clear Screen Erase to End of Line, Erase to End of Page)

The CM function sends the cursor to the Home position where the erase begins. Format protect functions are inhibited so that the entire memory is erased. The Function flip-flop is cleared and the erase terminated by the End of Memory signal. The CS function sends the cursor to the Home position where the erase begins. Format protect functions are not inhibited so that only unprotected characters are erased. The Function flip-flop is cleared and the erase terminated by the End of Memory signal. The EEOL and EEOP functions begin the erase at the present cursor position. Format protect functions are not inhibited so that only unprotected characters are erased. The cursor remains in its position The Fucntion flip-flop is cleared and the erase terminated at the End of Line signal for EEOL and at the End of Memory signal for EEOP.

LOAD CURSOR ADDRESS FUNCTION

When the LCA code is received a control flip-flop is set which steers the one's complements of the next code received to the horizontal section of the cursor counter. At that time, the first control is cleared and a second control is set. The one's complement of the next code goes to the vertical section of the cursor counter and the second control is cleared. When either control flip-flop is set, codes received can not be interpreted as data or functions.

INSERT AND DELETE FUNCTIONS - (Insert Line, Insert Character, Delete Line, Delete Character)

If there is a protected field anywhere in the Page Memory, the Insert and Delete functions are inhibited. The Function flip-flop is cleared immediately ending the function before it begins. The following descriptions assume no protected areas.

INSERT AND DELETE LINE SEQUENCE

Insert and Delete Line functions follow a similar sequence. Both functions move the cursor to the beginning of the line by clearing the Cursor Horizontal Address Counter to zero. Then the Line Memory clock and video are disabled and two control flip-flops set.* The first flip-flop activates a signal that forces space codes into the Page Memory and the second controls the gating of the Page Memory clock and output to the Line Memory. At the End of Line signal the first flip-flop is cleared. The combination of the first flip-flop cleared and the second flip-flop set, gates the Line Memory output to the Page Memory input. At this point, the Line Memory and Page Memory are in series and one line of space has been loaded into the Page Memory. The memories are clocked together until the function is terminated.**

* A Cursor Compare signal sets the two flip-flops for the Insert Line functions while an End of Memory signal is used for the Delete Line function.

** An End of Memory signal terminates the Insert Line Function while a Cursor Compare signal is used for the Delete Line function.

INSERT AND DELETE CHARACTER SEQUENCE

The Insert and Delete Character functions follow a similar sequence. For both functions the Line Memory clock and video are disabled and the Page Memory clock is gated to the Line Memory. The first complete (full line) Cursor Compare Vertical causes the Load Line Memory signal to go active. After the End of Line signal the data in the Line Memory is recirculated. At this point the two functions differ:

Insert Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input. The following Cursor Compare (both vertical and horizontal) loads the Page Memory with a space at the cursor position and inhibits the Line Memory Clock on character time losing the last character in the line.

Delete Character - The next Cursor Compare Vertical causes the Line Memory output to become Page Memory input and loads the Line Memory with a space at the end of the line. The following Cursor Compare (both vertical and horizontal) inhibits the Page Memory Clock one character time losing the delete character.

Both functions are terminated by the next End of Line signal.

COUNTER - Board 5. See Functional Diagram, Figure 18

This board contains 3 binary counters and 2 comparators. All counters are organized by line and column i.e. 40 counts horizontally and 24 counts vertically. A vertical count pulse is generated when horizontal section rolls over from 39 to 0.

PAGE MEMORY COUNTER

This is a count up only counter which is advanced one count each time the Page Memory is clocked. It therefore contains the address of the character currently being read from and being loaded into the Page Memory. Since the PM is 1024 character long, a master reset pulse is generated at vertical count 25 and horizontal count 24 to reset both sections to 0 (Row "24" is completely blank.)

DISPLAY COUNTER

This is also a count up only counter. It is advanced 40 counts during each Scan A and is reset to 0 during vertical retrace. It therefore contains the address of the next character to be loaded into the Line Memory for display.

CURSOR COUNTER

This is a count up, count down and directly presettable counter. It contains the address of the cursor position on the screen. Count down roll over from 0 to 39 horizontal and 0 to 23 vertical is provided by the borrow outputs which preset 39 into the horizontal counter and 23 into the vertical counter. Invalid addresses are detected and inhibit the Load Cursor Address function. An invalid address is "dumped" allowing the display to continue in sequence.

A "Bell" signal is generated when the Horizontal section goes from 29 to 30 or the Vertical section goes from 22 to 23. This signal goes to the interface to operate the keyboard bell.

COMPARATORS

The Cursor Comparator indicates coincidence between the Page Memory Counter and the Cursor Counter for loading the page memory and for displaying the cursor.

The Display comparator indicates coincidence between the Page Memory Counter and Display Counter for entering information into the LIne Memory for subsequent display.

