TEKTRONIX®

7904 OSCILLOSCOPE

SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
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Beaverton, Oregon 97005

Serial Number ______________________

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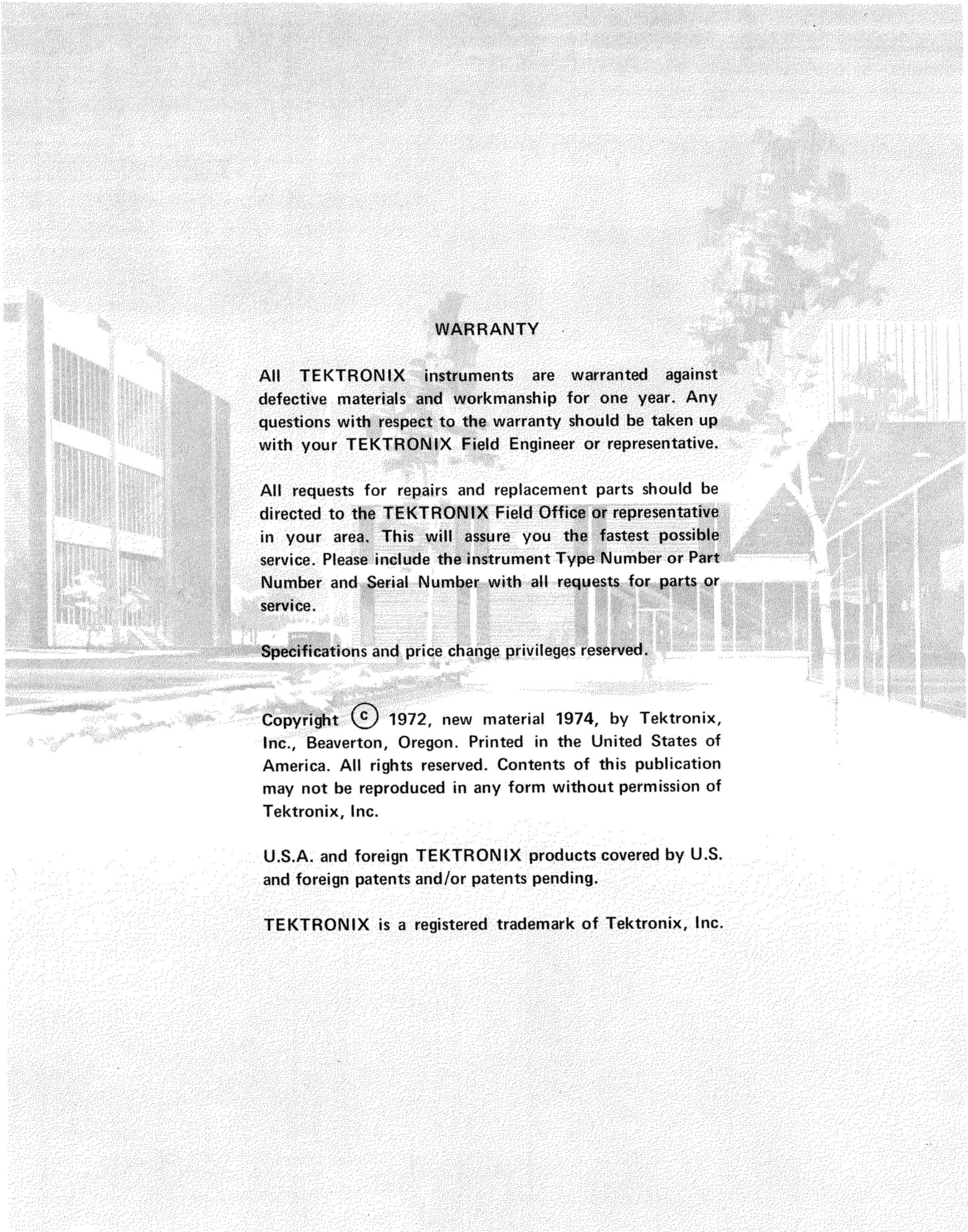

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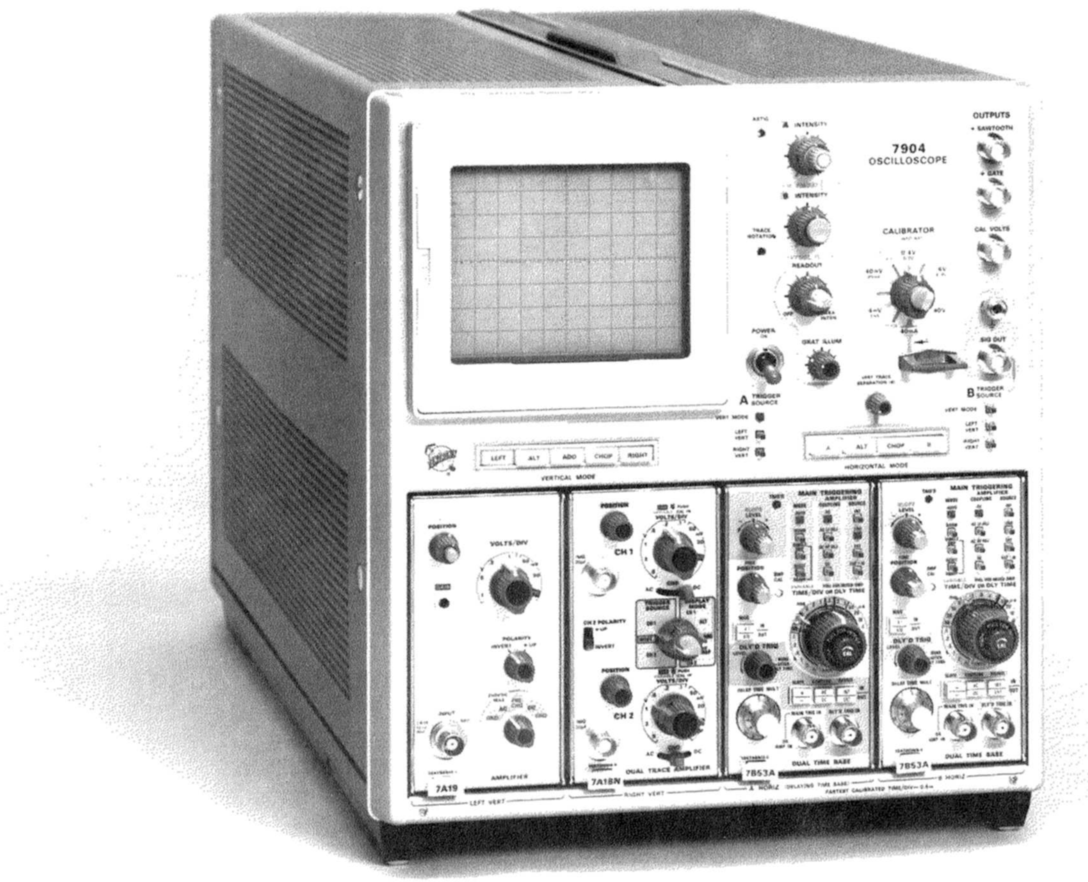
NOTE

Refer to the 7904 Operators Manual for specifications and complete operating instructions.


7904
OSCILLOSCOPE
OUTPUTS
CALIBRATOR
INTENSITY
READOUT
POWER
GRAT ILLUM
CAL VOLTS
SIG OUT
TRIGGER SOURCE
LEFT
ALT
ADD
CHOP
RIGHT
VERTICAL MODE
HORIZONTAL MODE
POSITION
VOLTS/DIV
CH 1
CH 2
MAIN TRIGGERING
TIME/DIV OR DLY TIME
DLY'D TRIG
7A19
AMPLIFIER
7A18N
DUAL TRACE AMPLIFIER
7B53A
DUAL TIME BASE
LEFT VERT
RIGHT VERT

CIRCUIT DESCRIPTION

INTRODUCTION

This circuit description begins with a discussion of the 7904 Oscilloscope, using the basic block diagram. Next, each circuit is described in detail, using detailed block diagrams when appropriate, to show the relationship between the stages in each major circuit. Detailed schematics of each circuit are located in the Diagrams section at the back of this manual; refer to these schematics throughout the following circuit description for specific electrical values and relationships.

The theory of operation for circuits unique to this instrument is described in detail in this discussion. Circuits commonly used in the electronics industry are not discussed in detail. If more information is desired on these commonly used circuits, refer to the following textbooks (also see books under Logic Fundamentals):

Tektronix Circuit Concepts Books (order from your local Tektronix Field Office or representative).

Cathode-Ray Tubes, Tektronix Part 062-0852-01.

Horizontal Amplifier Circuits, Tektronix Part 062-1144-00.

Oscilloscope Trigger Circuits, Tektronix Part 062-1056-00.

Power Supply Circuits, Tektronix Part 062-0888-01.

Sweep Generator Circuits, Tektronix Part 062-1098-01.

Vertical Amplifier Circuits, Tektronix Part 062-1145-00.

Phillip Cutler, "Semiconductor Circuit Analysis", McGraw-Hill, New York, 1964.

Lloyd P. Hunter (Ed.), "Handbook of Semiconductor Electronics", second edition, McGraw-Hill, New York, 1962.

Jacob Millman and Herbert Taub, "Pulse, Digital, and Switching Waveforms", McGraw-Hill, New York, 1965.

The detailed circuit analysis is written around the detailed block diagrams that are given for each major circuit. These detailed block diagrams give the names of the individual stages within the major circuits and show how they are connected together to form the major circuit. The block diagrams also show the inputs and outputs for each circuit and the relationship of the front-panel controls to the individual stages. The circuit diagrams from which the detailed block diagrams are derived are shown in the Diagrams section.

NOTE

All references to direction of current in this manual are in terms of conventional current; i.e., from plus to minus.

LOGIC FUNDAMENTALS

Digital logic techniques are used to perform many functions within this instrument. The function and operation of the logic circuits are described using logic symbology and terminology. This portion of the manual is provided to aid in the understanding of these symbols and terms. The following information is a basic introduction to logic concepts, not a comprehensive discussion of the subject. For further information on binary number systems and the associated Boolean Algebra concepts, the derivation of logic functions, a more detailed analysis of digital logic, etc., refer to the following textbooks:

Tektronix Circuit Concepts Booklet, "Digital Concepts", Tektronix Part 062-1030-00.

Robert C. Baron and Albert T. Piccirilli, "Digital Logic and Computer Operation", McGraw-Hill, New York 1967.

Thomas C. Bartee, "Digital Computer Fundamentals", McGraw-Hill, New York, 1966.

Yaohan Chu, "Digital Computer Design Fundamentals", McGraw-Hill, New York, 1962.

Joseph Millman and Herbert Taub, "Pulse, Digital, and Switching Waveforms", McGraw-Hill, New York, Chapters 9-11, 1965.

Symbols

The operation of circuits in this instrument which use digital techniques is described using the graphic symbols set forth in military standard MIL-STD-806B. Table 1-1 provides a basic logic reference for the logic devices used within this instrument. Any deviations from the standard symbology, or devices not defined by the standard are described in the circuit description for the applicable device.

NOTE

Logic symbols used on the diagrams depict the logic function as used in this instrument and may differ from the manufacturer's data.

Logic Polarity

All logic functions are described using the positive logic convention. Positive logic is a system of notation where the more positive of two levels (HI) is called the true or 1-state; the more negative level (LO) is called the false or 0-state. The HI-LO method of notation is used in this logic description. The specific voltages which constitute a HI or LO state vary between individual devices.

NOTE

The HI-LO logic notation can be conveniently converted to 1-0 notation by disregarding the first letter of each step. Thus:

HI = 1

LO = 0

Wherever possible, the input and output lines are named to indicate the function that they perform when at the HI (true) state. For example, the line labeled "Z-Axis OFF Command" means that the Z-Axis is turned off when this line is HI.

Input/Output Tables

Input/Output (truth) tables are used in conjunction with the logic diagrams to show the input combinations important to a particular function, along with the resultant output conditions. This table may be given either for an individual device or for a complete logic stage. For examples of input/output tables for individual devices, see Table 1-1.

Non-Digital Devices

Not all of the integrated circuit devices in this instrument are digital logic devices. The function of non-digital devices is described individually, using operating waveforms or other techniques to illustrate their function.

TABLE 1-1

Basic Logic Reference

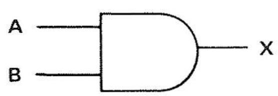
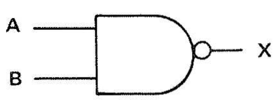
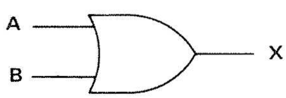
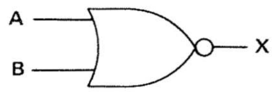
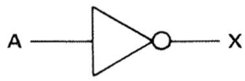
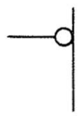
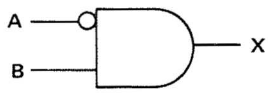
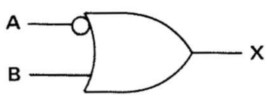
Device	Symbol	Description	Input/Output Table		
			Input		Output
AND gate		A device with two or more inputs and one output. The output of the AND gate is HI if and only if all of the inputs are at the HI state.	A	B	X
			LO	LO	LO
			LO	HI	LO
			HI	LO	LO
			HI	HI	HI
NAND gate		A device with two or more inputs and one output. The output of the NAND gate is LO if and only if all of the inputs are at the HI state.	A	B	X
			LO	LO	HI
			LO	HI	HI
			HI	LO	HI
			HI	HI	LO
OR gate		A device with two or more inputs and one output. The output of the OR gate is HI if one or more of the inputs are at the HI state.	A	B	X
			LO	LO	LO
			LO	HI	HI
			HI	LO	HI
			HI	HI	HI

TABLE 1-1 (cont)

<table>
<tr><th>Device</th><th>Symbol</th><th>Description</th><th>Input/Output Table</th></tr>
<tr><td>NOR gate</td><td>
</td><td>A device with two or more inputs and one output. The output of the NOR gate is LO if one or more of the inputs are at the HI state.</td><td>
<table>
<tr><th colspan="2">Input</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>X</td></tr>
<tr><td>LO</td><td>LO</td><td>HI</td></tr>
<tr><td>LO</td><td>HI</td><td>LO</td></tr>
<tr><td>HI</td><td>LO</td><td>LO</td></tr>
<tr><td>HI</td><td>HI</td><td>LO</td></tr>
</table></td></tr>
<tr><td>Inverter</td><td>
</td><td>A device with one input and one output. The output state is always opposite to the input state.</td><td>
<table>
<tr><th>Input</th><th>Output</th></tr>
<tr><td>A</td><td>X</td></tr>
<tr><td>LO</td><td>HI</td></tr>
<tr><td>HI</td><td>LO</td></tr>
</table></td></tr>
<tr><td>LO-state indicator</td><td>



</td><td>A small circle at the input or output of a symbol indicates that the LO state is the significant state. Absence of the circle indicates that the HI state is the significant state. Two examples follow:

AND gate with LO-state indicator at the A input.

The output of this gate is HI if and only if the A input is LO and the B input is HI.

OR gate with LO-state indicator at the A input:

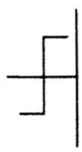
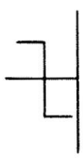
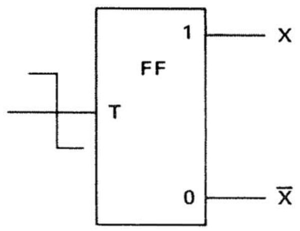
The output of this gate is HI if either the A input is LO or the B input is HI.</td><td>
<table>
<tr><th colspan="2">Input</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>X</td></tr>
<tr><td>LO</td><td>LO</td><td>LO</td></tr>
<tr><td>LO</td><td>HI</td><td>HI</td></tr>
<tr><td>HI</td><td>LO</td><td>LO</td></tr>
<tr><td>HI</td><td>HI</td><td>LO</td></tr>
</table>
<table>
<tr><th colspan="2">Input</th><th>Output</th></tr>
<tr><td>A</td><td>B</td><td>X</td></tr>
<tr><td>LO</td><td>LO</td><td>HI</td></tr>
<tr><td>LO</td><td>HI</td><td>HI</td></tr>
<tr><td>HI</td><td>LO</td><td>LO</td></tr>
<tr><td>HI</td><td>HI</td><td>HI</td></tr>
</table></td></tr>
<tr><td>Edge symbol</td><td>
</td><td>Normally superimposed on an input line to a logic symbol. Indicates that this input (usually the trigger input of a flip-flop) responds to the indicated transition of the applied signal.</td><td></td></tr>
</table>

TABLE 1-1 (cont)

Device | **Symbol** | **Description** | **Input/Output Table**

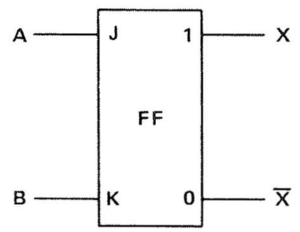
Triggered (toggle) Flip-Flop



A bistable device with one input and two outputs (either or both outputs may be used). When triggered, the outputs change from one stable state to the other stable state with each trigger. The outputs are complementary (i.e., when one output is HI the other is LO). The edge symbol on the trigger (T) input may be of either polarity depending on the device.

Input: Condition before trigger pulse		Output: Condition after trigger pulse	
X	$\overline{X}$	X	$\overline{X}$
LO	HI	HI	LO
HI	LO	LO	HI

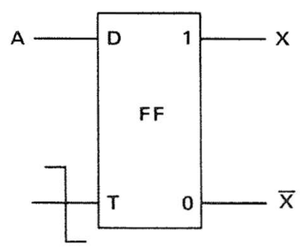
Set-Clear (J-K) Flip-Flop



A bistable device with two inputs and two outputs (either or both outputs may be used). The outputs change state in response to the states at the inputs. The outputs are complementary (i.e., when one output is HI the other is LO).

Input		Output	
A	B	X	$\overline{X}$
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Changes state	

D (data) Type Flip-Flop

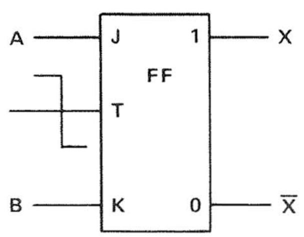


A bistable device with two inputs and two outputs (either or both outputs may be used). When triggered the state of the "1" output changes to the state at the data (D) input prior to the trigger. The outputs are complementary (i.e., when one output is HI the other is LO). The edge symbol on the trigger (T) input may be of either polarity, depending on the device.

Input	Output	
A	X	X
LO	LO	HI
HI	HI	LO

Output conditions shown after trigger pulse

Triggered Set-Clear (J-K) Flip-Flop

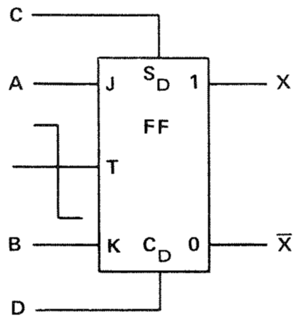


A bistable device with three or more inputs and two outputs (either or both outputs may be used). When triggered, the outputs change state in response to the states at the inputs prior to the trigger. The outputs are complementary (i.e., when one output is HI the other is LO). The edge symbol on the trigger (T) input may be of either polarity depending on the device.

Input		Output	
A	B	X	$\overline{X}$
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Changes state	

Output conditions shown after trigger pulse

TABLE 1-1 (cont)

<table>
<tr><th>Device</th><th>Symbol</th><th>Description</th><th>Input/Output Table</th></tr>
<tr>
<td>Flip-Flop with Direct Inputs (may be applied to all triggered flip-flops)</td>
<td>
</td>
<td>For devices with direct-set (S_D) or direct-clear (C_D) inputs, the indicated state at either of these inputs over-rides all other inputs (including trigger) to set the outputs to the states shown in the input/output table.</td>
<td>
<table>
<tr><th colspan="4">Input</th><th colspan="2">Output</th></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>X</td><td>X̄</td></tr>
<tr><td>1</td><td>1</td><td>LO</td><td>LO</td><td colspan="2">No change[1]</td></tr>
<tr><td>Φ</td><td>Φ</td><td>LO</td><td>HI</td><td>LO</td><td>HI</td></tr>
<tr><td>Φ</td><td>Φ</td><td>HI</td><td>LO</td><td>HI</td><td>LO</td></tr>
<tr><td>Φ</td><td>Φ</td><td>HI</td><td>HI</td><td colspan="2">Undefined</td></tr>
</table>
Φ = Has no effect in this case
[1]Output state determined by conditions at triggered inputs
</td>
</tr>
</table>

BLOCK DIAGRAM

Introduction

The basic block diagram in Fig. 1-1 shows the primary interconnections between the individual blocks; each block represents a major circuit within the instrument. The numbered diamond in each block refers to the circuit diagram (located at the rear of the manual) that covers that specific part of the instrument.

Block Diagram Description

Vertical signals to be displayed on the CRT are applied to the Vertical Channel Switch from both vertical plug-in compartments. The Vertical Channel Switch determines whether the signal from the left or right vertical unit is displayed. The selected vertical signal is then amplified by the Vertical Amplifier circuit to bring it to the level necessary to drive the vertical deflection plates of the CRT. This circuit also includes an input to produce the vertical portion of an alpha-numeric readout display.

Horizontal signals for display on the CRT are connected to the Horizontal Channel Switch from both horizontal plug-in compartments. The Horizontal Channel Switch determines whether the signal from the A or B horizontal unit is displayed. The horizontal signal selected by the Horizontal Channel Switch is connected to the Horizontal Amplifier circuit which amplifies it to provide the horizontal deflection for the CRT. This circuit also accepts the X-signal from the Readout System to produce the horizontal portion of the readout display.

The Readout System provides alpha-numeric display of information encoded by the plug-in units. This display is presented on the CRT, and is written by the CRT beam on a time-shared basis with the analog waveform display.

The internal trigger signals from the vertical plug-in units are connected to the A and B Trigger Channel Switch circuits. These circuits, in conjunction with the Trigger Select Logic circuit, determine whether the trigger signal from the left or right vertical unit is connected to the A or B horizontal unit. The B Trigger Channel Switch also produces the drive signal for the Output Signals circuit to provide an output that is a sample of the vertical signal. In addition, the Output Signals circuit provides a sawtooth output signal and a gate output signal.

The Calibrator circuit produces an output with accurate amplitude that can be used to check the calibration of this instrument and the compensation of probes. The repetition rate of the Calibrator signal is selectable between DC, one kilohertz, or one-half the B-gate signal. This signal is available as a voltage at the CAL VOLTS connector or as a current through the 40-mA current loop.

The Logic circuit develops control signals for use in other circuits within this instrument and the plug-in units. These control signals automatically determine the correct instrument operation in relation to the plug-in units installed or selected, plug-in control settings, and 7904 control settings. The CRT circuit contains the Z-Axis Amplifier which provides the drive signal to control the intensity level of the display. The CRT circuit also contains the controls necessary for operation of the cathode-ray tube.

The Converter/Rectifiers and Low-Voltage Regulator circuits provide the power necessary for operation of this

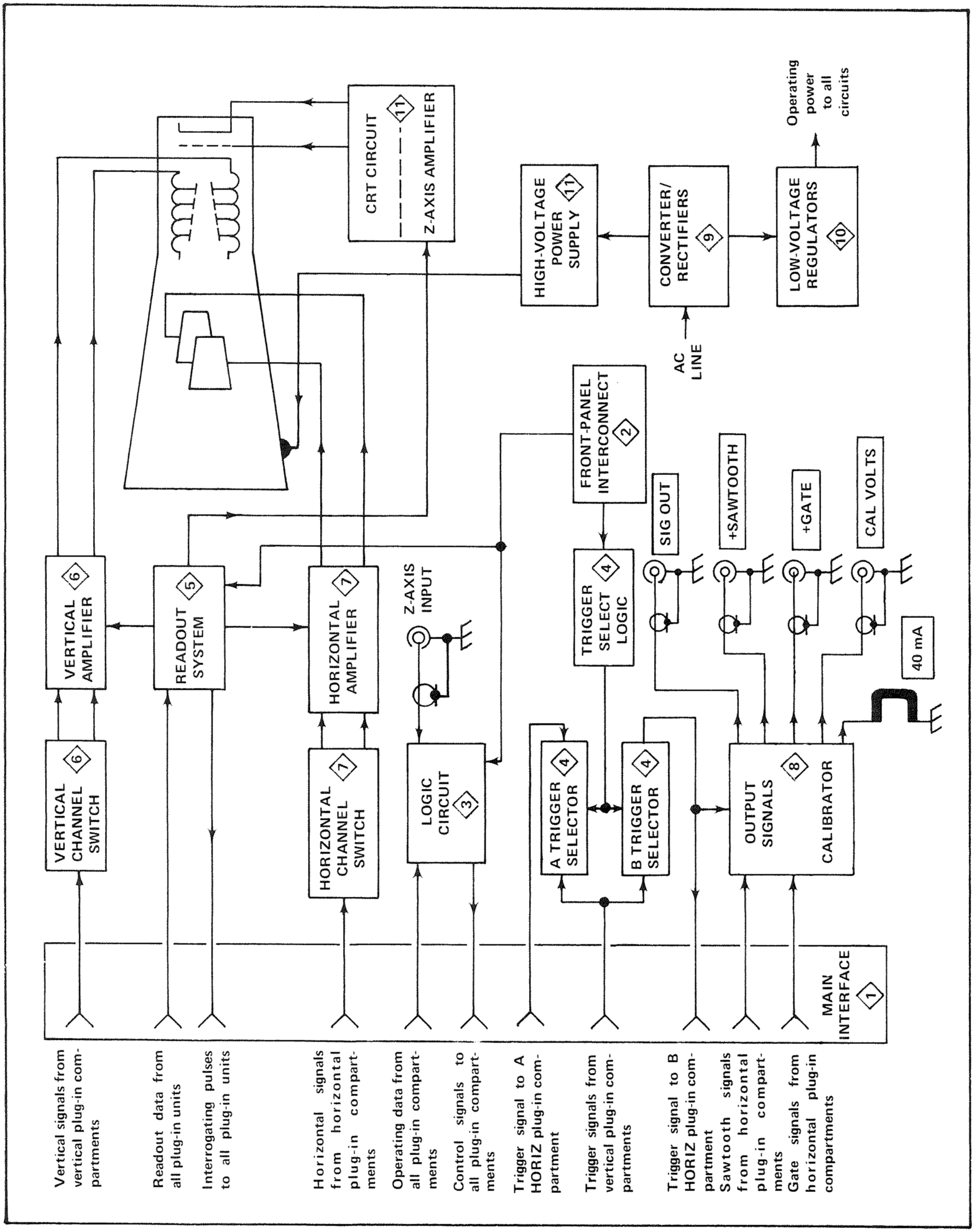


Fig. 1-1. Basic block diagram of the 7904 Oscilloscope.

Ⓐ

instrument. These voltages are connected to all circuits within the instrument. The High-Voltage Power Supply provides the positive accelerating potential for the CRT. The Front-Panel Interconnect circuit contains the front-panel controls, switches, and interconnection circuitry.

MAIN INTERFACE ⟨1⟩

Diagram 1 shows the plug-in interface and the interconnections between the plug-in compartments, circuit boards, etc. of this instrument. Also, the signal and voltage connections of each interface connector are identified. The signals connected to only the vertical plug-in interface connectors (J1 and J2) are labeled (V); those connected to only the horizontal connectors (J3 and J4) are labeled (H).

FRONT-PANEL INTERCONNECT ⟨2⟩

The Front-Panel Interconnect diagram shows the front-panel controls, switches, and interconnection circuitry.

LOGIC ⟨3⟩

Introduction

The Logic circuit develops control signals for use in other circuits within this instrument and any plug-in units installed. These control signals automatically determine the correct instrument operation in relation to the plug-in units installed or selected, plug-in control settings, and 7904 control settings. A block diagram of the Logic circuit is shown in Fig. 1-2.

This circuit description for the Logic circuit is written with the approach that each of the integrated circuits and its associated discrete components composes an individual stage as shown by the block diagram (Fig. 1-2). The operation of each stage is discussed, relating the input signals or levels to the output, with consideration given to the various modes of operation that may affect the stage. A logic diagram is also provided for each stage. These diagrams are not discussed in detail, but are provided to aid in relating the function performed by a given stage to standard logic techniques. It should be noted that these logic diagrams are not an exact representation of the internal structure of the integrated circuit, but are only a logic diagram of the function performed by the stage. An input/output table is given, where applicable, for use along with the circuit description and logic diagram. These input/output tables document the combination of input conditions that are of importance to perform the described function of an individual stage.

Horizontal Logic

The Horizontal Logic stage performs three separate logic functions: A Sweep Inhibit, B Sweep Inhibit, and Alternate Pulse Generator. Figure 1-3 identifies the three individual stages and the input and output terminals associated with each. Note that some of the input levels are connected internally to more than one of the individual stages.

A Sweep Inhibit. The A Sweep Inhibit stage produces an output level at the collector of Q362 that determines if the A HORIZ time-base unit can produce a sweep. If this output is HI, the A HORIZ unit is locked out (disabled) so it cannot produce a sweep. If the level is LO, the A HORIZ unit is enabled and can produce a sweep when triggered.

As shown by the logic diagram and input/output table of Fig. 1-4, only two combinations of input conditions produce an A Sweep Inhibit level (HI); if any of the prescribed conditions is not met, the A Sweep Inhibit level is LO and the A HORIZ time-base unit is enabled.

The first combination disables the A sweep while the B sweep is being displayed in the ALT horizontal mode (both units must be in time-base mode), if non-delayed operation is being used. The second combination disables the A sweep during delayed-sweep operation so that the B sweep can complete its holdoff before the next A sweep begins.

B Sweep Inhibit. The B Sweep Inhibit stage produces an output level at the collector of Q367 that determines if the B HORIZ time-base unit can produce a sweep. A HI output level locks out (inhibits) the B HORIZ unit and a LO level enables the B HORIZ unit to produce a sweep.

As shown by Fig. 1-5B, the output of this stage is HI only under one set of input conditions. This set of conditions disables the B sweep while the A sweep is being displayed in the ALT horizontal mode, if both units are in a time-base mode and non-delayed sweep is used. For any other combination of input conditions, the B Sweep Inhibit level is LO. However, the output level to the B time-base unit is determined by both the Delay Gate from the A time-base unit and the B Sweep Inhibit level produced by this stage. The B Sweep is enabled only when both of these levels are LO.

Figure 1-5A shows the logic diagram of the B Sweep Inhibit stage. The gate connected to the output of this stage is a phantom-OR gate shown on the Main Interface diagram. (A phantom-OR gate performs the OR-logic function merely by interconnection of the two signal lines.)

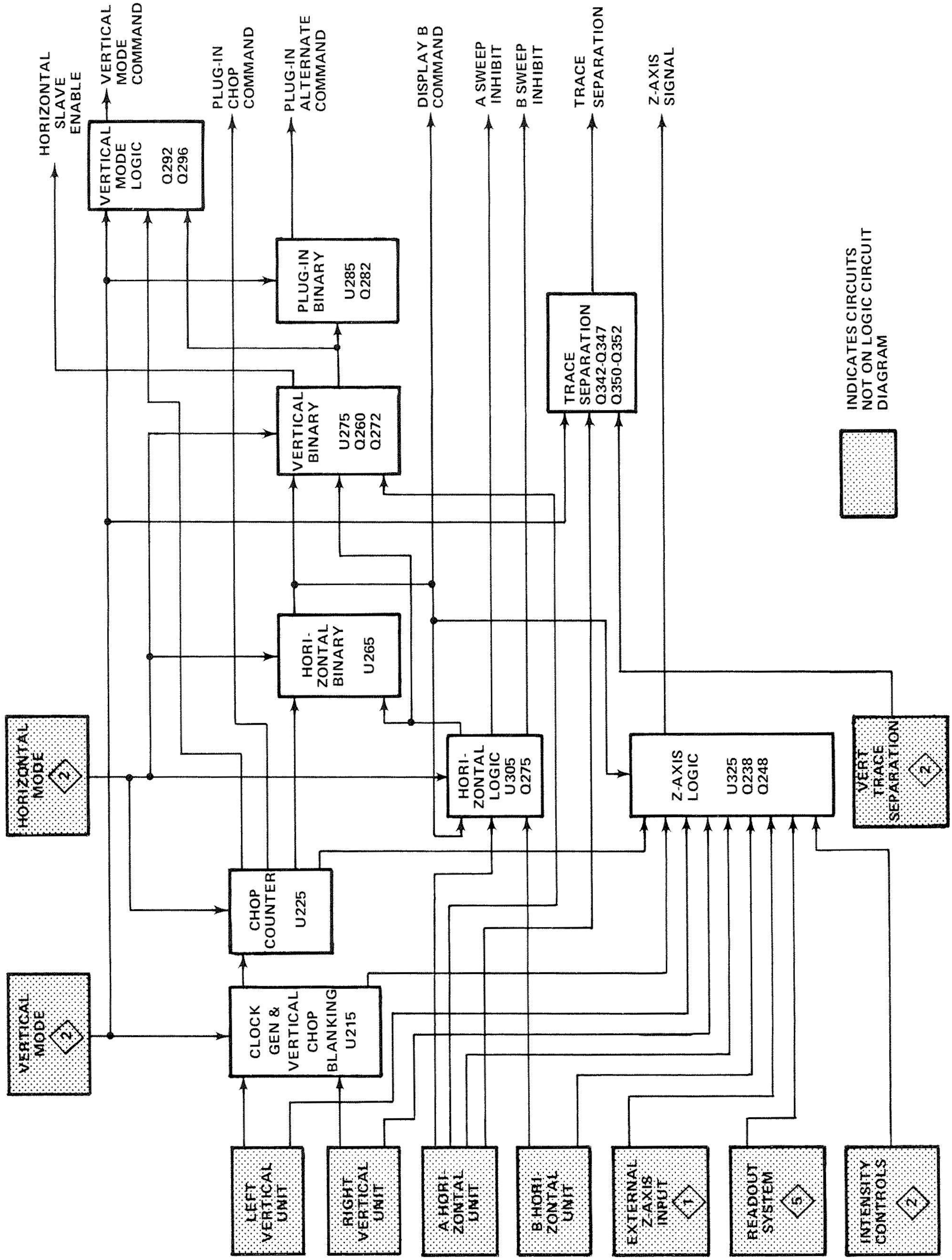


Fig. 1-2. Detailed block diagram of Logic circuit.

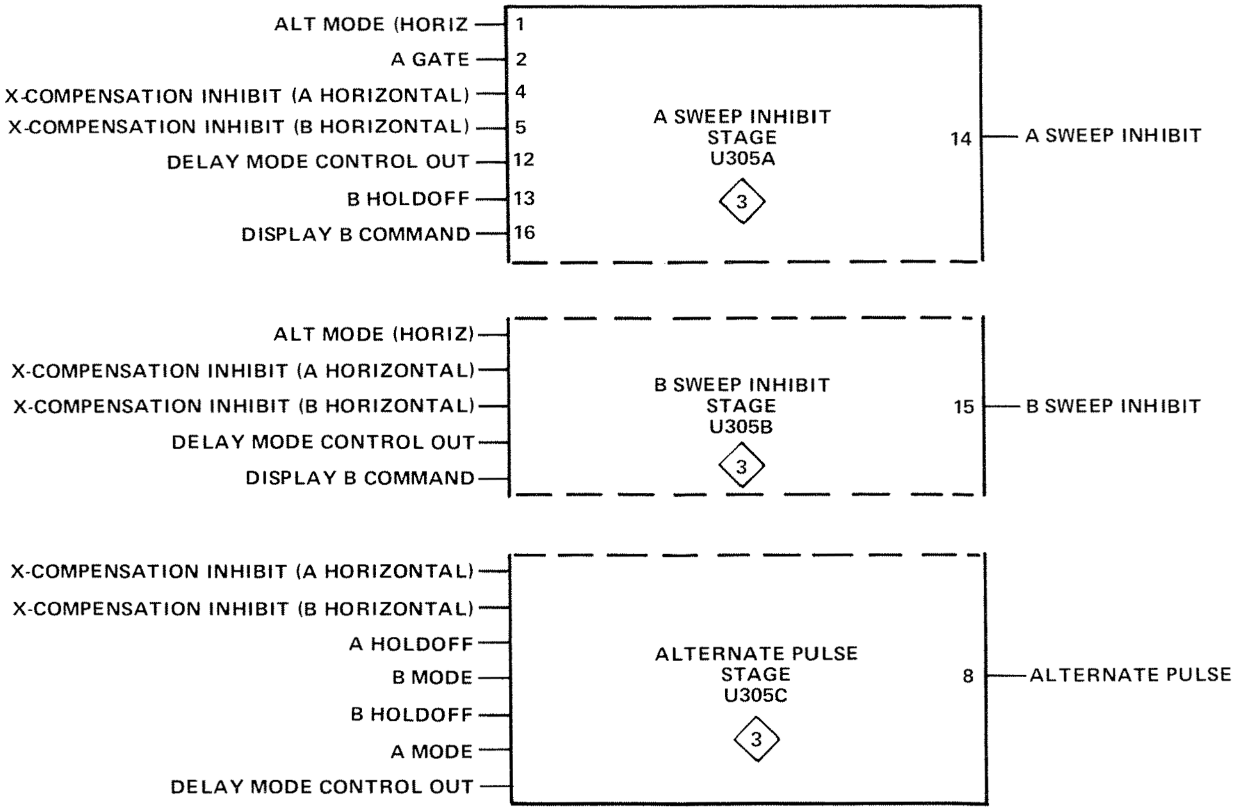
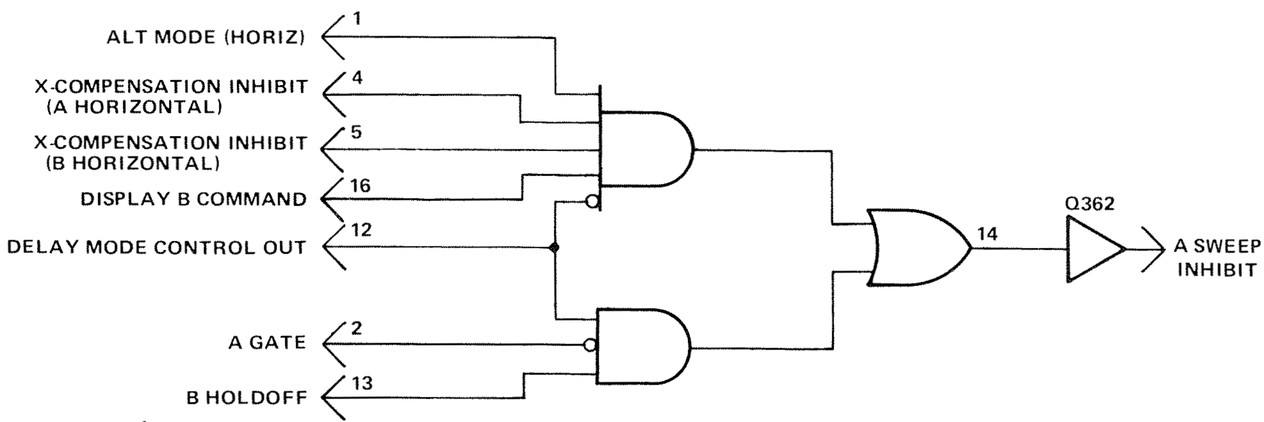


Fig. 1-3. Breakdown of separate stages within Horizontal Logic IC (U305) showing inputs and outputs for each stage.



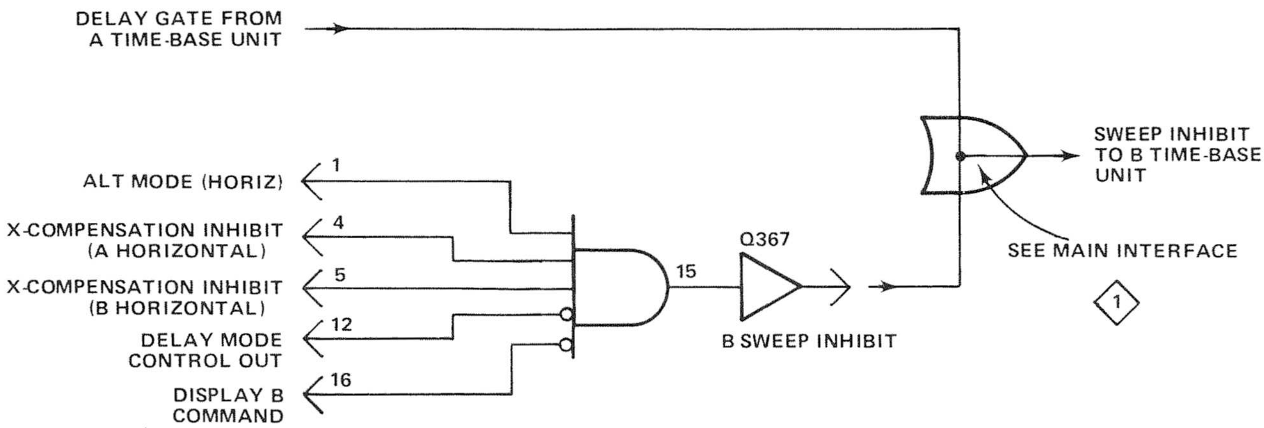
(A) U305A 3

INPUT							OUTPUT
ALT MODE (HORIZ)	A GATE	X-COMPENSATION INHIBIT (A HORIZONTAL)	X-COMPENSATION INHIBIT (B HORIZONTAL)	DELAY MODE CONTROL OUT	B HOLDOFF	DISPLAY B COMMAND	A SWEEP INHIBIT
1	2	4	5	12	13	16	14
HI	Φ	HI	HI	LO	Φ	HI	HI
Φ	LO	Φ	Φ	HI	HI	Φ	HI
ALL OTHER COMBINATIONS							LO

(B)

Φ = HAS NO EFFECT IN THIS CASE

Fig. 1-4. (A) Logic diagram for A Sweep Inhibit stage; (B) Table of input/output combinations.



(A) U305B 3

(B)

INPUT					OUTPUT
ALT MODE (HORIZ)	X-COMPENSATION INHIBIT (A HORIZONTAL)	X-COMPENSATION INHIBIT (B HORIZONTAL)	DELAY MODE CONTROL OUT	DISPLAY B COMMAND	B SWEEP INHIBIT
1	4	5	12	16	15
HI	HI	HI	LO	LO	HI
ALL OTHER COMBINATIONS					LO

Fig. 1-5. (A) Logic diagram for B Sweep Inhibit stage; (B) Table of input/output combinations.

Alternate Pulse Generator. The third function performed by the Horizontal Logic stage is to produce an Alternate Pulse signal for use by the Horizontal and Vertical Binary stages. The Alternate Pulse is produced at the end of either sweep, depending upon the operating conditions as shown in Fig. 1-6B. The holdoff gate produced at the end of the sweep by the respective time-base unit is differentiated by either C311 or C309 to provide a positive-going pulse to pin 6 or 9.

In Fig. 1-6A, note the resistors shown connected to pins 6 and 9. These resistors, which are internal to the IC, hold the levels at pins 6 and 9 LO unless a HI level is applied to the corresponding input. Since the holdoff gate is capacitively-coupled to pins 6 and 9, these inputs are at the LO level except when a differentiated A or B Holdoff gate is received.

The following discussions describe the operation of the Alternate Pulse Generator stage in relation to the various combinations of input conditions shown in Fig. 1-6B.

1. A (ONLY) MODE

An Alternate Pulse is produced at the end of each A sweep when the HORIZONTAL MODE switch is set to the A position.

2. B (ONLY) MODE

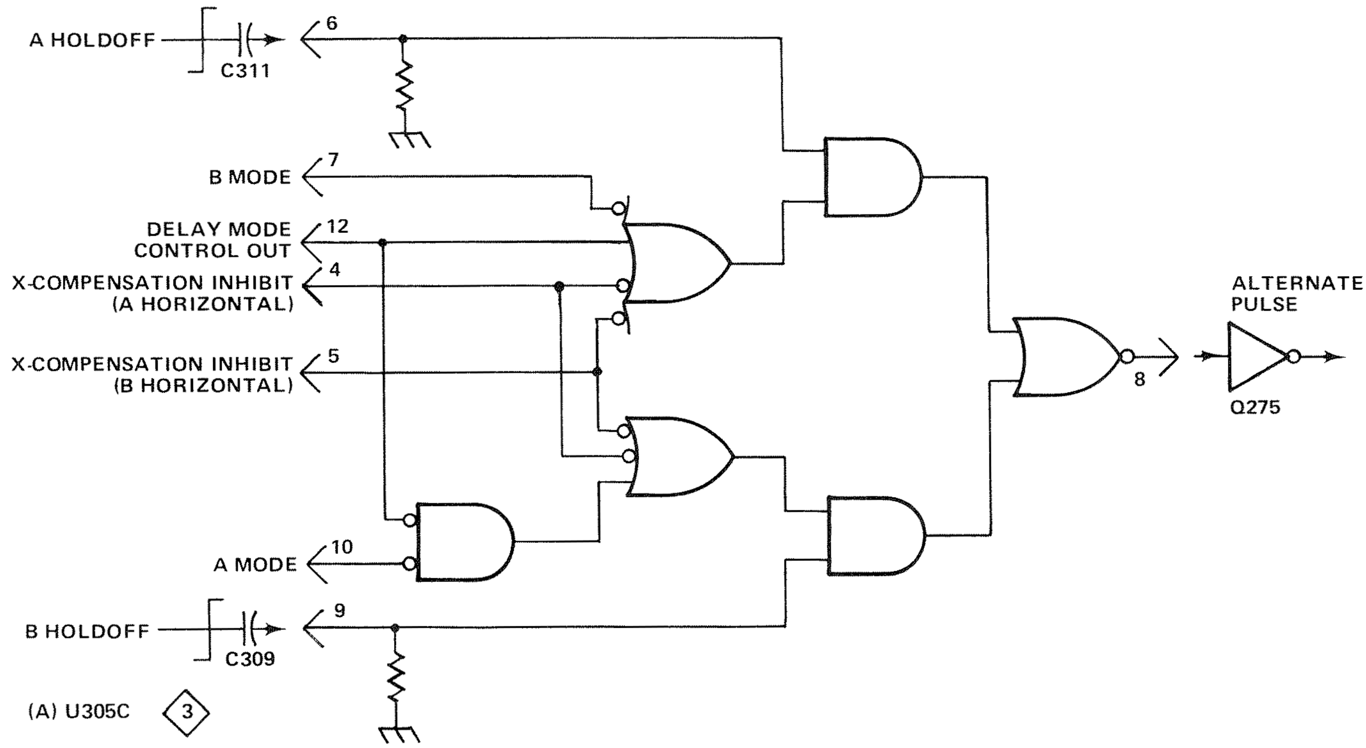
In the B position of the HORIZONTAL MODE switch, an Alternate Pulse is produced at the end of each B sweep (A time-base must be in independent, non-delayed mode).

3. ALT OR CHOP MODE

When the HORIZONTAL MODE switch is set to ALT or CHOP (A time-base unit must be in independent, non-delayed mode), an Alternate Pulse is produced at the end of each sweep. For example, an Alternate Pulse is produced at the end of the A sweep, then at the end of the B sweep, again at the end of the A sweep, etc. Although Alternate Pulses are produced in the CHOP horizontal mode, they are not used in this instrument.

4. DELAYED SWEEP (A DELAYS B)

When the A time-base unit is set for delayed operation, the operation of the Alternate Pulse Generator is changed so an Alternate Pulse is produced only at the end of the A sweep, even when the HORIZONTAL MODE switch is set to B. This is necessary since the A time-base establishes the amount of delay time for the B time-base unit whenever it is displayed.



(A) U305C ⟨3⟩

INPUT							OUTPUT	
X-COMPENSATION INHIBIT (A HORIZONTAL)	X-COMPENSATION INHIBIT (B HORIZONTAL)	A HOLDOFF	B MODE	B HOLDOFF	A MODE	DELAY MODE CONTROL OUT	TIME-BASE WHICH IS SOURCE OF ALTERNATE PULSE	
4	5	6	7	9	10	12	8[2]	HORIZONTAL CONDITIONS
HI	Φ	HI[1]	LO	Φ	HI	Φ	A	A ONLY
Φ	HI	Φ	HI	HI[1]	LO	LO	B	B ONLY
HI	HI	HI[1]	LO	HI[1]	LO	LO	A AND B	ALT OR CHOP
HI	HI	HI[1]	Φ	Φ	Φ	HI	A	A DELAYS B
HI	LO	HI[1]	LO	LO	Φ	Φ	A	A WITH VERTICAL UNIT IN B COMPARTMENT.
LO	HI	LO	Φ	HI[1]	LO	LO	B	B WITH VERTICAL UNIT IN A COMPARTMENT.
ALL OTHER COMBINATIONS							NO OUTPUT PULSE (LO AT OUTPUT)	

Φ = HAS NO EFFECT IN THIS CASE

[1]POSITIVE-GOING PULSE. WHERE BOTH A AND B HOLDOFF ARE REQUIRED TO BE HI, A HI AT EITHER INPUT PRODUCES AN ALTERNATE PULSE.

[2]NEGATIVE-GOING PULSE.

(B)

Fig. 1-6. (A) Logic diagram for Alternate Pulse Generator stage; (B) Table of input/output combinations.

5. AMPLIFIER UNIT IN HORIZONTAL COMPARTMENT

When an amplifier unit is installed in either of the horizontal plug-in compartments, the Alternate Pulse can be produced only from the remaining time-base unit. If amplifier units are installed in both horizontal compartments, an Alternate Pulse is not produced since there are no time-base units to produce a holdoff pulse.

Z-Axis Logic

The Z-Axis Logic stage produces an output current which sets the intensity of the display on the CRT. The level of this output current is determined by the setting of the A or B INTENSITY controls, by a current added during B sweep time to provide an intensified zone on the A sweep for delayed-sweep operation, or by an external signal. The input current from the A and B INTENSITY controls is switched so the output current matches the horizontal display. The Vertical Chopped Blanking, Horizontal Chopped Blanking, and readout blanking signals are applied to this stage to block the output current and blank the CRT display for vertical chopping, horizontal chopping, or during a readout display.

Figure 1-7 identifies the inputs to the Z-Axis Logic stage. This circuit is current-driven at all inputs except pins 5 and 15. The current at pins 1, 2, 9, and 16 is variable from zero to four milliamperes and is determined by the applicable current source to control the output current at pin 8.

The Vertical Chopped Blanking Inhibit connected to pin 6, and the Horizontal Chopped Blanking Inhibit connected

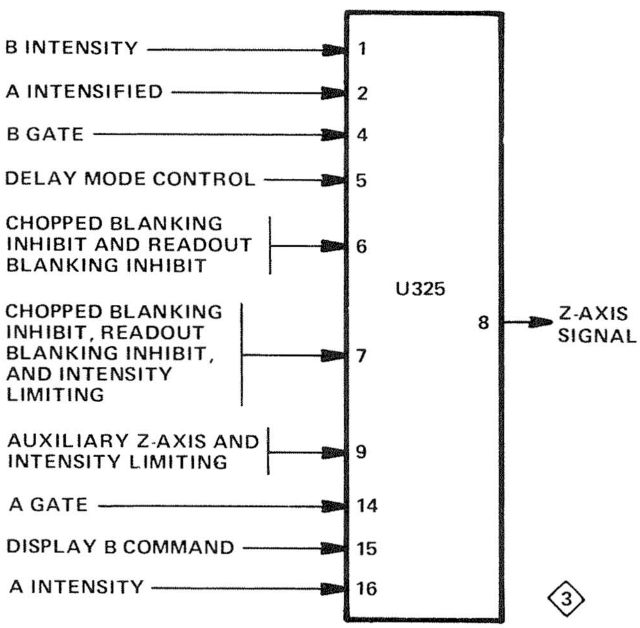


Fig. 1-7. Input and output pins for Z-Axis Logic IC (U325).

to both pins 6 and 7 through Q238-CR240-CR241, enables or disables this stage to control all output current. Quiescently, the level at pins 6 and 7 is HI so that the intensity current from pins 1, 2, 9, and 16 can pass to the output. However, pin 6 goes LO during Vertical Chopped Blanking and both pins 6 and 7 go LO for Horizontal Chopped Blanking or during a readout display. This blocks the output current and the CRT is blanked. The Vertical Chopped Blanking Inhibit signal is connected to pin 6 of U325 directly from pin 4 of U215. The Horizontal Chopped Blanking Inhibit signal is connected to U325 from pin 4 of U225 through LR232, Q238, and CR240-CR241. Notice that this signal is connected to the collector of Q238. This transistor is normally operating in the saturated condition, and the HI Horizontal Chopped Blanking Inhibit level from U225 is the collector source voltage. When the Horizontal Chopped Blanking Inhibit level goes LO, the current through Q238 drops to produce a corresponding LO level at its emitter. This level is connected to pins 6 and 7 of U325 through CR240 and CR241 respectively.

Q238 also controls the levels at pins 6 and 7 for readout displays. The Z-Axis Logic OFF Command from the Readout System is connected to the base of Q238 through VR235 and R237. This level is normally HI, so Q238 operates as controlled by the Horizontal Chopped Blanking Inhibit level at its collector. When a readout display is to be presented, the Z-Axis Logic OFF Command drops LO and this level is coupled to the base of Q238 through VR235 with very little voltage attenuation. Q238 is reverse biased to produce a LO level at its emitter. This level is coupled to pins 6 and 7 of U325 through CR240 and CR241 to block the Z-Axis Logic output current during the readout display. (The intensity of the readout display is determined by a separate READOUT intensity level connected directly to the Z-Axis Amplifier; see CRT Circuit description.) Diode CR239 clamps the emitter of Q238 at about −0.6 volt when this transistor is off.

The Beam I (current) Sense input from the CRT Circuit limits the output current of this stage to limit the maximum trace intensity. Further intensity limiting is provided for high CRT beam currents at slow sweep rates and X-Y operation by the Intensity Limit and X-Compensation Inhibit inputs respectively. For low and medium levels of CRT beam current, Q248 is reverse biased; resistors R241-R242-R243-R245-R246-R248 establish the current at pins 7 and 9 of U325. When the CRT beam current exceeds a safe level, the Beam I Sense level goes positive to forward bias Q248. When forward-biased, Q248 takes current from pins 7 and 9 of U325 to limit the output current from this stage.

The Intensity Limit and X-Compensation Inhibit inputs are connected to ground in the plug-in units for slow sweep rates and amplifier operation, respectively. This connects the emitter of Q248 to ground through CR248, CR250, or

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CR251 to further limit the output current of U325. The Intensity Limit and X-Compensation Inhibit inputs have no effect at low or medium CRT beam current levels since Q248 is reverse biased by the Beam I Sense input.

