Tektronix®

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4953/4954

GRAPHICS TABLET

INSTRUCTION MANUAL

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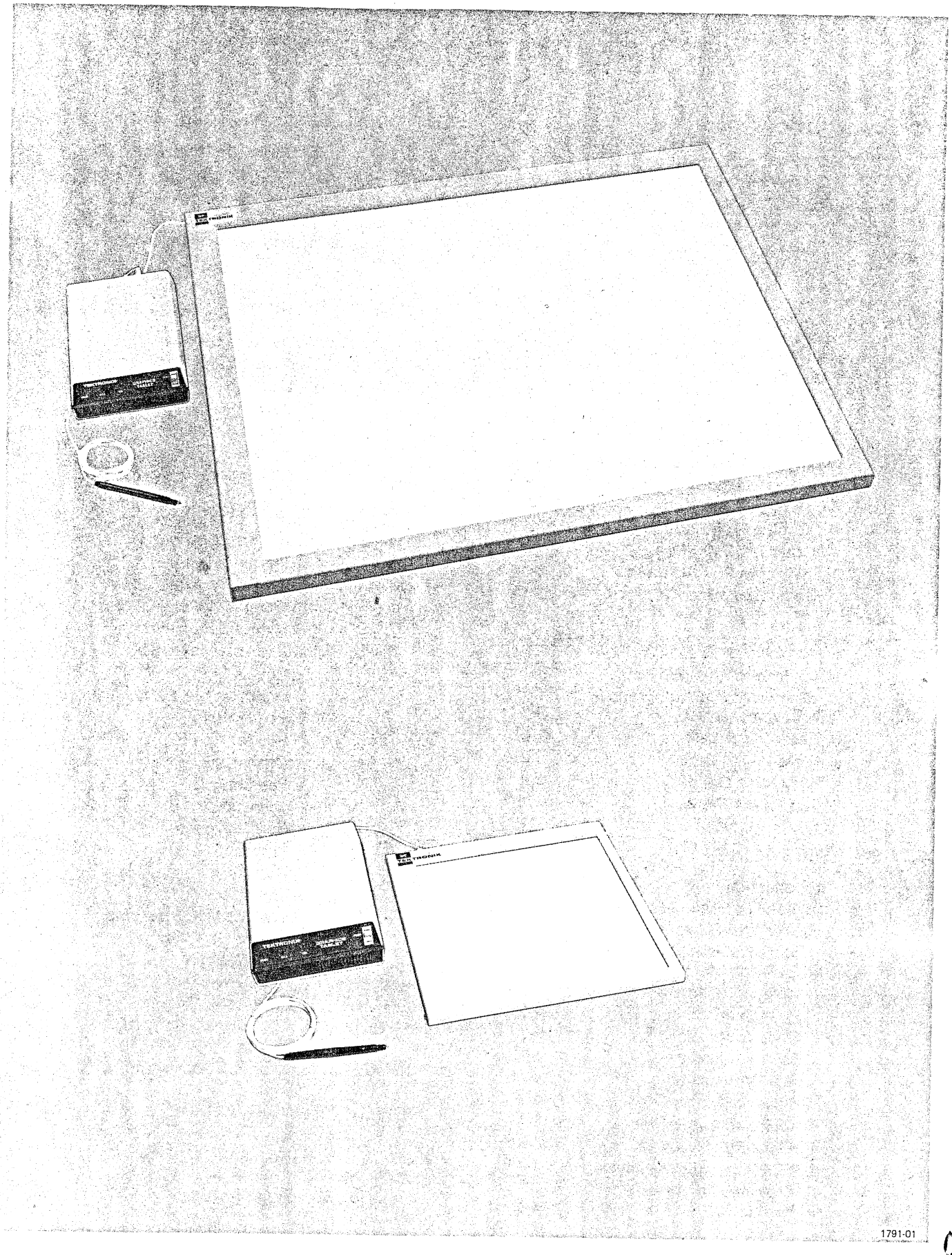


Fig. 1-1. 4953 and 4954 Graphics Tablets.

Section 1
DESCRIPTION

GENERAL

The 4953 and 4954 Graphics Tablets (Fig. 1-1) input graphic data to a computer, through a TEKTRONIX 4010-Series Graphic Display Terminal. The devices are identical except for the size of the tablets; the 4953 is an 11 inches by 11 inches tablet, while the 4954 is 40 inches by 30 inches.

CAUTION

Cleaning agents that contain hydrocarbons will dissolve the tablet surface. The polystyrene surface will react, similarly to most petroleum derivatives. Safe cleaning agents are alcohols—ethyl, methyl, isopropyl—or soaps and detergents that do not contain hydrocarbons.

The basic function of the Graphics Tablet is to convert the position of the pen on the tablet surface to a corresponding digital position that is in usable form for the 4010-Series Computer Display Terminal. The digital position may be simultaneously transmitted to the terminal and computer, or it may be transmitted to the computer through the terminal bus alone, with no local copy of the transmission appearing on the terminal display. The position of the Graphics Tablet in a computer/terminal system is shown in Fig. 1-2.

The 4010-family terminal can operate in a mode termed Graphic Input (GIN), in which identifiable points are digitized and sent to the computer. The Graphics Tablet extends the terminal's ability to input this type of graphic information, inputting points continuously or one at a time, in a mode similar to the terminal's Graphic Input mode.

Input is accomplished by first enabling the tablet with a three-character command string, and then positioning the pen along the surface of the tablet area. Data input may be continuous or one point at a time, it may be dependent on pen proximity only or on the condition of the pen-switch, and local display (on the screen of the 4010-series terminal) may be selected on or off. In addition, each coordinate value (X and Y) may be defined by 10 bits of data or 12 bits of data. All of the above variables are determined by the third character in the command string, as explained in the Operation Section.

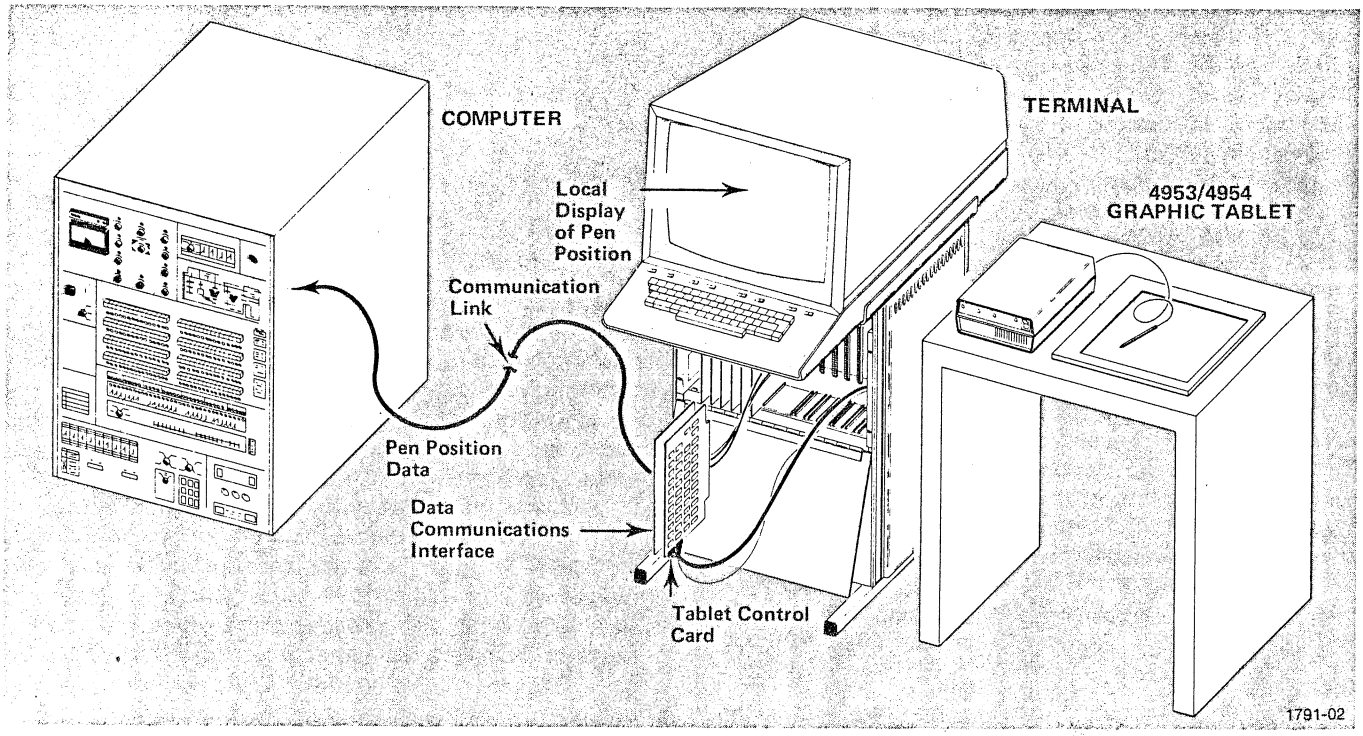


Fig. 1-2. Graphics Tablet position in a system.

The Graphics Tablet functions as an integral part of the terminal hardware by means of an interface card connected to the terminal minibus. The minibus is the terminal's main data routing avenue. Any device connected to the terminal minibus can respond to the Tablet data sent through that minibus. This allows the operator to format Graphics Tablet data off-line from a computer, and then send that data to the computer when the desired graphic input has been obtained.

GRAPHICS TABLET COMPONENTS

The four main components of the Graphics Tablet are the writing surface (Tablet), the Writing Pen, the Power Module, and the Tablet Control Card which plugs directly into the minibus of the 4010-Series Computer Display Terminal.

Tablet. The tablet is a flat writing surface, magnetically prebiased, on which paper (film, etc.) may be placed and then traced to input data to the computer. Under the surface of the tablet are two grids of magneto-strictive wires, one set for the X axis and one set for the Y axis. An acoustic wave is sent along these wires and detected by the writing pen; the time between when the wave is sent and when it is received allows identification of data points in a grid of 1024 X points by 1024 Y points. Identifiable points are 0.01 inch apart. The 4954 maintains 0.01 inch resolution by operating with 12 bits of graphic data per point, or 3840 by 3072 points.

Point identification can be more clearly understood if one thinks of the writing surface as containing 1024 vertical lines and 1024 horizontal lines. An identifiable location on the writing surface can be established at the intersection of any vertical and horizontal line. These identifiable locations directly correspond to the identifiable points of the terminal's display screen.

Writing Pen. The tip of the writing pen contains a sensitive pick-up coil which, when moved into the presence of the tablet, detects the change in magnetic field caused by the acoustic wave. The detected signal is then converted to digital information that directly relates to pen position. Once the specific operating mode has been established, the writing pen provides sufficient control to handle all data transfer (stop and go functions) to the terminal and computer. An optional ballpoint filler may be used in place of the dry filler for the pen, so the operator can draw the information he is sending to the computer; otherwise, the standard inkless filler can be used. The pen can be replaced by an optional accessory "cursor" if greater accuracy is required (such as tracing a drawing).

A pen switch is located within the pen, and is activated by pressing the pen tip against the tablet surface, pressing the filler slightly into the pen.

In the optional accessory cursor, the switch function is performed by the button on top of the cursor.

Power Module. The Power Module contains the power supply, the tablet pulser and preamp, and the connections which tie the Graphics Tablet components together. In addition, the Power Module's front panel contains the Power Switch and Indicators. The Indicators provide the following information:

Indicators

READY—"On" indicates that the Tablet is ready to send another point.

PEN—Illuminates when pen pressure is applied.

DATA—Illuminates when data is in the process of being transferred.

POWER—Illuminates when Power is applied to both the Graphic Tablet and the terminal.

Tablet Control Card. The Tablet Control card contains those circuits necessary to convert the pen signal to its digital equivalent. This card connects directly to the terminal minibus, and contains circuits for format changing, data transfer, "header character" data, and other tablet-related functions.

TABLET PRESENCE AREA

The Graphics Tablet responds to the pen (In Presence) whenever the pen is within 0.125 inch of the surface of the tablet. In addition, only a certain portion of the tablet surface represents the valid data area. The location of this area is dependent on the biasing of the tablet, but the size is standard for each of the tablet sizes. On the 4953, this area is 10.24 inches in each axis; on the 4954, this area is 38.4 inches in the X-axis by 30.72 inches in the Y axis. This area is not marked on the tablet surface, since it may move slightly each time the tablet is biased. It may be located by the operator by enabling the tablet with an ESC ! N, so that the tablet disarms when the presence area is exceeded. He may then slowly move the pen to the border of the tablet, and watch to see when the READY indicator is extinguished. This marks one presence boundary point. This point may be marked and the procedure repeated to find the complete boundary. An example is shown in Fig. 1-3.

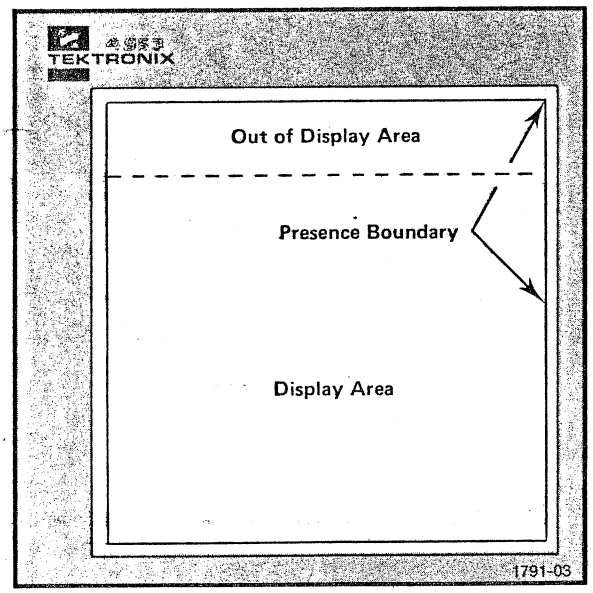


Fig. 1-3. Tablet presence area.

STANDARD ACCESSORIES

The following standard accessories are included with each Graphics Tablet.

Instruction Manual	070-1791-00
Reference Card	070-1787-00
Pen (with inkless filler)	119-0621-00
Biasing Magnet (4953)	119-0686-00
Biasing Magnet (4954)	119-0687-00

STANDARD ASSEMBLIES

Power Module	620-0240-00
Interconnecting Cable (Power Module to Tablet Control Card)	012-0568-00
Tablet Control Card	670-3536-XX
Tablet (4953 only)	119-0619-00
Tablet (4954 only)	119-0620-02

OPTIONAL ACCESSORIES

The following optional accessories are available for the Graphics Tablet, at additional cost.

Cursor (replaces pen)	119-0622-00
Software support package	
(with paper tape)	4010A0601
(with source card deck)	4010A06
Pen Fillers	
Dry	016-0335-00
Blue	016-0334-00

SPECIFICATIONS

Power Specifications

The Graphic Tablets operate from any of the line voltage ranges shown in Table 1-1.

TABLE 1-1

Operating Voltage Ranges

Voltage	Frequency	Tolerance	Range
104 V ac	48-440 Hz	±10%	94-114 V ac
115 V ac			104-126 V ac
208 V ac			187-228 V ac
240 V ac			216-264 V ac

Tablet Interface Current Requirements:

−15 V—at 80 mA, drawn from terminal bus
+15 V—at 40 mA, drawn from terminal bus
180 V—at 10 mA, supplied by the tablet power supply
+5 V—at 1.5 A, supplied by the tablet power supply

Environmental Specifications

Temperatures:

Operating, from 0° C to 40° C
Storage, from −30° C to 40° C

Humidity:

Storage to 95% humidity at 30° C

Presence Distance Specification

With the pen or cursor within 0.125 inch of the tablet surface, the data obtained will be stable with respect to the steadiness of the physical positioning of the pen or cursor.

Presence Area Specification

4953	10.24 inches by 10.24 inches
4954	38.4 inches by 30.72 inches

Tablet Error

The maximum error produced by the Graphics Tablet in the digitizing procedure is defined as 1/4 of a least significant bit per inch, or 0.0025 inch of error per inch of tablet surface. This translates to a maximum error specification as follows:

4953	±0.03 inch over entire tablet surface
4954	±0.10 inch over entire tablet surface

Section 2
OPERATION

INSTALLATION

Installation of the Graphics Tablet consists of making certain the unit is wired for the available line voltage and connecting to a power source, selecting Strappable Options to fit user requirements, connecting the Graphics Tablet components together, and installation of the Tablet Control card into the terminal minibus. Line Voltage Selection and Strappable Options are covered under separate headings within Section 3. To connect the Graphics Tablet components together, proceed as follows.

1. Connect the cable from the pen to J1014 on the rear panel of the Power Module. There is a keying notch on the top of the rear panel connector, which is to align with the key on the tablet cable connector (Fig. 2-1).

2. Connect the cable from the pen to J1016 on the rear panel of the Power Module. There is a keying notch on this connector also, to align with the key on the pen cable connector (Fig. 2-1).

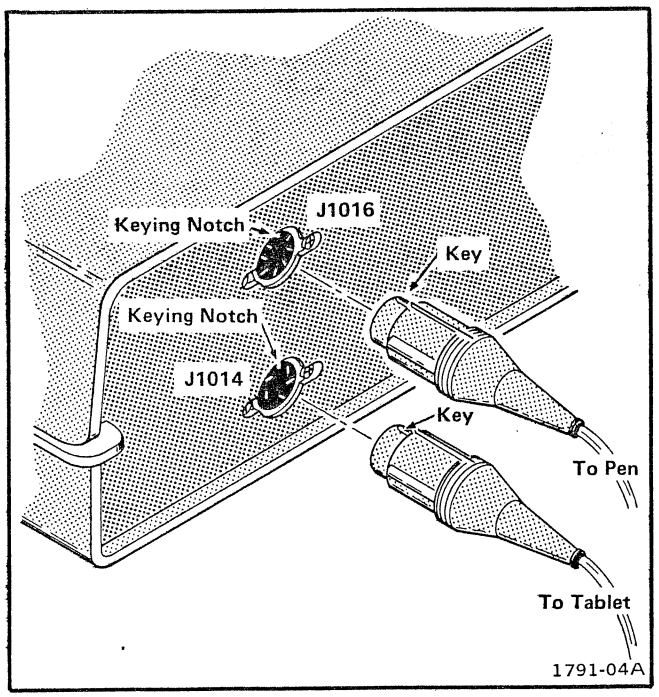


Fig. 2-1. Pen and Tablet connection.

3. Connect the 25-pin connector on the Tablet Control card interconnecting cable to J1010 on the Power Module rear panel, and secure with the two attaching screws (Fig. 2-2).

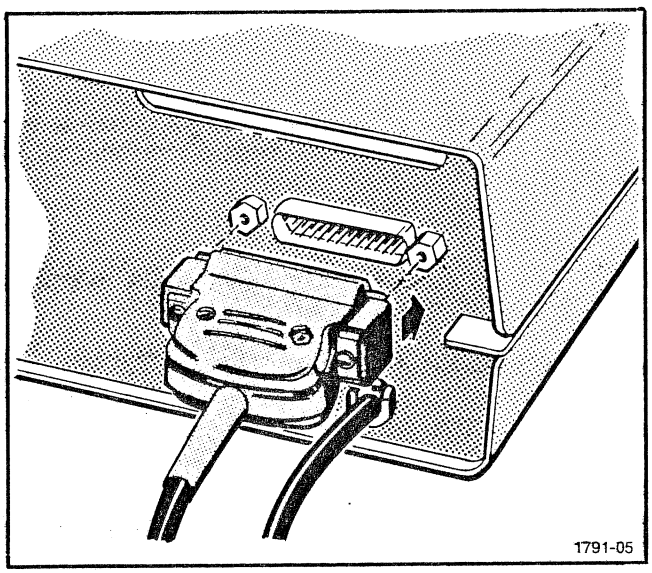


Fig. 2-2. Tablet Control Card cable connection.

4. Install the Tablet Control card into a spare slot in the terminal minibus. Thread the cable from J1010 on the Power Module through the access slot on the rear of the terminal pedestal, then attach the two harmonica connectors (P231 and P232) to their positions on the Tablet Control card (Fig. 2-3). (Make certain that pin 1 of each connector aligns with pin 1 of the card connectors; they are marked with small carets.) Connect the ground lug to the ground spades under the card rack within the terminal pedestal.

It may be necessary to install a Mother Board extender in the terminal to provide room for the Tablet Control card. Refer to the terminal manual for details.