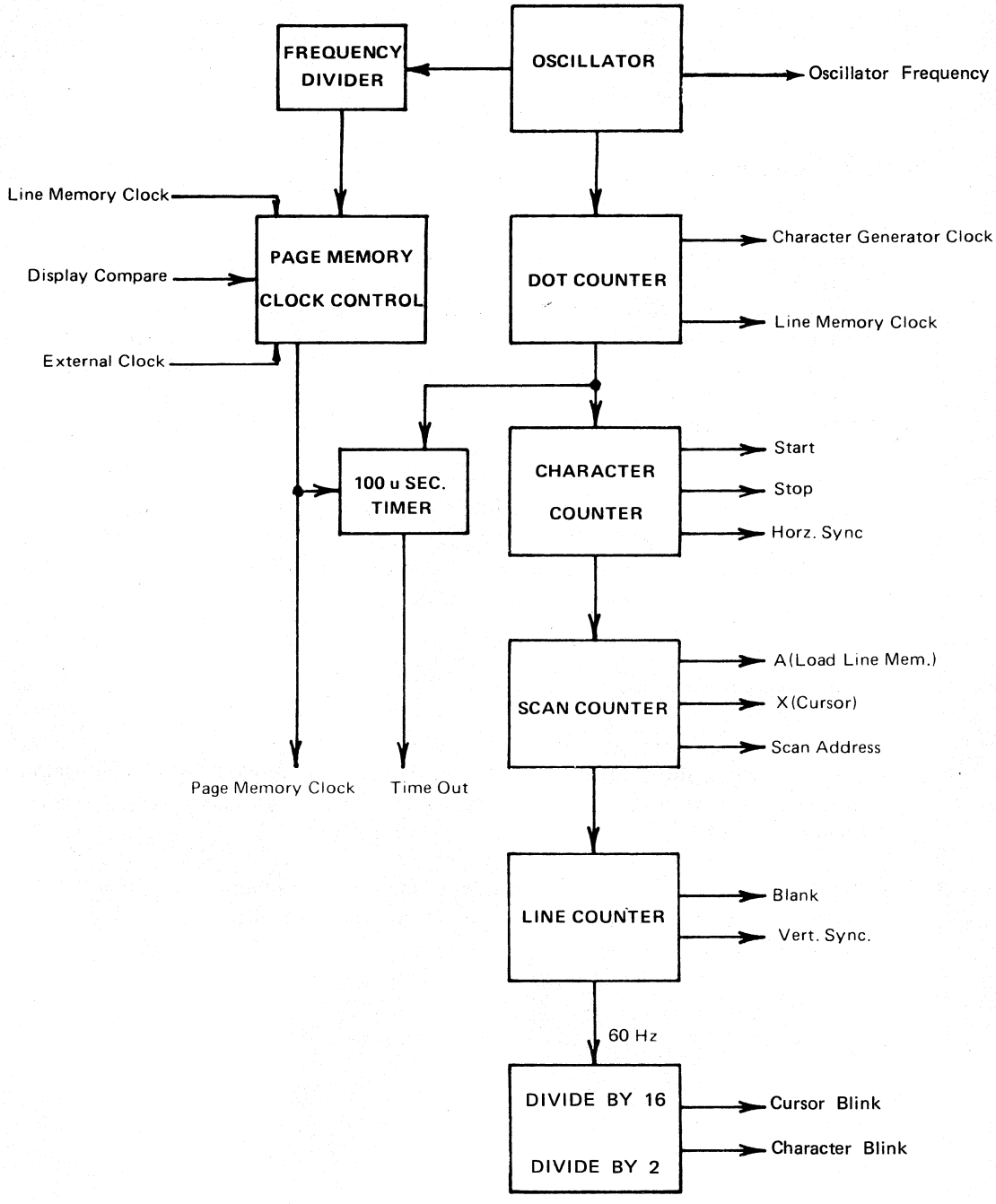


FIGURE 14. FUNCTIONAL DIAGRAM – TIMING GENERATOR PCB

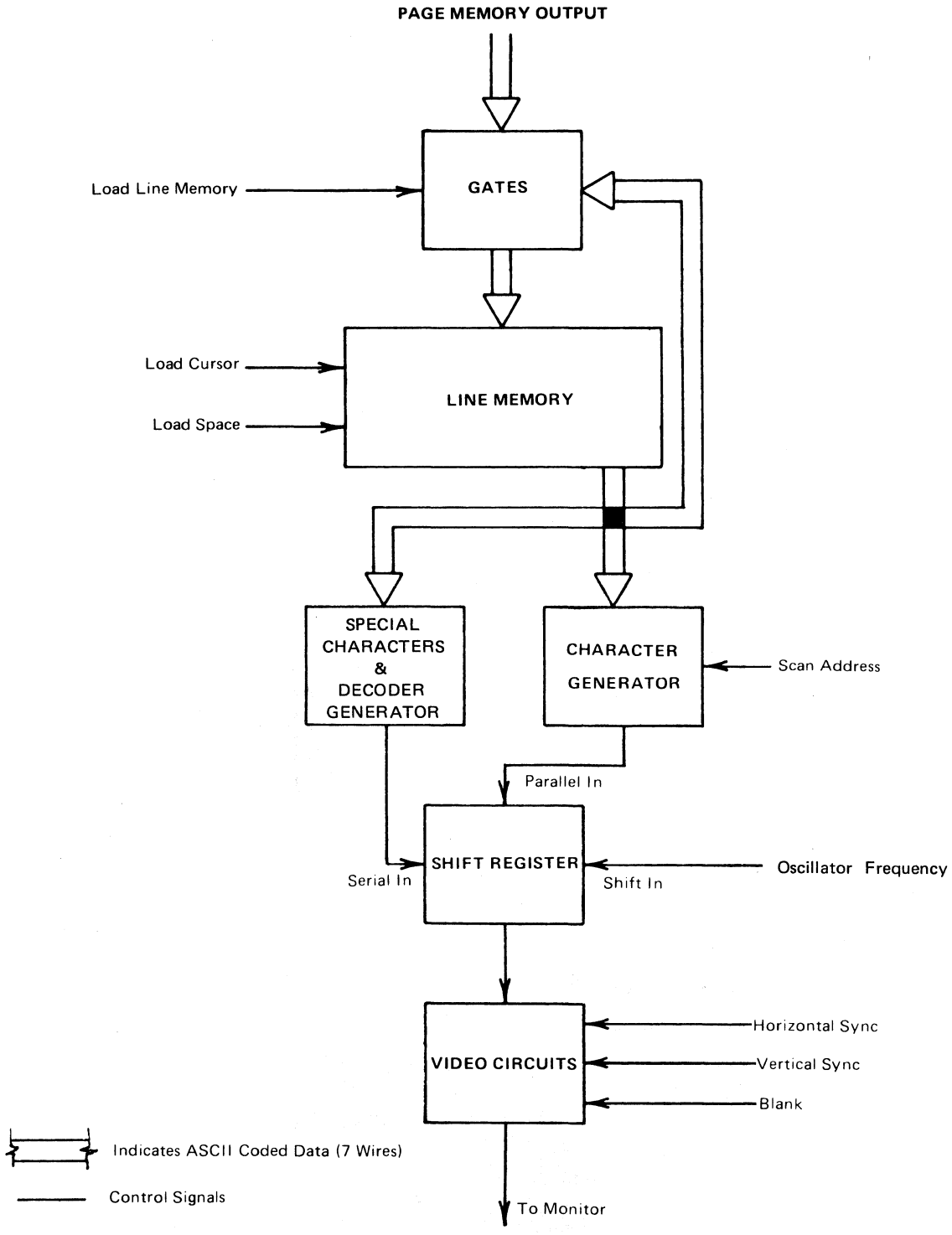


FIGURE 15. FUNCTIONAL DIAGRAM – LINE MEMORY and CHARACTER GENERATOR PCB

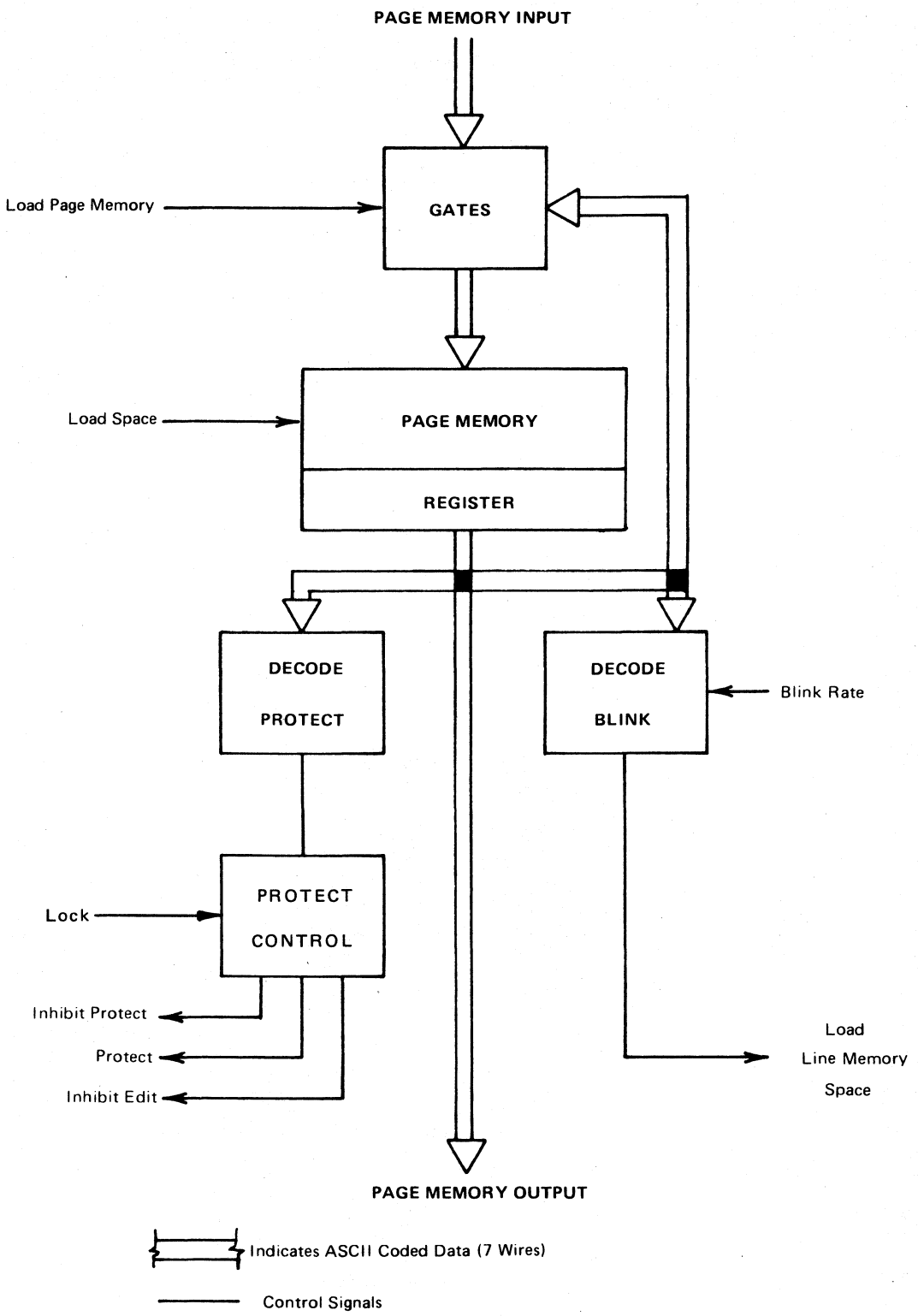


FIGURE 16. FUNCTIONAL DIAGRAM – PAGE MEMORY PCB

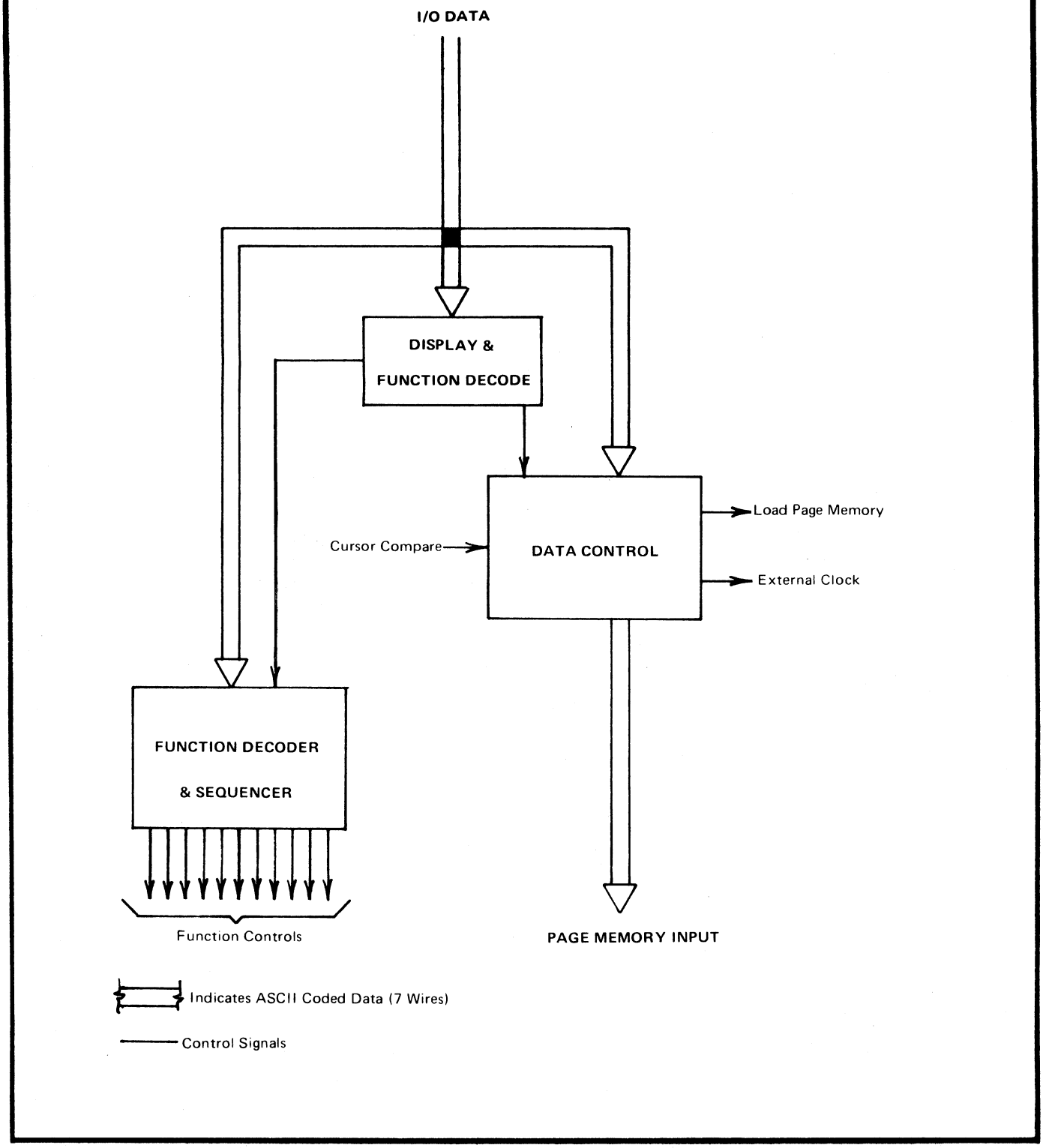


FIGURE 17. FUNCTIONAL DIAGRAM – CONTROL PCB

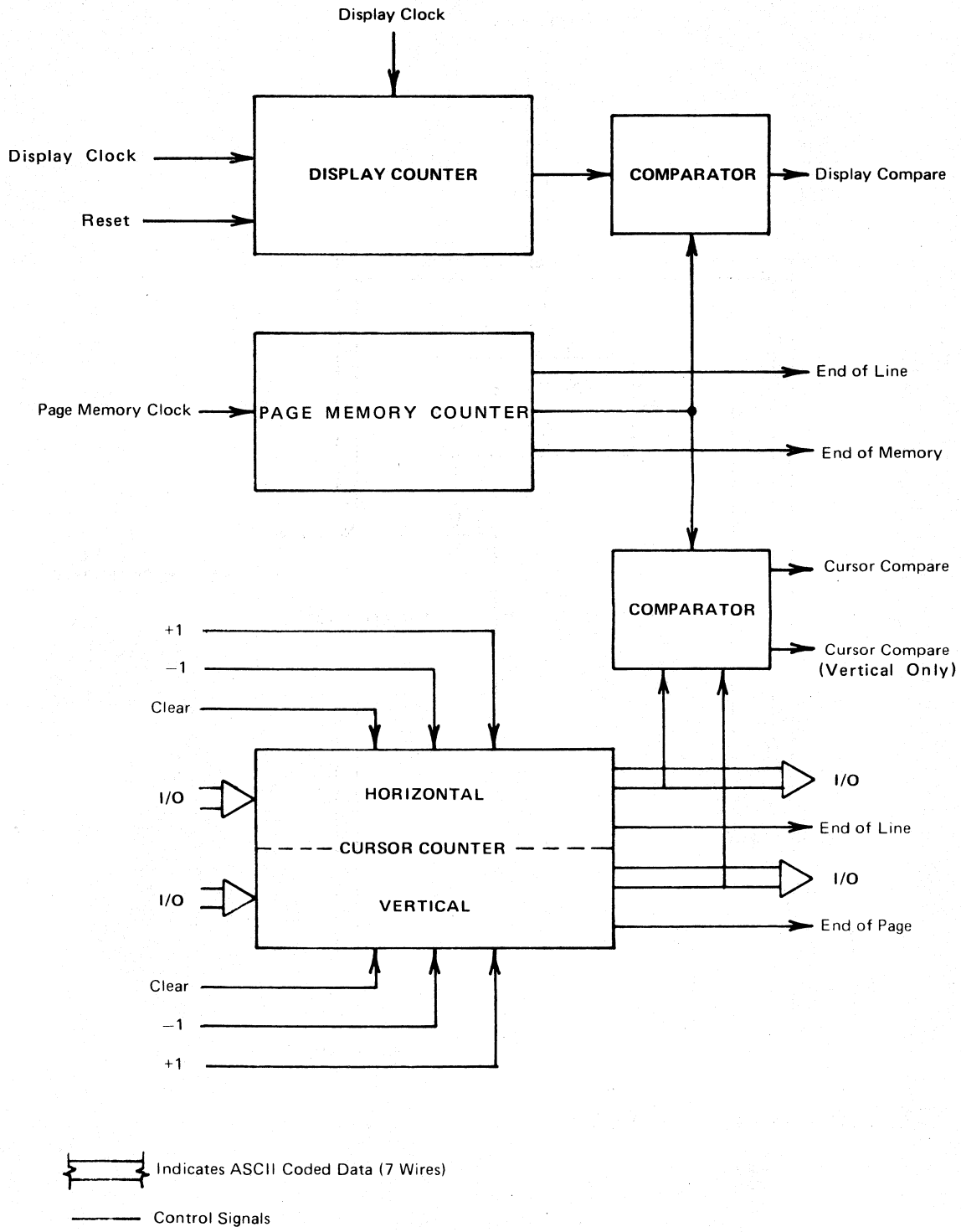


FIGURE 18. FUNCTIONAL DIAGRAM – COUNTER PCB

INTERFACE DESCRIPTION – Boards 6 & 8. See Functional Diagram, Figure 19.

The interface, which is common to Models 450, 455 and 456 is an electronic simulation of the mechanical and electrical hardware present in modern teletypewriters. It is compatible with teleprinters and computer systems using full-duplex TTY's including the automatic answer-back feature. In most cases, Models 450, 455 and 456 replace TTY's without requiring major system reprogramming or the use of additional interface hardware.

The TTY-Compatible interface physically consists of two printed circuit boards, the back panel wires on the card cage, an I/O connector mounted on the PCB for connection to external modems or current loop systems, and a keyboard connector. See Figure 20 for more detail on modem, and keyboard connectors and Table 1 for specification of connector types.

The TTY compatible interface is a data serializer and signal level converter mounted on a printed circuit board which plugs into the basic Series 400 DATA–SCREEN Terminal. The interface performs these following functions:

1. Transfers and interprets character sequences from a processor to the basic DATA–SCREEN Terminal, DATA·PANEL Display and Printer.

2. Transfers data from the terminal keyboard to the processor.

3. Provides an EIA (RS-232C,) 20 to 60 ma current loop or TTL interface for convenient attachment to a processor. (It is recommended that the current loop interface be used only for speeds at or below 2400 baud, although operation at 9600 baud is possible.)

4. Provides an asynchronous 10 or 11 bit character format; start bit (space), 7 bit USASCII code, parity bit (odd or even) and stop bits (one or two marks).

5. Provides for transfer rates of 110 thru 9600 baud. The basic oscillator may be set to any speed within the range indicated for special transfer rates.

TABLE 3 CONNECTORS

FUNCTION	CON-NECTOR	NO. OF PINS	ADAPTOR CONNECTOR	CABLE CONNECTOR
I/O to/from Modem	J1 PCB No. 8	25	781013-003*	781014-003* Cinch DB 25S
Printer Option (Hard Copy Ad.)	J4 PCB No. 10	15	781013-002*	781014-002* (Cinch DA 15S)
Keyboard	J3 PCB No. 6	37	781014-004*	781013-004* (Cinch DC 37P)

KEYBOARD CONNECTOR SIGNAL DEFINITIONS

The keyboard connector will accept the matching keyboard. The connector has the following pin assignments:

PIN	NAME
1,2	+5V power to keyboard
3	CHASSIS GND
6	$\overline{\text{KYBD ACK}}$ (acknowledge signal for repeat function)
5	REMOTE, LOCAL LIGHT CONTROL
11	$\overline{\text{BIT 1}}$
9	LOCAL SWITCH
12	$\overline{\text{BIT 2}}$
13	$\overline{\text{BIT 3}}$
14	BIT 4
15	$\overline{\text{BIT 5}}$
16	$\overline{\text{BIT 6}}$
17	$\overline{\text{BIT 7}}$
18	$\overline{\text{STROBE}}$ (level change)
20,21,22	Ground (for power leads)
25	WAIT LIGHT CONTROL
26	$\overline{\text{BEL}}$ (negative-going edge triggers bell)
27	$\overline{\text{BREAK}}$
28	REMOTE SWITCH
30-37	Signal Ground (for data bits & signals)

No connection to pins 4, 7, 8, 10, 19, 23, 24, 29.

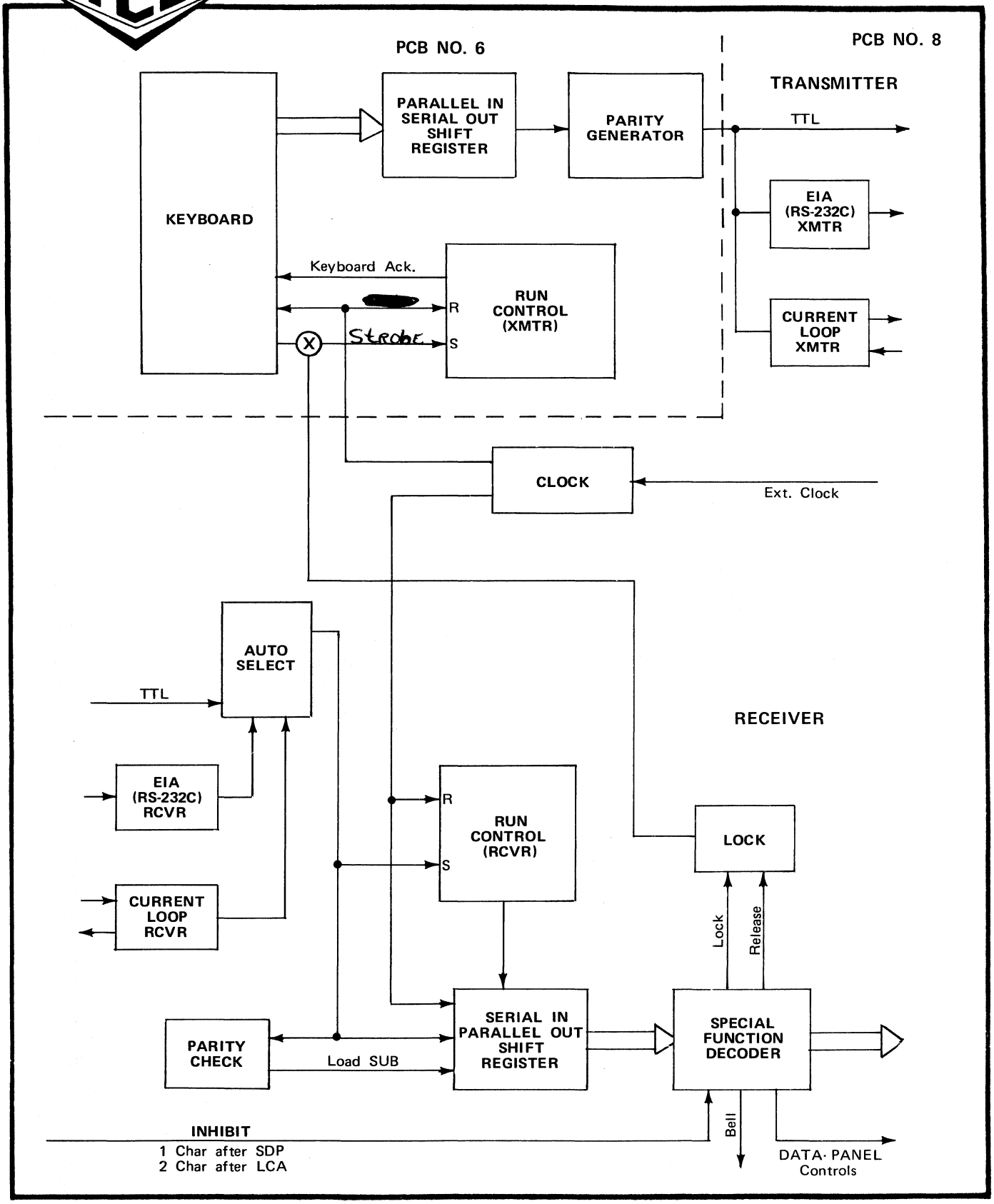


FIGURE 19. FUNCTIONAL DIAGRAM – SERIAL I/O PC BOARDS 6 and 8

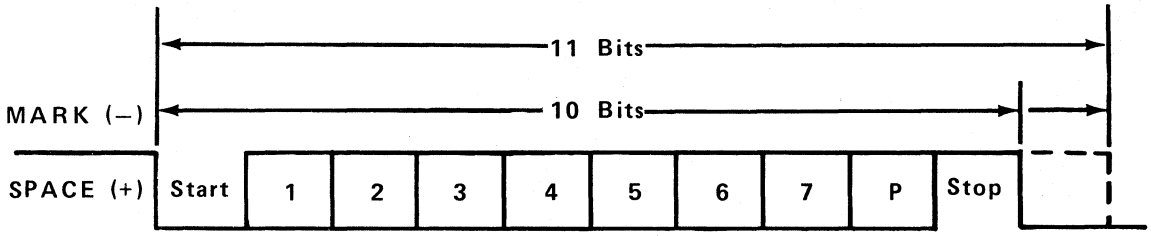
A slide-lock arrangement is provided on the keyboard connector for secure connection to the keyboard cable hood.

INTERFACE DATA TRANSFER RATE

The basic oscillator is pre-set at the baud rate specified by the customer. However, the rate may be field changed (within a 110 to 9600 baud range) by a single potentiometer adjustment (oscillator) plus a switch selection (divider). See Figure 26.

INTERFACE DATA TRANSFER BIT SEQUENCE

The following bit sequence is used for the transmitted and received data on all interfaces. Each character is composed for a 10 or 11 bit word as shown on the next page.



The bit sequence on the communications line is left to right in the diagram shown above. The stop bit may have a length of "one" or "two" bit times and the parity bit may be "even" or "odd" (bit time is dependent on data transfer rate).

NOTE: stop bits and parity are pre-set to customer specification, but may be field changed by moving a switch connection. See Figures 25 & 26.

Unless otherwise specified, 110 Baud units will be set for 11 bit word-length, and all other speeds will be set for 10 bit word-length at time of manufacture and final inspection.

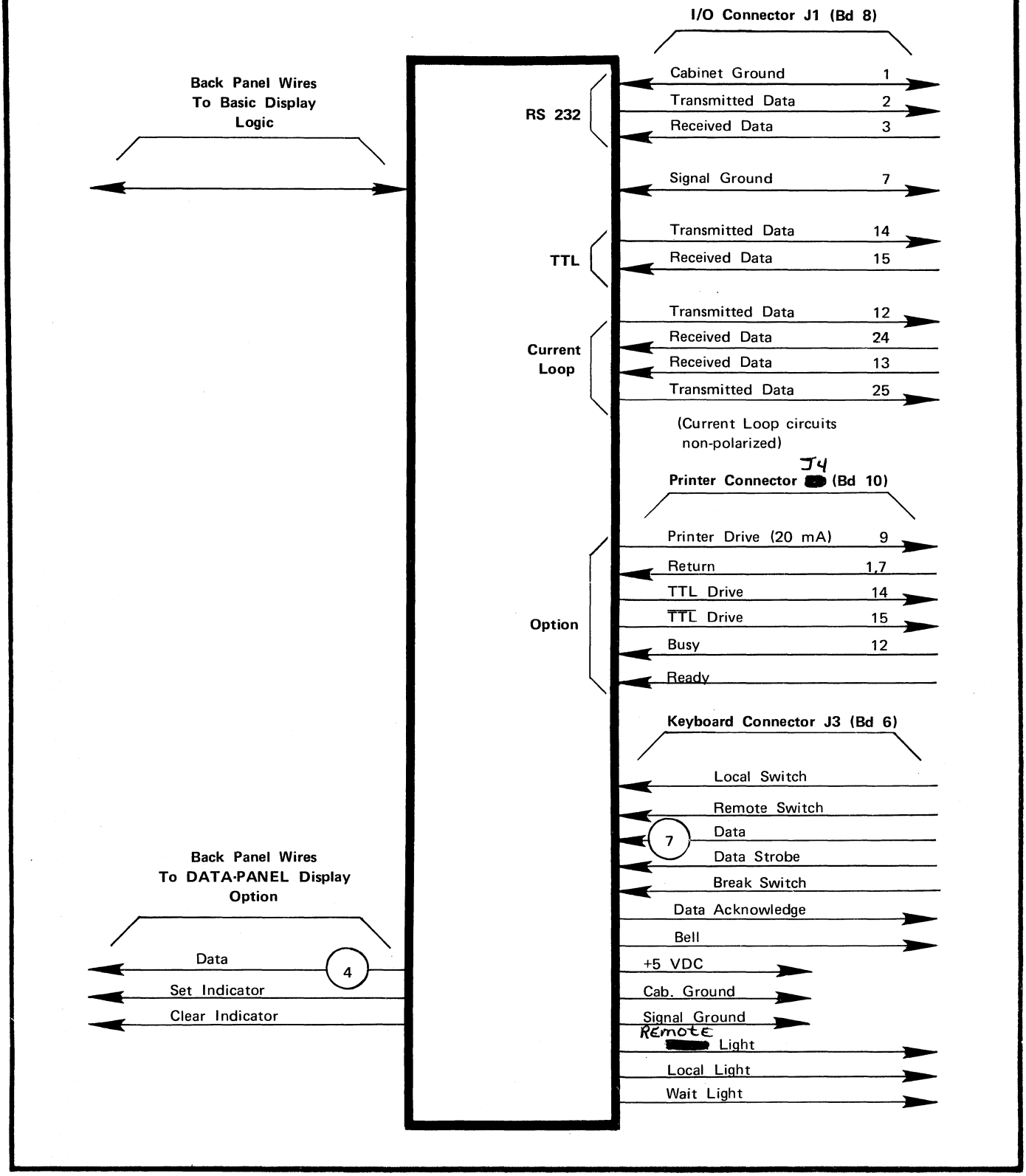


FIGURE 20. INTERFACE CONNECTIONS

EIA INTERFACE (RS-232-C)

Nominal specifications of the interface are:

TRANSMITTER

Voltage Levels

Marking: (Logic 1 or OFF) −7V nom.

Spacing: (Logic 0 or ON) +7V nom.

RECEIVER

Input impedance: 5000 ohms nom.

Marking Level: +.8 to −15

Spacing Level: +2.6 to +15V

Open circuit interpreted as mark

SIGNALS ENABLED

Transmit: Always present when unit is in remote mode but forced to marking condition when in local mode.

Receive: Always enabled, first come-first selected basis.