The A INTENSITY control sets the output current level when the A Gate at pin 14 is HI and the Display B Command at pin 15 is LO. Whenever the A Gate level goes LO indicating that the A sweep is complete or the Display B Command goes HI indicating that the B sweep is being displayed, the A INTENSITY current is blocked. The current from the A INTENSITY control is connected to pin 16 through R335.

In the delayed mode, current is added to the A INTENSITY current during the A-sweep time to intensify a portion of the trace. This intensified portion is coincident with the B-sweep time to provide an indication of which portion of the A sweep is displayed in the delayed mode. The A Intensified current is supplied to pin 2 of U325 from the A INTENSITY control through R331. With this configuration, the intensified current increases as the A INTENSITY control setting is advanced to provide a proportional intensity increase in the intensified zone as the overall A-sweep intensity increases. Therefore, the intensified zone is more readily visible at high intensity levels. The intensified current is added to the A INTENSITY current to produce an intensified zone on the A sweep under the following conditions: HI A Gate level at pin 14, LO Display B Command at pin 15, HI B Gate level at pin 4, and HI Delay Mode Control Out level at pin 5.

The B INTENSITY control determines the output current when the B Gate level at pin 4 and the Display B Command at pin 15 are both HI. The current from the B INTENSITY control is connected to the Z-Axis Logic stage through R337.

The current level established by the intensity controls can be altered by the Auxiliary Z-Axis current level at pin 9. The current at this pin can come from the Z AXIS INPUT connector on the rear panel (see diagram 1) or from any of the plug-in compartments. This current either increases or decreases (depending on polarity) the output current to modulate the intensity of the display. Input from the Z AXIS INPUT connector allows the trace to be modulated by external signals. The Auxiliary Z-Axis inputs from the plug-in compartments allow special-purpose plug-in units to modulate the display intensity. Diodes CR253 and CR254 limit the maximum voltage change at pin 9 to about + and −0.6 volt to protect the Z-Axis Logic stage if an excessive voltage is applied to the Z AXIS INPUT connector.

Figure 1-8A shows a logic diagram of the Z-Axis Logic stage. Notice the current-driven inputs as indicated by the current-generator symbols at the associated inputs. An input/output table for the Z-Axis Logic stage is given in Fig. 1-8B.

Horizontal Binary

The Horizontal Binary stage produces the Display B Command to determine which horizontal unit provides the sweep display on the CRT. When this level is HI, the B HORIZ unit is displayed; when it is LO, the A HORIZ unit is displayed.

The Display B Command is used in the following stages within the Logic circuit: Horizontal Logic (A and B Sweep Inhibit), Z-Axis Logic, Vertical Binary, and Trace Separation. In addition, it is connected to the following circuits elsewhere in the instrument to indicate which horizontal unit is to be displayed: Main Interface (A and B HORIZ plug-in compartments), Horizontal Amplifier (for horizontal channel selection), and the CRT Circuit.

Figure 1-9 identifies the function of the input pins for this stage. Notice that the levels at pins 3, 4, 7, and 10 are determined by the HORIZONTAL MODE switch (see diagram 2). This switch indicates which horizontal mode has been selected by providing a HI output level on only one of four output lines; the remaining lines are LO. Therefore, at any one time, either pin 3, pins 4 and 7 (notice that pins 4 and 7 are tied together at U265), or pin 10 can be HI and the two unselected lines from the HORIZONTAL MODE switch remain LO.

The Horizontal Binary stage operates as follows for each position of the HORIZONTAL MODE switch (refer to Fig. 1-10B for input/output conditions):

1. A MODE

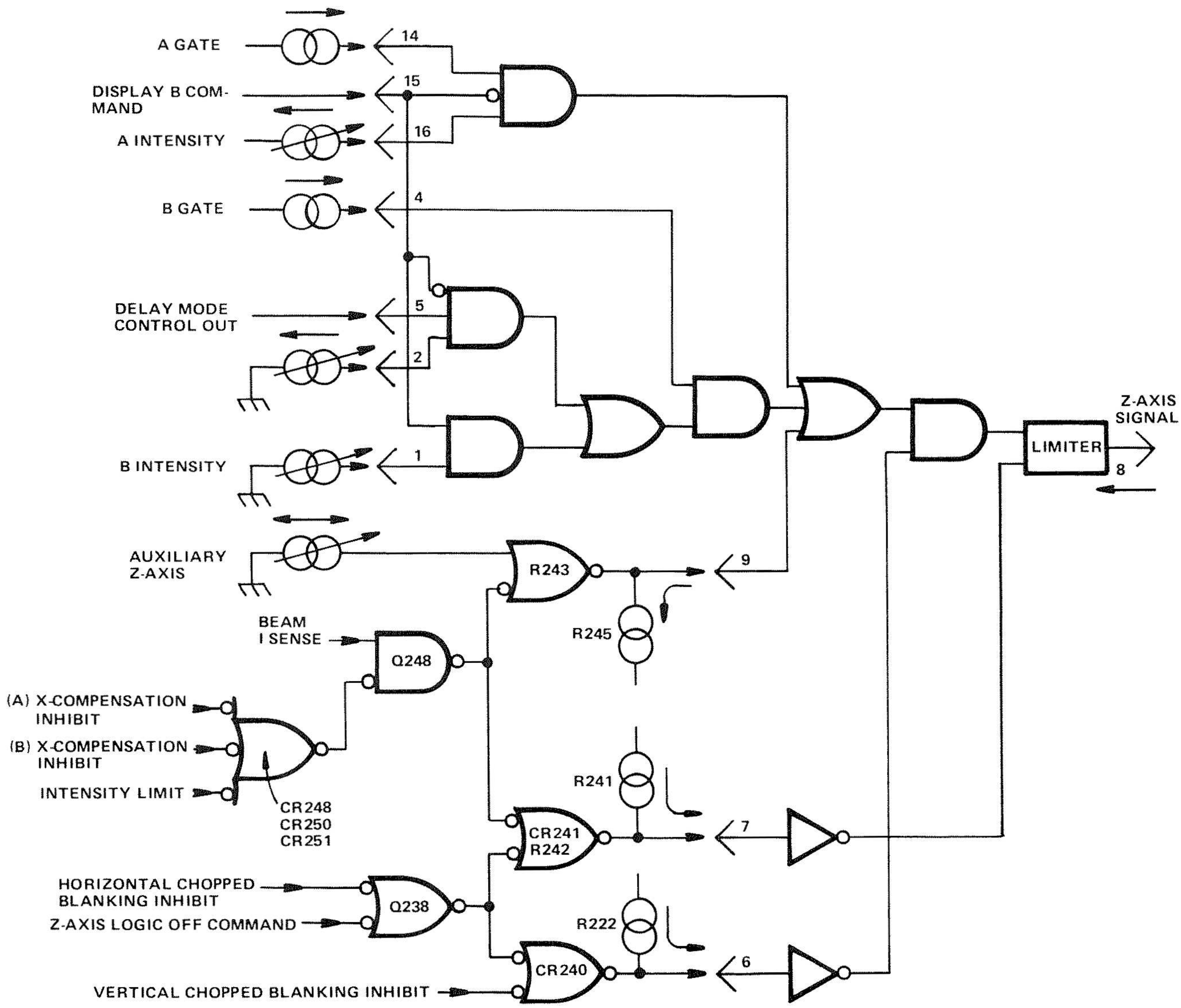
When the HORIZONTAL MODE switch is set to A, the Display B Command is LO to indicate to all circuits that the A HORIZ unit is to be displayed.

2. B MODE

Selecting the B horizontal mode provides a HI Display B Command to all circuits.

3. CHOP MODE

In the CHOP position of the HORIZONTAL MODE switch, the Display B Command switches between the HI and LO levels to produce a display that switches between the A and B HORIZ units at a 0.2-megahertz rate. The repetition rate of the Display B Command in this mode is determined by the Horizontal Chopped Blanking pulse.



(A) ◇3

INPUT										OUTPUT	
B INTENSITY	A INTENSIFIED	B GATE	DELAY MODE CONTROL OUT	CHOPPED BLANKING INHIBIT OR READOUT BLANKING INHIBIT	READOUT BLANKING INHIBIT OR INTENSITY LIMITING	AUXILIARY Z-AXIS AND INTENSITY LIMITING	A GATE	DISPLAY B COMMAND	A INTENSITY	Z-AXIS SIGNAL	CURRENT SOURCE CONTROLLING Z-AXIS SIGNAL
1[1]	2[1]	4	5	6	7	9[1]	14	15	16[1]	8[1]	
Φ	Φ	Φ	LO	HI	HI	Φ[2]	HI	LO	HI	HI	A INTENSITY
HI	Φ	HI	Φ	HI	HI	Φ[2]	Φ	HI	Φ	HI	B INTENSITY
Φ	HI	HI	HI	HI	HI	Φ[2]	HI	LO	HI	HI	A INTENSITY AND B INTENSIFIED
Φ	Φ	Φ	Φ	HI	HI	HI	Φ	Φ	Φ	LO	EXTERNAL SIGNAL
ALL OTHER COMBINATIONS											NO OUTPUT SIGNAL

LO = MINIMUM VOLTAGE OR CURRENT.
HI = MAXIMUM VOLTAGE OR CURRENT.
Φ = HAS NO EFFECT IN THIS CASE.

[1] CURRENT LEVEL. LO = 0 mA
HI = VARIABLE FROM 0 TO 4 mA

[2] CURRENT CAN BE ADDED OR SUBTRACTED FOR INTENSITY MODULATION.

Fig. 1-8. (A) Logic diagram for Z-Axis Logic stage; (B) Table of input/output combinations.

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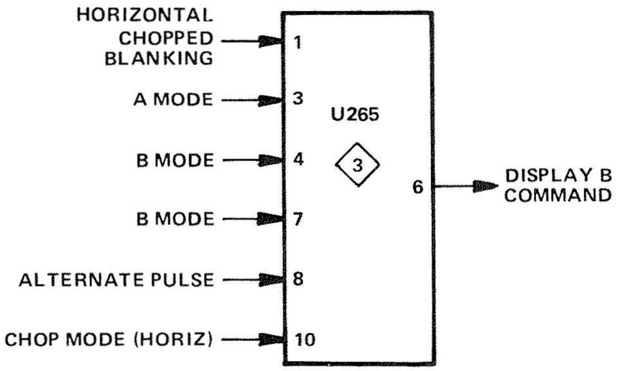
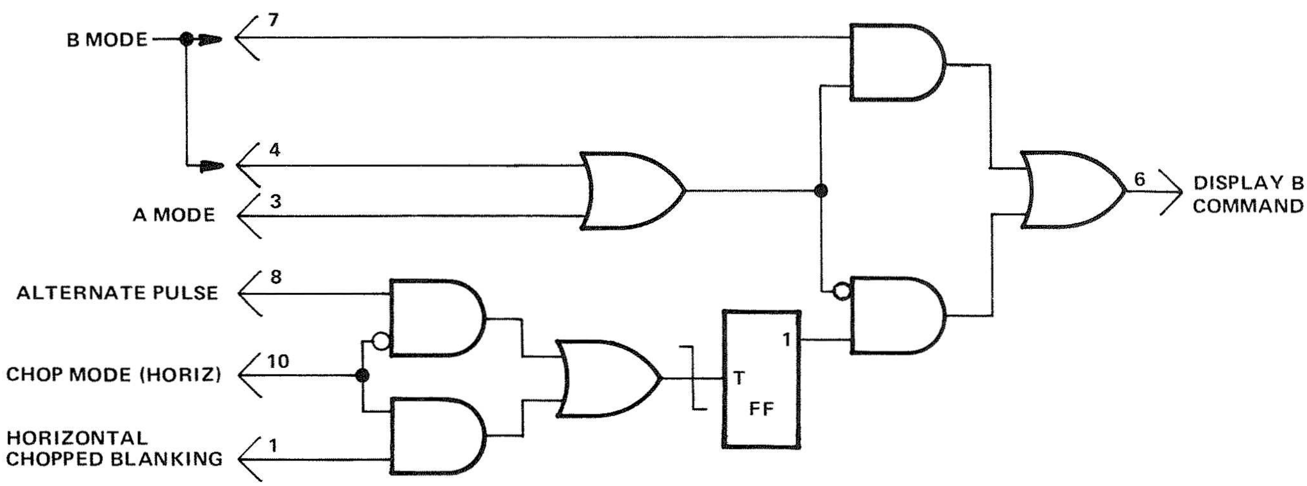


Fig. 1-9. Input and output pins for Horizontal Binary IC (U265).

(See Chop Counter stage for further information on this pulse.) Each time the Horizontal Chopped Blanking pulse at pin 1 drops LO, the output at pin 6 switches to the opposite state.

4. ALT MODE

For ALT horizontal operation, the Display B Command switches to the opposite state each time the negative portion of the Alternate Pulse is received from the Horizontal Logic stage. Repetition rate of the Display B Command in this mode is one-half the repetition rate of the Alternate Pulse.



(A) U265 ◇3

INPUT						OUTPUT	
HORIZONTAL CHOPPED BLANKING	A MODE	B MODE	B MODE	ALTERNATE PULSE	CHOP MODE (HORIZ)	DISPLAY B COMMAND	
1	3	4	7	8	10	6	HORIZONTAL DISPLAY
Φ	HI	LO	LO	Φ	LO	LO	A HORIZONTAL UNIT
Φ	LO	HI	HI	Φ	LO	HI	B HORIZONTAL UNIT
LO[1]	LO	LO	LO	Φ	HI	n+1[2]	CHOP BETWEEN A AND B
Φ	LO	LO	LO	LO[1]	LO	n+1[3]	ALTERNATE BETWEEN A AND B

Φ = HAS NO EFFECT IN THIS CASE

n+1 = IF OUTPUT IS LO PRIOR TO LO[1], IT GOES HI, AND VICE VERSA

[1] ACTUATED BY NEGATIVE-GOING EDGE.

[2] REPETITION RATE ONE-HALF HORIZONTAL CHOPPED BLANKING RATE.

[3] REPETITION RATE ONE-HALF ALTERNATE PULSE RATE.

Fig. 1-10. (A) Logic diagram for Horizontal Binary stage; (B) Table of input/output combinations.

Figure 1-10A shows a logic diagram for the Horizontal Binary stage. An input/output table showing the conditions for each position of the HORIZONTAL MODE switch is shown in Fig. 1-10B.

Vertical Binary

The Vertical Binary stage produces the Display Right Command to determine which vertical unit is to be displayed on the CRT. When this output level is HI, the RIGHT VERT unit is displayed; when it is LO, the LEFT VERT unit is displayed. In the ALT or CHOP positions of the HORIZONTAL MODE switch (non-delayed operation only), the output of this stage is slaved to the output of the Horizontal Binary stage so that the Display Right Command is always HI when the Display B Command is LO, and vice versa. This action allows independent-pairs operation (sweep-slaving) in the ALT position of the VERTICAL MODE switch and the ALT or CHOP positions of the HORIZONTAL MODE switch, whereby the LEFT VERT unit is always displayed at the sweep rate of the B time-base and the RIGHT VERT unit is displayed at the sweep rate of the A time-base. Thus, independent-pairs operation can simulate dual-beam operation for repetitive sweeps.

When the A time-base unit is set to the delaying mode, the repetition rate of the Display Right Command is one-half the repetition rate of the Display B Command input. This results in each vertical unit being displayed first against the A time-base unit (delaying), then the B time-base unit (delayed), before the display is switched to the other vertical unit.

The Display Right Command is used in the following stages within the Logic circuit: Plug-In Binary, Vertical Chopped Blanking, and Vertical Mode Logic. It is also connected to the following circuits elsewhere in the instrument to indicate which vertical unit is to be displayed (through Vertical Mode Logic stage; ALT vertical mode only): Main Interface (LEFT and RIGHT VERT plug-in compartments), Vertical Amplifier, and Trigger Selector.

Also, the Vertical Binary stage produces the Horizontal Slave Enable output to indicate that the HORIZONTAL MODE switch is set to ALT or CHOP and that the A time-base unit is set for non-delayed operation. These are the horizontal-mode conditions necessary for independent-pairs operation. When this output level is HI, the horizontal-mode conditions are correct for independent-pairs operation. A LO output level indicates improper horizontal modes for independent-pairs operation. The Horizontal Slave Enable output is used within the Vertical Binary stage, and is also connected to the Trigger Selector circuit. This enables the trigger-selection circuitry to automatically select the correct internal trigger signal source for both time-base units when operating in the independent-pairs mode (VERT MODE trigger source; see Trigger Selector circuit).

Figure 1-11 identifies the function of the input pins for the Vertical Binary IC (U275). This stage uses the same type of IC as the Horizontal Binary stage. Notice the Display A level at pin 7. This input is the inverse of the Display B level at pin 8. Therefore, the Display A level is always HI when the Display B level is LO, and vice versa.

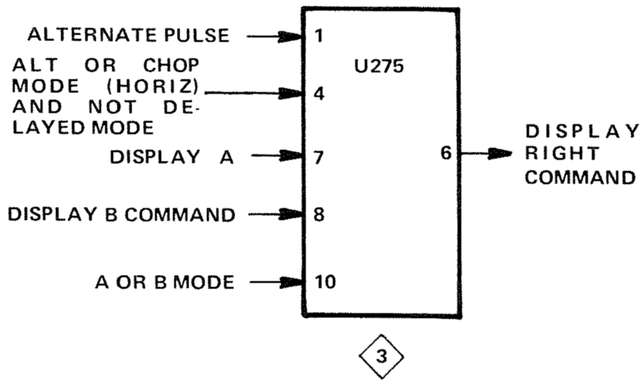


Fig. 1-11. Input and output pins for Vertical Binary IC (U275).

The following discussions describe the operation of the Vertical Binary stage in relation to the modes of operation that can occur.

NOTE

Although the output at pin 6 of U275 is always controlled by the HORIZONTAL MODE switch as described here, this level determines the Vertical Mode Control level at the collector of Q296 only in the ALT position of the VERTICAL MODE switch due to AND gate CR201-CR204. See the discussion on the Vertical Mode Logic stage in this section for further information.

1. A OR B MODE

When the HORIZONTAL MODE switch is set to either A or B, the Display Right Command switches to the opposite state each time an Alternate Pulse is received from the Horizontal Logic stage. Repetition rate of the Display Right Command in this mode is one-half the repetition rate of the Alternate Pulse. The input conditions for these modes are:

Pin 1 LO—Alternate Pulse generated by Horizontal Logic stage goes negative.

Pin 4 LO—HORIZONTAL MODE switch in any position except ALT or CHOP, or the A time-base unit is set for delayed sweep.

Pin 10 HI—HORIZONTAL MODE switch set to A or B.

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2. ALT OR CHOP MODE (HORIZ)—NON-DELAYED

In the ALT or CHOP positions of the HORIZONTAL MODE switch, the output level at pin 6 is the same as the Display A level at pin 7. The Display A level is produced by inverting the Display B Command from the Horizontal Binary stage. Therefore, the repetition rate of the output signal is the same as the Display B Command. The result, with the VERTICAL MODE switch set to ALT and the A time-base unit set for non-delayed operation, is that the RIGHT VERT unit is always displayed at the sweep rate of the A time-base unit, and the LEFT VERT unit at the sweep rate of the B time-base unit (independent-pairs operation or sweep slaving). The input conditions to provide a HI output level so that the RIGHT VERT unit can be displayed at the A-sweep rate are:

Pin 4 HI—HORIZONTAL MODE switch set to ALT or CHOP with non-delayed sweep.

Pin 7 HI—A sweep is to be displayed (Display B Command LO).

Pin 10 LO—HORIZONTAL MODE switch set to any position except A or B.

The input conditions to provide a LO output level so the LEFT VERT unit can be displayed at the B-sweep rate are:

Pin 4 HI—HORIZONTAL MODE switch set to ALT or CHOP with non-delayed sweep.

Pin 7 LO—B sweep is to be displayed (Display B Command HI).

Pin 10 LO—HORIZONTAL MODE switch set to any position except A or B.

The Display Right Command switches from HI to LO along with the Display A level at pin 7 (inverse of Display B Command). However, notice that the Display Right Command changes from HI to LO as the Display B Command changes from LO to HI, and vice versa.

3. ALT OR CHOP MODE (HORIZ)—DELAYED

If the A time-base unit is set to the delayed mode when the HORIZONTAL MODE switch is set to either ALT or CHOP, the operation of the stage is changed from that discussed above. Now, the Display Right Command switches between the HI and LO states at a rate that is one-half the repetition rate of the Display B Command. The resultant CRT display in the ALT position of the VERTICAL MODE switch allows the RIGHT VERT unit to be displayed first against the A sweep (delaying) and then against the B sweep (delayed). Then the display switches to the LEFT VERT unit and is displayed consecutively against the A and B sweeps in the same manner. The input conditions for this mode of operation are:

Pin 4 LO— A time-base unit set for delayed operation.

Pin 8 LO— Display B Command generated by Horizontal Binary stage goes negative.

Pin 10 LO—HORIZONTAL MODE switch set to any position except A or B.

A logic diagram of the Vertical Binary stage is shown in Fig. 1-12A. Several logic functions in this stage are performed by logic devices made up of discrete components. The components that make up these logic devices are identified on the logic diagram. An input/output table for the Vertical Binary stage is given in Fig. 1-12B.

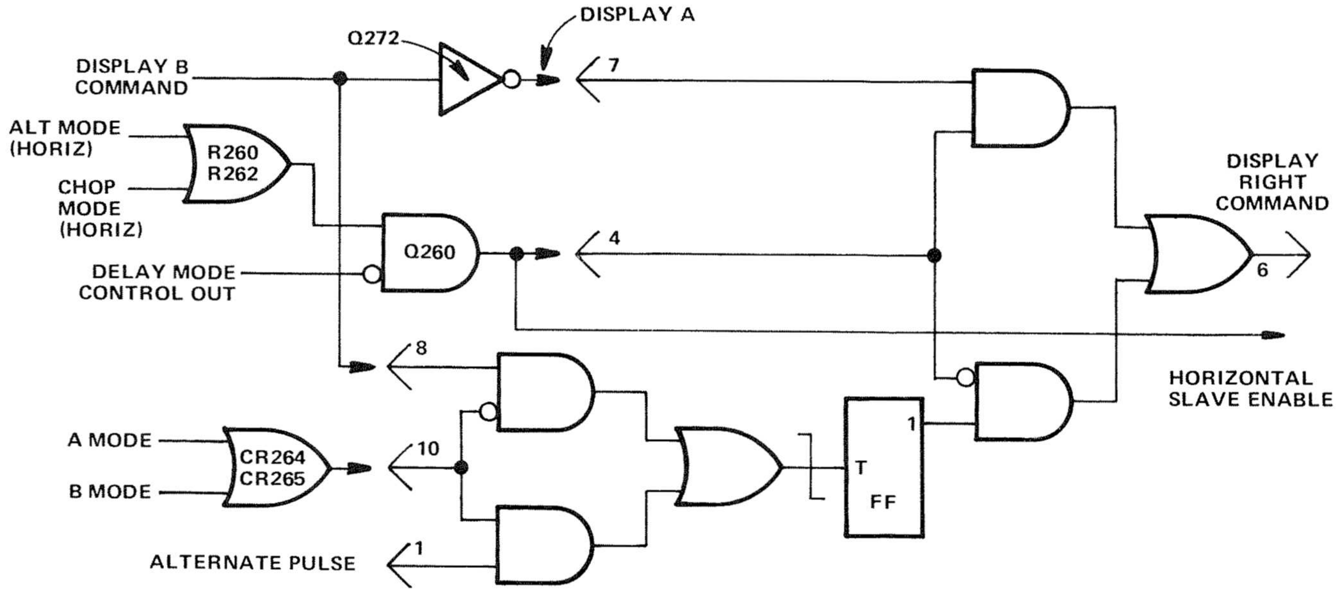
Plug-In Binary

The Plug-In Binary stage produces the Plug-In Alternate Command to dual-trace units. Figure 1-13 identifies the function of the input pins for the Plug-In Binary IC, U285. This stage uses the same type of integrated circuit as the Horizontal Binary and Vertical Binary stages.

When the Plug-In Alternate Command level is HI and the plug-in unit is set for alternate operation, Channel 2 of the dual-trace unit is displayed. When it is LO, Channel 1 is displayed. The repetition rate of the Plug-In Alternate Command is determined by the setting of the VERTICAL MODE switch. For all positions of the VERTICAL MODE switch except ALT, the Plug-In Alternate Command level is the same as the Display Right Command from the Vertical Binary stage. Since the Display Right Command is derived directly from the Display B Command, this allows the two channels of a dual-trace vertical unit to be slaved to the time-base units (non-delayed, dual-sweep horizontal modes only) in the same manner as previously described for independent-pairs operation between the vertical and time-base units. The resultant CRT presentation, when the dual-trace unit is set for alternate operation, displays the Channel 1 trace at the sweep rate of the B time-base unit and the Channel 2 trace at the sweep rate of the A time-base unit. Input conditions for a LO output level so that Channel 1 of the vertical plug-in can be displayed at the B-sweep rate are:

Pin 4 HI—VERTICAL MODE switch set to any position except ALT.

Pin 7 LO—B sweep to be displayed (Display Right Command and Display B Command HI).



(A) U275 ◇3

INPUT					OUTPUT	
ALTERNATE PULSE	ALT OR CHOP MODE (HORIZ) AND NOT DELAYED MODE	DISPLAY A	DISPLAY B COMMAND	A OR B MODE	DISPLAY RIGHT COMMAND	
1	4	7	8	10	6	HORIZONTAL MODE
LO[1]	LO	Φ	Φ	HI	n+1[2]	A OR B
Φ	HI	HI	LO	LO	HI	DISPLAY RIGHT } ALT OR CHOP, NON-DELAYED MODE (SWEEP-SLAVING)
Φ	HI	LO	HI	LO	LO	DISPLAY LEFT } ALT OR CHOP, NON-DELAYED MODE (SWEEP-SLAVING)
Φ	LO	Φ	LO[1]	LO	n+1[3]	ALT OR CHOP, DELAYED MODE

Φ = HAS NO EFFECT IN THIS CASE.

n+1 = IF OUTPUT IS LO PRIOR TO LO[1] IT GOES HI, AND VICE VERSA.

[1] ACTUATED BY NEGATIVE-GOING EDGE.

[2] REPETITION RATE ONE-HALF ALTERNATE PULSE RATE.

(B) [3] REPETITION RATE ONE-HALF DISPLAY B RATE.

Fig. 1-12. (A) Logic diagram for Vertical Binary stage; (B) Table of input/output combinations.

The input conditions to provide a HI output level so that Channel 2 of the plug-in unit can be displayed at the A-sweep rate are:

Pin 4 HI—VERTICAL MODE switch set to any position except ALT.

Pin 7 HI— A sweep to be displayed (Display Right Command and Display B Command LO).

The Plug-In Alternate Command switches from HI to LO as the Display B Command from the Horizontal Binary stage switches from LO to HI, and vice versa.

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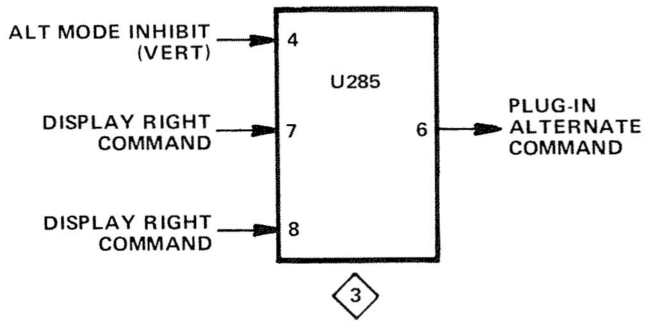


Fig. 1-13. Input and output pins for Plug-In Binary IC (U285).

When the VERTICAL MODE switch is set to ALT, the Display Right Command from the Vertical Binary stage switches the vertical display between the two vertical units. However, if either of the vertical plug-in units are dual-trace units, they can be operated in the alternate mode also. To provide a switching command to these units, the Plug-In Binary stage produces an output signal with a repetition rate that is one-half the repetition rate of the Display Right Command. The sequence of operation, when two dual-trace vertical units are installed in the vertical plug-in compartments and they are both set for alternate operation, is as follows (VERTICAL MODE and HORIZONTAL MODE switches set to ALT): 1. Channel 1 of LEFT VERT unit at sweep rate of B time-base unit, 2. Channel 1 of RIGHT VERT unit at sweep rate of A time-base unit, 3. Channel 2 of LEFT VERT unit at sweep rate of B time-base unit, 4. Channel 2 of RIGHT VERT unit at sweep rate of A time-base unit. Notice that under these conditions, both channels of the LEFT VERT unit are displayed at the B-sweep rate and that both channels of the RIGHT VERT unit are displayed at the A-sweep rate. The repetition rate at the output of this stage is one-half the Display Right Command rate. Input conditions when the VERTICAL MODE switch is set to ALT are:

Pin 4 LO—VERTICAL MODE switch set to ALT.

Pin 8 LO—Display Right Command generated by Vertical Binary stage goes negative.

Figure 1-14A shows a logic diagram of the Plug-In Binary stage. An input/output table for this stage is given in Fig. 1-14B.

Clock Generator

Part of integrated circuit U215, along with the external components shown in Fig. 1-15A, make up the Clock Generator stage. R1, Q1, Q2, and Q3 represent an equivalent circuit within U215A. This circuit, along with discrete components C213-R212-R213-R214, compose a two-megahertz free-running oscillator to provide a timing (Clock) signal used to synchronize the vertical, horizontal, and plug-in chopping modes.

This stage operates as follows: Assume that Q2 is conducting and Q1 is off. The collector current of Q2 produces a voltage drop across R1 to cut off Q1. This negative level at the collector of Q2 is also connected to pin 14 through Q3 (see waveforms in Fig. 1-15B at time T_0). Since there is no current through Q1, C213 begins to charge towards −15 volts through R212-R213. The emitter of Q1 goes negative as C213 charges, until it reaches a level about 0.6 volt more negative than the level at its base. Then, Q1 is forward biased and its emitter rapidly rises positive (see time T_1 on waveforms). Since C213 cannot change its charge instantaneously, the sudden change in voltage at the emitter of Q1 pulls the emitter of Q2 positive also, to reverse-bias it. With Q2 reverse biased, its collector rises positive to produce a positive output level at pin 14.

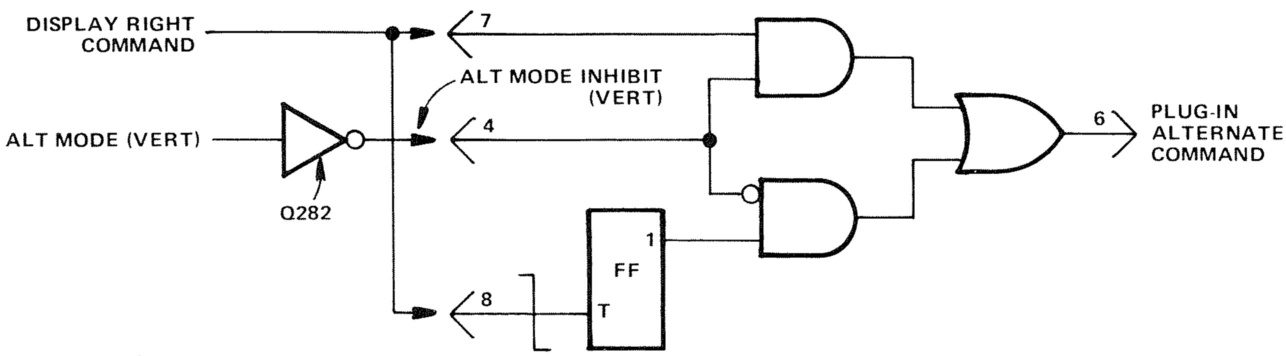
Now, conditions are reversed. Since Q2 is reverse biased, there is no current through it. Therefore, C213 can begin to discharge through R214. The emitter level of Q2 follows the discharge of C213 until it reaches a level about 0.6 volt more negative than its base. Then, Q2 is forward biased and its collector drops negative to reverse-bias Q1. The level at pin 14 drops negative also, to complete the cycle. Once again, C213 begins to charge through R212-R213 to start the second cycle.

Two outputs are provided from this oscillator. The Delay Ramp signal from the junction of R212-R213 is connected to the Vertical Chopped Blanking stage. This signal has the same waveshape as shown by the waveform at pin 13; its slope is determined by the divider ratio between R212-R213. A square-wave output is provided at pin 14. The frequency of this square wave is determined by the overall RC relationship between C213-R212-R213-R214, and its duty cycle is determined by the ratio of R212-R213 to R214.

The square wave at pin 14 is connected to pin 16 through C218. C218, along with the internal resistance of U215A, differentiates the square wave at pin 14 to produce a negative-going pulse coincident with the falling edge of the square wave (positive-going pulse coincident with rising edge has no effect on circuit operation). This negative-going pulse is connected to pin 15 through an inverter-shaper that is also part of U215A. The output at pin 15 is a positive-going Clock pulse with a repetition rate of about two megahertz.

Vertical Chopped Blanking

The Vertical Chopped Blanking stage is made up of the remainder of U215. This stage determines if Vertical



(A) U285 ⟨3⟩

INPUT			OUTPUT	
ALT MODE INHIBIT (VERT)	DISPLAY RIGHT COMMAND	DISPLAY RIGHT COMMAND	PLUG-IN ALTERNATE COMMAND	
4	7	8	6	COMMENTS
LO	Φ	LO[1]	n+1[2]	ALT VERTICAL MODE
HI	LO	Φ	LO	CHANNEL 1 DISPLAYED } ALL VERTICAL MODES EXCEPT ALT PROVIDE SWEEP-SLAVING FOR NON-DELAYED DUAL-SWEEP OPERATION.
HI	HI	Φ	HI	CHANNEL 2 DISPLAYED

Φ = HAS NO EFFECT IN THIS CASE.

n+1 = IF OUTPUT IS LO PRIOR TO LO[1] IT GOES HI, AND VICE VERSA.

[1] ACTUATED BY NEGATIVE-GOING EDGE.

(B) [2] REPETITION RATE ONE-HALF DISPLAY RIGHT COMMAND RATE.

Fig. 1-14. (A) Logic diagram for Plug-In Binary stage; (B) Table of input/output combinations.

Chopped Blanking pulses are required, based upon the operating mode of the vertical system or the plug-in units (dual-trace units only). Vertical Chopped Blanking pulses are produced if: 1. VERTICAL MODE switch is set to CHOP; 2. Dual-trace vertical unit is operating in the chopped mode and that unit is being displayed; 3. Dual-trace vertical unit operating in the chopped mode with the VERTICAL MODE switch set to ADD. The repetition rate of the negative-going Vertical Chopped Blanking pulse output at pin 4 is two megahertz for all of the above conditions as determined by the Clock Generator stage.

Figure 1-16 shows a logic diagram and an input/output table for the Vertical Chopped Blanking stage. Notice the comparator block on the diagram. The output of this comparator is determined by the relationship between the levels of its inputs. If pin 10 is more positive (HI) than the grounded input, the output is HI also: if it is more negative, the output is LO.

The Delay Ramp signal from the Clock Generator stage determines the repetition rate and pulse width of the Vertical Chopped Blanking pulses. The Delay Ramp applied to pin 10 starts to go negative from a level of about +1.1 volts coincident with the leading edge of the Clock pulse (see waveforms in Fig. 1-17). This results in a HI quiescent condition for the Vertical Chopped Blanking pulse. The slope of the negative-going Delay Ramp is determined by the Clock Generator stage. As it reaches a level slightly negative from ground, the Vertical Chopped

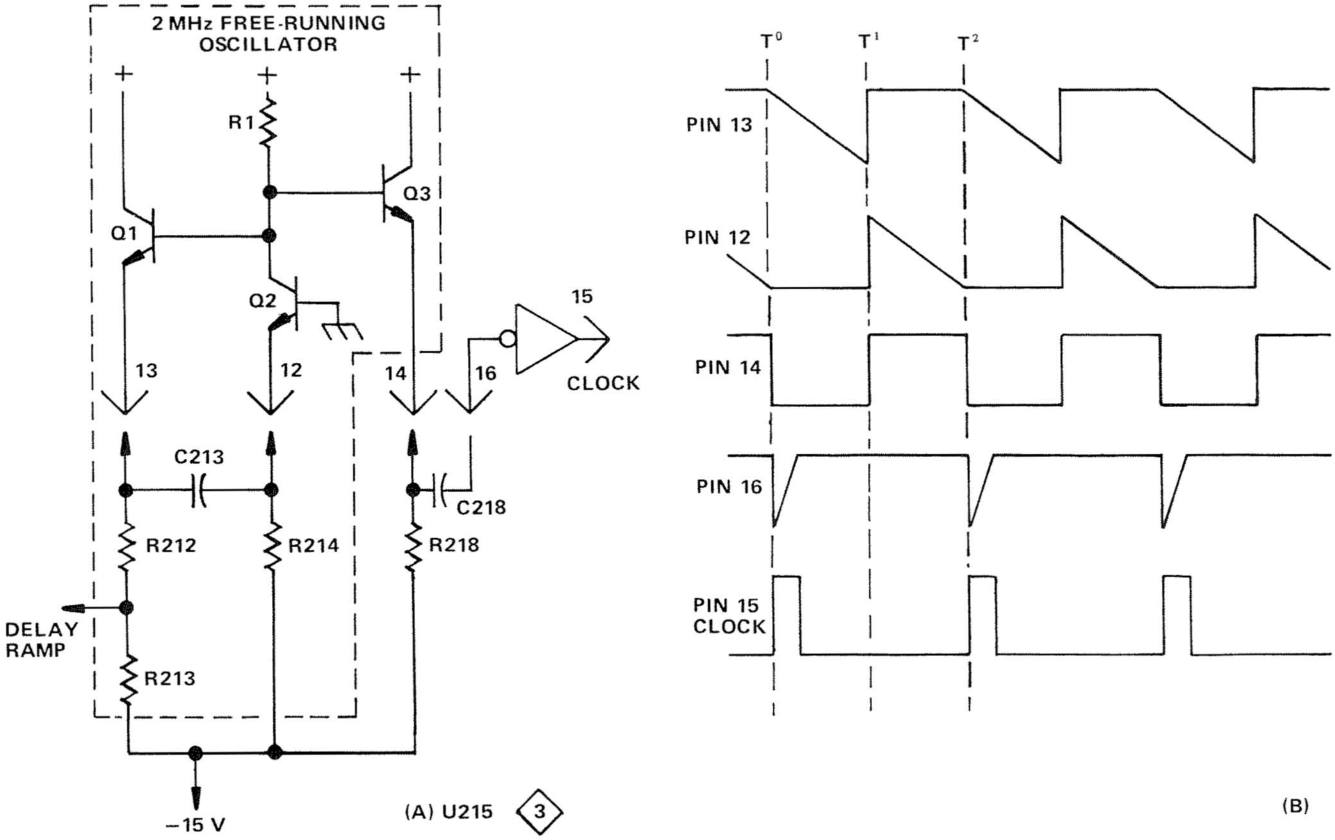


Fig. 1-15. (A) Diagram of Clock Generator stage; (B) Idealized waveforms for Clock Generator stage.

Blanking pulse output level changes to the LO state and remains LO until the Delay Ramp goes HI again.

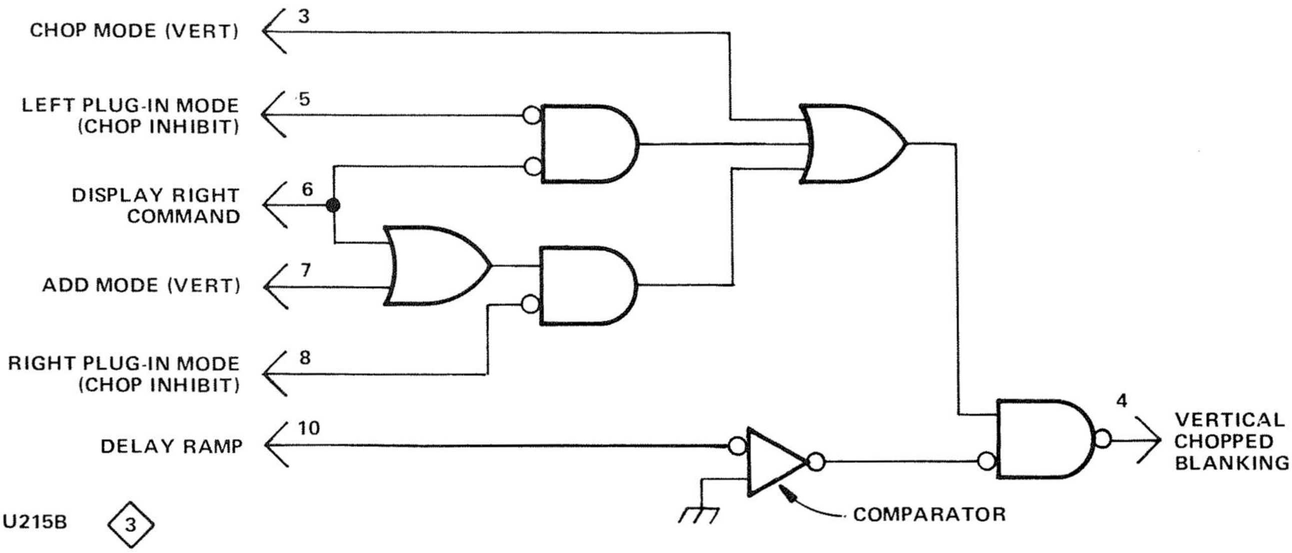
Notice the delay between the leading edge of the Clock pulse generated by U215A, and the leading edge of the Vertical Chopped Blanking pulses. The amount of delay between the leading edges of these pulses is determined by the Delay Ramp applied to pin 10. This delay is necessary due to the delay line in the vertical deflection system. Otherwise, the trace blanking resulting from the Vertical Chopped Blanking pulse would not coincide with the switching between the displayed traces. The duty cycle of the square wave produced in the Clock Generator stage determines the pulse width of the Vertical Chopped Blanking pulses (see Clock Generator description for more information).

Chop Counter

The Chop Counter stage (U225) produces the Vertical Chopping signal, the Plug-In Chop Command, and the Horizontal Chopped Blanking signal. The Clock pulse produced by the Clock Generator stage provides the timing signal for this stage. The functions of the input and output pins for the Chop Counter IC, U225, are identified in Fig. 1-18A. Idealized waveforms showing the timing relationship between the input and output signals for this stage are shown in Fig. 1-18B.

The repetition rate of the output signals from this stage is determined by the setting of the HORIZONTAL MODE switch. When the HORIZONTAL MODE switch is set to any position except CHOP, the repetition rate of the Vertical Chopping Signal output at pin 1 is one megahertz (one-half Clock rate). This determines the switching between the LEFT and RIGHT VERT units when the VERTICAL MODE switch is set to CHOP. At the same time, the repetition rate of the Plug-In Chop Command at pin 8 is 0.5 megahertz (one-fourth Clock rate). This provides a chopping signal to dual-trace vertical units to provide switching between the two channels. The relationship between these output signals and the Clock input is shown by the waveforms in Fig. 1-18B in the area between T_0 and T_1. During this time, the level at pin 4 remains HI.

When the HORIZONTAL MODE switch is set to CHOP, the basic repetition rate of the Vertical Chopping Signal and the Plug-In Chop Command is altered. For example, if the HORIZONTAL MODE switch is changed to the CHOP position at time T_1 (see Fig. 1-18B), a HI level is applied to pin 6. This stage continues to produce outputs at pins 1 and



(A) U215B ◇3

INPUT						OUTPUT	
CHOP MODE (VERT)	LEFT PLUG-IN MODE (CHOP INHIBIT)	DISPLAY RIGHT COMMAND	ADD MODE (VERT)	RIGHT PLUG-IN MODE (CHOP INHIBIT)	DELAY RAMP	VERTICAL CHOPPED BLANKING	
3	5	6	7	8	10[1]	4[2]	CONDITIONS
HI	Φ	Φ	LO	Φ	LO	LO	CHOP MODE (VERT)
LO	LO	LO	LO	Φ	LO	LO	LEFT PLUG-IN CHOPPED
LO	Φ	HI	LO	LO	LO	LO	RIGHT PLUG-IN CHOPPED
LO	LO[3]	LO	HI	LO[3]	LO	LO	ADD MODE, LEFT OR RIGHT PLUG-IN CHOPPED
ALL OTHER COMBINATIONS						HI	NO VERTICAL CHOPPED BLANKING PULSES AT OUTPUT

Φ = HAS NO EFFECT IN THIS CASE

[1] RAMP SIGNAL; CONSIDERED LO WHEN MORE NEGATIVE THAN ABOUT ZERO VOLTS.

[2] NEGATIVE-GOING PULSE AT TWO MEGAHERTZ RATE.

(B) [3] PIN 5 CAN BE HI AND NOT AFFECT OPERATION IF PIN 8 IS LO, AND VICE VERSA.

Fig. 1-16. (A) Logic diagram for Vertical Chopped Blanking stage; (B) Table of input/output combinations.

8 in the normal manner until both outputs are at their HI level. (See time T_2; this condition only occurs once every fifth Clock pulse when the HORIZONTAL MODE switch is set to CHOP.) When both of these outputs are at their HI level, the next Clock pulse switches both outputs LO, and at the same time switches the Horizontal Chopped Blanking to the LO level.

This change at time T_2 does not appear at pin 4 immediately, due to a delay network in the circuit. The delay is necessary to make the Horizontal Chopped Blanking coincide with the Vertical Chopped Blanking produced by U215A and the switching between the displayed signals. (Compare bottom two waveforms of Fig. 1-18B; also see Vertical Chopped Blanking for further information.) After the delay time, the output level at pin 4 goes LO where it remains for about 0.5 microsecond which is equal to the period of the Clock pulse (two-megahertz repetition rate).

The Horizontal Chopped Blanking time must be longer than the Vertical Chopped Blanking time, since it takes

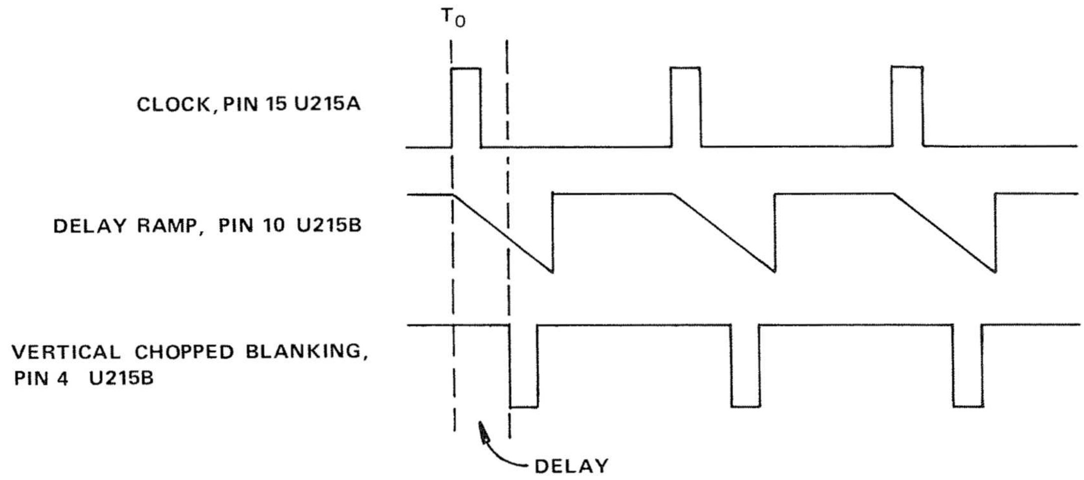


Fig. 1-17. Idealized waveforms for Vertical Chopped Blanking stage.

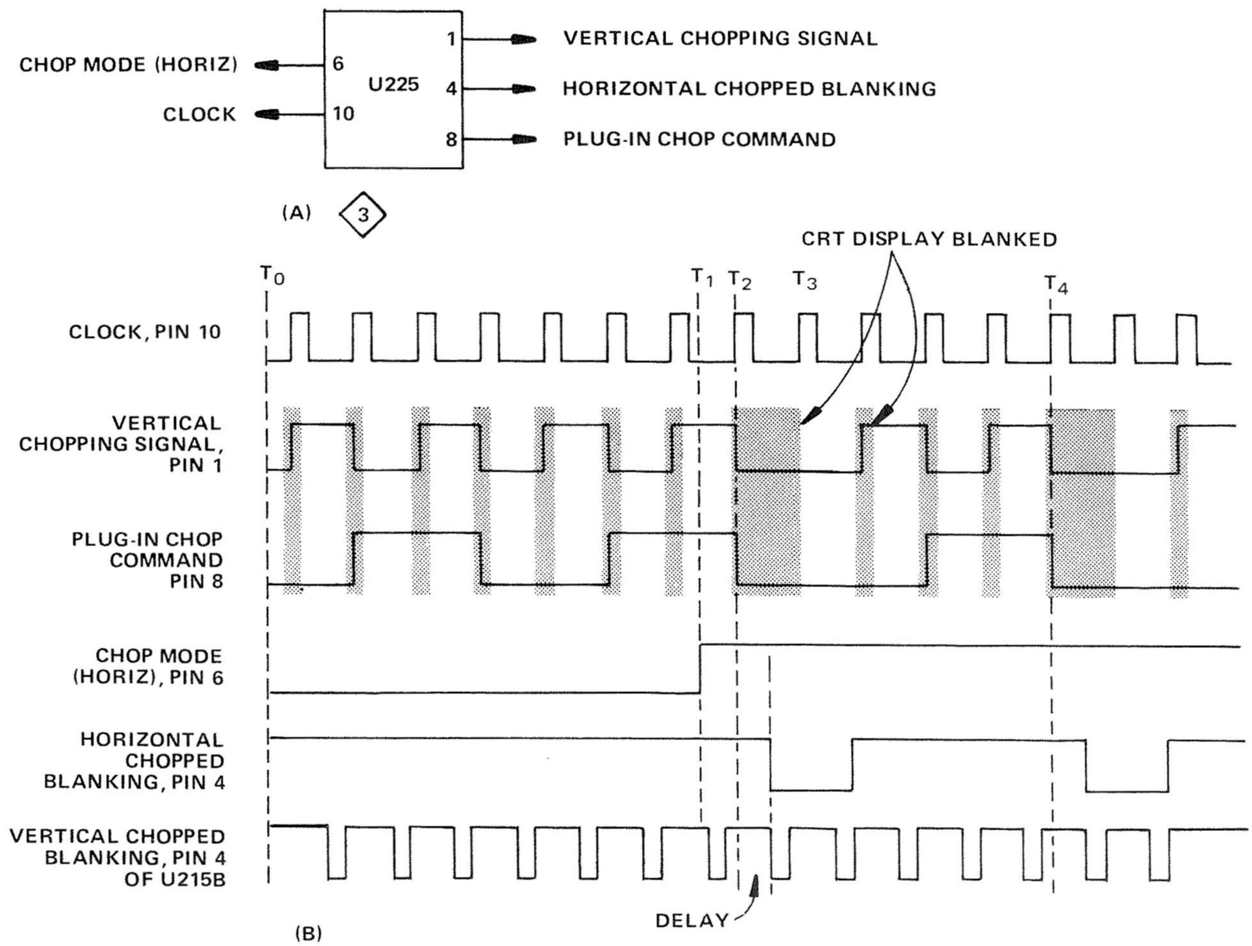


Fig. 1-18. (A) Input and output pins for Chop Counter IC, U225; (B) Idealized waveforms for Chop Counter stage.

more time for the display to switch between horizontal units than between vertical units. During the time that the level at pin 4 is LO, the CRT is blanked and the Vertical Chopping Signal and the Plug-In Chop Command cannot change levels. The Clock pulse at T_3 changes only the Horizontal Chopped Blanking output at pin 4. The level on this pin goes HI after the delay time to unblank the CRT.

For the next three Clock pulses, the Vertical Chopping Signal output and Plug-In Chop Command operate in the normal manner. However, just prior to the fourth Clock pulse (time T_4), both outputs are again at their HI level. The fourth Clock pulse at T_4 switches the output at pin 1, pin 8, and pin 4 (after delay) to the LO level to start the next cycle. Notice that a Horizontal Chopped Blanking pulse is produced at pin 4 with every fifth Clock pulse. Also notice that with the HORIZONTAL MODE switch set to CHOP, two complete cycles of the Vertical Chopping Signal are produced with each five Clock pulses (repetition rate two-fifths Clock rate) and one complete cycle of the Plug-In Chop Command for every five Clock pulses (one-fifth Clock rate). Notice that the large shaded area produced by the Horizontal Chopped Blanking pulse (see Fig. 1-18B) is not part of the display time (CRT display blanked). However, about the same time segment is displayed from the vertical signal source with or without Horizontal Chopped Blanking, due to the change in repetition rate when in the CHOP horizontal mode.

The Vertical Chopping Signal at pin 1 of U225 is connected to the Vertical Mode Logic stage (see following description) through L224-R224. This signal is HI when the RIGHT VERT unit is to be displayed and it is LO when the LEFT VERT unit is to be displayed. The Plug-In Chop Command at pin 8 is connected to the plug-in units in the vertical compartments through L228-R228 via the Main Interface board. When this signal is HI, Channel 2 of the plug-in units can be displayed; when this level is LO, Channel 1 can be displayed. The Horizontal Chopped Blanking signal at pin 4 is connected through LR232 to the Horizontal Binary stage U265, and to the Z-Axis Logic stage U325 by way of Q238. When this signal is HI, the CRT is unblanked to display the selected signal. When it is LO, the CRT is blanked to allow switching between the horizontal units.

A logic diagram of the Chop Counter stage is shown in Fig. 1-19. Details of operation for the flip-flops (FF) are shown in Table 1-1 at the front of this section. Use the waveforms given in Fig. 1-18B along with this diagram.

Vertical Mode Logic

The Vertical Mode Logic stage is made up of discrete components CR202-CR203, CR201-CR204, and buffer Q292-Q296. These components develop the Vertical Mode Command, which is connected to the Main Interface, Vertical Amplifier, and Trigger Selector circuits to indicate which vertical unit is to be displayed. When this output level is HI, the RIGHT VERT unit is displayed; when it is LO, the LEFT VERT unit is displayed.