OPERATION

Operating Procedure

Operation of the Graphics Tablet consists of enabling one of the four basic Operating Modes, then manipulating the pen on the tablet surface. The pen may be pressed as

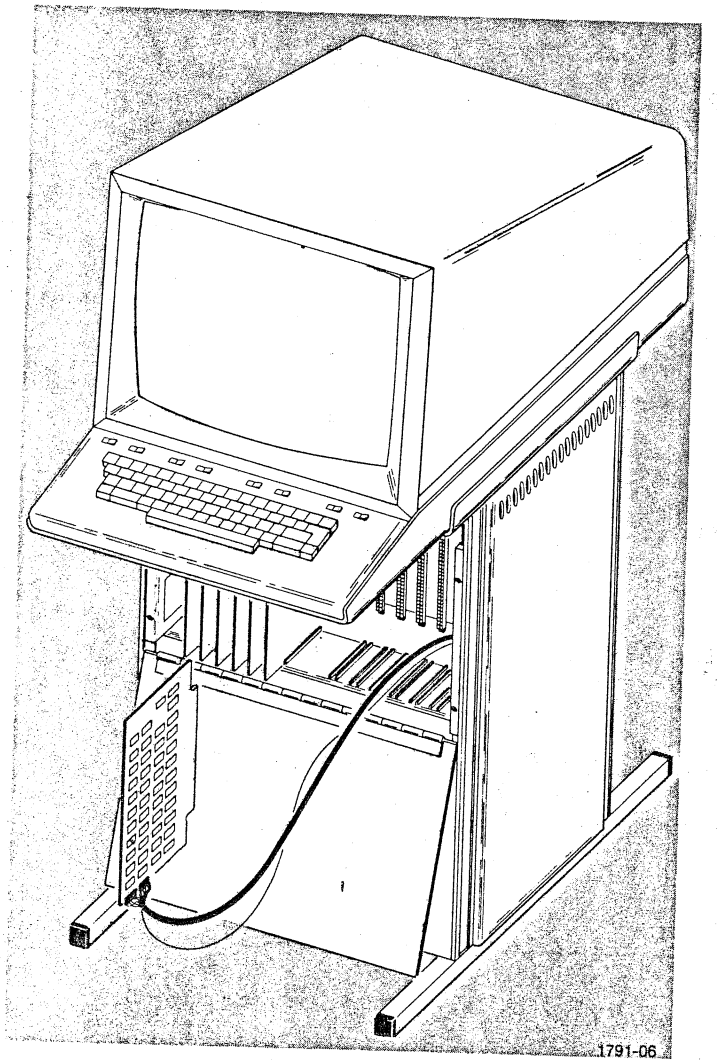


Fig. 2-3. Installing the Tablet Control Card.

necessary to input coordinate points. An Operating Mode is enabled by transmitting a three-character Control Command sequence, either from the terminal keyboard or from the computer, under program control. The selected Operating Mode determines when data is sent, how much data is sent, and when it is necessary to press the pen to transmit data. Operating Modes and mode variables are described in the Operating Modes and Control Commands descriptions within this section.

When enabled and operating, the Graphics Tablet transmits digital coordinate data corresponding to the pen position; this data is sent through the terminal bus to the terminal display and/or to the computer. The use of this data is defined by the program which is using it. It may be used to define single points which, in turn, may be defined as some value or answer in a "menu selection" routine. The data may also be used to draw vectors between points, or it may be used to trace or input a curved, continuous line, such as in a mapping routine. The possiblities are dependent on the computer software that is using the data.

Header Characters

Each coordinate point is preceded by a Header Character, which sets the terminal to the appropriate mode to accept the data that follows. In addition, the Header Characters are used by computer software to interpret the data string that follows. The particular Header character that is transmitted before each coordinate point is dependent on the Operating Mode and the action of the pen, as explained in each Operating Mode description. The Graphics Tablet is factory-wired to respond with one of four Header Characters. (Header Characters may be changed from Control Characters to letter characters, as described in the Strappable Options description, but the terminal will display M and O characters rather than graphics; Local Display is therefore not recommended when letter Header Characters are used.)

Control Commands

The Graphics Tablet is active whenever power is applied to both the terminal and the Graphics Tablet. The tablet is enabled and the Operating Mode is established by a Control Command sequence consisting of three ASCII characters; these are ESC ! and a third character (Command Character), the first five bits of which establish the variables of the Operating Mode (Table 2-2). Command Characters may be selected for their desired functions from Table 2-3, which is an ASCII code chart appended to show which functions are associated with each character. Note that the Control Command sequence does not print on the terminal screen if the tablet is connected and enabled.

TABLE 2-1

Operating Mode Variables

Bit	Condition	Operation
1 (LSB)	1	Local Display On. This bit condition causes the transferred data to be displayed on the terminal screen. Graphic data is displayed only if the HEADER strap is in the CONTROL position. If the HEADER strap is in the LETTER position alphanumeric characters will be displayed; Local Display is not recommended.
	0	Local Display Off. This bit condition causes the data to be transferred through the terminal bus without terminal screen display.
2 (also see additional functions)	1	Multiple Point. The Tablet is allowed to send as many points as desired, until another Control Command is received to clear the tablet or change operating modes.
	0	Single Point. One point is sent, the Tablet then is disabled. The Tablet must be enabled again with another Control Command to send more data. (Only one operation is allowed for each enabling.) Operations are Data Point To Host, Sending Status On Leaving Presence, and Disarming the Cross Hairs.
3	1	Presence. The alpha cursor tracks the pen when the pen is in presence (within 1/8 inch of tablet surface), if Local Display is selected. When the pen is pressed, graphic coordinate points are sent to the computer. Information for positioning the terminal's Alpha cursor, which is generated while the pen is in presence and the pen switch is open, is not transmitted to the computer unless the COMSUP strappable option is in the OUT position.
	0	Pen. A coordinate set is sent when the pen is depressed.
4 (also see additional functions)	1	Disable on Leaving Presence. Setting this bit, with the status strap set to IN, will disble the Graphics Tablet when the pen is removed from tablet presence (lifted 1/8 inch or moved past the presence boundary) if the terminal is ON LINE. The Graphics Tablet must be enabled again to send more data. *Regardless of the condition of Bit 4, an INQUIRE signal is transmitted by the tablet interface when the pen leaves presence. INQUIRE causes the terminal to place its current status information on the data lines, just as if the terminal had received an ESC ENQ sequence from the computer. When Single Point is selected (Bit 2) and the pen leaves presence, the INQUIRE signal is transmitted the next time the tablet is enabled.*
	0	No Disabling on Leaving Presence. Pen Leaving Presence has no effect on the Tablet enable, but still sends terminal status if the status strap is set to IN.
5	1	12 bit. 12 bits of data are sent for each coordinate. (See Graphic Data Input)
	0	10 bit. 10 bits of data are sent for each coordinate. (See Graphic Data Input.)
6 & 7		Not used.
Additional functions		Clear. Any character with bit 4 = 1 and bit 2 = 0 will clear (disable) the tablet. Terminal status will automatically be sent the next time the Tablet is enabled if the pen leaves presence after the last data transmission.

Terminal/Tablet Interaction

Some knowledge of the terminal operating modes is required for complete understanding of Graphics Tablet operation. Refer to the terminal Users Manual for such information.

TABLE 2-2

COMMAND CHARACTER ASCII CHART

BITS B4 B3 B2 B1	10 BITS	12 BITS	10 BITS	12 BITS	10 BITS	12 BITS	10 BITS	12 BITS
	B7 B6 B5 Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		HIGH X & Y GRAPHIC INPUT		LOW X		LOW Y	
Ø Ø Ø Ø	NUL 0	DLE 16	SP 32	0 48	@ 64	P 80	\ 96	p 112
Ø Ø Ø 1	SOH 1	DC1 17	! 33	1 49	A 65	Q 81	a 97	q 113
Ø Ø 1 Ø	STX 2	DC2 18	" 34	2 50	B 66	R 82	b 98	r 114
Ø Ø 1 1	ETX 3	DC3 19	# 35	3 51	C 67	S 83	c 99	s 115
Ø 1 Ø Ø	EOT 4	DC4 20	$ 36	4 52	D 68	T 84	d 100	t 116
Ø 1 Ø 1	ENQ 5	NAK 21	% 37	5 53	E 69	U 85	e 101	u 117
Ø 1 1 Ø	ACK 6	SYN 22	& 38	6 54	F 70	V 86	f 102	v 118
Ø 1 1 1	BEL 7	ETB 23	' 39	7 55	G 71	W 87	g 103	w 119
1 Ø Ø Ø	BS 8	CAN 24	(40	8 56	H 72	X 88	h 104	x 120
1 Ø Ø 1	HT 9	EM 25	) 41	9 57	I 73	Y 89	i 105	y 121
1 Ø 1 Ø	LF 10	SUB 26	* 42	: 58	J 74	Z 90	j 106	z 122
1 Ø 1 1	VT 11	ESC 27	+ 43	; 59	K 75	[91	k 107	{ 123
1 1 Ø Ø	FF 12	FS 28	, 44	< 60	L 76	\ 92	l 108	¦ 124
1 1 Ø 1	CR 13	GS 29	- 45	= 61	M 77	] 93	m 109	} 125
1 1 1 Ø	SO 14	RS 30	. 46	> 62	N 78	^ 94	n 110	~ 126
1 1 1 1	SI 15	US 31	/ 47	? 63	O 79	_ 95	o 111	RUBOUT (DEL) 127

LOCAL OFF / LOCAL ON	SINGLE POINT	PEN PRESENCE	PEN LEAVING PRESENCE HAS NO EFFECT ON TABLET ENABLE
LOCAL OFF / LOCAL ON	MULTIPLE POINT		
LOCAL OFF / LOCAL ON	SINGLE POINT		
LOCAL OFF / LOCAL ON	MULTIPLE POINT		
CLEAR			TABLET IS DISABLED WHEN PEN LEAVES PRESENCE
LOCAL OFF / LOCAL ON	MULTIPLE POINT	PEN PRESENCE	
CLEAR			
LOCAL OFF / LOCAL ON	MULTIPLE POINT		

1791-07

The Graphics Tablet operates in four basic modes; slight differences occur depending on whether Local Display is selected, whether 10 or 12 bits of data is to be transferred, and whether it is desired that the tablet be disabled when the pen leaves tablet presence. The four basic modes are Single Point/Pen, Single Point/Presence, Multiple Point/Pen, and Multiple Point/Presence. All modes are enabled by transmitting a Control Command sequence consisting of three ASCII characters; these are ESC ! and a third character to select the Operating Mode and its variables. (See Control Commands.)

Regardless of the Graphics Tablet Operating Mode, when the pen is brought into presence and the terminal is in Graphic Plot or Alpha Mode, no data is input from the Graphics Tablet, if COMSUP is strapped IN as described in Strappable Options. (Note that if COMSUP is OUT, Alpha Cursor positioning data is transferred to the computer.) However, if the terminal is ON LINE and is in Graphic Input (GIN) mode with the crosshair displayed, the Graphics Tablet sends the : (colon) Header Character when the pen is brought into presence. This causes the terminal to transmit the coordinates of the crosshair intersect point, and causes the crosshair cursor to disappear. Because the terminal transmits crosshair position data bytes in the reverse order of the Graphics Tablet (crosshair transmission order is HIX, LOY, HIY, and LOY; Graphics Tablet transmission order is HIY, LOY, HIX and LOX), the colon character that is followed by the crosshair coordinates notifies software to look at that coordinate data string in reverse order. Software can then be readied for the first graphic input bytes from the Graphics Tablet. (Note that if Single Point is selected in the Operating Mode, transmission of the crosshair coordinate disables the tablet; it must be re-enabled with another Control Command.)

Operating Modes

NOTE

Do not change Operating Modes while the pen is in presence; erroneous Header Characters may be transmitted.

Single Point/Pen. Single Point/Pen mode is enabled by a Control Command which has bits 2 and 3 = 0 in the Command Character; for example, ESC ! 1 (12 bits) or ESC ! ! (10 bits). In this mode, a single coordinate point, preceded by a GS Header Character, is sent when the pen is depressed in the presence area of the tablet; the tablet is then disabled from sending more data until another Control Command is received. After another Control Command is received, the pen may be pressed again to enter another coordinate preceded by a SUB Header; pen pressure must be released to release the pen switch between each point, but the pen may not leave presence. If Local Display is selected and the pen remains in presence between points, vectors are drawn between successive points; the alpha cursor is not displayed after entry of the first point.

The first point after entering presence is always preceded by a GS Header Character; subsequent points are preceded by a SUB Header if the pen has not left presence between points. If the pen leaves presence while the Graphics Tablet is enabled, it signals, the terminal to transmit status if the terminal is ON LINE, just as if it had received an ESC ENQ sequence from the computer. If the pen leaves presence after data has been sent, while the tablet is not enabled, then status will be sent the next time the tablet is enabled. If the Graphics Tablet is again armed for Single Point/Pen and the pen is brought into presence and pressed, another GS Header Character is transmitted followed by the pen coordinates; the alpha cursor is no longer displayed. Subsequent points are again preceded by SUB Header Characters. A typical operating sequence is illustrated in Fig. 2-4.

First-Time Operation; Single Point/Pen Mode. This procedure may be used to familiarize the operator with the characteristics of Single Point/Pen Mode when operating the Graphics Tablet for the first time.

1. Strappable Options should be in their factory-wired positions: COMSUP in, DELAY in, ESUP out, CR out, and HEADER in the CONTROL position. The Tablet Size strap should be set to SMALL for the 4953, or LARGE for the 4954.

2. With the Graphics Tablet installed and with power applied to the tablet and the terminal, enable the Graphics Tablet for Single Point/Pen mode with a three-character Control Command sequence from the terminal keyboard (ESC ! 1 for 12 bits; ESC ! A for 10 bits). The READY indicator should light.

3. Place the terminal's LOCAL/LINE switch in the LINE position.

4. Bring the pen into presence at the lower left corner of the tablet, (about 1-1/2 inches in from the bottom and left tablet margins), and press the pen once. The DATA and PEN indicators should blink, and the READY indicator should be extinguished.

5. Without removing the pen from tablet presence, move the pen to a point half way up the tablet surface and 1-1/2 inches in from the right margin. Transmit another Control Command sequence from the terminal keyboard. Use ESC ! 1 for 12 bits, or ESC ! A for 10 bits. The READY indicator should light.

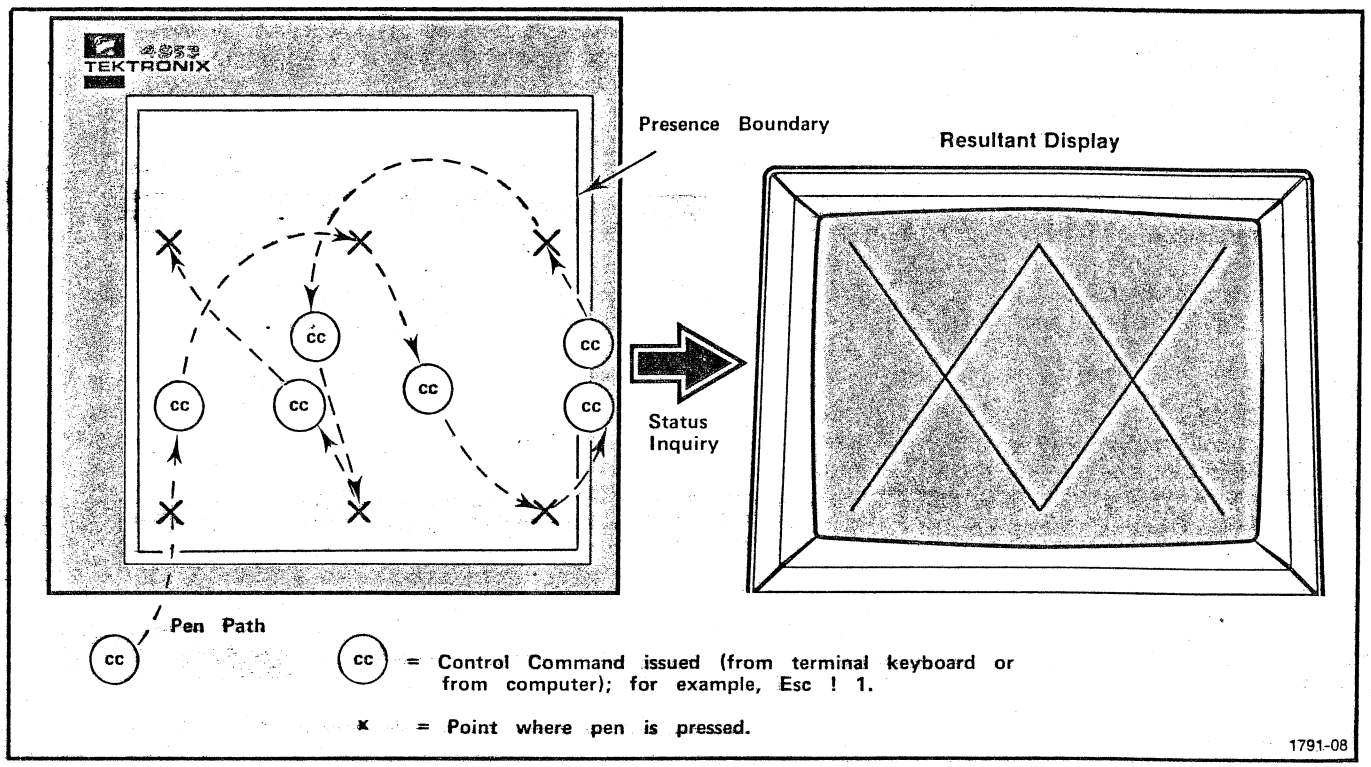


Fig. 2-4. Operation sequence in Single Point/Pen mode. Note that vectors are drawn between points where the pen is pressed if the pen does not leave presence. If the pen leaves presence, two Control Commands are required to re-enable; the first causes Status transmission and the second enables the tablet.

6. Press the pen. The DATA and PEN indicators should blink once, and the READY indicator should be extinguished. On the terminal screen, a vector should be displayed between the lower left and upper right corners of the screen.

7. Lift the pen from presence, and while it is lifted send the Control Command (same as previously used) from the terminal keyboard. Note that when the Command Character (third character) is sent, the DATA indicator blinks once. This occurs when the ENQ signal occurs, causing the terminal to transmit status. Repeat the sequence and note that the READY indicator illuminates.

8. Bring the pen into presence about 1-1/2 inches in from the lower right corner, and press the pen once. The DATA and PEN indicators should blink once, and the READY indicator should be extinguished; no display should occur on the screen. Leave the pen in presence.

9. Enable the Single Point/Pen mode with another Control Command (ESC ! 1 for 12 bits; ESC ! A for 10 bits) from the terminal keyboard. The READY indicator should illuminate.

10. Without leaving presence, move the pen to a point about 1-1/2 inches from the left-hand tablet border, about 3/4 of the distance to the top edge of the tablet. Press the pen once; the DATA and PEN indicators should blink once, and the READY indicator should be extinguished. A vector should appear on the screen, from the lower right corner of the screen to the upper left corner.

Single Point/Presence. Single Point/Presence mode is enabled by a Control Command which has bit 2 = 0 and bit 3 = 1 in the Command Character; for Example, ESC ! 5 (12 bits) or ESC ! % (10 bits). In this mode, one single coordinate point is compiled and sent for each time the tablet is enabled; however, *when* that point is compiled and sent is dependent on the COMSUP Strappable Option.

When COMSUP is strapped IN (factory-set position), single presence sends no data to the computer until the pen is pressed while in presence. Note, however, that when the tablet is enabled for Single Point/Presence with Local Display on, the terminal's alpha cursor tracks the pen as long as it is in presence and not pressed. When the pen is pressed, a single coordinate point is sent, preceded by a GS Header and the tablet is disabled. A second point may be sent in several ways, depending on user requirements.

If the pen is held depressed while the Graphics Tablet is re-enabled, then another coordinate is sent, preceded by a SUB Header Character, and a vector is drawn between the first and second point. The point which is transmitted is

the pen position at the time the Control Command is received.

If, on the other hand, pen pressure is released between points while the tablet is re-enabled with another Control Command, then the next point is transmitted. In this case, the second point is preceded by a US Header, indicating the release of the pen. If the Tablet is again rearmed, the terminal Alpha Curser will track as before. Using this procedure, therefore, alternates GS and US Header Characters; no vectors are drawn even if Local Display is selected. Note, however, that if the computer program is set to re-enable the tablet as soon as the point is transmitted, then more than one point may be transmitted for each pen depression, as above. The intermediate points will be preceded by SUB Header Characters. A typical operating sequence is illustrated in Fig. 2-5.

If the COMSUP option is strapped OUT, operation differs in the following ways. When the tablet is enabled, the first point is transmitted as soon as the pen enters presence, preceded by the SUB Header. The transmitted coordinate is that of the pen's position when it entered presence. If Local Display is selected, the terminal's alpha cursor will move to the display position relative to that of the pen. If the pen remains in presence while the tablet is enabled again, another point will be transmitted as soon as the Control Command Sequence is completed. This point will be the coordinates of the pen's position when the Control Command sequence is completed, and will also be preceded by a SUB Header Character; the cursor will move to the new pen location. No vectors are drawn in this mode, if COMSUP is strapped OUT, but coordinate points are sent to the computer.

Regardless of the condition of COMSUP, if the STATUS strap is IN, leaving presence causes the terminal to send status, as if it had received an ESC ENQ sequence from the computer; the way in which it is sent differs somewhat. If COMSUP is strapped IN, this occurs in the following ways: If the Graphics Tablet is enabled with the pen in presence but the pen has not been pressed, status is transmitted as soon as the pen leaves presence. If the pen has been pressed, transmitting a point, and the pen then leaves presence, status is sent when the next Control Command is received. If COMSUP is OUT, the pen must be removed from presence and the tablet then enabled; status will then be sent.