TTL INTERFACE

The TTL interface shares the basic timing and other characteristics of the normal RS-232 interface (previous section). The voltage levels, however, are normal TTL levels:

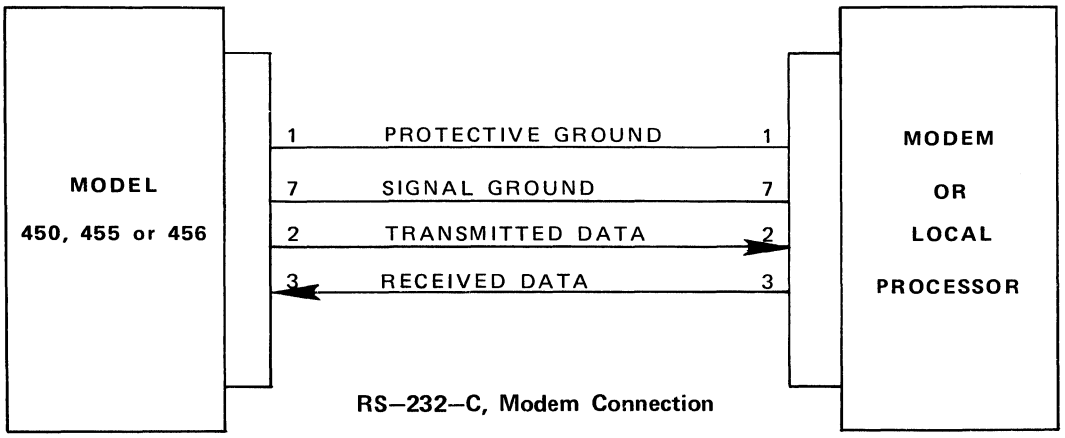
Marking Level: 0 to −.8V, +0.3V nominal

Spacing Level: +2.8 to +5V, +3V nominal

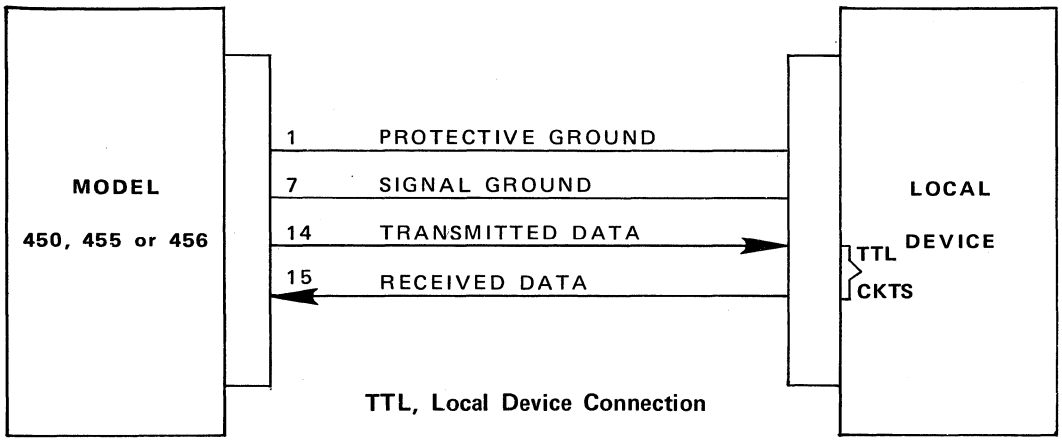
Current Limiting: 68 ohm resistive with diode protection above +5V and below GND.

Transmitted Data (Pin 14 enabled whenever in remote mode but forced to marking level when in local mode).

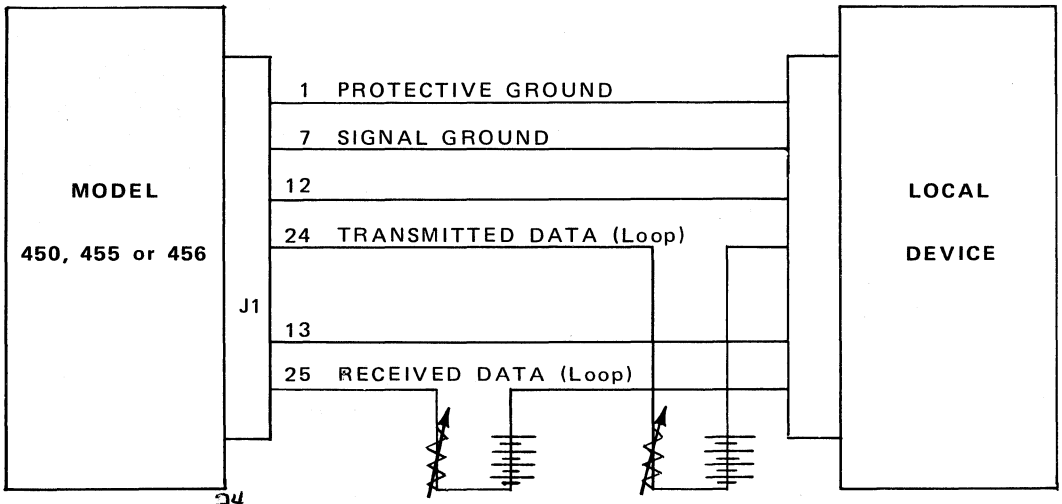
Received Data (Always enabled, first come-first selected basis).



RS–232–C, Modem Connection



TTL, Local Device Connection



NOTE: pins 12 & 24 may be interchanged.
pins 13 & 25 may be interchanged.

Current Loop, External Power Source
(Power sources shown separate - may be shared)

FIGURE 21. TYPICAL INTERFACE CONNECTIONS

CURRENT LOOP INTERFACE

The Current Loop interface shares the basic timing and other characteristics of the normal RS-232 and TTL interfaces described above. The marking and spacing conditions, however, are not voltage levels but rather represent contact closures as follows:

		Current	
		Min.	Max.
Marking Condition:	"Closed contacts"	5mA	100mA
Spacing Condition:	"Open contacts"	zero	0.1mA
Voltage Drop at 20 ma:	Receiver	3.0 typ.	
	Transmitter	2.0V typ.	

Transmit: Always present when unit is in remote mode, but forced to marking condition when in local mode.

Receive: Always enabled, first come-first selected basis.

AUTOMATIC RS-232, TTL, or CURRENT LOOP INTERFACE SELECTION

The Model 450, 455 & 456 terminals automatically assume the proper communications mode (RS-232, TTL, Current Loop) as long as the communications connector is not connected or disconnected while power is on. If it is done while power is oh, the first received character could be altered. This feature allows the terminal to communicate with systems operating on different interfaces at the same time as long as transmission on the various communications lines do not occur simultaneously. This feature also removes a possible source of error during set-up because the receiver will automatically select whichever interface is operating and disregard the other two. The receiver assumes that an open circuit on the EIA (RS-232) interface is interpreted as a mark and an open circuit on the current loop or TTL interfaces is interpreted as a space.

BASIC DISPLAY TERMINAL SIGNAL LEVELS.

All signals which are transferred between the serial interface adaptor and the basic display (first five cards in the card rack) are standard TTL logic levels, as used in Series 7400 Integrated Circuits. In general, control signals are idle at logic one and are active at logic zero so that removal of option cards or basic logic cards does not enable spurious control functions.

The same is true of all signal levels between the serial interface and the keyboard and the DATA·PANEL Display assembly. In addition, however, +5VDC power is fed to the keyboard via the interconnecting cable.

BASIC DISPLAY TERMINAL SIGNAL CONNECTIONS

All basic display unit connections to the adaptor are prewired i.e. the basic interface wires are independent of the I/O adaptor.

OPERATION OF THE INTERFACE

The interface forms the control and communications link between the basic DATA–SCREEN Terminal, the optional keyboard, a remote printer (selector magnet drive only), the optional DATA·PANEL Display, and a full duplex asynchronous communications line or modem with a speed range of 110 to 9600 baud.

FULL OR HALF DUPLEX

Operation mode may be switch-selected by the operator to either full duplex of half duplex. In full duplex the keyboard and serial transmitter serve as an independent unit driving the "transmit" side of the communications line. The serial receiver and the basic display (and printer and DATA·PANEL if used) are driven by the "receive" side of the communication line. In order to record keyboard data on the screen in full-duplex mode, the processor at the other end of the communications line must "echo" the character back via the "receive" line.

In half-duplex operation, an internal connection is made to receive directly any character transmitted as well as receive any character arriving via the communication line. Thus, any character typed will appear on the screen without "echoing" the character externally. However, if a character is generated internally at or near the same time as one is received via the communications line, the result will be garbage, i.e. some combination of the bits of both characters, OR'ed together.

The interface is forced to full-duplex mode during the operation of the READ mode.

LOCAL–REMOTE

The operator may also keyboard-select remote or local operation. In remote operation the interface operates as described previously. When the terminal is set in the local mode, all three transmitting interfaces are forced to the MARKING condition, the external receiver line is disabled and the unit is forced in to half-duplex regardless of the position of the communications-mode switch. The local condition is used primarily for checkout of the display and for operator training.

INCOMING SIGNAL SEQUENCES

The interface card will assemble incoming serial data characters and perform the functions requested. Speed of the terminal does not restrict function sequences. See Section III for a description of the functions which can be performed by the terminal.

OUTGOING SIGNAL

The interface will accept keyboard codes, serialize them, add the proper control and parity and place them on the outgoing signal lines. See the Keyboard Data Code Chart for the codes that can be generated by the keyboard and transmitted by the adaptor.

The "break" key on the keyboard does not generate a code, but causes the outgoing signal to go to the spacing level for as long as the key is depressed. (RS-232: +7V; TTL: +5V; Current Loop: open circuit)

OPERATING TIMING

The speed of the interface and the basic DATA–SCREEN Terminal does not limit the sequence of functions to be performed. Communications line speed will be the limiting factor in most cases. The highest data rate accepted by the terminal is 9600 baud or 104 microseconds per bit. Using a 10 bit character, this gives a character time of 1.04 milliseconds on the communications lines. The slowest operation performed by the interface and the basic DATA–SCREEN Terminal is the Insert Line (I.L.) and Delete Line (D.L.) and they require less than 1.5 milliseconds. Above 4800 baud, it is recommended that editing functions, including Tab, be followed by a single NUL character.

SECTION V

OPTIONS

Options for Models 450, 455 & 456 DATA–SCREEN Terminals consist of switch/jumper wire selectable display controls and accessory equipment i.e., keyboard, fixed message indicators and slave monitors. Since the options are either a part of the basic terminal or are modular for each model, the sub-system design and application can vary from supply controlling an output display monitor to a high speed operator oriented peripheral sub-system (See Figure 5). The options and their operating characteristics are explained in the following.

PCB OPTIONS

All models have the following switch/jumper wire options.

Display of blank Carriage Return symbol
Display or blank Cursor symbol
Enable or disable Automatic Line Feed
Enable or disable Automatic Roll-Up
Display black on white or white on black.

The effect these options have on the Display are self-evident except:

Auto-Line Feed moves cursor to first column, next line on CR command.

Auto-Roll Up moves all lines up one on CR command when cursor is in last line.

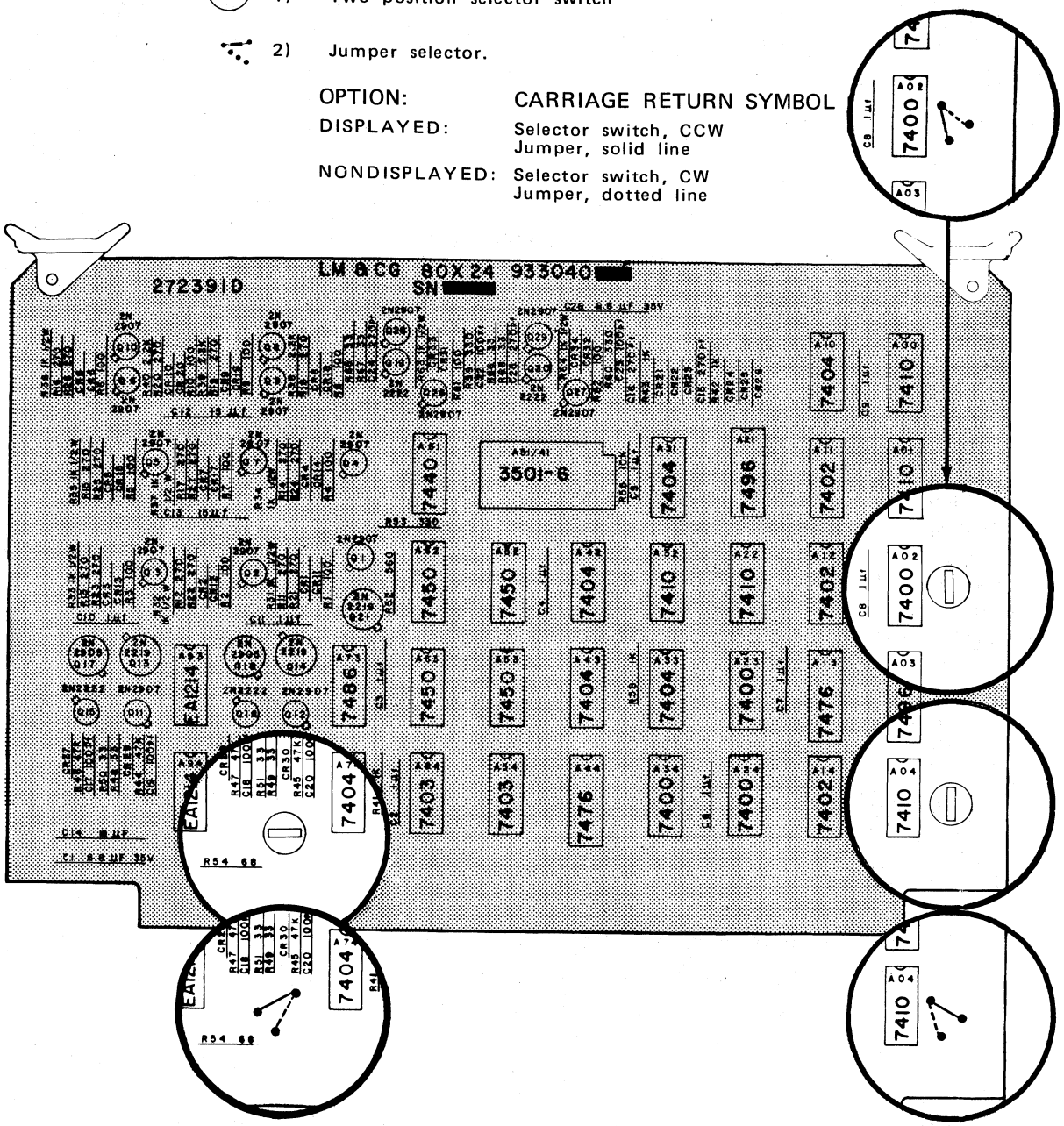
Figures 22 through 26 show the switch/jumper wire locations of the options on their respective Printed Circuit Boards.

NOTE: TWO METHODS OF PCB OPTION SELECTION ARE USED

1) Two position selector switch

2) Jumper selector.

OPTION:	CARRIAGE RETURN SYMBOL
DISPLAYED:	Selector switch, CCW Jumper, solid line
NONDISPLAYED:	Selector switch, CW Jumper, dotted line



OPTION:	CHARACTER COLOR
Black on White:	Selector switch, CW Jumper dotted line
White on Black	(Normal Video): Selector switch, CCW Jumper, solid line

OPTION:	CURSOR SYMBOL
DISPLAYED:	Selector switch, CW Jumper, solid line
NONDISPLAYED:	Selector switch, CCW Jumper, dotted line

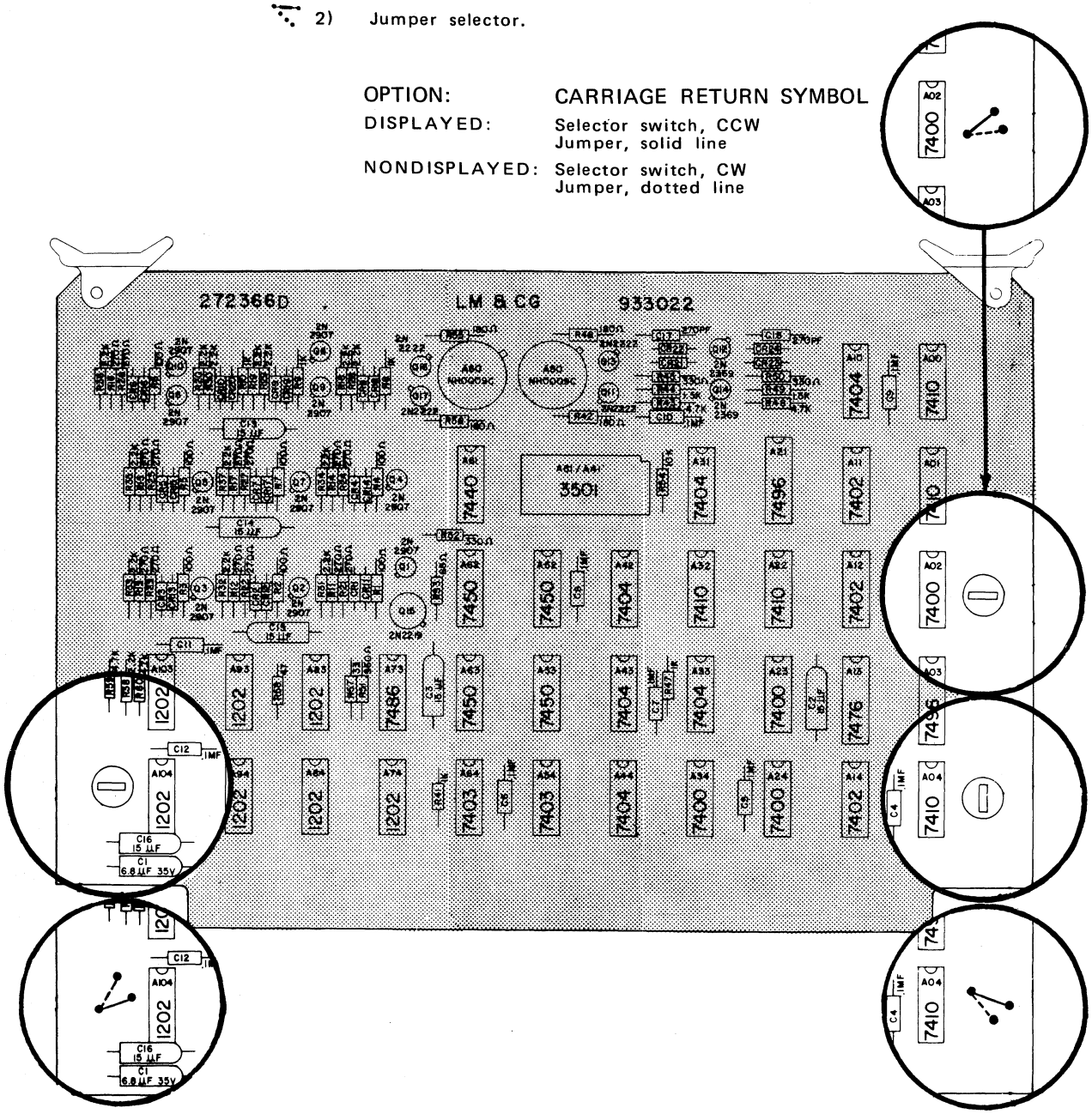
FIGURE 22. SWITCH/JUMPER OPTIONS ON MODEL 455
LINE MEMORY & CHARACTER GENERATOR PCB

NOTE: TWO METHODS OF PCB OPTION SELECTION ARE USED

1) Two position selector switch

2) Jumper selector.