The VERTICAL MODE switch shown on diagram 2 provides control levels to this stage. This switch provides a

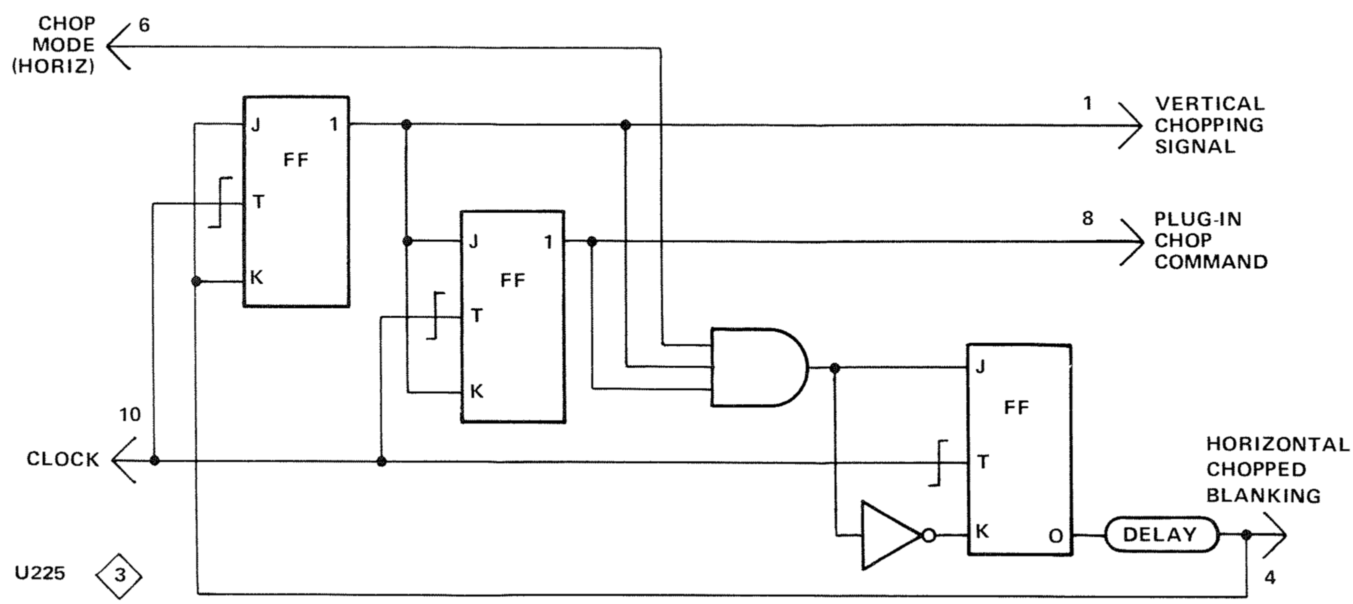


Fig. 1-19. Logic diagram of Chop Counter stage.

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HI level on only one of five output lines to indicate the selected vertical mode; the remaining lines are LO. Notice that only four of the lines from the VERTICAL MODE switch are connected to the Logic circuit. Operation of this stage is as follows:

When the VERTICAL MODE switch is set to RIGHT, a HI level is connected to the base of Q292 through R204. This forward biases Q292, and the positive-going level at its emitter is connected to the emitter of Q296. The collector of Q296 goes HI to indicate that the RIGHT VERT unit is to be displayed. For the CHOP position of the VERTICAL MODE switch, a HI level is applied to the anodes of CR202-CR203 through R202. Both diodes are forward biased so that the Vertical Chopping Signal from pin 1 of U225 can pass to the base of Q292. This signal switches between the HI and LO levels at a one-megahertz rate and produces a corresponding Vertical Mode Command output at the collector of Q296. When the output is HI, the RIGHT VERT unit is displayed and when it switches to LO, the LEFT VERT unit is displayed.

In the ALT position of the VERTICAL MODE switch, a HI level is applied to the anodes of CR201-CR204 through R201. These diodes are forward biased so the Display Right Command from pin 6 of the Vertical Binary stage can pass to the base of Q292 to determine the Vertical Mode Command level. The Display Right Command switches between its HI and LO levels at a rate determined by the Vertical Binary stage.

The control levels in the LEFT and ADD positions of the VERTICAL MODE switch are not connected to this stage. However, since only the line corresponding to the selected vertical mode can be HI, the RIGHT, CHOP, and ALT lines must remain at their LO level when either LEFT or ADD are selected. Therefore, the base of Q292 remains LO to produce a LO Vertical Mode Command output level at the collector of Q296.

A logic diagram of the Vertical Mode Logic stage is shown in Fig. 1-20. The discrete components that make up each logic function are identified.

Trace Separation

The Trace Separation stage is made up of discrete components Q342, Q347, Q350, and Q352. This stage produces the Trace Separation output to the Vertical Amplifier circuit to offset the B-sweep display when operated in a dual-sweep mode (horizontal). The level of this output current is determined by the setting of the VERT TRACE SEPARATION (B) control. The current from the VERT TRACE SEPARATION (B) control is switched so that the Trace Separation output is provided only when the B sweep is being displayed in the ALT or CHOP horizontal modes and not when B sweep only is being displayed, nor for independent-pairs operation (sweep slaving). Operation of this stage is as follows:

The VERT TRACE SEPARATION (B) control provides current to the Trace Separation output through R351 and Q352 when Q352 is forward biased. When the B sweep is being displayed (for ALT or CHOP horizontal operation), the Display B Command at the base of Q347 is HI. This forward biases Q347 causing its collector to go negative to forward-bias Q350. This causes Q350 to saturate and its collector goes positive to forward bias Q352. During the time the A sweep is being displayed, the Display B Command is LO. This reverse biases Q347 and Q350; Q352 is reverse biased through CR349 and R349. Since Q352 is reverse biased, the VERT TRACE SEPARATION (B)

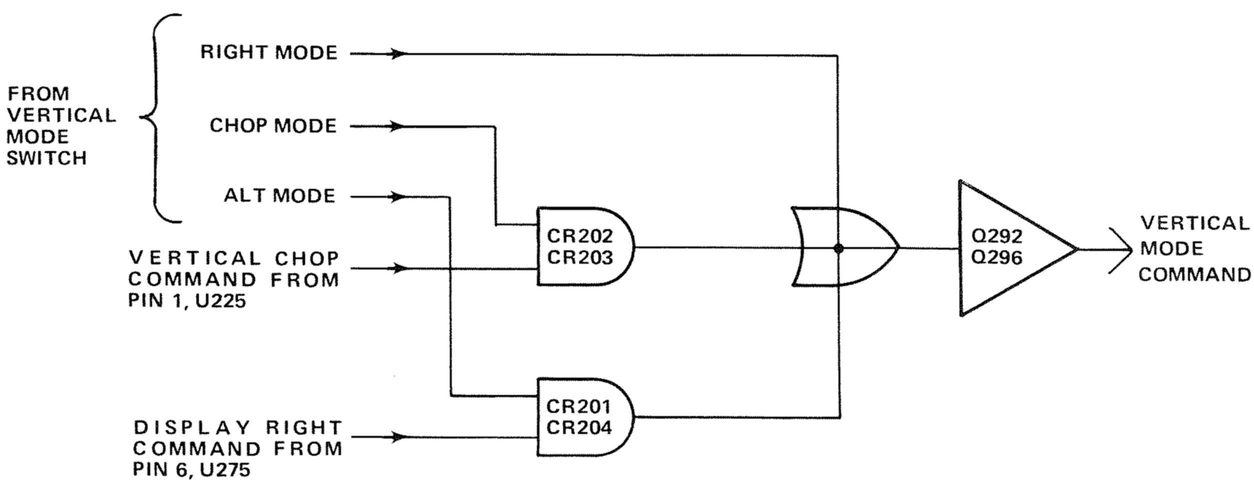


Fig. 1-20. Logic diagram of Vertical Mode Logic stage.

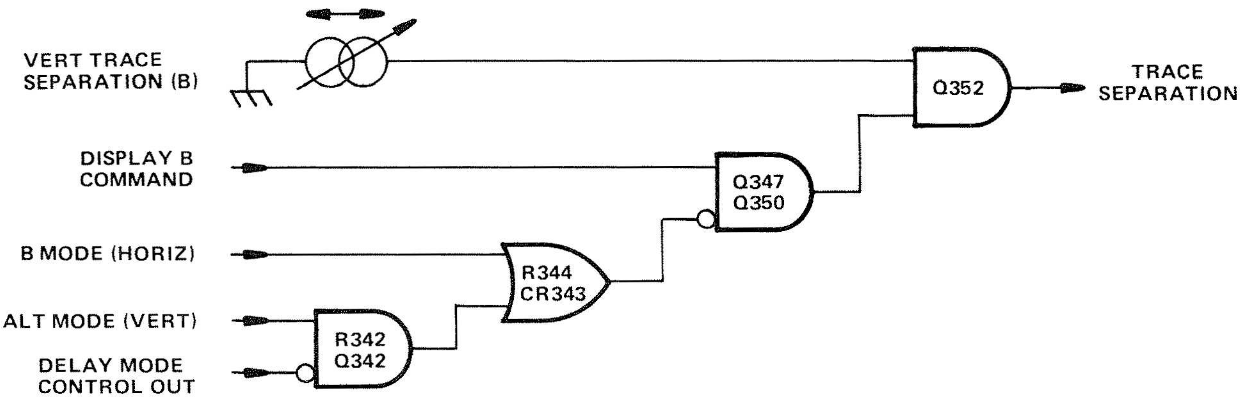
control is disconnected while the A sweep is being displayed.

When the HORIZONTAL MODE switch is set to B (only), a HI level is connected to the emitter of Q347 through R344. This reverse biases Q347 even though the Display B Command at its base is HI for this mode. Therefore, the VERT TRACE SEPARATION (B) control has no effect. When the VERTICAL MODE switch is set to ALT and the Delay Mode Control Out level from the A time-base unit is LO (indicating non-delayed sweep operation), a HI level is applied to the emitter of Q347 through R342 and CR343. This HI level reverse biases Q347 even though the Display B Command is HI. This action disconnects the VERT TRACE SEPARATION (B) control for independent-pairs operation so that the vertical position of the B-sweep display is determined by the slaved LEFT VERT plug-in unit only. If delayed-sweep operation is selected, the Delay Mode Control Out level is HI to forward bias Q342 and Q347. This allows the VERT TRACE SEPARATION (B) control to position the B-sweep display, since independent-pairs operation is not possible when operating in a delayed-sweep mode.

A logic diagram of the Trace Separation stage is shown in Fig. 1-21A. The discrete components which make up each logic function are identified. An input/output table for this stage is given in Fig. 1-21B.

TRIGGER SELECTOR ⟨4⟩

The Trigger Selector circuit determines the source of the internal triggering signals connected to the A and B HORIZ plug-in compartments. In addition, the B Trigger Channel Switch stage provides the drive for the Vertical Signal



(A) ⟨3⟩

(B)

INPUT: DISPLAY B COMMAND	B MODE (HORIZ)	ALT MODE (VERT)	DELAY MODE CONTROL OUT	OUTPUT: TRACE SEPARATION (B)
HI	LO	HI	HI	YES
HI	LO	LO	Φ	YES
ALL OTHER COMBINATIONS				NO OUTPUT

Φ = HAS NO EFFECT IN THIS CASE

Fig. 1-21. (A) Logic diagram of Trace Separation stage; (B) Table of input/output combinations.

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Amplifier stage (see diagram 8). Figure 1-22 shows a detailed block diagram of the Trigger Selector circuit.

Slave Enable

The Slave Enable stage provides an output to the A and B Trigger Select Logic stages to indicate when independent-pairs operation (sweep slaving) is selected. The output of this stage is determined by the Horizontal Slave Enable level from the Logic circuit and by the VERTICAL MODE switch. (For further information on independent-pairs operation and the Horizontal Slave Enable level, see the description of the Vertical Binary stage in the Logic circuit.) When independent-pairs operation is selected, the output of the Slave Enable stage (at the emitter of Q428) is LO. In this condition, the Left Vertical unit provides the B Horizontal trigger signal and the Right Vertical unit provides the A Horizontal trigger signal in the VERT MODE position of the trigger source switches.

A and B Trigger Select Logic

The A and B Trigger Select Logic stages select the operation of the A and B Trigger Channel Switch stages as determined by the Horizontal Slave Enable level from the Logic circuit and the setting of the VERTICAL MODE, A TRIGGER SOURCE, and B TRIGGER SOURCE switches. These stages also include the circuitry to illuminate the trigger-source pushbutton lights.

Table 1-2A and Table 1-2B show the output of the A and B Trigger Select Logic stages respectively for each combination of the Horizontal Slave Enable level, the setting of the VERTICAL MODE switch, and the setting of the trigger source switches. The trigger-source pushbutton illuminated for each combination is also shown. Notice that only the trigger source switches control the output when in the LEFT or RIGHT VERT positions; the trigger signal is obtained from the indicated plug-in compartment.

A and B Trigger Channel Switch

The A and B Trigger Channel Switch stages determine which input signal provides the internal trigger signal to the horizontal units as controlled by the trigger Right and Add signals from the trigger select logic stages.

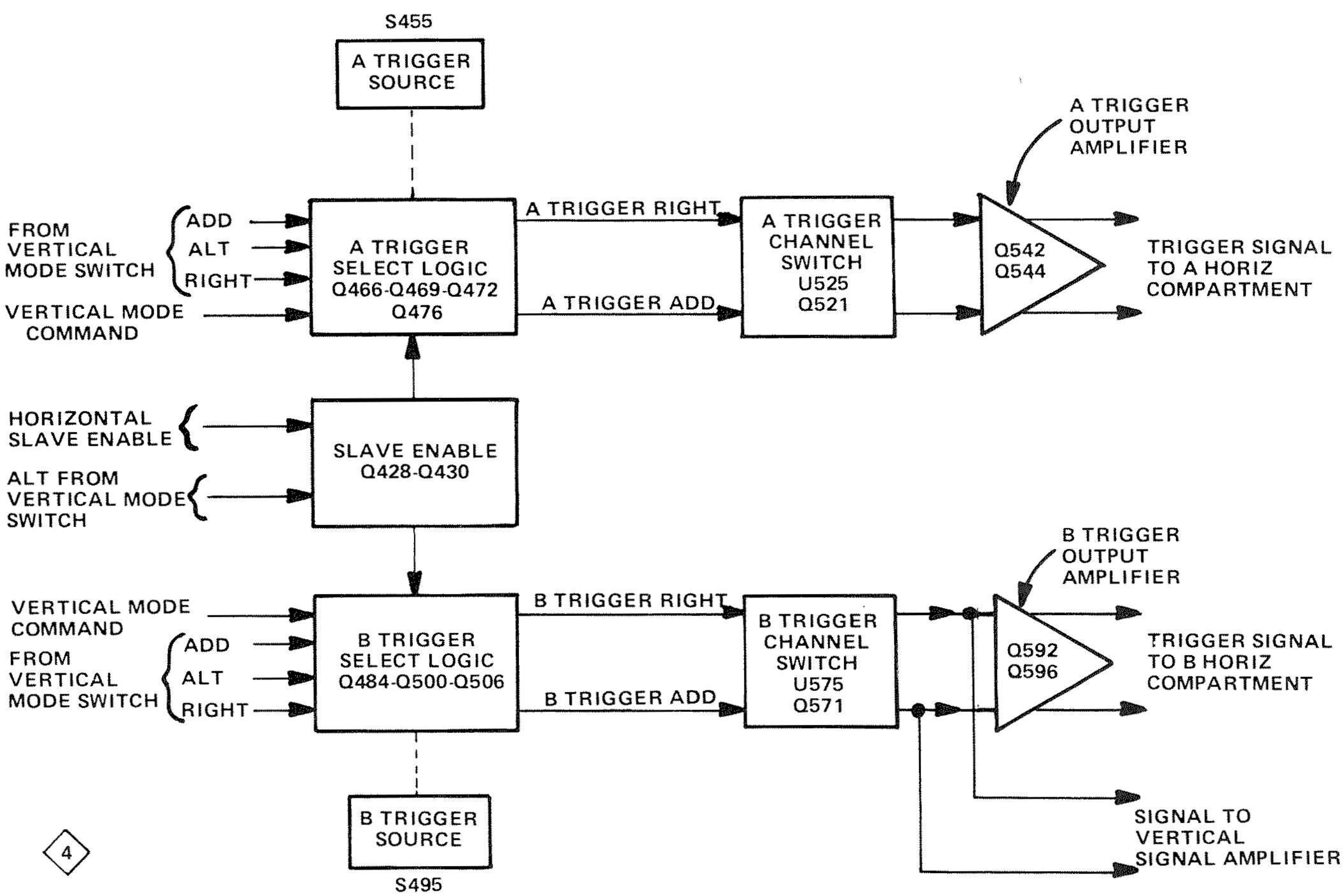

Fig. 1-22. Detailed block diagram of Trigger Selector circuit.

TABLE 1-2A

Input/Output Combinations for A Trigger Select Logic

A TRIGGER SOURCE Switch	VERTICAL MODE Switch	Horizontal Slave Enable	Vertical Mode Command	A Trigger Select Logic Output A Trigger Right	A Trigger Select Logic Output A Trigger Add	A TRIGGER SOURCE Pushbutton Lights LEFT VERT	RIGHT VERT	VERT MODE
LEFT VERT	Φ[1]	Φ	Φ	LO	LO	on	off	off
RIGHT VERT	Φ	Φ	Φ	HI	LO	off	on	off
VERT MODE	LEFT	Φ	LO	LO	LO	on	off	on
↓	ALT	LO	Alt[2]	Alt[2]	LO	on	on	on
↓	ALT	HI	Alt[2]	HI	LO	off	on	on
↓	ADD	Φ	LO	LO	HI	on	on	on
↓	CHOP	Φ	Chop[2]	LO	LO	on	off	on
↓	RIGHT	Φ	HI	HI	LO	off	on	on

[1] Φ = Has no effect in this case.

[2] Switches between HI and LO at a rate determined by Logic circuit.

TABLE 1-2B

Input/Output Combinations for B Trigger Select Logic

B TRIGGER SOURCE Switch	VERTICAL MODE Switch	Horizontal Slave Enable	Vertical Mode Command	B Trigger Select Logic Output B Trigger Right	B Trigger Select Logic Output B Trigger Add	B TRIGGER SOURCE Pushbutton Lights LEFT VERT	RIGHT VERT	VERT MODE
LEFT VERT	Φ[1]	Φ	Φ	LO	LO	on	off	off
RIGHT VERT	Φ	Φ	Φ	HI	LO	off	on	off
VERT MODE	LEFT	Φ	LO	LO	LO	on	off	on
↓	ALT	LO	Alt[2]	Alt[2]	LO	on	on	on
↓	ALT	HI	Alt[2]	LO	LO	on	off	on
↓	ADD	Φ	LO	LO	HI	on	on	on
↓	CHOP	Φ	Chop[2]	LO	LO	on	off	on
↓	RIGHT	Φ	HI	HI	LO	off	on	on

[1] Φ = Has no effect in this case.

[2] Switches between HI and LO at a rate determined by Logic circuit.

Resistor networks R401-R402-R403, R405-R406-R407, R409-R410-R411, and R413-R414-R415 are connected as 50-ohm power dividers. These power dividers, along with R510-R512-R514-R516-R560-R562-R564-R566, provide a 100-ohm differential load for the trigger outputs of the vertical plug-in units and establish the input resistance of the trigger channel switch stages.

The A and B Trigger Channel Switch stages are made up primarily of integrated circuits U525 and U575. An input/output table for U525 and U575 is given in Table 1-3. U525 and U575 provide a differential input for the trigger signal from the left vertical unit at pins 6-7 and 8-9 and for the trigger signal from the right vertical unit at pins 18-19 and 20-21. The output signal at pins 1 and 2 is a differential signal. The sum of the DC current at pins 1 and 2 is always equal to the sum of the DC currents at pins 4-5, 10-11, 16-17, and 22-23 in all modes. This provides a constant DC bias to the following stages as the A or B TRIGGER SOURCE switches or the VERTICAL MODE switch are changed. Resistors R525-R526, R527-R528, R529-R530, and R531-R532 establish the operating levels for the A Trigger Channel Switch stage. Q521 provides a temperature-compensated operating voltage for U525. The B Trigger Channel Switch stage operates in a similar manner.

TABLE 1-3

Input/Output Table for U525—U575

Input		Output
Trigger Right Pin 14	Trigger Add Pin 15	Trigger Output Signal Pins 1 and 2
LO	LO	Left trigger signal
HI	LO	Right trigger signal
LO	HI	Both (added algebraically)

A Trigger Output Amplifier

The A Trigger Output Amplifier stage provides isolation between the A Trigger Channel Switch IC and the A Horizontal plug-in unit. Resistors R537-R540 provide a 100-ohm differential load for the A Trigger Channel Switch IC. Centering adjustment R543 balances the emitter current of Q542-Q544 for equal DC output levels. Gain adjustment R549 sets the emitter degeneration of Q542-Q544 to adjust the gain of the A Trigger Output Amplifier. The output impedance of this stage is 100 ohms differentially, determined primarily by R553 and R558.

B Trigger Output Amplifier

The B Trigger Output Amplifier stage operates in a manner similar to the A Trigger Output Amplifier. Components in the Vertical Signal Amplifier stage (see diagram 8) provide a 100-ohm differential load for the B Trigger Channel Switch IC.

READOUT SYSTEM ⟨5⟩

Introduction

The Readout System provides alpha-numeric display of information encoded by the plug-in units. This display is presented on the CRT and is written by the CRT beam on a time-shared basis with the analog waveform display.

The definition of several terms follows:

Character—A character is a single number, letter, or symbol displayed on the CRT, either alone or in combination with other characters.

Word—A word is made up of a related group of characters. In the 7904 Readout System, a word can consist of up to ten characters.

Frame—A frame is a display of all words for a given operating mode and plug-in combination. Up to eight words can be displayed in one frame. Figure 1-23 shows the position of each word in a complete frame.

Column—One of the vertical lines in the Character Selection Matrix (see Fig. 1-24). Columns C-0 (column zero) to C-10 (column 10) can be addressed in the 7904 system.

Row—One of the horizontal lines in the Character Selection matrix. Rows R-1 (row 1) through R-10 (row 10) and R-14 (row 14) can be addressed in the 7904 system.

Time-Slot—A location in a pulse train. In the 7904 Readout System, the pulse train consists of 10 negative-going pulses. Each time-slot pulse is assigned a number between one and ten. For example, the first time-slot is TS-1.

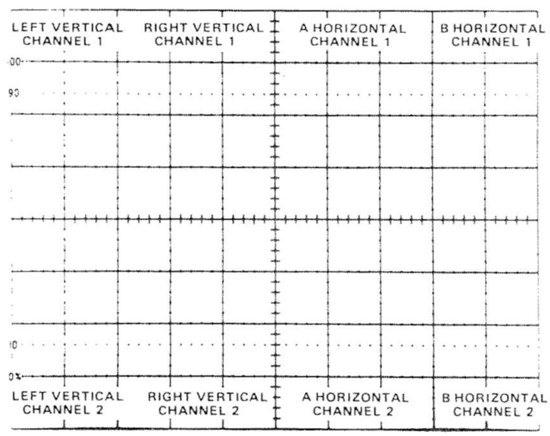

Fig. 1-23. Location of readout words on the CRT identifying the originating plug-in and channel (one complete frame shown, simulated readout).

ROW NUMBER ↓ / COLUMN NUMBER →	CURRENT (MILLI-AMPERES)	C-0	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	≥ 1.0
R-1	0		0	1	2	3	4	5	6	7	8	9
R-2	0.1		↙	<	I	/	+	−	+	C	Δ	>
R-3	0.2		ADD[1] ONE ZERO	ADD[1] TWO ZEROS	SHIFT[1] PREFIX ←	SHIFT[1] PREFIX ← AND ADD ONE ZERO						IDENTIFY[1]
R-4	0.3		m	μ	n	p	X	K	M	G	T	R
R-5	0.4	↕ SKIP[1]	S	V	A	W	H	d	B	c	Ω	E
R-6	0.5		U	N	L	Z	Y	P	F	J	Q	D
R-7	0.6				DECIMAL[1] POINT LOCATION NO. 3	DECIMAL[1] POINT LOCATION NO. 4	DECIMAL[1] POINT LOCATION NO. 5	DECIMAL[1] POINT LOCATION NO. 6	DECIMAL[1] POINT LOCATION NO. 7			
R-8	0.7											
R-9	0.8											
R-10	0.9	ADD SPACE IN DISPLAY[1]										

(Shaded) UNUSED LOCATIONS. AVAILABLE FOR FUTURE EXPANSION OF READOUT SYSTEM.

[1]OPERATIONAL ADDRESS.

Fig. 1-24. Character Selection Matrix for 7904 Readout System.

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Time-multiplexing—Transmission of data from two or more sources over a common path by using different time intervals for different signals.

Display Format

Up to eight words of readout information can be displayed on the CRT. The position of each word is fixed and is directly related to the plug-in unit from which it originated. Figure 1-23 shows the area of the graticule where the readout from each plug-in unit is displayed. Notice that Channel 1 of each plug-in unit is displayed within the top division of the CRT and Channel 2 is displayed directly below within the bottom division. Figure 1-25 shows a typical display where only Channel 2 of the Right Vertical and B Horizontal units is selected for display.

Each word in the readout display can contain up to 10 characters, although the typical display will contain between two and seven characters per word. The characters are selected from the Character Selection Matrix shown in Fig. 1-24. In addition, 12 operational addresses are provided for special instructions to the Readout System. The unused locations in the Matrix (shaded area) are available for future expansion of the Readout System. The method of addressing the locations in the Character Selection Matrix is described in the following discussion.

Developing the Display

The following basic description of the Readout System uses the block diagram shown in Fig. 1-26. This description is intended to relate the basic function of each stage to the operation of the overall Readout System. Detailed information on circuit operation is given later.

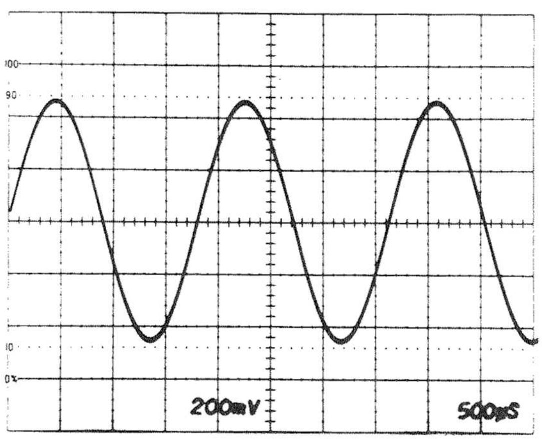


Fig. 1-25. Typical readout display where only channel 2 of the Right Vertical and B Horizontal units is displayed.

The key block in the Readout System is the Timer stage. This stage produces the basic signals that establish the timing sequences within the Readout System. Period of the timing signal is about 250 microseconds (drops to about 210 microseconds when Display-Skip is received; see detailed description of Timer stage for further information.) This stage also produces control signals for other stages within this circuit and interrupt signals to the Vertical Amplifier, Horizontal Amplifier, and Logic circuits, which allow a readout display to be presented. The Time-Slot Counter stage receives a trapezoidal voltage signal from the Timer stage and directs it to one of ten output lines. These output lines are labeled TS-1 through TS-10 (time-slots one through ten) and are connected to the vertical and horizontal plug-in compartments as well as to various stages within the Readout System. The output lines are energized sequentially, so there is a pulse on only one of the 10 lines during any 250-microsecond timing period. After the Time-Slot Counter stage has counted time-slot 10, it produces an End-of-Word pulse which advances the system to the next channel.

Two output lines, row and column, are connected from each channel of the plug-in unit back to the Readout System. Data is typically encoded on these output lines by connecting resistors between them and the time-slot input lines. The resultant output is a sequence of ten analog current levels that range from zero to one milliampere (100 microamperes/step) on the row and column output lines. This row and column correspond to the row and column of the Character Selection Matrix in Fig. 1-24. The standard format for encoding information onto the output lines is given in Table 1-4. (Special-purpose plug-in units may have their own format for readout; these special formats will be defined in the manuals for these units.)

The encoded column and row data from the plug-in units is selected by the Column Data Switch and Row Data Switch stages respectively. These stages take the analog currents from the eight data lines (two channels from each of the four plug-in compartments) and produce a time-multiplexed analog voltage output containing all of the column or row information from the plug-ins. The Column Data Switch and Row Data Switch are sequenced by the binary Channel Address Code from the Channel Counter.

The time-multiplexed output of the Column Data Switch is monitored by the Display-Skip Generator to determine if it represents valid information that should be displayed. Whenever information is not encoded in a time-slot, the Display-Skip Generator produces an output level to prevent the Timer stage from producing the control signals that normally interrupt the CRT display and present a character.

The analog outputs of the Column Data Switch and Row Data Switch are connected to the Column Decoder and Row Decoder stages respectively. These stages sense the

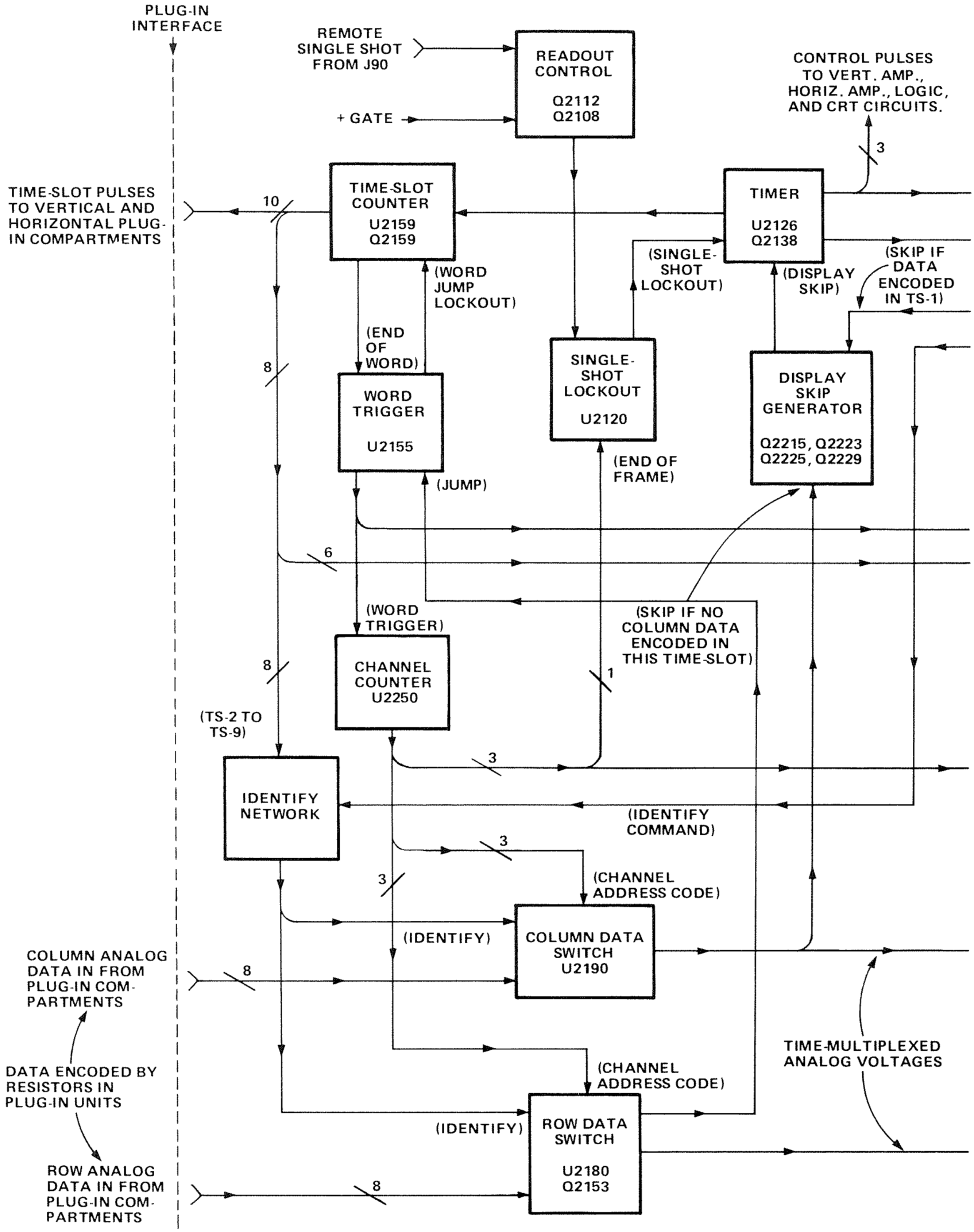


Fig. 1-26. Detailed block diagram of Readout System.

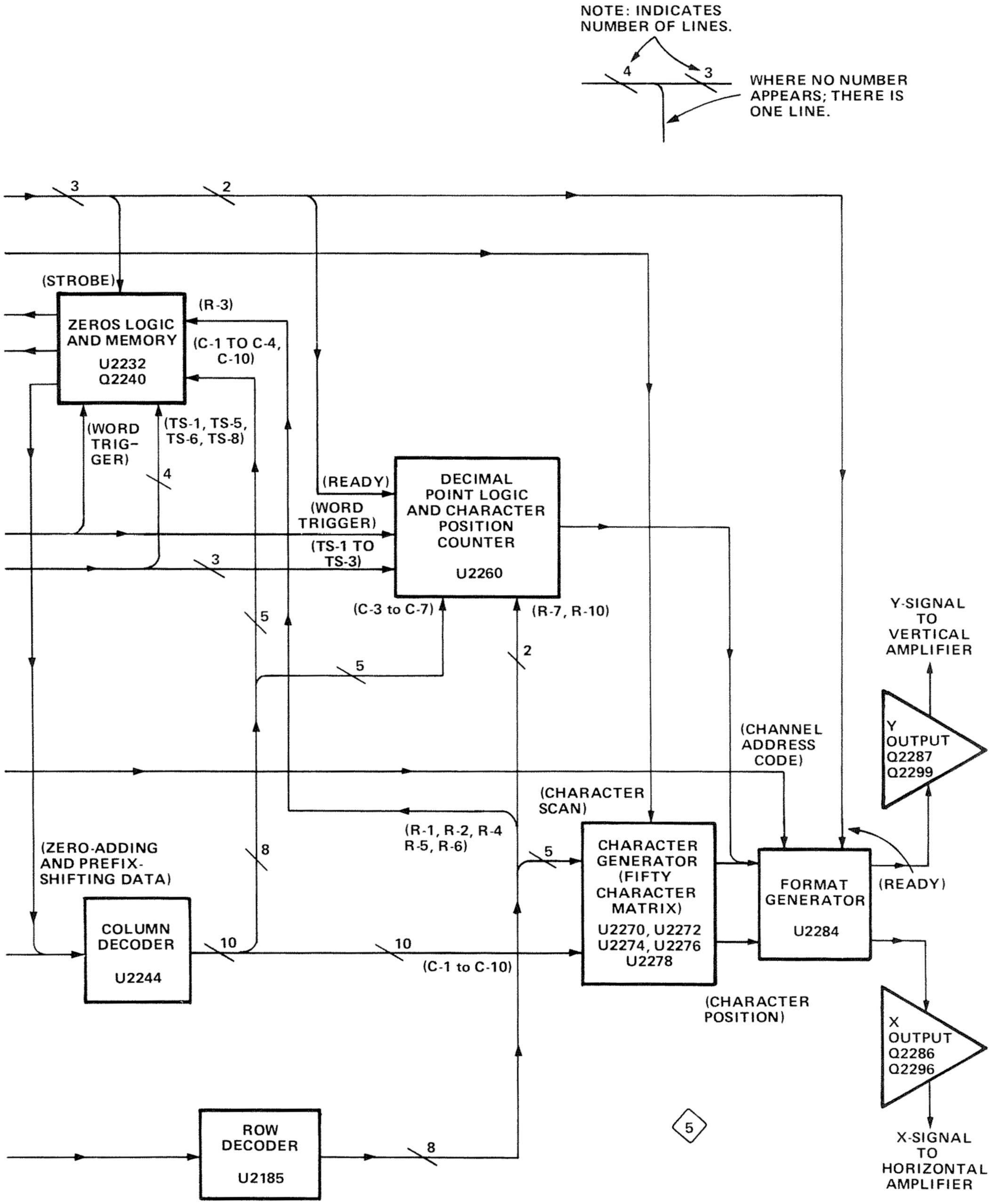

NOTE: INDICATES NUMBER OF LINES.
4
3
WHERE NO NUMBER APPEARS; THERE IS ONE LINE.
3
2
(STROBE)
ZEROS LOGIC AND MEMORY
U2232
Q2240
(R-3)
(C-1 TO C-4, C-10)
(WORD TRIG-GER)
(TS-1, TS-5, TS-6, TS-8)
4
(READY)
(WORD TRIGGER)
(TS-1 TO TS-3)
3
DECIMAL POINT LOGIC AND CHARACTER POSITION COUNTER
U2260
(C-3 to C-7)
(R-7, R-10)
5
5
2
Y-SIGNAL TO VERTICAL AMPLIFIER
(CHANNEL ADDRESS CODE)
Y OUTPUT Q2287 Q2299
(CHARACTER SCAN)
(R-1, R-2, R-4 R-5, R-6)
5
(ZERO-ADDING AND PREFIX-SHIFTING DATA)
8
CHARACTER GENERATOR (FIFTY CHARACTER MATRIX)
U2270, U2272
U2274, U2276
U2278
FORMAT GENERATOR
U2284
(READY)
COLUMN DECODER
U2244
10
10
(C-1 to C-10)
(CHARACTER POSITION)
X OUTPUT Q2286 Q2296
5
ROW DECODER
U2185
8
X-SIGNAL TO HORIZONTAL AMPLIFIER

Fig. 1-26. (cont).

magnitude of the analog voltage input and produce an output current on one of ten lines. The outputs of the Column Decoder stage are identified as C-1 through C-10 (column 1 through 10) corresponding to the encoded column information. Likewise, the outputs of the Row Decoder stage are identified as R-1 through R-10 (row 1 through 10) corresponding to the encoded row information. The primary function of the row and column outputs is to select a character from the Character Selection Matrix to be produced by the Character Generator stage. These outputs are also used at other points within the system to indicate when certain information has been encoded. One such stage is the Zeros Logic and Memory. During time-slot 1 (TS-1), this stage checks if zero-adding or prefix-shifting information has been encoded by the plug-in unit, and stores it in memory until time-slots 5, 6, or 8. After storing this information, it triggers the Display-Skip Generator stage so that there is no display during time-slot 1 (as defined by Standard Readout Format; see Table 1-4). When time-slots 5, 6, and 8 occur, the memory is addressed and any information stored there during time-slot 1 is transferred to the input of the Column Decoder stage to modify the analog data during the applicable time-slot.

TABLE 1-4

Standard Readout Format

Time-Slot Number	Description
TS-1	Determines decimal magnitude (number of zeros displayed or prefix change information) or the IDENTIFY function (no display during this time-slot).
TS-2	Indicates normal or inverted input (no display for normal).
TS-3	Indicates calibrated or uncalibrated condition of plug-in variable control (no display for calibrated condition).
TS-4	Scaling.
TS-5 TS-6 TS-7	Not encoded by plug-in unit. Left blank to allow addition of zeros by Readout System.
TS-8	Defines the prefix which modifies the units of measurement.
TS-9 TS-10	Define the units of measurement of the plug-in unit. May be standard units of measurement (V, A, S, etc.) or special units selected from the Character Selection Matrix.

Also, the Zeros Logic and Memory stage produces the IDENTIFY function. When time-slot 1 is encoded for IDENTIFY (column 10, row 3), this stage produces an output level, which connects the Column Data Switch and Row Data Switch to a coding network within the Readout System. Then, during time-slots 2 through 9, an analog current output is produced from the Column Data Switch and Row Data Switch, which addresses the correct points in the Character Selection Matrix to display the word "IDENTIFY" on the CRT. The Zeros Logic and Memory stage is reset after each word by the Word Trigger pulse.

The Character Generator stages produce the characters which are displayed on the CRT. Any of the 50 characters shown on the Character Selection Matrix of Fig. 1-24 can be addressed by proper selection of the column and row currents. Only one character is addressable in any one time-slot; a space can be added into the displayed word by the Decimal Point Logic and Character Position Counter stage when encoded by the plug-in. The latter stage counts the number of characters generated and produces an output current to step the display one character position to the right for each character. In addition, the character position is advanced once during each of time-slots 1, 2, and 3, whether a character is generated during these time-slots or not. This action fixes the starting point of the standard-format display such that the first digit of the scaling factor always starts at the same point within each word regardless of the information encoded in time-slot 1, 2, or 3 preceding this digit. Also, by encoding row 10 and column 0 during any time-slot, a blank space can be added to the display. Decimal points can be added to the display at any time by addressing the appropriate row and column. (See Character Selection Matrix for location of decimal points.) The Decimal Point Logic and Character Position Counter stage is reset after each word by the Word Trigger pulse.

The Format Generator stage provides the output signals to the vertical and horizontal deflection systems of the instrument to produce the character display. The binary Channel Address Code from the Channel Counter stage is connected to this stage, so that the display from each channel is positioned to the area of the CRT associated with the plug-in and channel originating the word (see Fig. 1-23). The positioning current or decimal point location current generated by the Decimal Point Logic and Character Position Counter stage is added to the Horizontal (X) signal at the input to the Format Generator stage to provide horizontal positioning of the characters within each word. The X- and Y-Readout signals are connected to the Horizontal Amplifier and Vertical Amplifier through the X- and Y-Buffer stages.

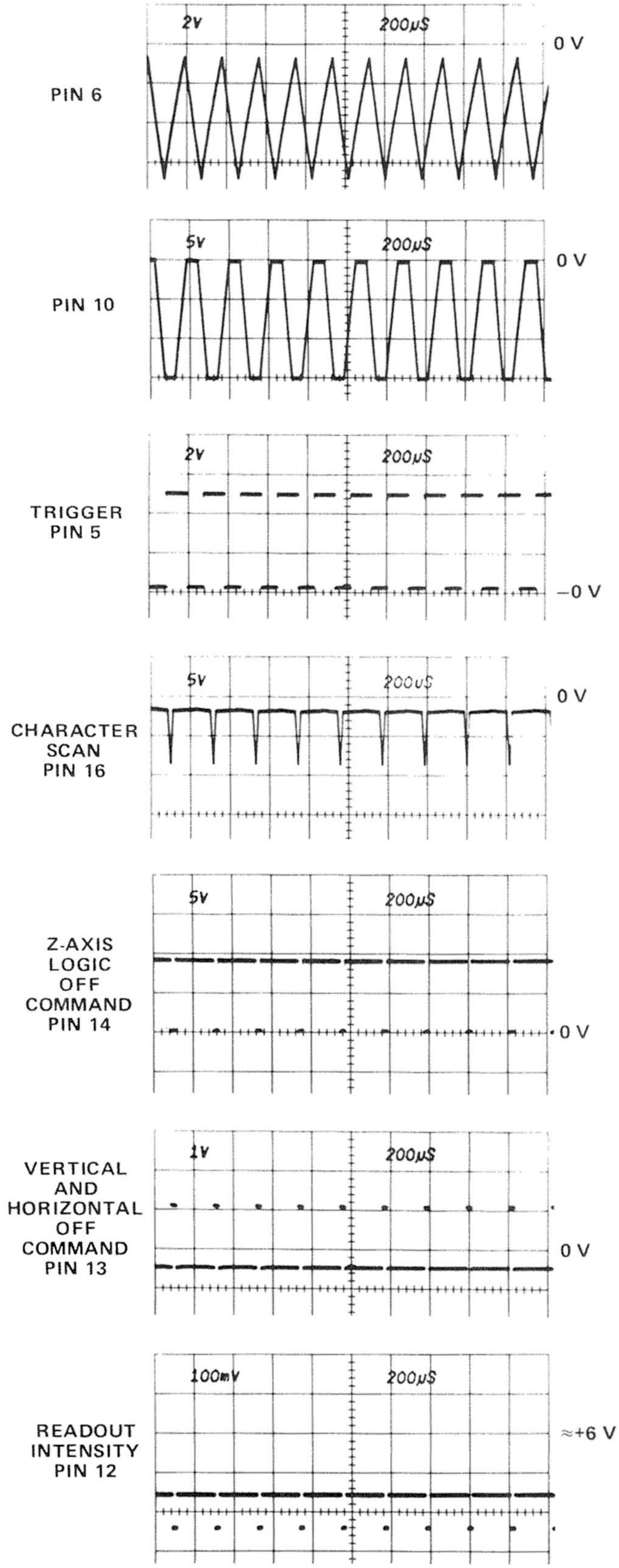
The Word Trigger stage produces a trigger from the End-of-Word pulse generated by the Time-Slot Counter stage after the tenth time-slot. This Word Trigger pulse advances the Channel Counter to display the information from the next channel or plug-in. It also provides a reset pulse to the Zeros Logic and Memory stage and the Decimal Point Logic and Character Position Counter stage. The Word Trigger stage can also be advanced to jump a complete word or a portion of a word when a Jump command is received from the Row Data Switch stage.

The Single-Shot Lockout stage allows the display sequence of the Readout System to be changed. Normally, the Readout System operates in a free-running mode, so the waveform display is interrupted randomly to display characters. However, under certain conditions (such as single-shot photography), it is desirable that the Readout System operate in a triggered mode where the readout portion of the display is normally blanked out, but can be presented on command. The Readout Mode switch, S2110, determines the operating mode of the Readout System.

Timer

Timer U2126 establishes the timing sequence for all circuits within the Readout System. This stage produces seven time-related output waveforms (see Fig. 1-27). The triangle waveform produced at pin 6 forms the basis for the remaining signals. The basic period of this triangle waveform is about 250 microseconds as controlled by RC network R2135-C2135. The triangle waveform is clipped and amplified by U2126 to form the trapezoidal output signal at pin 10. The amplitude of this output signal is exactly 15 volts as determined by U2126 (exact amplitude necessary to accurately encode data in plug-in units; see Encoding the Data). The Trigger output at pin 5 provides the switching signal for the Time-Slot Counter and Word Trigger stages.

The signals at pins 12, 13, 14, and 16 are produced only when the triangle waveform is on its negative slope and the trapezoidal waveform has reached the lower level. The timing sequence of these waveforms is important to the operation of the Readout System (see expanded waveforms in Fig. 1-28). The Z-Axis Logic OFF Command at pin 14 is produced first. This negative-going signal provides a blanking pulse to the Z-Axis Logic stage (see diagram 3) to blank the CRT before the display is switched to the Readout System. It also produces the Strobe pulse through Q2138 and CR2142 to signal other stages within the Readout System to begin the sequence necessary to produce a character. The collector level of Q2138 is also connected to Character Generator No. 2, U2272, through CR2140. This activates U2272 during the quiescent period of the Strobe pulse (collector of Q2138 negative) and diverts the output current of Row Decoder U2185 to row 2. The purpose of this configuration is to prevent the Zeros Logic and Memory stage U2232 from storing incorrect data during the quiescent period of the Strobe pulse. When the Strobe pulse goes positive, CR2140 is reverse-biased to



NOTE: TEST OSCILLOSCOPE EXTERNALLY TRIGGERED FROM TP2251.

Fig. 1-27. Output waveforms of Timer stage.

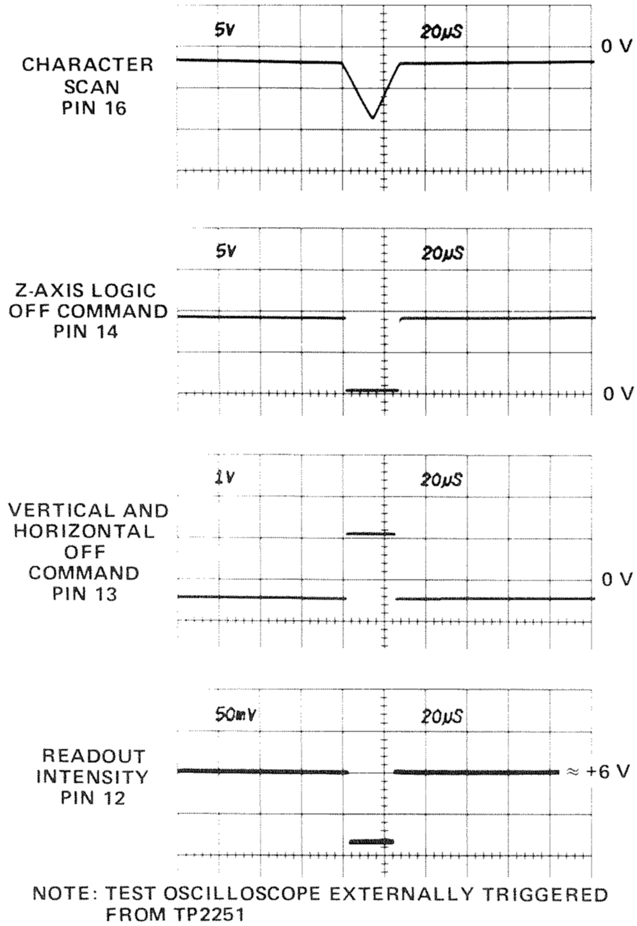


Fig. 1-28. Detail of output at pins 12, 13, 14, and 16 of U2126.

disconnect Q2138 from U2272 and allow the Row Decoder to operate in the normal manner.

The next signal to be produced is the Vertical and Horizontal OFF Command at pin 13. This positive-going signal disconnects the plug-in signals from the vertical and horizontal deflection systems, so the plug-in units do not control the position of the CRT beam during the readout display. The Ready signal derived from this output is connected to the Decimal Point Logic and Character Position Counter stage and the Format Generator stage.

The Readout Intensity output at pin 12 is produced next. This current is connected to the CRT Circuit to unblank the CRT to the intensity level determined by the READOUT intensity control. The Character Scan ramp at pin 16 started to go negative as this timing sequence began. However, character generation does not start until the readout intensity level has been established. The triangular Character Scan ramp runs from about −2 volts to about −8.5 volts, then returns back to the original level. This waveform provides the scanning signal for the Character Generator stages. Full Character Scan adjustment R2128 sets the DC level of the Character Scan ramp for complete characters on the display.

The Timer stage operates in one of two modes as controlled by the Display-Skip level at pin 4. The basic mode just described is a condition that does not occur unless all ten characters of each word (80 characters total) are displayed on the CRT. Under typical conditions only a few characters are displayed in each word. The Display-Skip level at pin 4 determines the period of the Timer output signal. When a character is to be generated, pin 4 is LO and the circuit operates as just described. However, when a character is not to be displayed, a HI level is applied to pin 4 of U2126 through CR2125 from the Display-Skip Generator stage. This signal causes the Timer to shorten its period of operation to about 210 microseconds. The waveforms in Fig. 1-29 show the operation of the Timer stage when the Display-Skip condition occurs for all positions in a word. Notice that there is no output at pins 12, 13, 14, and 16 under this condition. This means that the CRT display is not interrupted to display characters. Also notice that the triangle waveform at pin 6 does not go as far negative, and that the negative portion of the trapezoidal waveform at pin 10 is shorter. Complete details on operation of the Display-Skip Generator are given later.

The Timer operation is also controlled by the Single-Shot Lockout level at pin 2. If this level is LO, the Timer operates as just described. However, if the Single-Shot Lockout stage sets a HI level at this pin, the Timer stage is locked out and can not produce any output signals (see Single-Shot Lockout description for further information).

READOUT intensity control R2124 (see diagram 2) sets the intensity of the readout display independently of the A or B INTENSITY controls. The READOUT intensity control also provides a means of turning the Readout System off when a readout display is not desired. When R2124 is turned fully counterclockwise, the switch in series with the Readout Intensity line opens. The current to pin 11 of U2126 is interrupted, and at the same time, a positive voltage is applied to pin 4 through CR2124. The positive voltage switches the stage to the same conditions as were present under the Display-Skip condition. Therefore, the CRT display is not interrupted to present characters. However, time-slot pulses continue to be generated.

Time-Slot Counter

Time-Slot Counter U2159 is a sequential switch which directs the trapezoidal waveform input at pin 8 to one of its 10 output lines. These time-slot pulses are used to interrogate the plug-in units to obtain data for the Readout System. The Trigger pulse at pin 15 switches the Time-Slot Counter to the next output line; the output signal is

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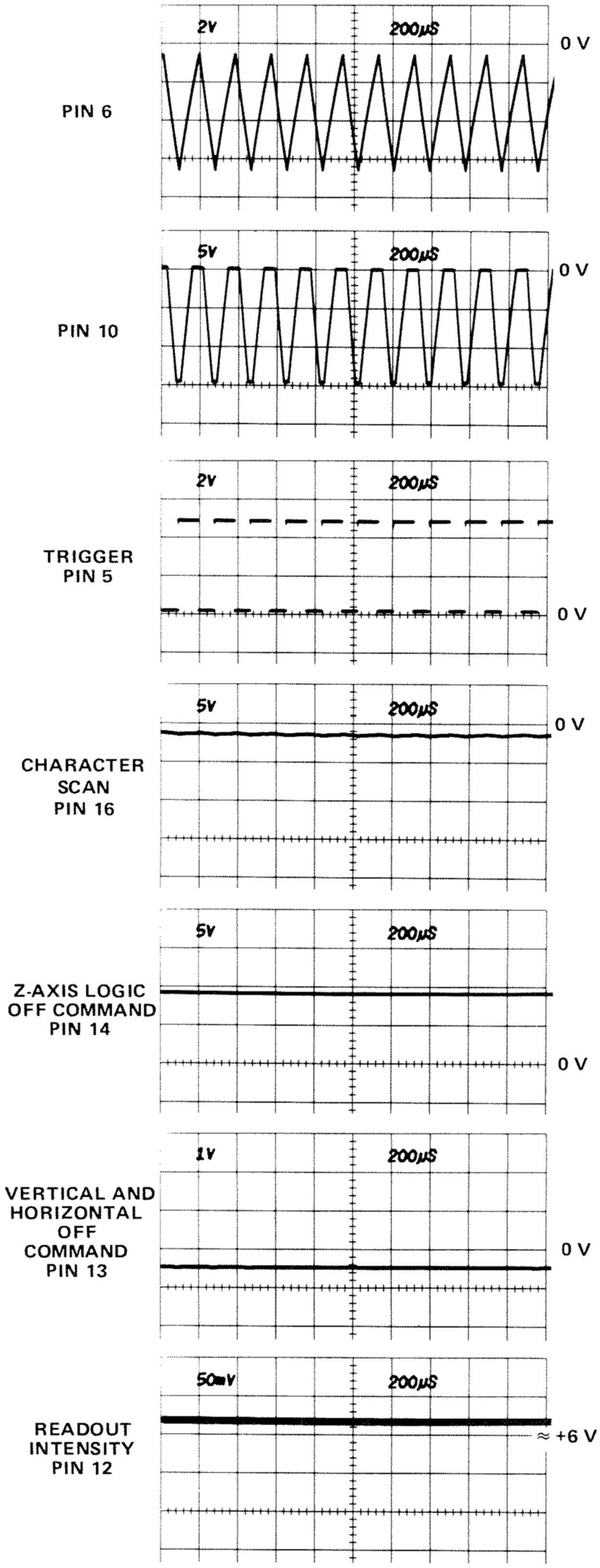


NOTE: TEST OSCILLOSCOPE EXTERNALLY TRIGGERED FROM TP2251.