First-Time Operation; Single Point/Presence Mode. This procedure may be used to familiarize the operator with the characteristics of this mode when operating the Graphics Tablet for the first time.

1. Strappable Options should be in their factory-wired positions: COMSUP in, DELAY in, ESUP out, CR out, and

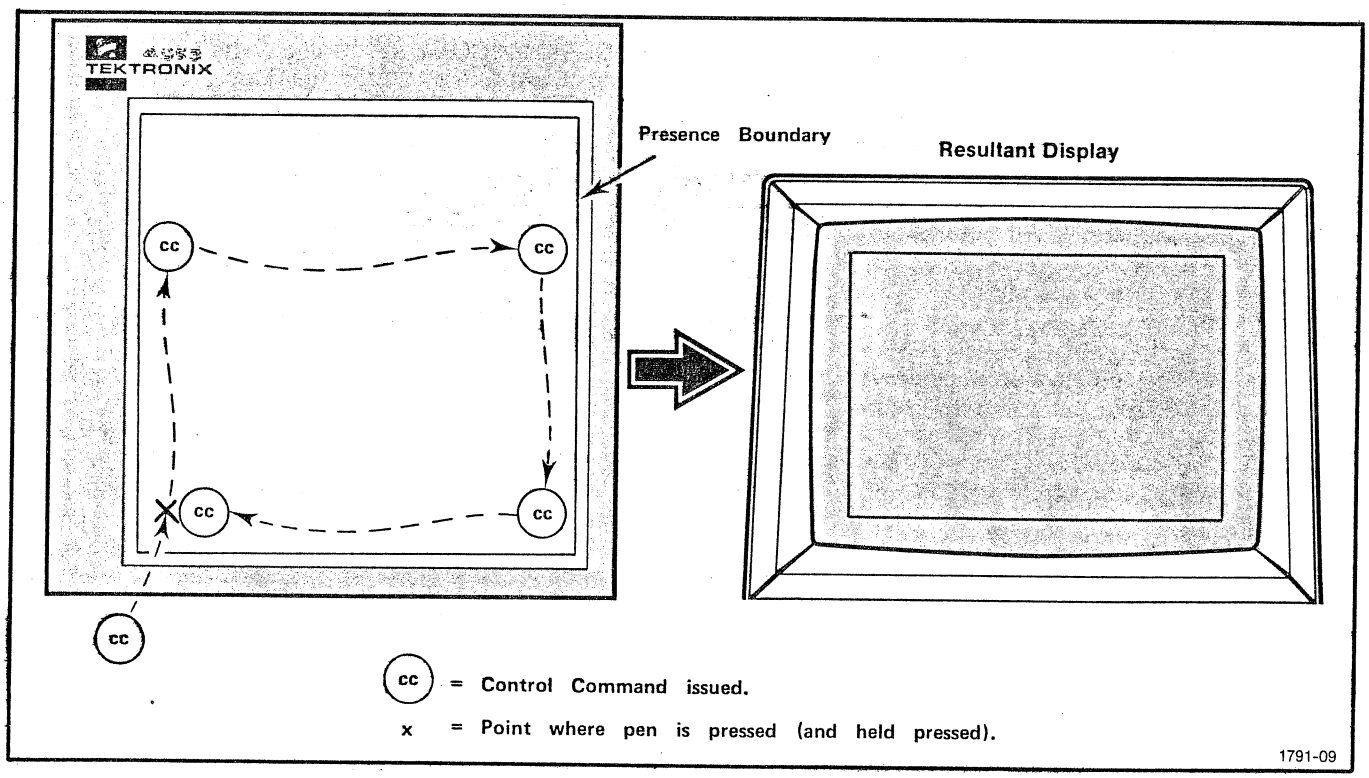


Fig. 2-5. Operation sequence in Single Point/Presence mode. Note that vectors are drawn between Control Commands if the pen is held depressed.

HEADER in the CONTROL position. The Tablet Size strap should be set to SMALL for the 4953, or LARGE for the 4954.

2. With the Graphics Tablet installed and with power applied to the tablet and the terminal, enable Single Point/Presence mode with a three-character Control Command sequence from the terminal keyboard (ESC ! 5 for 12 bits; ESC ! E for 10 bits). The READY indicator should light.

3. Place the terminal's LOCAL/LINE switch in the LINE position.

4. Bring the pen into presence at the lower left corner of the tablet (about 1-1/2 inches in from the bottom and left tablet margins). Press the pen and hold it depressed. The DATA indicator should blink once, the READY indicator should be extinguished, and the PEN indicator should remain lit.

5. Holding the pen depressed, move it to a point about 1-1/2 inches from the right tablet margin, and about 3/4 of the distance to the top margin of the tablet.

6. While still pressing the pen, send the Control Command sequence from the terminal keyboard (ESC ! 5 for 12 bits; ESC ! E for 10 bits). The DATA and READY indicators should blink once, and a vector should be drawn on the terminal screen between the first and second relative points.

7. Lift the pen from presence, and send the same Control Command used previously from the terminal keyboard. The DATA and READY indicators should blink once. Send the sequence again and the READY indicator should illuminate.

8. Repeat steps 4 though 6 between two other random points; a vector should again be drawn between the two points.

Multiple Point/Pen. Multiple Point/Pen mode is enabled by a Control Command which has bit 2 = 1 and bit 3 = 0 in the Command Character; for example ESC ! 3 (12 bits) or ESC ! C (10 bits). This mode is used for drawing straight vectors from one point to another, with a single enabling of the Graphics Tablet. Once the Graphics Tablet is enabled, if the pen is pressed while in presence a single coordinate is sent, preceded by the GS Header Character. If pen pressure is released (but the pen does not leave presence), then the pen moved to another location and pressed again, a second point is sent, preceded by a SUB Header Character. A vector is drawn between these points, if Local Display is selected. Note that after the initial point, each subsequent point is preceded by a SUB Header Character as long as the pen remains in presence between points. If the STATUS strap is IN, and the pen is removed from presence, status is transmitted from the terminal, and the next transmitted point is preceded by a GS Header Character. Thus, if a sequence of points is sent, the pen lifted out of presence, then placed back in presence and pressed again, no vector will be drawn between the last two points; vectors will be drawn between subsequent points, however, as long as the pen remains in presence between points. A typical operation sequence is illustrated in Fig. 2-6.

NOTE

If the terminal screen is erased while the pen is in presence (by pressing the PAGE key) the Graphic Plot mode is disabled. No further vectors will be drawn until the pen is removed from presence and brought back into presence again. This will enable another GS Header Character, and vectors will once again be drawn.

First-Time Operation; Multiple Point/Pen Mode. This procedure may be used to familiarize the operator with the characteristics of Multiple Point/Pen Mode when operating the Graphics Tablet for the first time.

1. Strappable Options should be in their factory-wired positions: COMSUP in, DELAY in, ESUP out, CR out, and HEADER in the CONTROL position. The Tablet Size strap should be set to SMALL for the 4953, or LARGE for the 4954.

2. With the Graphics Tablet installed and with power applied to the tablet and the terminal, enable the Graphics Tablet for Single Point/Pen mode with a three-character Control Command sequence from the terminal keyboard (ESC ! 3 for 12 bits; ESC ! C for 10 bits). The READY indicator should light.

3. Place the terminal's LOCAL/LINE switch in the LINE position.

4. Bring the pen into presence and press it once. The PEN and DATA indicators should blink once; the READY indicator should remain lit.

5. Without lifting the pen from presence, move it to another position and press it once again. The indicators should blink again, and a vector should appear between the first and second relative pen points on the terminal screen.

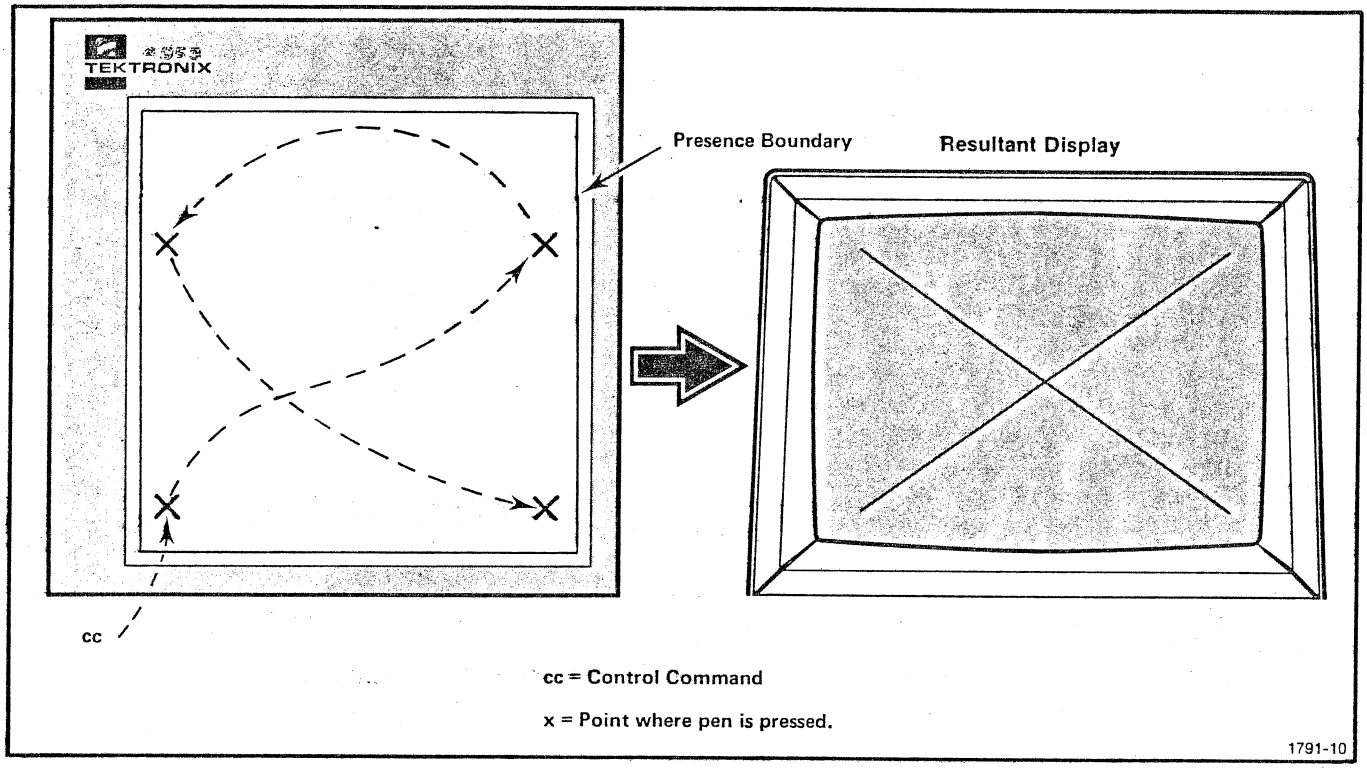


Fig. 2-6. Operation sequence in Multiple Point/Pen mode. Note that vectors are drawn between pen depression points as long as the pen remains in presence between points.

6. Lift the pen from presence. The READY indicator should blink off momentarily as the terminal transmits status.

7. Bring the pen back into presence and press it again. No vector should be drawn between this point and the last; the indicators should blink once.

8. Move the pen without leaving presence and press it again; a vector should be drawn between this point and the last.

Multiple Point/Presence. Multiple Point/Presence mode is enabled by a Control Command which has bits 2 and 3 = 1 in the Command Character; for example, ESC ! 7 (12 bits) or ESC ! G (10 bits). Multiple Point/Presence mode permits a continuous sequence of points to be input to the terminal and/or computer, permitting graphic representation of the pen's path. This mode may be used for inputting complicated lines, curves, etc.

When the Graphics Tablet is enabled for Multiple Point/Presence mode with Local Display selected, and the pen is brought into presence, the alpha cursor moves to the terminal screen position relative to the pen's position on the tablet. As long as the pen is kept in presence and not pressed, the terminal's alpha cursor follows the pen. If COMSUP is strapped IN, this cursor positioning data (pen coordinates) is not sent to the computer; if COMSUP is strapped OUT, pen coordinates are continuously sent to the computer, preceded by SUB Header Characters.

Once the pen is pressed, closing the pen switch, all further coordinates *are* sent to the computer, as long as the pen remains pressed. The first coordinate is preceded by a GS Header Character; subsequent points are preceded by a SUB Header Character and vectors are drawn between coordinates when Local Display is selected. Thus, as long as the pen is held depressed in the presence area of the tablet, coordinates are continuously compiled and sent out to the computer. The time between coordinates, and therefore the pen locations that the Graphics Tablet will transmit to the computer and/or terminal, is dependent upon DELAY time and the terminal's data transmission rate when the terminal is On Line. (For further information about DELAY time, refer to the description in Strappable Options.)

When pen pressure is released (but the pen kept in presence), the Graphics Tablet sends the coordinates of the last point preceded by a US Header Character. If Local Display is selected, the terminal's alpha cursor appears at the screen position relative to the last point of the pen, and follows the pen as long as it remains in presence. No vectors are drawn even though coordinates continue to be compiled for alpha cursor positioning. This cursor positioning data is not transmitted to the computer. If the pen is pressed again, another GS is transmitted and the above process is repeated.

When the pen leaves presence, the tablet causes the terminal to send its current status information, just as if the tablet has received an ESC ENQ sequence from the computer. This occurs only if the terminal is On Line. A typical operation sequence is illustrated in Fig. 2-7.

First-Time Operation; Multiple Point/Presence Mode. This procedure may be used to familiarize the operator with the characteristics of Multiple Point/Presence Mode when operating the Graphics Tablet for the first time.

1. Strappable Options should be in their factory-wired positions: COMSUP in, DELAY in, ESUP out, CR out, and HEADER in the CONTROL position. The Tablet Size strap should be set to SMALL for the 4953, or LARGE for the 4954.

2. With the Graphics Tablet installed and with power applied to the tablet and the terminal, enable the Graphics Tablet for Multiple Point/Presence Mode with a three-character Control Command sequence from the terminal keyboard (ESC ! 7 for 12 bits; ESC ! G for 10 bits). The READY indicator should light.

3. Place the terminal's LOCAL/LINE switch in the LINE position.

4. Bring the pen into the presence area of the tablet. Press the pen; hold it pressed and move it around on the tablet surface. The PEN indicator should remain lit as long as the pen remains pressed, the DATA and READY indicators should blink repeatedly, and the pen's path should be displayed on the terminal screen.

5. Lift the pen from presence. The READY indicator should blink off momentarily as the terminal transmits status.

GRAPHIC DATA INPUT

Any X and Y address between 0 and 1023 (1024 points) can be entered to the computer and/or the Terminal buffers. Data input to the 4010-series buffers causes writing beam deflection to the point. However, Y ad-

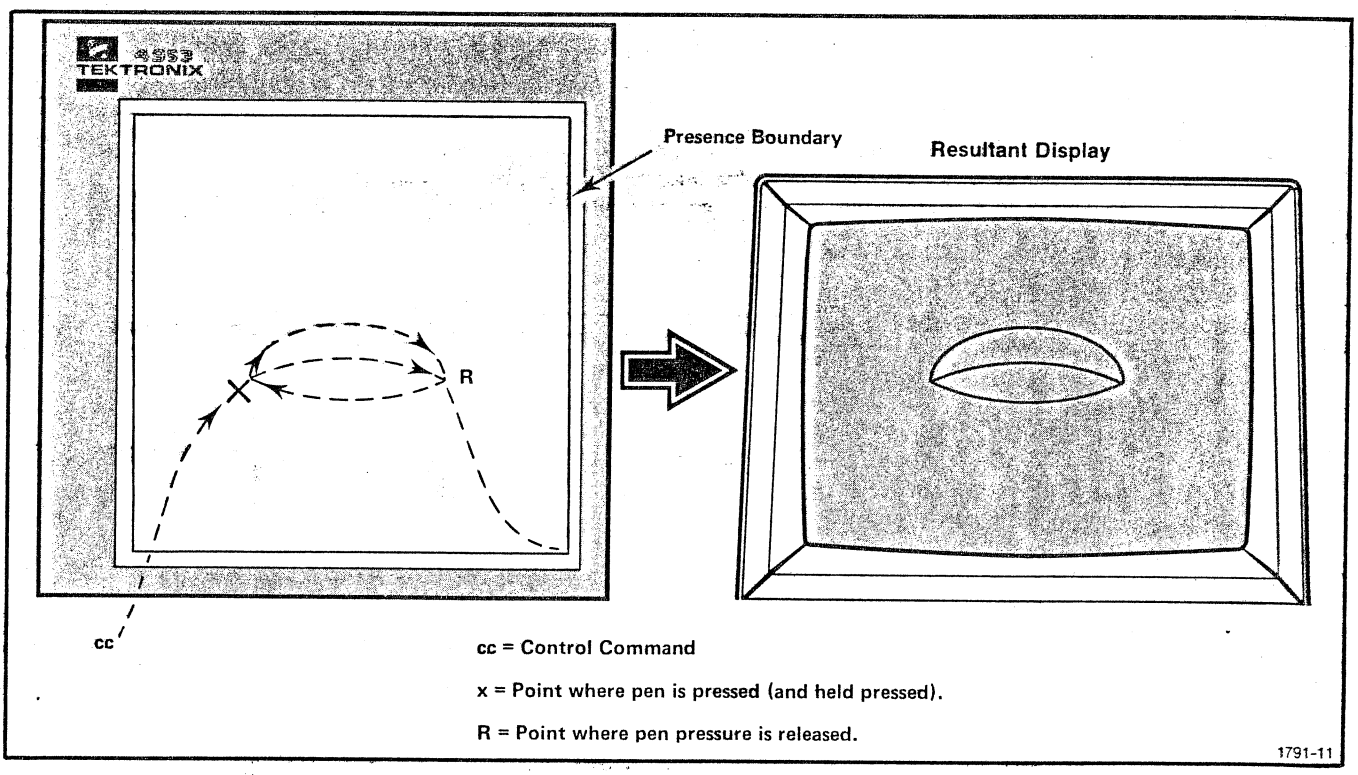


Fig. 2-7. Operation sequence in Multiple Point/Presence mode. Note that the pen's path is drawn on the screen as long as the pen is held depressed.

dresses greater than 780 will fall outside the viewing area of the display. Principal address locations are as follows:

Bottom screen area	Y = 0
Top of main screen area	Y = 780
Left of screen	X = 0
Right of screen	X = 1023

It takes 20 bits of binary data to establish a single coordinate address...10 bits for the Y coordinate number and 10 bits for the X coordinate number. However, the terminal doesn't handle 10 bit numbers; therefore, each number is divided into two 5-bit bytes, 5 bits representing the 5 most significant bits and 5 bits representing the 5 least significant bits.

Thus, a point coordinate is transmitted in four 5-bit bytes for 10-bit operation. For each coordinate byte, bits 1-5 contain coordinate information (BIT 6 = 1, BIT 7 = 0). In 12-bit operation, data is sent in five 5-bit bytes, thus allowing up to 4096 points.

The Tablet Control card controls the functioning of the tablet circuitry, determines the current X and Y coordinates, and assembles this information in a suitable format before putting it on the Terminal minibus.

Data is transferred as a Header Character followed by four to six data characters as follows:

HIY: This contains the five most significant bits of the Y coordinate. As in the following characters, the data is contained in bits 5 through 1 of the character.

XLOY: If the "12 Bit" (bit 5 in the Command Character) is a zero, the XLOY byte will not be sent. When the "12 Bit" is a one, bit 5 of XLOY is the margin bit and always equals 0; bits 4 and 3 are the least significant bits for the Y coordinate, and bits 2 and 1 are the least significant bits for X. Bits 1 and 3 are then the least significant bits in a data format, 12 bits per coordinate value. For a small Tablet, these bits contain meaningless data.

LOY: The five least significant bits of the Y coordinate, except in 12-bit format where LOY contains bits 3 through 7 and XLOY contains Y bits 1 and 2.

HIX: The five most significant bits of the X coordinate.

LOX: The five least significant bits of the X coordinate, except in 12-bit format where LOX contains bits 3 through 7 and XLOY contains X bits 1 and 2.

CR: Optional CR carriage return character (see Strappable Options).

Section 3

SUPPLEMENTAL INFORMATION

AC POWER REQUIREMENTS

CAUTION

The Graphics Tablet is intended to be operated from a single-phase power source that has one of its current-carrying conductors (neutral) at ground (earth) potential. Operation from other power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a multi-phase system, or across the legs of a 115/230 volt single-phase three-wire system) is not recommended, since only the line conductor has over-current (fuse) protection within the instrument.

The Graphics Tablet is designed to operate from either a 115- or 230-volt nominal line voltage source that has a frequency of 50 to 400 Hz. In addition, either of two voltage ranges for 115 V ac or 230 V ac may be selected. Voltage, current and power requirements are listed in Table 3-1.