OPTION:	CARRIAGE RETURN SYMBOL
DISPLAYED:	Selector switch, CCW Jumper, solid line
NONDISPLAYED:	Selector switch, CW Jumper, dotted line



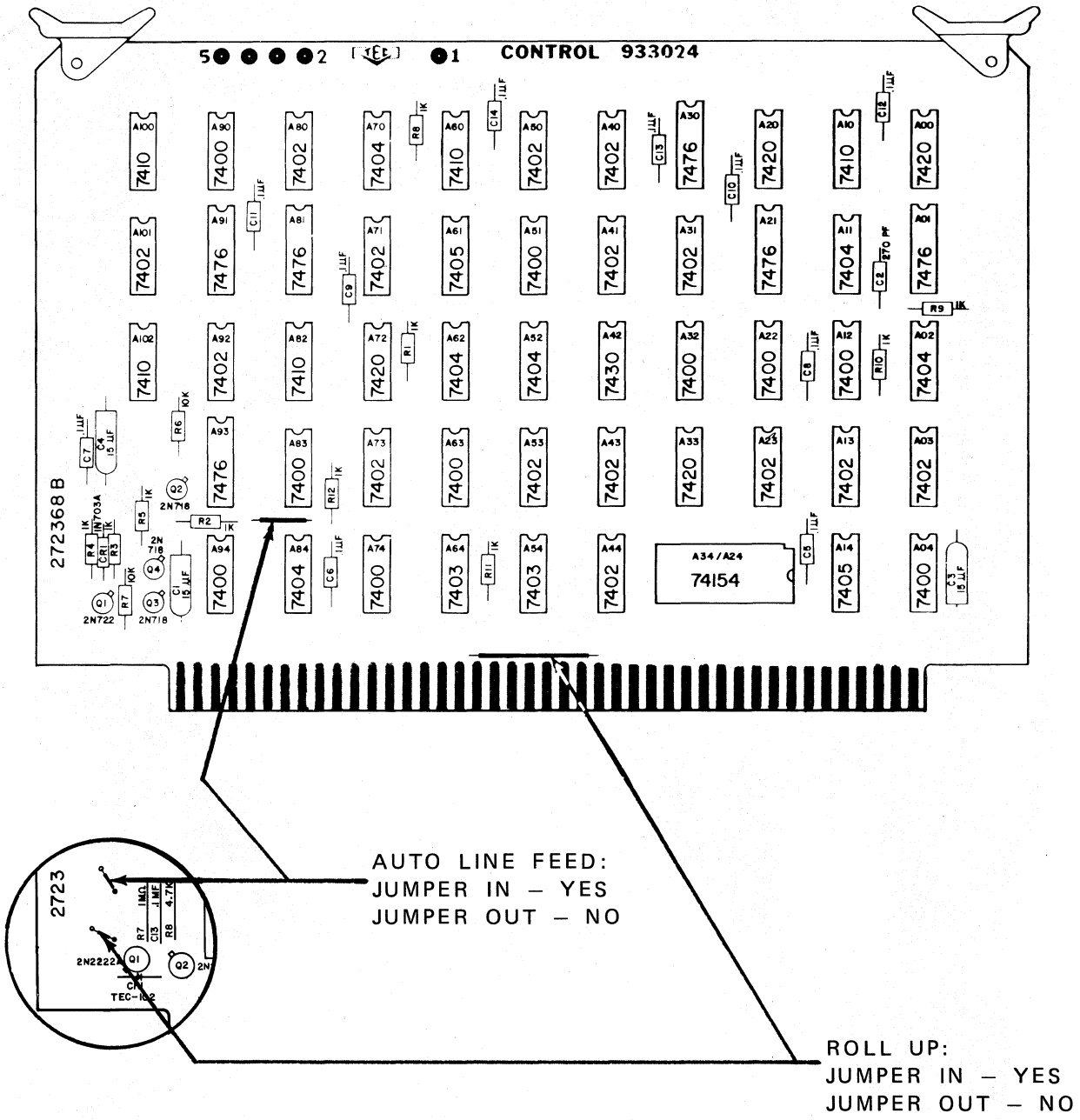
40/50 CHARACTER LINE*
*Not a user option, factory set.

40 CHARACTER LINE (Model 416 only)
Selector switch, CW; Jumper dotted line

50 CHARACTER LINE (Model 410 only)
Selector switch, CCW; Jumper, solid line

OPTION:	CURSOR SYMBOL
DISPLAYED:	Selector switch, CW Jumper, solid line
NONDISPLAYED:	Selector switch, CCW Jumper, dotted line

FIGURE 23. SWITCH/JUMPER OPTIONS ON MODELS 450 & 456 LINE MEMORY & CHARACTER GENERATOR PCB



NOTE: TWO CONTROL PCB LAYOUTS ARE IN USE AND AFFECT THE LOCATION OF JUMPER WIRE LOCATIONS AS SHOWN.

FIGURE 24. JUMPER WIRE OPTIONS ON MODELS 450, 455, 456 CONTROL PCB

NOTE: TWO METHODS OF PCB OPTION SELECTION ARE USED

1) Two position selector switch

2) Jumper selector.

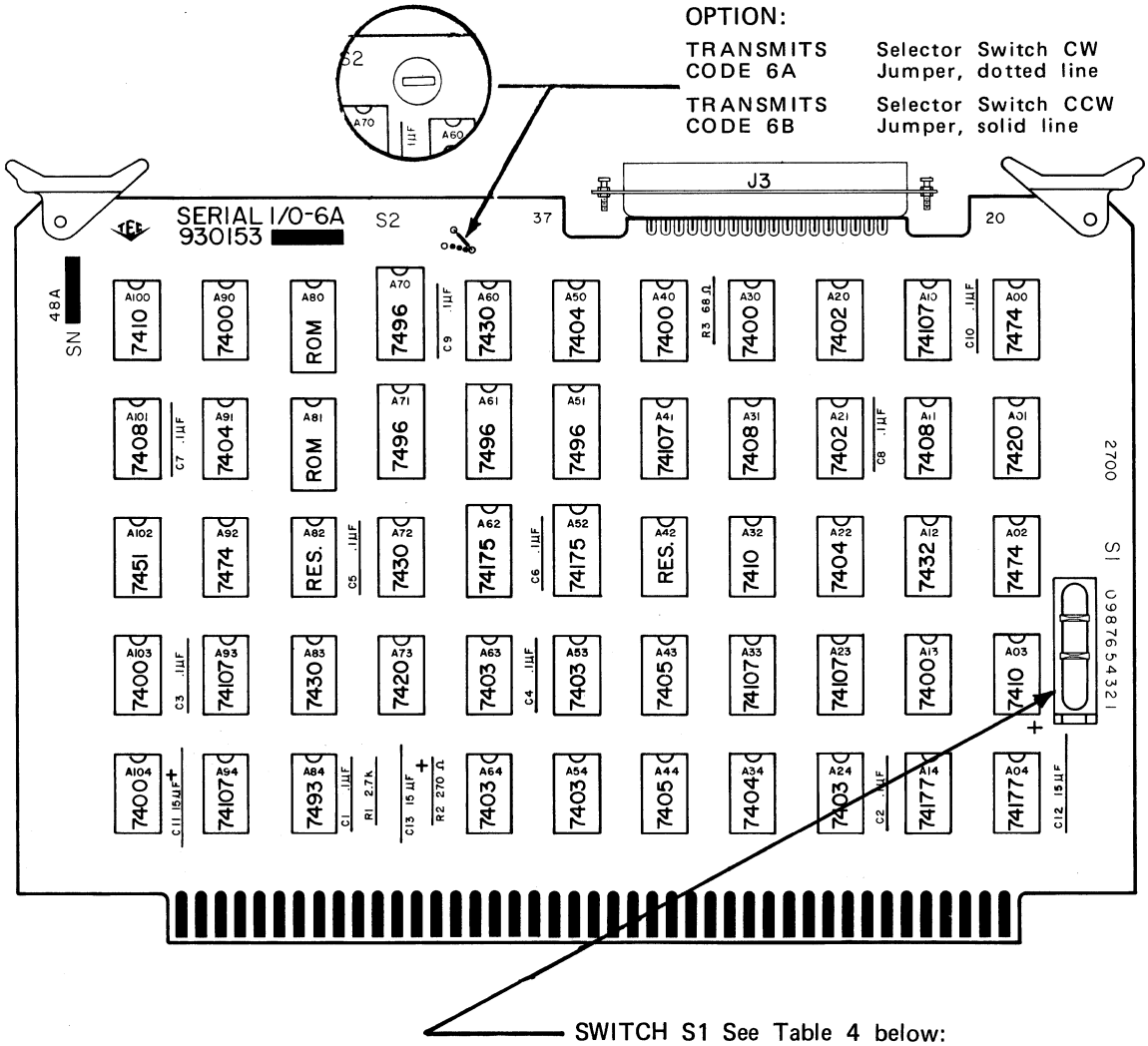


TABLE 4

SWITCH SETTINGS: SERIAL I/O, BOARD 6A

SWITCH	ROTOR	POSITION	
S1	A	1	Not Used
		2	Even Parity - Transmitted
		3	Odd Parity - Transmitted
		4	No Parity - Mark Transmitted
S1	B	6	10 Bits Transmitted
		7	11 Bits Transmitted
S1	C	9	EOL Bell Disabled
		0	EOL Bell Enabled

FIGURE 25. SWITCH OPTIONS, SERIAL I/O 6A PCB

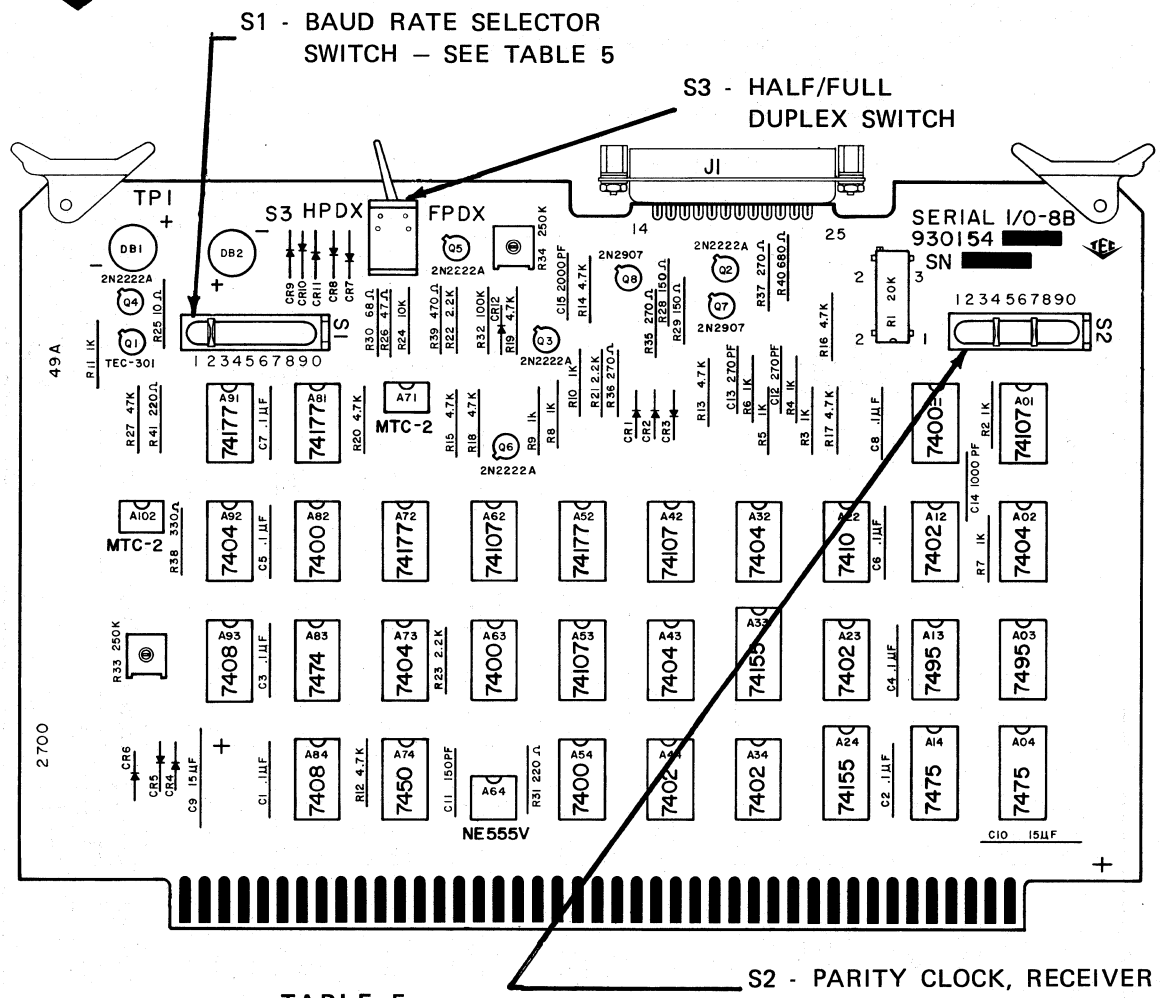


TABLE 5

SWITCH SETTINGS: SERIAL I/O, BOARD 8B

SWITCH	ROTOR	POSITION	
S1	A	3	150 Baud (also 110 Baud)
		4	300 Baud
		5	600 Baud
		6	1200 Baud
		7	2400 Baud (also 1800 Baud)
		8	4800 Baud
		9	9600 Baud
		0	EXTERNAL CLOCK (Baud Rate Switch Option)
S2	A	1	No Parity Check on RCV
		2	Odd Parity RCVD
		3	Even Parity RCVD
		5	Normal Clock
		6	Special Clock
		8	Inhibit RCV During Xmit
		9	No Inhibit RCV During Xmit
		0	Not Used
S3(Toggle)		UP	Half-Duplex
		DOWN	Full-Duplex

FIGURE 26. SWITCH OPTIONS, SERIAL I/O 8B PCB

OPTIONS

HARD COPY ADAPTOR (930071)

The Hard Copy Adaptor option is available on Models 450, 455 and 456 DATA–SCREEN Terminals. Jumper wire options on the PCB combined with both 20 ma Current Loop and TTL level output allow connection to a variety of printers.

Operation of the Hard Copy Adaptor begins upon receipt of a Print Command from the Interface. It then checks the Printer Ready signal line and if the Printer is ready a Carriage Return code followed by a Line Feed code is sent to initialize the Printer. The character in the cursor position is transferred to the Print Adaptor shift register where Start, Parity and Stop bits are appended and then send serially (least significant bit first) to the TTY Drive logic where it is converted to a 20 ma current for transmission to the Printer. Transmission continues with the Hard Copy Adaptor sending a Carriage Return and Line Feed at the end of each line until the ETX position is reached, or the end of the page is reached, if no ETX is present. A Halt-Local-Output (HLO) command will cause the printer to stop printing after the present character is complete. HLO can only be sent from the processor, via the communications line.

Switches installed on the Hard Copy Adaptor PCB set Baud rate, Parity and Polarity. See Figure 28 and Table 6 for switch locations and set as follows.

OTHER SPEEDS

Select range switch, Switch S1 Rotor 1 to the proper range.

75 - 150 Baud	Position 1
150 - 300 Baud	Position 2
300 - 600 Baud	Position 3
600 - 1200 Baud	Position 4

Set Resistor Selector, switch S1 Rotor 3 to Position 9.

Adjust R6 (potentiometer nearest S1) so that cycle time observed at TP2 (also available on A50 pin 14) is as follows:

$$T = 416 \times \frac{75 \blacksquare \times 2^N}{\text{(desired baud rate)}} \text{ in microseconds.}$$

Where the exponent N is the position of Rotor no. 1 in switch S1.

example: if desired rate is 525 baud (for whatever reason)

a. 525 baud is between 300 and 600 baud. Therefore, Switch S1 rotor 1 is set to position 3, and N=3.

$$T = 416 \times \frac{75 \times 2^3}{525} = 416 \times \frac{75 \times 8}{525} = 416 \times \frac{600}{525} = 475 \text{ uSec.}$$

Parity Setting - Test Point 7 has the 7 bit character code in serial form and Test Point 1 has the entire 11 bit character including start, parity and stop bits.

Even Parity - Switch S2 Rotor 3 to Position 7
Odd Parity - Switch S2 Rotor 3 to Position 8
Mark Parity - Switch S2 Rotor 3 to Position 9

Polarity Setting - Jumper wires at B and R accomodate printers having different polarity signals.

Printer Busy (negative signal) - Switch S2 Rotor 1 to Position 1
Printer Busy (positive signal) - Switch S2 Rotor 1 to Position 2
Printer Ready (negative signal) - Switch S2 Rotor 2 to Position 4
Printer Ready (positive signal) - Switch S2 Rotor 2 to Position 4

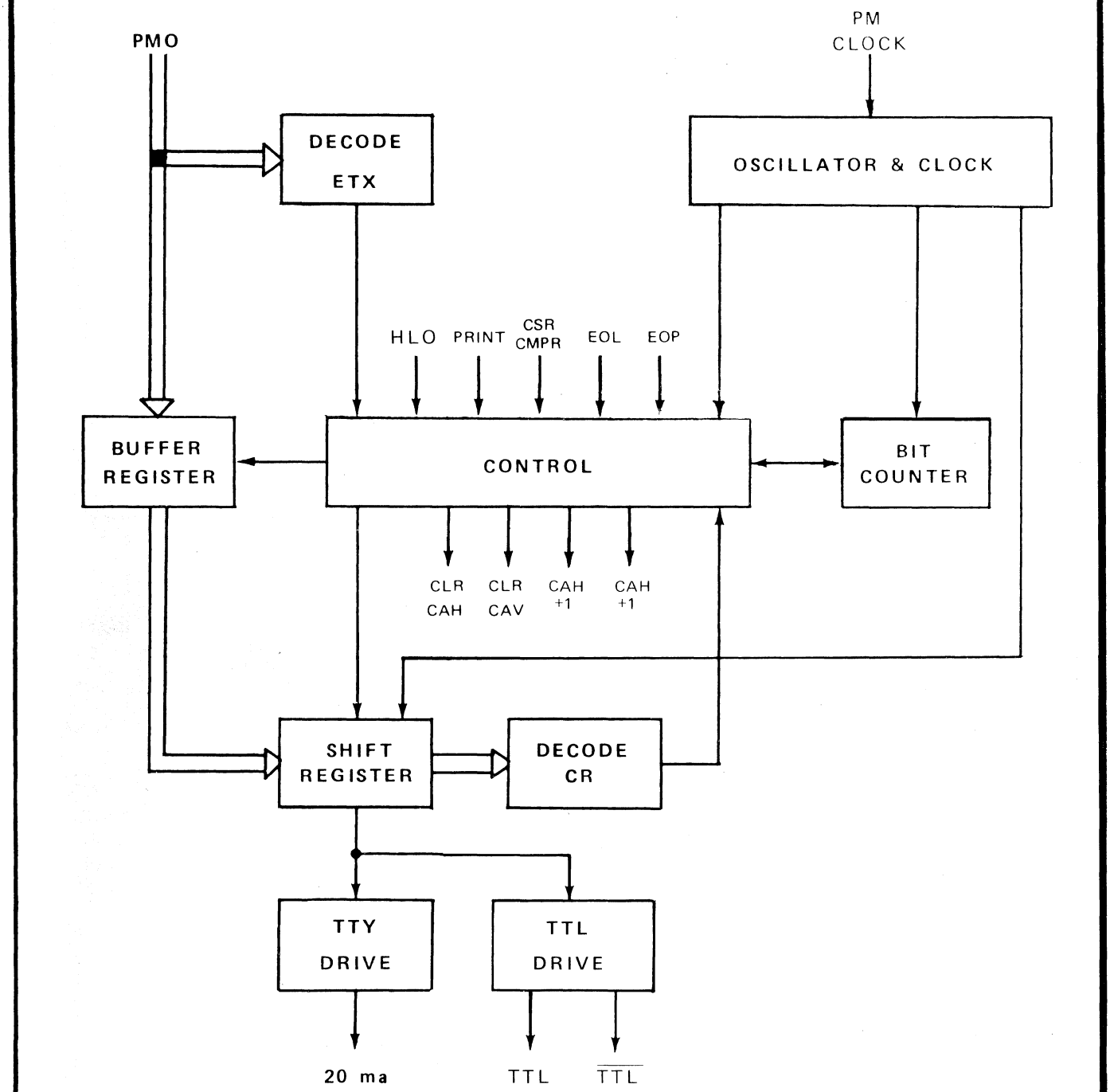
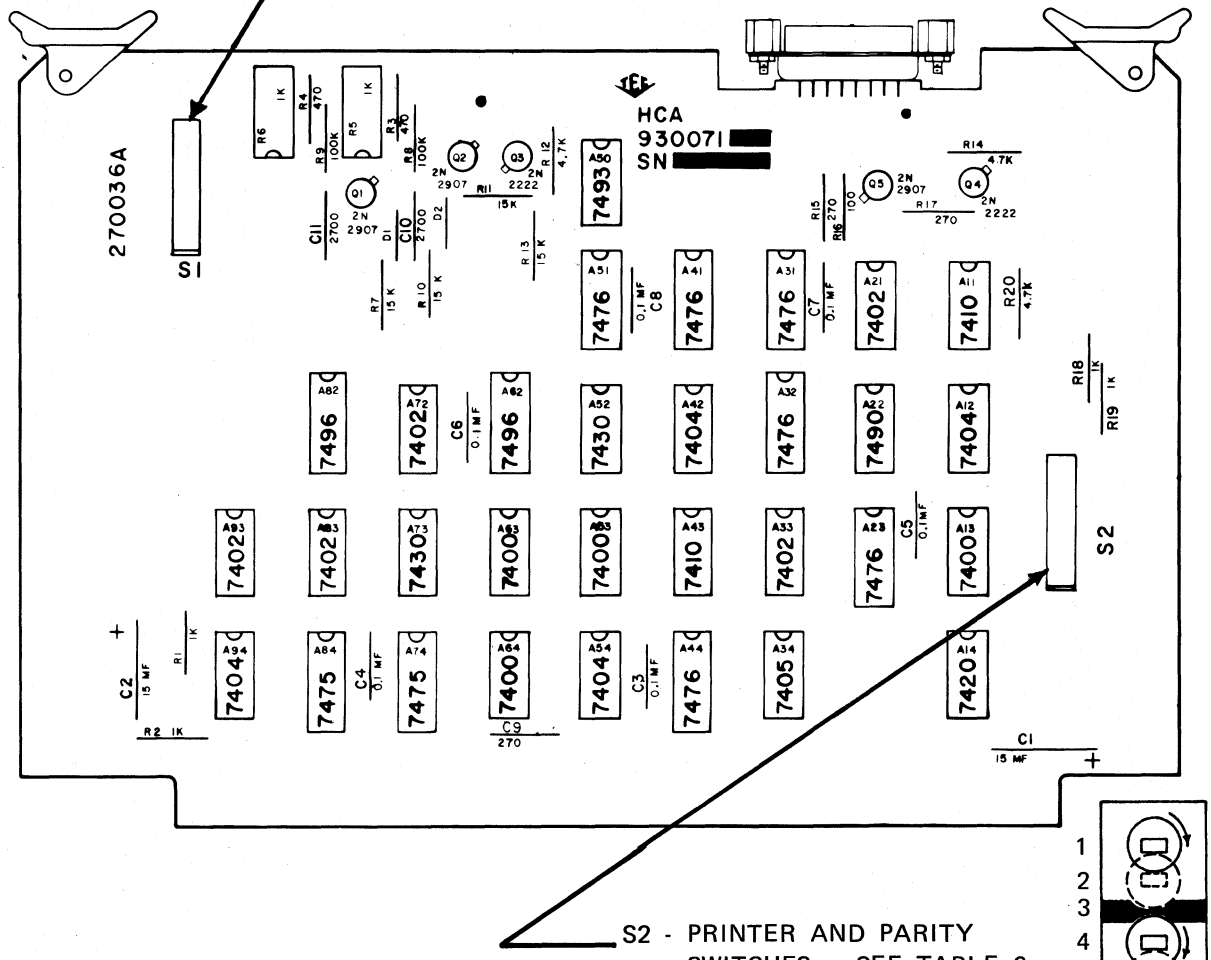
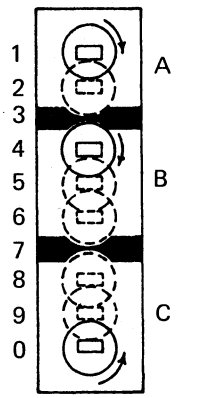