Fig. 1-29. Timer stage operation when Display-Skip condition occurs.

sequenced consecutively from time-slot 1 through time-slot 10. Figure 1-30 shows the time relationship of the time-slot pulses. Notice that only one line carries a time-slot pulse at any given time. When time-slot 10 is completed, a negative-going End-of-Word pulse is produced at pin 2. The End-of-Word pulse provides a drive pulse for the Word Trigger stage and also provides an enabling level to the Display-Skip Generator during time-slot 1 only.

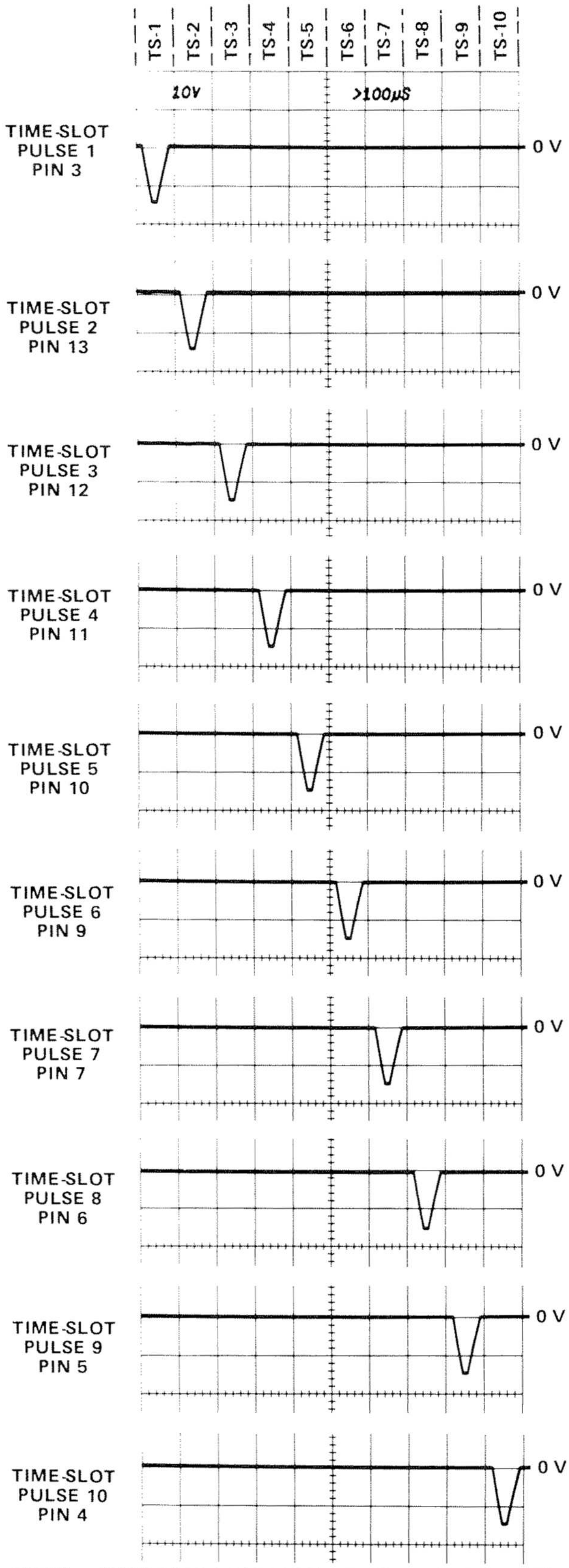
Pin 16 is a reset input for the Time-Slot Counter. When this pin is held LO, the Time-Slot Counter resets to time-slot 1. The Time-Slot Counter can be reset in this manner only when a Jump Command is received by U2155C and D (see following discussion).

Word Trigger

The Word Trigger stage is made up of U2155A and B. Quiescently, pin 3 of U2155A is LO as established by the operating conditions of U2155C and D. Therefore, the LO End-of-Word pulse produced by the Time-Slot Counter results in a HI level at pin 1 of U2155A. This level is inverted by U2155B to provide a negative-going Word Trigger pulse to the Channel Counter.

Also, a Word Trigger pulse is produced by U2155B when a Jump Command is received at pin 8 of U2155C. This condition can occur during any time-slot (see Row Decoder for further information on origin of the Jump Command). U2155C and D are connected as a bistable flip-flop. The positive-going Jump Command at pin 8 of U2155C produces a LO at pin 10. This LO is inverted by U2155D to produce a HI at pin 13, which allows pin 9 to be pulled HI through CR2156. The flip-flop has now been set and remains in this condition until reset, even though the Jump Command at pin 8 returns to its LO level. The HI output level at pin 13 turns on Q2159 to pull pin 16 of the Time-Slot Counter LO. This resets the Time-Slot Counter to time-slot 1 and holds it there until the Word Trigger is reset. At the same time, a HI level is applied to pin 4 of the Timer through CR2157 and CR2125. This HI level causes the Timer to operate in the Display-Skip mode, so a character is not generated.

The next Trigger pulse is not recognized by the Time-Slot Counter, since U2159 is locked in time-slot 1 by U2155. However, this Trigger pulse resets the Word Trigger stage through C2155. Pin 13 of U2155D goes LO to enable the Time-Slot Counter and Timer stages for the next time-slot pulse. Simultaneously, when U2155D switches output states, the resulting negative-going edge is connected to pin 3 of U2155A. This results in a negative-going Word Trigger output at pin 4 to advance the Channel Counter to the next word. When the next Trigger pulse is received at pin 15, the Time-Slot Counter returns to the normal sequence of operation and produces an output on the time-slot 1 line.



NOTE: TEST OSCILLOSCOPE EXTERNALLY TRIGGERED FROM TP2251. SWEEP RATE UNCALIBRATED.

Fig. 1-30. Time relationship of the time-slot (TS) pulses produced by U2159.

Channel Counter

Channel Counter U2250 is a binary counter that produces the Channel Address Code for the Column and Row Decoder stages and the Format Generator stage. This code instructs these stages to sequentially select and display the eight channels of data from the plug-ins. Table 1-5 gives the eight combinations of the Channel Address Code and the resultant channel selected with each combination.

Readout Control

Q2108 and Q2112, along with S2110, control the operating mode of the Readout System through the Single-Shot Lockout stage. When Readout Mode switch S2110 is in the Free-Run position, the Readout System runs continously in a free-running manner. The emitter of Q2108 has no ground return in this position, so it can not conduct. The collector of Q2108 rises positive through R2108 to enable the Readout System.

In the Gate Trig'd position, the emitter of Q2108 is connected to ground through R2109 and S2110 to produce a LO lockout level to the Single-Shot Lockout stage. At the end of the selected gate, a negative level is applied to the base of emitter-follower Q2112. The negative level at the emitter of Q2112 is differentiated by C2112-R2112. The resulting negative-going pulse reverse biases Q2108 to momentarily allow its collector to go HI. This enables the Single-Shot Lockout stage for a single-shot readout display. (For further information, see the following discussion.)

TABLE 1-5

Channel Address Code

Pin 11 U2250	Pin 8 U2250	Pin 9 U2250	Channel Displayed
LO	LO	LO	Channel 2 Left Vertical
LO	LO	HI	Channel 1 Left Vertical
LO	HI	LO	Channel 2 Right Vertical
LO	HI	HI	Channel 1 Right Vertical
HI	LO	LO	Channel 2 A Horizontal
HI	LO	HI	Channel 1 A Horizontal
HI	HI	LO	Channel 2 B Horizontal
HI	HI	HI	Channel 1 B Horizontal

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Single-Shot Lockout

U2120 makes up the Single-Shot Lockout stage. This stage allows a single readout frame (eight complete words) to be displayed on the CRT, after which the Readout System is locked out, so further readout displays are not presented until the circuit is reset. U2120B and U2120C are connected to form a bistable flip-flop. For normal operation, pin 8 of U2120C is pulled HI through R2108. This activates U2120C to result in a LO output level at pin 10, enabling the Timer stage to operate in the free-running manner described previously.

The output of the Single-Shot Lockout stage remains LO to allow U2126 to operate in the free-running mode until a LO is received at pin 8 of U2120C. When this occurs, the output level at pin 10 of U2120C does not change immediately. However, the Readout System is now enabled as far as the single-shot lockout function is concerned. If the Channel Counter has not completed word eight (Channel 1 of B HORIZ unit), the Readout System continues to operate in the normal manner. However, when word eight is completed, the negative-going End-of-Frame pulse is produced at pin 11 of U2250 as the Channel Counter shifts to the code necessary to display word one. This pulse is coupled to pin 6 of U2120B. The momentary HI at pin 6 activates U2120B and its output stage goes LO to disable U2120C (pin 8 already LO). The output of U2120C goes HI to disable the Timer, so it operates in the Display-Skip mode. The HI at pin 10 of U2120C also holds U2120B enabled, so it maintains control of the flip-flop.

The Single-Shot Lockout stage remains in this condition until a positive-going trigger pulse is applied to pin 8 of U2120C. This trigger pulse produces a LO at pin 10 of U2120C to enable U2126 and disable U2120B. Now, the Timer can operate in the normal manner for another complete frame. When word eight is completed, the Channel Counter produces another End-of-Frame pulse to again lock out the Timer stage. (For further information on the Readout Mode, see the Readout Control description.)

Encoding the Data

Data is conveyed from the plug-in units to the Readout System in the form of an analog (current level) code. The characters that can be selected by the encoded data are shown on the Character Selection Matrix (see Fig. 1-24). Each character requires two currents to define it; these currents are identified as the column current and the row current, corresponding to the column and row of the matrix. The column and row data is encoded by programming the plug-in units. Figure 1-31 shows a typical encoding scheme using resistors for a voltage-sensing amplifier plug-in unit. Notice that the 10 time-slot (TS) pulses produced by the Time-Slot Counter stage are connected to the plug-in unit. However, time-slots 5, 6, 7, and 10 are not used by the plug-in unit to encode data when using the Standard Readout Format. (See Table 1-4 for Standard Readout Format.) The amplitude of the time-slot pulse is exactly −15 volts as determined by the Timer stage. Therefore, the resultant output current from the plug-in units can be accurately controlled by the programming resistors in the plug-in units.

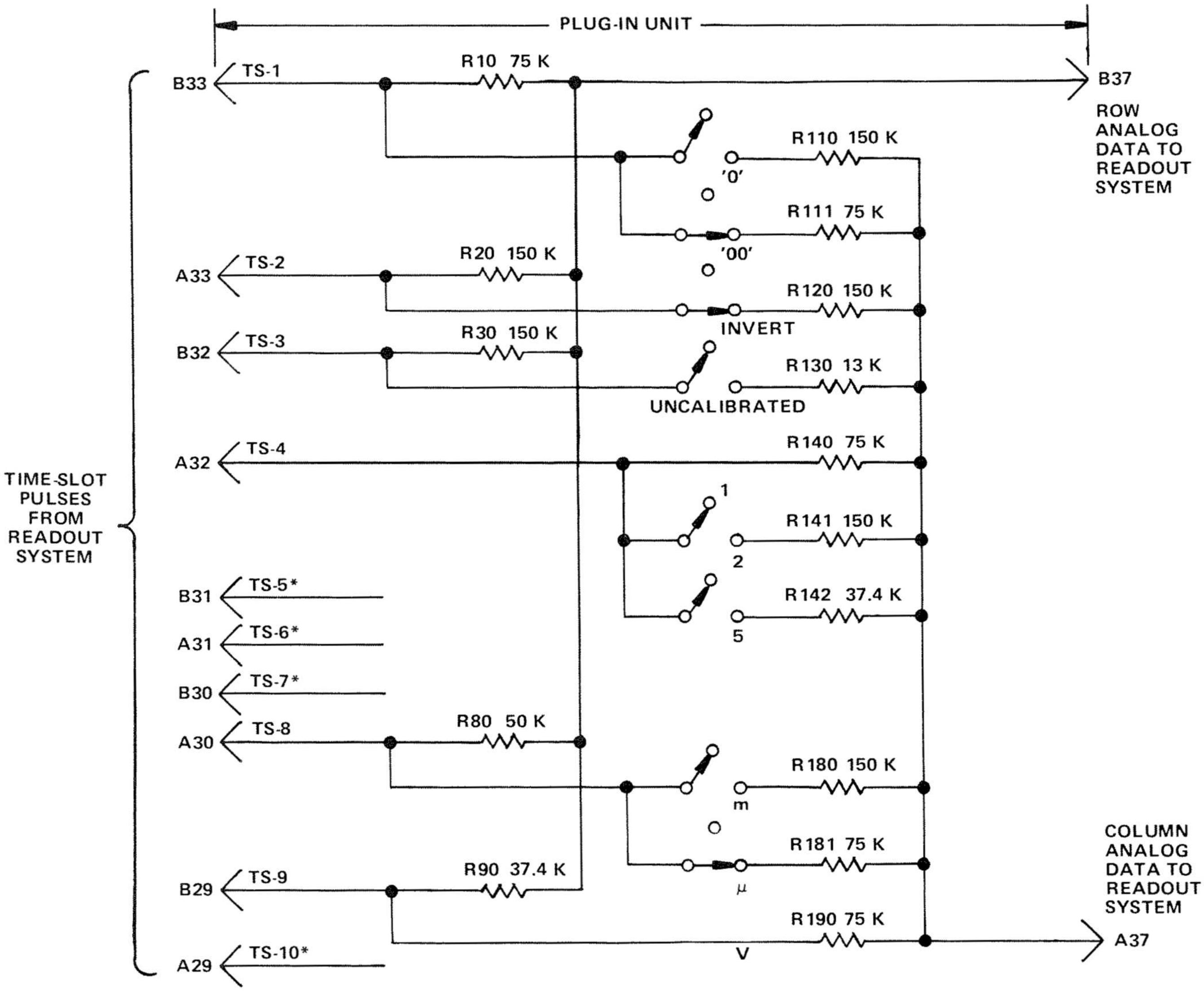
For example, in Fig. 1-31 resistors R10 through R90 control the row analog data, which is connected back to the Readout System. Figure 1-32A shows an idealized output current waveform of row analog data, which results from the time-slot pulses. Each of the row levels of current shown in these waveforms corresponds to 100 microamperes of current. The row numbers on the left-hand side of the waveform correspond to the rows in the Character Selection Matrix (see Fig. 1-24). The row analog data is connected back to the Readout System via terminal B37 of the plug-in interface.

The Column analog data is defined by resistors R110 through R190. The program resistors are connected to the time-slot lines by switch closures to encode the desired data. The data as encoded by the circuit shown in Fig. 1-31 indicates a 100-microvolt sensitivity with the CRT display inverted and calibrated deflection factors. This results in the idealized output current waveforms shown in Fig. 1-32B at the column analog data output, terminal A37 of the plug-in interface.

Resistor R111, connected between time-slot 1 and the column analog data output, encodes two units of current during time-slot 1. Referring to the Character Selection Matrix, two units of column current, along with the two units of row current encoded by resistor R10 (row 3), indicates that two zeros should be added to the display. Resistor R120 adds one unit of column current during time-slot 2 and, along with the one unit of current from the row output, the Readout System is instructed to add an invert arrow to the display. Resistor R130 is not connected to the time-slot 3 line, since the deflection factor is calibrated. Therefore, there is no column current output during this time-slot and no display on the CRT. (See Display-Skip Generator for further information.)

During time slot 4, two units of column current are encoded by R140. There is no row current encoded during this time-slot; this results in the numeral 1 being displayed on the CRT. Neither row nor column analog data is encoded during time-slots 5, 6, and 7 as defined by the Standard Readout Format. During time-slot 8, two units of column current and three units of row current are encoded by resistors R181 and R80, respectively. This addresses the μ prefix in the Character Selection Matrix.

The final data output is provided from time-slot 9 by R190 connected to the column output and R90 to the row



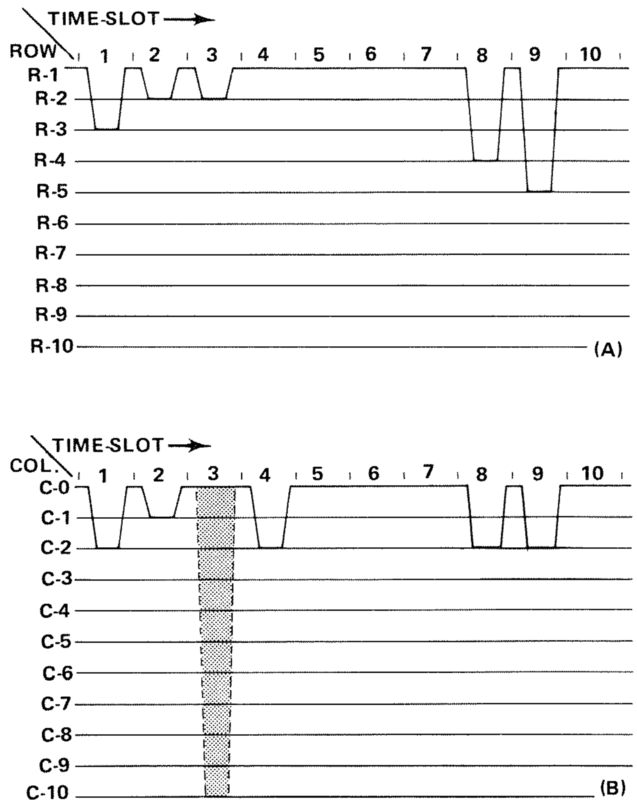
* NOT USED IN STANDARD FORMAT.

Fig. 1-31. Typical encoding scheme for voltage-sensing plug-in unit. Coding shown for deflection factor of 100 microvolts.

output. These resistors encode two units of column current and four units of row current to cause a V (volts) to be displayed. Time-slot 10 is not encoded, in accordance with the Standard Readout Format. The resultant CRT readout will be ↓ 100 μV.

In the above example, the row analog data was programmed to define which row of the Character Selection Matrix was addressed to obtain information in each time-slot. The column data changes to encode the applicable readout data as the operating conditions change. For example, if the variable control of the plug-in unit was activated, R130 would be connected between time-slot 3 and the column analog data output line. This encodes 10 units of column current (see shaded area in time-slot 3 of the waveform shown in Fig. 1-32B). Since one unit of row current is also encoded during this time-slot by R30, a > symbol is added to the display. The CRT readout will now show ↓>100 μV. In a similar manner, the other switches can change the encoded data for the column output and thereby change the readout display. See the descriptions which follow for decoding this information.

The column analog data encoded by most plug-in units can be modified by attenuator probes connected to the input connectors of amplifier plug-in units. A special coding ring around the input connector of the plug-in unit senses the attenuation ratio of the probe (with readout-coded probes only). The probe contains a circuit that provides additional column current. For example, if a 10X attenuator probe is connected to a plug-in unit encoded for 100 microvolts as shown in Fig. 1-31, an additional unit of



PROGRAM FOR 100 µV, INVERTED, CALIBRATED (UNCALIBRATED OPERATION SHOWN BY SHADED AREA)

Fig. 1-32. Idealized current waveforms of: (A) Row analog data, (B) Column analog data.

current is added to the column analog data during time-slot 1. Since two units of current were encoded by R111 (see Fig. 1-31), this additional current results in a total of three units of column analog current during this time-slot. Referring to the Character Selection Matrix, three units of column current, along with the two units of row current encoded by R10, indicates that the prefix should be shifted one column to the left. Since this instruction occurs in the same time-slot that previously indicated that two zeros should be added to the display and only one instruction can be encoded during a time-slot, the zeros do not appear in the display. The CRT readout will now be changed to 1 mV (readout program produced by plug-in same as for previous example).

Three other lines of information are connected from the plug-in compartments to the Readout System. The column and row analog data from Channel 2 of a dual-channel plug-in are connected to the Readout System through terminals A38 and B38 of the plug-in interface, respectively. Force readout information is encoded on terminal A35; the function of this input is described under Column and Row Data Switches.

The preceding information gave a typical example of encoding data from an amplifier plug-in unit. Specific encoding data and circuitry is shown in the individual plug-in unit manuals.

Column and Row Data Switches

The encoding data from the plug-in units is connected to the Column and Row Data Switch stages. A column-data line and a row-data line convey analog data from each of the eight data sources (two channels from each of the four plug-in compartments).

The Column Data Switch U2190 and the Row Data Switch U2180 receive the Channel Address Code from the Channel Counter. This binary code directs the Column Data Switch and the Row Data Switch as to which channel should be the source of the encoding data. Table 1-5 gives the eight combinations of the Channel Address Code and the resultant channel selected with each combination. These stages have nine inputs and provide a time-multiplexed output at pin 7, which includes the information from all of the input channels. Eight of the nine inputs to each stage originate in the plug-in units; the ninth input comes from a special data-encoding network composed of resistors R2191 through R2199 and R2201 through R2209. (See Zeros Logic and Memory description for further information on ninth channel.)

In addition to the encoding data inputs from the plug-in units, inputs are provided to the Column Data Switch from the VERTICAL MODE and HORIZONTAL MODE switches to inhibit the readout for any plug-in unit(s) not selected for display (see Diagram 2). When a plug-in unit is selected, a HI level is applied to the inhibit input for the opposite channel. The channel inhibit lines are LO only when the associated plug-in unit has been selected for display. When a unit is not selected, the respective line is HI to forward bias the associated diodes: CR2162-CR2163, CR2166-CR2167, CR2170-CR2171, or CR2174-CR2175. The forward-biased diodes cause the channel switches to bypass the encoded data from the inhibited channel. However, since it may be desired to display information from special-purpose plug-in units (even though they do not produce a normal waveform display on the CRT), a feature is provided to over-ride the channel inhibit. This is done by applying a LO to the associated Force Readout input. The LO level diverts the HI channel-inhibit current and allows the data from this plug-in unit to reach the Column Data Switch, even though it has not been selected for display by the mode switch.

Row Match adjustment R2182 sets the gain of the Row Data Switch to match the gain of the Row Decoder for correct output. Column Match adjustment R2213 performs the same function for the Column Data Switch stage.

Display-Skip Generator

The Display-Skip Generator is made up of Q2215, Q2233, Q2225, and Q2229. This stage monitors the time-multiplexed column data at the output of the Column Data Switch during each time-slot to determine if the information at this point is valid data that should result in a CRT display. Quiescently, there is about 100 microamperes of current flowing through R2213 from Q2240 and the Zeros Logic and Memory stage. (The purpose of this quiescent current will be discussed in connection with the Zeros Logic and Memory stage.) This current biases Q2215A so that its base is about 0.2 volt more positive than the base of Q2215B in the absence of column data. Therefore, since Q2215A and Q2215B are connected as a comparator, Q2215A will remain on unless its base is pulled more negative than the base of Q2215B.

The analog data output from the Column Data Switch produces a 0.5-volt (approximately) change for each unit of column current that has been encoded by the plug-in unit. Whenever any information appears at the output of the Column Data Switch, the base of Q2215A is pulled more negative than the base of Q2215B, resulting in a negative (LO) Display-Skip output to the Timer stage through Q2225. Recall that a LO was necessary at the skip input of the Timer so it could perform the complete sequence necessary to display a character.

Q2223-Q2229 also provide Display-Skip action. The End-of-Word level connected to their emitters is LO only during time-slot 1. This means they are enabled only during this time-slot. These transistors allow the Zeros Logic and Memory stage to generate a Display-Skip signal during time-slot 1 when information that is not to be displayed on the CRT has been stored in memory (further information is given under Zeros Logic and Memory).

Column and Row Decoders

The Column Decoder U2244 and Row Decoder U2185 sense the magnitude of the analog voltages at their inputs (pin 10) and produce a binary output on one of ten lines corresponding to the column or row data encoded by the plug-in unit. These outputs provide the Column Digital Data and Row Digital Data, which is used by the Character Generator stages to select the desired character for display on the CRT. The column and row data is also used throughout the Readout System to perform other functions.

The input current at pin 9 of the Column Decoder stage is steered to only one of the ten Column Digital Data outputs. When a Display-Skip signal is present (collector of Q2225 HI), pin 9 is pulled HI through CR2226. This ensures that no current is connected to the Character Generator stage under this condition. Notice the corresponding input on the Row Decoder. This input is connected to ground and causes only one of the ten row outputs to saturate to ground.

The network at the input of the Row Decoder, made up of Q2153 and its associated components, is a Row-14 detector that produces the Jump Command. This row current is encoded by special-purpose plug-ins to cause all or part of a word to be jumped. Whenever row 14 (thirteen units of row current, or 1.3 milliamperes) is encoded, the base of Q2153 is pulled negative enough so that this transistor is reverse biased to produce a HI Jump Command output at its collector. The Jump Command is connected to the Word Trigger stage to advance the Channel Counter to the next word and to reset the Time-Slot Counter to time-slot 1.

Zeros Logic and Memory

The Zeros Logic and Memory stage U2232 stores data encoded by the plug-in units to provide zeros-adding and prefix-shifting logic for the Readout System. The Strobe pulse at pin 15 goes positive when the data has stabilized and can be inspected. This activates the Zeros Logic and Memory stage so that it can store the encoded data. A block representation of the memory sequence is shown in Fig. 1-33.

Typical output waveforms for the five possible input conditions that can occur are shown in Fig. 1-34. When time-slot 1 occurs, a store command is given to all of the memories. If the plug-in units encoded data for column 1, 2, 3, 4, or 10 during time-slot 1, the appropriate memory (or memories) is set. Notice that row 3 information from the Row Decoder must also be present at pin 16 for data to be stored in the memory of U2232.

If data was encoded during time-slot 1, a negative-going output is produced at pin 7 while the memories are being set. This negative-going pulse is connected to the base of Q2229 in the Display-Skip Generator to produce a Display-Skip output. Since the information encoded during time-slot 1 was only provided to set the memories and not intended to be displayed on the CRT at this time, the Display-Skip output prevents a readout display during this time-slot.

During time-slot 5, memory A is interrogated. If information was stored in this memory, a positive-going output is produced at pin 7. This pulse is connected to pin 10 of the Column Decoder through Q2240 to add one unit of current at the input of the Column Decoder. This produces a zero after the character displayed during time-slot 4. During time-slot 6, memory B is interrogated to see if another zero should be added. If another zero is necessary, a second positive output is produced at pin 7,

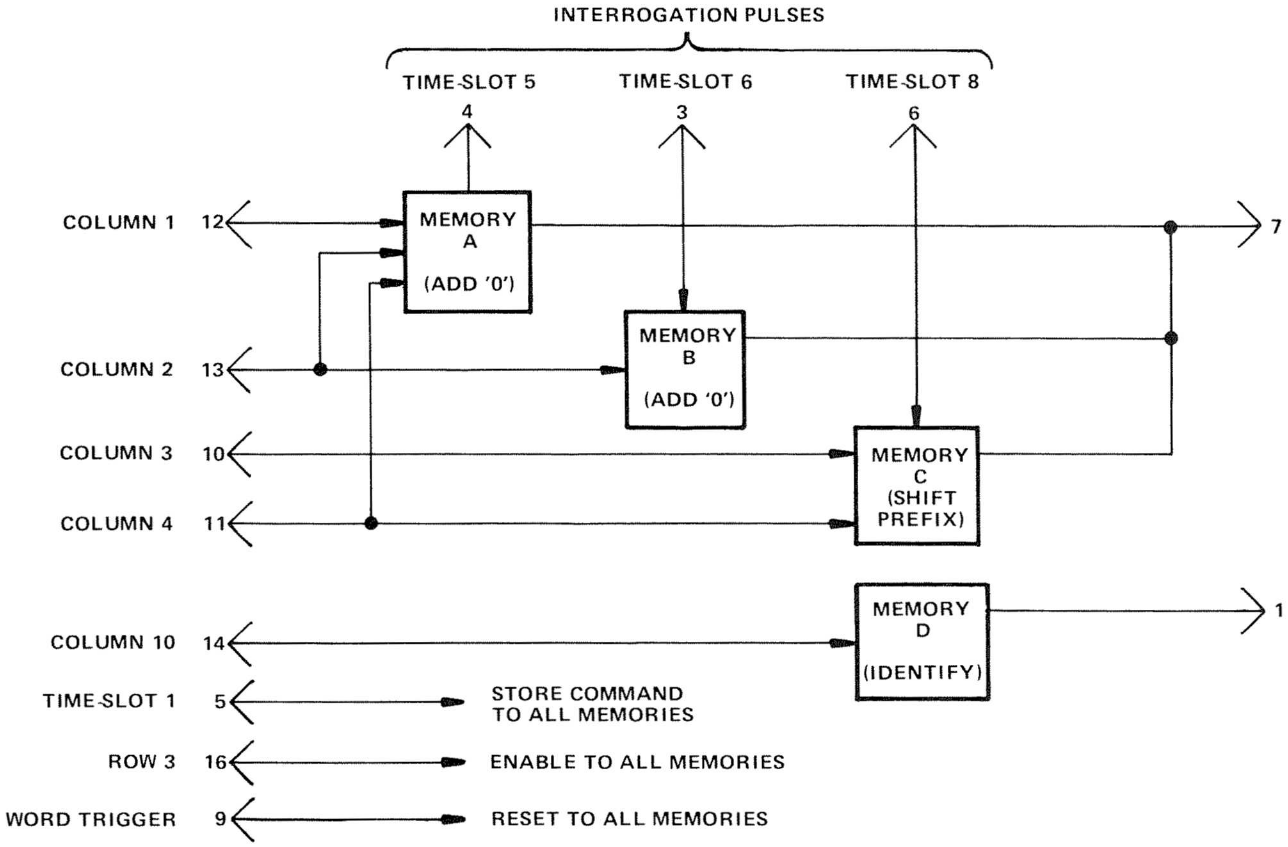


Fig. 1-33. Block representation of memory sequence in U2232.

which again results in a column 1 output from the Column Decoder and a second zero in the CRT display.

Finally, memory C is interrogated during time-slot 8 to obtain information on whether the prefix should be changed, or left at the value that was encoded. If data has been encoded that calls for a shift in prefix, a negative-going output level is produced at pin 7. This negative level subtracts one unit of column current from the data at the input to the Column Decoder. Notice on the Character Selection Matrix of Fig. 1-24 that when row 4 is programmed, a reduction of one column results in a one-column shift of the prefix. For example, with the 100 μV program shown in Fig. 1-31, if the data received from the plug-in called for a shift in prefix, the CRT readout would be changed to 1 mV (zeros deleted by program; see Encoding the Data).

The 100 microamperes of quiescent current through R2213 provided by Q2240 (see Display-Skip Generator) allows the prefix to be shifted from m (100 microamperes column current, column 1) to no prefix (zero column current, column zero) so only the unit of measurement encoded during time-slot 9 is displayed. Notice that reducing the prefix program from column 1 to column 0 programs the Readout System to not display a character at this readout location.

A further feature of the Zeros Logic and Memory is the Identify function. If 10 units of column current are encoded by the plug-in unit along with row 3 during time-slot 1, the Zeros Logic and Memory produces a negative-going output pulse at pin 1 to switch the Column Data Switch and Row Data Switch to the ninth channel. Then, time-slot pulses 2 through 9 encode an output current through resistors R2191-R2199 for column data and R2201-R2209 for row data. This provides the currents necessary to display the word IDENTIFY in the word position allotted to the channel that originated the Identify command. After completion of this word, the Column Data Switch and Row Data Switch continue with the next word in the sequence.

The Word Trigger signal from the Word Trigger stage is connected to pin 9 of U2232 through C2242. At the end of each word of readout information, this pulse goes LO. This erases the four memories in the Zeros Logic and Memory in preparation for the data to be received from the next channel.

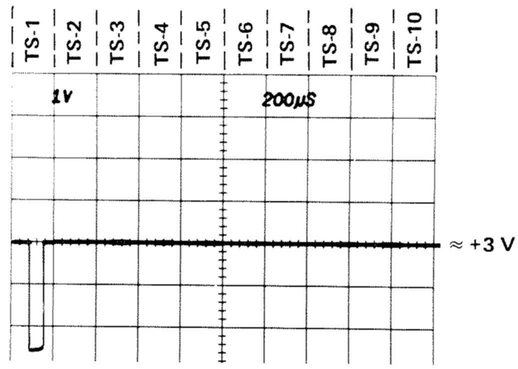
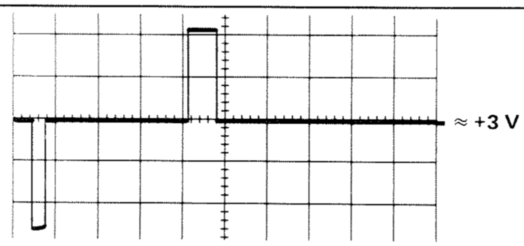
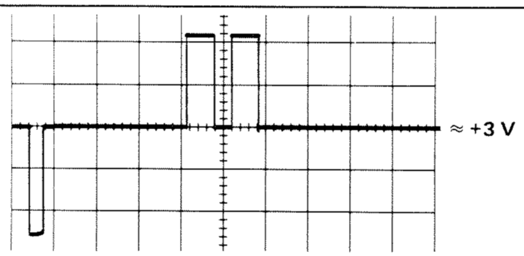
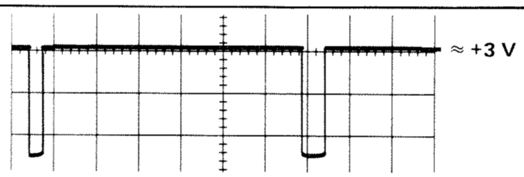
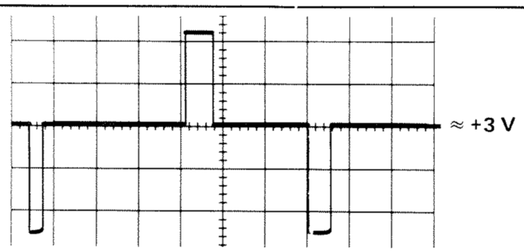
INPUT PIN OF U2232 ACTIVATED	COMMAND	TIME-SLOTS
14	IDENTIFY	
12	ADD ONE ZERO	
13	ADD TWO ZEROS	
10	DECREASE PREFIX	
11	DECREASE PREFIX AND ADD ONE ZERO	

Fig. 1-34. Typical output waveforms for Zeros Logic and Memory stage operation (at pin 7 of U2232).

Character Generators

The Character Generator stage consists of five similar integrated circuits (U2270 through U2278), which generate the X (horizontal) and Y (vertical) outputs at pins 16 and 1, respectively, to produce the character display on the CRT. Each integrated circuit can produce 10 individual characters. U2270 (designated "Numerals") can produce the numerals 0 through 9 shown in row 1 of the Character Selection Matrix (Fig. 1-24). U2272 can produce the symbols shown in row 2 of the Character Selection Matrix and U2274 produces the prefixes and some letters, used as prefixes, shown in row 4. U2276 and U2278 produce the remaining letters shown in rows 5 and 6 of the Character Selection Matrix.

All of the Character Generator stages receive the Column Digital Data from the Column Decoder U2244 in parallel. However, only one of the Character Generators receives

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row data at a particular time and only the stage receiving this row data is activated. For example, if column 2 is encoded, the five Character Generators are enabled so that either a 1, <, μ, V, or an N can be produced. If row 4 has been encoded at the same time, only the Prefix Character Generator U2274 will produce an output to result in a "μ" being displayed. The activated Character Generator provides current output for the Format Generator to produce the selected character on the CRT. In a similar manner, any of the characters shown in the Character Selection Matrix can be displayed by correct addressing of the row and column.

Decimal Point Logic and Character Position Counter

Decimal Point Logic and Character Position Counter U2260 performs two functions. The first function is to add a staircase current to the X (horizontal) signal to space the characters horizontally on the CRT. After each character is generated, the negative-going edge of the Ready signal at pin 5 advances the Character Position Counter. This produces a current step output at pin 3 which, when added to the X signal, causes the next character to be displayed one character space to the right. This stage can also be advanced when a Space instruction is encoded so a space is left between the displayed characters on the CRT. Row 10 information from the Row Decoder is connected to pin 4 of U2260. When row 10 and column 0 are encoded, the output of this stage advances one step to move the next character another space to the right. However, under this condition, no display is produced on the CRT during this time-slot, since the Character Generators are not activated.

Time-slot pulses 1, 2, and 3 are also connected to pin 4 of U2260 through VR2262, VR2263, and VR2264 respectively and R2262-R2265. This configuration adds a space to the displayed word during time-slots 1, 2, and 3 even if information is not encoded for display during these time-slots. With this feature, the information displayed during time-slot 4 (scaling data) always starts in the fourth character position whether data has been displayed in the previous time-slots or not. Therefore, the resultant CRT display does not shift position as normal-invert or cal-uncal information is encoded. The Word Trigger pulse connected to pin 8 resets the Character Position Counter to the first character position at the end of each word.

The Decimal Point Logic portion of this stage allows decimal points to be added to the CRT display. With the Standard Readout Format, row 7, encoded coincident with columns 3 through 7, addresses a decimal at one of the five locations identified in row 7 of the Character Selection Matrix (Fig. 1-24). This instruction refers to the decimal point location in relation to the total number of characters possible in one word (see Fig. 1-35). For example, column 3 encoded with row 7 during time-slot 1 places a decimal point in location No. 3. As shown in Fig. 1-35, this displays a decimal point after the third character that can be displayed on the CRT. (The first three time-slots produce a space whether data is encoded or not; see previous paragraph.)

When decimal-point data is encoded, the CRT is unblanked so a readout display is presented. Since row 7 does not activate any of the five Character Generators, the CRT beam is deflected vertically by the application of row-7 data to the Y input of the Format Generator through R2280. This places the decimal point between the characters along the bottom line of the readout word. After the decimal point is produced in the addressed location, the

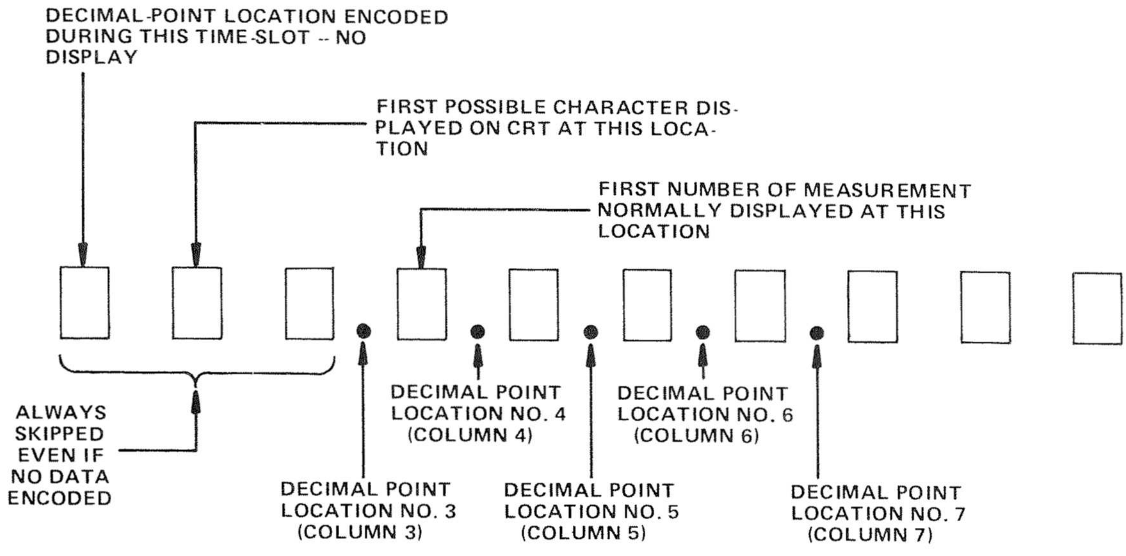

Fig. 1-35. Readout word relating 10 possible character locations to the decimal point instructions that can be encoded, and the resultant CRT display.

CRT beam returns to the location indicated by the Character Position Counter to produce the remainder of the display.

Format Generator

The X- and Y- deflection signals produced by the Character Generator stage are connected to pins 2 and 7, respectively, of Format Generator U2284. The Channel Address Code from the Channel Counter is also connected to pins 1, 8, and 15 of this stage. The Channel Address Code directs the Format Generator to add current to the X and Y signals to deflect the CRT beam to the area of the CRT associated with the plug-in channel that originated the information (see Fig. 1-23). The Channel Address Code and the resultant word positions are shown in Table 1-5. The Ready signal at pin 13 (coincident with the Vertical and Horizontal OFF Command output) activates this stage when a character is to be displayed on the CRT. R2274 and R2275 determine the horizontal and vertical size, respectively, of the displayed characters. In instruments serial Number B090000 and higher, R2273 provides an adjustment to set the vertical size of the characters (Character Height) as desired. The character position current from the Decimal Point Logic and Character Position Counter stage is added to the X (horizontal) input signal to space the characters horizontally on the CRT (see previous discussion).

Y-Output Amplifier

The Y-output signal at pin 6 of Format Generator U2284 is connected to the Y-Output Amplifier Q2287-Q2299. This stage provides a low-impedance load for the Format Generator while providing isolation between the Readout System and the driven circuits. Vertical Separation adjustment R2291 changes the gain of this stage to control the vertical separation between the readout words displayed at the top and bottom of the graticule area.

X-Output Amplifier

The X-Output Amplifier Q2286-Q2296 operates like the Y-Output Amplifier, to provide the horizontal deflection from the readout signal available at pin 4 of U2284. The gain of this stage is fixed by the values of the resistors in the circuit.

Display Sequence

Figure 1-36 shows a flow chart for the Readout System. This chart illustrates the sequence of events that occurs in the Readout System each time a character is generated and displayed on the CRT.

VERTICAL AMPLIFIER ⟨6⟩

General

The Vertical Amplifier circuit includes the Vertical Channel Switch and Main Vertical Amplifier circuits. The Vertical Channel Switch circuit selects the vertical deflection signal from the output of the LEFT or RIGHT VERT plug-in unit. This circuit also accepts an input from the Readout System to block the vertical signal while readout information is displayed on the CRT. The Main Vertical Amplifier circuit provides the final amplification for the vertical signal before it is applied to the vertical deflection plates of the CRT. This circuit includes the delay line and an input to produce the vertical portion of a readout display. The BEAM FINDER switch limits the dynamic range of this circuit to compress an over-scanned display within the viewing area of the CRT. An input from the Readout System is provided to over-ride the beam-finder function, so the BEAM FINDER switch has no effect on the readout portion of the CRT display. In addition, this circuit accepts the Auxiliary Y-Axis input from the Main Interface circuit.

Figure 1-37 shows a detailed block diagram of the Vertical Amplifier circuit. A schematic of this circuit is shown on diagram 6 at the rear of this manual.

Vertical Channel Switch

The Vertical Channel Switch determines which input signal provides the vertical signal to the Main Vertical Amplifier as controlled by the Vertical Mode Command from the Logic circuit. This stage is made up primarily of integrated circuit U625. An input/output table for U625 is shown in Fig. 1-38. The positive- and negative-signal channels from the vertical plug-in compartments are connected to the inputs of U625 through 50-ohm coaxial cables. Each coaxial cable is terminated in its characteristic impedance by U625 and external components. For example, R602-R603-C603 and U625 (at pins 6 and 7) terminate the Left Vertical positive-signal channel. R602 is selected for a termination impedance of exactly 50 ohms. Bias inputs to U625 permit the characteristics of each channel to be set by external components. For example, the Left Vertical positive-signal channel operating level is set by R621-R624-R625; the accuracy of the current gain is set by R622; frequency compensation is provided by R623-C623 and R620-C620. Likewise, other components in the same configuration perform these same functions for the remaining signal channels.

The output signal at pins 1 and 2 is a push-pull signal, which is connected to the Main Vertical Amplifier through Delay Line DL650. R646 is selected to set the output impedance of U625 at exactly 100 ohms differentially to accurately reverse-terminate the delay line. The sum of the DC current at the output pins is always equal to the sum of

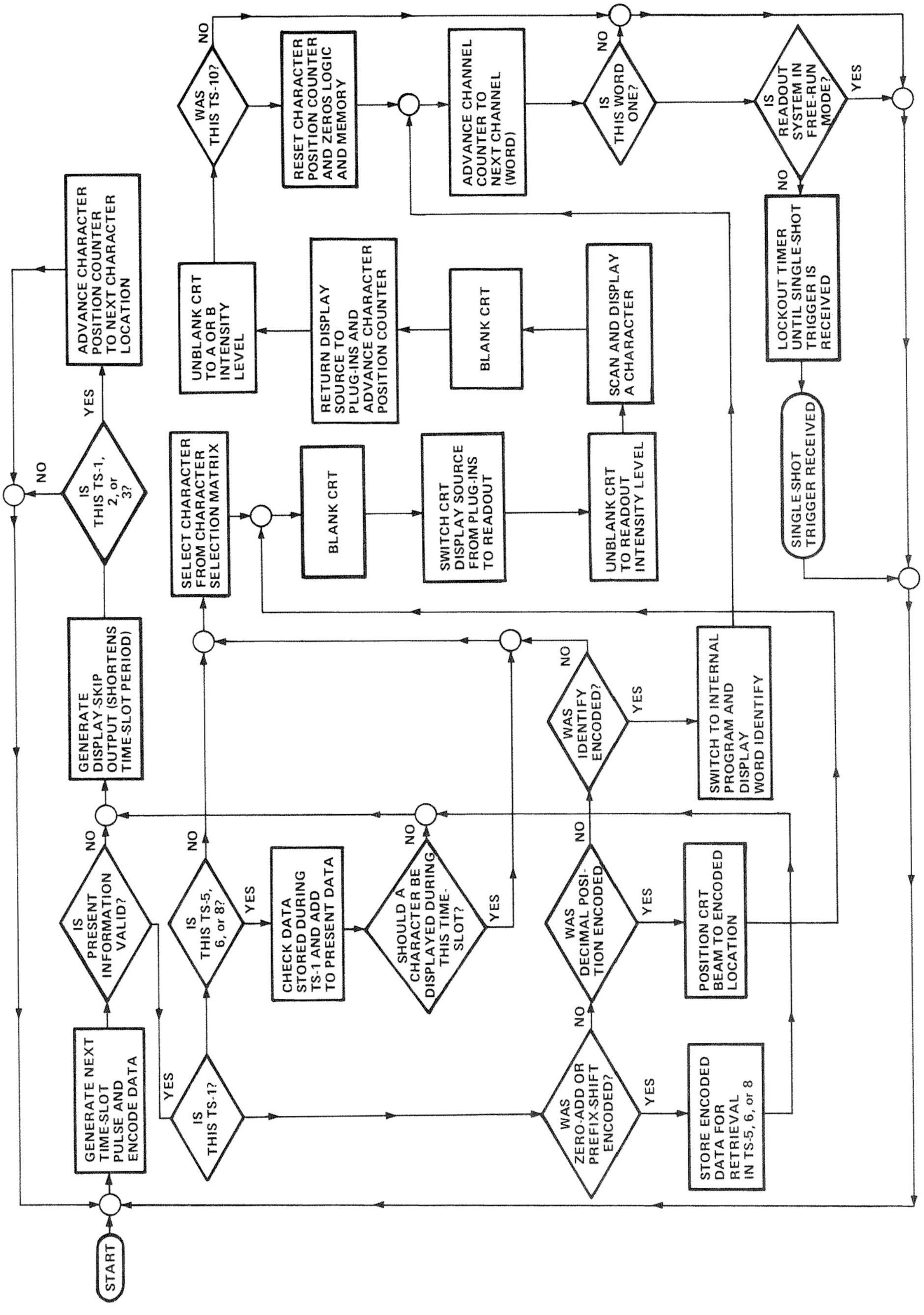

Fig. 1-36. Flow chart for character generation by the Readout System.

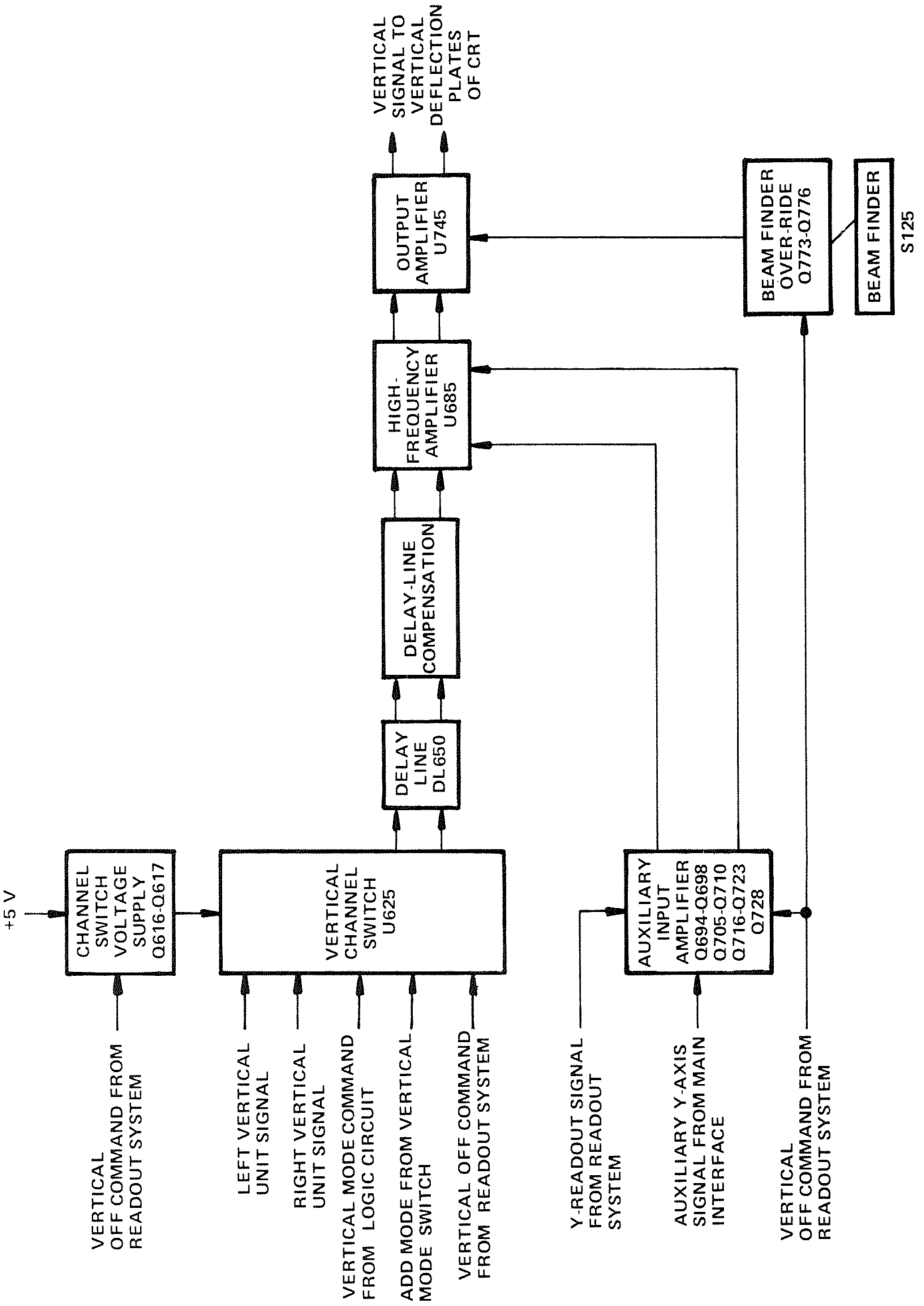

Fig. 1-37. Vertical Amplifier detailed block diagram.

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INPUT: VERTICAL MODE COMMAND	INPUT: ADD MODE	INPUT: VERTICAL/ HORIZONTAL OFF COMMAND	OUTPUT: OUTPUT SIGNAL
LO	LO	LO	LEFT VERTICAL SIGNAL
HI	LO	LO	RIGHT VERTICAL SIGNAL
LO	HI	LO	BOTH (ADDED ALGEBRAICALLY)
Φ	Φ	HI	NEITHER (BLOCKED BY READOUT SYSTEM)

Φ = HAS NO EFFECT IN THIS CASE

Fig. 1-38. Input/output table for Vertical Channel Switch IC, U625.

the DC currents at the bias inputs in all modes. This provides a constant DC bias to the following stage as the VERTICAL MODE switch is changed.

Operating voltage for U625 is derived from the +5-Volt Supply by the Channel Switch Voltage Supply, Q616 and Q617. The voltage provided to pin 3-U625 is determined by an input from the Readout System. When the Vertical OFF Command from the Readout System is LO, the output at the emitter of Q617 is approximately +2.5 volts as established by divider R613-R614-R615-CR615 at the base of Q617. A HI-level Vertical OFF Command saturates Q616 to effectively short-circuit R615-CR615. This lowers the voltage at the base of Q617 to supply a lower voltage to U625 when readout information is to be displayed.

Auxiliary Input Amplifier

The Auxiliary Input Amplifier controls the bias current to the High-Frequency Amplifier stage to provide centering for the Main Vertical Amplifier circuit. This stage also provides readout and auxiliary inputs to the Main Vertical Amplifier circuit.

Auxiliary Y-axis signals are connected to the base of Q694. Q694-Q698 are connected as a paraphase amplifier to convert the single-ended input to a push-pull output to drive Q710-Q716. The Vertical OFF Command from the Readout System goes HI when readout information is to be displayed. This HI level turns on Q705; the emitter of Q705 goes HI to turn off Q694-Q698, thus blocking any auxiliary Y-axis signals. During the readout time, bias current to Q710-Q716 is supplied through R707-R708-R709. Readout Vertical Centering adjustment R707 balances this bias current to adjust the vertical position of the readout portion of the CRT display. The Vertical Centering adjustment R712 balances the quiescent DC levels in this stage so the trace is displayed at the center of the CRT when the inputs to the Main Vertical Amplifier circuit are at the same potential.