TABLE 3-1

4953/4954 Operating Voltages

Nominal Voltage	Tolerance	Voltage Range	Frequency	Line Fuse Value
104 V ac	±10%	94 to 114 V ac	48-440 Hz	0.3 A slow-blow
115 V ac		104 to 126 V ac		
208 V ac		187 to 228 V ac		0.2 A slow-blow
230 V ac		207 to 253 V ac		

A fuse change and a transformer jumper arrangement permit the Graphics Tablet to be modified to suit the voltage supply. The back panel identifies the internal voltage setting for which the unit is wired when shipped from the factory. If the jumper arrangement is changed for any reason (changing the internal voltage setting) attach a tag with the new voltage setting to the back panel, covering the old setting.

AC Power Cord and Grounding Requirements

This instrument has a three-wire power cord with a three-wire terminal polarized plug for connection to the power source and safety earth. See Fig. 3-1 for USA standard plugs. The Safety Earth terminal of the plug is directly connected to the instrument frame for electric-shock protection. Insert this plug only in a mating outlet with a safety earth contact, or otherwise connect the frame of the unit to a safety earth system. The color coding of the cord conductors is in accordance with recognized standards as shown below. In other jurisdictions, replace the USA standard plug with a plug that satisfies local authorities.

POWER CORD COLOR CODING

NOTE

The power cord on Tektronix instruments may conform to either of the following two electrical codes:

Conductor	*USA (NEC) & Canada*	*IEC*
Line	*Black*	*Brown*
Neutral	*White*	*Light Blue**
Safety-Earth	*Green w/yellow stripe*	*Green w/yellow stripe*

**Tinned copper conductor.*

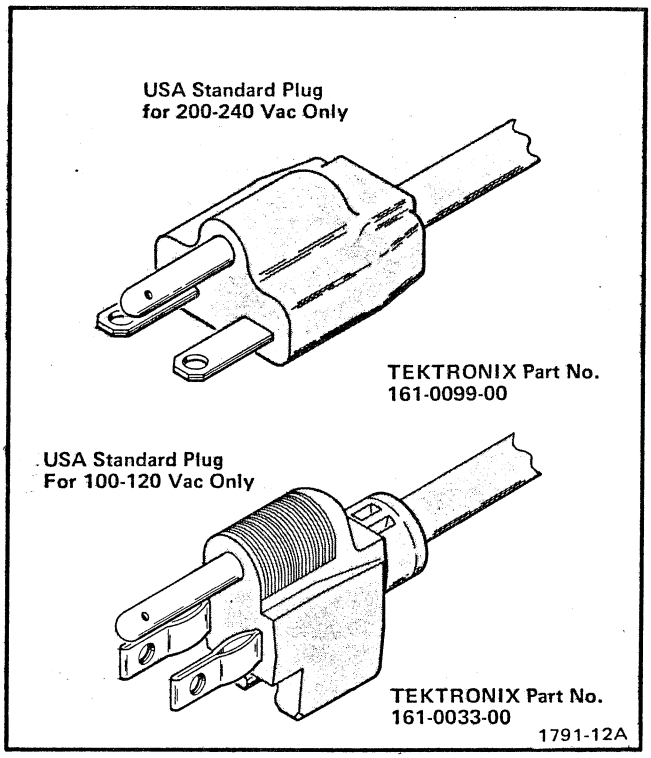


Fig. 3-1. USA standard power cord plugs.

LINE VOLTAGE SELECTION

To change the line voltage selection, the unit should be disconnected from the power source. Access must first be gained to the transformer jumper arrangement on the Power Supply circuit board, within the Power Module. This consists of removing 4 screws on the bottom of the unit and removing the bottom cover. The two screws that attach the top cover may then be removed, and the top cover removed. The location of the jumper connections is shown in Fig. 3-2. Wiring instructions are shown in Fig. 3-3. Note that in Fig. 3-3 the dotted lines indicate connections between transformer wires and the jumper holes on the circuit board.

WARNING

Dangerous voltages exist at several places inside the unit. Disconnect the Power Module from the power source before changing transformer connections. Power may still be applied to the transformer and several other points unless the power cord is disconnected.

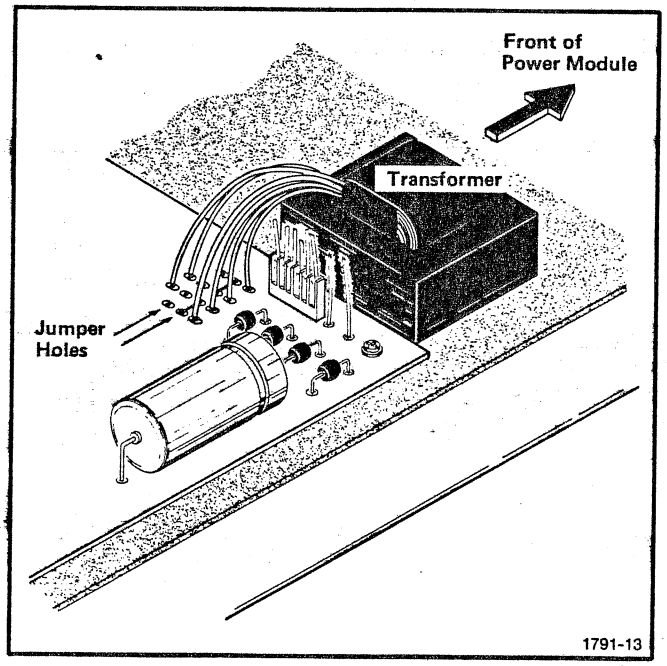


Fig. 3-2. Line voltage jumper hole locations.

FUSES

There is one fuse, located at the lower corner of the back panel. The line voltage fuse is a 0.3 A slow-blow fuse for operation in the 115 V ac range; it must be changed to a 0.2 A slow-blow fuse for operation in the 230 V ac range.

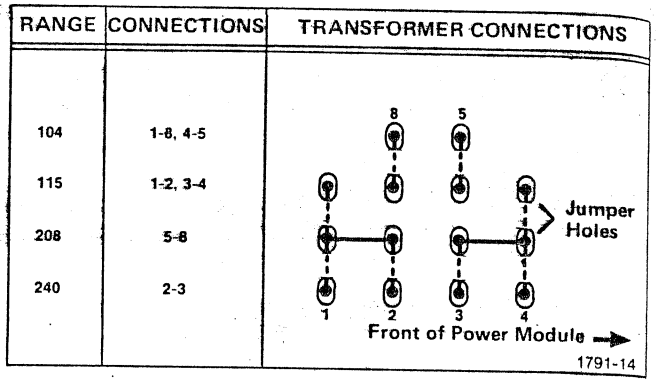


Fig. 3-3. Line voltage selection wiring. (Shown strapped for 115 V ac.) Broken (dashed) lines indicate permanent connections between transformer wires and jumper holes.

STRAPPABLE OPTIONS

There are several strappable options on the 4953/4954 Tablet Control card, which allow certain tablet features to be configured to user requirements. The function of these strappable features is as described in the following section; the location of these straps is shown in Fig. 3-4.

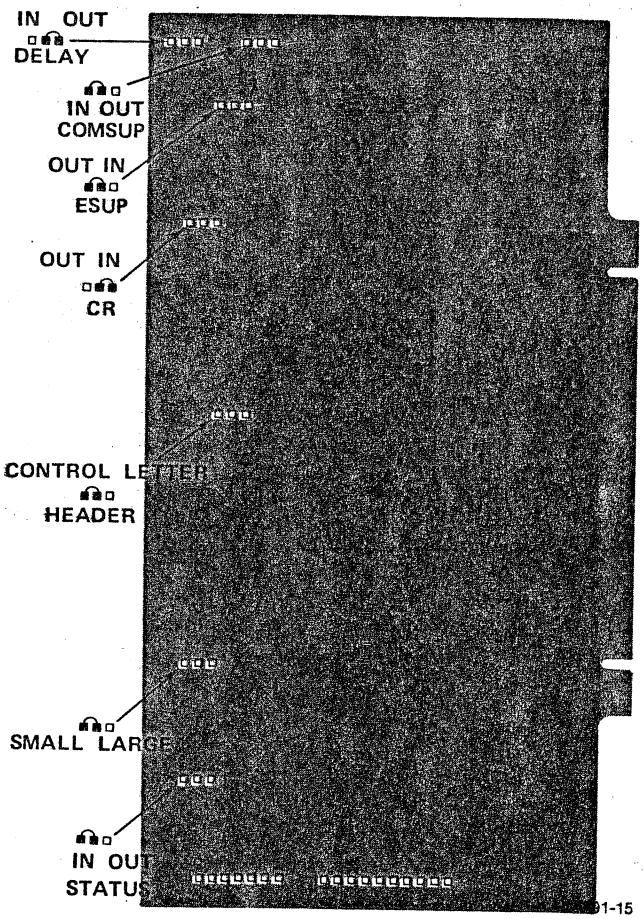


Fig. 3-4. Tablet Control Card strap locations.

CR

In some systems, CR is interpreted as the end of the data transfer. When connected to the IN position, the tablet generates and transmits the CR (Carriage Return) after each generated coordinate point.

HEADER

This strap is to accommodate some computer systems which do not accept CONTROL characters. Each data string originated and transmitted by the tablet is preceded by a Header character, which determines how the computer is to use the data that follows. This strap is normally connected in the CONTROL position to allow proper local display (when selected). If Local Display is selected (see Control Commands) with the strap in the LETTER position, M and O characters will be written on the terminal screen; Letter Headers are therefore not recommended with Local Display. The HEADER strap allows changing the Header characters as follows:

CONTROL	LETTER
SUB	J
GS	M
US	O
:	*

LARGE/SMALL

The position of this strap causes the necessary changes to operate the LARGE size (4954) tablet or the SMALL size (4953) tablet. The 4953 is a 10-bit system; in order for this to fill the terminal screen in Local Echo, the strap is placed in the SMALL position. This shifts the 10 bits of data to the most significant 10 bits of the 12 allowed for each coordinate. (12 bits of data may still be sent, but the 2 least significant bits of both bytes are meaningless.

DELAY

This strap selects whether or not a delay will occur between each coordinate sent, by selecting the delay IN or OUT. With delay IN, there is an adjustable 15- to 60-ms delay after each coordinate sent. With delay OUT, the delay is about 6-ms.

CAUTION

If delay is selected OUT or if delay time is adjusted too short, crt damage can occur in Multiple Point Presence mode, with 4010, 4012, and 4013 terminals.

ESUP (Echo Suppression)

In some systems, the computer echoes the data sent by the Tablet. When that data is not to be displayed, the ESUP strap is placed in the IN position; the terminal will then respond to data from the tablet only if Local Display is in effect. It is recommended that the Tablet be cleared, using a Control Command sequence, prior to addressing other peripherals if ESUP is strapped in.

Certain echoed control characters do get through to the terminal. These are SOH, ETX, DC1, DC3, HT, EM, VT, and ESC.

COMSUP (Computer Suppression)

The COMSUP option affects data transfer in Multiple Presence and Single Presence modes. With the COMSUP option IN, data is only transmitted to the computer when the pen is down and the Tablet is enabled or when the pen is leaving presence (with the STATUS strap IN), as described in the Operation Section. When the COMSUP option is strapped OUT, data is transferred to the computer whenever the Tablet is enabled and the pen is in presence. The strap is normally set in the IN position. (See Multiple Presence in the Operation Section for details on Header Characters.)

NOTE

On Tablet Control Cards prior to the J1-4052 version, the strap option consists of a jumper from pin 2 of U285. When the strap is in, the jumper connects to U175 pin 13; when the strap is out, the jumper connects to U285 pin 1 (Fig. 3-5).

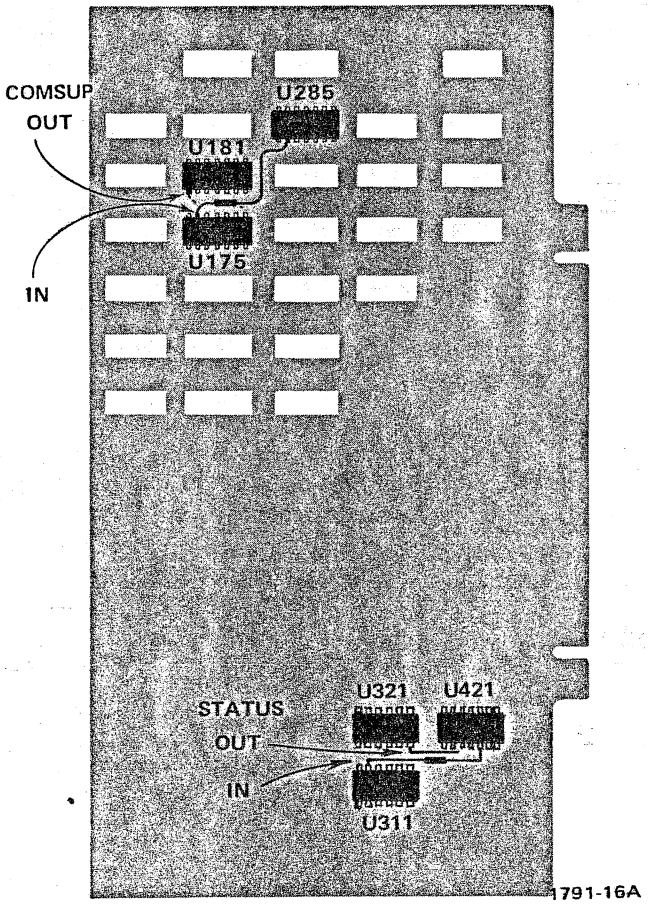


Fig. 3-5. Early version strap locations.

STATUS

The Graphics Tablet has several modes where it will cause the terminal to transmit status, normally when the pen leaves presence. This is described in the preceding Operating Modes descriptions, where it is assumed that the strap is in the IN position. With this strap in the IN position, the Graphics Tablet is operated in this manner, sending status as described.

The alternate OUT position disables the Send Status operation. All other operations remain the same when the strap is in the OUT position; the Send Status step is merely bypassed. What this means is that the operations enabling sequences remain the same, but the terminal will not send its status bytes to the computer.

For example, suppose that the Graphics Tablet is enabled for Single Point/Pen mode with the pen in presence, and the Status strap in the IN position. When the pen leaves presence, the tablet causes the terminal to transmit status to the computer (when operating On-Line). It is then necessary to re-enable the Graphics Tablet to send another point. With the Status strap in the OUT position and operating as above, leaving presence does not cause the terminal to transmit status. The Graphics Tablet behaves however as if it had sent a coordinate; it is still necessary to rearm the tablet to send another point.

BIASING THE TABLET

The Graphics Tablet contains grids of magnetically biased wires under the tablet surface. The biasing is done at the factory, but it can be disrupted if a magnet or magnetized article is placed on the Tablet. This will result in digitizing errors (Fig. 3-6). To correct this problem, the Tablet must be rebiased.

Rebiasing should be done as follows:

1. Place the magnet on the upper left corner of the Tablet surface, as shown in Fig. 3-7. Be sure the arrows on the magnet label are pointing as shown.
2. Place one hand on the center of the magnet assembly. Apply pressure to the center of the magnet assembly, and slowly draw the magnet across the Tablet surface diagonally from the upper left to the lower right. This should be done in one continuous, sweeping motion taking two or three seconds. Do this two times, being sure to lift the magnet clear off the Tablet surface when again placing it in the upper left-hand corner of the surface.
3. Store the magnet away from the Tablet area.

STYLUS REFILL REPLACEMENT

The pen stylus has been designed to allow the user to replace the ball point refill. This can be done when the ink is exhausted or when it is desired to replace the color.

To replace the refill:

1. Unscrew the front section of the stylus.
2. Grasp the internal front section, and carefully pull it straight off.

CAUTION

If the internal front section comes off with the outer cover, remove the inner section before attempting to reassemble the stylus, or you may damage the miniature connector.

3. Pull out the refill, and replace it with a new one.
4. Replace the front inner section, and mate the connectors.
5. Replace the outer cover.

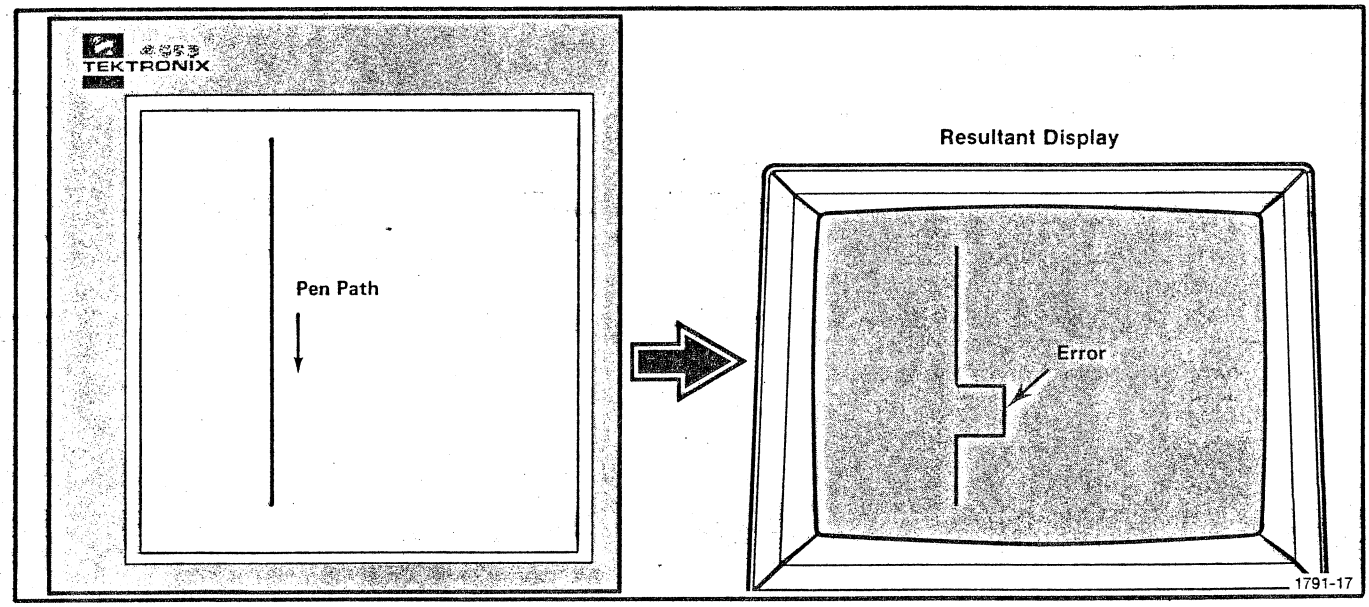


Fig. 3-6. Error caused by uneven tablet bias.

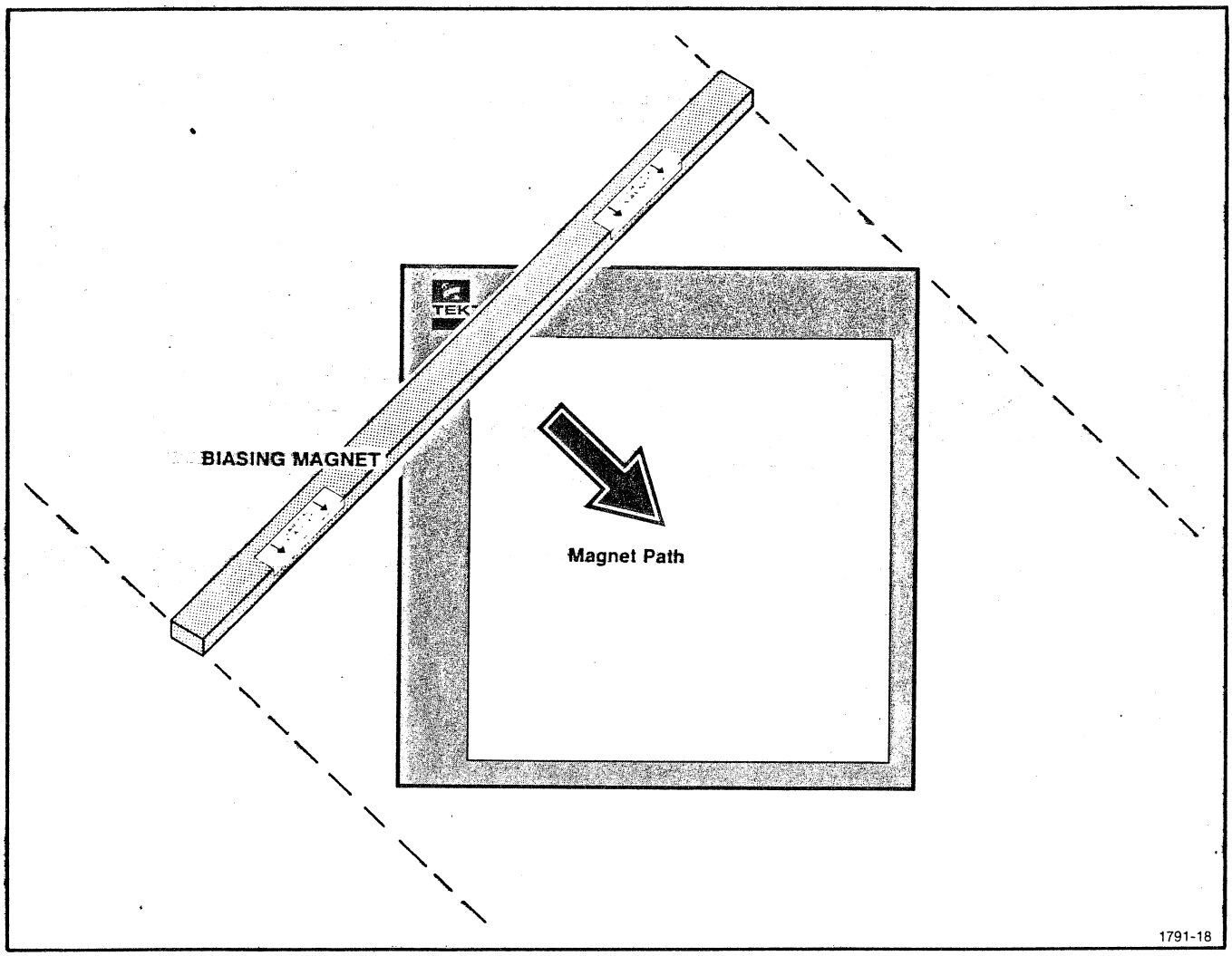


Fig. 3-7. Biasing the tablet.