FIGURE 27. FUNCTIONAL DIAGRAM – HARD COPY ADAPTOR PCB



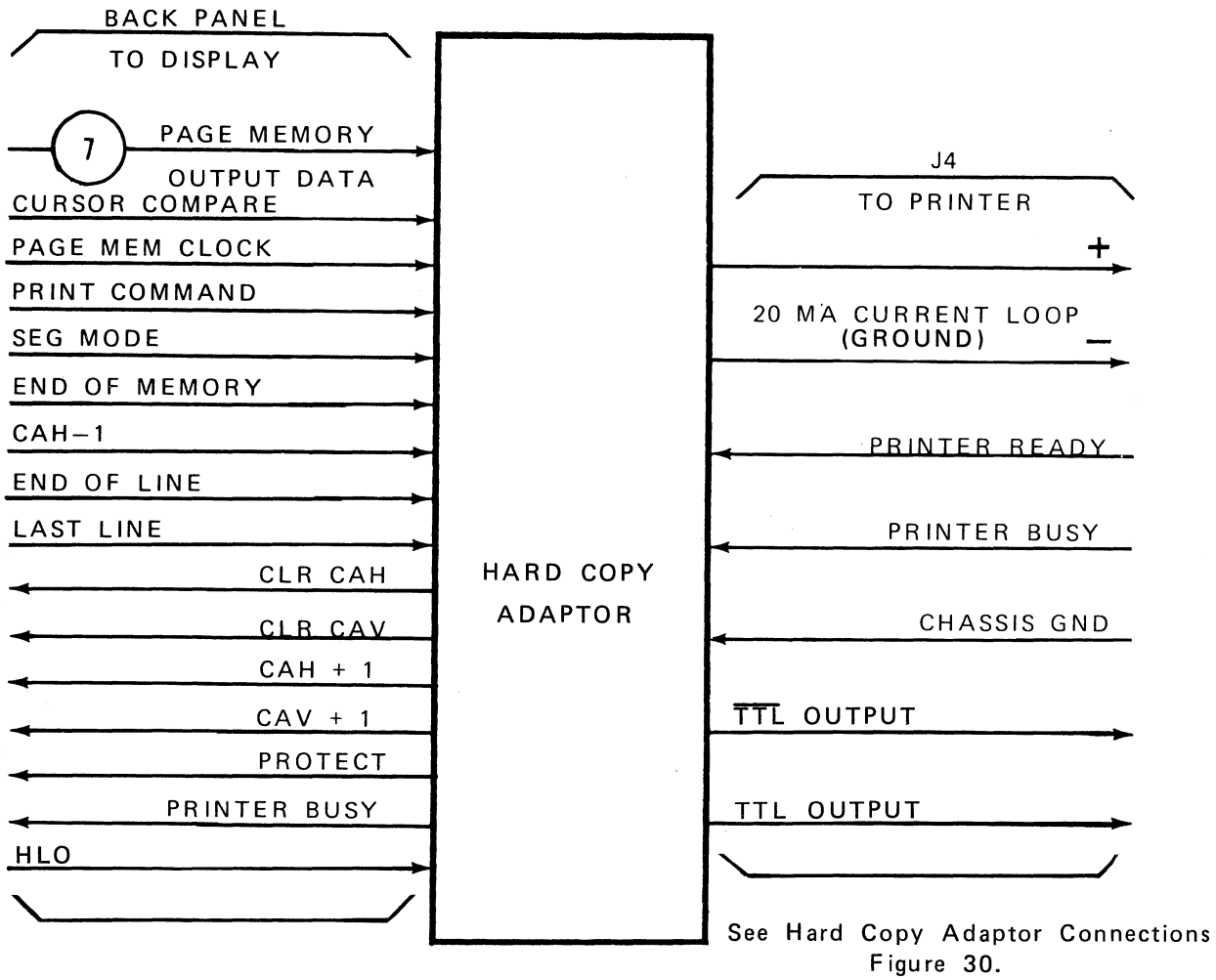


TYPICAL SWITCH NUMBERING

TABLE 6

SWITCH	ROTOR	POSITION	
S1	A	1	150 Baud (110 Baud)
		2	300 Baud (220 Baud)
		3	600 Baud (440 Baud)
		4	1200 Baud (880 Baud)
		6	Controlled SEG Mode
		7	Force SEG Mode
		9	110-880 Baud Sequence
		0	150-1200 Baud Sequence
S2	A	1	Printer Busy - Neg.
		2	Printer Busy - Pos.
		4	Printer Ready - Neg.
		5	Printer Ready - Pos.
		7	Even Parity
		8	Odd Parity
		9	No Parity (Mark transmitted)

FIGURE 28. SWITCH OPTIONS, HARD COPY ADAPTOR PCB



See Hard Copy Adaptor Connections Figure 30.

FIGURE 29. HARD COPY ADAPTOR INTERFACE SIGNALS.

The Hard Copy Adaptor is a self-contained modular unit consisting of pre-wired card cage connections, a printed circuit board mounting in card position 10 and a 15 pin interface connector (J4) mounted on the rear edge of the PCB. The inter-connecting cable and printer logic and motor power is supplied by the User. Connection data is shown in FIGURE 30.

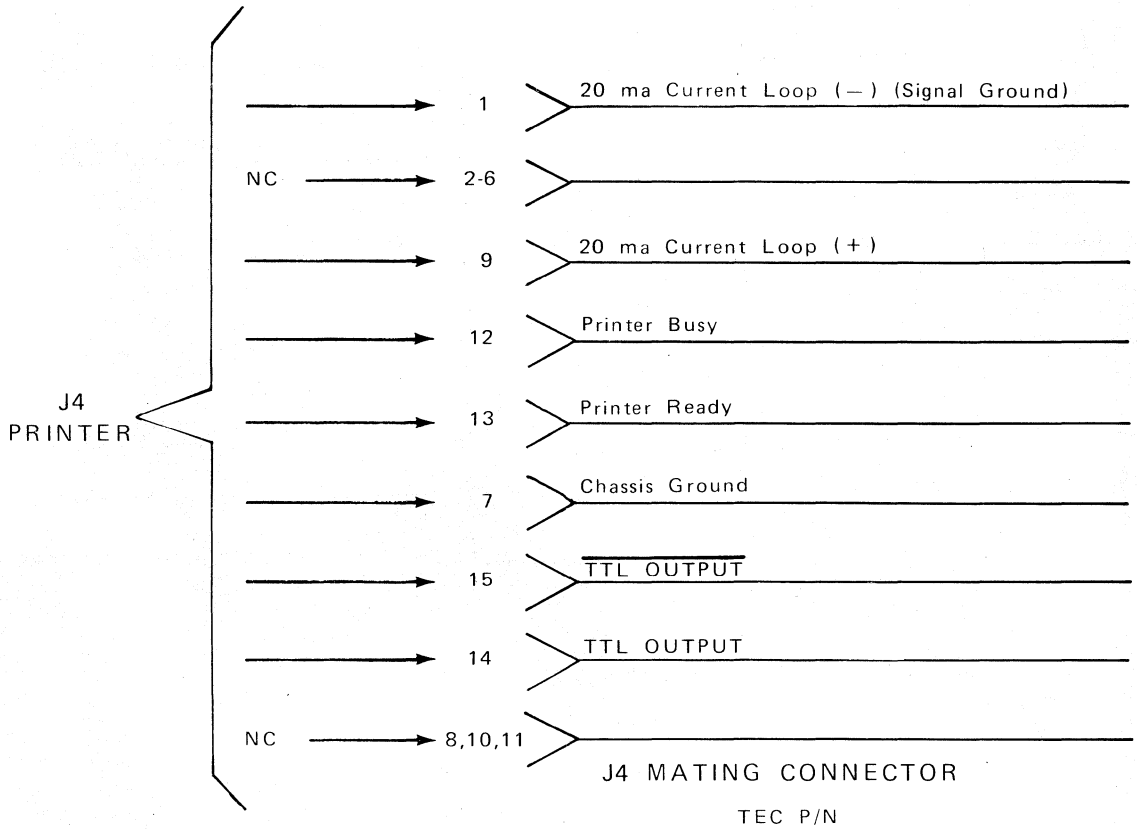


FIGURE 30. HARD COPY ADAPTOR TO PRINTER CONNECTIONS

OPTIONS

DATA·PANEL DISPLAY

The DATA·PANEL Display option is available on desk or rack mounted terminals with monitors. From one to 16 fixed message, software actuated indicators can be implemented. The messages appear to the right of the CRT with the CRT shifted left from center to accomodate the assembly. The messages are not visable when extinguished.

See Figure 34 for Ordering Information.

Individual indicators are turned on by issuing a Set Data Panel (SDP - ASCII code 6E) followed by the indicator's address code which is brought into the Terminal through the normal communications channel as serial data codes (See FIGURE 32). Decoding is done by the Terminal logic. All indicators are turned off by issuing a Clear Data Panel (CDP - ASCII code 6F).

The Display Assembly is a self-contained modular unit consisting of incandescent lamps, power supply, decoder, memory and driver logic to control each indicator and, a wiring harness with push-on terminals that connect to the wire-wrap pins on the Terminal card cage (See FIGURE 31). Legends for each indicator appear in black type in sizes from 10 to 24 points on a 1.375 inch wide by .400 inch high red, orange, blue, yellow, or white background when lit.

DATA·PANEL Connector	Wire Color	Connection P6	Signal Name	Card Cage DPA Edge Connector
1	Red	Pin 1	+5V	1
7	Violet	Pin 17	Bit 1	7
8	Gray	Pin 18	Bit 2	8
3	Orange	Pin 19	Bit 3	3
4	Yellow	Pin 20	Bit 4	4
5	Green	Pin 25	Strobe	5
6	Blue	Pin 27	Reset	6
9	White	Pin 79	Master Clear	9
K	Brown	Pin 85	GND	10

FIGURE 31. DATA·PANEL® DISPLAY CONNECTIONS

BITS [1]							
7	6	5	4	3	2	1	FUNCTION
0	1	1	1	1	1	1	DP INDICATOR 1
0	1	1	1	1	1	0	DP INDICATOR 2
0	1	1	1	1	0	1	DP INDICATOR 3
0	1	1	1	1	0	0	DP INDICATOR 4
0	1	1	1	0	1	1	DP INDICATOR 5
0	1	1	1	0	1	0	DP INDICATOR 6 [2]
0	1	1	1	0	0	1	DP INDICATOR 7
0	1	1	1	0	0	0	DP INDICATOR 8
0	1	1	0	1	1	1	DP INDICATOR 9
0	1	1	0	1	1	0	DP INDICATOR 10
0	1	1	0	1	0	1	DP INDICATOR 11
0	1	1	0	1	0	0	DP INDICATOR 12
0	1	1	0	0	1	1	DP INDICATOR 13
0	1	1	0	0	1	0	DP INDICATOR 14
0	1	1	0	0	0	1	DP INDICATOR 15
0	1	1	0	0	0	0	DP INDICATOR 16

Also position of indicators mounted in Terminal.

1 BITS 7, 6 & 5 may be 010, 011 100 or 101.

2 See Set DATA·PANEL FUNCTION," Page 30.

FIGURE 32. DATA·PANEL® DISPLAY CODES

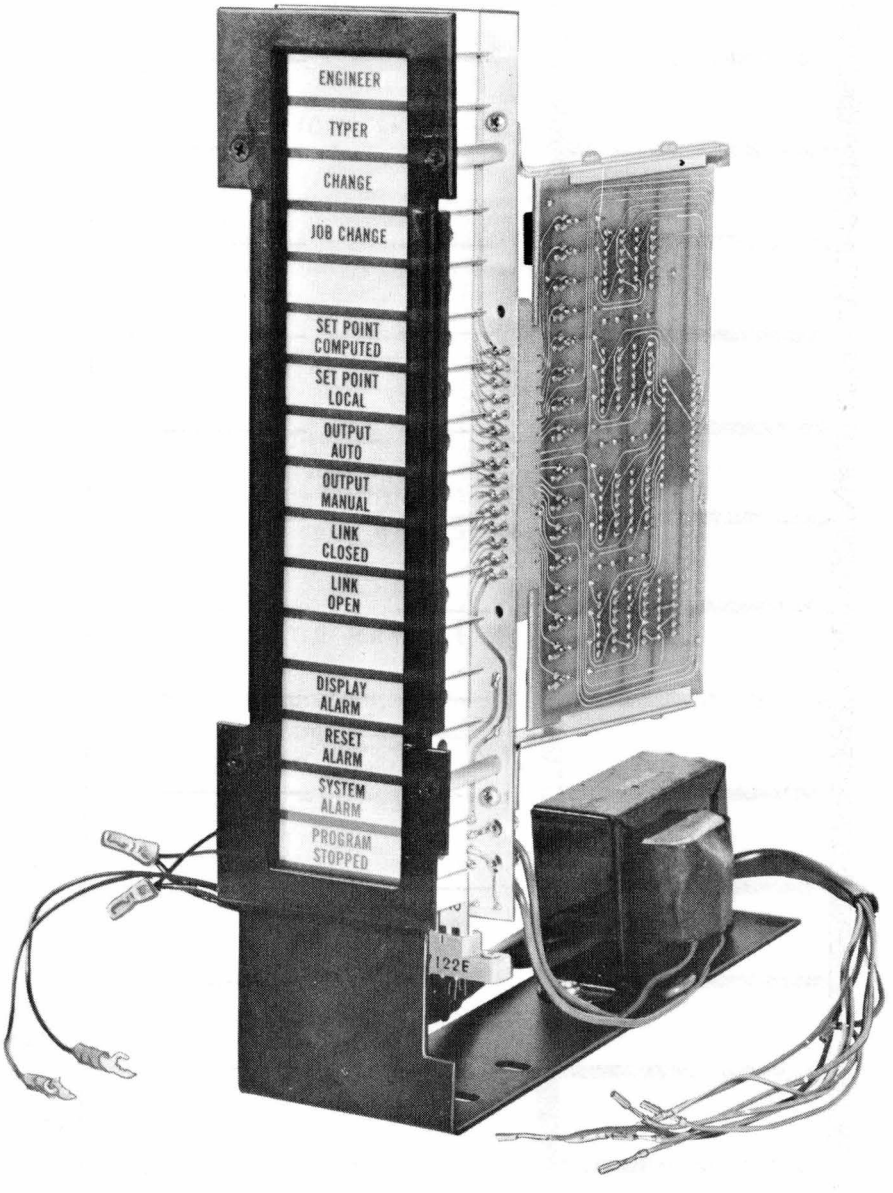


FIGURE 33. DATA·PANEL® DISPLAY ASSEMBLY

DATA·PANEL Display Specifications: (Each of 16 display areas measures 1.375" wide x .400" high). Black letters on colored background.

POSITION	LEGEND	TYPE SIZE PT.	BACKGROUND COLOR
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

= Standard colors: RED, GREEN, BLUE, YELLOW, WHITE.

TYPE SIZE CHART

News Gothic Bold Condensed

10 pt.= .100 high
Avg. 15 capital letters per module, 2 lines max.

12 pt.= .120 high
Avg. 13 capital letters per module, 2 lines max.

14 pt.= .140 high
Avg. 11 capital letters per module, 1 line max.

18 pt.= .182 high
Avg. 9 capital letters per module, 1 line max.

24 pt.= .245 high
Avg. 7 capital letters per module, 1 line max.

10 pt. **DATA • PANEL**

12 pt. **DATA • PANEL**

14 pt. **DATA • PANEL**

18 pt. **DATA • PANEL**

24 pt.
DATA • PANEL

FIGURE 34. DATA·PANEL® DISPLAY ORDERING INFORMATION

OPTIONS

BAUD RATE SWITCH

A separate baud rate switch is available as an option, on Models 450, 455 and 456. This switch, TEC P/N 930081 (See Price List Page 114), allows rapid selection of one of nine pre-set baud rates between 110 and 9600 baud. The switch is located on the back panel of desk mount DATA–SCREEN Terminal models with monitor and is mounted on the rear of rack mount displays. See Figure 35.