The signal at the collectors of Q710-Q716 is applied to the bases of Q723-Q728 through R718-R721. For readout displays, the Y-signal from the Readout System is connected to the base of Q723 through R719. Since the signal from the vertical units is blocked in the Vertical Channel Switch, the readout signal provides the only vertical deflection. Although this signal is connected to the base of Q723 as a single-ended signal, this transistor pair acts as a paraphase amplifier to convert the signal to push-pull. The output of this stage at the collectors of Q723-Q728 is connected to the bias inputs of U685 in the High-Frequency Amplifier stage.

Delay Line

Delay Line DL650 provides approximately 60 nanoseconds of delay for the vertical signal to allow the horizontal circuits time to initiate a sweep before the vertical signal reaches the vertical deflection plates of the CRT. This allows the instrument to display the leading edge of the signal originating the trigger pulse when using internal triggering. The delay line used in this instrument has a characteristic impedance of 100 ohms differentially. It is of the coaxial type that does not produce preshoot or phase distortion in the CRT display.

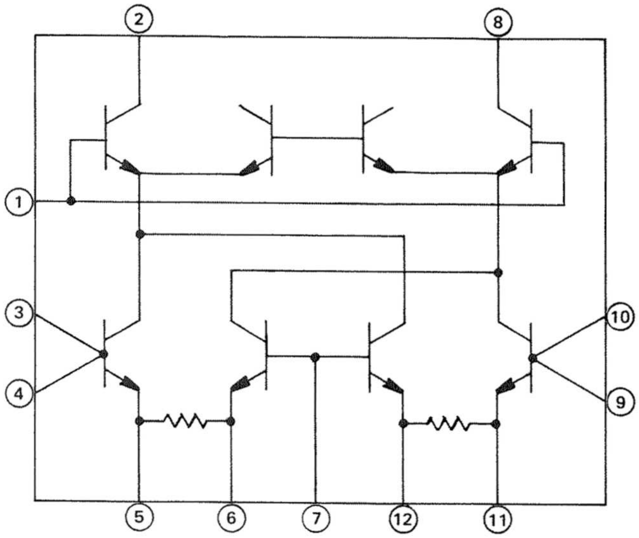

Fig. 1-39. U685 internal circuitry representation.

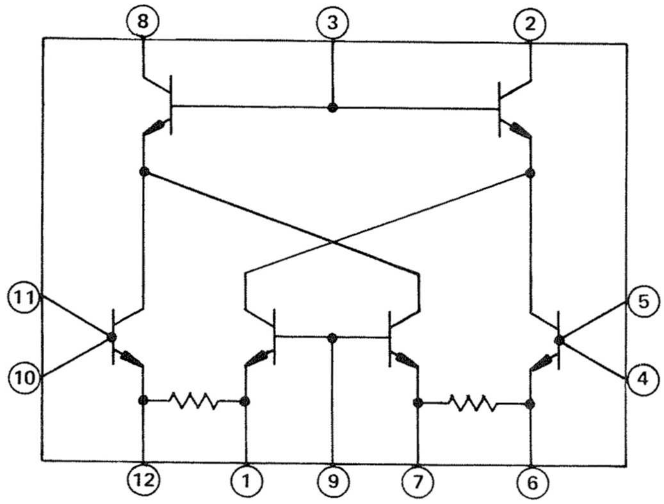

Fig. 1-40. U745 internal circuitry representation.

High-Frequency Amplifier

The High-Frequency Amplifier stage, consisting primarily of integrated circuit U685, provides a 50-ohm input impedance (100 ohms differentially) for the Main Vertical Amplifier circuit to permit accurate delay-line termination. The components connecting the input signal to U685 provide forward termination and compensation for the delay line. R658-C658 provide adjustable high-frequency compensation. The internal circuitry of U685 is represented in Fig. 1-39. Terminals to the emitters of the input transistors of U685 at pins 5-6 and 11-12 permit the quiescent operating conditions of the stage to be set by discrete components. R682 and R689 set the quiescent operating level; R684 and R688 are selected to accurately set the gain of the differential channels. These emitter inputs also provide a means of injecting the output of the Auxiliary Y-Axis Amplifier. The Vertical Gain adjustment R730 and sensistor R731 set the resistance between the output terminals of U685 to control the current gain of this stage. This adjustment sets the overall gain of the Main Vertical Amplifier circuit; the sensistor provides thermal compensation.

Output Amplifier

The Output Amplifier stage, consisting primarily of integrated circuit U745, provides final amplification for the vertical signal to drive the CRT vertical deflection plates. A representation of the internal circuitry of U745 is shown in Fig. 1-40. Terminals to the emitters of the input transistors at pins 1-12 and 6-7 allow the use of discrete components to establish the quiescent operating characteristics of this stage. R741 and R756 are selected to accurately set the gain of the differential channels. R753-R754-R767-R768-R770 set the operating level of this stage. The series RC networks in parallel with R741 and R756 provide frequency compensation for uniform gain at all frequencies within the bandpass of this instrument.

The BEAM FINDER switch, S125, switches the emitter current source for U745 to provide the beam finder function. Normally, the emitter current for U745 is supplied from ground through S125. However, when S125 is actuated, the only emitter current source for U745 is through R771. This limits the dynamic range of this stage by limiting its current, so the display is compressed vertically within the graticule area.

The signal at the output collectors of U745 is connected directly to the vertical deflection plates of the CRT. A distributed deflection plate system is used in this instrument for maximum frequency response and sensitivity. The signal at the output of U745 is connected to the deflection-plate structure in the CRT and then to termination network LR780-R782A-LR784—R782B. As the signal passes through the deflection-plate structure in the CRT, its velocity is essentially the same as the velocity of the electron beam passing between the vertical deflection plates. This synchronism of the deflection signal and the electron beam reduces the loss in high-frequency sensitivity due to electron-transit time through the deflection-plate structure.

Beam Finder Over-Ride

The Beam Finder Over-Ride stage switches the current source for the Output Amplifier stage to over-ride the beam-finder function as determined by the Vertical OFF Command from the Readout System. Quiescently, the Vertical OFF Command is LO with Q776 conducting to cut off Q773. When the BEAM FINDER switch is actuated, R771 limits the current for the Output Amplifier. When readout information is to be displayed, the Vertical OFF Command goes HI to cut off Q776. The resultant HI on the

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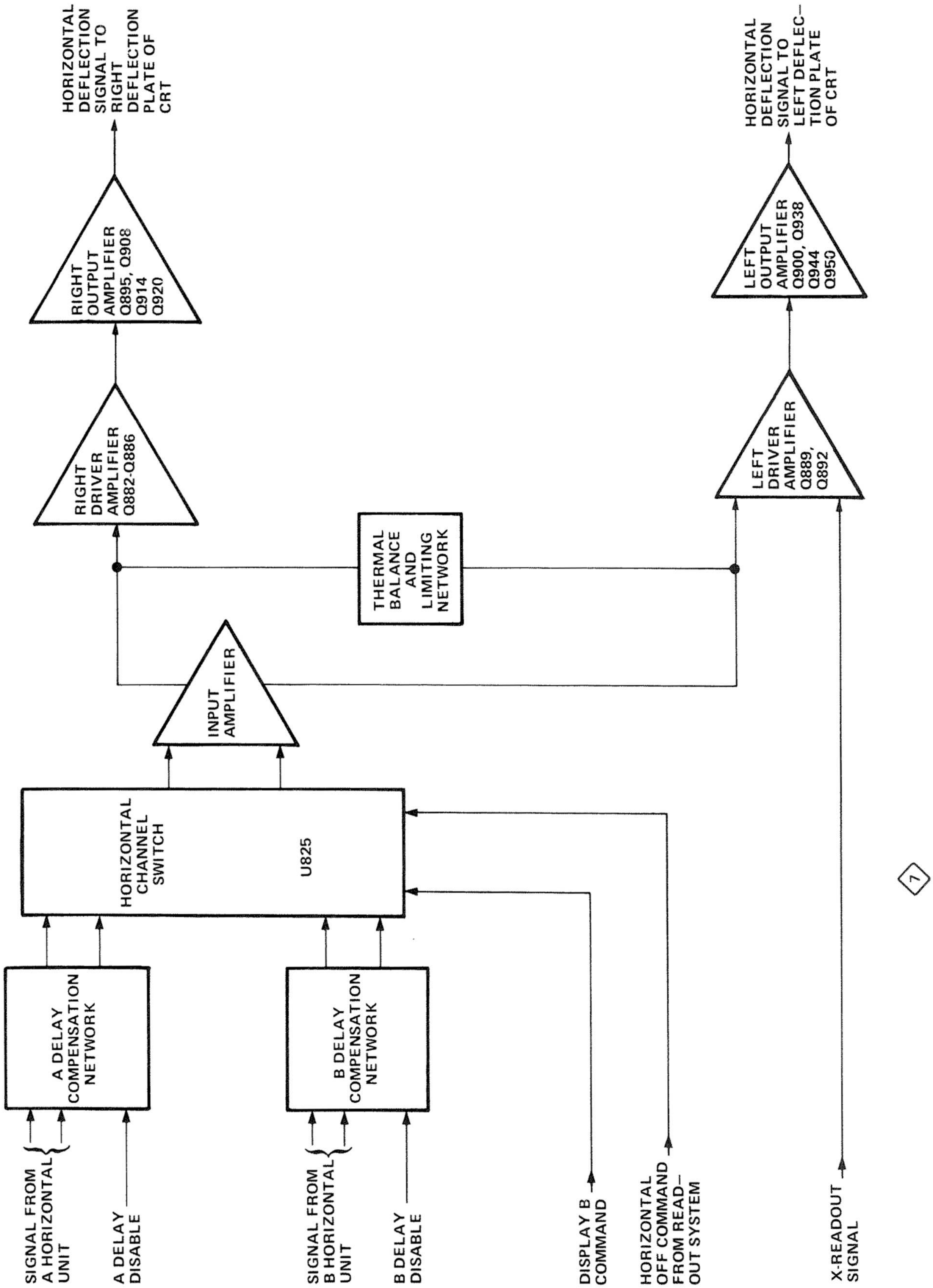

Fig. 1-41. Horizontal Amplifier detailed block diagram.

emitter of Q776 causes Q773 to saturate. The current necessary for full-range operation of U745 is supplied from ground through Q773 during this time.

HORIZONTAL AMPLIFIER ⟨7⟩

General

The Horizontal Amplifier circuit includes the X-Y Delay Compensation Network (Option 2 only), Horizontal Channel Switch, and Main Horizontal Amplifier circuits. The X-Y Delay Compensation Network provides a delay for the horizontal (X) signal portion of an X-Y display to match the delay of the vertical (Y) signal due to the Delay Line. The Horizontal Channel Switch portion of the circuit selects the horizontal deflection signal from the output of the A HORIZ or B HORIZ plug-in unit. The Main Horizontal Amplifier circuit amplifies the push-pull horizontal deflection signal from the Horizontal Channel Switch for application to the horizontal deflection plates of the CRT. This circuit also accepts the X-signal from the Readout System to produce the horizontal portion of a readout display. Figure 1-41 shows a detailed block diagram of the Horizontal Amplifier circuit. A schematic of this circuit is shown on diagram 7 at the rear of this manual.

X-Y Delay Compensation (Option 2 Only)

Time-Base Operation. When the plug-in unit installed in the A or B HORIZ compartment is operated as a standard time-base unit to produce a horizontal sweep for deflection of the CRT beam, the A or B Delay Compensation Networks are effectively disabled. The delay disable command is HI and relays K802-K805 or K812-K815 are not actuated. Therefore, the relay contacts remain in the normally-closed position so the horizontal signal passes directly through this network to the Horizontal Channel Switch without delay.

X-Y Operation. If the time-base unit installed in the A or B HORIZ compartment is operated as an amplifier, or if an amplifier unit is installed in a horizontal compartment, the delay disable command to the applicable Delay Compensation Network drops to the LO level (zero volts). This provides an actuating level to relays K802-K805 or K812-K815 to connect the Delay Compensation Network into the circuit. For example, if the A Delay Disable command from the A HORIZ unit goes LO, K802 and K805 close to route the A HORIZ signal through the A Delay Compensation Network. Diode CR801 shunts the voltage produced across the relays when the actuating level is removed.

The Delay Compensation Network provides maximally flat time delay with frequency. LC network L806-C806, L807-C807, L808-C808, L809-C809 is an all-pass lattice network with a 100-ohm input impedance when terminated in 100 ohms (50 ohms each side). Low-pass network L802-R802, C803-C804, L805-R805 also has a 100-ohm input impedance when terminated in 100 ohms. Only the low-pass network determines the bandwidth of the Delay Compensation Network. The total time delay is the sum of the low-pass and lattice-network time delays. C804, in the low-pass network, is adjusted to match the horizontal-system time delay to the vertical-system time delay up to at least one megahertz.

The Delay Compensation Network normally produces negative preshoot distortion along with some corner rounding of fast step functions. The A Delay Disable switch S801 allows selection of a display with either minimum phase-shift characteristics or optimum step response. When this switch is set to Out, the A Delay Disable command is disconnected from relays K802-K805. Now, the signal from the A HORIZ unit passes directly to the Horizontal Channel Switch without delay to provide a horizontal display with optimum step response.

The B Delay Compensation Network operates in the same manner as described above. The X-Y Delay Compensation Network is an optional feature. For instruments which are not equipped with this feature, the horizontal signals from the plug-in units are connected directly to the Horizontal Channel Switch through the Horizontal Interconnect board.

Horizontal Channel Switch

The Horizontal Channel Switch determines which input signal provides the horizontal signal to the Main Horizontal Amplifier as controlled by the Display B Command from the Logic circuit. Resistors R821-R823 and R825-R827 establish the 50-ohm input resistance of this stage and provide a load for the A and B HORIZ units or terminate the actuated Delay Compensation Network (Option 2 only). Resistors R835-R836-R837 and R845-R846-R847 establish the operating levels for this stage. R835-R836 and R845-R846 set the current gain for each channel.

This stage is made up primarily of integrated circuit U825. An input/output table for U825 is shown in Fig. 1-42. U825 provides a differential input for the signal from the A HORIZ unit at pins 2 and 15 and the signal from the B HORIZ unit at pins 7 and 10. The output signal at pins 12 and 13 is a differential signal which is connected to the Main Horizontal Amplifier circuit. The sum of the DC current at pins 12 and 13 is always equal to the sum of the DC currents at pins 1, 8, 9, and 16 in all modes. This provides a constant DC output current level to the following stage as the HORIZONTAL MODE switch is changed.

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INPUT		OUTPUT
DISPLAY B COMMAND	HORIZONTAL OFF COMMAND	OUTPUT SIGNAL
4	6	12, 13
LO	LO	A HORIZONTAL SIGNAL
HI	LO	B HORIZONTAL SIGNAL
Φ	HI	NEITHER (BLOCKED BY READOUT SYSTEM)

Φ = HAS NO EFFECT IN THIS CASE

Fig. 1-42. Input/output table for Horizontal Channel Switch IC, U825.

The Horizontal OFF Command from the Readout System, which is applied to pin 6, has final control over the output signal from this stage. Quiescently, this signal is LO and the signal from the selected horizontal unit can pass to output pins 12 and 13. However, when the Readout System is ready to display readout information, the level at pin 6 goes HI. This level blocks the signal from both horizontal units so there is no signal output from this stage under this condition.

Input Amplifier

The signal from the Horizontal Channel Switch is connected to the bases of Q864 and Q869. The gain of this stage is controlled by the resistive network between the emitters of Q864-Q869. Horizontal Gain adjustment R867 is variable to set the overall gain. Horizontal Centering adjustment R859 balances the emitter currents of Q864-Q869 to horizontally center the display. The emitter current for this stage is normally supplied from the +15-Volt Supply through L857 and BEAM FINDER switch S125. However, when the BEAM FINDER switch is actuated, the emitter current is supplied through R857. This results in less current to Q864 and Q869, so their dynamic range is limited. This reduces the effective gain of the horizontal system to keep the display within the horizontal limits of the graticule, regardless of the setting of positioning controls or signal amplitude.

Left and Right Driver Amplifiers

The Left and Right Driver Amplifiers each consist of an operational amplifier and emitter follower to drive their respective output amplifier stages. Q882 is the operational amplifier for the Right Driver Amplifier; R864 is R_i and R881 is R_f. Emitter-follower Q886 provides a low output impedance to drive the Right Output Amplifier. Q886, a PNP-type transistor, responds best to negative-going signals. Q889 is the operational amplifier for the Left Driver Amplifier; R869 is R_i and R888 is R_f. Emitter-follower Q892 is complementary to the corresponding transistor in the Right Driver Amplifier. Therefore, this stage provides the best response to positive-going signals.

Limiting Network CR863-CR870-CR873-CR874 limits the input to the succeeding stages, so they always operate within their dynamic range and are not overdriven by excessive current from the Input Amplifier stage. Since the output from the Input Amplifier stage is a current signal, very little voltage change occurs across the Limiting Network. When horizontal deflection signals that produce an on-screen display are applied, CR863 and CR870 remain forward biased and CR873-CR874 are reverse biased. However, if high-amplitude signals are applied to this circuit, either CR863 or CR870 is reverse biased, depending on the polarity of the overdrive signal. This results in a sufficient voltage change at the anode of either CR873 or CR874 to forward bias it. The shunt diodes provide a current path for the signal current to limit the current change at the bases of Q882-Q889 during the overdrive condition. Limit Center adjustment R876 balances the quiescent current at the bases of Q882 and Q889 so limiting does not occur during the displayed portion of the horizontal deflection signal. Thermal Balance adjustment R877 sets the bias on Q882 and Q889 and thereby determines their operating voltage. This adjustment reduces low-frequency signal cross talk and DC shift in the CRT display.

Right Output Amplifier

The Right Output Amplifier consists of two current-driven feedback amplifiers. Low-frequency signals at the emitter of Q886 are amplified by Q920 and Q914. The feedback network for the low-frequency amplifier is R918-C918 and R925-C925; R925 is R_i and R918 is R_f. C925 adjusts the high-frequency gain of the low-frequency amplifier. High-frequency signals at the emitter of Q886 are amplified by Q895 and Q908. C897-C898 and R898 provide series feedback. C898 and R898 are variable to adjust the gain of the high-frequency amplifier. The output transistors Q908 and Q914 are connected in the complementary configuration to provide less resistive loading at the output.

Left Output Amplifier

Basic operation of the Left Output Amplifier is the same as just described for the Right Output Amplifier.

OUTPUT SIGNALS AND CALIBRATOR ⟨8⟩

General

The Output Signals and Calibrator circuit provides output signals to the connectors located in the OUTPUT section of the front panel. These output signals are either generated within this instrument or are samples of signals from the associated plug-in units. Figure 1-43 shows a detailed block diagram of the Output Signals and Calibrator circuit. A schematic of this circuit is shown on diagram 8 at the rear of this manual.

Vertical Signal Amplifier

The vertical signal selected by the B TRIGGER SOURCE switch (see Trigger Selector description for more information) is connected to the emitters of transistors Q1013 and Q1016 through resistors R1003 and R1005 respectively. These resistors establish an input resistance of about 50 ohms for this stage and terminate the B Trigger Channel Switch stage; see Trigger Selector. Resistors R1007-R1008-R1010-R1012 along with R1014-R1015 determine the bias levels for this stage. DC Centering adjustment R1007 is set for a zero-volt quiescent output level. The single-ended signal at the collector of Q1021 is connected to the front-panel SIG OUT connector J1029 through CR1022. CR1022 and CR1024 protect this stage if high-level voltages are accidentally applied to the SIG OUT connector.

Sawtooth Amplifier

The sweep signals (sawtooth waveforms) from the A time-base unit or the B time-base unit are connected to the emitter of Q1042 through series resistor R1033 or R1038 respectively. The Sweep switch S1035 determines which sawtooth signal provides the output. The other sawtooth signal is terminated by S1035 grounding the previously mentioned series resistor to provide a similar load to the signal source. The signal at the collector of Q1042 is connected to transistors Q1046-Q1052, which compose an inverting feedback amplifier. The signal at the collector of Q1052 is connected to the front-panel +SAWTOOTH connector J1059 through R1057.

Gate Amplifier

The output signal at the front-panel + GATE connector J1089 is selected from three input gate signals by Gate switch S1065. In the A position, the A Gate signal from the A time-base unit is connected to the base of emitter-follower Q1069 through R1067. The base of Q1073 is connected to ground by S1065 in this position so it

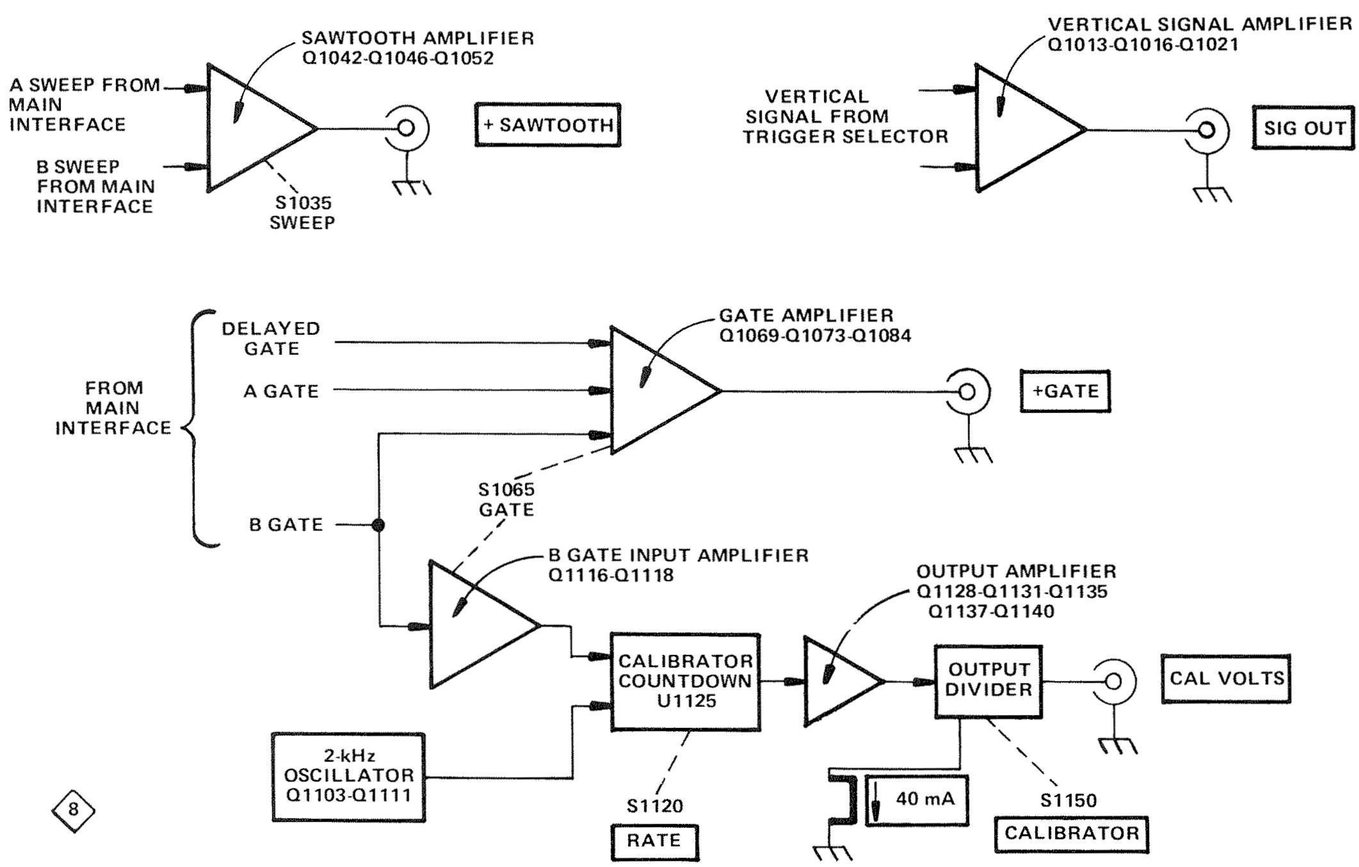

Fig. 1-43. Output Signals and Calibrator circuit detailed block diagram.

operates as a common-base stage. Q1069 provides a high input impedance for the stage, while the emitter coupling between Q1069-Q1073 provides temperature compensation. Operation is the same in the B position of S1065 except that the B Gate signal from the B time-base unit provides the input signal. In the Dly'd position, S1064 connects the base of Q1069 to ground through R1067 and disconnects both the A and B Gate signals. Now, the Delayed Gate signal from a delaying time-base unit (in either A or B HORIZ compartments) can pass to the base of Q1073 through R1077. Q1073 inverts this negative-going input signal so the gate output signals at the + GATE connector are all positive-going. C1070 provides high-frequency compensation for this stage.

The input gate signal selected by S1065 is connected to the emitter of Q1084. Diode CR1081 provides temperature compensation for Q1084. The signal at the collector of Q1084 is connected to the + GATE connector through CR1086. CR1086 protects Q1084 if a high-level positive voltage is applied to the + GATE connector, and CR1087 clamps the output at about −0.6 volt if a negative voltage is applied to this connector.

B Gate Amplifier

The B Gate signal from the B time-base unit is connected to the base of Q1118. Q1118 amplifies and inverts the B Gate signal to provide a negative-going gate signal to the Calibrator circuit for B GATE ÷ 2 operation of the Calibrator. Q1116 provides temperature compensation for this stage.

Calibrator

General. The Calibrator circuit provides a 40-milliampere current output at the front-panel 40 mA current loop and a voltage output in calibrated steps from four millivolts to 40 volts at the front-panel CAL VOLTS connector. The repetition rate of the output signal is selected by the calibrator RATE switch; voltage or current output and the output voltage amplitude are selected by the CALIBRATOR switch.

2 kHz Oscillator. Q1103 and Q1111 are connected as a two-kilohertz, square-wave oscillator to provide the drive signal for the Calibrator Countdown stage (one-kilohertz output rate only). Oscillation occurs as follows: Assume that Q1103 is conducting and Q1111 is off. The collector current of Q1103 through R1101-R1102 produces a voltage level which holds the base of Q1111 low. This keeps Q1111 turned off and since there is no current through it, its collector is positive to produce the positive portion of the square wave. At the same time, C1108 begins to charge toward −50 volts through R1109. The emitter of Q1111 goes negative also, as C1108 charges, until it reaches a level about 0.6 volt more negative than the level at its base. Then, Q1111 is forward biased and its emitter rapidly rises positive. Since C1108 cannot change its charge instantaneously, the sudden change in voltage at the emitter of Q1111 pulls the emitter of Q1103 positive also, to reverse bias it. The current through Q1111 produces a voltage drop at its collector to produce the negative portion of the square wave.

Now, conditions are reversed. Since Q1103 is reverse biased, there is no current through it. Therefore, C1108 can begin to discharge through R1106. The emitter level of Q1103 follows the discharge of C1108 until it reaches about −0.6 volt. Then, Q1103 is forward biased and its collector drops negative to reverse bias Q1111. This interrupts the current through Q1111 and its collector goes positive again to complete the square wave. Once again, C1108 begins to charge through R1109 to start the second cycle. The signal produced at the collector of Q1111 is a two-kilohertz square wave. C1114 differentiates this signal to produce positive- and negative-going output pulses, coincident with the rise and fall of the square wave, which provides negative-going trigger pulses for the Calibrator Countdown stage (positive-going pulses have no effect on circuit operation). The 1 kHz adjustment, R1101, sets this stage so an accurate one-kilohertz square wave is produced at the output of the Calibrator circuit.

Calibrator Countdown. Integrated circuit U1125 is a triggered set-clear (J-K) flip-flop. The calibrator RATE switch S1120 selects the source of the trigger signal for U1125. S1120 is a cam-type switch; a contact-closure chart showing its operation is given on diagram 8. The dots on this chart indicate when the associated contact is closed. For the DC position (contacts on diagram shown in this position), a LO level is applied to the J input (pin 1) and a HI level is applied to the K input (pin 3). The next negative-going trigger from the 2-kHz Oscillator stage switches the output at pin 7 to its LO level. The output at pin 7 remains at the LO level as long as the RATE switch remains in this position.

For the 1 kHz position, all contacts except 1 are closed. This places a LO level at both the J and K inputs so that pin 7 changes output levels with each negative-going trigger from the 2-kHz Oscillator stage. This results in a one-kilohertz square-wave output signal at pin 7. The J and K inputs are also held LO in the B GATE ÷ 2 position of S1120 so that U1125 changes output levels with each negative-going pulse at its trigger input. However, the signal from the 2-kHz Oscillator is disconnected and the B Gate signal provides the trigger to pin 2, resulting in an output square wave with a repetition rate that is one-half the B Gate repetition rate.

Output Amplifier. Transistors Q1135 and Q1137 are connected as a comparator; the reference level at the base of Q1137 is determined by network R1144-R1145-R1146-

R1148-Q1140. This network establishes a voltage level at the base of Q1137 that results in a 40-volt level at its collector when it is on. The 0.4 V adjustment R1148 is set in the 0.4 V position of the CALIBRATOR switch to provide accurate calibrator output voltages at the CAL VOLTS connector J1169. With R1148 accurately set, Output Voltage Divider resistors R1150 through R1162 form a current divider such that eight milliamperes flows through R1152 and the current loop when the CALIBRATOR switch is in the 40 mA position. The current loop is a five-turn current transformer, so the effective current applied to a current probe is 40 milliamperes.

The output of the Calibrator Countdown stage is connected to the base of Q1128 through R1126. Q1128 acts as a switch to control the current through Q1131, and the output of Q1131 controls the conduction of comparator Q1135-Q1137. When DC operation is selected by the calibrator RATE switch, a LO level is applied to the base of Q1128 to cut it off. Therefore, there is no current through Q1131 and the base of Q1135 rises positive to cut it off also. Now, the collector current of Q1137 produces a voltage drop across the output voltage divider to provide a DC voltage output or current output as determined by the CALIBRATOR switch.

For the 1 kHz and B GATE ÷ 2 positions of the RATE switch, the base of Q1128 varies between the LO and HI levels at the rate selected by the RATE switch. When the base of Q1128 is LO, Q1135 is off and Q1137 is conducting. This produces an output as for DC operation. When the level at the base of Q1128 is switched to HI, Q1135 conducts and Q1137 is reverse biased. Now, the output drops to zero. The level at the base of Q1128 is HI in the OFF position of the RATE switch to provide zero output.

Output Divider. The collector current of Q1137 in the Output Amplifier stage is applied across the voltage divider made up of R1150-R1153-R1155-R1156-R1158-R1159-R1161-R1162. This divider is designed to provide a low output resistance in all positions except 40 V while allowing selection of output voltages between 4 mV and 40 V. CALIBRATOR switch S1150 selects the output from the divider to provide the output voltages listed on the front panel (into high-impedance load). The values shown in brackets indicate the output voltage into a 50-ohm load (notice that the 40 V position lists no output into 50 ohms and should not be used in this manner). S1150 is a cam-type switch and the dots on the contact-closure chart (see diagram 8) indicate when the associated contact is closed.

CONVERTER/RECTIFIERS ⟨9⟩

Block Diagram

The Converter/Rectifiers circuit provides the operating power for this instrument from an AC line-voltage source. This circuit includes a Line Selector assembly to permit selection of the nominal operating voltage for the instrument. Figure 1-44 shows a detailed block diagram of the Converter/Rectifiers circuit.

Line Input

Power is applied through the Line Filter, line fuse F1200, POWER switch S1200, and Line Selector switch S1212. The Line Filter is designed to keep power-line interference from entering the instrument and to keep the 25-kilohertz (approximately) Inverter signal from entering the power line. L1201-L1203, with C1201-C1203, provide EMI (electromagnetic interference) filtering. R1201-R1203 provide common-mode resonance damping. R1205-C1205-C1206 suppress reverse-recovery transients of CR1215.

Line Selector switch S1212 allows the instrument to operate from either a 115-volt nominal or a 230-volt nominal line-voltage source. In the 115-volt position, rectifier CR1215 operates as a full-wave doubler with energy-storage capacitors C1216-C1217, so the voltage across the two capacitors in series will be the peak-to-peak value (approximately) of the line voltage. For 230-volt operation, CR1215 is connected as a bridge rectifier and the voltage across C1216-C1217 will be the peak value (approximately) of the line voltage. As a result, the output voltage applied to the Inverter stage is about the same for either 115-volt or 230-volt operation.

Thermistor R1209 limits the surge current demanded by the power supply when it is first turned on. After the instrument is in operation, the resistance of the thermistor drops so it has little effect on the operation of this stage. When the instrument is turned off, the Inverter is turned off by the Inverter Control Line Stop stage to prevent the sudden discharge of C1216 and C1217; C1216 and C1217 discharge slowly through R1221. The discharge time-constant of C1216-C1217-R1221 is about equal to the thermistor thermal-recovery time. This ensures sufficient thermistor resistance to limit the turn-on surge current to a safe level. Since C1216 and C1217 discharge slowly, dangerous potentials exist within the power supply for several minutes after the POWER switch is turned off. The presence of voltage in the circuit is indicated by the relaxation oscillator R1219-C1219-DS1219. Neon bulb DS1219 will blink until the potential across C1216-C1217 drops to about 80 volts.

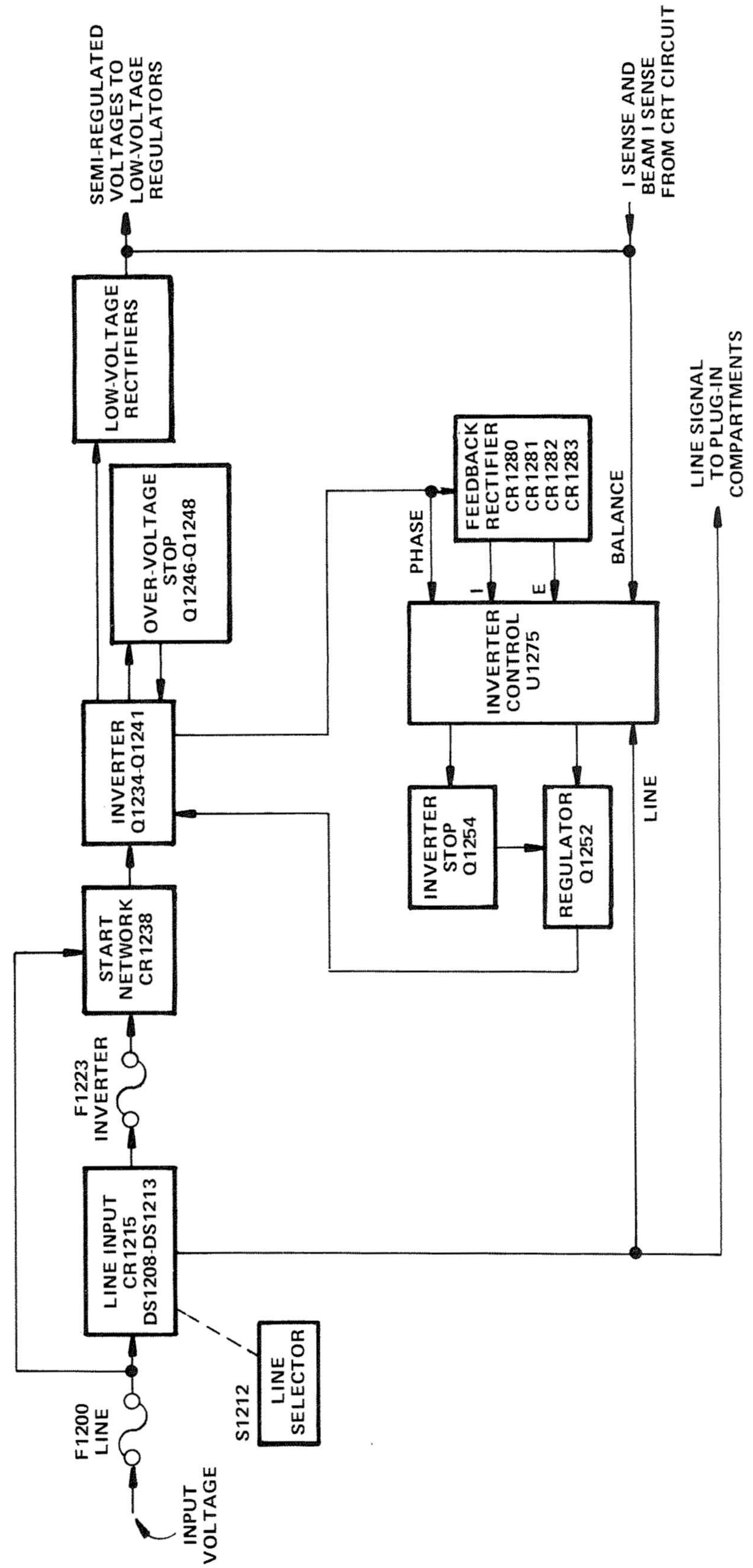

Fig. 1-44. Detailed block diagram of Converter/Rectifiers circuit.

DS1208-DS1213 are surge-voltage protectors. When the Line Selector switch is in the 115-volt position, only DS1208 is connected across the line input. If a peak voltage greater than 230 volts is present on the line, DS1208 will break down and demand high current. This excess current will quickly open line fuse F1200 to interrupt the input power before the instrument can be damaged. In the 230-volt position, DS1208 and DS1213 are connected in series across the line input to provide protection for peak voltages greater than 460 volts.

Transformer T1208 provides a sample of the line voltage to the plug-in connectors in the Main Interface circuit for internal triggering at line frequencies. This line-frequency signal is also connected to the Inverter Control Line Stop stage to indicate when line voltage is applied and the POWER switch is on. F1223 protects the Inverter stage if excessive current is demanded due to a malfunction.

Start Network

Voltage divider R1210-R1242 is connected between the input line (AC) and the negative side of C1217 (through T1225). The voltage across R1242 charges C1242 on each half cycle of the input line voltage. When the charge on C1242 reaches about 32 volts, trigger diode CR1238 conducts and C1242 is discharged through CR1238 to provide base drive to turn on Q1241 through C1239. When Q1241 is turned on, it shock-excites series-resonant network L1237-C1237 to generate a damped oscillation. This damped oscillation provides the drive necessary to start the Inverter switching action. After the Inverter is operating, the recurrent waveform at the collector of Q1241 keeps C1242 discharged through CR1242. This disables the Start Network while the instrument is on.

Inverter

The Inverter stage converts the DC output of the Line Input stage to a sine-wave current to drive Power Transformer T1310. Once the Inverter has been started by the Start Network, transformer T1230 provides feedback to the bases of Q1234 and Q1241 to sustain oscillation. The polarity of the windings causes Q1234 and Q1241 to switch alternately (i.e., only one transistor on at a time). These transistors operate at a forced beta of four due to the turns ratio of T1230. Also, T1230 provides an input from the Inverter Control and Regulator stages for pre-regulation and fault protection. This is accomplished by effectively short-circuiting one-half of the 60-turn, center-tapped winding to either delay the turn-on of Q1234-Q1241 or to completely stop their switching action.

The switching action of Q1234-Q1241 generates a square-wave voltage at the emitter of Q1234 with an amplitude approximately equal to the DC voltage at the input to this stage. The square-wave voltage at the emitter of Q1234 supplies the drive necessary to maintain a sine-wave current in the series-resonant network of L1237-C1237. Diodes CR1234 and CR1241 provide reverse-conduction paths across Q1234 and Q1241 respectively when these transistors are held off for pre-regulation.

To aid in understanding circuit operation, Fig. 1-45A shows a representation of the Inverter stage with a DC input voltage equal to E. The three possible states of the Inverter are depicted by the three possible positions of switch S1: Q1234 is on in position (a); Q1241 is on in position (c); or, both transistors are held off for pre-regulation in position (b). In the composite current waveform of Fig. 1-45B, the relative phase and amplitude of each component of I_t is shown for periods T_a, T_b, and T_c corresponding to the three positions of S1 or the three states of the Inverter. The idealized voltage waveforms in Fig. 1-45C and Fig. 1-45D show the relationship of their amplitude to the DC input voltage and their phase with respect to the current waveform of Fig. 1-45B.

The normal sequence of operation is as follows: Assume that I_t is passing through zero and is increasing in the direction to cause CR1234 to conduct. At zero crossing, the Regulator stage (Q1252) is turned on to hold off Q1234 and Q1241; CR1234 is forward biased to conduct I_1 as shown in Fig. 1-45B. After zero crossing, at a time determined by the Inverter Control stage, the Regulator allows Q1241 to conduct and reverse bias CR1234. Q1241 conducts as I_2 goes through its peak and back to zero. At zero crossing, with current increasing in the opposite direction, the Regulator is turned on to hold off Q1234 and Q1241. During this pre-regulation hold-off time, CR1241 conducts I_3. When the Regulator is turned off, Q1234 is turned on to conduct I_4 and reverse bias CR1241. Q1234 conducts as I_4 goes through its peak and back to zero. The cycle then repeats itself.

The Inverter operates on the low side of the resonant frequency of L1237-C1237, which is about 29 kilohertz. Pre-regulation is achieved by varying the hold-off time of the Inverter transistors (T_b in Fig. 1-45B) and thereby varying the Inverter frequency. The power delivered to T1310 varies with the Inverter frequency because the impedance of the series-resonant network varies with frequency. At the lowest line voltage and highest load, the Inverter will operate at a frequency close to the resonant frequency. If either the line voltage is increased or the load is reduced, the Inverter frequency will decrease.

Over-Voltage Stop

The Over-Voltage Stop stage stops the Inverter whenever the voltage across the primary of T1310 exceeds a safe level to protect Inverter components from damage. This stage is activated whenever the normal voltage regulating path through Q1252 and T1230 is inoperative.

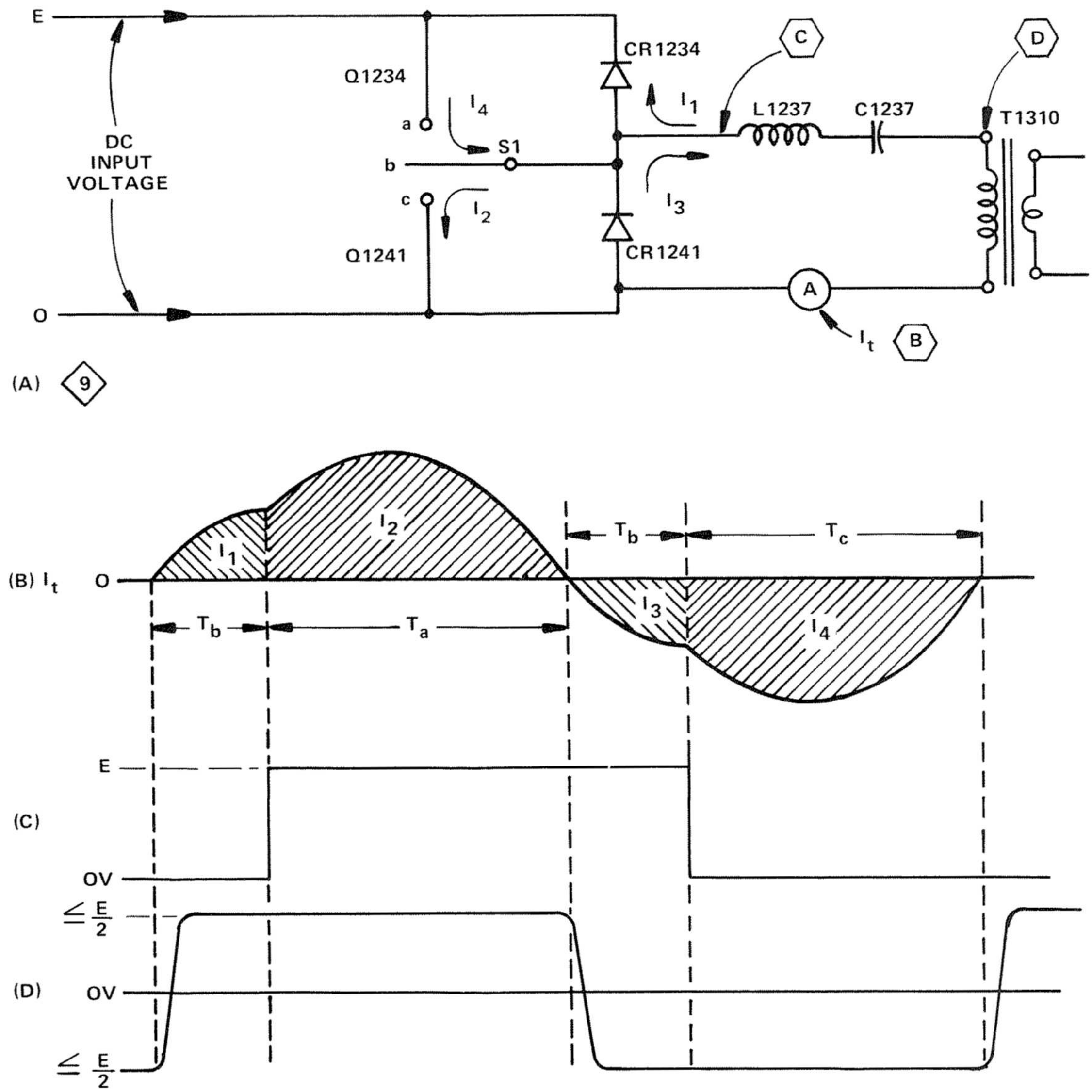

Fig. 1-45. (A) Representation of Inverter stage. Idealized waveforms of: (B) Total Inverter current, I_t; (C) voltage at junction of CR1234-CR1241; and (D) voltage across primary of T1310.

C1243 is charged through CR1244 to the peak of the voltage across the primary of T1310. If this voltage exceeds a safe level, VR1246 conducts to trigger SCR Q1248 into its forward-conduction state. C1243 then discharges through R1248, Q1248, and the base-emitter junction of Q1246. This discharge current turns on Q1246 to effectively short-circuit the base-drive winding of T1230 and stop the Inverter switching action. Since CR1249 becomes forward biased when Q1248 is triggered on, R1245-C1243 is effectively paralleled with C1242 in the Start Network. The relatively large capacitance of C1243 prevents C1242 from charging to the breakdown voltage of CR1238, thus preventing the Start Network from turning the Inverter on. Q1248 and Q1246 continue to conduct until the discharge current of C1243 drops below the holding current of Q1248. After Q1248 returns to its forward-blocking state, CR1249 remains forward biased to inhibit the Inverter Start Network while C1243 is charged through R1247. When the charge on C1243 is sufficient to reverse bias CR1249, the Start Network can start the Inverter.

Inverter Control

The Inverter Control stage, made up primarily of U1275, provides pre-regulation and fault protection for the low- and high-voltage power supplies. For pre-regulation purposes, U1275 provides the Regulator output to the Regulator stage to vary energy delivered by the Inverter by varying the frequency. Fault protection is achieved through the Regulator output (as for pre-regulation) or by providing the Stop Trigger output to the Inverter Stop stage to turn the Inverter off.

U1275 includes a variable pulse-width monostable multivibrator which is initially triggered by current-phase information fed back from the Inverter. The charge ramp for the multivibrator is available at pin 12 of U1275. R1300-C1300 determine the rate-of-rise of the charge ramp. The sensing inputs to U1275 determine the pulse width of the charge ramp (i.e., the multivibrator on time). The pulse width of the charge ramp corresponds to the Inverter hold-off time (T_b, in Fig. 1-45B). The multivibrator Regulator output drives the Regulator stage through pin 9-U1275. Under normal operating conditions, only the E Sense input at pin 15 has control over the output pulse width for pre-regulation. However, an error detected by any of the sensing inputs will affect the output pulse width and will also produce a Stop Trigger to the Inverter Stop stage. The operation of each individual function of the Inverter Control stage is described in the following discussion.

Pre-Regulator. The Pre-Regulator portion of U1275, in conjunction with the Regulator stage, maintains constant voltages at the outputs of the Low- and High-Voltage Rectifiers.

Transformer T1235 provides Inverter power and phase information to U1275. The phase information is connected to the trigger input of the Inverter Control Multivibrator via pins 10 and 11 through C1275 and C1276. Bridge rectifier CR1280-CR1281-CR1282-CR1283 provides positive and negative operating voltages to U1275. A shunt regulator in U1275 regulates the +7.5-volt output of the bridge rectifier connected to pin 6. The −2-volt (nominal) output connected to pin 7 is unregulated. VR1297 provides a stable reference voltage for the sensing-divider resistors R1292-R1293-R1294-R1296-R1297. R1293 in this divider adjusts the voltage level at the E Sense input to the Pre-Regulator (pin 15-U1275) to set the output voltage of the rectifiers by controlling the +130-Volt Supply. The output of the other supplies is set by the turns ratio of T1310.

In the stable state of the Inverter Control multivibrator, the Regulator output at pin 9 is near ground to turn off the Regulator stage. After the Inverter current passes through zero, either pin 10 or pin 11 will go positive to trigger the Inverter Control multivibrator on. While the multivibrator is on, the Regulator output voltage level is positive to turn on the Regulator stage. The duration of the on state is determined by the voltage level at the E Sense input at pin 15. If this voltage level is low, the duration is short. As this voltage level increases, the duration increases.

Fault Protection. The fault-protection portions of U1275 provide protection for the power-supply components from damage due to short circuits, turn-on surge currents, and other malfunctions. When a fault is detected at the Balance or I (current) Sense inputs (pins 2 and 13 respectively), a current output from the Sample Period Timer output (pin 1) charges C1264. If the detected fault lasts longer than about 15 milliseconds, C1264 will charge positive enough to produce a positive Stop Trigger output at pin 8 to turn the Inverter off. When the Inverter is shut off, the current charging C1264 is interrupted and C1264 will discharge. Once pin 8 goes positive, C1259 discharges through R1261 and the base-emitter junctions of Q1254 and Q1252. The discharge of C1259 keeps Q1254 and Q1252 turned on, and the Inverter turned off, for about 250 milliseconds. After this period, pin 8 returns to a near zero-volt level, turning off Q1254 and Q1252 to allow the Inverter to run. This cycle repeats until the fault is corrected, with the Inverter on for about 15 milliseconds then off for about 250 milliseconds.

Inverter Current Limiter. The Inverter Current Limiter provides protection for the Inverter components from damage due to excessive current. Operation of this stage is similar to the Pre-Regulator (voltage regulation). The Inverter Current Limiter takes control of the Inverter Control Regulator output pulse width during turn-on or whenever an overload causes the Inverter current to reach the limit value.

R1287 is the current-sensing resistor. The voltage at the junction of R1287-R1286-CR1288 is the negative rectified Inverter current. The I Sense input at pin 13 is normally held positive through R1285. If the Inverter current increases, the voltage at the I Sense input will become more negative. The Inverter Control Regulator output pulse width (i.e., Inverter hold-off time) increases until the Inverter current reaches a level that will hold pin 13 near the zero-volt level. If the voltage at pin 13 remains near zero for more than approximately 15 milliseconds, the Stop Trigger output at pin 8 will go positive to trigger the Inverter Stop stage. The Inverter Current Limiter will limit the peak Inverter current to about five amperes under fault conditions.

Balance. The Balance portion of U1275 provides overload protection for the Low- and High-Voltage Rectifiers by sensing a malfunction in these circuits. Beam I (current) Sense and I (current) sense inputs from the CRT Circuit and outputs from the Low-Voltage Rectifiers are applied to the Balance Sense input at pin 2-U1275 through divider R1302-R1304-R1305. During normal operation, this divider biases the Balance Sense input near a zero-volt level. If one of the inputs changes sufficiently to cause the voltage level at pin 2 to vary about 200 millivolts (positive or negative) for more than about 15 milliseconds, a positive Stop Trigger output is produced at pin 8-U1275.

Line Stop. The Line Stop portion of U1275 protects the Line-input components from damage due to turn-on surge current. This is achieved by triggering the Inverter Stop stage to stop the Inverter when the POWER switch is turned off. The Line Stop stage will also stop the Inverter if the AC line voltage falls below a minimum value.

The line-frequency signal from transformer T1208 is connected to the Line Stop Sense input of U1275 at pin 4. During normal operation, the line-frequency signal causes the Line Stop Timer terminal (pin 3) to be near a zero-volt level (ground). This zero-volt level keeps C1267 from being charged toward +7.5 volts through R1267. When the line-frequency signal is interrupted or falls below a minimum value, C1267 will begin to charge to +7.5 volts. When the voltage at pin 3 reaches approximately +0.7 volt, the Line Stop stage will produce a positive Stop Trigger output at pin 8-U1275 to trigger the Inverter Stop stage.

Regulator

The Regulator stage operates in conjunction with the Inverter Control and Inverter Stop stages to regulate the Inverter switching. Q1252 acts as a switch controlled by the Regulator output of U1275 (pin 9) or by the Inverter Stop stage. When Q1252 is turned on, CR1251 or CR1252 is forward biased. This effectively short circuits one-half of the 60-turn, center-tapped winding of T1230 to shut off the Inverter. For further information, see the discussion of the Inverter stage.

Inverter Stop

The Inverter Stop stage, Q1254, is controlled by the Stop Trigger output of U1275 (pin 8) to shut off the Inverter through the Regulator stage (Q1252). During the start period, T1230 supplies current to charge C1256-C1259 through CR1256-CR1259. Also during this time, Q1254 is reverse biased by U1275. Once triggered on by a positive Stop Trigger, Q1254 will stay on while C1256-C1259 discharge through the base of Q1254. If U1275 is removed from its socket or is otherwise nonfunctional, the Inverter Stop stage will stop the Inverter after about two or three Inverter cycles.

Low-Voltage Rectifiers

The rectifiers and filter components in the secondaries of T1310 provide rectified, pre-regulated voltages for re-regulation by the Low-Voltage Regulators circuit.

LOW-VOLTAGE REGULATORS ⟨10⟩

General

The Low-Voltage Regulators convert semi-regulated voltages from the Converter/Rectifiers circuit to stabilized, low-ripple output voltages. The regulators are series type, using the −50-Volt Supply as a reference for the remaining voltage supplies. Figure 1-46 shows a detailed block diagram of the Low-Voltage Regulators circuit. A schematic is given on diagram 10.

−50-Volt Supply

Semi-regulated −54 volts from the Converter/Rectifiers circuit provides the unregulated voltage source for this supply. Transistors Q1508-Q1522-Q1534 operate as a feedback-stabilized amplifier to maintain a constant −50 volt output level. Q1508 is connected as a differential amplifier to compare the feedback voltage at the base of Q1508B against the reference voltage at the base of Q1508A. The error output at the collector of Q1508B reflects the difference, if any, between these two inputs. The change in error output level at the collector of Q1508B is always in the opposite direction to the change in the feedback input at the base of Q1508B.