Section 4
SERVICING

INTRODUCTION

Servicing the Graphics Tablet is necessary only when it ceases to operate properly; routine maintenance is not required. The procedures required for changing the line voltage selection, biasing the tablet's magnetic surface, and selecting strappable options are located in Section 3. This section contains a Performance Check to determine whether the Tablet is operating properly. In addition, information on the interconnecting signals and a general overview of the Graphics Tablet system is located here.

EQUIPMENT REQUIRED

The following equipment is required for the Performance Checks to the Graphics Tablet.

1. Test Oscillscope. Bandwidth: dc to at least 30 megahertz. Minimum deflection factor: 5 millivolts per division. For example, a TEKTRONIX Model 465 Oscilloscope.

2. Precision DC Voltmeter. Accuracy: within ±0.5%. For example, a TEKTRONIX TM 500 series mainframe with the DM 501 Digital Multimeter.

3. Ohmmeter.

PERFORMANCE CHECKS

Performance Checks are to be made with the Graphics Tablet connected to the 4010-series terminal. For the majority of the checks, this is the only equipment required; a few of the checks require an oscilloscope or a voltmeter.

For the purpose of this procedure, placing the terminal ON LINE refers to placing the LOCAL/LINE switch to the LINE position, with an interface installed in the bus. It is not necessary to be connected to a computer for this check.

Prior to these performance checks the tablet surface should be biased, by following the instructions in Biasing the Tablet, Section 3.

Whenever it is necessary to change a strap position on the Tablet Control card, the terminal power should be switched off prior to strap positioning unless the strap can be reached without removing the card. The strappable options are to be set as follows except where specified otherwise.

CAUTION

Do not remove or replace circuit cards with power applied to the terminal.

Performance Check Strap Positions

CR—IN

HEADER—CONTROL

LARGE/SMALL—Set to appropriate tablet size

TRANSMIT DELAY—IN

ESUP—OUT

COMSUP—OUT

WARNING

When the Power Module is operated with the cover removed, dangerous voltages are present. Be careful to contact only the instructed points.

Miscellaneous Circuit Verifications

1. Check the relay voltage for −9 to −12 V, measuring from ground to R317, on the side of R317 (100 Ω) closest to the relay.

2. Check the 5 V supply across U291 pins 7 (ground and 14 (+5) for +5 V ±.05 V. If not correct, adjust R89 on the Control board (within the Power Module) for the voltage specified.

3. Check the voltage across U415 pins 7 (ground) and 14 (+5 V) on the Control for an increase of less than 0.2 V from the 5 V across U291 (step 2).

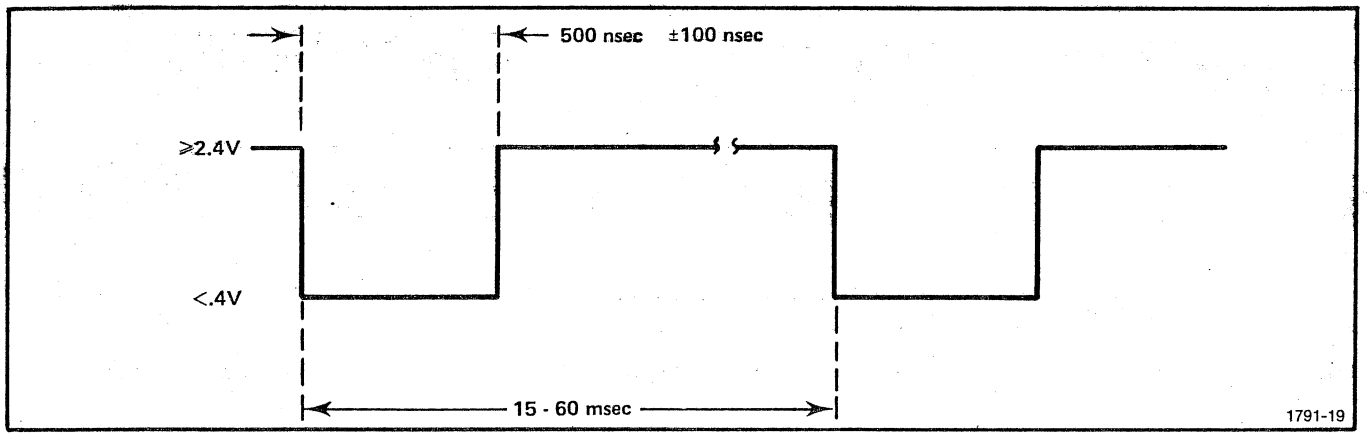


Fig. 4-1. Delay pulse timing.

4. Place an oscilloscope probe on U301 pin 1. Check for a positive pulse of 2 to 4 ms (3.2 nominally).

5. Arm the Tablet with ESC ! 6, then place the terminal ON LINE and place the pen in presence. Connect an oscilloscope probe to U281 pin 8. Positive trigger the oscilloscope on U165 pin 1. The positive pulse that occurs on U281 pin 8 must occur 175 to 300 ns (200 ns nominal) after the oscilloscope triggers. This pulse is affected by C394, R392, CR391, and U281C (see Fig. 4-2).

6. Place the terminal back in LOCAL mode.

7. Check the $\overline{\text{PEN}}$ signal at J231-3 for low signals of ≥0.4 V and high signals of ≥2.4 V. The PEN light should light when the pen is depressed.

Delay Verification

1. Place the terminal in Local. With the pen out of presence, arm the Tablet with ESC ! f. The READY indicator will light, and the DATA indicator will blink once.

2. Come into presence, but do not press the pen. READY will be dim, as it will be blinking rapidly. The frequency of the blinking will be dependent upon the setting of the Delay potentiometer. The DATA indicator will light.

3. Connect an oscilloscope probe to TP235 and check the range of R92, the Delay potentiometer. The range should be 15 to 60 ms, and may occur in steps.

4. Adjust R92 for a delay of approximately 30 ms between negative pulses and check for the pulses shown in Fig. 4-1.

5. Move the DELAY strap to the OUT position. Arm with ESC ! f. The repetition rate of the negative pulses should be one about every 6 ms.

CAUTION

With delay strapped OUT, crt damage can occur on 4010, 4012, and 4013 terminals, if the pen is held in the same spot for too long, with Local Display selected. (Local display should not occur during this check.)

6. Place the DELAY strap back to the IN position.

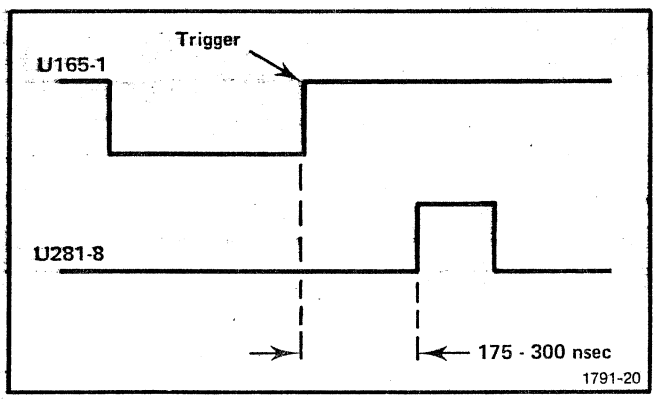


Fig. 4-2.

Bit 1 Verification

1. Page the terminal. With the pen out of presence, arm the tablet with ESC ! Ø. The READY indicator should light, and the DATA indicator should blink once.

2. Place the terminal ON LINE. Bring the pen into presence, then leave presence; the Tablet should then be disabled.

3. Return the terminal to LOCAL operation, and rearm Tablet with ESC ! Ø.

4. Bring the pen into presence; nothing should happen. Press the pen and the Tablet should be disabled. Leave the pen in presence with no pressure applied.

5. Rearm the Tablet with ESC ! Ø. Press the pen again and the tablet should be disabled. Leave the pen in presence with no pressure applied.

6. Rearm the tablet with ESC ! Ø, and place the terminal ON LINE. Leave presence and the Tablet should be disabled. The cursor should still be in the home position.

7. Return the terminal to LOCAL, and arm the Tablet with ESC ! A. Come into presence and press the pen. Type Control Shift 0; the alpha cursor should reappear on the terminal screen relative to the position where the pen was pressed.

Bit 2 Verification

1. Arm the Tablet with ESC ! K.

2. Place the terminal ON LINE, then bring the pen into presence and press the pen several times without leaving presence. The READY and DATA indicators should blink each time the pen is pressed. The PEN indicator should light each time the pen is pressed, and remain lit until pen pressure is released.

3. Leave presence and the Tablet should be disabled.

Bit 3 Verification

1. Return the terminal to LOCAL mode, then arm the Tablet with ESC ! J. The READY indicator should light.

2. Bring the pen into presence and press the pen switch. The READY and DATA indicators should blink once; the PEN indicator should remain illuminated as long as the pen is pressed.

3. Release pen pressure but do not leave presence. The READY indicator should remain illuminated; the others should be extinguished. Place the terminal ON LINE.

4. Remove the pen from tablet presence and the Tablet should be disabled (the READY indicator should be extinguished). Place the terminal in LOCAL.

5. Rearm the Table with ESC ! N. The READY indicator should be illuminated.

6. Bring the pen into presence, but do not press the pen. The READY and DATA indicators should blink rapidly. Place the terminal ON LINE.

7. Remove the pen from presence and the Tablet should be disabled. The READY indicator should be extinguished.

Bit 4 Verification

1. Place the terminal in LOCAL, then arm the Tablet with ESC ! J.

2. Bring the pen into presence and press the pen several times. Note that as long as the pen remains in presence, the READY and DATA indicators blink once whenever the pen is pressed down. Place the terminal ON LINE.

3. Leave presence and the Tablet should be disabled. Place the terminal in LOCAL.

4. Rearm the Tablet with ESC ! B.

5. Bring the pen into presence and press the pen. The READY and DATA indicators should blink once. Place the terminal ON LINE.

6. Release pen pressure, then remove the pen from presence. The READY indicator should remain illuminated.

7. Bring the pen into presence and press the pen. The READY and DATA indicators should blink once for each pen pressing. Place the terminal in LOCAL.

8. Clear the Tablet with ESC ! H. The indicators should be extinguished.

Bit 5 Verification

1. Connect an oscilloscope probe to pin 8 of U421 or pin 3 of the bus and set the oscilloscope to 5 V/Div, Negative Trigger, and 5 μs/Div.

2. Arm the Tablet with ESC ! 7 (12 bit). Bring the pen into presence. Seven $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope screen. (Fig. 4-3).

3. Leave presence, then arm the tablet with ESC ! G (10 bit). Bring the pen into presence. Six $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope screen (Fig. 4-3). There will be a missing $\overline{\text{CSTROBE}}$ between the second and third $\overline{\text{CSTROBE}}$.

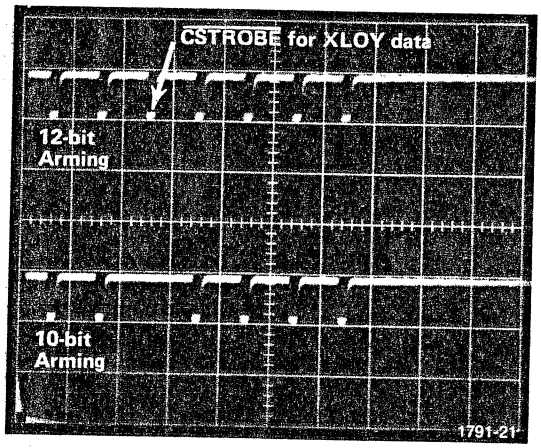


Fig. 4-3. Bit 5 verification.

4. Leave presence.

CR Strap Verification

1. With the CR strap IN, and with the oscilloscope connected as in the previous check, arm the tablet with ESC ! 6.

2. Bring the pen into presence, and leave it. Seven $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope screen (Fig. 4-4).

3. Position the CR strap to the OUT position.

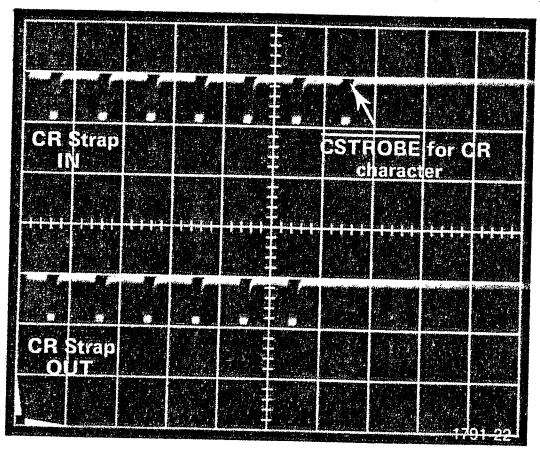


Fig. 4-4. CR strap verification.

4. If it has left presence, place the pen in presence and leave it. Six $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope screen; CR is not strobed on to the bus (Fig. 4-4).

5. Switch the terminal power off; place the CR strap back to the IN position, then switch terminal power back on. Disconnect the oscilloscope.

ESUP Strap Verification

1. Switch the terminal power off, position the ESUP strap IN, then turn the terminal power back on. Position the terminal LOCAL/LINE switch to LOCAL and arm the tablet with ESC ! 7.

2. Bring the pen into presence, and the alpha cursor should move to the relative pen position. Press the pen and the pen's path should be drawn on the terminal screen.

3. Position the ESUP strap OUT. Position the alpha cursor toward the center of the screen area, then position the ESUP strap in.

4. Type keyboard characters. HT (TAB) and VT are the only characters that should get through ESUP to the terminal display.

5. Type ESC ! 8 to disable the tablet.

6. Position the ESUP strap to OUT. All characters will type on the screen.

HEADER Strap Verification

1. Arm the Tablet with ESC ! 7.

2. Bring the pen into tablet presence and press it. The pen's path should be displayed on the terminal screen as long as the pen is pressed.

3. Release pen pressure and the alpha cursor should appear on the screen at the pen's relative position on the screen. The cursor should follow the pen as long as it remains in presence.

4. Press the pen again and go off the edge of the tablet. The alpha cursor should appear at a point on the valid screen viewing area.

5. Move the HEADER strap to LETTER. Bring the pen into presence and press it. An M should appear when the pen is pressed, and an O when pen pressure is released. The cursor should follow the pen when it is in the tablet's presence.

6. Place the HEADER strap back to CONTROL.

Crosshair Operation Verification

1. Place the terminal in LOCAL, move the pen out of presence, and arm the Tablet with ESC ! C.

2. Type ESC SUB (CNTRL Z) from the terminal keyboard. The terminal crosshair cursor should appear on the screen.

3. Place the terminal ON LINE, then bring the pen into presence but do not press it. The crosshair should disappear.

4. Place the terminal into LOCAL. Press the RESET key on the terminal. Arm the Tablet with ESC ! G. Type ESC Ctrl Z to turn on the terminal crosshairs.

5. Place the terminal ON LINE.

6. Lift the pen out of presence. Nothing should happen.

7. Bring the pen back into presence. The crosshair cursor should disappear.

COMSUP Strap Verification

1. Place the COMSUP strap in the IN position, and place an oscilloscope probe on the $\overline{\text{CSTROBE}}$ line (pin 3 of the bus or pin 8 of U421C on the Tablet Control card). Set the oscilloscope to 2 V/Div, Negative Trigger, and 5 μs/Div.

2. Arm the Graphics Tablet with ESC ! 7. Bring the pen into presence; the alpha cursor should track the pen on the terminal screen, but no $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope display.

3. Press the pen; the pen's path should be displayed on the terminal screen and $\overline{\text{CSTROBE}}$'s should appear on the oscilloscope display.

4. Release the pen; the alpha cursor should appear again, and track the pen on the terminal display.

5. Place the COMSUP strap back into the desired position.

Major Component Verification

If the Graphics Tablet fails to operate properly even after other performance checks have been performed and the tablet has been biased, the following procedure may be used to check performance of the tablet proper, the pulser, and the preamp.

1. Remove the tablet cover by first removing the attaching screws from the tablet frame.

2. Connect an oscilloscope probe to the X-axis pulser wire at the upper left corner of the tablet (Fig. 4-5), and connect another probe to trigger from the rising edge of the FIREX pulse (J231-7 on the Tablet Control card). Set the oscilloscope to 10 V/Div, 1 μs per division. The displayed waveform should resemble that in Fig. 4-6.

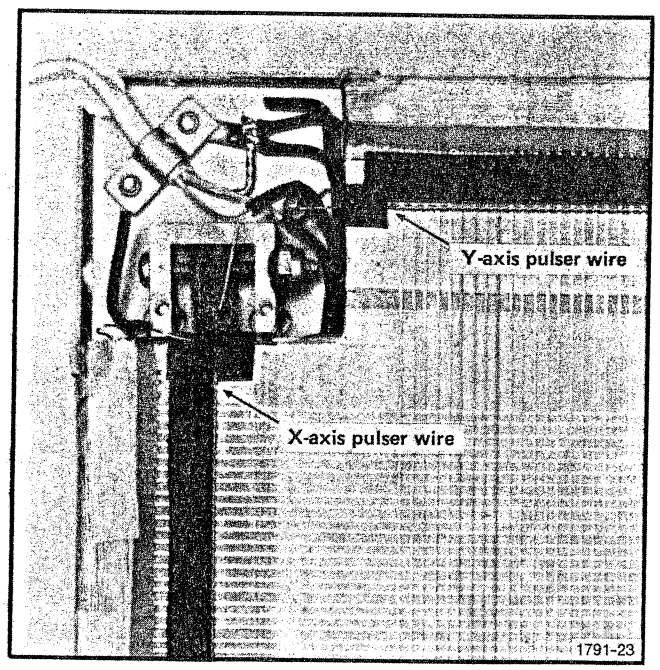


Fig. 4-5. Pulser wire locations.

3. Repeat step 2 for the Y-axis pulser wire (Fig. 4-5), triggering from the FIREY pulse (J231-6). The displayed waveform should resemble that in Fig. 4-7.

4. If one or both of the above waveforms are not as specified, disconnect the tablet and measure with an

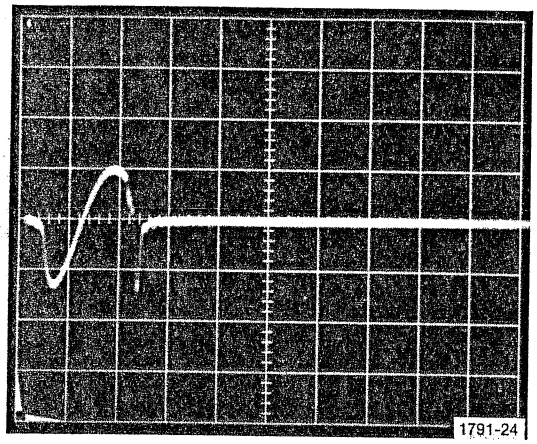


Fig. 4-6. X-axis wire pulsing waveform.

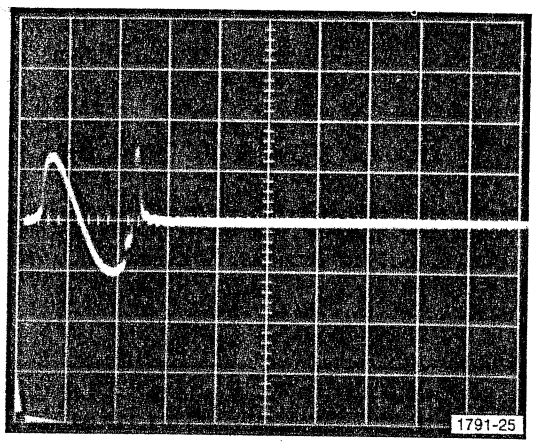


Fig. 4-7. Y-axis wire pulsing waveform.

ohmmeter between pins 1 and 2 of the tablet connector (P1014) on the end of the tablet connector cable. Repeat for pins 3 and 4; both should measure about 1 Ω.

5. If the tablet checks out properly, replace the frame and the four attaching screws, then check the FIREX and FIREY pulses (J231-7 and J231-6, respectively). This is accomplished by placing an oscilloscope probe on the appropriate connector and setting the oscilloscope to positive trigger internally. Set the oscilloscope controls for 2 V/Div and 2 μs/Div. The pulse for each axis should resemble that in Fig. 4-8. If not, the pulser is not operating properly.