The baud rate switch option includes: printed circuit board; switch; oscillator and electronic circuits; mounting hardware; cable to connect the assembly to the terminal's mother-board wiring.

The following speeds are available as standard:

			TEST POINT 1		TEST POINT 2	
POSITION		BAUD RATE	TIME/CYCLE	CYCLES/SEC	TIME/CYCLE	CYCLES/SEC*
ccw	1.	110	8.87 uSec.	112,640	568.2 uSec.	1760
	2.	150	6.52	153,600	416.7	2400
	3.	300			208.3	4800
	4.	600			104.2	9600
	5.	1200			52.1	19,200
	6.	1800	8.68	115,200	34.7	28,800
	7.	2400	6.52	153,600	26.0	38,400
	8.	4800			13.04	76,800
cw	9.	9600			6.52	153,600

* = 16 times the baud rate

TABLE 7

Settings of the three trimmer resistors can be checked as follows:

Place a frequency counter probe on Test point 1 (closest to switch) and set baud rate switch to position 1 (for 110 baud). Set trimmer R1 (closest to switch) so that count is 112,640 cycles per second. (Alternately, measure time per cycle at 8.87 uSec.) Set baud rate switch to position 2 (for 150 baud). Set trimmer R2 (middle one of three) so that count is 153,600 cycles per second. (Alternately,

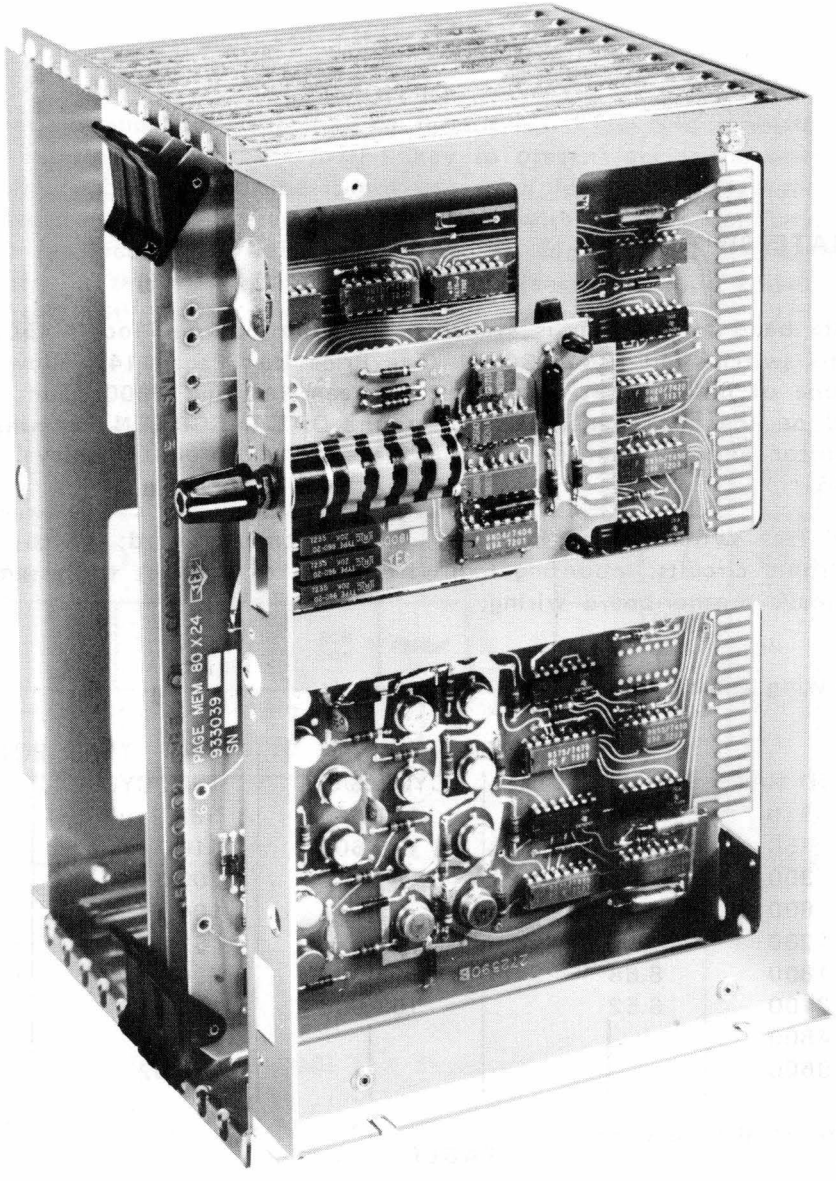


FIGURE 35. BAUD RATE SWITCH ASSEMBLY

measure time per cycle at 6.52 uSec.) Set baud rate switch to position 6 (for 1800 baud). Set trimmer R3 (farthest from switch) so that count is 115,200 cycles per second (Alternately, measure time per cycle at 8.68 uSec.) The counts may be verified at test point 2 by cycling through all nine positions of the switch In each case, the count will be 16 times the desired baud rate. (See Table 7).

As with any analog circuit, certain errors may result due to drift with respect to temperature. The warm-up drift may be anticipated to be between 2% and 3% of the initial frequency. In addition, extended operation may result in an additional drift of ±1%. Since most asynchronous circuits will tolerate a frequency error over a 10% frequency band (5% above and 5% below nominal, generally), the baud-rate oscillator can easily be tuned to remain in tolerance from turn-on through continuous 24 hour per day operation. Less tolerant circuits, however, may require minor trimming of the baud rate oscillator after warm-up.

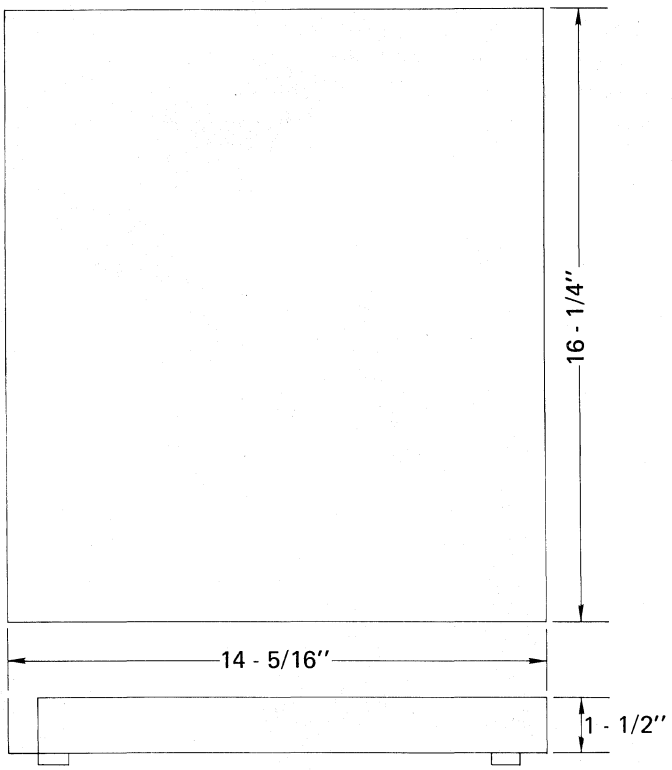
The baud rate switch is an option which may be added at any time to any Model 450, 455 or 456 DATA–SCREEN Terminal. Card cages provided with Models 450, 455 and 456 are pre-drilled and pre-punched for the baud-rate switch, and the back plane mother-board has provision for the oscillator cable. Retrofit may be done by the customer or, for an additional charge, the terminal may be retrofited at the factory.

OPTIONS

FAN MOUNTING BASE (980042)

When Series 400 DATA–SCREEN Terminals are subjected to operation in ambient temperature levels in excess of +40 °C (104°F), TEC recommends the use of an optional fan assembly designed to reduce component temperatures within the terminal. Ambient temperatures to +45 °C (113°F) are acceptable when the fan assembly is employed. This option may be installed at any time.

The Fan Mounting Base is a separate assembly consisting of fan and plenum upon which the terminal is placed and forced air directed upward through the card cage assembly. The terminal's rubber feet fit within the sides of the Fan Mounting Base (which also has rubber feet) and no mechanical attachments are required.



Power for the fan is taken from the AC terminals of the power supply strip. Both 115 or 230 VAC 50/60 Hz options are available. See Parts & Price List, pages 116 - 117.

OUTLINE DRAWING: FAN MOUNTING BASE

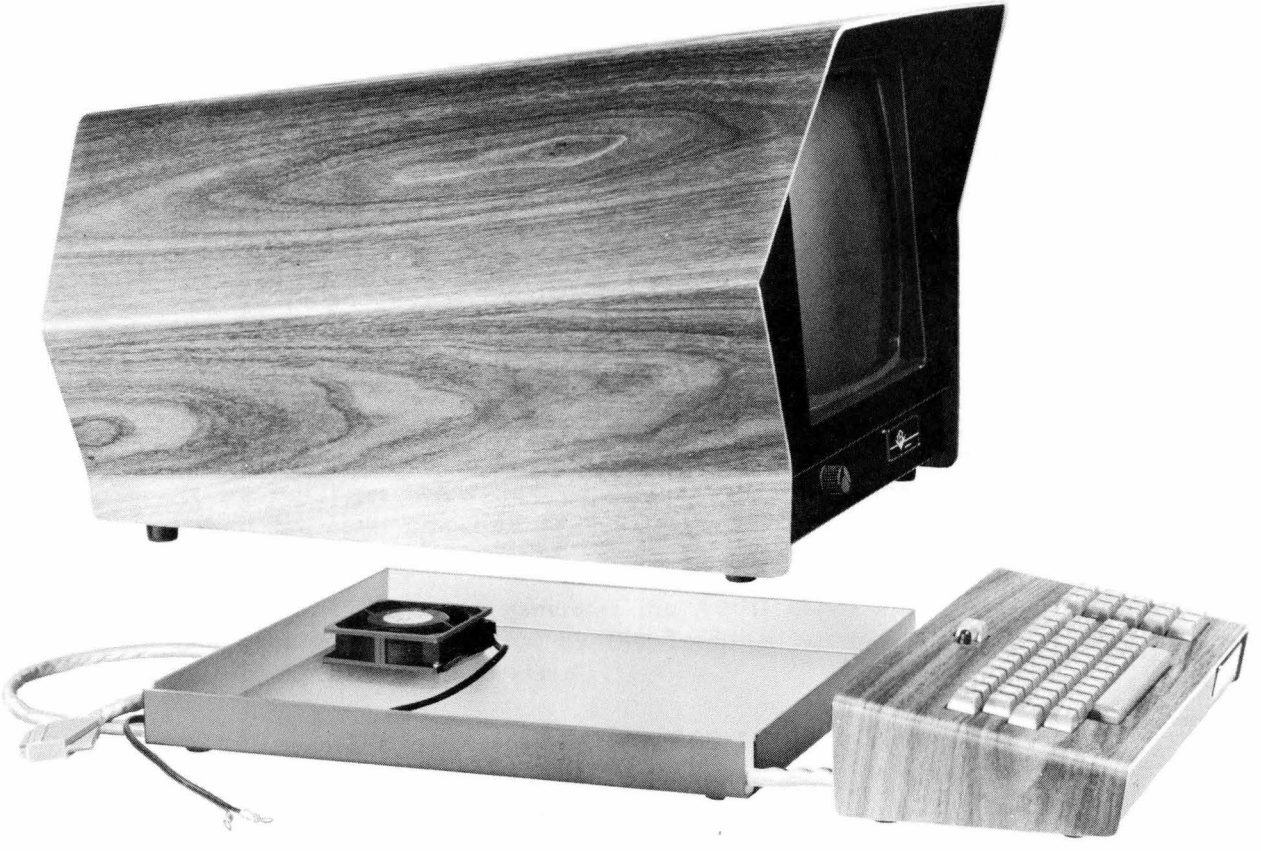


FIGURE 36. FAN MOUNTING BASE ASSEMBLY

SECTION VI

SPECIFICATIONS

GENERAL

Display	Model 450	Model 455	Model 456
CRT size	12 in.	12 in.	12 in.
Viewing area	74 sq. in.	74 sq. in.	74 sq. in.
Scan method*	Raster	Raster	Raster
Refresh rate	60 Hz STD 50 Hz OPT	60 Hz STD 50 Hz OPT	60 Hz STD 50 Hz OPT
Screen capcity	1000 char.	1920 char.	960 char.
Characters per line	50	80	40
Line per page	20	24	24
Character size (h x w)	.21 x .15	.20 x .08	.21 x .15
Character generation	5 x 7 Dot Matrix	5 x 7 Dot Matrix	5 x 7 Dot Matrix
Character set	67	67	67
Character codes	ASCII	ASCII	ASCII
Display Black on White	Optional	Optional	Optional
Format Control Features			
Display CR symbol	Optional	Optional	Optional
Auto Line Feed	Optional	Optional	Optional
Auto Roll-Up (Bottom line entry)	Optional	Optional	Optional
Field TAB	STD	STD	STD
Blink Characters	STD	STD	STD
Protect characters	STD	STD	STD
Edit Control Features			
Display Cursor symbol	Optional	Optional	Optional
Load Cursor Address	STD	STD	STD
Position Cursor (Keyboard or Processor)	STD	STD	STD
Read Cursor Address (Processor)	STD	STD	STD

*Monitor resolution: Minimum resolution is 750 lines at the center of the CRT screen and 650 lines at the corners as measured in accordance with EIA RS–375.

Edit Control Features	Model 450	Model 455	Model 456
Repeat Character/function (kbd)	15 Hz rate	15 Hz rate	15 Hz rate
Display Parity Error Symbol (SUB)	STD	STD	STD
Insert/Delete Character	STD	STD	STD
Insert/delete Line	STD	STD	STD
Erase to End of Line	STD	STD	STD
Erase to End of Page	STD	STD	STD
Clear Screen (un-protected areas)	STD	STD	STD
Clear Memory (entire screen)	STD	STD	STD
Man/Machine Features			
Remote (Display ON-line)	STD	STD	STD
Local (Display OFF-line)	STD	STD	STD
End of Line/Page Bell	STD	STD	STD
Set/Clear DATA·PANEL	STD	STD	STD
Note: DATA·PANEL Optional			
Memory			
Type	MOS S.R.	MOS S.R.	MOS S.R.
Capacity	1000	1920	960
Operation	Serial	Serial	Serial
Processor Interface			
Data Format	7 Bit Parallel	7 Bit Parallel	7 Bit Parallel
Data Transfer Rate	110 to 9600 baud	110 to 9600 baud	110 to 9600 baud
TTL Drivers/Receivers	15 ft. max.	15 ft. max.	15 ft. max.
RS–232 Drivers/Receivers	1000 ft. max.	1000 ft. max.	1000 ft. max.
Current Loop Drivers/Receivers	1000 ft. max.	1000 ft. max.	1000 ft. max.
Parity Check Odd or Even	OPT	OPT	OPT
Parity Generate, Odd or Even	OPT	OPT	OPT
Printer Interface (Hard Copy Adaptor - Optional)			
Data Format*	11 Bit Serial	11 Bit Serial	11 Bit Serial
Even/Odd Parity*	Optional	Optional	Optional
Data Transfer Rate*	110-1200 Baud	110-1200 Baud	110-1200 Baud
20 ma Current Loop	STD	STD	STD

Note: Hard Copy Adaptor speed independent of Interface speed.

Options

DATA·PANEL Display	w/monitor	w/monitor	w/monitor
Desk Mount with Monitor	YES	YES	YES
Desk Mount without Monitor	YES	YES	YES
Rack Mount with Monitor	YES	YES	YES
Rack Mount without Monitor	YES	YES	YES
Keyboard	YES	YES	YES
Slave Monitors	YES	YES	YES
Answerback to "HERE IS"	YES	YES	YES
Hard Copy Adaptor	YES	YES	YES

Display Controls

ON–OFF Switch	STD	STD	STD
Brightness	STD	STD	STD

Power Requirements

115 VAC, 60 Hz, 180 w max.	STD	STD	STD
240 VAC, 50 Hz, 180 w max.	Optional	Optional	Optional

Physical Specifications (all models)

Dimensions – See FIGURES 47 through 49.
Standard Finish – Armorhide Blue – or selected vinyl finishes.
Operating Temperature – +10°C to +40°C @ 80% relative humidity (non-condensing)
Storage Temperature – 40°C to +65°C @ 80% relative humidity (non-condensing)
Shipping Weights –
- Desk Mount with Monitor & keyboard – 68 pounds
- Desk Mount with keyboard, without Monitor – 48 pounds
- Rack Mount with Monitor & Keyboard, without front panel 65 pounds
- Rack Mount with keyboard, without Monitor & front panel 39 pounds
- Keyboard – 15 pounds
- Shipping carton with internal padding – 8 pounds*

* included in shipping weights

All specifications subject to change without notice.