Zener diode VR1505 sets a reference level of about −9 volts at the base of Q1508A. A sample of the output voltage from the −50-Volt Supply is connected to the base of Q1508B through divider network R1512-R1513-R1514. R1513 in this divider is adjustable to set the output level of this supply. Notice that the feedback voltage to this divider is obtained from a line labeled −50 V Sense. If the feedback voltage were obtained at the supply, the voltage at the load would not stay constant, due to the inherent resistance of the interconnecting cable between the supply and its load (as the load current varies, the voltage drop along the cable also varies). The Sense configuration overcomes this problem by sensing the voltage at the load. Since the current in the Sense line is small and constant, the load voltage is held constant regardless of the load current.

Regulation of the supply occurs as follows: If the output level of this supply decreases (becomes less negative) due to an increase in load or a decrease in input voltage (as a result of line-voltage changes or ripple), the voltage across divider R1512-R1513-R1514 decreases also. This results in a more positive level at the base of Q1508B than that established by the −50-Volt Reference stage at the base of Q1508A. Since the transistor with the more positive base controls the conduction of the differential amplifier, the output current at the collector of Q1508B increases. This increase in output from Q1508B causes an increase in current through Q1522. This allows more current to flow through Q1534, resulting in increased conduction of Q1538, the −50-V Series Regulator. The load current increases and the output voltage of this supply also increases (becomes more negative). As a result, the feedback voltage from the −50 V Sense line increases and the base of Q1508B returns to the same level as the base of Q1508A. Similarly, if the output level of this supply increases (more negative), the output current of Q1508B decreases. The feedback through Q1522 and Q1534 reduces the conduction of the −50-V Series Regulator to decrease the output voltage of this supply. The −50 Volts adjustment, R1513, sets the output level of this supply.

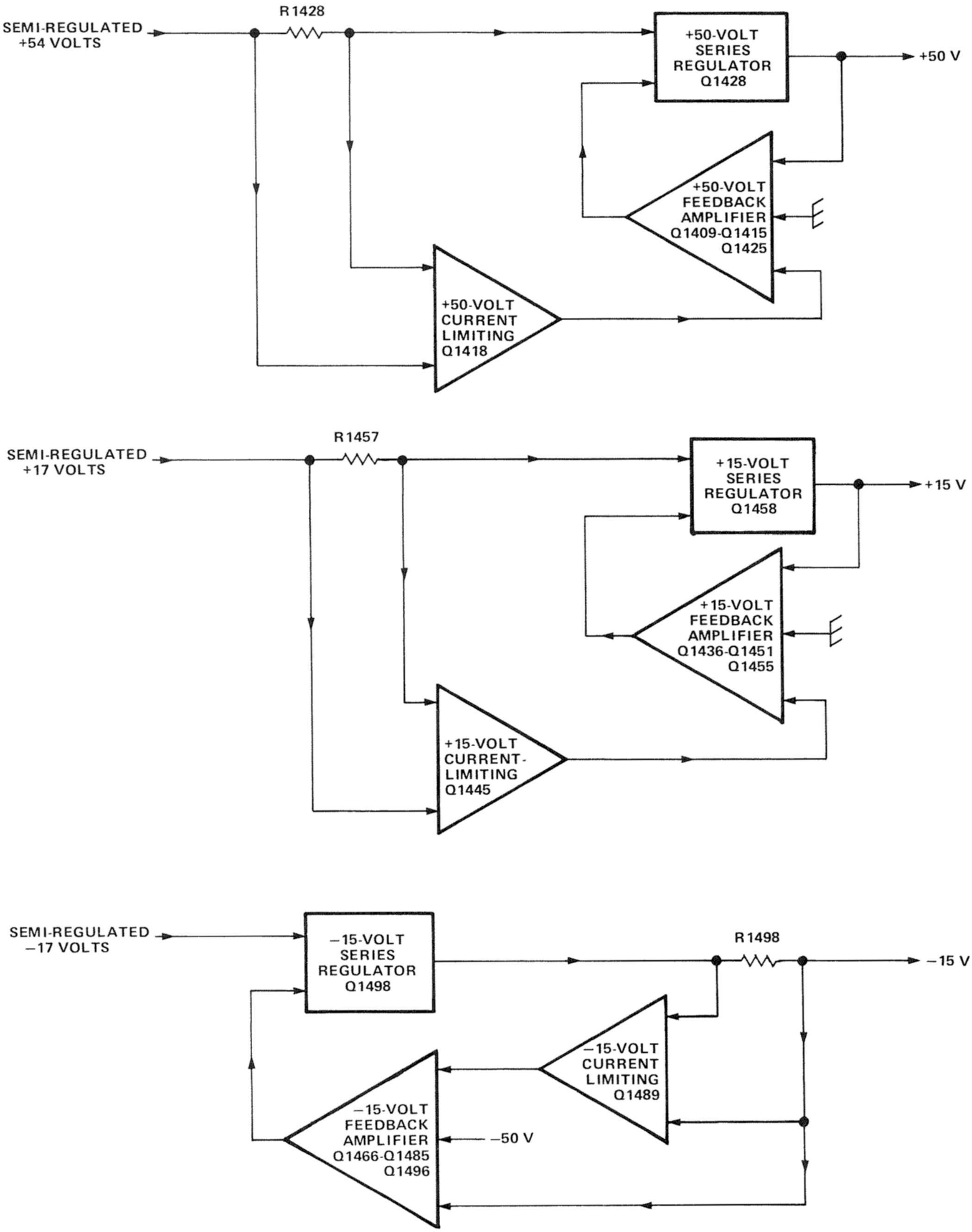

Fig. 1-46. Detailed block diagram of Low-Voltage Regulators circuit.

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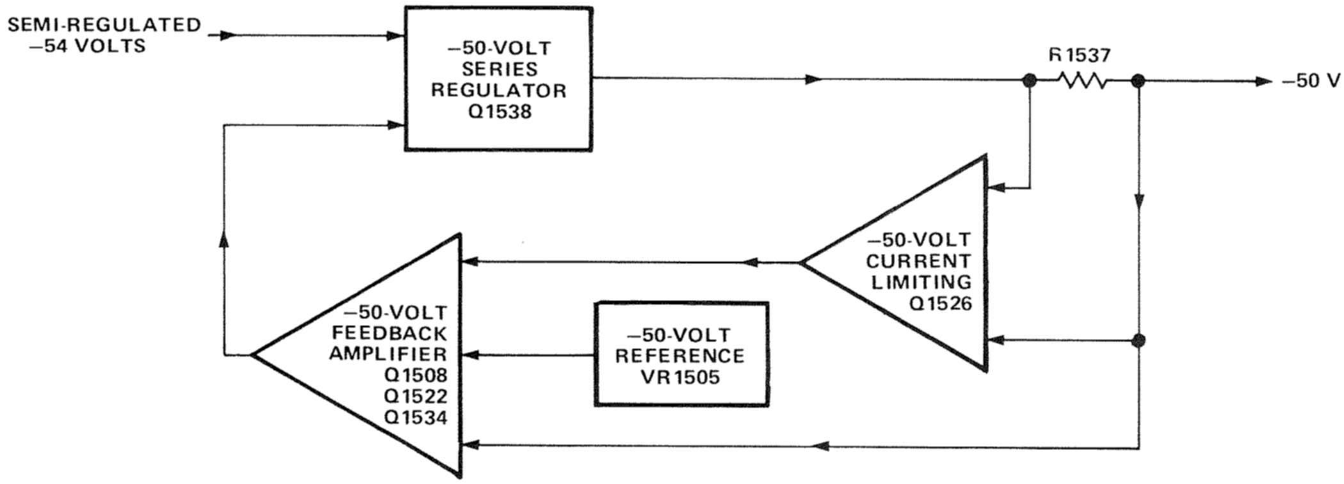
SEMI-REGULATED
−54 VOLTS
−50-VOLT
SERIES
REGULATOR
Q1538
R1537
−50 V
−50-VOLT
CURRENT
LIMITING
Q1526
−50-VOLT
FEEDBACK
AMPLIFIER
Q1508
Q1522
Q1534
−50-VOLT
REFERENCE
VR1505

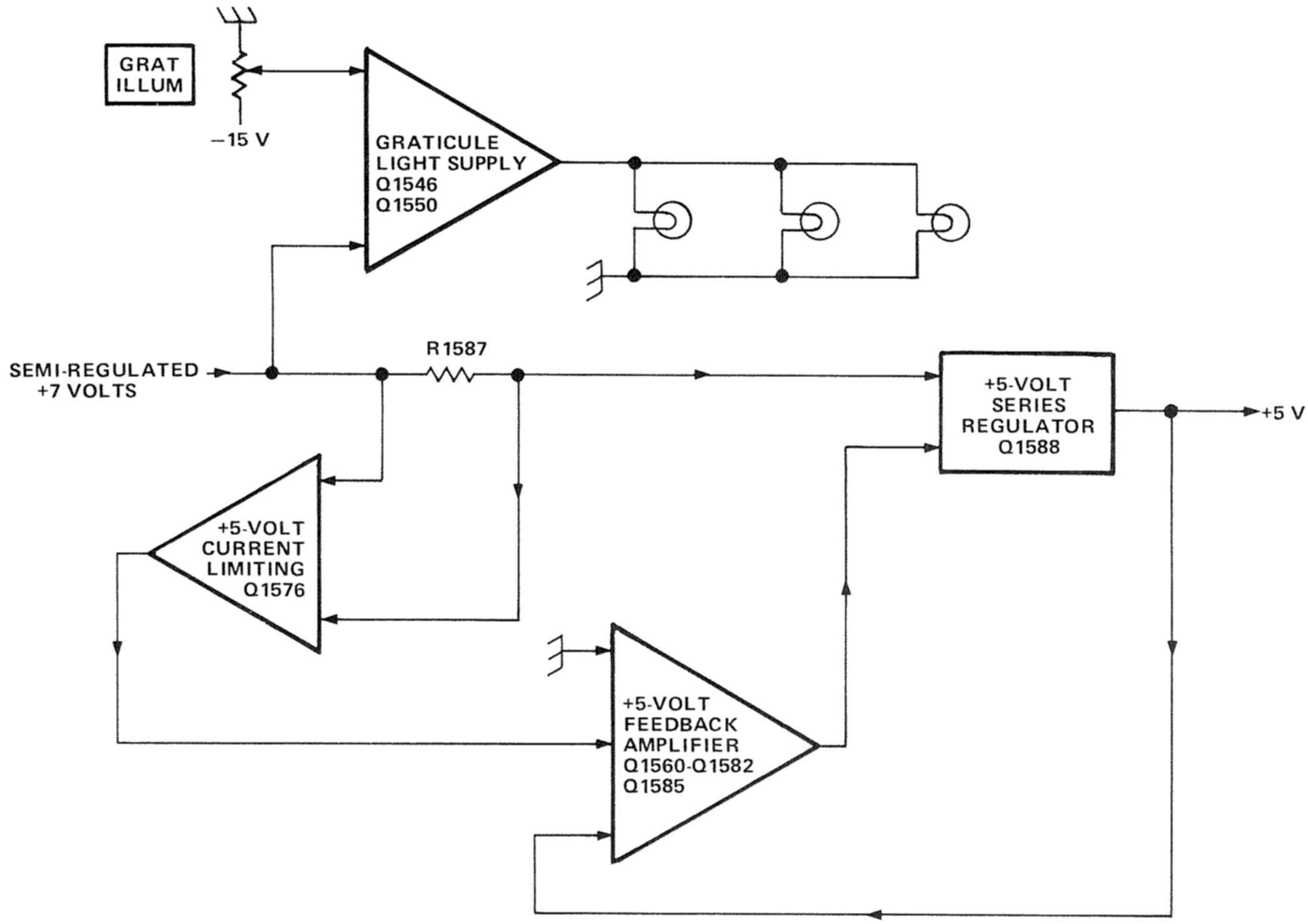
GRAT
ILLUM
−15 V
GRATICULE
LIGHT SUPPLY
Q1546
Q1550
SEMI-REGULATED
+7 VOLTS
R1587
+5-VOLT
SERIES
REGULATOR
Q1588
+5 V
+5-VOLT
CURRENT
LIMITING
Q1576
+5-VOLT
FEEDBACK
AMPLIFIER
Q1560-Q1582
Q1585

Fig. 1-46. (cont.)

The –50-V Current Limiting stage (Q1256) protects the –50-Volt Supply if excess current is demanded from this supply. Since the load is connected to this supply through R1537, all current from the –50-Volt Supply must flow through this resistor. Transistor Q1526 senses the voltage drop across R1537. Under normal operation there is insufficient voltage drop across R1537 to forward bias Q1526. However, when excess current is demanded from the –50-V Series Regulator due to a short circuit or similar malfunction at the output of this supply, the voltage drop across R1537 increases until it is sufficient to forward bias Q1526. The collector current of Q1526 results in a reduction of current through Q1522 and Q1534 to limit the conduction of Q1538. This current limiting protects Q1538 from damage due to excess power dissipation.

Several protection diodes are also included in this circuit. CR1539 prevents the output of this supply from going more positive than about +0.6 volt if it is shorted to a positive supply. VR1501 and CR1502 supply a turn-on voltage for Q1508 to start the –50-Volt Supply when the instrument is first turned on. As soon as the –50-Volt Supply turns on, VR1501 and CR1502 turn off to disconnect the turn-on voltage from Q1508.

–15-Volt Supply

Basic operation of all stages in the –15-Volt Supply is the same as for the –50-Volt Supply. Reference level for this supply is established by divider R1463-R1464 between ground and the –50 V Sense voltage. The divider ratio of R1463-R1464 sets a level of –15 volts at the base of Q1466A. The level on the –50 V Sense line is held stable by the –50-Volt Supply. Any change at the output of the –15-Volt Supply appears at the base of Q1466B as an error signal. The output voltage is regulated in the same manner as described for the –50-Volt Supply. CR1499 limits the output of this supply from going more positive than about +0.6 volt if it is shorted to one of the positive supplies. Diodes CR1468 and CR1469 provide reverse voltage protection for transistors Q1466B and Q1466A, respectively.

+5-Volt Supply

The operation of the +5-Volt Supply is basically the same as described for previous supplies. The reference level for this supply is established by the ground connection at the base of Q1560A. Feedback voltage to the base of Q1560B is provided by divider R1564-R1589 between the –50 V Sense line and the +5 V Sense line. The divider ratio of R1564-R1589 is 10:1, so the base of Q1560B is at zero volt when the supply is operating normally. The level on the –50 V Sense line is held stable by the –50-Volt Supply. Therefore, any change at the output of the +5-Volt Supply appears at the base of Q1560B as an error signal. The output voltage is regulated in the manner described previously for the –50-Volt Supply. Diode CR1589 limits the output of this supply to about –0.6 volt if it is shorted to one of the negative supplies.

The +5-Volt Current Limiting stage (Q1576A and B) protects this supply from damage due to a demand for excessive output current. Q1576A and Q1576B are connected as a comparator to detect excessive current through R1587. With normal supply current through R1587, the voltage drop across R1587 is such that the base of Q1576B is more positive than the base of Q1576A. Therefore, Q1576A is cut off and CR1576 is reverse biased. If the current through R1587 increases above a safe level, the base of Q1576B becomes more negative than the base of Q1576A. Now, Q1576B is cut off and Q1576A conducts. The collector current of Q1576A forward biases CR1576 and decreases the voltage on the base of Q1582. This limits the conduction of Q1588 to a safe current level.

+15-Volt Supply

The +15-Volt Supply regulates in the same manner as the –50-Volt Supply; current limiting operates in the manner described for the +5-Volt Supply. The ground connection at the base of Q1436A provides the reference for this supply. Feedback voltage to the base of Q1436B is provided through divider R1440-R1459 between the –50 V Sense line and the +15 V Sense line. The divider ratio of R1440-R1459 sets the base of Q1436B at zero volts. Any change in the output level of the +15-Volt Supply appears at the base of Q1436B as an error signal. This results in an opposite change at the collector of Q1436B and at the base of Q1451. This change is connected to the +15-V Series Regulator stage through Q1455 to correct the error in the output voltage of the supply.

Diode CR1439 protects Q1436B against negative voltages if the +15-Volt Supply is shorted to ground. Diode CR1459 limits the output of this supply to about –0.6 volt if it is shorted to one of the negative supplies.

+50-Volt Supply

Operation of the +50-Volt Supply is basically the same as described for the –50-Volt Supply; current limiting operates in a similar manner as described for the +5-Volt Supply. Reference voltage for this supply is established by the ground connection through R1406 at the base of Q1409A. Feedback voltage to the base of Q1409B is provided by divider R1412-R1429 between the –50 V Sense line and –15 V Sense line. The divider ratio of R1412-R1429 sets the base level of Q1409B at zero volts when the output of this supply is correct. The protection diodes in this circuit operate similarly to those in the other supplies.

Graticule-Light Supply

The Graticule-Light Supply provides voltage to the graticule lights, DS1552-DS1553-DS1554. The front-panel GRAT ILLUM control, R1541, sets the output of this supply to set the brightness of the graticule lights. Q1546-Q1550-CR1549 form a pseudo differential amplifier. The output voltage at the collector of Q1550 follows the voltage set at the base of Q1546 by the divider made up of R1544, R1545, R1543, and the GRAT ILLUM control R1541. R1551 limits the output current from this supply to protect Q1550 from damage due to a short circuit.

CRT CIRCUIT ⟨11⟩

General

The CRT Circuit provides the high voltage and control circuits necessary for operation of the cathode-ray tube (CRT). This circuit also includes the Z-Axis Amplifier and the Auto-Focus Amplifier. Figure 1-47 shows a detailed block diagram of the CRT Circuit. A schematic of this circuit is shown on diagram 11 in the rear of this manual.

Power Tranformer

Power Transformer T1310 provides semi-regulated voltages for the CRT heater and high-voltage supplies. One secondary winding of T1310 provides 6.3 volts for the CRT heater. The CRT heater is elevated to the cathode potential through R1690. The high-voltage winding of T1310 provides a three-kilovolt peak-to-peak square-wave voltage to the Anode Voltage Multiplier, CRT Cathode Supply, Control-Grid DC Restorer, and Focus-Grid DC Restorer stages. One end of the high-voltage winding is connected to ground through current-sensing resistor R1604.

Anode Voltage Multiplier

Positive accelerating potential for the CRT anode is supplied by the seven times voltage multiplier contained within U1615. The applied voltage to the input of U1615 from the high-voltage secondary of T1310 is about three kilovolts peak-to-peak. This results in an output voltage of about +21 kilovolts at the CRT anode. The Beam I Sense output of U1615 is fed back to the Converter/Rectifiers and Logic circuits to limit the CRT beam current if it exceeds a safe level.

CRT Cathode Supply

The negative three-kilovolt accelerating potential for the CRT cathode is generated by a voltage doubler consisting of CR1607-CR1608-C1607-C1608. High-frequency filtering is accomplished by R1609-C1609-R1612-C1612. R1612 and C1612 also provide an AC-coupling path for error correction from the Cathode-Supply Regulator.

Cathode-Supply Regulator

The Cathode-Supply Regulator maintains the potential on the CRT cathode and reduces the AC ripple from the CRT Cathode Supply. A sample of the output of the CRT Cathode Supply is connected to the Cathode-Supply Regulator stage through divider resistors R1640B-R1640A. High-frequency changes from the CRT Cathode Supply are coupled to the Cathode-Supply Regulator through C1642-R1642.

The Cathode-Supply Regulator consists of a non-inverting preamplifier U1635 and an inverting output amplifier Q1627-Q1631. The +50-V Supply, connected to R1640A, and the ground connected to pin 2 of U1635 through R1637, provide the reference for error amplifier U1635. Q1627 and Q1631 are connected as a collector-coupled, complementary amplifier driven by U1635 to provide error correction to the CRT Cathode Supply.

Regulation occurs as follows: If the CRT cathode voltage becomes less negative, a positive-going change is coupled to the input of U1635 at pin 3 and results in a positive-going output at pin 6. This positive-going change is inverted by Q1627-Q1631 into a negative-going change at their collectors. This results in a voltage increase across C1606 during the positive half cycle of the high-voltage winding of T1310. (Note that the voltage across C1606 is the difference between the positive voltage on T1310 and the voltage at TP1625.) During the negative half cycle, the increased voltage across C1606 increases the output voltage of the CRT Cathode Supply to correct the original error. High-frequency correction signals from the Cathode-Supply Regulator are AC coupled to the CRT cathode through C1612. Short-circuit protection for the Cathode-Supply Regulator is provided by CR1625-CR1632-CR1638-CR1639.

Z-Axis Amplifier

The Z-Axis Amplifier provides the drive signal to the CRT control grid to control the CRT intensity. The Z-Axis signal from the Logic circuit and the Readout Intensity signal from the Readout System are connected to the emitter of Q1805 through R1801-R1802, and form the input signals to the Z-Axis Amplifier. The output of the Z-Axis Amplifier provides the drive signal to control the CRT intensity level through the Control-Grid DC Restorer.

Transistor Q1805 is a common-base amplifier to establish a low input impedance for the Z-Axis Amplifier. Q1808-Q1824-Q1815-Q1827 form a non-inverting, current-driven, operational amplifier. The Z-Axis Amplifier Gain and Output Level are set in this stage through R1810 and R1817 respectively. The output stage of the Z-Axis Amplifier circuit consists of Q1834-Q1836-Q1854-Q1874-Q1876 in a high-speed operational amplifier configuration.

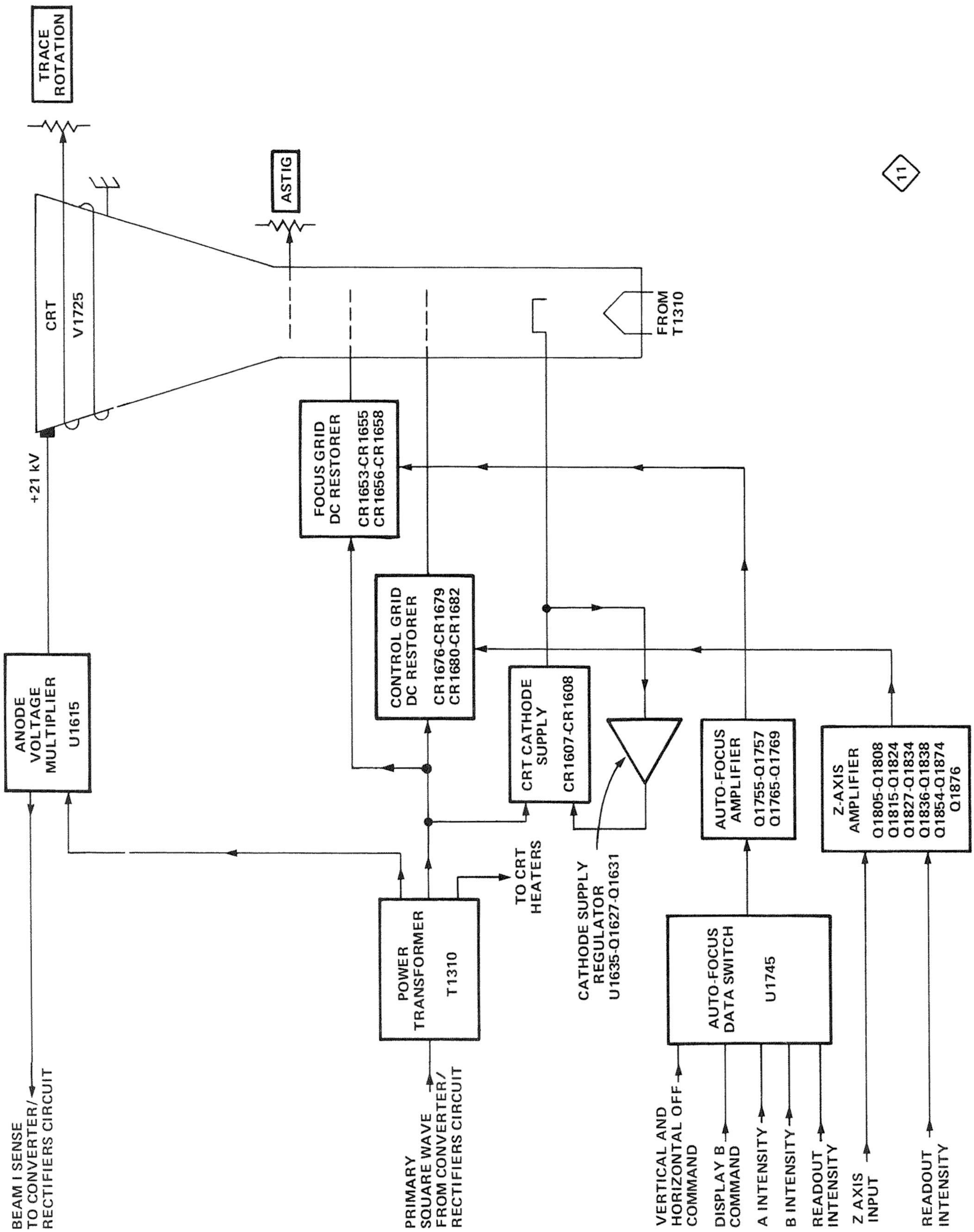

Fig. 1-47. Detailed block diagram of CRT Circuit.

Transistor Q1838 is a constant-current source for Q1834-Q1836. The signal at the emitter of Q1827 is DC coupled to the bases of Q1834-Q1836 through R1833 to provide a fast rising pulse at the output of Q1854. Transistors Q1874-Q1876 maintain the output level of the Z-Axis Amplifier. The Z-Axis Amplifier is compensated to provide a fast rising pulse with optimum square corner by C1871-C1842-R1842-C1846.

Control-Grid DC Restorer

The Control-Grid DC Restorer couples DC and low-frequency components of the Z-Axis Amplifier signal to the CRT control grid. This allows the Z-Axis Amplifier to control the CRT beam current (intensity). The potential difference between the Z-Axis Amplifier output and the control grid (about 3000 volts) prohibits direct coupling.

The DC restorer is actually a cathode-referenced bias supply for the CRT control grid. Quiescently, its output voltage is more negative than the cathode by an amount set by CRT Grid Bias adjustment R1674.

The Control-Grid DC Restorer is current driven from the high-voltage winding of T1310 through R1618-R1619-R1671-R1672. This drive signal is an approximately 25-kilohertz signal connected to the junction of CR1676-CR1680-C1678. CR1676 and CR1680 limit the peak-to-peak amplitude of the drive at their junction to the difference between their forward-bias levels. CRT Grid Bias adjustment R1674 and the output level of the Z-Axis Amplifier set the forward-bias levels of CR1676 and CR1680 respectively. C1678 couples the limited-amplitude drive to the junction of CR1679-CR1682. During positive half cycles of the drive, CR1682 clamps the cathode of CR1679 to the level of the CRT cathode (−3000 volts). This provides the reference level for the Control-Grid DC Restorer stage. During negative half cycles of the drive, CR1679 charges the control-grid side of C1680 to a level more negative than the CRT cathode. The resulting control-grid voltage is more negative than the cathode by an amount equal to the difference between the CRT Grid Bias adjustment setting and the Z-Axis Amplifier output level.

Auto-Focus Stages

The Auto-Focus Data Switch and Amplifier stages provide control voltages to maintain optimum focus of the CRT display. When the FOCUS control is set for best definition of the CRT display at low to medium settings of the intensity controls, these stages maintain optimum focus for all portions of the display as it is switched between readout, A Horizontal, and B Horizontal displays.

U1745 is a current driven data switch that provides the correct input to the Auto-Focus Amplifier. U1745 is the same type of IC as used for the Column and Row Data Switches in the Readout System. U1745 selects either the A Intensity, B Intensity, or Readout Intensity input as determined by the Vertical and Horizontal OFF Command at pin 2 and Display B Command at pin 1. The input/output table shown in Fig. 1-48 shows the output at pin 7 for each combination of input conditions.

Q1755-Q1757-Q1765-Q1769 are connected as a non-inverting operational amplifier to amplify the output of U1745 and drive the focus-grid electrode of the CRT. Resistors R1751-R1752-R1753-R1754, in conjunciton with diodes CR1753 and CR1754, shape the output of U1745. Auto-Focus Gain adjustment R1751 determines the amount of signal to the base of Q1755 to set the overall gain of the Auto-Focus Amplifier. Output Level adjustment R1757 determines the output level of this stage.

Focus-Grid DC Restorer

The Focus-Grid Restorer couples DC and low-frequency components of the Auto-Focus Amplifier signal to the CRT focus grid. This allows the Auto-Focus Amplifier to control the focus-grid potential. The potential difference between the Auto-Focus Amplifier output and the focus grid (about 3000 volts) prohibits direct coupling.

The DC restorer is actually a bias supply for the CRT focus grid. The output of this stage is referenced to the level set by Focus Preset adjustment R1711. Quiescently, the focus-grid voltage is more negative than the reference level by 10 volts.

INPUT		OUTPUT
VERTICAL AND HORIZONTAL OFF COMMAND	DISPLAY B COMMAND	DATA OUT
2	1	7
LO	LO	A INTENSITY
LO	HI	B INTENSITY
HI	ϕ	READOUT INTENSITY

ϕ = HAS NO EFFECT IN THIS CASE.

Fig. 1-48. Input/output table for Auto-Focus Data Switch IC, U1745.

The Focus-Grid DC Restorer is current driven from the high-voltage winding of T1310 through R1618-R1619-R1651-R1652. This drive signal is an approximately 25-kilohertz signal connected to the junction of CR1653-CR1656-C1654. CR1653 and CR1656 limit the peak-to-peak amplitude of the drive at their junction to the difference between their forward-bias levels. The +130-Volt Supply and the output level of the Auto-Focus Amplifier set the forward-bias levels of CR1653 and CR1656 respectively. C1654 couples the limited-amplitude drive to the junction of CR1655-CR1658. During positive half cycles of the drive, CR1658 clamps the cathode of CR1658 to the level set by Focus Preset adjustment R1711. This provides the reference level for the Focus-Grid DC Restorer stage. During negative half cycles of the drive, CR1655 charges the focus-grid side of C1656 to a level more negative than the reference level. The resulting focus-grid voltage is more negative than the reference level by an amount equal to the difference between the +130-Volt Supply and the Auto-Focus Amplifier output level.

CRT Control Circuits

The ASTIG adjustment, R1733, used in conjunction with the FOCUS control to obtain a well-defined display, varies the potential on the astigmatism grid of the CRT. The Geometry adjustment, R1727, varies the potential on the CRT mesh to control the overall geometry of the display.

Two adjustments control the trace alignment by varying the magnetic field around the CRT. The Y-Axis Align adjustment, R1730, controls the current through L1730, which affects the CRT beam after vertical deflection but before horizontal deflection. Therefore, R1730 affects only the vertical (Y) components of the display. TRACE ROTATION adjustment R1725 controls the current through L1725, which affects both the vertical and horizontal rotation of the CRT beam.

MAINTENANCE

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, or troubleshooting of the 7904.

Panel Removal

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the covers removed, do not touch exposed connections or components. Some transistors have voltages present on their cases. Disconnect power before cleaning the instrument or replacing parts.

The side panels of the 7904 are held in place by four slotted fasteners. To remove the panels, turn each fastener counterclockwise a quarter turn with a large screwdriver, coin, or similar device. Then, pull the panel out at the top and lift away from the instrument. The bottom panel is also held in place with slotted fasteners. This panel can be removed to gain access to the bottom areas of the instrument. The panels protect this instrument from dust in the interior, and also provide protection to personnel from the operating potentials present. They also reduce the EMI radiation from the instrument or EMI interference to the display due to other equipment.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the 7904 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

General. The 7904 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path which may result in instrument failure. The side panels provide protection against dust in the interior of the instrument. Operation without the panels in place necessitates more frequent cleaning.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. In particular, avoid chemicals which contain benzene, toluene, xylene, acetone, or similar solvents.

Exterior. Loose dust accumulated on the outside of the 7904 can be removed with a soft cloth or small brush. The brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

CRT. Clean the plastic light filter, faceplate protector, and the CRT face with a soft, lint-free cloth dampened with denatured alcohol.

The CRT mesh filter (furnished with Option 3 only) can be cleaned in the following manner:

1. Hold the mesh filter in a vertical position and brush lightly with a soft No. 7 water-color brush to remove light coatings of dust or lint.

2. Greasy residues or dried-on dirt can be removed with a solution of warm water and a neutral-pH liquid detergent. Use the brush to lightly scrub the filter.

3. Rinse the filter thoroughly in clean water and allow to air dry.

4. If any lint or dirt remains, use clean low-pressure air to remove it. Do not use tweezers or other hard cleaning tools on the filter, as the special finish may be damaged.

5. When not in use, store the mesh filter in a lint-free, dust-proof container such as a plastic bag.

Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air. Remove any dirt which remains with a soft brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips and circuit boards.

The high-voltage circuits, particularly parts located in the high-voltage compartment and the area surrounding the post-deflection anode leads, should receive special attention. Excessive dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

Lubrication

General. The reliability of potentiometers, switches, and other moving parts can be maintained if they are kept properly lubricated. However, over-lubrication is as detrimental as too little lubrication. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order TEKTRONIX Part No. 003-0342-01.

Visual Inspection

The 7904 should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

Semiconductor Checks

Periodic checks of the semiconductors in the 7904 are not recommended. The best check of semiconductor performance is actual operation in the instrument. More details on checking semiconductor operation are given under troubleshooting.

Recalibration

To assure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the 7904. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles, particularly where integrated circuits are used.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the 7904.

1. Transistor Tester

Description: Dynamic-type tester. Must be capable of measuring reverse breakdown voltages of at least 400 volts.

Purpose: To test the semiconductors used in this instrument.

Recommended type: TEKTRONIX Type 576 Curve Tracer.

2. Multimeter

Description: VTVM, 10 megohm input impedance and 0 to 500 volts range, AC and DC; ohmmeter, 0 to 50 megohms. Accuracy, within 3%. Test probes must be insulated to prevent accidental shorting.

Purpose: To check voltages and for general troubleshooting in this instrument.

NOTE

A 20,000 ohms/volt VOM can be used to check the voltages in this instrument if allowances are made for the circuit loading of the VOM at high-impedance points.

3. Test Oscilloscope

Description: Frequency response, DC to 150 megahertz minimum; deflection factor, 5 millivolts to 5 volts/division and 1 milliampere to 1 ampere/division. A 10X, 10-megohm voltage probe should be used to reduce circuit loading for voltage measurements.

Purpose: To check operating waveforms in this instrument.

Recommended type: TEKTRONIX 7704A Oscilloscope with 7A16 Amplifier, 7A14 Current Probe Amplifier, and 7B70 Time Base plug-in units. Use a P6053 10X probe and a P6021 Current Probe.

4. Isolation Transformer

Description: 1:1 turns ratio, 500 volt-amperes minimum rating, 50-60 cycle. Must have three-wire power cord, plug, and receptacle with ground connection carried through from input to output.

Purpose: To isolate the 7904 from the line potential when troubleshooting in the power supply.

Recommended type: Stancor #P6298 (for 115-volt line only) modified to include three-wire power cord, plug, and receptacle.

5. Variable Autotransformer

Description: Output variable from 0 to 140 volts, 10 amperes minimum rating. Must have three-wire power cord, plug, and receptacle.

Purpose: To vary the input line voltage when troubleshooting in the power supply.

Recommended type: General Radio W10MT3W Variac Autotransformer.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operators Manual.

2. Check Associated Equipment. Before proceeding with troubleshooting of the 7904, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source. The associated plug-in units can be checked for proper operation by substituting other units which are known to be operating properly (preferably of the same types). If the trouble persists after substitution, the 7904 is probably at fault.

3. Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

4. Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble appears in one circuit. The apparent trouble may only be a result of misadjustment or may be corrected by calibration. Complete calibration instructions are given in the Calibration section.

5. Isolate Trouble to a Circuit. To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. For example, poor focus indicates that the CRT circuit (includes Auto Focus circuit) is probably at fault. When trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings. Also check for the correct output signals at the front-panel output connectors with a test oscilloscope. If the signal is correct, the circuit is working correctly up to that point. For example, correct sawtooth output indicates that the time-base unit and sawtooth out portion of the Output Signals circuit is operating correctly. If a malfunction in the Readout System is suspected of causing trouble to appear in the Z-Axis Amplifier, Vertical Amplifier, or Horizontal Amplifier circuits, the trouble can be localized by removing the Readout System circuit board. This board can be removed without affecting the operation of other circuits in the instrument. After the defective circuit has been located, proceed with steps 6 and 7 to locate the defective component(s).

If incorrect operation of the power supplies is suspected, connect the 7904 to a variable autotransformer. Then, check each power supply for correct regulation with a DC voltmeter (0.1% accuracy), and correct ripple with a test oscilloscope, while varying the autotransformer throughout the regulating range of this instrument (see rear-panel Line Selector for regulating range of this instrument).

Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. Table 2-1 lists the tolerances of the power supplies in this instrument. These voltages are measured between the power-supply test points (on Regulator board) and the GND SENS test point on this board. See Fig. 2-1 for power-supply test point location. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedure given in the Calibration section to adjust the power supplies.

TABLE 2-1

Power Supply Tolerance and Ripple
(referenced to TP GND SENS)

Power Supply	Test point (see Fig. 2-1)	Tolerance	Typical ripple (peak-to-peak)
−50 volt	TP −50	±0.20 volt	2 millivolts
−15 volt	TP −15	±0.15 volt	1 millivolt
+5 volt	TP +5	±0.10 volt	1 millivolt
+15 volt	TP +15	±0.15 volt	1 millivolt
+50 volt	TP +50	±0.50 volt	3 millivolts
+130 volt	TP +130	±5.2 volts	500 millivolts

6. Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit.

7. Check Individual Components. The following procedures describe methods of checking individual components in the 7904. Components which are soldered in place are best checked by first disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. SEMICONDUCTORS.

CAUTION

Power switch must be turned off before removing or replacing semiconductors.

A good check of transistor operation is actual performance under operating conditions. A transistor can be most effectively checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

IC's (integrated circuits) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential to troubleshooting circuits using IC's. Use care when checking voltages and waveforms around the IC's so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin IC's is with an IC test clip. This device also doubles as an extraction tool.

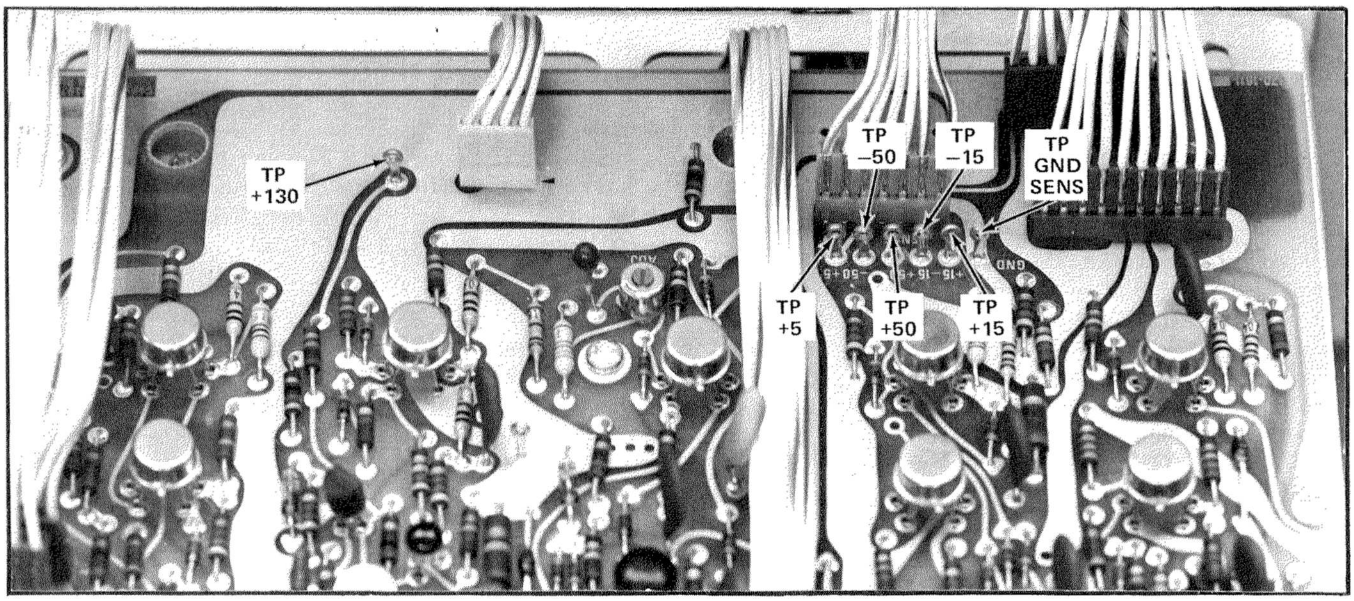

Fig. 2-1. Location of power-supply test points on Regulator board.

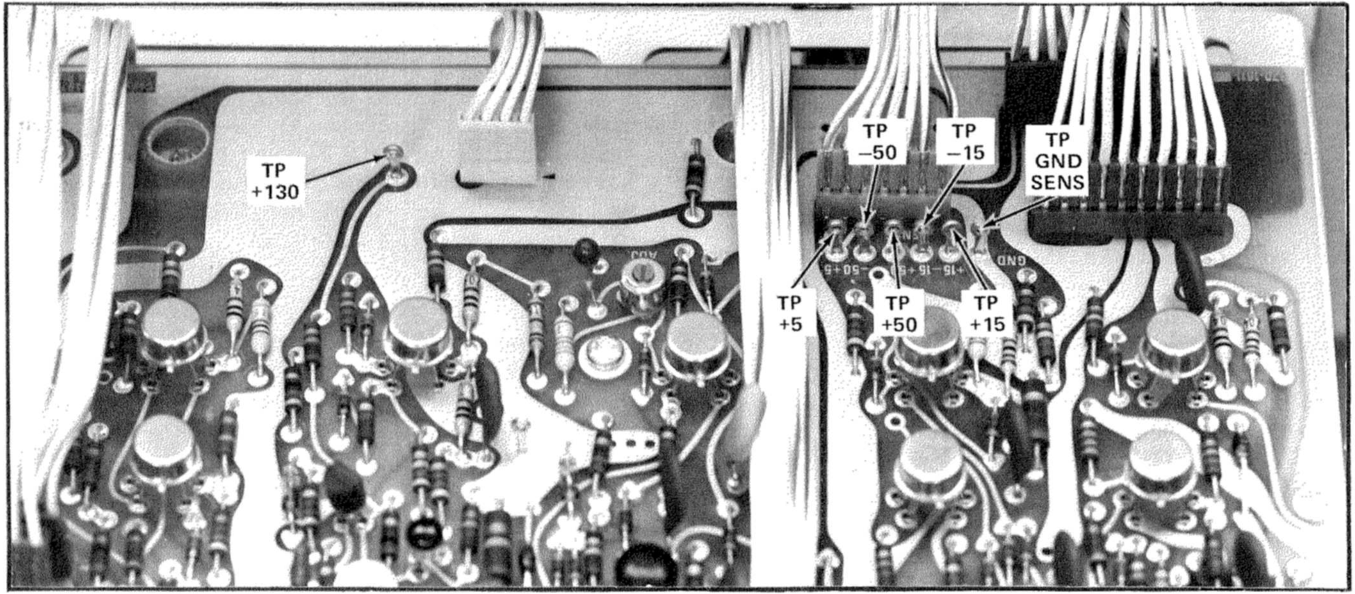

Fig. 2-1. Location of power-supply test points on Regulator board.

Fig. 5-1 in the Diagrams section shows the lead configuration for the semiconductors used in this instrument.

B. DIODES.

A diode can be checked for an open or for a short circuit by measuring the resistance between terminals with an ohmmeter set to the R X 1k scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed. Do not check tunnel diodes or back diodes with an ohmmeter.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents may damage the diode.

The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot. For most silicon or germanium diodes with a series of stripes, the color-code identifies the three significant digits of the TEKTRONIX Part Number using the resistor color-code system (e.g., a diode color-code pink-, or blue-, brown-gray-green indicates TEKTRONIX Part Number 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

C. RESISTORS.

Check the resistors with an ohmmeter. See the Electrical Parts List for the tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

D. INDUCTORS.

Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit. Partial shorting often reduces high-frequency response (roll-off).

E. CAPACITORS.

A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter or by checking if the capacitor passes AC signals.

8. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core, electronic-grade solder. The choice of soldering iron is determined by the repair to be made. When soldering on circuit boards, use a 35- to 40-watt pencil-type soldering iron with a 1/8-inch wide, wedge-shaped tip. Keep the tip properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material. Avoid excessive heat; apply only enough heat to remove the component or to make a good solder joint. Also, apply only enough solder to make a firm solder joint; do not apply too much solder.

CAUTION

Several of the circuit boards in the 7904 are multi-layer type boards with a conductive path laminated between the top and bottom board layers. All soldering on these boards should be done with extreme care to prevent breaking the connections to this center conductor; only experienced maintenance personnel should attempt repair of these boards.

For metal terminals (e.g., switch terminals, potentiometers, etc.), a higher wattage-rating soldering iron may be required. Match the soldering iron to the work being done. For example, if the component is connected to the chassis or other large heat-radiating surface, it will require a 75-watt or larger soldering iron. The pencil-type soldering iron used on the circuit board can be used for soldering to switch terminals, potentiometers, or metal terminals mounted in plastic holders.

Component Replacement

WARNING

Disconnect the instrument from the power source before replacing components.

General. The exploded-view drawings associated with the Mechanical Parts List (Section 6) may be helpful in the removal or disassembly of individual components or sub-assemblies. Fig. 5-2 in the Diagrams section shows the location of circuit boards within the 7904.

Power-Unit Removal. The power unit can be slid out of the rear of the 7904 to gain better access to the Logic, X-Y Delay Compensation, and Regulator circuit boards and for power-unit maintenance. To remove the power unit, first remove the four screws which hold the power unit to the rear frame of the instrument. Slide the power unit out of the rear of the instrument until it can be set down on the work surface (guide the power cables so they do not catch on other parts of the instrument). The power unit remains connected to the rest of the instrument so it can be operated in this position for troubleshooting purposes. If it is necessary to operate this instrument with the power unit removed for a period of time, it is recommended that the power unit be secured to the instrument with spacers between the rear frame and the power unit. Reverse this procedure when replacing the power unit; be careful not to pinch the power cables as the power unit is replaced. Be sure that all the securing screws are tight to hold the power unit in place properly.

WARNING

Extreme caution must be used when troubleshooting in the power supply due to the line voltage and the high voltage/high current potentials present. Refer to the discussion entitled Access to Components in Power Unit for information on how to remove the protective cover/shield from the power unit.

Access to Components in Power Unit. To reach the components located inside the power unit for maintenance or repair, use the following procedure:

WARNING

Disconnect the instrument from the power source before removing the power-unit cover. The primary storage capacitors, C1216 and C1217, remain charged with high voltage DC for several minutes after the line power is disconnected. A warning indicator (neon bulb), located on the Power Supply Inverter board, *flashes when this stored voltage exceeds about 80 volts. Do not remove the power-unit cover while this light is flashing.*

1. Slide out the power unit as described previously.

2. Disconnect the CRT anode plug from the jack located at the front of the power unit. Ground this lead to the chassis to dissipate any stored charge.

3. Disconnect all the multi-pin connectors which connect the power unit to the rest of the instrument.

4. Disconnect the power-unit ground lead (green-with-yellow stripe wire terminated with spade lug) by loosening the securing screw at the rear of the Z-Axis chassis (near A16, Z-Axis circuit board).

5. Remove the nut holding the POWER switch to the front panel. Remove this switch and the interconnecting cable through the rear of the instrument.

6. Remove the screws which secure the protective cover to the front and bottom of the power unit and pull the cover off of the power unit.

7. The power unit is now open for maintenance or repair. For information on circuit board removal and replacement, see the instructions given under Circuit Board Replacement for the applicable board. To replace the transformer, see Power Transformer Replacement.

8. Reverse the order of removal to replace the power-unit cover.

Circuit Board Replacement. If a circuit board is damaged beyond repair, replace the entire assembly including all soldered-on components. Part numbers are given in the Mechanical Parts List for completely wired circuit boards.

Most of the circuit boards in this instrument are mounted on the chassis; pin connectors are used for interconnection with other circuit boards and components mounted off the boards. Several boards plug onto the front and rear of the Main Interface board; feed-thru and/or coaxial end-lead connectors connect the plug-on board to the Main Interface board. Use the following procedure to remove the chassis-mounted circuit boards (removal instructions for plug-on boards and boards requiring unique removal procedures will be given later).

Pin Connector Color-Code. The pin connectors, except for coaxial-type connectors, used for interconnection between circuit boards are color-coded to aid in identification and circuit tracing. The color of the connector body matches the resistor color-code for the last digit of the connector circuit number; e.g., P601 is brown, P603 is orange, etc.

A. CHASSIS-MOUNTED BOARDS.

1. Disconnect all pin connectors connected to the board or which connect the board to other portions of the instrument.

2. Remove the securing screws.

3. Remove the board.

4. To replace the board, reverse the order of removal. Match the arrows on the multi-pin connectors to the arrows on the board. Correct location of the pin connectors is shown on the circuit board illustrations in the Diagrams section.

B. PLUG-ON BOARDS.

1. Remove plug-in units or slide out the power unit (as given previously) as necessary to gain access to boards mounted on the front or rear respectively of the Main Interface board.

2. Disconnect any coaxial end-lead connectors located on the front of the board, or which pass across a portion of the board.

3. Loosen all of the securing screws on the board.

4. Pull out on the edges of the board until the board clears the feed-thru terminals. Hold the board parallel to the Main Interface board until the board is free, so as not to bend the feed-thru terminals.

5. To replace a plug-on circuit board, position it so the feed-thru pins and sockets mate properly.

6. Gently press the circuit board against the mounting surface. Be sure that all the feed-thru pins and sockets mate properly.

7. Uniformly tighten the securing screws. Recommended torque, four to six inch-pounds.

C. MAIN INTERFACE CIRCUIT BOARD.

Use the following procedure to replace the Main Interface circuit board:

1. Slide out the power-unit as described previously.

2. Remove all of the plug-on circuit boards from the Main Interface circuit board as given previously (remove plug-in units to gain access to plug-on boards on front of Main Interface board).

3. Disconnect the pin connectors from the Main Interface board. Note the order of these connectors so they can be correctly replaced.

4. Remove the screws from inside each plug-in compartment which hold the plug-in interface connectors to the chassis of this instrument. Also remove the screws which hold the ground straps to the chassis.

5. Slide the Main Interface board assembly to the rear and remove it from the instrument.

6. To replace the Main Interface board, reverse the order of removal. Match the arrows on the pin connectors to the arrows on the board. Correct location of the pin connectors is shown in the circuit board illustrations in the Diagrams section. Also see Pin Connector Color-Code under Troubleshooting in this section.

D. CALIBRATOR—SIGNALS BOARD.

To replace the Calibrator—Signals circuit board, proceed as follows:

1. Disconnect all pin connectors and cables from the board.

2. Set the CALIBRATOR and RATE switches as necessary to gain access to the shaft-coupling set screws (one in front of both switch sections). Note the knob positions so they can be correctly replaced.

3. Loosen the set screw in the rear shaft coupling with a 0.050-inch hex-key wrench. Remove the RATE knob and shaft through the front of the instrument.

4. Loosen the front set screw in the front shaft coupling with a 5/64-inch hex-key wrench. Remove the CALIBRATOR knob and shaft through the front of the instrument.

5. Remove the screws which hold the switch/board assembly to the chassis and remove the assembly from the instrument.

6. To replace the Calibrator-Signals switch/board assembly, reverse the removal procedure. Match the arrows on the multi-pin connectors to the arrows on the board. Correct location of the pin connectors and coaxial cables is shown on the circuit board illustration in Section 7. Be sure the front-panel knobs are installed so they indicate the correct switch positions.

E. LV REGULATOR BOARD.

To remove and replace the LV Regulator circuit board, use the following procedures:

REMOVAL:

1. Slide the power unit out of the rear of the instrument as described previously.

2. Disconnect the multi-pin connectors from the board.

3. Remove the mounting hardware securing the plastic-cased power transistors to the rear heatsink. Note the orientation of the lockwashers so they can be correctly replaced.

4. Remove the screws which hold the LV Regulator board to the top chassis. Remove the board along with the plastic-cased transistors.

REPLACEMENT:

1. Apply a thin coat of silicone grease on the back (mounting surface) of each plastic transistor case.

2. Place the LV Regulator board on the chassis. Replace the screws which hold the board to the chassis; do not yet tighten these screws.

3. Check that the plastic transistors are aligned with their mounting holes and that the insulating washers are in place between the transistor cases and the rear heatsink.

4. Secure the transistors to the heatsink with the mounting hardware. Do not over-tighten the nuts; recommended torque, 4 to 6 inch-pounds.

5. Tighten the screws holding the LV Regulator board to the chassis.

6. Connect the multi-pin connectors to the board. Match the arrows on the connectors to the arrows on the board.

7. Replace the power unit in the instrument.

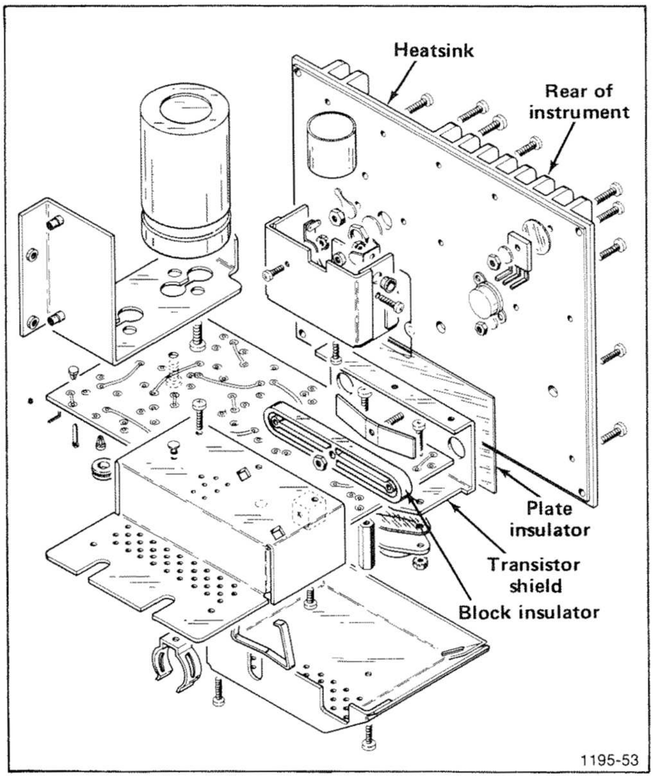

Fig. 2-2. Exploded-view drawing of a portion of the power unit identifying several critical parts.