6. Remove both covers from the Power Module by first removing the four screws that attach the bottom cover, then the two internal screws that attach the top cover. Remove the cover from the pen preamp by removing the two attaching screws.

7. Attach an oscilloscope probe to pin 12 of the 72702 IC within the preamp (Fig. 4-9). Set the oscilloscope to

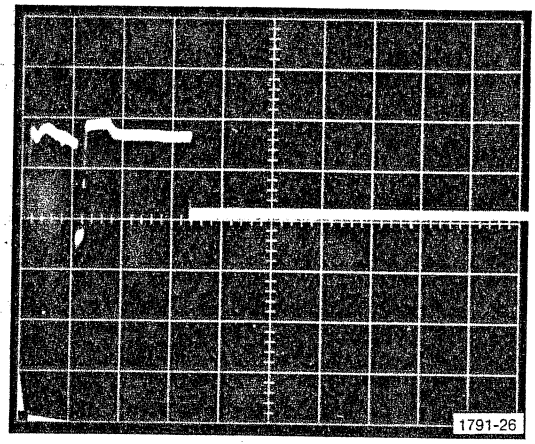


Fig. 4-8. FIREX/FIREY waveform.

trigger from the FIREX pulse, and to display 1 V/Div and 5 μs/Div. The displayed waveform should resemble that in Fig. 4-10. (The pen must be in presence.)

8. Repeat step 7 above, triggering from the FIREY pulse. The same waveform should occur.

9. If the above checks (steps 7 and 8) are not as specified, disconnect the pen and measure between pins 1 and 7 of the pen cable connector (P1012) for a measurement of about Ø Ω. Substantially higher resistance indicates a bad pen or pen cable. If not, the pen preamp may be bad; proceed to step 10.

10. Place an oscilloscope probe on pin 12 of U415 on the Power Supply board. Set the oscilloscope to 5 V/Div, 5 μs/Div, and connect again to trigger from the rising edge of the FIREX pulse. The displayed waveform should approximate that in Fig. 4-11.

11. Repeat, triggering from FIREY; a similar waveform should occur. (Note that the horizontal position of the pulses moves according to the pen position, in both steps 10 and 11.)

12. If these pulses do not occur, the preamp is not operating properly.

13. After all checks and any necessary replacements are completed, replace the top cover on the Power Module and secure it with the two attaching screws. Then replace the bottom cover and secure it with its four attaching screws. Connect the components together as described in the Installation description.

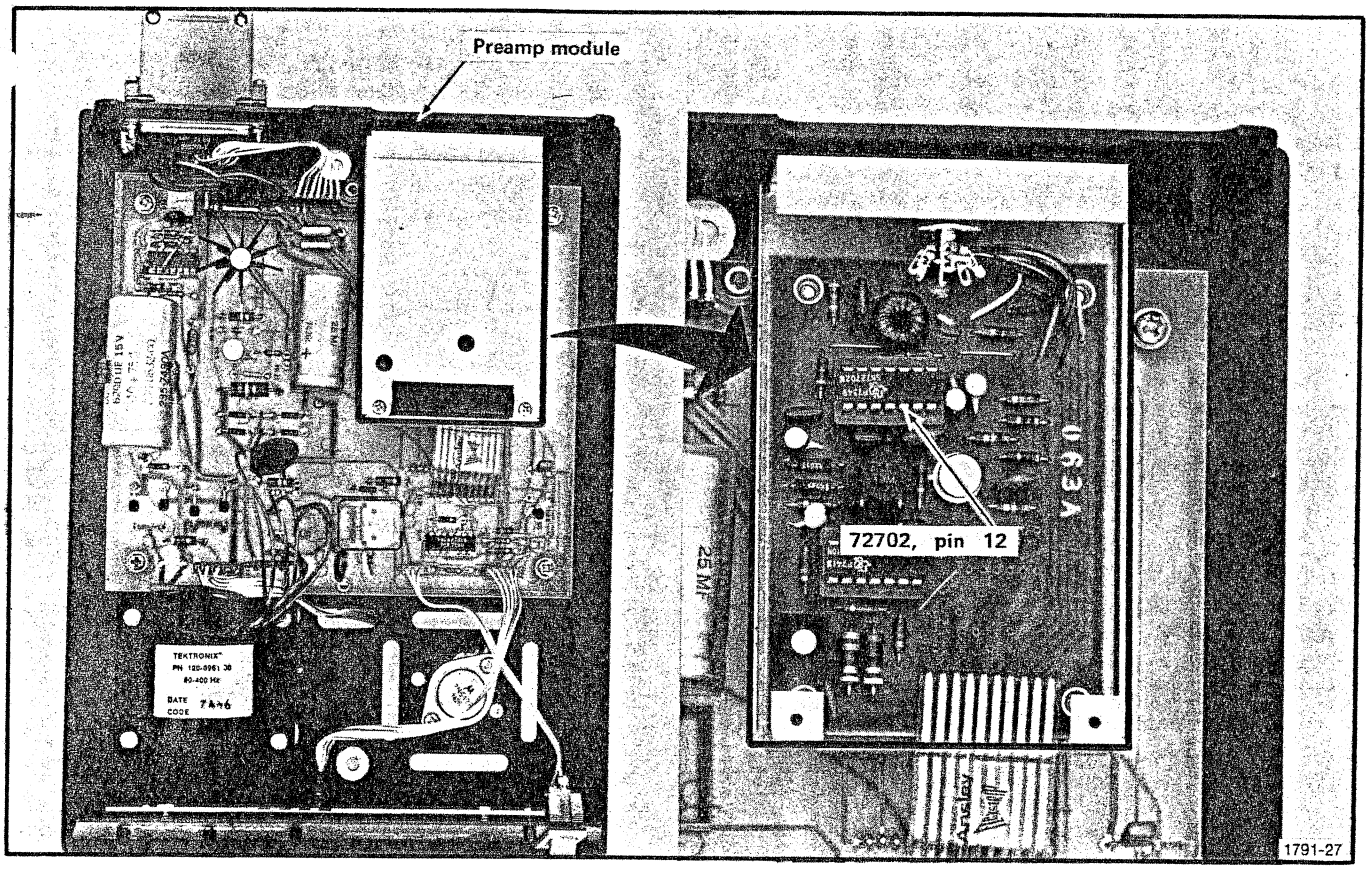


Fig. 4-9. Preamp test point location.

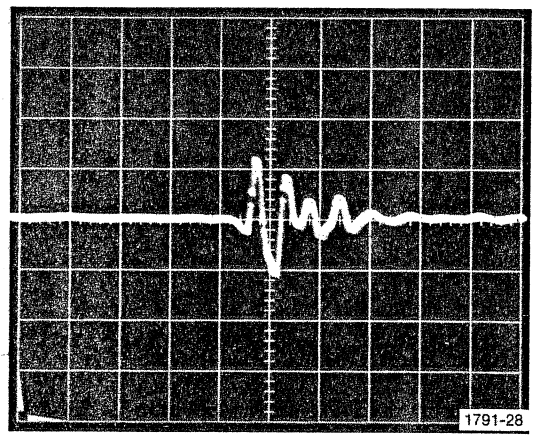


Fig. 4-10. Preamp waveform. This waveform is very sensitive. The probe must connect directly to pin 12 (not through a clip-extender), or the nearest lead of the 150 pF capacitor. Note also that variation may occur between tablets, due to biasing and pen position.

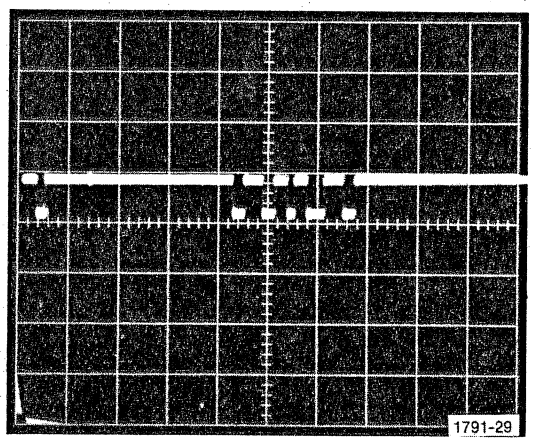


Fig. 4-11. DONE pulse waveform.

INTERCONNECTING SIGNALS

The Graphics Tablet operates as a peripheral to the 4010-series terminal, with the Tablet Control card plugged directly to the terminal bus. The interconnecting signals between the terminal and the Tablet Control card conform to the bus signal definitions and descriptions found in the terminal manual.

The interconnecting signals between the Tablet Control card and Power Module are defined in Table 4-1; locations are shown in Table 4-2.

TABLE 4-1

Power Module to Tablet Control Card Signal Definitions

Signal Name	Function
FIREX	FIREX goes high to initiate the transmission of the wave along the X-axis wires in the tablet. Each FIREX pulse is at least 5 μs long; wave transmission occurs approximately 3 μs after the FIREX pulse occurs. When the X-axis pulse is sent, it momentarily pulls the FIREX signal down. It is from the falling edge of this timing reference mark, within the FIREX pulse, that all timing occurs.
FIREY	Identical to FIREX, but for the Y-axis.
OFFSET	This signal is the result of a strap within the PEN connector, to determine whether the pen or the cursor is being used. When the pen is connected, OFFSET is grounded.
$\overline{\text{DONE}}$	$\overline{\text{DONE}}$ goes low, upon detection of the tablet wave, to stop the X and Y position counters. $\overline{\text{DONE}}$ also goes low when either of the tablet waves are sent; these pulses are disallowed by circuitry on the Tablet Control card.
$\overline{\text{PEN}}$	$\overline{\text{PEN}}$ goes low when the pen (or cursor button) is pressed. The PEN indicator on the Power Module lights whenever $\overline{\text{PEN}}$ is present.
$\overline{\text{READY}}$	$\overline{\text{READY}}$ goes low when the tablet is armed and ready to transmit data. The READY indicator lights when $\overline{\text{READY}}$ is present.
$\overline{\text{DATA}}$	$\overline{\text{DATA}}$ goes low when data is being transferred from the tablet interface to the screen and/or computer. The DATA indicator illuminates when $\overline{\text{DATA}}$ is present.
RVCC	RVCC senses the +5 V on the Tablet Control card for power regulation on the Power Supply board.
+5	+5 V at 1.4 A from the Power Module to the Tablet Control card (2 lines).
GROUND	3 wires
+15	+15 V at 40 mA from the Tablet Control card to the Power Module.
−15	−15 V at 80 mA from the Tablet Control card to the Power Module. A relay in the Power Module prevents the tablet from turning on when −15 V is not present.
SHIELD GROUND	Shield ground is to be connected to chassis ground in the terminal pedestal; it is connected to chassis ground within the Power Module through an RC filter network.

TABLET DIGITIZATION

When the tablet is installed and power is applied to the tablet and the terminal, the Tablet Control card is reading Bits 1-7 on the terminal bus to detect an enabling Control Command sequence. When ESC ! and a third ASCII character are detected, the tablet is enabled and ready to transmit digitized points. The bits in the third character of the Control Command determine the operating mode, which in turn determines how many points will be sent, under which conditions they will be sent, and how many bits define each point.

Tablet Digitization is accomplished by sending a 180-volt pulse simultaneously along all wires of one axis (X-axis) under the tablet surface, followed by the other axis (Y-axis). When a pulse is fired, it causes an acoustical

TABLE 4-2

Power Module to Tablet Control Card Signal Locations

POWER MODULE CONNECTION	BACK PANEL CONNECTION	TABLET CONTROL CARD CONNECTION	SIGNAL
J237-1	J1010-7	J231-7	FIREX
J237-2	J1010-6	J231-6	FIREY
J237-3	J1010-5	J231-5	OFFSET
J237-4	J1010-4	J231-4	$\overline{\text{DONE}}$
J237-5	J1010-3	J231-3	$\overline{\text{PEN}}$
J237-6	J1010-2	J231-2	$\overline{\text{READY}}$
J237-7	J1010-1	J231-1	$\overline{\text{DATA}}$
J236-1	J1010-24	J232-8	−15
J236-2	J1010-23	J232-7	+15
J236-3	J1010-13	J232-6	GROUND
J236-4	J1010-12	J232-5	GROUND
J236-5	J1010-11	J232-4	GROUND
J236-6	J1010-10	J232-3	+5
J236-7	J1010-9	J232-2	+5
J236-8	J1010-8	J232-1	RVCC
	J1010-18	Spade	Shield
		Connector	Ground

wave to travel along the wires; a coil in the pen or cursor can then detect the wave. The time between the firing of the pulse and detection of the wave by the coil in the pen determines the pen's position on the tablet surface. When the pen detects this wave, a DONE pulse is generated, stopping the appropriate axis counters. The counters for both axes operate at 21.08 MHz, causing each tablet clock pulse to represent 0.01 inch of wave travel. This process is occurring whenever the tablet is installed and the power applied; it is used by the counters only when the tablet is enabled, however.

The 180-volt pulse is fired by the tablet pulser upon receipt of a FIREX (or FIREY) signal from the tablet sequencer on the Tablet Control card. When the pulse is actually sent, FIREX or FIREY is momentarily pulled low. This momentary low is the timing reference mark for the appropriate axis' counter; all timing is done from the falling edge of the timing reference mark.

The $\overline{\text{DONE}}$ pulse is a result of the detection by the pen (or cursor) of the acoustical wave in the tablet. It is shaped by the Preamp and sent to the Tablet Control card to stop the counters. Due to $\overline{\text{DONE}}$ pulses that may occur during the firing of the 180 V pulse, $\overline{\text{DONE}}$ pulses occurring during the first 128 counts of the 21.08 MHz clock are ignored. This delay changes to 120 counts if the tablet cursor is being used, due to the larger diameter of the cursor pickup coil.

During the next 96 counts of the 21.08 MHz clock, a $\overline{\text{DONE}}$ pulse indicates that the pen is to the left or the top of the working area of the tablet. This is considered to be an Out-of-Presence condition. After these delays, the counters begin to count until a $\overline{\text{DONE}}$ pulse stops them; it is this digitized count that determines the pen coordinates. If the counter counts past its maximum value, an Out-of-Presence condition exists again.

For more information on the Digitization procedure, refer to the timing diagram in Fig. 4-12. In addition, a Block Diagram and description follow in this section.

BLOCK DIAGRAM DESCRIPTION

The Graphics Tablet Block Diagram (Fig. 4-13) is a simplified view of the Graphics Tablet, and is provided to give an overall view of the operation of the Graphics Tablet circuitry. Each of the blocks represents some section of the circuitry on the Tablet Control card, or else one of the major replaceable components (the tablet, pulser, or preamp). The operation of each circuit block is further detailed in the Circuit Description section of this manual. The circuit blocks function together as described in the following paragraphs.

The Tablet Clock provides the operating frequency for the tablet, with each pulse of the 21.08 MHz clock representing 0.01 inch of acoustic wave travel on the tablet surface. This clock is synchronized with the divided 614 kHz clock in the Sync circuitry, and input to the Tablet Sequencer. The Tablet Sequencer is responsible for the FIREX and FIREY signals, which cause the Pulser (within the Power Module) to sequentially fire the X and Y 180 V pulses. These pulses cause an acoustical wave to travel along the X and Y axis wires in the tablet and be detected by the pen. At the same time, the Wait One-Shot and the Digital Delay portion of the circuitry prevent the Tablet Sequencer from accepting extraneous $\overline{\text{DONE}}$ signals from the Preamp, which occur when the 180 V pulse is fired.

The Tablet Sequencer also provides the Tablet Clock to the X and Y Counters. The counters continue to operate until a valid $\overline{\text{DONE}}$ pulse is received from the Preamp. The $\overline{\text{DONE}}$ pulse indicates that the pen has sensed the acoustic wave traveling past the pen position. Since the counters register the number of counts since the wave started, and since each count represents a set wave travel distance, the position of the pen with respect to the starting position of the wave has been determined. This count is latched into the Output Shift Registers to be transferred onto the terminal bus.

Another portion of the circuitry provides for Tablet enabling. This circuitry begins with the Address Decoder,

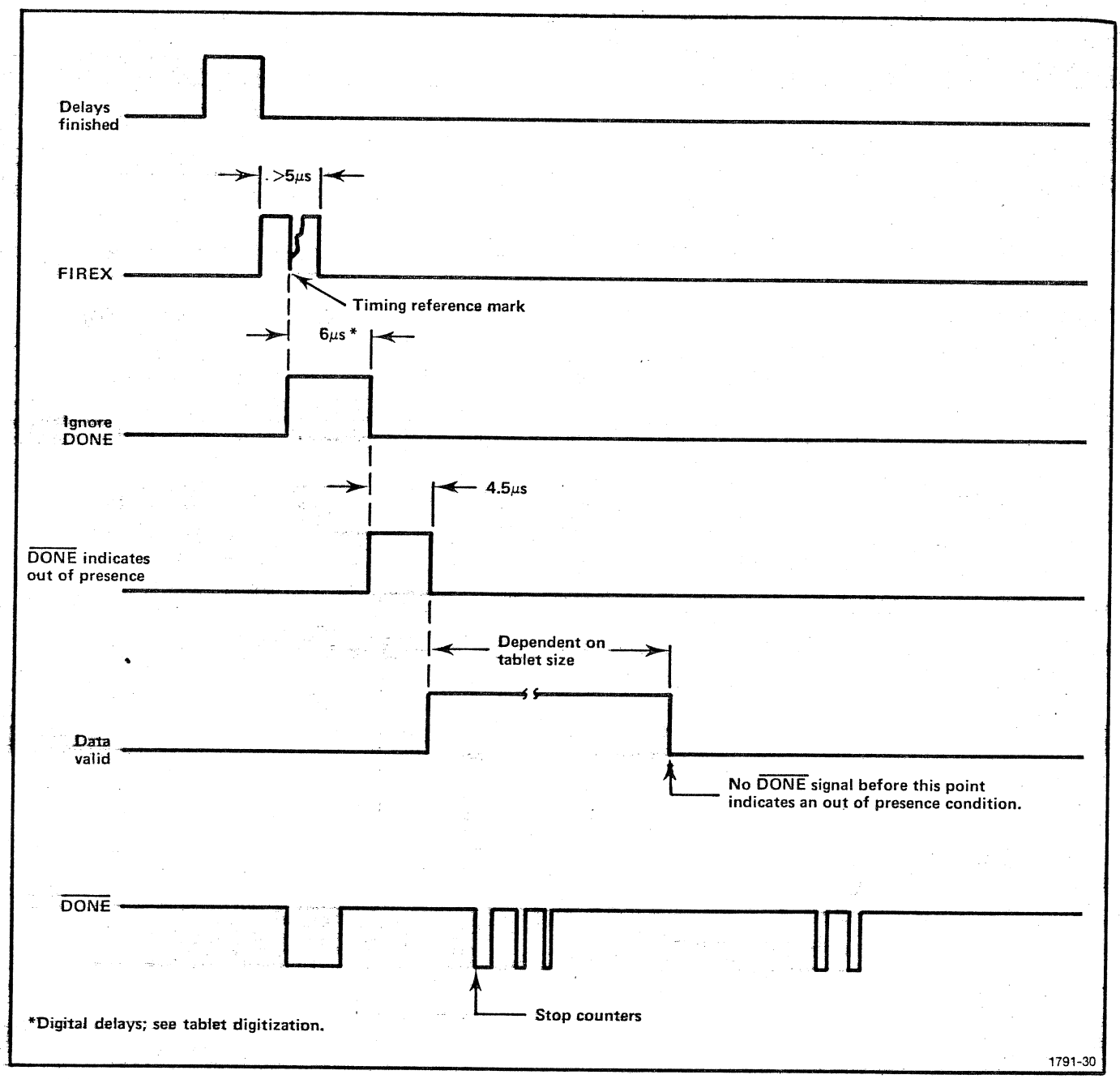


Fig. 4-12. Graphics Tablet timing.

which senses the bits on the terminal bus lines. When a sequence of ESC ! is detected, the tablet is armed; the next character is then latched into the Command Character Buffer. The bits in this third character determine the specifics of the Graphics Tablet operating mode.

The Pen Mode circuit block allows transmission of coordinates only when the pen is pressed, and when the Tablet is armed for pen mode. Otherwise, the Transmit Initiate block is allowed to operate freely when the Tablet Sequencer is ready to initiate a sending sequence. The Transmit Enable block determines when the initiation can begin (through the Delay One-Shot) and how many points can be sent, dependent on whether the tablet is set for Single or Multiple Point.