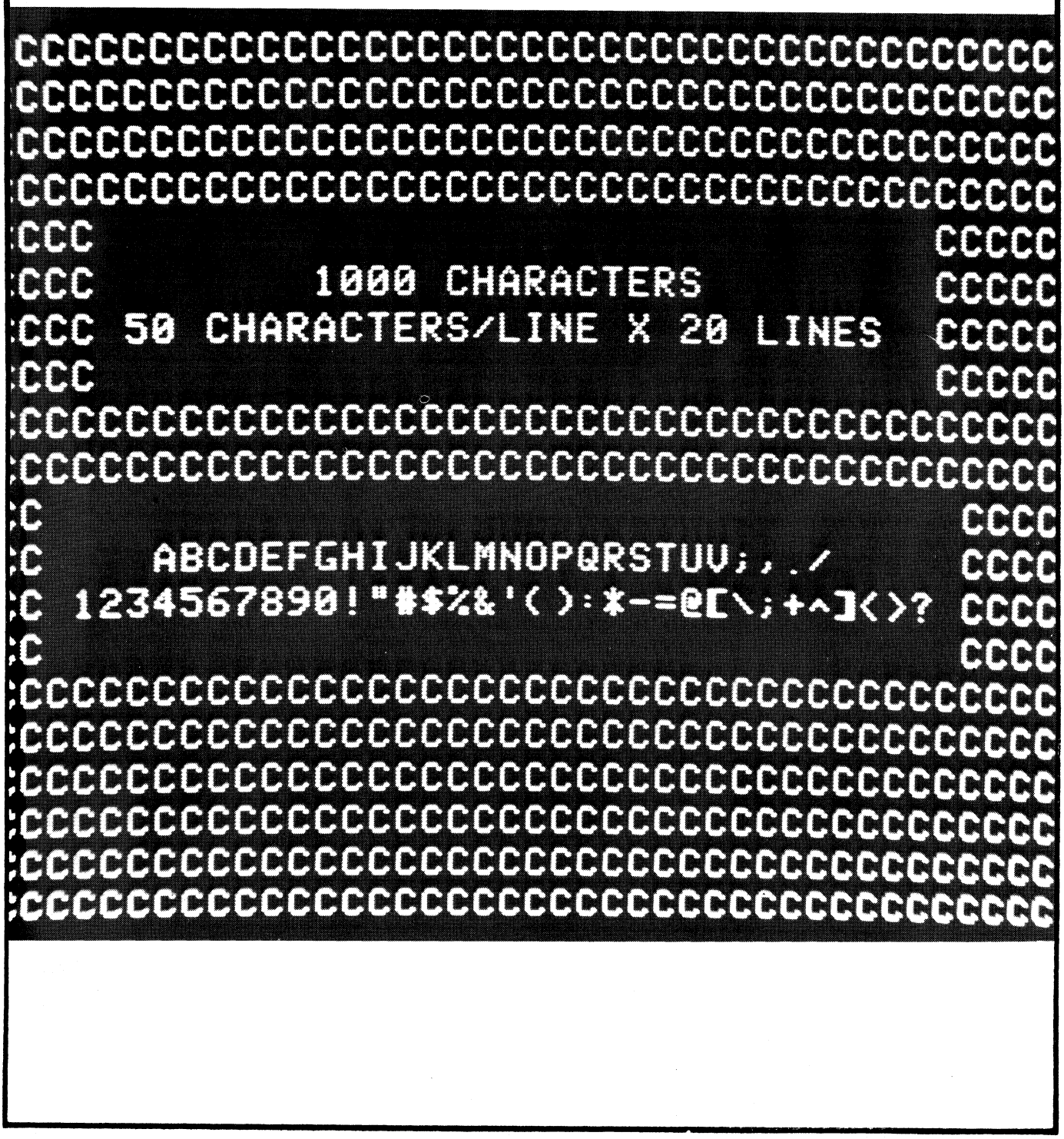


FIGURE 37. PHOTOGRAPH –ACUAL SIZE– OF MODEL 450 CHARACTER SET

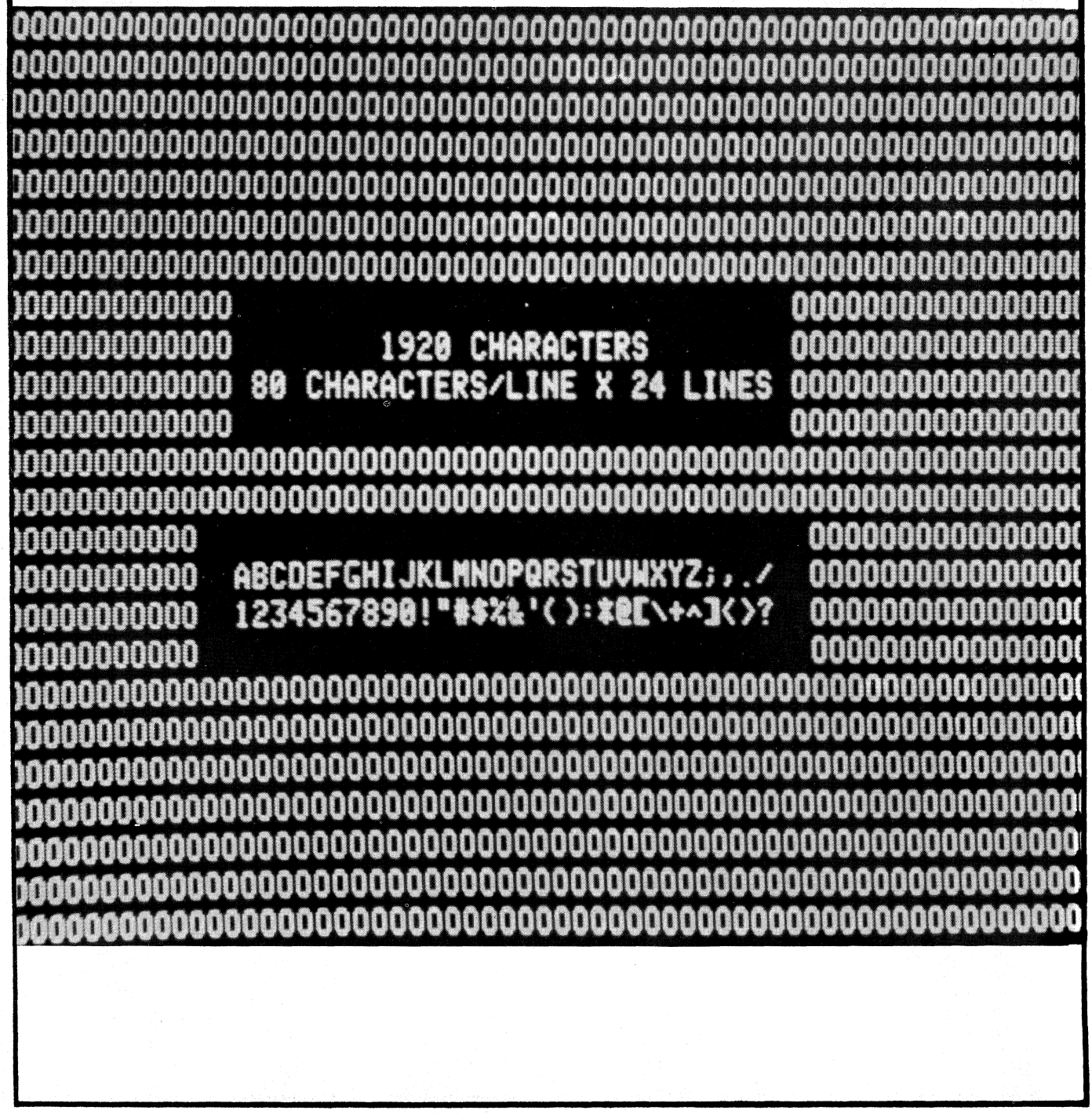


FIGURE 38. PHOTOGRAPH –ACTUAL SIZE– OF MODEL 455 CHARACTER SET

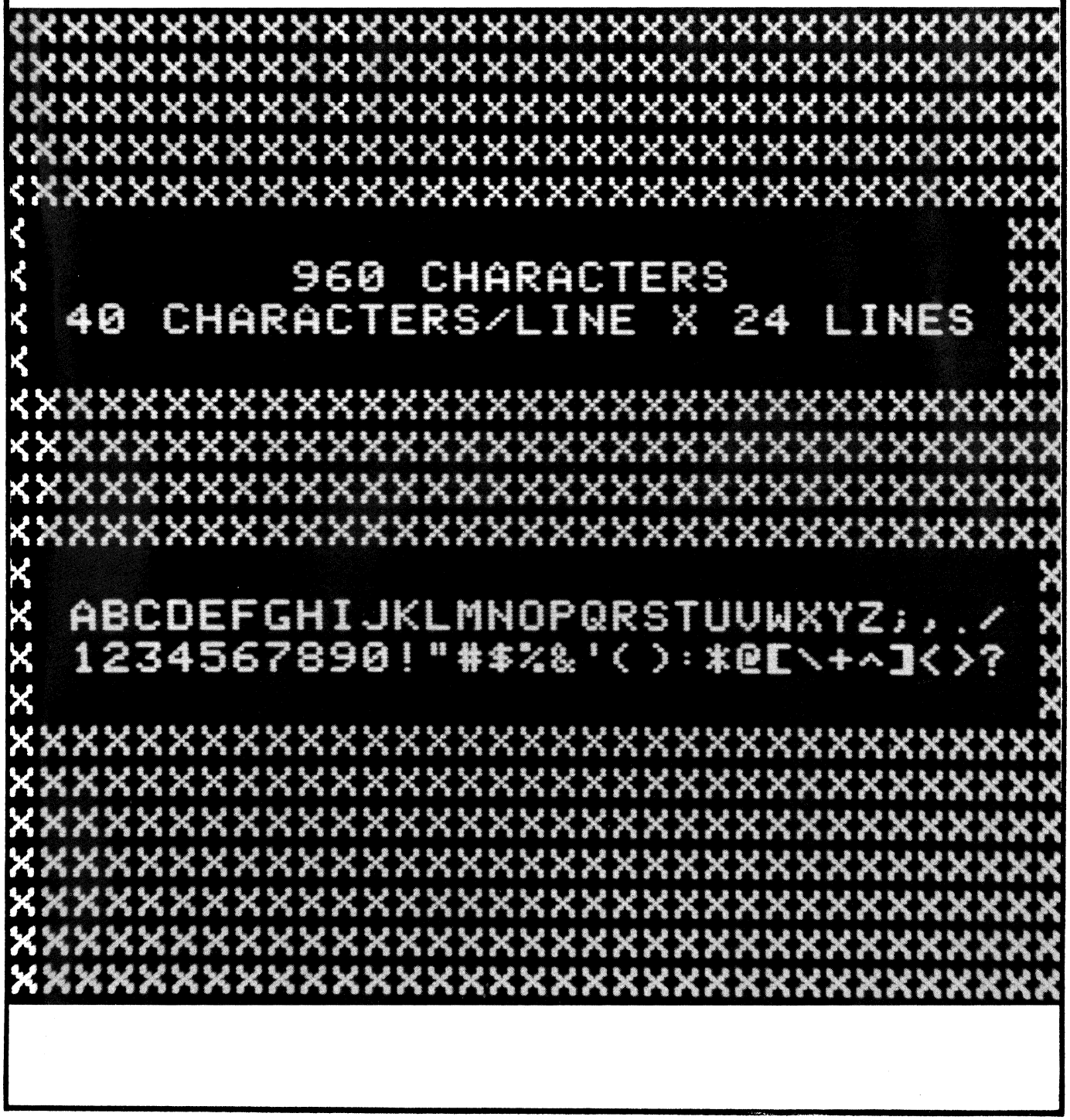
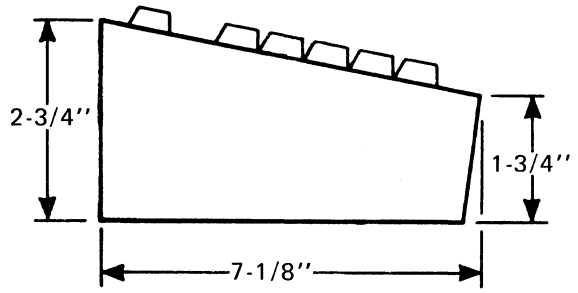
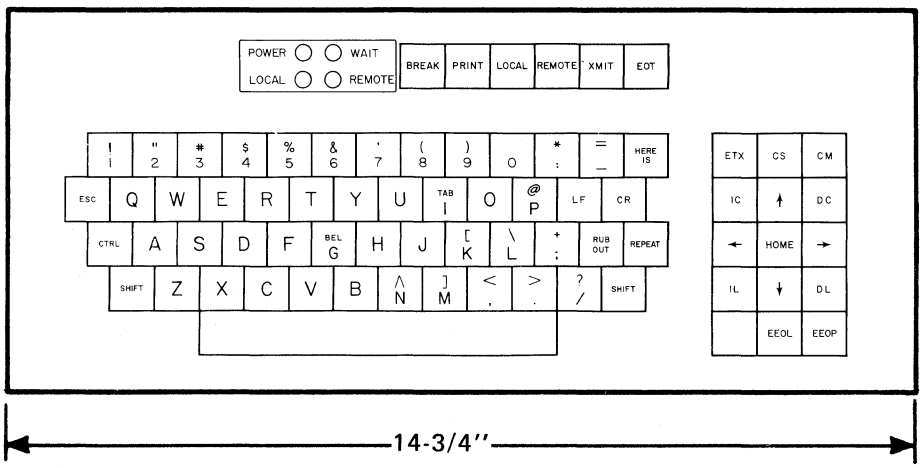


FIGURE 39. PHOTOGRAPH –ACTUAL SIZE– OF MODEL 456 CHARACTER SET.

FIGURE 40. EXPLODED VIEW – DATA–SCREEN TERMINAL





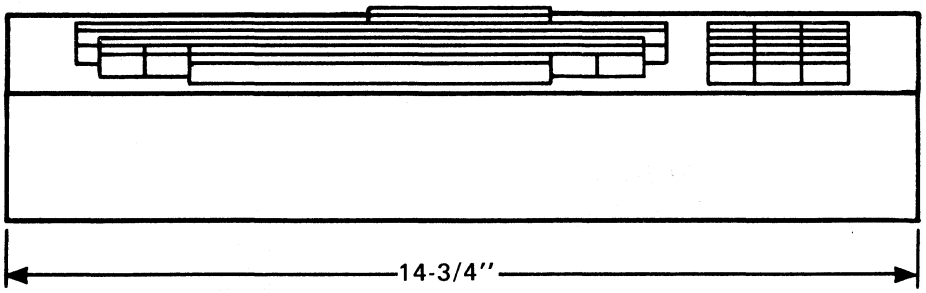
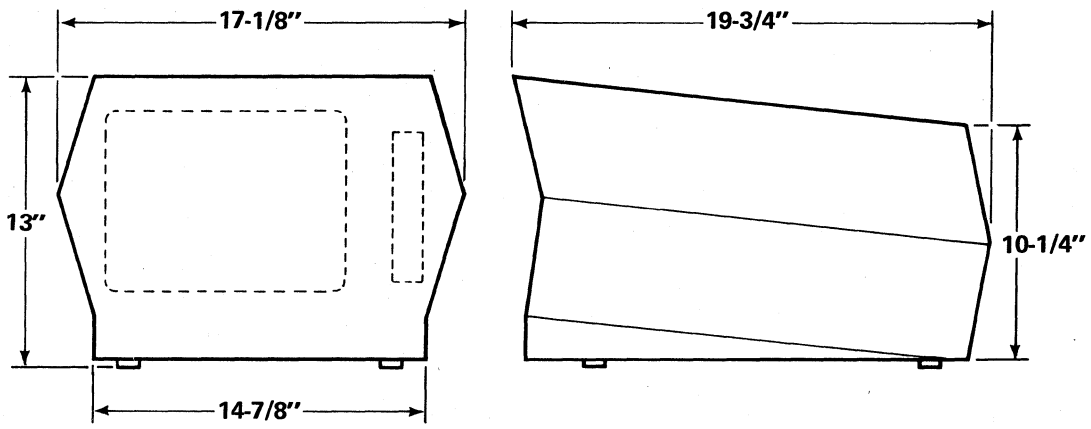
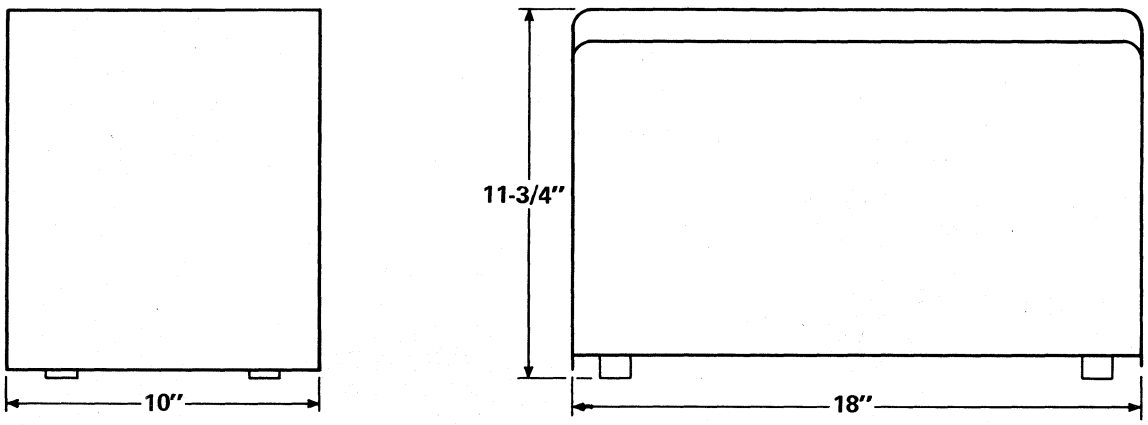


FIGURE 41. KEYBOARD DIMENSIONS

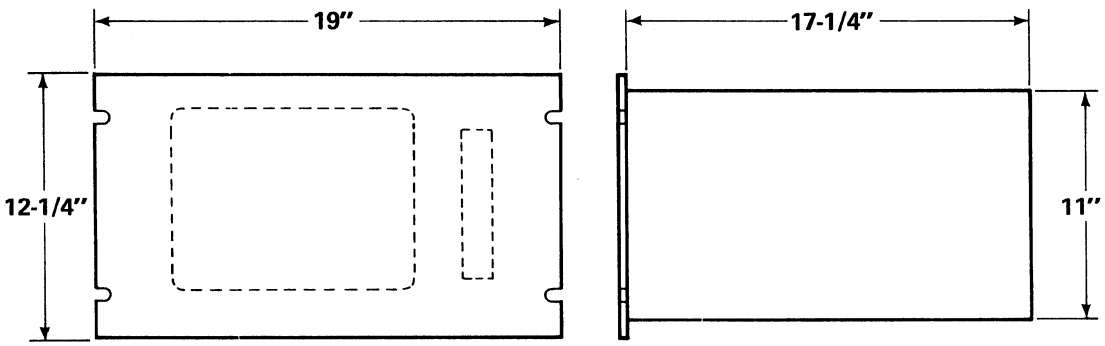


DESK TOP MODEL WITH MONITOR

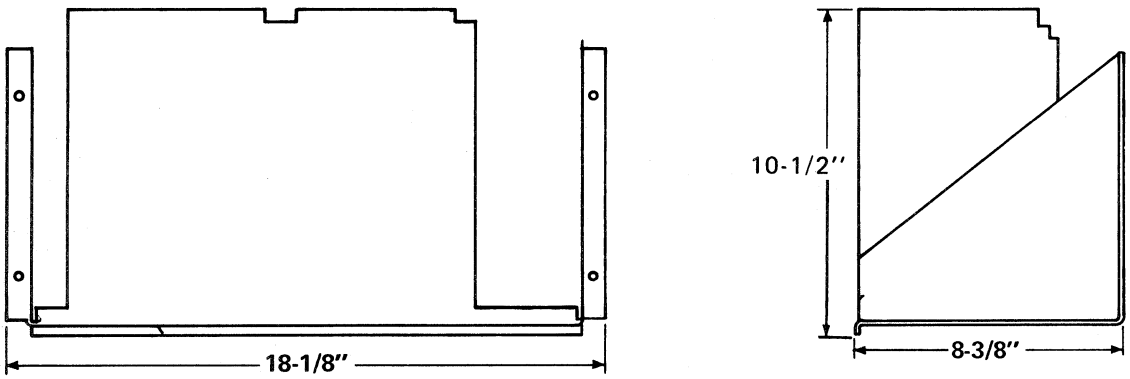


DESK TOP MODEL WITHOUT MONITOR

FIGURE 42. DESK TOP MODEL DIMENSIONS



RACK MOUNT MODEL WITH MONITOR



RACK MOUNT MODEL WITHOUT MONITOR

FIGURE 43. RACK MOUNT MODEL DIMENSIONS

PARTS LIST	MODEL 450		MODEL 455		MODEL 456	
PARTS DESCRIPTION	PART NUMBER	PART NUMBER	PART NUMBER	UNIT PRICE	PART NUMBER	UNIT PRICE
TIMING GENERATOR (TG) PCB	933021 *Exchange	$121.00 $ 48.40	933038 *Exchange	$121.00 $ 48.40	930065 *Exchange	$121.00 $ 48.40
LINE MEMORY & CHARACTER GENERATOR (LM & CG) PCB	933022 *Exchange	$409.00 $163.60	933040 *Exchange	$409.00 $163.60	933022 *Exchange	$409.00 $163.60
PAGE MEMORY (PM) PCB	933023 *Exchange	$270.00 $108.00	933039 *Exchange	$410.00 $164.00	933023 *Exchange	$270.00 $108.00
CONTROL PCB	933024 *Exchange	$118.00 $ 47.20	933024 *Exchange	$118.00 $ 47.20	933024 *Exchange	$118.00 $ 47.20
CURSOR COUNTER (CC) PCB	933025 *Exchange	$142.00 $ 56.80	933035 *Exchange	$202.00 $ 80.80	930066 *Exchange	$142.00 $ 56.80
COMMUNICATION INTFC #8	930154 *Exchange	$210.00 $ 84.00	930154 *Exchange	$210.00 $ 84.00	930154 *Exchange	$210.00 $ 84.00
KEYBOARD INTFC #6	930153 *Exchange	$151.00 $ 60.40	930153 *Exchange	$151.00 $ 60.40	930153 *Exchange	$151.00 $ 60.40
DATA-PANEL LAMP DRIVE PCB	933371 *Exchange	$ 60.00 $ 24.00	933371 *Exchange	$ 60.00 $ 24.00	933371 *Exchange	$ 60.00 $ 24.00
HARD COPY ADAPTOR	930071 *Exchange	$270.00 108.00	930071 *Exchange	$270.00 108.00	930071 *Exchange	$270.00 108.00

	ALL MODELS	
PARTS DESCRIPTION	PART NUMBER	UNIT PRICE
EXTENDER PCB	933030	$50.00
BAUD RATE SWITCH	930081	$75.00
FAN MOUNTING BASE		
115 VAC 50/60 Hz	980042-001	$49.50
230 VAC 50/60 Hz	980042-002	$49.50

*TEC's Printed Circuit Board exchange program permits return of defective, out of warranty PCB's for 60% credit toward the purchase of an exchange PCB of the same type. Exchange PCB's carry the same 90 day warranty from date of shipment as new PCB's. Warranty is void on any PCB new or exchange, if TEC inspection reveals customer attempts to repair or alter function of PCB.