F. POWER SUPPLY INVERTER BOARD.

To remove and replace the Power Supply Inverter board, use the following procedures. An exploded-view drawing of the power unit is shown in Fig. 3 in the Mechanical Parts List. Parts and subassemblies referred to in this procedure are identified (in parentheses) by the Index Number used on this exploded-view drawing. All references to direction or location (e. g., left side) assume that the power unit is placed as shown in this drawing. Several critical parts are identified in Fig. 2-2, an exploded-view drawing of a portion of the power unit.

WARNING

The power-unit assembly has been tested at the factory to assure safe operation. Improper repair of this unit can result in hazardous voltages on the chassis of this instrument. Do not remove the plate insulator, block insulator, or transistor shield from the rear heat-sink (see Fig. 2-2).

REMOVAL:

1. Disconnect the instrument from the power source.

2. Remove the power unit from the instrument as described under Power-Unit Removal.

3. Remove the protective cover from the power unit as described under Access to Components in Power Unit.

4. Disconnect the multi-pin connectors from **A12**, Cap-Rectifier board (109).

5. Remove the mounting hardware (4 and 6) securing the plastic-cased power transistors (3) to the rear heatsink (1). Note the orientation of the lockwashers (4) so they can be correctly replaced.

6. Remove the Regulator chassis (40). This chassis is secured to the rear heatsink (1) by two screws (41); access to the remaining four screws (42) is provided by holes in **A13**, LV Regulator board (43). Remove this chassis along with the LV Regulator board and plastic-cased transistors.

7. Remove the right side cover (103). This cover is secured to the rear heatsink (1) by two screws (2) and to the side by one screw (62).

8. Remove the left side cover (105). This cover is secured to the rear heatsink (1) by two screws (2) and to the side by four screws (53).

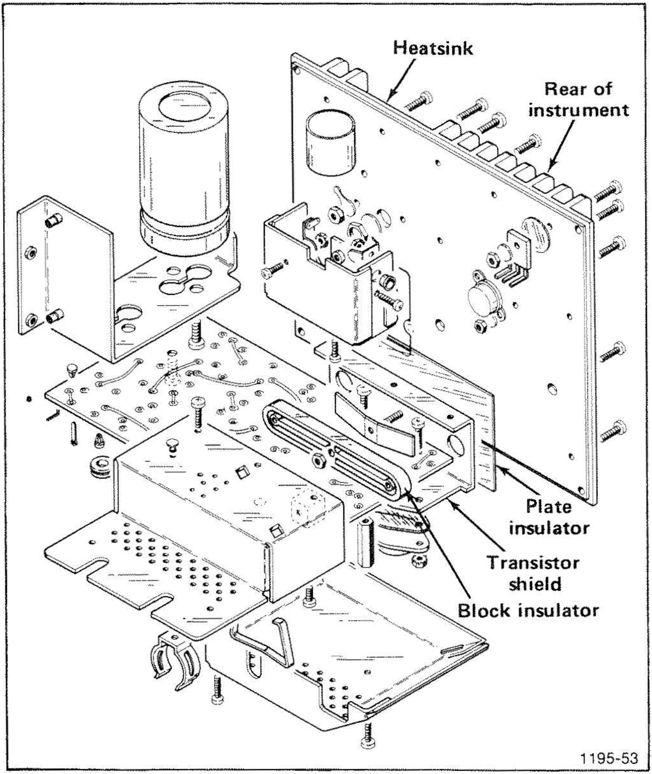

Fig. 2-2. Exploded-view drawing of a portion of the power unit identifying several critical parts.

9. Remove transistor shield (63) from **A11**, Power Supply Inverter board (65), by removing two plastic screws (64) and split lockwashers.

10. Unsolder the three power-transformer leads from **A11**, Power Supply Inverter board (65). These leads, which pass through holes in the board, are identified on the circuit-board illustration in the Diagrams section. Remove the excess solder from the board with a vacuum-type desoldering tool.

11. The left side of **A12**, Cap-Rectifier board (109) is secured to the capacitor bracket (52) by two screws (119). Remove these screws.

12. The top right corner of **A12**, Cap-Rectifier board (109), is secured to the nut block (61) by a screw (62). Remove this screw.

13. The left side of **A11**, Power Supply Inverter board (65), is secured to two capacitors (54) by four screws (55). Remove these screws to remove the capacitors (54) and capacitor bracket (52).

14. Move the bottom edge of **A12**, Cap-Rectifier board (109), away from **A11**, Power Supply Inverter board (65), until the interconnecting pins are cleared. Remove **A12**, Cap-Rectifier board, and the high-voltage supply box (95) as a unit.

15. Unsolder the eight line-input leads from **A11**, Power Supply Inverter board (65). These leads are identified on the circuit board illustration, Fig. 5-18, in the Diagrams section. Remove the excess solder from the board with a vacuum-type desoldering tool.

16. The line-filter shield (29) is held to the rear heatsink (1) by two screws (30). Remove these screws; it is not necessary to disconnect the line-filter leads.

17. Remove the two transistors (21) by removing the nuts (23) and pulling the transistors from their sockets.

18. Shield (56) is held to the insulator block (25) by three screws (59). Remove these screws.

19. Move **A11**, Power Supply Inverter board (65), away from the heatsink-shield (75) until the transistor mounting studs (71) clear the heatsink-shield (75). Remove **A11**, Power Supply Inverter board, and shield (56) as a unit.

REPLACEMENT:

1. Set the back of the rear heatsink (1) on the work surface. Replace **A11**, Power Supply Inverter board (65), with shield (56), by guiding the transistor mounting studs (71) through the holes in the heatsink-shield (75).

2. Secure the shield (56) to the insulator block (25) with three screws (59).

3. Apply a thin coat of silicone grease to both sides of the transistor insulating washers (22) and place these washers over the transistor mounting studs (71).

4. Replace transistors (21) and secure with nuts (23).

5. Secure the line-filter shield (29) to the rear heat-sink (1) with the two screws (30). Be sure no wires get caught between the shield and heatsink.

6. To mount **A12**, Cap-Rectifier board (109), and high-voltage supply box (95), guide the power-transformer leads through the appropriate holes in **A11**, Power Supply Inverter board (65). Then, align **A12**, Cap-Rectifier board (109), to properly mate the inter-connecting pins and sockets.

7. Replace the screw (62) which secures **A12**, Cap-Rectifier board (109), to the nut block (61).

8. Place the power-unit ground lead and power-switch cable in the slot in the top of **A12**, Cap-Rectifier board (109).

9. Mount the capacitors (54) with capacitor bracket (52) to **A11**, Power Supply Inverter board (65), with four screws (55).

10. Replace the two screws (119) which secure **A12**, Cap-Rectifier board (109), to the capacitor bracket (52).

11. Solder the three power-transformer leads and eight line-input leads to **A11**, Power Supply Inverter board (65). Correct connection of these leads is shown on the circuit board illustration, Fig. 5-18, in the Diagrams section.

12. Replace the transistor shield (63); secure with two plastic screws (64).

13. Replace the left side cover (105); secure with screws (53 and 2).

14. Replace the right side cover (103); secure with screws (62 and 2).

15. Before replacing the Regulator board chassis (40) along with **A13**, LV Regulator board (43) and plastic power transistors (3), apply a thin coat of silicone grease to the back (mounting surface) of each transistor case. Check that the transistor insulating washers (5) are in place on the rear heatsink (1). If any of these insulating washers are replaced, apply a thin coat of silicone grease to each side.

16. Place the Regulator board chassis (40) on the power unit. Check that the plastic transistors (3) are aligned with their mounting holes and that the insulating washers (5) are still in place between the transistor cases and the rear heatsink (1).

17. Replace the screws (41 and 42) which secure the Regulator board chassis (40); do not yet tighten these screws.

18. Secure the plastic transistors (3) to the rear heatsink (1) with the mounting hardware (4 and 6). Do not over-tighten these nuts; recommended torque, 4 to 6 inch-pounds. Tighten the screws replaced in the previous step.

19. Connect the multi-pin connectors to **A12**, Cap-Rectifier board (109); match the arrows on the connectors to the arrows on the board.

20. Replace the power-unit cover and install the power unit in the mainframe.

G. CAP-RECTIFIER BOARD.

To remove and replace the Cap-Rectifier circuit board, use the following procedure:

1. Follow the first 12 steps of the removal procedure for the Power Supply Inverter board, as given previously.

2. Unsolder the power-transformer leads connected to the rear side of the board. Remove the excess solder with a vacuum-type desoldering tool.

3. Remove the screws which hold the circuit board to the high-voltage supply box.

4. To replace the board, reverse the order of removal. Place all of the power-transformer leads in the circuit board holes; then re-solder them to the board. To replace the Regulator board chassis along with the LV Regulator board and plastic power transistors, see the instructions given in the replacement procedure for the Power Supply Inverter board.

H. HIGH-VOLTAGE AND AUTO FOCUS BOARDS.

The High-Voltage and Auto Focus circuit boards are located in the high-voltage supply box and are removed as a unit. To replace either of these boards, proceed as follows:

1. Follow the first six steps given under Access to Components in Power Unit.

2. Disconnect the remaining multi-pin connectors from the LV Regulator board.

3. Remove the hardware which secures the plastic power transistors to the rear heatsink.

4. Remove the four screws which hold the Regulator chassis to the power unit (accessible through holes in the LV Regulator board).

5. Remove the two screws securing the lip of the Regulator chassis to the rear heatsink.

6. Remove the Regulator chassis along with the LV Regulator board and plastic transistors.

7. Remove the screw securing the High-Voltage board to the high-voltage supply box.

8. Unsolder the five power-transformer leads connected to the High-Voltage board. Note the location of these leads so they can be correctly re-connected. Remove the excess solder from the board with a vacuum-type desoldering tool.

9. Remove the High-Voltage and Auto Focus boards from the high-voltage supply box.

10. To replace the two boards, reverse the removal procedure. To replace the Regulator chassis along with the

LV Regulator board and plastic transistors, see the instructions given in the replacement procedure for the Power Supply Inverter board.

Plug-In Interface Connectors. The individual contacts of the plug-in interface connectors can be replaced. However, it is recommended that the entire Main Interface board be replaced if a large number of the contacts are damaged. An alternative solution is to refer the maintenance of the damaged Main Interface board to your local TEKTRONIX Field Office or representative. Use the following procedure to replace an individual contact of the plug-in interface connector.

NOTE

The plug-in interface contacts mounted on the Follower circuit boards cannot be replaced individually; the Follower board with contacts and interconnecting cables is replaced as a unit. See Follower Circuit Board.

1. Remove the Main Interface circuit board from the instrument as described previously.

2. Snap the connector cover (white plastic) off the side of the plug-in interface connector which needs repair.

3. Unsolder and remove the damaged contact.

4. Install the replacement contact. Carefully form it to the required shape to fit against the connector body.

5. Snap the connector cover back onto the plug-in interface connector. Check that the contact which was replaced is aligned with the other contacts.

6. Replace the Main Interface board.

Follower Circuit Board. A Follower circuit board with six interface contacts is used in each vertical (two left plug-in compartments) plug-in interface connectors to provide optimum signal and trigger connections between the plug-in unit and the 7904. The Follower board is held in place by a follower spring so the board can move back and forth within the interface connector to compensate for length differences between plug-ins. If a contact on the Follower board is damaged, the entire board with contacts and interconnecting cables is replaced as a unit.

To remove a Follower circuit board, use the following procedure:

1. Disconnect the Follower board coaxial leads from the Main Interface board.

2. Using long-nosed pliers, disengage the follower spring from the Follower board (a hole in the Main Interface board provides access to the follower spring from the rear of the board). Push the follower spring away from the Follower board toward the top of the interface connector.

3. Remove the Follower board and interconnecting cables from the rear of the interface connector through the hole in the Main Interface board.

To replace a Follower board, a folded length of thin shim stock as wide as the Follower board is required to compress the contacts while the board is inserted into the interface connector. Proceed as follows:

1. Hold the Follower board between the ends of the shim stock with the fold directly in front of the contacts. With the shim stock held against the sides of the board, the contacts on the sides of the board should be pressed together.

2. Insert the folded end of the shim stock (with the Follower board) into the rear of the interface connector through the hole in the Main Interface board. When the Follower board contacts are fully inserted into the connector, hold the board in place and remove the shim stock through the front of the interface connector.

3. Secure the Follower board with the follower spring.

4. Reconnect the Follower board coaxial leads to the Main Interface board.

Semiconductor Replacement. Semiconductors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of semiconductors may affect the calibration of this instrument. When semiconductors are replaced, check the operation of the part of the instrument which may be affected.

CAUTION

POWER switch must be turned off before removing or replacing semiconductors.

Replacement semiconductors should be of the original type or a direct replacement. Fig. 4-3 shows the lead configuration of the semiconductors used in this instrument. Some plastic case transistors have lead configurations which do not agree with those shown here. If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the standard basing used for metal-case transistors. Transistors which have heat radiators or are mounted on the chassis use silicone grease to increase heat transfer. Replace the silicone grease when replacing these transistors.

WARNING

Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

An extracting tool should be used to remove the 14- and 16-pin integrated circuits to prevent damage to the pins. This tool is available from Tektronix, Inc. Order TEKTRONIX Part No. 003-0619-00. If an extracting tool is not available when removing one of these integrated circuits, pull slowly and evenly on both ends of the device. Try to avoid having one end of the integrated circuit disengage from the socket before the other, as the pins may be damaged.

To replace one of the power transistors mounted on the heat radiator on the rear of the power unit, first remove the mounting screw. Then, unsolder and remove the defective transistor. When replacing the transistor, be sure to install the insulating washer between the transistor and the heat radiator (use silicone grease as described previously). Tighten the mounting screw just tight enough to hold the transistor in place. Then solder the replacement transistor to the Regulator board.

Interconnecting Pin Replacement. Two methods of interconnection are used in this instrument to connect the circuit boards with other boards and components. When the interconnection is made with a coaxial cable, a special end-lead connector plugs into a socket on the board. Other interconnections are made with a pin soldered onto the board. Two types of mating connectors are used for these interconnecting pins. If the mating connector is mounted on a plug-on circuit board, a special socket is soldered into the board. If the mating connector is on the end of a lead, an end-lead pin connector is used which mates with the interconnecting pin. The following information provides the replacement procedure for the various types of interconnecting methods.

A. COAXIAL-TYPE END-LEAD CONNECTORS

Replacement of the coaxial-type end-lead connectors requires special tools and techniques; only experienced maintenance personnel should attempt replacement of these connectors. It is recommended that the cable or wiring harness be replaced as a unit. For cable or wiring harness part numbers, see the Mechanical Parts List. An alternative solution is to refer the replacement of the defective connector to your local TEKTRONIX Field Office or representative.

B. CIRCUIT-BOARD PINS.

NOTE

A circuit-board pin replacement kit including necessary tools, instructions, and replacement pins is available from Tektronix, Inc. Order TEKTRONIX Part No. 040-0542-00.

To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the circuit board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Ream out the hole in the circuit board with a 0.031-inch drill. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin. Then, solder the pin on both sides of the circuit board. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

C. CIRCUIT BOARD PIN SOCKETS.

The pin sockets on the circuit boards are soldered to the rear of the board. To replace one of these sockets, first unsolder the pin (use a vacuum-type desoldering tool to remove excess solder). Then straighten the tabs on the socket and remove it from the hole in the board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the tabs of the socket to the circuit board; be careful not to get solder into the socket.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.

D. END-LEAD PIN CONNECTORS.

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and installed as a multi-pin connector. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.

Cathode-Ray Tube Replacement. To replace the cathode-ray tube, proceed as follows:

WARNING

Use care when handling a CRT. Protective clothing and safety glasses should be worn. Avoid striking it on any object which might cause it to crack or implode. When storing a CRT, place it in a protective carton or set it face down in a protected location on a smooth surface with a soft mat under the faceplate to protect it from scratches.

A. REMOVAL:

1. Remove the plastic CRT mask, light filter, and metal light shield.

2. Remove the four screws securing the CRT bezel to the front panel. Disconnect the multi-pin connector from the left rear of the CRT bezel.

3. Release the CRT anode lead from the plastic fasteners near the top of the instrument. Disconnect the anode plug from the jack on the power unit. Ground this lead to the chassis to dissipate any stored charge.

4. Disconnect the deflection-plate connectors. Be careful not to bend these pins.

5. Remove the CRT base socket from the rear of the CRT.

6. Loosen the two screws located on each side of the CRT socket until the tension of the springs on these screws is released. Then, press in on the screws to be sure that the CRT clamp is loose.

7. Hold one hand on the CRT faceplate and push forward on the CRT base with the other. As the CRT starts out of the shield, grasp it firmly. Guide the anode lead through the cutout in the CRT shield as the CRT is removed.

B. REPLACEMENT:

1. Insert the CRT into the shield. Guide the anode lead through the hole in the CRT shield. Set the CRT firmly against the cushions mounted on each corner of the frame panel.

2. Clean the CRT faceplate, plastic faceplate protector, and the light filter with denatured alcohol.

3. Place the black plastic CRT mask over the CRT faceplate.

4. Reconnect the multi-pin connector to the CRT bezel (align arrow on connector with arrow on bezel). Hold the clear faceplate protector in position and install the CRT bezel. Firmly tighten the four screws.

5. Push forward on the CRT base to be certain that the CRT is as far forward as possible. Then tighten the two screws beside the CRT base socket until the springs on the screws are fully compressed.

6. Replace the CRT base socket.

7. Fasten the CRT anode lead into the plastic fasteners. Reconnect the CRT anode plug.

8. Carefully reconnect the deflection-plate connectors. After each connector is installed, lightly pull on its lead to be sure that it will remain in place.

9. Replace the metal light shield and the tinted filter. Then snap the plastic CRT mask into the CRT bezel.

10. Check the calibration of the complete instrument. Calibration procedure is given in Section 3.

Switch Replacement. Several different types of switches are used in this instrument. The toggle, slide, and rotary switches should be replaced as a unit if damaged. Observe the soldering precautions given earlier in this section when replacing these switches. The following special maintenance information is provided for the cam-type and pushbutton switches.

CAUTION

Repair of cam-type switches should be undertaken only by experienced maintenance personnel. Switch alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For assistance in maintenance of the cam-type switches, contact your local TEKTRONIX Field Office or representative.

A. CAM-TYPE SWITCHES.

NOTE

A cam-type switch repair kit including necessary tools, instructions, and replacement contacts is available from Tektronix, Inc. Order TEKTRONIX Part No. 040-0541-00.

The cam-type switches consist of a rotating cam, which is turned by the front-panel knob, and a set of contacts mounted on an adjacent circuit board. These switch contacts are actuated by lobes on the cam. The CALIBRATOR and RATE cam-type switches can be disassembled for inspection, cleaning, repair, or replacement as follows:

1. Remove the Output Signals and Calibrator board/ switch assembly as described previously.

2. Remove the screws which hold the metal covers on the switches. The front switch section on the board is the CALIBRATOR switch and the rear switch section is the RATE switch. The switches are now open for inspection or cleaning.

3. To completely remove either of the switches from the board, remove the four screws which hold the cam switch to the circuit board (from rear side of board).

4. To remove the cam from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam out of the support block. Be careful not to lose the small detent roller.

5. To replace defective switch contacts, follow the instructions given in the switch repair kit.

6. To replace the switch assembly, reverse the above procedure.

B. PUSHBUTTON SWITCHES.

The pushbutton switches are not repairable and should be replaced as a unit if defective. Components which are mounted on the circuit board associated with the pushbutton switch can be replaced using the normal replacement procedures. See the information under Light-Bulb Replacement for instructions on replacing the light bulbs.

Mode Switches. Use the following procedure to replace the VERTICAL MODE or HORIZONTAL MODE pushbutton switches:

1. Disconnect the multi-pin connectors from the rear of the Front-Panel Interconnect board.

2. Remove the plastic screws securing the Front-Panel Interconnect board and remove this board.

3. Remove the two Phillips-head screws holding the upper plug-in guide bar to the top of the plug-in compartments associated with the mode switch which is being removed (vertical compartments for VERTICAL MODE switch, horizontal compartments for HORIZONTAL MODE switch).

4. Remove the switch from the instrument. It will be necessary to carefully guide the switch around the cabling and structural members of the instrument as it is removed.

5. To replace the switch, reverse the above procedure. Be sure the EMI gasketing is in place between the switch and the front panel when the switch is replaced. Match the arrows on the multi-pin connectors to the arrows on the Front-Panel Interconnect board.

Trigger Source Switches. To replace the A TRIGGER SOURCE or B TRIGGER SOURCE pushbutton switches, proceed as follows:

1. Disconnect the multi-pin connectors from the Front-Panel Interconnect board.

2. Remove the plastic screws securing the Front-Panel Interconnect board and remove this board.

3. Press the center of the release bar on the switch holder, then press on the front-panel pushbuttons to remove the switch from the holder.

4. To replace the switch, reverse the above procedure. Press the center of the release bar as the switch is pressed into place. Match the arrows on the multi-pin connectors to the arrows on the Front-Panel Interconnect board.

Light-Bulb Replacement. The following procedures describe replacement of the light bulbs in this instrument.

A. MODE SWITCHES.

Use the following procedure to replace light bulbs in the VERTICAL MODE or HORIZONTAL MODE switches:

1. Remove the applicable mode switch as given previously.

2. Unsolder the leads of the bulb and the plastic holder from the circuit board; remove these items from the switch assembly as a unit.

3. Remove the defective bulb from the plastic holder.

4. Install the new bulb in the plastic holder; install this unit in the switch assembly.

5. Solder the bulb and holder to the circuit board.

6. Replace the mode switch as described previously.

B. TRIGGER SOURCE SWITCHES.

To replace light bulbs in the A TRIGGER SOURCE or B TRIGGER SOURCE switches, proceed as follows:

1. Remove the applicable trigger source switch, using the procedure described previously.

2. Remove the light-bulb cover by prying between the cover and the circuit board.

3. Unsolder the defective bulb from the circuit board.

4. Install the new bulb so it is positioned in the same manner as the original bulb.

5. Solder the bulb to the circuit board. If possible, use a heat sink to protect the bulb during soldering.

6. Replace the bulb cover.

7. Install the switch using the procedure described previously.

C. INTENSITY INDICATORS.

The light bulbs which provide an indication of which intensity control is active are mounted in a cap which snaps into a holder mounted behind the front panel of the instrument. To replace either of these bulbs, pull the bulb/cap assembly off the holder. Then unsolder and remove the defective bulb. Replace the new bulb so it is positioned in the same manner as the original. Snap the bulb/cap assembly back into the holder.

D. GRATICULE BULB REPLACEMENT.

To replace the graticule bulbs, first remove the plastic CRT mask, light filter, and metal light shield. Pull on the white tabs to remove the graticule lamp assembly. Now, slide the lamp retaining strips to the side, off the bulb base. Pull the bulb out of the circuit board. Reverse the order of removal for replacement.

Relay Replacement. The relays on the X-Y Delay Compensation board (optional feature) are mounted in sockets. The basing (as well as the internal connections) of these relays is symmetrical so that these relays may be plugged into their socket facing in either direction.

Power Transformer Replacement. Replace the power transformer only with a direct replacement TEKTRONIX transformer. To replace the power transformer, proceed as follows:

1. Remove the Line Inverter board assembly, Cap-Rectifier, and High-Voltage/Auto Focus boards as given under Circuit Board Replacement.

2. Remove the brass spring retainers which hold the transformer windings and core in place and remove these items.

3. To replace the power transformer, reverse the order of removal.

Fuse Replacement. The fuses used in this instrument are as follows:

Fuse Ratings

Circuit Number	Rating	Function	Location
F1200	4A Fast	Line Input	Line Selector Assembly
F1223	2A Fast	Inverter	Line Selector Assembly

Vertical Amplifier Replacement. Vertical Amplifiers U685 and U745 can be replaced without removing the Vertical Amplifier board from the chassis, but only if the code number on the integrated circuit board matches the code replacement. See Fig. 2-3.

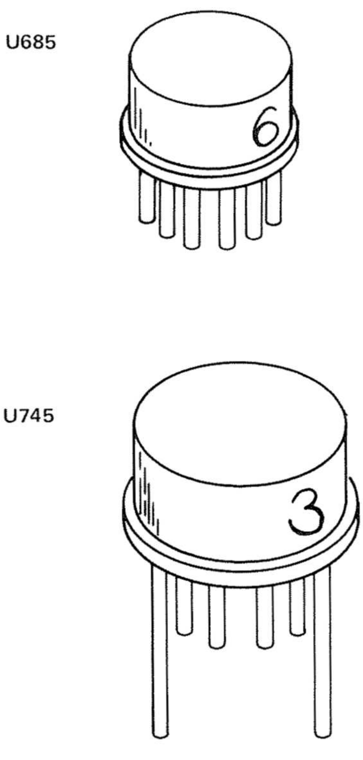

Fig. 2-3.

To remove U745 without removing the board, the CRT connectors must be unsoldered from the integrated circuit leads. Touch a low-wattage iron to the leads near the solder connection and push the leads away from the connectors. See Fig. 2-4.

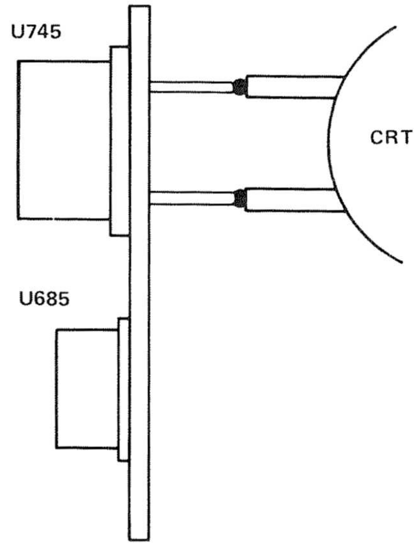

Fig. 2-4.

If the code number on the replacement does not match the number on the original integrated circuit, the emitter shunt resistors must also be replaced. Table 2-2 lists the resistor value to be used with each code. The shunt resistors are located on the bottom of the board near the integrated circuits. Replacement transistors must be 1/8 watt rating.

TABLE 2-2

Shunt Resistor Replacement Values

U685		U745	
Code	R684, R688	Code	R741, R756
1	91Ω	1	110Ω
2	100Ω	2	130
3	110Ω	3	160Ω
4	130Ω	4	220Ω
5	160Ω	5	300Ω
6	220Ω	6	510Ω
7	300Ω	7	1000Ω
8	510Ω		

Vertical Interface Circuit Board Replacement. U625 may not be replaced alone; the complete Vertical Interface circuit board must be replaced if U625 is found defective.

To isolate a problem to the Vertical Interface board, U525 or U575 (Trigger Selector IC's) can be used as a temporary substitute for U625.

Many of the components for the Vertical Interface circuit board are selected to achieve proper performance. Table 2-3, which can be used to aid in troubleshooting and repair, lists the components that are normally selected, and the purpose of each component.

TABLE 2-3

Vertical Interface Selected Components

Component	Purpose
R602, R605 R608, R611	Sets each of the four board inputs to exactly 50Ω from ground.
C603, C606, C609, C612	Selected for least high-frequency reflections at each of the four inputs.
R622, R628, R634, R640	Selected for proper channel switch operation point and balance.
R646	Sets output gain to proper value.
R644, C644	Controls initial overshoot of transient response.
R620, R623, R626, R629, C629, R632, R635, C635, R638, R641	Sets proper compensation throughout the frequency range.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Since the low-voltage supplies affect all circuits, calibration of the entire instrument should be checked if work has been done in the low-voltage supplies or if the power transformer has been replaced. See Section 3 for a complete calibration procedure.

Instrument Repackaging

If this instrument is to be shipped for long distances by commercial means of transportation, it is recommended that it be repackaged in the original manner for maximum protection. The original shipping carton can be saved and used for this purpose. An illustration associated with the Mechanical Parts List shows how to repackage the 7904 and gives the part number for the packaging components. New shipping cartons can be obtained from Tektronix, Inc. Contact your local TEKTRONIX Field Office or representative.

CALIBRATION

Calibration Interval

To assure instrument accuracy, check the calibration of the 7904 every 1000 hours of operation, or every six months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

TEKTRONIX Field Service

Tektronix, Inc. provides complete instrument repair and recalibration at local Field Service Centers and the Factory Service Center. Contact your local TEKTRONIX Field Office or representative for further information.

Using This Procedure

General. This section provides several features to facilitate calibration of the 7904. These are:

Index. An index is given preceding the Calibration procedure to aid in locating steps.

Performance Check. The performance of this instrument can be checked by performing only the √ CHECK steps. The √ preceding a step indicates that performing this step checks the instrument against the tolerances listed as a Performance Requirement (see Specification section in Operators manual). Limits and tolerances given in other check steps are calibration guides and should not be interpreted as instrument specifications. Operator front-panel adjustments are adjusted as part of the Performance Check procedure.

Partial Calibration. A partial calibration is often desirable after replacing components, or to touch up the adjustment of a portion of the instrument between major recalibrations. To calibrate only part of the instrument, set the controls as given under Preliminary Control Settings and start with the nearest Equipment Required list preceding the desired portion. To prevent unnecessary recalibration of other parts of the instrument, readjust only if the tolerance given in the CHECK—part of the step is not met. If re-adjustment is necessary, also check the calibration of any steps listed in the INTERACTION—part of the step.

Complete Calibration Procedure. Completion of each step in the complete Calibration procedure insures that this instrument is correctly adjusted and performing within all given tolerances.

NOTE

All waveforms shown in this section were taken with a TEKTRONIX Oscilloscope Camera System, unless noted otherwise.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or its equivalent, is required for complete calibration of the 7904. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, the specifications of any test equipment used must meet or exceed the listed specifications. All test equipment is assumed to be correctly calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed. The high-frequency characteristics of the 7904/7A19/7B92 Oscilloscope System must be checked and adjusted as a unit. The calibration of the plug-in units should first be checked according to the procedure given in their respective service manuals before performing the 7904 calibration.

Special Calibration Fixtures

Special TEKTRONIX calibration fixtures are used in this procedure only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local TEKTRONIX Field Office or representative.

Calibration Equipment Alternatives

All of the listed test equipment, or its equivalent, is required to completely check and adjust this instrument. The Calibration procedure is based on the first item of equipment given as an example of applicable equipment. When other equipment is substituted, control settings or calibration setup may need to be altered slightly to meet the requirements of the substitute equipment. If the exact item of test equipment given as an example in the Test Equipment list is not available, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Usage column to see what this item of test equipment is used for. If used for a check or adjustment which is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.

The following procedure is written to completely check and adjust the 7904 to the Performance Requirements given in the Operators Manual and to allow inter-changeability of 7000-series plug-in units between 7000-series mainframes without the need to completely recalibrate the instruments each time. If the applications for which you will use the 7904 do not require the full available performance from the 7904/plug-in combination, this procedure and the required equipment list can be shortened accordingly. For example, the basic measurement capabilities of this instrument can be verified by just checking vertical deflection accuracy and basic horizontal timing with 7000-series real-time plug-in units and the 7904 Calibrator signal. Also, if the 7904/plug-in combination is to be used as a fixed system without the need to inter-change plug-in units, all tests can be made by substituting vertical plug-in units and applicable test signals for the 067-0587-01 signal standardizer calibration fixture.

TEST EQUIPMENT

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
1. Precision DC voltmeter	Range, zero to 150 volts; accuracy, within 0.1% of reading ±1 count.	Calibrator output voltage adjustment. Low-voltage power supply adjustment and check.	a. TEKTRONIX 7D13 Digital Multimeter (either test oscilloscope or 7904 under calibration must have Readout System). b. Fluke Model 825A Differential DC Voltmeter.
2. DC voltmeter (VOM)	Range, zero to 150 volts; accuracy, within 3%.	Auto-focus adjustment.	a. Use item 1. b. Triplett Model 630-NA. c. Simpson Model 262.
3. Time-mark generator	Marker outputs, two nanoseconds to 0.5 second; marker accuracy, within 0.1%; trigger output, one millisecond.	CRT geometry adjustment. Horizontal timing adjustment. Horizontal amplifier thermal balance adjustment. Calibrator 1 kHz repetition rate adjustment. CRT edge-focus adjustment.	a. TEKTRONIX 2901 Time-Mark Generator. b. TEKTRONIX Type 184 Time-Mark Generator.
4. Medium-frequency constant-amplitude signal generator	Frequency, 500 kilohertz to two megahertz; reference frequency, 50 kilohertz; output amplitude, variable from 50 millivolts to two volts peak to peak into 50 ohms; amplitude accuracy, constant within 3% of reference frequency as output frequency changes.	External Z-axis check. X-Y phasing adjustment (with Option 2 only). Horizontal bandwidth check.	a. TEKTRONIX 191 Constant Amplitude Signal Generator.

TEST EQUIPMENT (cont)

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
5. High-frequency constant-amplitude signal generator	Frequency, 220 megahertz to 500 megahertz; reference frequency, 10 megahertz or lower; output amplitude, variable from 0.5 to four volts; amplitude accuracy, constant within 1% of reference as output frequency changes.	Vertical bandwidth check. Vertical channel isolation check.	a. TEKTRONIX 067-0532-01 Calibration Fixture. b. TEKTRONIX 067-0650-00 Calibration Fixture. c. General Radio 1362 UHF Oscillator with 1263-C Amplitude-Regulating Power Supply. d. Wiltron Model 610B Swept Frequency Generator with Model 61083, 10 to 1220 megahertz plug-in.
6. Low-frequency signal generator	Frequency, 35 kilohertz; output amplitude, variable from 50 to 100 millivolts.	X-Y phasing check.	a. General Radio 1310-B Oscillator.
7. Test-oscilloscope system (dual-trace)	Bandwidth, DC to 75 megahertz; minimum deflection factor, 10 millivolts/division; accuracy, within 3%.	Z-Axis DC Level adjustments. Z-axis transient response adjustment. Horizontal DC limit centering adjustment. Trigger selector adjustments.	a. TEKTRONIX 7704 Oscilloscope with 7A18A/AN Amplifier unit, 7B50 or 7B70 Time Base, and two P6053 probes. b. TEKTRONIX 454A Oscilloscope with two P6054 probes.
8. Amplifier plug-in unit (two identical units required)	TEKTRONIX 7A-series. 80 megahertz bandwidth required for complete procedure as written.	Used throughout procedure to provide vertical input to 7904 under calibration. Identical units required only for X-Y phasing adjustment.	a. TEKTRONIX 7A18A/AN or 7A16 Amplifier. May be shared with 7000-series test oscilloscope. b. Any 7A-series plug-in unit (tolerances in some steps may be limited if low-frequency units are used).
9. Wide-band amplifier plug-in unit	TEKTRONIX 7A-series. 500 megahertz bandwidth required for complete procedure as written.	Vertical amplifier bandwidth and isolation checks. Horizontal timing adjustment. Gate output high-frequency compensation.	a. TEKTRONIX 7A19 Amplifier.

TEST EQUIPMENT (cont)

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
10. Time-base plug-in unit (two required)	TEKTRONIX 7B-series. 0.5 nanosecond sweep rate required for complete procedure.	Used throughout procedure to provide sweep. 0.5 nanosecond sweep required only for high-frequency horizontal timing (one unit only).	a. TEKTRONIX 7B92 and 7B70 or 7B71 Time Base. May be shared with 7000-series test oscilloscope. b. Any 7B-series plug-in unit (high-frequency timing cannot be adjusted if 0.5 nanosecond sweep not available).
11. Signal standardizer calibration fixture	Produces gain-check and pulse-response waveforms.	Used through procedure to standardize instrument so plug-in units can be interchanged without complete recalibration.	a. TEKTRONIX 067-0587-01 Calibration Fixture. b. Calibrated 7000-series plug-in units with suitable signal sources may be substituted if lower performance is acceptable.
12. Plug-in extender	Provides connection to internal trigger system outputs.	Trigger selector adjustments.	a. TEKTRONIX 067-0589-00 Calibration Fixture.
13. Pulse generator	Risetime, 70 picoseconds or less; pulse width, at least 350 nanoseconds; aberrations, less than ±3%, 3% total peak-to-peak within first 2 nanoseconds after step; amplitude, at least 200 millivolts into 50-ohm load.	Vertical high-frequency compensation.	a. TEKTRONIX Type 284 Pulse Generator. b. TEKTRONIX S-52 Pulse Generator Head used with 7S12 TDR/Sampler or Type 285 Power Supply.
14. Attenuator	Impedance, 50 ohms; attenuation, 2X; connectors, GR874.	Vertical high-frequency compensation.	a. TEKTRONIX Part No. 017-0080-00.
15. Attenuator	Impedance, 50 ohms; attenuation, 5X; connectors, GR874.	Vertical amplifier bandwidth check. Vertical channel isolation check.	a. TEKTRONIX Part No. 017-0079-00.
16. T connector	Connectors, BNC.	External Z-axis check. X-Y phasing check and adjustment.	a. TEKTRONIX Part No. 103-0030-00.
17. Termination (two required)	Impedance, 50 ohms; accuracy, ±2%; connectors, BNC.	X-Y phasing check and adjustment. Calibrator 1 kHz repetition rate adjustment. Trigger selector adjustments.	a. TEKTRONIX Part No. 011-0049-01.

TEST EQUIPMENT (cont)

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
18. Cable (two required)	Impedance, 50 ohms; type RG-58/U; length, 42 inches; connectors, BNC.	Used throughout procedure for signal interconnection. Two required for trigger selector adjustments.	a. TEKTRONIX Part No. 012-0057-01.
19. Cable	Impedance, 50 ohms; type, RG-58/U; length, 18 inches; connectors, BNC.	Used throughout procedure for signal interconnection.	a. TEKTRONIX Part No. 012-0076-00.
20. GR in-line termination	Impedance, 50 ohms; accuracy, ±2%; connectors, GR874 input with BNC male output.	External Z-axis check. X-Y phasing check and adjustment. Horizontal bandwidth check.	a. TEKTRONIX Part No. 017-0083-00.
21. Cable	Impedance, 50 ohms; type, RG-213/U; electrical length, five nanoseconds; connectors, GR874.	External Z-axis check. X-Y phasing check and adjustment. Horizontal bandwidth check. Vertical high-frequency compensation.	a. TEKTRONIX Part No. 017-0502-00.
22. Adapter	Connectors, GR874 and BNC male.	Vertical bandwidth check. Vertical amplifier isolation check.	a. TEKTRONIX Part No. 017-0064-00.
23. BNC post jack	Adapts BNC connector to clip post.	Calibrator output voltage adjustment. Calibrator 40 V risetime check.	a. TEKTRONIX Part No. 012-0092-00 (one supplied as standard accessory).
24. BNC to alligator clip adapter	Connectors, BNC female and two alligator clips.	Readout System adjustment.	a. TEKTRONIX Part No. 013-0076-00.
25. 10X passive probe	Compatible with 7A-series used in test oscilloscope. Combined risetime of vertical unit and probe must be less than two microseconds.	Calibrator 40 V risetime check.	a. TEKTRONIX P6053 Probe.
26. Screwdriver	Three-inch shaft, 3/32-inch bit.	Used throughout procedure to adjust variable resistors.	a. Xcelite R-3323.
27. Low-capacitance screwdriver	1 1/2-inch shaft.	Used throughout procedure to adjust variable capacitors.	a. TEKTRONIX Part No. 003-0000-00.
28. Nylon tuning tool	Fits 5/64-inch (ID) hex cores.	Vertical high-frequency compenstion.	a. Handle and insert, TEKTRONIX Part Nos. 003-0307-00 and 003-0310-00.
29. Screwdriver	Seven-inch shaft.	Trigger selector adjustments.	a. TEKTRONIX Part No. 003-0001-00.

CALIBRATION PROCEDURE

7904, Serial No. ______________________

Calibration Date ______________________

Calibrated by ______________________

Introduction

The following procedure returns the 7904 to correct calibration. All limits and tolerances given in this procedure are calibration guides, and should not be interpreted as instrument specifications except as listed as a Performance Requirement in the Operators manual.

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Preliminary Procedure for Calibration

NOTE

This instrument should be calibrated at an ambient temperature of 25°C ±5°C for best overall accuracy.

1. Remove the side covers from the 7904.

2. Connect the 7904 to a power source which meets the voltage and frequency requirements of this instrument. The applied voltage should be near the center of the voltage range selected by the Line Selector assembly (see Operators manual for information on converting this instrument from one operating voltage to another).

NOTE

If correct line voltage is not available, use a variable autotransformer to provide the correct input voltage.

3. Set the controls as given under Preliminary Control Settings. Allow at least 20 minutes warmup before proceeding.

NOTE

Titles for external controls of this instrument are capitalized in this procedure (e.g., A INTENSITY). Internal adjustments are initial capitalized only (e.g., Vertical Amplifier Gain).

Preliminary Control Settings

Set the 7904 controls as follows:

Display Controls

A INTENSITY	Midrange
FOCUS	Adjust for a well-defined display
B INTENSITY	Midrange
BEAM FINDER	In
READOUT	OFF
CONTROL ILLUM	LOW
GRAT ILLUM	Midrange
POWER	ON

Mode Selectors

VERTICAL MODE	LEFT
A TRIGGER SOURCE	VERT MODE
HORIZONTAL MODE	A
B TRIGGER SOURCE	VERT MODE
VERT TRACE SEPARATION (B)	Midrange

Calibrator

CALIBRATOR	4 V
RATE	1 kHz

POWER SUPPLY CALIBRATION

Equipment Required	
1. Precision DC voltmeter	2. Three-inch screwdriver

Control Settings

Set the controls as given under Preliminary Control Settings.

1. Adjust −50 Volt Power Supply

a. Change the following control settings:

POWER	Off
A INTENSITY	Counterclockwise
B INTENSITY	Counterclockwise
CONTROL ILLUM	OFF
GRAT ILLUM	Counterclockwise
RATE	OFF

b. Using the instructions given in the Maintenance Section, slide the power unit out of the rear of the 7904 and remove the power-unit cover (inter-connecting cables remain connected).

WARNING

Extreme caution must be used when operating the 7904 with the power-unit cover removed due to the line voltage and high voltage/high current potentials present. Refer to the Maintenance section for information on how to remove the protective cover/shield from the power unit.

c. Return the POWER switch to on.

d. Connect the precision DC voltmeter between TP −50 V and TP GND SENS on the Regulator circuit board (see Fig. 3-1A).

e. CHECK—Meter reading; −50 volts ±0.2 volt.

f. ADJUST— −50 Volts adjustment R1513 for a meter reading of −50 volts within 0.2 volt.

g. INTERACTION—Check steps 2 and 3. Any change in setting of R1513 may also affect operation of all circuits within the 7904.

2. Check Remaining Power-Supply Voltages

a. CHECK—Table 3-1 lists the low-voltage power supplies in this instrument. Check each supply with the precision DC voltmeter for output voltage within the given tolerance (connect meter ground lead to TP GND SENS). Power-supply test points are shown in Fig. 3-1A.

b. Disconnect the precision DC voltmeter.

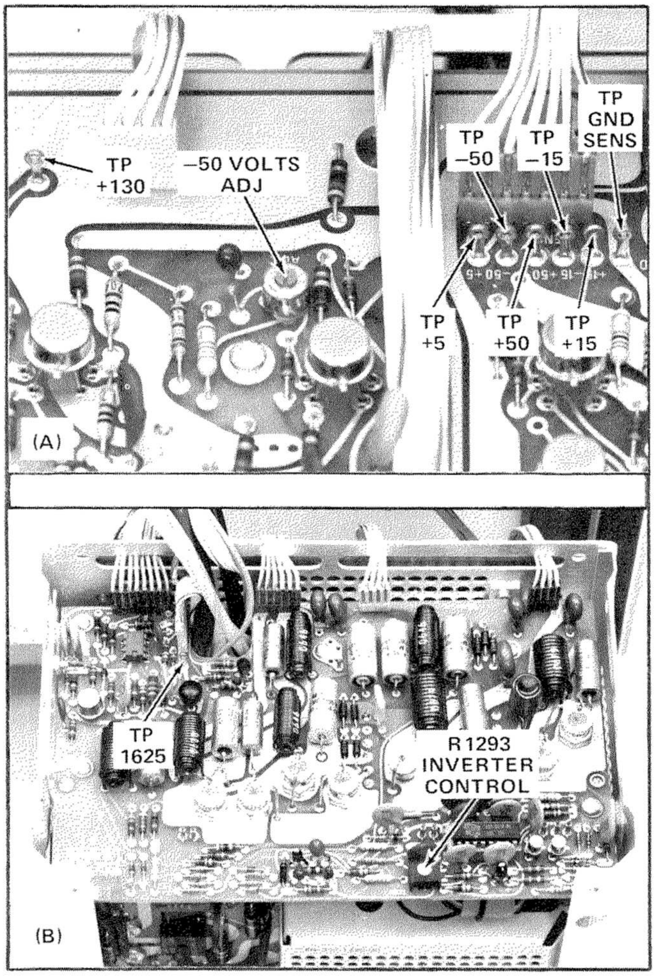

Fig. 3-1. (A) Location of low-voltage power supply test points and −50 Volts adjustment on Regulator board, (B) Location of Inverter Control adjustment and TP 1625 on Cap-Rectifier board.

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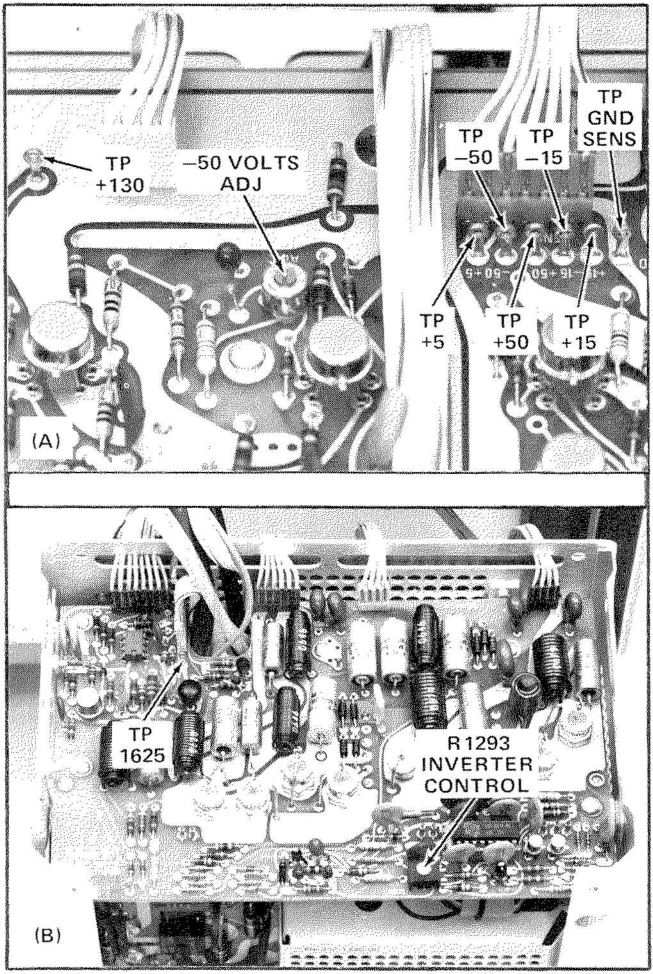


Fig. 3-1. (A) Location of low-voltage power supply test points and −50 Volts adjustment on Regulator board, (B) Location of Inverter Control adjustment and TP 1625 on Cap-Rectifier board.

NOTE

Ripple and regulation of the individual power supplies can be checked using the procedure given under Troubleshooting Techniques in Maintenance section.

TABLE 3-1

Power Supply Tolerance

Power Supply	Output Voltage Tolerance
−50 Volt	±0.20 volt
−15 Volt	±0.15 volt
+5 Volt	±0.10 volt
+15 Volt	±0.15 volt
+50 Volt	±0.50 volt
+130 Volt	±5.2 volts
Control Illum (+5 V Lights)	+0.2 to −0.5 volt

c. Connect the precision DC voltmeter between TP −2960 (see Fig. 3-2) and chassis ground.

d. CHECK—Meter reading −2960 ±14 volts.

3. Adjust Inverter Control

a. Connect the precision DC voltmeter between TP 1625 (Cap-Rectifier board; see Fig. 3-1B) and chassis ground.

b. CHECK—Meter reading; +40 volts ±5 volts. If the meter reading is within the given tolerance, proceed to part e of this step; otherwise, perform parts c, d, and e.

c. ADJUST—Inverter Control adjustment R1293 (Cap-Rectifier board; see Fig. 3-1B) for a meter reading of 40 volts ±5 volts.

d. INTERACTION—Check steps 1 and 2.

e. Set the POWER switch to off and disconnect all test equipment.

f. Replace the power-unit cover.

g. Install the power unit in the instrument and return the POWER switch to on.

Z-AXIS AND DISPLAY CALIBRATION

Equipment Required

1. Signal standardizer calibration fixture
2. 7B92 plug-in unit
3. 7B70 plug-in unit
4. DC voltmeter (VOM)
5. Test-oscilloscope system with 10X probe
6. 7A19 plug-in unit
7. Time-mark generator
8. Medium-frequency constant-amplitude signal generator
9. 18-inch 50-ohm BNC cable
10. 42-inch 50-ohm BNC cable
11. Five-nanosecond GR cable
12. BNC T connector
13. GR to BNC male adapter
14. Three-inch screwdriver
15. Low-capacitance screwdriver

Control Settings

Set the controls as given under Preliminary Control Settings.

Location of Adjustments and Test Points

The z-axis adjustments and test points are located on the Z-Axis board (right side of instrument). The location of the adjustments and test points for steps 4 and 5 is shown in Fig. 3-2; the remainder are shown in Fig. 3-3.

4. Adjust Z-Axis DC Levels

a. Install the 7A19 in the LEFT VERT compartment and the 7B92 in the A HORIZ compartment.

b. Set the 7B92 for a free-running sweep at a rate of 0.2 second/division. Vertically center the trace.

c. Set the A and B INTENSITY controls fully counterclockwise.

d. Connect the 10X probe to the input of the test oscilloscope. Check the probe compensation.

e. Set the test oscilloscope for a vertical deflection factor of 0.2 volt/division (two volts/division at probe tip) and a sweep rate of one millisecond/division.

f. Establish a ground reference for the test oscilloscope by either grounding the probe tip or setting the input coupling to ground. Then, position the test oscilloscope trace to the bottom horizontal line of the graticule. Do not change the test-oscilloscope position control after setting this ground reference.

g. Connect the probe tip to TP 1876; connect the probe ground to chassis ground with a short grounding strap.

h. CHECK—Test oscilloscope trace for DC level of +9 volts ±1 volt (five divisions within 0.5 division above ground reference level).

i. ADJUST—Z-Axis Amplifier Level adjustment R1817 for a DC level of exactly +9 volts (five divisions above ground reference level).

j. Connect the DC voltmeter (VOM) between TP 1778 and chassis ground.

k. CHECK—Meter reading; +123 volts ±3 volts.

l. ADJUST—Focus Amplifier Output Level adjustment R1757 for a meter reading of exactly +123 volts.

m. Set the A INTENSITY control for a DC level of exactly +14 volts (test oscilloscope trace seven

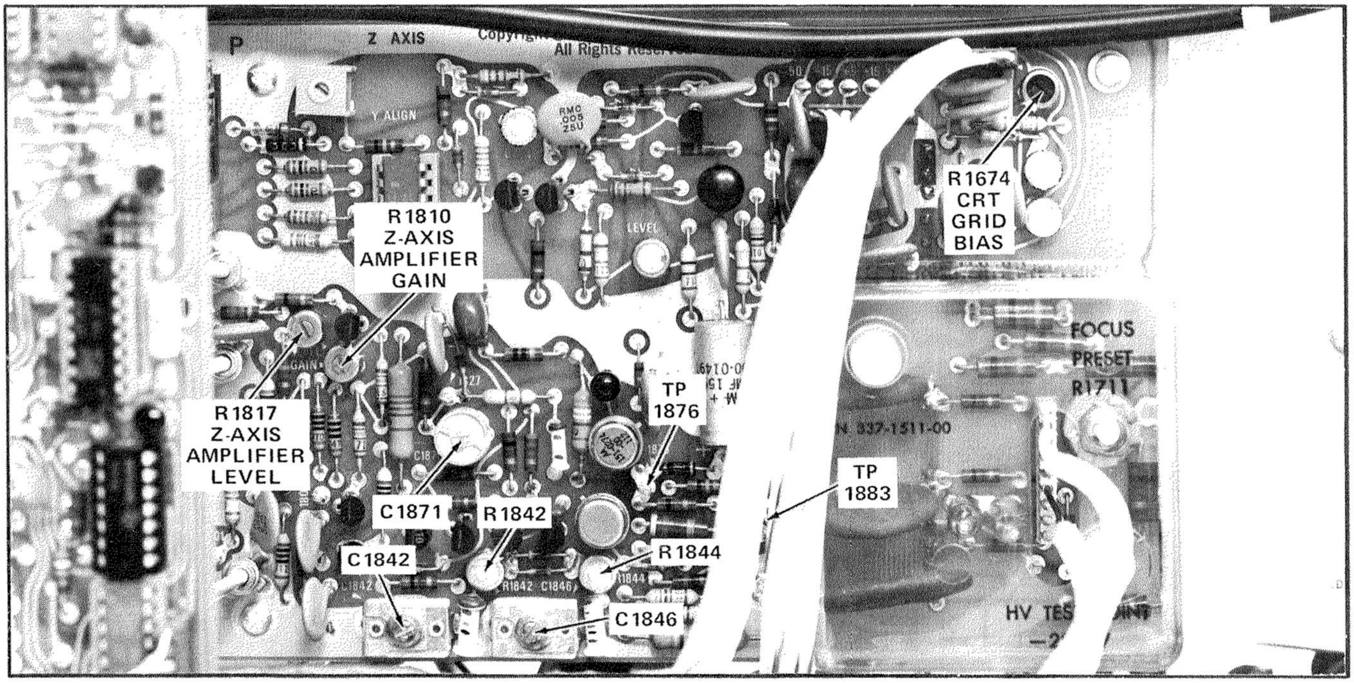


Fig. 3-2. Location of z-axis DC levels and transient response adjustments and test points.

divisions above ground reference level). Disregard the momentary DC level shift to the +9-volt level during sweep retrace.

n. ADJUST—CRT Grid Bias adjustment R1674 so the dot on the CRT screen is just extinguished.

o. Set the 7A19 Position control fully clockwise.

p. Set the test oscilloscope for a vertical deflection factor of one volt/division (ten volts/division at probe tip).

q. Set the A INTENSITY control fully clockwise.

r. CHECK—Test oscilloscope display for a pulse waveform with a peak amplitude of 74 volts ±3 volts above the ground reference level.

s. ADJUST—Z-Axis Amplifier Gain adjustment R1810 for a displayed waveform amplitude of 74 volts peak above the ground reference level.

t. Repeat parts b through p until no interaction is noted.

u. Repeat parts c, h, l, m, n, and o for B HORIZ.

v. Disconnect the probe.