When the above conditions are all met, the Output Sequencer is allowed to initiate a sequence of outputting the graphic bytes to the terminal bus. It enables the Output Shift Registers to begin transmission, and allows the Character Identifier and Strobes Out blocks to begin placing the appropriate Identifier signals on the bus, along with the appropriate Strobes. The Pen Status block enables the appropriate headers and, when Comsup is

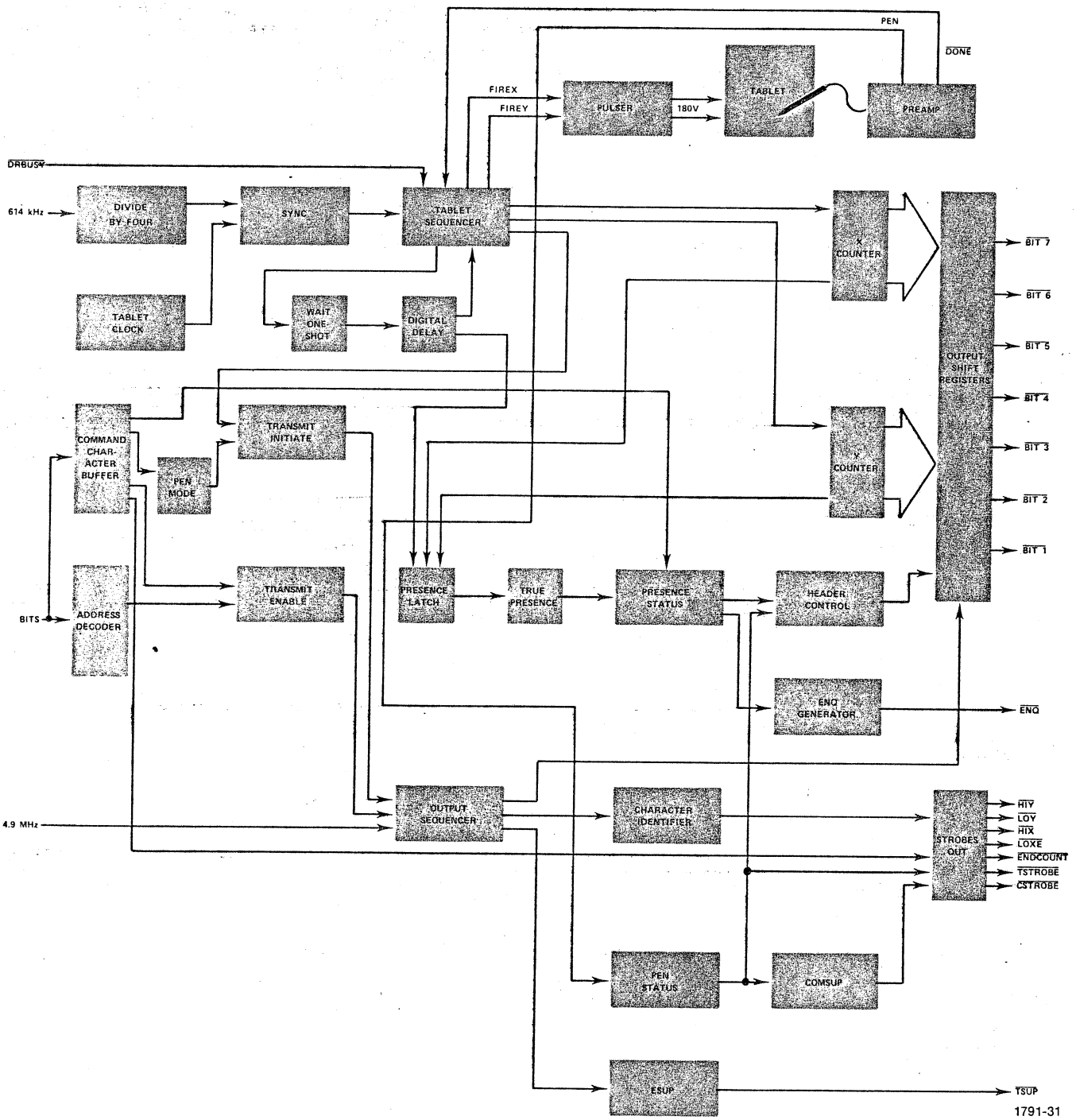


Fig. 4-13. Graphics Tablet Block Diagram.

strapped in, allows $\overline{\text{CSTROBES}}$ only when the pen is pressed. The ESUP block, when strapped in, suppresses the terminal to echoed data characters.

The three presence blocks (Presence Latch, True Presence, and Presence Status) enable the appropriate Header Characters for the pen's presence status, and initiates transmission when the Tablet is armed for Send on Presence. In addition, the Presence Status enables the Enq Generator when the pen leaves presence, so that an Enq signal is then placed on the bus.

Section 5

CIRCUIT DESCRIPTIONS

TABLET CONTROL CARD

Tablet Clock

The Tablet clock (see Tablet Control Card Diagram) is a crystal-controlled oscillator that provides the 21.08 MHz square-wave frequency necessary for the Tablet counters to operate. Each clock pulse represents 0.01 inches of wave travel on the wires within the tablet.

Divide-by-four

U201 (A&B) form a divide-by-four circuit. This divides the 614 kHz terminal clock down to 153 kHz.

Sync

This portion of the circuit, consisting of U111A, delays the 153. kHz clock generated above to coincide with the 21.08 MHz clock. The output of U111A (pin 5) provides clocking for the Tablet Sequencer.

Tablet Sequencer

This portion of the Tablet Control card consists of 3 flip-flops (U211A, U211B, and U111B) and associated gates to determine the output functions of the flip-flops. When initialized, pins 5 and 9 of the three flip-flops are all low. This is the load condition of the sequencer, and preloads the X and Y counters with their initial values. (The counters are described in detail elsewhere in these circuit descriptions.)

Upon receipt of the first pulse from pin 5 of U111A, the output of U211B is accepted as an input to U111B, causing the pin 9 output of U111B to go high. When this happens, the FIREX pulse is generated and output to the tablet pulser through J231 pin 7. Simultaneously the X-Y flip-flop is set to the count X condition, awaiting an enabling pulse from the output of the Digital Delay portion of the circuitry to start counting.

The Wait One-shot is fired when the timing reference mark occurs in the FIREX pulse. Upon receipt of the second pulse, U211 pin 5 goes high, the FIREX signal is disabled, and the unit enters the Wait state until the one-shot has timed out. The Wait state produces a low on pin 3 of U101A to disable the 153 kHz clock. (Refer to Digital Delay and Wait One-shot.) After the Digital Delay, assuming $\overline{\text{UNDERFLOW}}$ does not occur, the X-counter is enabled by U31A, and counts until a $\overline{\text{DONE}}$ pulse is received or $\overline{\text{XOVERFLOW}}$ occurs on pin 3 of U163. The $\overline{\text{DONE}}$ pulse clears U131A, which disables U31A.

At the end of the 3 ms pulse output from the Delay one-shot, the 153 kHz clock is re-enabled. The next pulse from U111A then produces a high on pin 9 of U211B. U11A then produces a FIREY pulse on J231 pin 6. The Wait and Count sequence follows the order that occurred for the X count; counting begins with the timing reference mark in the FIREY signal.

At the end of the 3 ms delay for the Y count, the 153 kHz clock is re-enabled. U211A pin 6 is then high and U211B pin 9 is high. This produces the TABLET STROBE signal on pin 6 of U21C.

The Tablet Sequencer is stopped by $\overline{\text{DRBUSY}}$ whenever a Hard Copy is being made, or when the screen is being paged. The sequencer re-initializes when $\overline{\text{DRBUSY}}$ is no longer present.

Wait One-Shot

The Wait One-Shot provides a pulse of approximately 3 ms duration (one-half of the tablet cycle), during which the Digital Delay circuit is allowed to count.

X-Counter

The X-counter is a 13-bit counter comprising U41B, U135, U141, U145, and the associated gates. U41B and the first stage of U135 (pin 8) are bypassed via U35A and U35D when the tablet size is strap selected as small. This causes the two least significant bits to be ignored by disabling the 21.08 MHz clock ($\overline{\text{COUNTX}}$), causing the counter to become an 11-bit counter, and the counter overflows on 2^{10+1} counts. When the Tablet Size is selected as large, the counter uses the full 13 bits and X overflow occurs on 3841 counts. The count occurs at the frequency of the 21.08 MHz clock that is gated through U31A; each clock pulse represents 0.01 inch of wave travel on the tablet wire grid X-axis. $\overline{\text{TABLET INITIALIZE}}$ loads the X counter data outputs with zeroes.

Y-Counter

The Y-counter is a 13-bit counter comprising U41A, U235, U251, U151, and the associated gates. While this counter is truly a 13-bit up counter, the outputs are all inverted to make it function as a down counter, since the origin of the wave pulse for the Y-axis is located at the top edge of the tablet. The down counter is preset with the binary complement of the tablet size, and counts up to the tablet's Y = 0. Like the X-counter, the Y counter becomes an 11-bit counter when the Tablet Size strap is set to small; when strapped for LARGE, pin 10 of U151 is high, due to the 30" Y-axis as opposed to the 40" X-axis on the 4954.

The Y axis counter is loaded to the complement of 3072 for the large origin and the complement of 1024 for the small origin. When counting, the Y counter counts the 21.08 MHz clock that is gated through U31C. $\overline{\text{TABLET INITIALIZE}}$ presets the counter with the ones complement of 3072 for large origin or the complement of 1024 for small origin.

Digital Delay

The Digital Delay portion of the circuit is made up of two 4-bit counters (U301 and U311) forming a single 8-bit counter between them. Its purpose is to provide a digitally-regulated delay between the time the X or Y pulser is fired and the time a valid DONE signal from the pen preamp can be accepted, due to DONE signals that occur as the pulser fires. In the quiescent state, it is preset to all zeroes when the parallel load signal on pin 1 of U301 and U311 is triggered by the Wait One-shot. The exception occurs when a high on OFFSET is input on J231 pin 5 (present when the cursor is used; not present with the pen). In the case where OFFSET is present, a one is loaded into the bit 4 position (pin 11 of U301); this represents an offset of 8 counts.

When the Wait One-shot is fired, the counters are released to count at 21.08 MHz from their preset value (zero or eight). If a $\overline{\text{DONE}}$ pulse occurs prior to the completion of the 128-count Digital Delay, it is ignored. If the $\overline{\text{DONE}}$ pulse occurs during the next 96 counts, $\overline{\text{UNDERFLOW}}$ is asserted, indicating that the pen is too far to the left or top of the tablet surface to be considered in presence. The counters count until pins 2, 9, and 12 of U311 are all high—a count of 224. At that time the RS flip-flop formed by U221C and U221D is set and the COUNT ENABLE flip-flop U131A is set, beginning the X count.

Address Decoder

The Address Decoder located in U451 senses $\overline{\text{BITS 1-7}}$ on the terminal bus in addition to $\overline{\text{BTSUP}}$ and LCE. When the ESC character is transmitted, LCE goes high and remains high until after the following character is received. The ESC ! sequence is thereby decoded in this one gate. When this two-character sequence is detected, U371A is latched, and the $\overline{\text{ARMING}}$ signal occurs on the pin 5 output of U371A. Pin 6 of that gate then allows a TSTROBE to enter pin 9 of U461, to latch bits 1-5 of the third character in the command string into U461.

During the time that the Tablet is arming for operation, the bus is not available. This is due to U231A, which is sensing LCE, and the pin 5 output of arming latch U371A. Note that each time the tablet is armed, the Delay One-shot fires. This causes the DATA indicator on the Power Module to blink momentarily.

Transmit Enable

When the tablet is armed, regardless of arming for multiple or single point, U401A is latched. In single point, $\overline{\text{MULTI}}$ is present on pin 5 of U411B. After each coordinate point, $\overline{\text{FREE}}$ is output from pin 6 of U165B, enabling U411B to reset U401A after the first coordinate point. If the Tablet was armed for Multiple Point, pin 5 of U411B remains low, preventing $\overline{\text{FREE}}$ from causing a reset; Multiple Point transmission is then allowed.

In addition, the Delay Control circuitry determines how much delay occurs between points, when delay is strapped in. This is accomplished by one-shot U85A, in conjuction with potentiometer R92, which delays the READY signal when delay is strapped in.

ESUP

Whenever the tablet is armed, U401B is set. Pin 9 then enables the ESUP gate U275B to suppress characters that do not occur in conjunction with the outputs of the Tablet Sequencer, effectively suppressing echoed data from being displayed (via $\overline{\text{TSUP}}$). There are eight exceptions (echoed characters which do not get suppressed); these are listed in Section 3 in the description of the ESUP Strappable Option.

Transmit Initiate

This circuit consists of U61B, U261B, U261C, U361C and U85B. When the tablet is armed to send on presence, the logic gates in that block determines that CLEAR TO GO is high, a $\overline{\text{TABLET STROBE}}$ is received from U21C, and $\overline{\text{KLOCK}}$ is not present. When these conditions are true, GO one-shot U85B fires, producing a high on pin 6 of U175B. This is input to pin 8 of U475, which is the clock input of the character identifier. Since no data was in transfer at this point (the beginning of a coordinate cycle), a high is clocked into the first position of the serial input of U475 (pins 1 and 2). This starts the Character Identifier sequence in U475 (see Character Identifier.)

Output Sequencer

The Output Sequencer generates the bus strobes, and is enabled by a high on pin 6 of U381A, which is input to pin 2 of U165A. This clocks a high into U285B. The next 614 kHz clock pulse that occurs clocks this high into U385B pin 9. The fourth 4.9 MHz clock pulse to occur is output from the divide-by-four circuit comprising U491A and U491B, and clocks the high from U395B pin 9 into U485B pin 9. Pin 10 of U485B then resets U385B. The next four 4.9 MHz clock pulses into the divide-by-four circuit cause another pulse to occur on pin 12 of U491, clocking the one from U485B into U485A. Two 4.9 MHz pulses later, the one is clocked into U385A.

As the above output pulses occur, they are input to U381B. The presence of any of these signals causes a DATA OUT pulse, which is then input to pin 3 of U465B and other data bits. This same signal, which is an output of U381B, is fed back into pin 8 of U481C to prevent any other sequence to be started while this sequence is in progress.

The pin 9 output of U485B is used to enable bus strobes. Through U281D and U421C, each output of U485B pin 9 generates a $\overline{\text{CSTROBE}}$. Through U281D and U281B, this same output enables the Character Identifier to sequentially send $\overline{\text{HIY}}$, $\overline{\text{LOY}}$, $\overline{\text{HIX}}$, $\overline{\text{LOXE}}$, and $\overline{\text{END-COUNT}}$ signals along with $\overline{\text{TSTROBE}}$s, when LOCAL DISPLAY is true on pin 2 of U461.

Character Identifier

The Character Identifier consists of U475, which works in conjunction with the Strobes Out circuitry and the Output Sequencer. When a $\overline{\text{GO}}$ pulse is received on pin 4 of U175, no data is being sent; SENDING (U381A, pin 6) is therefore low. That signal is inverted through U265A, and a high is clocked into the serial inputs of U475. This high immediately causes a high on pin 3 of U475, causing U381A to output a high, which then returns through U265A to place a low in the next input position (pins 1 and 2 of U475). This low will not be accepted until another clock pulse is received on pin 8 of U475.

The high in the Character Identifier, which is now on pin 3 of U475, will move through the output positions of U475 with each clock pulse in the following order—pin 3, pin 4, pin 5, pin 6, pin 10, pin 11, pin 12. Each of those outputs serves to identify which character is being strobed onto the bus from the tablet, through the Terminal Strobes bus circuitry. The first clock input, which strobed the high into U475, occurs when $\overline{\text{GO}}$ occurs on pin 12 of U85B. Subsequent clock pulses are generated by pin 6 of U385A, after each cycle of the output sequencer. Note that when the XLOY position is true, and 10 bit operation has been signalled by the third character in the Control Command sequence (pin 7 of U461), the $\overline{\text{CSTROBE}}$ for the $\overline{\text{XLOY}}$ byte is disabled, and that byte does not appear on the bus.

When the Character Identifier passes through the last position ($\overline{\text{LOX}}$—pin 11), the $\overline{\text{LOXE}}$ byte is strobed onto the bus. If the pen's path is being displayed on the terminal screen, the GS header character will have set the $\overline{\text{GRAF}}$ on the terminal bus line true (low), and $\overline{\text{LOXE}}$ is the last signal strobed onto the bus. However, if $\overline{\text{GRAF}}$ is high, it enables U465C, causing an $\overline{\text{ENDCOUNT}}$ to occur immediately after $\overline{\text{LOXE}}$ to disable the display.

Output Shift Registers

The Output Shift Registers are U351, U335, U345, U341, and U331. The coordinate data point, which is generated in the X and Y counters, is latched into the Output Shift Registers with a $\overline{\text{LOAD}}$ pulse. $\overline{\text{LOAD}}$ is output from U291B, pin 6, and can only occur after a TABLET STROBE has occurred, indicating a valid data point.

The output of the X and Y counters, along with the appropriate Header, is latched into the inputs of the Shift Registers on the following pins: pin 6—Header, pin 5—HIY, pin 4—XLOY, pin 3—LOY, pin 14—HIX, pin 13—LOX, and pin 12—CE.

When the Shift Registers are loaded, and when the HEADER output of U475 (pin 3) is high, the conditions of bits 1-5 of the header character are latched into their positions (pin 6) of the Shift Registers. The bits are defined as follows: Bits 1 and 3 are high for GS and US, low for SUB and :, as defined by the output state of U261A. Bit 2 is low for GS and high for other characters, as defined by the output state of U261D. Bit 4 is tied high; Bit 5 is tied high for control characters and low for letter headers, as defined by the HEADER strap. Bit 7 is the inverse of bit 5, and is defined by the HEADER strap and U431B. Bit 6 is low for GS, US, and SUB, but high for the : header character. This bit is determined by the pin 4 input of U365B, which is determined by the pin 1 output of U481A. This is normally low when sending a Header or a CR. However, when the : header character is sent, no data is being transmitted and the HEADER line is low, causing a high input to pin 4 of U365B. This causes bit 6 to be true (low) as it is placed on the bus. (Recall that the terminal bus operates on negative logic.)

When the Header Character is a GS or a US, pin 9 of U345 is high. This is tied back to U281A, which then enables U365D to place a $\overline{\text{TSTROBE}}$ on the bus for GS or US Headers.

The Shift Registers then shift one position when the SHIFT line goes high (U385A, pin 7), placing the HIY bite in the output positions of the Shift Registers (pin 9 of each). At the same time, pin 6 of U385A clocks U475, moving the single high bit into the HIY position (pin 4). This sequence occurs for each byte strobed onto the bus.

Presence Latch/True Presence

The Presence Latch detects all conditions under which the pen is considered to be out of presence; these are labled $\overline{\text{UNDERFLOW}}$, $\overline{\text{XOVERFLOW}}$ and $\overline{\text{YOVERFLOW}}$. When the Graphics Tablet is initialized, the output of U221B (pin 6) is high, and the pen is considered to be in presence. The first $\overline{\text{UNDERFLOW}}$ (which results from a DONE pulse prior to the timing out of the Digital Delay portion of the circuitry) or $\overline{\text{OVERFLOW}}$ (which results from the X or Y counters passing their maximum values) will cause an out-of-presence condition, indicated by a low on pin 6 of U221B.

The output of the Presence Latch is input to the True Presence block on pins 1 and 2 of U191A. As long as the presence condition is true (1), the Tablet Strobe signal clocks a one onto pin 5, which passes through U291A (when ARMED-B is also true) and into the Presence Status block placing a high on pin 12 of U181B. As soon as the pen leaves presence, a low is applied to pins 1 and 2 of U191A; this clears the flip-flop, and holds the output low. This condition is also input to the Presence Status block through the same routing as the in presence condition.

Pen Status

The Pen Status portion of the circuitry consists of U121A, U181A, U81A and the associated gates. U121A is a one-shot that debounces the pulse from the pen switch ($\overline{\text{PEN}}$). When the pen switch is closed, a high is output from pin 13 of U121A, and is clocked through U181A and U81A by the 614 kHz clock. This clocking results in a 1.6 μs delay between the outputs of U181A (pins 5 and 6) and the resultant outputs of U81A (pins 6 and 7). This delay allows U275A to detect when the pen has been up and is then pressed (PEN DOWN) and allows U375C to detect when the pen has been pressed and is then released (PEN UP). When the pen is out of presence, the output of the True Presence latch holds U121A cleared.

Header Control

The Header Control portion of the circuitry consists of U71A and U71B, with associated gating. The two outputs of the circuit block are labeled according to the Header Character normally associated with the output. A high on pin 14 of U71A produces a low $\overline{\text{GS}}$ header through U261D, for the first coordinate point after the pen is pressed. As soon as the $\overline{\text{PEN DOWN}}$ pulse times out, the GS is clocked high by the next $\overline{\text{LOAD}}$ pulse output from U291B, pin 6. Subsequent headers are preceded by the SUB header haracter, which results from a high output on pin 11 of J71B, through U261A. When the pen is released, U71B is cleared, resulting in a low on pin 11, and a high on pin 3 of U261A. The $\overline{\text{GS}}$ line remains high also; a high on both the $\overline{\text{SUB}}$ and $\overline{\text{GS}}$ lines results in a US Header Character.