PARTS LIST	ALL MODELS	
PARTS DESCRIPTION	PART NUMBER	UNIT PRICE
CLEAR EPOXY COATED PCB's (for environmental protection)	Price of PCB plus	$20.00/Board
MIRATEL MONITOR ASSEMBLY with CRT (For DATA–SCREEN Terminals [redacted] – See Parts List, Page [redacted] 119		
115 Volt, 50/60 Hz — P 4 Plain CRT	752547-001	$246.00
115 Volt, 50/60 Hz — P 4 Etched CRT	752547-002	
115 Volt, 50/60 Hz — P31 Plain CRT	752547-003	
115 Volt, 50/60 Hz — P31 Etched CRT	752547-004	
220/240 Volt, 50/60 Hz — P 4 Plain CRT	742571-001	$296.00
220/240 Volt, 50/60 Hz — P 4 Etched CRT	742571-002	
220/240 Volt, 50/60 Hz — P31 Plain CRT	742571-003	
220/240 Volt, 50/60 Hz — P31 Etched CRT	742571-004	
MOTOROLA MONITOR ASSEMBLY with CRT (For DATA–SCREEN Terminals with Non-glare tube & bezel Front Panel – See Parts List, Page [redacted] 118.		
105-135/210-270 VAC 50-60 Hz — P 4 (White) Phosphor CRT	740031-001	$246.00
105-135/210-270 VAC 50-60 Hz — P31 (Green) Phosphor CRT	740031-002	
EKA 8002 KEYBOARD**	980039	$350.00
REPLACEMENT KEYBOARD SWITCH	880031-001	$ .75 ea.
KEYBOARD EXTENDER CABLE (xxx=length in inches)	933390-xxx	$50 + $1.00/ft.
MATING CONNECTOR FOR		
J1 – (Cinch DB–25 S)	781014-003	$ 7.50
Hood for above (Cinch DB 51 226–1)	741184-000	$ 1.60
J2 – (Cinch DE–9S)	781014-001	$ 3.30
Junction shell for above (Cinch 19977–5)	740034	$ 1.60
POWER SUPPLY ASSEMBLY (includes Regulator PCB)	982413	$250.00
PRODUCT DESCRIPTION MANUAL (Additional copies)	[redacted] 938	$ 7.50
SHIPPING CARTON (with internal padding)	211366	$25.00 + FRT.

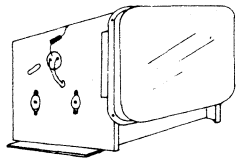
Prices subject to change without notice. Minimum order $25.00.

**Keyboard repair - TEC will repair DATA–SCREEN Terminal keyboards for a fixed charge of $150.00 provided that the keyboard has not been subjected to excessive shock, heat or other abuse, or if liquids, harmful vapors or abrasive matter have not penetrated the interior to an excessive degree, or if attempts to repair or modify the keyboard's functions, or operate it outside its electrical design parameters are not evidenced. Only keyboard parts and components replaced in the repair operation will be warranted for 90 days.

Note: TEC's decision as to the condition of parts returned for exchange or repair will be final.

MONITOR IDENTIFICATION

MOTOROLA MONITORS CAN BE
IDENTIFIED BY THIS CHASSIS DESIGN

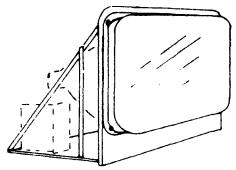


(Refer to monitor manufacturer's schematic)

SYMBOL	PARTS DESCRIPTION	TEC PART NUMBER	MOTOROLA PART NUMBER	MANUFACTURER/ PART NUMBER	UNIT PRICE
——	PCB Assembly	930092	1Y25016A23	MOTOROLA	$77.20
D1	Diode, Silicon	560025	48S134921	MOTOROLA	.90
D9-D12	Rectifier, Silicon	570026	48S191A07	MOTOROLA	.85
F1, F2	Fuse, .4A @ 250 V	740038	65S138562	MOTOROLA	.65
L4	Coil, Horizontal Width (Includes C42 & R68)	750032	24V25000A74	MOTOROLA	1.55
L5	Deflection Yoke, 114°	750033	24D68523A10	MOTOROLA	9.50
Q9	Transistor, Horizontal Output, A3H, 2N3902	510031	48S134995	MOTOROLA	5.75
Q13	Transistor, Vertical Output, A1C, 2N5151	510032	48S134900	MOTOROLA	5.75
Q14	Transistor, Regulator Driver, A2J, 2N4400	510033	48S134952	MOTOROLA	1.45
Q16	Transistor, Regulator A8W, 2N3442	510034	48S137368	MOTOROLA	2.90
R5	Control, Contrast, 250 Ohms	700030	18D67559A63	MOTOROLA	.65
R80	Varistor	700031	6C66263A08	MOTOROLA	.25
SW1	Switch, Slide, DPDT, 115-230V	880030	40S10624A01	MOTOROLA	.85
T2	Transformer, H. V. Complete	750034	24D69791A09	MOTOROLA	4.85
T3	Transformer, Vertical Output	750035	25D65870A22	MOTOROLA	5.20
T4	Transformer, Power	750036	25D68164A17	MOTOROLA	10.65
——	Insulator, Mica	740039	14A543810	MOTOROLA	.07
——	Rod, Adjustment	740040	14C66082A04	MOTOROLA	.10
——	Insulator, Molded Vinyl	740041	14C68842A04	MOTOROLA	.10

MONITOR IDENTIFICATION

MIRATEL MONITORS CAN BE
IDENTIFIED BY THIS CHASSIS DESIGN



(Refer to monitor manufacturer's schematic)

SYMBOL	PARTS DESCRIPTION	TEC PART NUMBER	MIRATEL PART NUMBER	MANUFACTURER/ PART NUMBER	UNIT PRICE
C1	Capacitor, Fixed; 3300 uf. 60 V, Electrolytic	620026	1-012-2156	MIRATEL	$ 6.10
CRT	Bridge Rectifier, VS148	570025	1-021-0413	VARO	5.40
L1	Vertical Choke	750029	6-003-0321	MIRATEL	6.80
L101	Coil, Width	750030	1-016-0276	MIRATEL	2.25
Q1	Transistor, 2N3055	510030	1-015-1134	RCA 2N3055	7.90
Q106	Transistor, SP2597	510029	1-015-1160	MOT SP2597	8.10
R107	Resistor, Variable, Film, 2.5M ±20%, 1/8 W, Composition	700026	1-011-5566	MIRATEL	4.10
R121	Resistor, Variable, Film 10K ±20%, 1/8 W, Composition	700027	1-011-5312	MIRATEL Type RBX	1.30
R124	Resistor, Variable, Film, 100 Ohms ±20%, 1/8 W, Composition	700028	1-011-5095	MIRATEL	.13
R208	Resistor, Variable, Film, 50 Ohms ±20%, 1/5 W, Composition	700029	1-011-5604	CTS Type 201	1.70
T1	Transformer, Power, 120 VAC	750027	6-003-0322	MIRATEL	21.45
T1	Transformer, Power, 240 VAC	750028	6-003-0323	MIRATEL	33.45
T2	Transformer, High Voltage (TV-B12 & TV-TC12)	750026	6-003-0325	MIRATEL	32.50
VR102	Diode, VR56	580025	1-021-0420	ST VR56	3.35
——	Low Voltage Circuit Board Assembly	930078	6-003-0459	MIRATEL	21.45
——	Main Chassis Circuit Board Assembly (TV-TC12)	930079	6-002-0477	MIRATEL	78.05
——	Power Supply Module	930080	6-003-0318	MIRATEL	22.30
——	Deflection Coil Assembly	750031	6-004-0314	MIRATEL	21.45

SECTION VII

TROUBLE SHOOTING GUIDE

TEC's DATA–SCREEN Terminals have proved exceptionally reliable in field use. It is possible, however, that failures can occur in one of the thousands of interconnections or components used in these complex devices. To reduce terminal downtime to a minimum, this section provides a suggested PCB and subassembly replacement sequence based on malfunctions visible on the screen.

Most problems are caused by failures in one printed circuit board. Such fail ures do not normally cause "chain reaction" failures of other components on the affected PCB, or on other PCB's in the terminal. By maintaining a spare set of PCB's, the great majority of problems can be repaired in a matter of minutes. Suspect PCB's can be returned to TEC for replacement on an "exchange" plan (see Parts & Price List – pages 116 & 117.)

NOTE: Good trouble shooting practice requires that supply voltages be checked to avoid damaging replacement PCB's. Nominal supply voltages are listed behind the rear panel on a label located next to the Power ON–OFF switch. Voltages are measured on the terminal strip labeled 0 to 11 in the power supply assembly.

CAUTION: 120 Volt supply is present on this strip. Ex. ercise caution when placing probes at the various test points.

DISPLAY PROBLEMS

Displays some Wrong Alpahnumerics (e.g. B displays as A)

- change LM & CG PCB
- change PM PCB
- change CONTROL PCB
- change SERIAL I/O - 6A
- change SERIAL I/O - 8B

No Display, No Sync

- check voltages
- change TG
- change LM & CG
- change monitor

No Display, Good Raster

- change CC PCB
- change TG PCB
- change LM & CG PCB
- check voltages
- change monitor

TG = Timing Generator (Board 1)
LM & CG = Line Memory & Character Generator (Board 2)
PM = Page Memory (Board 3)
CONTROL = Control (Board 4)
CC = Cursor Counter (Board 5
SERIAL I/O 6A (Board 6)
SERIAL I/O 8B (Board 8)

Good Cursor, No Characters

- change LM & CG PCB
- change CC PCB
- change SERIAL I/O - 6A
- change SERIAL I/O - 8B
- change CONTROL PCB
- change PM PCB

No Display, No Raster

- check fuses
- check voltages
- change monitor

Distorted Characters

- change LM & CG PCB
- change TG PCB
- change monitor

Good Alphanumerics, No Special Characters

- change LM & CG PCB
- change TG PCB
- change CONTROL PCB

DISPLAY PROBLEMS (cont'd)

Good Display, But Rolls

↓ check vertical sync on monitor*
↓ change TG PCB
↓ change LM & CG PCB

* See Monitor Manufacturers manual.

Comes On With Screen Full of One Character

↓ change PM PCB
↓ change LM & CG PCB

Display Is Wrong Height or Width

↓ check monitor
↓ change TG PCB

Little or No Brightness Control

↓ check brightness control
↓ change monitor

Cursor Won't Move in One or More Directions

↓ change CONTROL PCB
↓ change CC PCB
↓ change keyboard

Whole Display Moves

↓ change CC PCB
↓ change TG PCB
↓ check voltages

Comes On With Screen Full of Random Characters

↓ change CONTROL PCB
↓ change SERIAL I/O - 6A
↓ change SERIAL I/O - 8B

Display Shows Jagged Lines (may be crackling noise)

↓ change monitor

Characters or bits Added or Dropped on Edit Functions

↓ change LM & CG PCB
↓ change CONTROL PCB
↓ change PM PCB

Cursor Disappears Off End of Display

↓ change CC PCB
↓ change CONTROL PCB

Screen Slowly Fills With Spaces or any Character

↓

check keyboard (stuck key)

Can't Clear Screen (CS & CM key do not work)

↓

change CONTROL

↓

change PM PCB

↓

change Keyboard

INPUT/OUTPUT PROBLEMS

No Input From or Output to CPU

↓

change SERIAL I/O - 8B

↓

change SERIAL I/O - 6A

↓

change CC PCB

Cursor Won't Move on Input From Keyboard

↓

change SERIAL I/O - 6A

↓

change CC PCB

One or More Lights on DATA·PANEL stays on or won't light

↓

change DATA·PANEL PCB

↓

change SERIAL I/O - 6A

↓

change SERIAL I/O - 8B

One Particular Character Won't Enter from Keyboard

↓

change keyboard

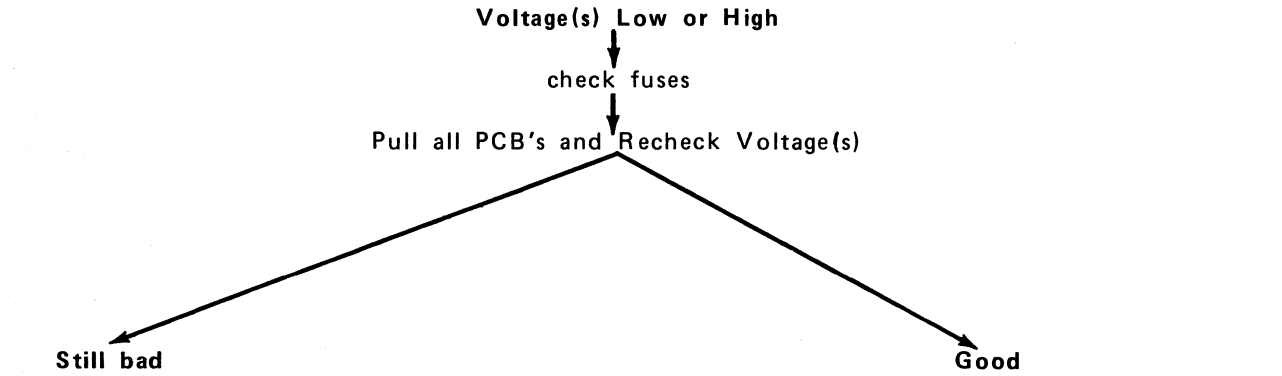
Protect or Blink Functions Won't Work

↓

change PM PCB

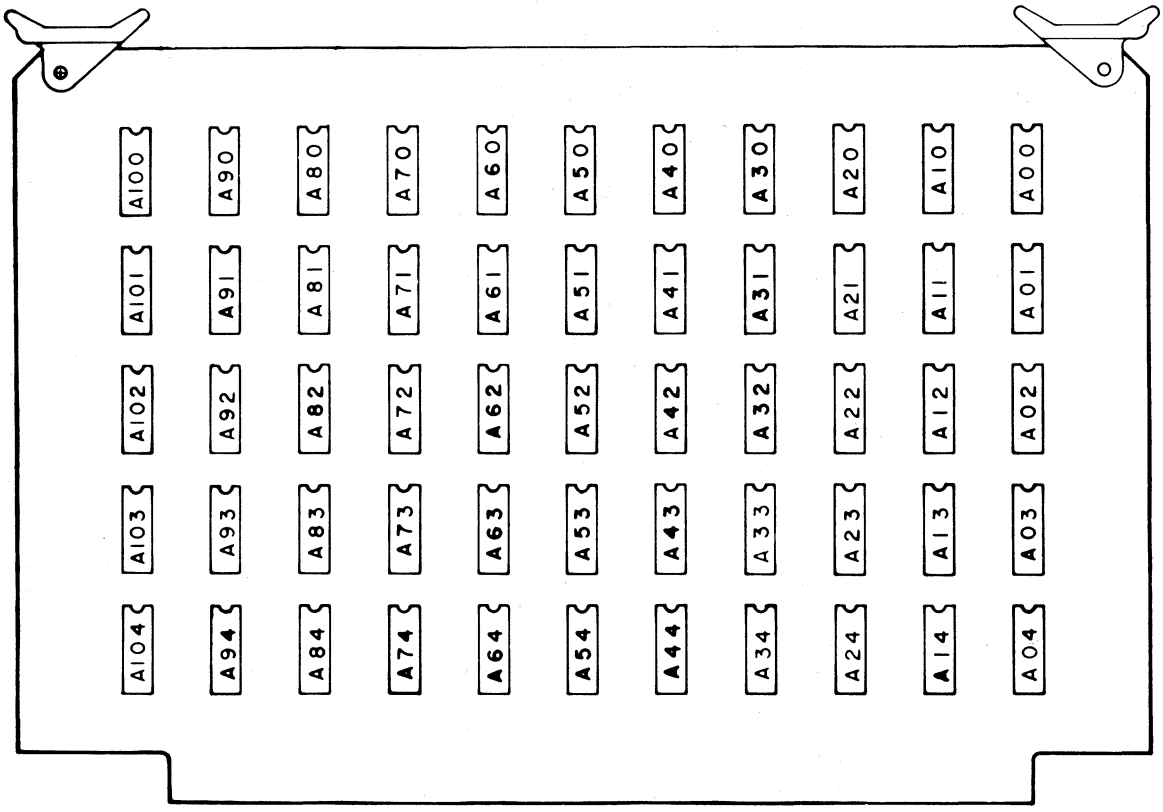
↓

change CONTROL PCB



change power Supply

Reinsert PCB's one at a time until voltage(s) go bad. Last PCB inserted is bad.



I–C MODULE NUMBERING SEQUENCE

WARRANTY

The Seller agrees, represents, and warrants that the equipment delivered hereunder shall be free from defects in material and workmanship. Such warranty shall not apply to accessories, parts or material purchased by the Seller unless they are manufactured pursuant to Seller's design, but shall apply to the workmanship incorporated in the installation of such times in the complete equipment.

Seller's obligations under said warranty is conditioned upon the return of the defective equipment, transportation charges prepaid, to the Seller's factory, and the submission of resonable proof to Seller prior to return of the equipment that the defect is due to a matter embraced within Seller's warranty hereunder. Any such defect in material and workmanship must have become apparent and Buyer must have notified Seller thereof within ninety (90) days after delivery, or ninety (90) days after installation if the installation was accomplished by the Seller.

Said warranty shall not apply if the equipment shall not have been operated and maintained in accordance with the Seller's written instructions applicable to such equipment, or if such equipment shall have been repaired or altered or modified without Seller's approval; provided, however, that the foregoing limitatations of warranty insofar as it related to repairs, alterations or modifications shall not be applicable to routine preventive and corrective maintenance which normally occurs in the operation of the equipment.

The extent of Seller's liability under said warranty is limited to the repair or replacement of any defective accessory, part or material with a similar item free from defect, and the correction of any defect in workmanship. Said warranty does not extend to loss of use or consequential damages.

TEC® INCORPORATED

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