Crosshair

The Crosshair circuitry consists of U191B and U171A, and is active only when the tablet is initialized while the TRUE GIN signal is present, indicating the terminal is in GIN mode. When this occurs, a high is present on pin 12 of U191B. This is clocked into U191B when the pen is brought into presence; this clocking occurs on pin 11 of U191B. This outputs a high from pin 9, into pins 4 and 1 of U171A. Then when the Bus is Available (pin 2 of U171A) and the next Clear-to-Go pulse occurs (pin 5 of U171A), a pulse is output from pin 6 of U171A into pin 10 of U285B. This causes the Output Sequencer to begin sending the colon (:) header character. The pulse from U171A is also input to U291B, the output of which places the Header Character circuitry in the SUB configuration. However, since the Character Identifier circuitry is not identifying this character as a Header but rather as a Data Character, the Bit 6 gate is outputting a low (1), transforming the SUB to a : (colon) character. This causes the terminal to respond with the crosshair intersect coordinates, and causes the crosshair to disappear.

Pen Mode

The Pen Mode circuitry consists of U75A, working in conjunction with the early portions of the Transmit Initiate circuitry (U65A and associated gates). U75A is preset when the pen is out of presence; coming into presence releases U75A from the preset state. Then, when the pen is pressed, U75A is cleared, placing a high from pin 14 of U75A into pin 4 of U65A and enabling a Tablet Strobe signal to start the Transmit Inititate by firing Go one-shot U85B. Prior to pressing the pen, a high is present on U261B pin 4, causing the Tablet Strobe to be blocked (through U361C) from starting an initiation of transmission. Note that when the tablet is armed for send on presence, the Pen Mode circuitry has no effect on transmission, since the $\overline{\text{SEND ON PRESENCE}}$ signal enables U261B regardless of the state of U75A and U65A.

Comsup

The Comsup circuitry consists of a strap option that determines when coordinate data is to be sent to the computer. When Comsup is strapped out, a high is applied to pin 2 of U285A. The first Load pulse after that (output from U291B) clocks the high through U285A, placing a high on its Q output, pin 5. This then enables the Strobes Out circuitry to send $\overline{\text{CSTROBES}}$ through U421C.

When Comsup is strapped in, a low is placed on pin 2 of U285A, disabling the $\overline{\text{CSTROBE}}$ circuitry. When the pen is pressed, a high is placed on pin 2 of U285A, enabling $\overline{\text{CSTROBES}}$ as above. The flip-flop remains enabled until the pen is released and the US Header Character transmission is completed.

Enq Generator

The Enq Generator is cleared by the Leaving Presence pulse, which is input (on pin 1 of U271A) to the flip-flop consisting of U165C and U271A. This allows the circuitry to generate an $\overline{ENQ}$ pulse to be placed on the terminal bus when the other appropriate conditions are ready. These are that the Bus is Available (U291D, pin 12), not in GIN Mode (U171B, pin 13), Clear-to-Go present (U171B, pin 10). The Enq Generator flip-flop will then fire an $\overline{ENQ}$ pulse (U371B, pin 8) upon receipt of the next $\overline{GO}$ pulse on U171B, pin 9. This causes the terminal to transmit status to the computer, just as if it had received an Esc Enq sequence.

Presence Status

The Presence Status circuitry consists of U181B, U81B, and associated gates. The condition of whether the pen is in presence or out of presence is input to U181B pin 12. The condition is then clocked through U181B and U81B by the 614 kHz terminal clock. This clocking results in a 1.6 μs delay between the two flip-flops. U275C can therefore determine when the pen has been out of presence (pin 11) and then enters presence (pin 10). If pin 9 is also high (Send on Presence), a low output occurs.

In the same fashion, U375A can determine when the pen has been in presence (pin 1) and then leaves presence (pin 13), allowing it to output a Leaving Presence pulse. Note that U161D allows changing Presence Status only when Clear-to-Go is true, to prevent changing status in the middle of a coordinate.

CONTROL BOARD

The Control Board (see Control Board Diagram) contains circuitry to provide +5 V for the logic circuitry contained on the Tablet Control card and within the Power Module. Also provided is the 180 V required to the pulser to fire "acoustic" waves in the X and Y axes of the tablet grid. In addition, strapping for the selectable line voltage ranges is provided on the Control board.

Line Filter

The Line Filter consists of two capacitors (C201, C218) and one resistor (R217). Its function is to shunt high frequency spikes in the line voltage supply to ground through one of the capacitors. R217 serves to discharge the capacitors when power is not applied.

Line Voltage Strapping

The line voltage strapping allows the selection of 110 or 220 V ac input, with a low and high range in either of those voltages. Details regarding Line Voltage ranges, and strap selections for those ranges, is found in Section 3 of this manual.

Power-on Relay

When the Graphics Tablet POWER switch is in the On position, a path to ground is provided through the relay for the terminal's −15 V, which is sensed on the Tablet Control card. When the −15 V supply is present, the relay closes S1 and S2, providing power to the transformer. When power is removed, diode CR316 provides a shunt path for the field stored in K305 relay coil.

180 V Supply

CR121, CR125, CR221, CR225 and C235 form a bridge rectifier for the unregulated 180 V supply. R149 provides a discharge path when power is removed. Q155 and Q185, with their associated resistances and VR161, provide a regulator for the above supply. In normal operation, the emitter of Q185 will be at 180 V, and the base of Q155 will be at approximately 11.6 V. R165 provides base drive for Q185; Q155 shunts the excess current. If the current drawn by the load (on the emitter of Q185) decreases, the voltage at this point has a tendency to increase. This increases the voltage on the base of Q155, which, in turn, increases the current drawn by its collector. This decreases the available base current for Q185, lowering the voltage on its emitter. In this way, the 180 V supply is regulated. (The circuit works in the opposite way when the load on the emitter of Q185 is increased, rather than decreased.) VR161 is a voltage reference that serves to make the action of Q155 independent of its emitter current.

+5 V Regulator

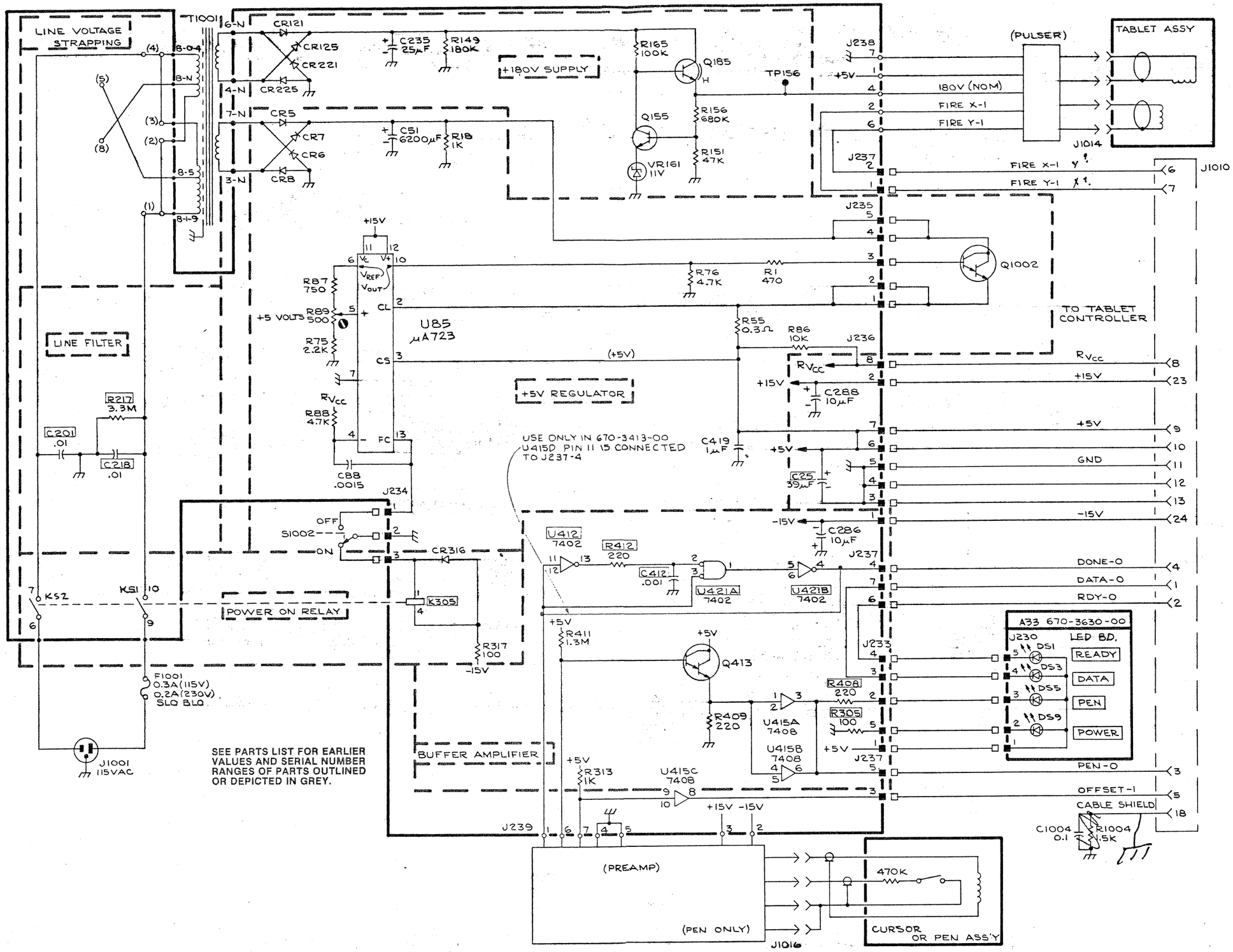
CR5, CR6, CR7, CR8 and C51 form a bridge rectifier for unregulated +5 V supply. R18 provides a discharge path when power is removed. The +5 V supply is regulated as follows: U85 provides an output reference voltage of about +7 V on pin 6. This voltage is divided down to about 5 V by R86, R89, and R75 and fed back into pin 5. U85 also senses the voltage output on pin 4 through R87 (return from the Tablet Control Card) with reference to pin 5. It then

adjusts the base drive for Q1002 (the output of pin 10) to maintain +5 V on pin 4 and to the Tablet Control Card regardless of load current. If the load current on J236 pins 6 and 7 increases, the voltage across R55 increases, making U85 pin 2 more positive with respect to pin 3. When this increase is approximately 0.6 V, U85 current-limits, decreasing the base drive to Q1002. The value of R55 is selected to cause current limiting to occur when the +5 V current exceeds approximately 1.5 A. C419 provides regulating action against short-duration load current spikes. C88 provides a path to stablize the high-frequency response characteristics of U85. When power is switched off, pin 13 is tied directly to ground through the power switch, to immediately clamp the +5 V supply, independent of the discharge of C51. The output voltage is adjusted by R89. R88 between RVCC and +5 V provides a path for the feedback voltage in case of a break in the RVCC line from the Tablet Control Card.

Buffer Amplifier

The Buffer Amplifier prevents the closing of the pen switch from generating a signal in the pen's pickup coil. Q413 functions with R411, and R409, to provide a switch buffer amplifier for the $\overline{\text{PEN}}$ signal, provided whenever the pen switch is depressed. When the $\overline{\text{PEN}}$ signal is not present (Pin 6 of the Preamp high), Q413 provides a high input for U415A and B. When pin 6 of the preamp goes low (when the pen is depressed), Q413 is turned off and the voltage on the inputs of U415A and U415B (pins 1, 2, 4, and 5) falls below the threshold of the gates, the outputs go low. This provides the PEN signal on J237 pin 5, and the $\overline{\text{PEN}}$ indicator LED current. U415C buffers the offset signal from the preamp before it is transmitted to the Tablet Control Card.

U415D buffers the $\overline{\text{DONE}}$ signal from the preamp. It is then applied to pin 2 of U421A, and to U421D, an inverter. Since pin 2 of U421A is already low (in its quiescent state), the output of U421A goes high, to be inverted through U421B, producing a low output. The low output remains only until C412 charges, producing a high on pin 2 of U421A. This circuitry produces a low pulse on the falling edge of the pen input, when that input goes low and stays low.



GRAPHICS TABLET 4953/4954

(2118)1791-34
REV D, FEB 1979

670-3413-00 & UP
CONTROL BOARD

TABLET SEQUENCER

TABLET CLOCK

SYNC

WAIT ONE-SHOT

TRUE PRESENCE

PRESENCE LATCH

DIGITAL DELAY

PEN STATUS

HEADER CONTROL

PEN MODE

COMSUP

ENQ GEN

PRESENCE STATUS

CROSS-HAIRS

TRANSMIT INITIATE

CROSSHAIR

COMMAND CHARACTER BUFFER

BUS AVAILABLE

LOCAL DISPLAY

CHARACTER IDENTIFIER

OUTPUT SEQUENCER

STROBES OUT

TERMINAL STROBES OUT

ADDRESS DECODER

TRANSMIT ENABLE

ESUP

X COUNTER

Y COUNTER

OUTPUT SHIFT REGISTERS

TABLET CONTROL

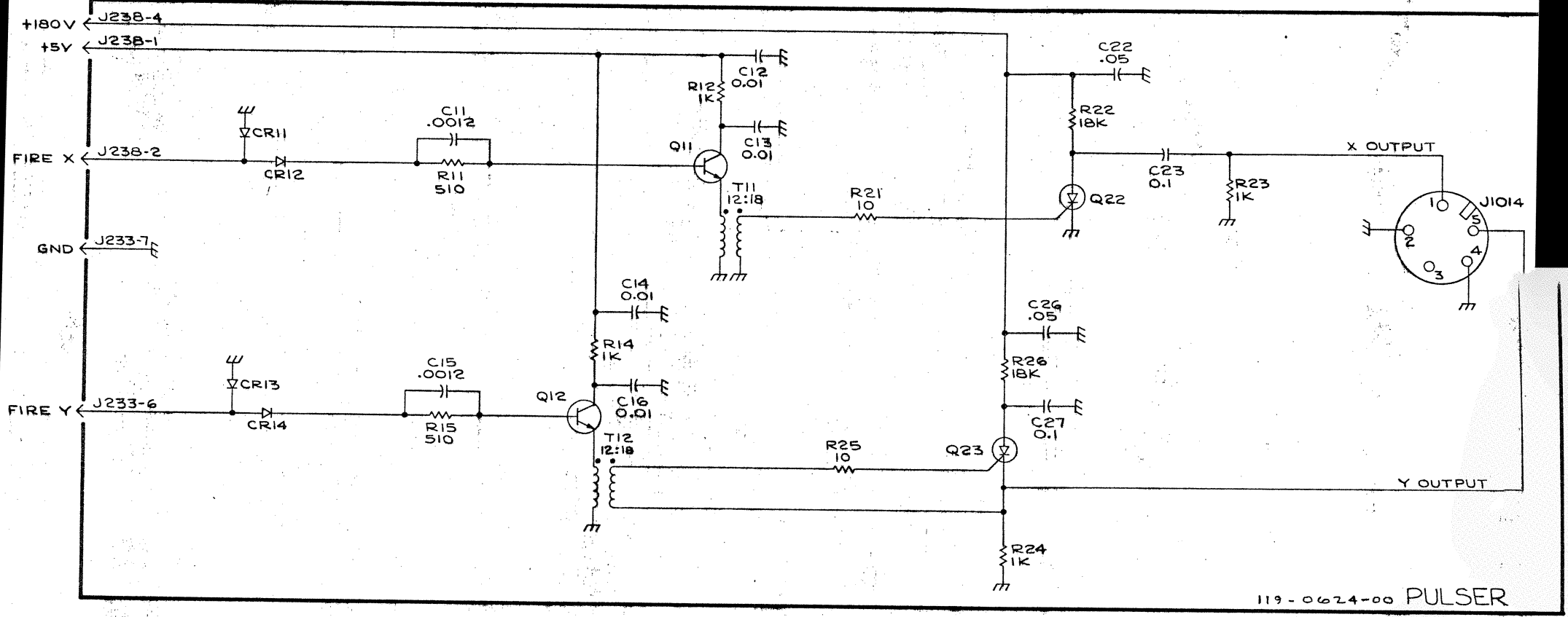
UI 4052-00

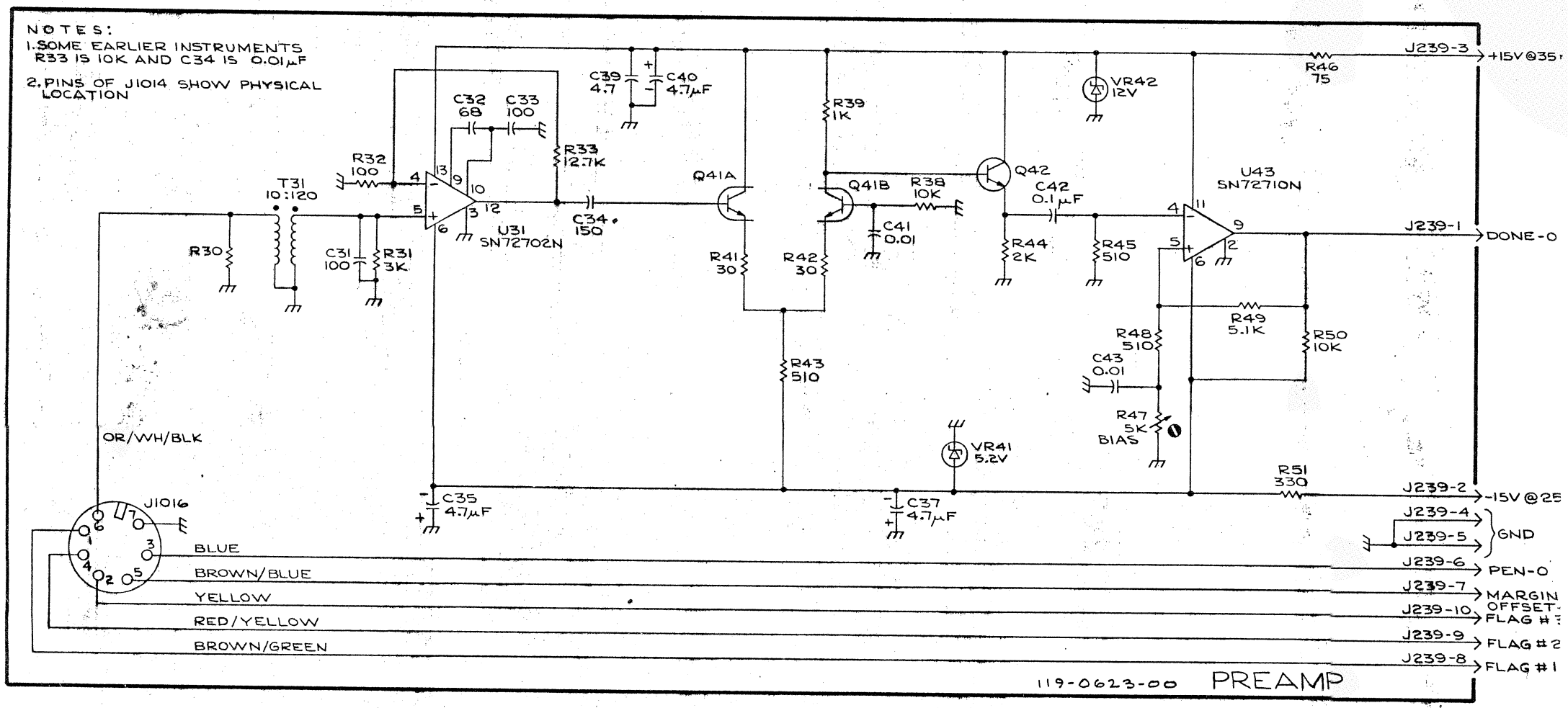
670-3536-01,03,05,06,07,09

4953/4954

REV. C, AUG. 1977

1791-35


+180V
J238-4
+5V
J238-1
FIRE X
J238-2
GND
J233-7
FIRE Y
J233-6
CR11
CR12
CR13
CR14
C11 .0012
C12 0.01
C13 0.01
C14 0.01
C15 .0012
C16 0.01
R11 510
R12 1K
R14 1K
R15 510
Q11
Q12
T11 12:18
T12 12:18
R21 10
R25 10
C22 .05
C23 0.1
C26 .05
C27 0.1
R22 18K
R23 1K
R26 18K
Q22
Q23
X OUTPUT
Y OUTPUT
J1014
R24 1K
119-0624-00 PULSER


NOTES:
1. SOME EARLIER INSTRUMENTS R33 IS 10K AND C34 IS 0.01μF
2. PINS OF J1014 SHOW PHYSICAL LOCATION
T31 10:120
R30
C31 100
R31 3K
R32 100
C32 68
C33 100
R33 12.7K
U31 SN72702N
C34 150
C39 4.7
C40 4.7μF
Q41A
Q41B
R38 10K
R39 1K
R41 30
R42 30
R43 510
C41 0.01
Q42
C42 0.1μF
R44 2K
R45 510
U43 SN72710N
R46 75
VR42 12V
R49 5.1K
R50 10K
R48 510
C43 0.01
R47 5K BIAS
VR41 5.2V
R51 330
C35 4.7μF
C37 4.7μF
OR/WH/BLK
J1016
BLUE
BROWN/BLUE
YELLOW
RED/YELLOW
BROWN/GREEN
J239-3 +15V@35
J239-1 DONE-0
J239-2 -15V@25
J239-4
J239-5
GND
J239-6 PEN-0
J239-7 MARGIN
J239-10 OFFSET-FLAG #3
J239-9 FLAG #2
J239-8 FLAG #1
119-0623-00 PREAMP