5. Adjust Z-Axis Transient Response

a. Set the 7B92 for a sweep rate of 0.1 microsecond/division.

b. Connect the test oscilloscope 10X probe tip to TP 1883; connect the probe ground to the ground TP in the middle of the Z Axis board (Fig. 3-2).

c. Set the test oscilloscope for a vertical deflection factor of .1 volt/division (1 volt/division at probe tip) and a sweep rate of .05 microsecond/division.

d. Adjust the B INTENSITY control for five divisions of vertical deflection on the test oscilloscope. Position the display so the leading edge of the waveform is displayed.

e. CHECK—Test oscilloscope display for optimum square corner and flat top on displayed pulse. Aberrations must be ≤7% (.35 division).

f. ADJUST—C1871 for flat top and R1842, C1842, R1844, and C1846 for optimum square corner on displayed pulse (use low-capacitance screwdriver to adjust variable capacitors).

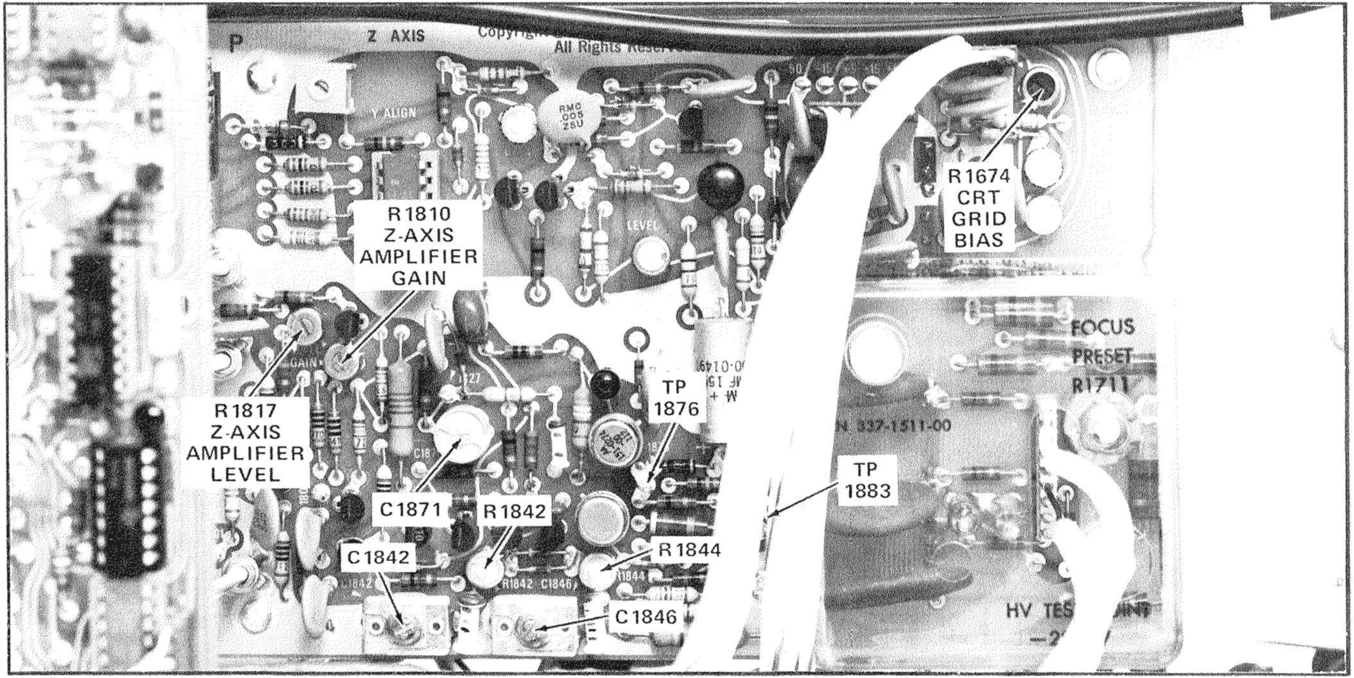


Fig. 3-2. Location of z-axis DC levels and transient response adjustments and test points.

g. CHECK—Position effect by adjusting B INTENSITY from maximum drive down to one division of displayed waveform on the test oscilloscope. Note any radical changes in the front corner.

h. ADJUST—R1842 and C1842 for optimum square corner at 1.5 divisions of displayed pulse.

i. ADJUST—R1844 and C1846 for optimum square corner at 5 divisions of displayed pulse.

j. Set the test oscilloscope sweep rate to 10 nanoseconds/division.

k. CHECK—The pulse risetime of approximately 10 nanoseconds (10% amplitude at 90% amplitude).

l. Disconnect the X10 probe.

m. Set the B INTENSITY control for a normal viewing level.

6. Shield Volts Preset

a. Change the VERTICAL MODE to RIGHT.

b. Connect the positive lead of the DC voltmeter to the lower lead of C1733 (see Fig. 3-3), on the Z Axis board.

c. CHECK—For a voltage reading of approximately 35.0 V.

d. ADJUST—Shield Volts adjustment R1733 for a voltage reading of 35.5 V.

7. CRT Trace Alignment Setup

a. Install a 7B70 in the RIGHT VERT compartment.

b. Install a 067-0587-01 Signal Standardizer in the A HORIZ compartment.

c. Set both 7B70 and 7B92 for 1 μs/div and EXT trigger.

d. Set the Signal Standardizer to VERT or HORIZ FREQ RESP, with REP RATE set to 100 kHz.

e. Set VERTICAL MODE to ALT and HORIZONTAL MODE to CHOP on the 7904.

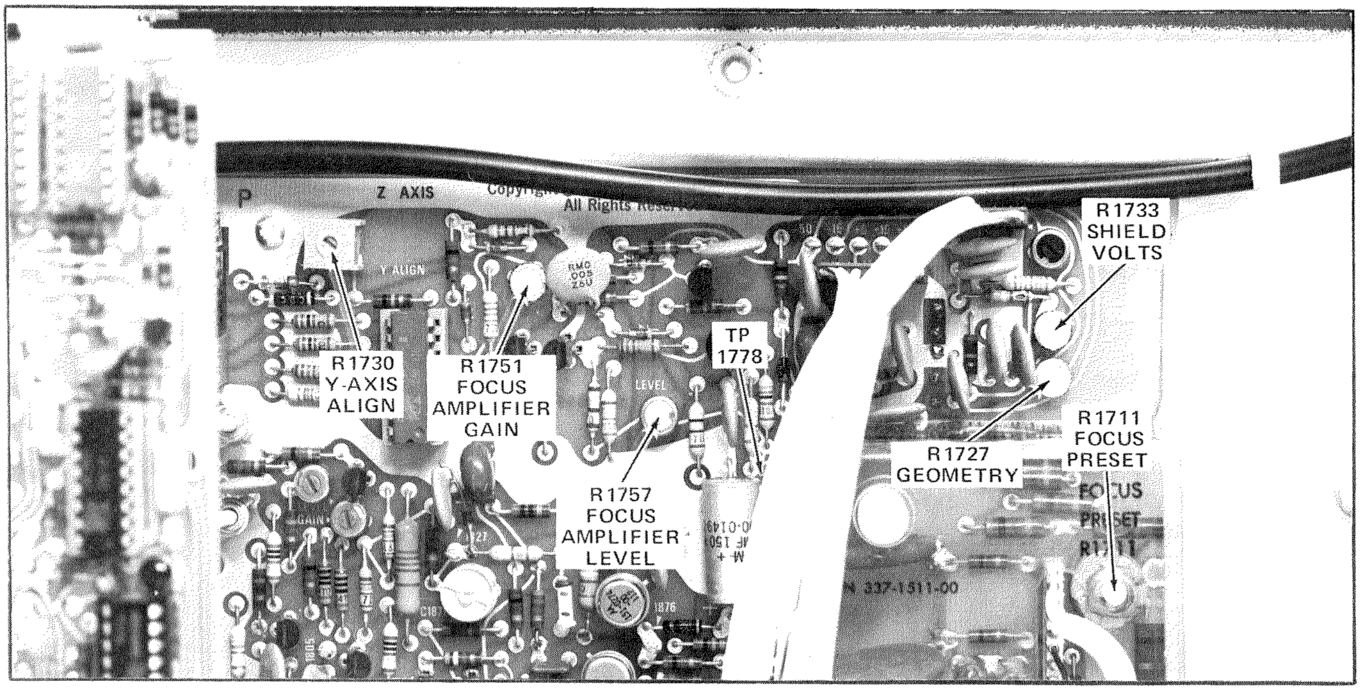


Fig. 3-3. Location of test points and adjustments for display calibration.

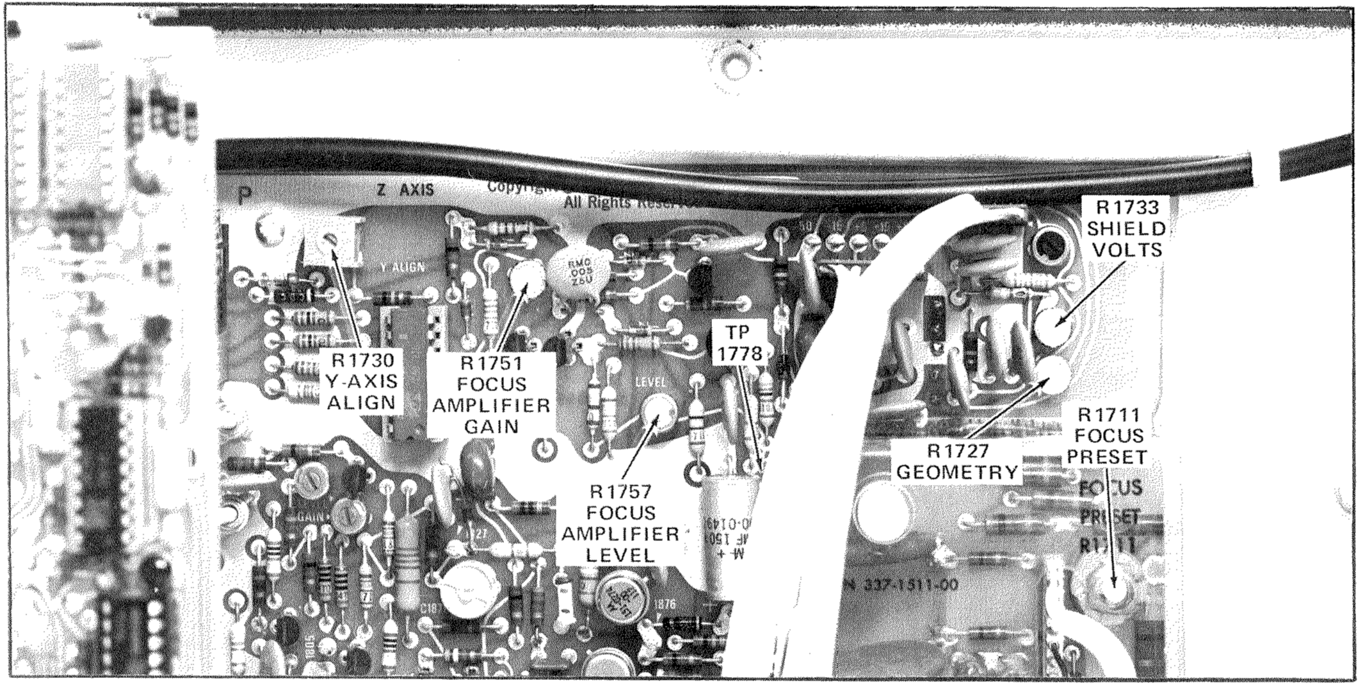


Fig. 3-3. Location of test points and adjustments for display calibration.

f. Connect the .4 V, 1 kHz from the CAL VOLTS connector to the 7A19 input.

g. Set the 7A19 INPUT switch to GND and the VOLTS/DIV switch to 50 mV.

h. Adjust the A and B INTENSITIES for equally bright vertical and horizontal traces.

i. Set the 7A19 POSITION control so the horizontal trace aligns with the center horizontal graticule line.

j. Set the Signal Standardizer POSITION control so the vertical trace aligns with the center vertical graticule line.

8. Adjust Trace Alignment

a. CHECK—The vertical trace aligns with the center vertical line within 0.1 division and the horizontal trace aligns with the center horizontal line within 0.1 division.

b. ADJUST—Front-panel TRACE ROTATION adjustment (horizontal adjustment) and Y Axis Align adjustment (vertical alignment) R1730 so the traces align with the vertical and horizontal center lines.

c. Set the 7A19 to DC and center the two horizontal traces with the POSITION control.

d. Set the 7A19 to DC and center the two horizontal traces with the POSITION control.

e. CHECK—Position the two horizontal traces over all horizontal graticule lines and check for alignment error of .1 division or less. Position the Signal Standardizer traces (vertical) over all vertical graticule lines and check for alignment error of .1 division or less.

9. Adjust Geometry

a. ADJUST—Geometry adjustment R1727 for minimum bowing of traces. Adjustment may have to be compromised to obtain less than .1 division bowing and tilt within the graticule area.

b. Set the front panel FOCUS control to midrange.

c. ADJUST—Focus preset adjustment R1711 (see Fig. 3-3), and front panel ASTIG adjustment for the best overall resolution.

d. Poor focus at one edge of the CRT may be compromised by adjusting the Shield Volts control R1733. If R1733 is re-adjusted, repeat part c of this step.

10. Adjust Auto-Focus Gain

a. Transpose the 7B70 and the 067-0587-01 Signal Standardizer.

b. Set the VERTICAL MODE to RIGHT and the HORIZONTAL MODE to A.

c. Set the Signal Standardizer to VERT or HORIZ +STEP RESP and the 7B70 to 2 ns/div INT.

d. Adjust the Signal Standardizer POSITION and AMPLITUDE control for a centered 4 division pulse as viewed on the 7904. Center the leading edge of the pulse to the middle of the CRT with the 7B70 POSITION control.

e. Increase the A intensity to maximum.

f. ADJUST—Focus Amplifier Gain adjustment R1751 for the sharpest and best defined pulse (do not touch front panel FOCUS and ASTIG controls).

g. Return A INTENSITY control to the normal viewing level.

h. Set the VERTICAL MODE to LEFT and the HORIZONTAL MODE to B.

i. Remove the BNC cable from the 7904 CAL VOLTS connector and connect it to the marker output of the Type 184 time-mark generator.

j. Connect a BNC cable between the trigger output of the Type 184 time-mark generator and the 7B92 MAIN TRIG IN.

k. Set the Type 184 marker and trigger outputs for .1 ms, the 7A19 VOLTS/DIV to .5 V and the 7B92 to .1 ms/div.

l. Adjust the 7B92 variable Time/Div control for 5 markers in 3 divisions.

m. CHECK—Set the 7B92 to 1 ms/div and check that the 17 markers/div can be defined over the entire graticule area.

n. CHECK—Transpose the 7B92 and the 7A19, being careful not to change the 7B92 variable control, and again check that the 17 markers/div can be defined over the entire graticule area.

o. Disconnect all cables and remove all plug-ins.

√11. Check External Z-Axis Operation

a. Connect the output of the medium-frequency constant-amplitude signal generator to the input of the 7A19 through the five-nanosecond GR cable, GR to BNC male adapter, and BNC T connector.

b. Set the 7A19 for a deflection factor of one volt/division.

c. Set the 7B70 for auto, internal triggering at a calibrated sweep rate of 10 microseconds/division.

d. Set the medium-frequency generator for a two-division display at its reference frequency (50 kilohertz).

e. Remove the cover from the Z-AXIS INPUT connector on the rear panel.

f. Connect the output of the BNC T connector to the Z-AXIS INPUT connector with the 42-inch 50-ohm BNC cable.

√g. CHECK—Top portion of displayed waveform blanked out.

h. Disconnect all test equipment and replace the cover on the Z-AXIS INPUT connector. Remove the plug-in units.

VERTICAL SYSTEM CALIBRATION

Equipment Required

1. 7B92 plug-in unit
2. Signal Standardizer calibration figure (067-0587-01)
3. High-frequency constant-amplitude signal generator
4. 7A19 plug-in unit
5. 7A15 plug-in unit
6. 7B70 plug-in unit
7. GR to BNC adapter
8. Pulse generator
9. 2X GR attenuator
10. 10X GR attenuator
11. Five-nanosecond GR cable
12. Three-inch screwdriver
13. Low-capacitance screwdriver
14. Nylon tuning tool

Control Settings

a. Install a 7B92 in the A HORIZ compartment.

b. Set the 7B92 for 2 ms/div, AUTO, AC, INT.

c. Install a 067-0587-01 Signal Standardizer in the RIGHT VERT compartment.

d. Set the Signal Standardizer to COM MODE and 100 kHz REP RATE.

e. Set the VERTICAL MODE to CHOP and the HORIZONTAL MODE to A.

12. Adjust Vertical Centering

a. CHECK—For no more than .5 divisions of separation between the two traces.

b. ADJUST—Vertical Centering adjustment R712 so that traces are no more than .4 division from graticule center in any VERTICAL MODE switch position.

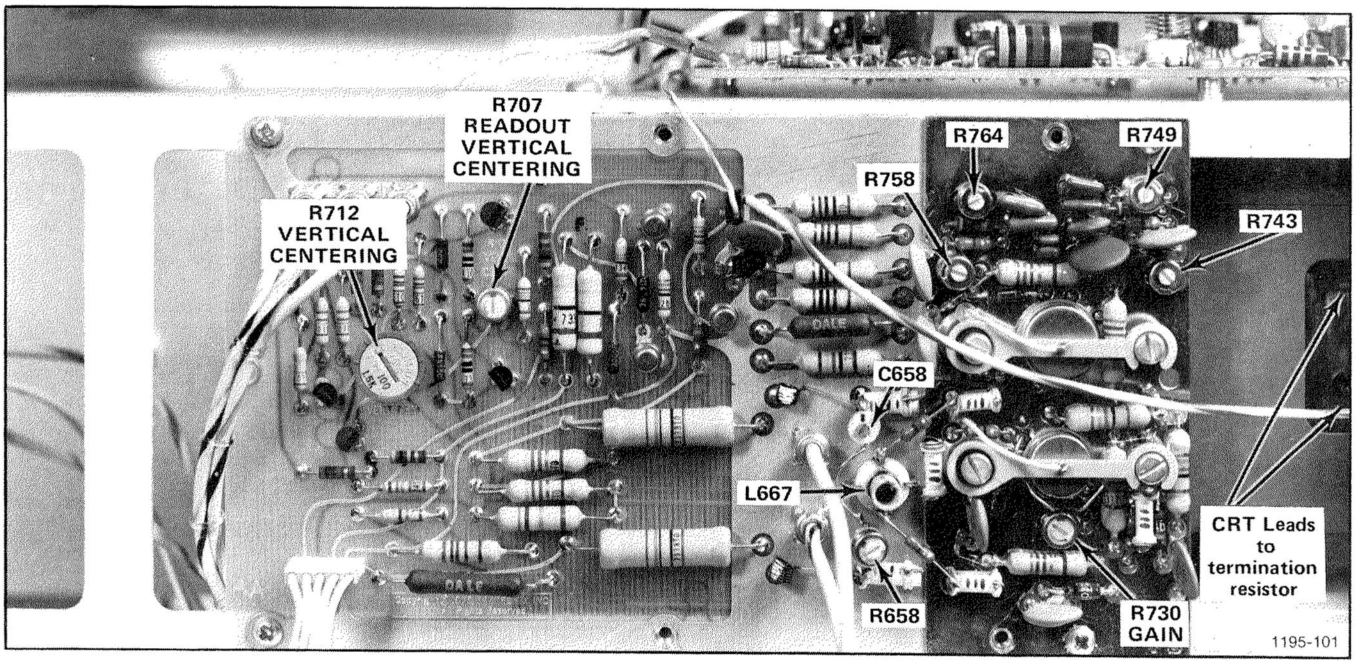


Fig. 3-4. Location of vertical system adjustments.

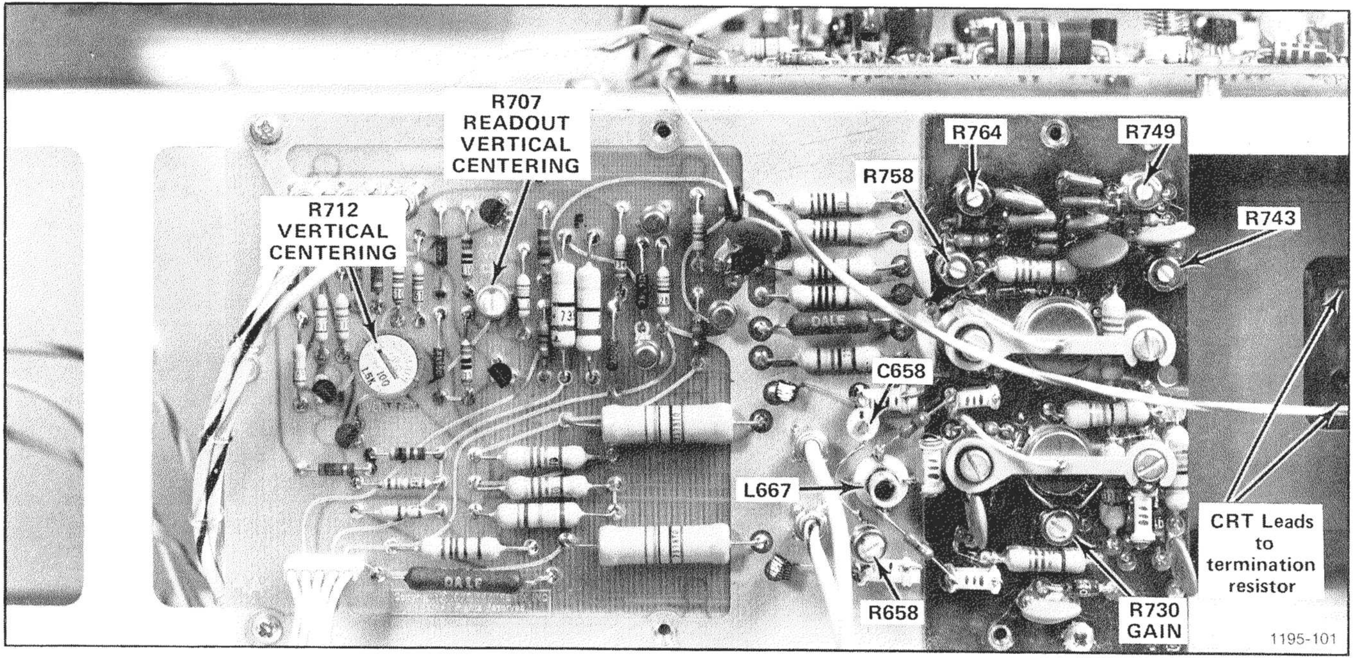


Fig. 3-4. Location of vertical system adjustments.

13. Adjust Vertical Amplifier Gain

a. Set VERTICAL MODE to RIGHT.

b. Set Signal Standardizer to VERT or HORIZ GAIN.

c. Position the display to align the bright center trace with the center horizontal line of the graticule.

d. CHECK—Deflection between the second and eighth traces should be six divisions ±.06 division.

e. ADJUST—Vertical Gain adjustment R730 for exactly six divisions of deflection between the second and eighth traces.

f. Remove the Signal Standardizer from the RIGHT VERT compartment and install it in the LEFT VERT compartment.

g. Set the VERTICAL MODE switch to LEFT.

h. CHECK—Deflection between the second and eighth traces should be six divisions ±.06 division.

i. ADJUST—If necessary, compromise the setting of R730 for optimum gain for both vertical compartments.

14. Check Low-Frequency Linearity

a. Set the Signal Standardizer to VERT or HORIZ +STEP RESP.

b. Set the Standardizer Amplitude control so the display is exactly two divisions in amplitude in the center of the graticule area.

c. CHECK—Position the two division display vertically and check for not more than 0.1 division of compression or expansion anywhere within the graticule area.

15. AUX Y AXIS

a. Set 7B92 to ALTERNATE SWEEP.

b. CHECK—That TRACE SEPARATION control on 7B92 moves the traces vertically ≈ four divisions.

NOTE

Step 16 for instruments with Readout only.

16. READOUT CENTERING — VERTICALLY

a. If the instrument is equipped with readout, turn the 7904 READOUT INTENSITY control clockwise until both displays (upper and lower) are visible.

b. CHECK—That readout characters are equally spaced above and below the center horizontal graticule line.

c. ADJUST—R707 for equal readout character spacing above and below the center horizontal graticule line.

17. Adjust Vertical Low-Frequency Compensation

a. Switch 7B92 out of ALTERNATE SWEEP.

b. Set Signal Standardizer to 100 Hz REP RATE and obtain a six division waveform.

c. CHECK—For optimum square corner and flat top on displayed pulse with aberrations not to exceed 1% (.06 division).

d. ADJUST—R764 and R749 for flat top within limits given in part c (SN B020000 & up).

e. Note how R749 affects readout characters. R749 must be adjusted for minimum vertical flutter of readout characters.

18. Adjust Vertical High-Frequency Compensation

a. CHECK—The following Signal Standardizer REP RATE positions for flat response.

Signal Standardizer	7B92	Spec.	
1 kHz	.2 ms	1%	.06 division
10 kHz	20 μs	1%	.06 division
100 kHz	2 μs	1%	.06 division

b. Set 7B92 to .2 μs/div and Signal Standardizer to 1 MHz REP RATE.

c. CHECK—Waveform for flat top within first 50 ns after leading edge.

d. ADJUST—R743 and R758 for a flat top in the first 50 ns of the waveform.

e. Set 7B92 to 20 ns/div.

f. CHECK—Delay line aberration ≈120 ns back of leading edge for ⩽2%.

g. Set 7B92 to 5 ns/div.

NOTE

The following front corner adjustments are extremely important, especially when new vertical ICs have been installed. Late production ICs have more overshoot on the leading edge of the transient response.

h. CHECK—The first 10 ns of the waveform for ⩽5% aberrations.

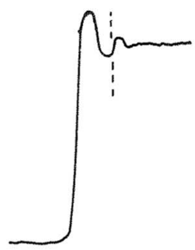
i. ADJUST—CRT termination leads for smoothest response ≈5 ns back of front corner.

j. ADJUST—L667 for best response in the 2—5 ns region back of front corner.

k. ADJUST—R658 and C658 to obtain the least aberration in the region **immediately following** the initial overshoot and undershoot.

l. If the waveform now has a large overshoot easily exceeding the 5% spec., remove the vertical board and check for presence of R736 and C736. Selectable components R736 and C736 may be added in series between pins 5 and 11 of U745 (bottom of board). Nominal 1.5 pF and 100 Ω:

1.5 pF — 283-0160-00
100 Ω — 317-0101-00



m. ADJUST—Repeat step k.

n. CHECK—Repeat step h.

o. Other possible waveform errors may be corrected by:

Rolloff or rise of first 3 nanoseconds may be corrected by changing length of L657 and L659 (bottom of board).

1. Short to raise corner.
2. Long to lower corner.

First nanosecond of waveform too positive or negative may be corrected by changing length of L730 and L731.

1. Long to raise corner.
2. Short to lower corner.

p. ADJUST—Repeat step k.

q. CHECK—Repeat step h.

r. Remove Signal Standardizer from LEFT VERT and install in RIGHT VERT compartment.

s. Set VERTICAL MODE to RIGHT.

t. Repeat steps 18a, 18g, and 18h.

NOTE

For optimum high-frequency performance, install the 7A19 normally used with the 7904 being calibrated.

u. Set the 7A19 for a vertical deflection factor of 20 millivolts/division with DC input coupling.

v. Connect the pulse generator output to the 7A19 with the 5 ns GR cable, 2X GR attenuator, and GR to BNC female adapter.

w. Set the 7B92 sweep rate to display several cycles of the pulse and note the peak-to-peak pulse amplitude. Vertically center the display.

x. Set the 7B92 for a sweep rate of 5 ns/div. Set the trigger controls for a stable display, triggered on the positive slope.

y. CHECK—Check for optimum square corner and flat top on displayed pulse. Aberrations should not exceed 7% of the pulse amplitude noted in part k. (For example: If the pulse amplitude noted in part k is 6 divisions, the aberrations should not exceed +0.42 or −0.42 division with total peak-to-peak aberrations 0.42 division or less.) Check in INVERT position for ⩽.54 divisions of aberrations.

z. ADJUST—R658—C658 may be adjusted for best waveform.

aa. Remove the 7A19 from the RIGHT VERT compartment and install it in the LEFT VERT compartment (leave signal connected).

ab. Set the VERTICAL MODE switch to LEFT.

ac. CHECK—Check for optimum square corner and flat top on displayed pulse. Aberrations should not exceed 7% of the pulse amplitude noted in part k. (For example: If the pulse amplitude noted in part k is 6 divisions, the aberrations should not exceed +0.42 or −0.42 division with total peak-to-peak aberrations 0.42 division or less.) Check for ⩽.54 division in the INVERT position.

ad. ADJUST—If necessary, compromise C658—R658 for optimum pulse response for both vertical compartments.

ae. Disconnect all test equipment.

af. INTERACTION—Check step 16.

√19. Check Vertical Amplifier Bandwidth

a. Connect the high-frequency constant-amplitude signal generator to the 7A19 with the 10X GR attenuator and GR to BNC male adapter.

b. Set the 7B92 for a free-running sweep at a sweep rate of 50 μs/div and the 7A19 to 10 mV/div.

c. Set the high-frequency generator for six divisions of deflection, centered on the graticule, at its reference frequency.

d. Without changing the output amplitude, increase the output frequency of the high-frequency generator until the display is reduced to 4.2 divisions (−3 dB point).

√e. CHECK—Output frequency must be 500 MHz or higher (400 MHz if checked outside the +20° C to +30° C temperature range). Actual frequency (LEFT VERT)____MHz.

f. Remove the 7A19 from the LEFT VERT compartment and install it in the RIGHT VERT compartment (leave signal connected).

g. Set the VERTICAL MODE switch to RIGHT.

√h. Repeat parts c through e. Actual frequency (RIGHT VERT)____MHz.

√19A. Check Vertical Channel Isolation

a. Set the high-frequency generator for eight divisions of deflection at 500 MHz.

b. Set the VERTICAL MODE switch to LEFT.

√c. CHECK—CRT display for not more than 0.2 division of signal (channel isolation at least 40:1 to 500 MHz) while changing the signal generator from 250—500 MHz.

d. Set the VERTICAL MODE switch to RIGHT.

e. Set the high-frequency generator for eight divisions of deflection at 250 MHz.

f. Set the VERTICAL MODE switch to LEFT.

g. √g. CHECK—CRT display for not more than 0.1 division of signal (channel isolation at least 100:1 to 250 MHz) while changing the signal generator from its lower limit to 250 MHz.

h. Remove the 7A19 from the RIGHT VERT compartment and install it in the LEFT VERT compartment (leave signal connected).

i. Set the high-frequency generator for eight divisions of deflection at 250 MHz.

j. Set the VERTICAL MODE switch to RIGHT.

√k. CHECK—CRT display for not more than 0.1 division of signal (channel isolation at least 100:1 to 250 MHz) while changing the signal generator from its lower limit to 250 MHz.

l. Set the VERTICAL MODE switch to LEFT.

m. Set the high-frequency generator for eight divisions of deflection at 500 MHz.

n. Set the VERTICAL MODE switch to RIGHT.

√o. CHECK—CRT display for not more than 0.2 division of signal (channel isolation at least 40:1 to 500 MHz) while changing the signal generator from 250—500 MHz.

p. Disconnect all test equipment.

√19B. Check Vertical Display Modes

a. Position the trace to the upper half of the graticule area with the 7A19 Position control.

b. Install the 7A15 in the RIGHT VERT compartment.

c. Position the trace to the lower half of the graticule area with the 7A15 Position control.

√d. CHECK—CRT display for two traces in the ALT and CHOP positions of the VERTICAL MODE switch.

e. Set the VERTICAL MODE switch to ADD.

√f. CHECK—CRT display for a single trace which can be positioned vertically with either vertical unit position control.

TRIGGER SYSTEM CALIBRATION

Equipment Required

1. Signal standardizer calibration fixture
2. 7B92 plug-in unit
3. 7B70 plug-in unit
4. 7A15 plug-in unit
5. Plug-in extender calibration fixture
6. Test-oscilloscope system (dual trace)
7. 42-inch 50-ohm BNC cable (two required)
8. 18-inch 50-ohm BNC cable
9. 50-ohm BNC termination (two required)
10. Three-inch screwdriver
11. Seven-inch screwdriver

NOTE

Install a 7B70 plug-in unit in B HORIZ compartment. If instrument has AUX triggers, the gain should decrease by 5%.

Control Settings

Set the controls as given under Preliminary Control Settings.

Location of Adjustments

The trigger system adjustments are located on the A and B Trigger Selector boards (on front of Main Interface board). The location of these adjustments is shown in Fig. 3-5.

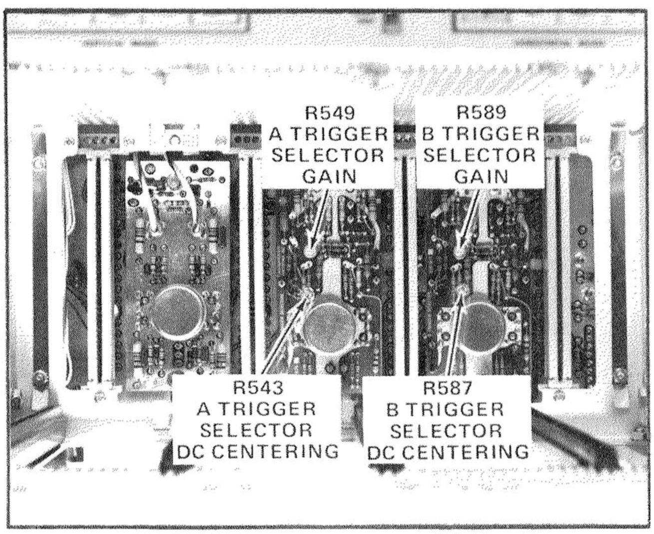


Fig. 3-5. Location of trigger system adjustments (A and B Trigger Selector boards).

20. Adjust A Trigger Selector DC Centering and Gain

a. Within the plug-in extender, disconnect the top connector on the left and right sides (labeled A20 and B20). Connect each female connector to one of the test oscilloscope channels with the 42-inch 50-ohm BNC cable and 50-ohm BNC termination.

b. Install the plug-in extender in the A HORIZ compartment.

c. Set both channels of the test oscilloscope for a deflection factor of 50 millivolts/division with the inputs grounded.

d. Set the test oscilloscope for differential operation between the two channels (added display mode with one channel inverted) at a sweep rate of 2 milliseconds/division.

e. Establish a ground reference level for the test oscilloscope by positioning the trace to the center horizontal line of the graticule. Do not change the test oscilloscope position controls after setting this ground reference.

f. Set both channels of the test oscilloscope for DC input coupling.

g. CHECK—Check the test oscilloscope display for a DC level within 0.5 division (25 millivolts) of the ground reference level in the LEFT, RIGHT, and ADD positions of the VERTICAL MODE switch.

h. ADJUST—A Trigger Selector DC Centering adjustment R543 for a display DC level within 0.5 division (25 millivolts) of ground reference level in the LEFT, RIGHT, and ADD positions of the VERTICAL MODE switch.

i. Install the signal standardizer calibration fixture in the LEFT VERT compartment.

j. Set the VERTICAL MODE switch to LEFT.

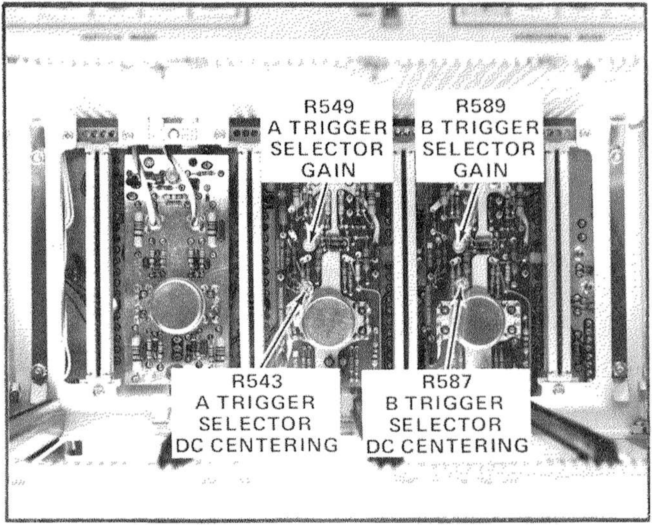


Fig. 3-5. Location of trigger system adjustments (A and B Trigger Selector boards).

k. Set the calibration fixture Test switch to Triggering Gain.

l. CHECK—Test oscilloscope display for nine traces with the deflection between the second and eighth traces of six divisions ±0.9 division (300 millivolts within 45 millivolts).

m. ADJUST—A Trigger Selector Gain adjustment R549 for a test oscilloscope display of nine traces with the deflection between the second and eighth traces of six divisions ±0.9 division (300 millivolts within 45 millivolts).

n. Remove Signal Standardizer from LEFT VERT compartment and install in RIGHT VERT compartment.

o. Set VERTICAL MODE to RIGHT.

p. CHECK—Repeat step m.

q. ADJUST—If necessary, compromise the setting of R549.

21. Adjust B Trigger Selector DC Centering and Gain

a. Remove 7B70 from RIGHT HORIZ compartment and install plug-in extender.

b. Set Signal Standardizer to COM MODE.

c. CHECK—Test scope display for a DC level within 0.5 div (25 mV) of the ground reference level in the LEFT, RIGHT, and ADD positions of the VERTICAL MODE switch.

d. ADJUST—B trigger selector DC Centering adjustment R587 for a display DC level within .5 div (25 mV) of ground reference level in the LEFT, RIGHT, and ADD positions of the VERTICAL MODE switch.

e. Set the Signal Standardizer to Triggering Gain.

f. Install the 7B70 in the LEFT HORIZ compartment and note a 5% decrease in gain if 7904 has AUX trigger.

g. CHECK—Test scope display for nine traces with a deflection between the second and eighth traces of 6 divisions ±.3 div (300 mV within 15 mV).

h. ADJUST—B Trigger Selector Gain Adjustment R589 is not accessible with the 7B70 in the LEFT HORIZ compartment. Remove the 7B70 and adjust R589 for nine traces with a deflection between the second and eighth traces of:

6.3 divisions ±.3 div — 7904 with AUX Trigger

6.0 divisions ±.3 div — 7904 without AUX Trigger

i. Remove the Signal Standardizer from the RIGHT VERT compartment and install in the LEFT VERT compartment.

j. Set the VERTICAL MODE switch to LEFT.

k. CHECK—Gain display for tolerances given in step h.

l. ADJUST—If necessary, compromise the setting of R589.

m. Remove the plug-in extender from the 7904.

√22. Check Trigger Selector Operation

a. Install the 7A15, 7B92, and 7B70 in the RIGHT VERT, A HORIZ, and B HORIZ compartments respectively.

b. Set the 7A15 for a deflection factor of two volts/division.

c. Set both time-base units for auto, internal triggering at a sweep rate of 0.2 millisecond/division.

d. Set the signal standardizer calibration fixture Test switch to Vert or Horiz +Step Resp and the Rep Rate switch to 10 kHz. Set the Amplitude control for a two-division display. Position the display in the upper half of the graticule area.

e. Set the VERTICAL MODE switch to RIGHT.

f. Connect the CAL VOLTS connector to the 7A15 with the 18-inch 50-ohm BNC cable.

g. Position the 7A15 display in the lower half of the graticule area.

h. Set the VERTICAL MODE switch to ALT.

√i. CHECK—Alternate display for the sweep triggered on both the 1 kHz and 10 kHz waveforms. Check that all three A TRIGGER SOURCE switch pushbuttons are illuminated.

j. Set the VERTICAL MODE switch to ADD.

√k. CHECK—CRT display for triggered sweep. Check that all three A TRIGGER SOURCE switch pushbuttons are illuminated.

l. Set the VERTICAL MODE switch to CHOP.

√m. CHECK—CRT display for the sweep triggered on the 10 kHz waveform only. Check that the VERT MODE and LEFT VERT pushbuttons of the A TRIGGER SOURCE switch are illuminated.

n. Set the A TRIGGER SOURCE switch to LEFT VERT.

√o. CHECK—Sequentially press each VERTICAL MODE switch pushbutton and check that a stable display of only the 10 kHz waveform can be obtained. Check that the LEFT VERT pushbutton only of the A TRIGGER SOURCE switch is illuminated.

p. Set the A TRIGGER SOURCE switch to RIGHT VERT.

√q. CHECK—Sequentially press each VERTICAL MODE switch pushbutton and check that a stable display of only the 10 kHz waveform can be obtained. Check that the LEFT VERT pushbutton only of the A TRIGGER SOURCE switch is illuminated.

r. Change the following control settings:

VERTICAL MODE	ALT
HORIZONTAL MODE	B
A TRIGGER SOURCE	VERT MODE

√s. CHECK—Alternate display for the sweep triggered on both the 1 kHz and 10 kHz waveforms. Check that all three B TRIGGER SOURCE switch pushbuttons are illuminated.

t. Set the VERTICAL MODE switch to ADD.

√u. CHECK—CRT display for triggered sweep. Check that all three B TRIGGER SOURCE switch pushbuttons are illuminated.

v. Set the VERTICAL MODE switch to CHOP.

√w. CHECK—CRT display for the sweep triggered on the 10 kHz waveform only. Check that the VERT MODE and LEFT VERT pushbuttons of the B TRIGGER SOURCE switch are illuminated.

x. Set the B TRIGGER SOURCE switch to LEFT VERT.

√y. CHECK—Sequentially press each VERTICAL MODE switch pushbutton and check that a stable display of only the 10 kHz waveform can be obtained. Check that the LEFT VERT pushbutton only of the B TRIGGER SOURCE switch is illuminated.

z. Set the B TRIGGER SOURCE switch to RIGHT VERT.

√aa. CHECK—Sequentially press each VERTICAL MODE switch pushbutton and check that a stable display of only the 1 kHz waveform can be obtained. Check that the RIGHT VERT pushbutton only of the B TRIGGER SOURCE switch is illuminated.

ab. Change the following control settings:

VERTICAL MODE	ALT
HORIZONTAL MODE	ALT
B TRIGGER SOURCE	VERT MODE

√ac. CHECK—CRT display. The 7B92 should be triggered on the 1 kHz waveform; the A TRIGGER SOURCE switch VERT MODE and RIGHT VERT push-buttons should be illuminated. The 7B70 should be triggered on the 10 kHz waveform; the B TRIGGER SOURCE switch VERT MODE and LEFT VERT push-buttons should be illuminated.

ad. Switch to CHOP. Repeat part ac.

ae. Disconnect all test equipment and remove the plug-in units.

HORIZONTAL SYSTEM CALIBRATION

Equipment Required

1. 7A19 plug-in unit
2. 7B92 plug-in unit
3. 7B70 plug-in unit
4. 7A15 plug-in unit (two required)
5. Signal standardizer calibration fixture
6. Time-mark generator
7. Test-oscilloscope system with two 10X probes
8. Low-frequency signal generator
9. Medium-frequency constant-amplitude signal generator
10. 42-inch 50-ohm BNC cable
11. 18-inch 50-ohm BNC cable
12. Five-nanosecond GR cable
13. 50-ohm BNC termination
14. BNC T connector
15. 50-ohm GR in-line termination
16. Three-inch screwdriver
17. Low-capacitance screwdriver

Control Settings

Set the controls as given under Preliminary Control Settings.

Location of Adjustments

The horizontal system adjustments (except X-Y delay compensation adjustments) are located on the Main Horizontal Amplifier board (top of instrument). These adjustments are shown in Fig. 3-6.

23. Adjust Horizontal Amplifier Centering (For Instrument SNB080000 and Above)

a. Install the 7B92 in the LEFT VERT compartment and the signal standardizer calibration fixture in the B HORIZ compartment.

compartment.

b. Set the Test switch on the calibration fixture to Triggering Gain.

c. Set the 7B92 for auto, internal triggering at a sweep rate of five microseconds/division.

d. CHECK—Vertical trace should align with the vertical center line of the graticule within 0.5 division. Check also with the HORIZONTAL MODE switch in the CHOP position.

e. ADJUST—Display Center adjustment R871 to position the trace to the vertical center line. If necessary, adjust for best compromise in the B and CHOP positions of the HORIZONTAL MODE switch.

23. Adjust Horizontal Amplifier Thermal Balance (For Instrument SNB080000 and Below)

a. Install the 7B70 in the B HORIZ compartment and the 7B92 in the A HORIZ compartment.

b. Install the 7A19 in the LEFT VERT compartment.

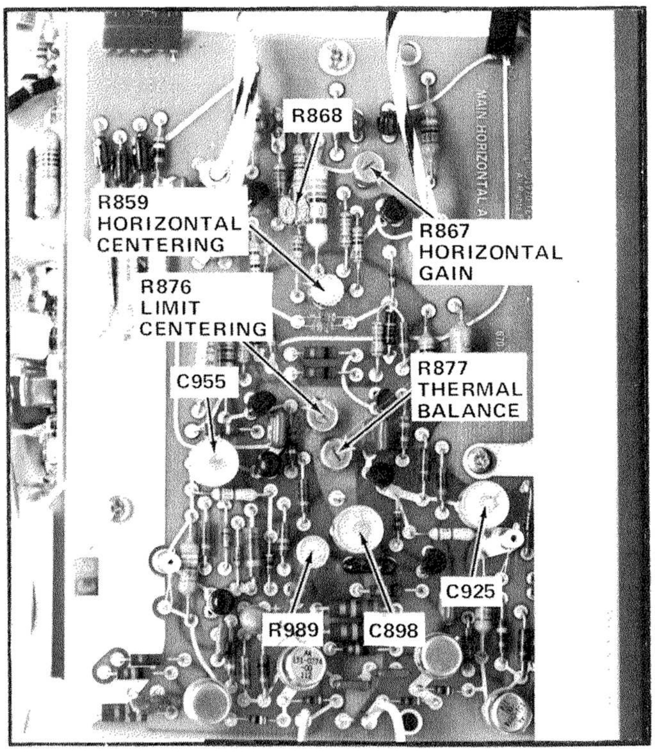


Fig. 3-6. Location of horizontal system adjustments on Main Horizontal Amplifier board.

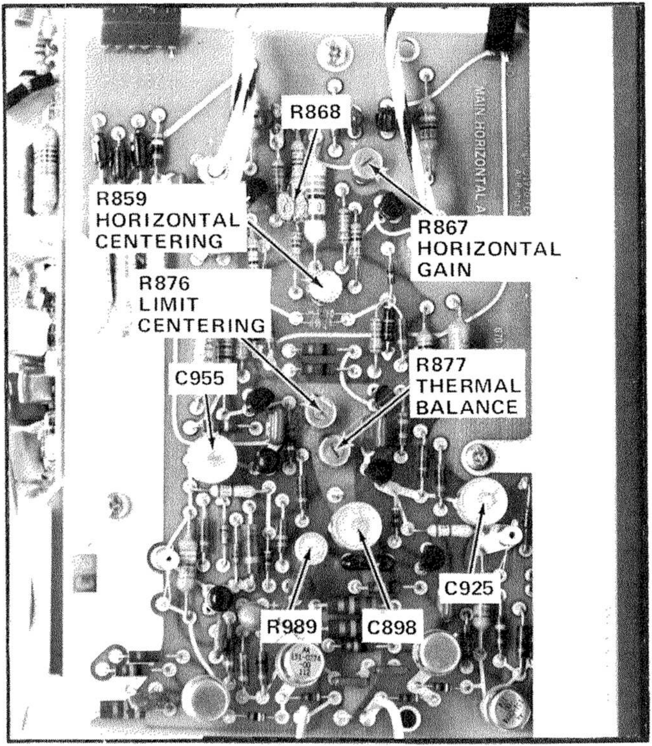


Fig. 3-6. Location of horizontal system adjustments on Main Horizontal Amplifier board.

c. Set the HORIZONTAL MODE switch to CHOP.

d. Set the 7B70 for auto, internal triggering at a sweep rate of five milliseconds/division with the magnifier on.

e. Set the 7B92 for auto, internal triggering at a sweep rate of five microseconds/division.

f. Connect the marker output of the time-mark generator to the input of the 7A19 with the 42-inch 50-ohm BNC cable.

g. Set the time-mark generator for five-microsecond markers. Set the deflection factor of the 7A19 so the markers are at least two divisions in amplitude.

h. Set the 7B92 for a stable, triggered display; set the 7B70 for free-running operation.

i. Position the start of the sweep produced by the 7B92 to the center vertical line.

j. CHECK—Not more than 0.1 division movement of the displayed markers. If this instrument contains a Readout System, set the READOUT intensity control for visible characters; check that the displayed characters do not move more than 0.1 division.

k. ADJUST—Thermal Balance adjustment R877 for minimum movement of the displayed markers or readout characters.

l. Remove the time-base plug-in units. Install the 7B70 in the A HORIZ compartment and the 7B92 in the B HORIZ compartment.

m. Position the start of the sweep produced by the 7B92 to the center vertical line.

n. CHECK—Not more than 0.1 division movement of the displayed markers. If this instrument contains a Readout System, set the READOUT intensity control for visible characters; check that the displayed characters do not move more than 0.1 division.

o. ADJUST—If necessary, compromise the setting of R877 for minimum movement of the displayed markers or readout characters in both checks j and n. If re-adjustment is necessary, recheck parts d through n.

p. INTERACTION—If R877 is adjusted, check steps 24 and 26.

q. Set the READOUT intensity control to OFF and disconnect all test equipment.

√ 24. Adjust Horizontal Gain and Check Low-Frequency Linearity (For Instrument SNB080000 and Above)

a. Set the calibration-fixture Test switch to Vert or Horiz Gain.

b. Set the HORIZONTAL MODE switch to B.

c. Position the display to align the bright center trace with the center vertical line of the graticule.

d. CHECK—Deflection between the second and tenth traces is eight divisions ±0.08 division. Note the exact deflection for step 24i.

e. ADJUST—Gain adjustment R875 for exactly eight divisions of deflection between the second and tenth traces.

√ f. CHECK—With the gain set exactly, all eleven vertical traces align with their respective graticule lines within 0.05 division.

g. Move the calibration fixture from the B HORIZ compartment to the A HORIZ compartment.

h. Set the HORIZONTAL MODE switch to A.

√ i. CHECK—Deflection between the second and tenth traces is the same as in step 24d ±1% (eight divisions ±0.08 division, if R875 was adjusted in step 24e).

j. ADJUST—If necessary, compromise the setting of R875 for optimum gain for both horizontal compartments. If re-adjustment is necessary, recheck steps 24b through i.

24. Adjust Horizontal Amplifier Centering (For Instrument SNB080000 and Below)

a. Remove both time-base units from the horizontal compartments. Install the 7B92 in the RIGHT VERT compartment.

b. Install the signal standardizer calibration fixture in the A HORIZ compartment.

c. Change the following control settings:

VERTICAL MODE	RIGHT
HORIZONTAL MODE	A

d. Set the Test switch on the calibration fixture to Triggering Gain.

e. CHECK—Vertical trace produced by 7B92 should align with the vertical center line of the graticule within 0.5 division. Check also with the HORIZONTAL MODE switch in the CHOP position.

f. ADJUST—Horizontal Centering adjustment R859 to position the trace to the vertical center line. If necessary, adjust for best compromise in the A and CHOP positions of the HORIZONTAL MODE switch.

g. INTERACTION—If R859 is adjusted, check steps 23 and 26.

25. Adjust Readout Centering (For Instrument SNB080000 and Above and Omit For Instrument with Option 1)

a. Remove all plug-in units.

b. Set the POWER switch to off. Remove Q2225 from its socket on the Readout board (see Fig. 3-10B). Return the POWER switch to on.

c. Set the READOUT control for visible characters (all zeros).

d. CHECK—CRT display for two rows of zeros, centered horizontally in the CRT viewing area (see Fig. 3-10A).

e. ADJUST—Readout Center adjustment R857 to horizontally center the readout display.

f. Set the POWER switch to off and replace Q2225 in its socket; return the POWER switch to on.

√ 25. Adjust Horizontal Gain and Low Frequency Linearity (For Instrument SNB080000 and Below)

a. Set the Test switch on the signal standardizer calibration fixture to Vert or Horiz Gain.

b. Set the HORIZONTAL MODE switch to A.

c. Position the display to align the bright center trace with the center vertical line of the graticule.

d. CHECK—Deflection between the second and tenth traces is eight divisions ±0.08 division. Note the exact deflection for step 25i.

e. ADJUST—Horizontal Gain adjustment R867 for exactly eight divisions of deflection between the second and tenth traces.

√f. CHECK—With gain set exactly, all eleven vertical traces align with their respective graticule lines within 0.05 division.

g. Move the calibration fixture from the A HORIZ compartment to the B HORIZ compartment.

h. Set the HORIZONTAL MODE switch to B.

√i. CHECK—Deflection between the second and tenth traces is the same as in part d ±1% (eight divisions ±0.08 division, if R867 was adjusted in part e).

j. ADJUST—If necessary, compromise the setting of R867 for optimum gain for both horizontal compartments. If re-adjustment is necessary, recheck parts b through i.

√ 26A. Adjust High-Frequency Timing (For Instruments SNB080000 and Below)

a. Install the 7B92 in the B HORIZ compartment and the 7A19 in the LEFT VERT compartment.

NOTE

For optimum performance at fast sweep rates, install the 7B92 normally used with the 7904 being calibrated.

b. Set the HORIZONTAL MODE switch to B.

c. Set the 7B92 for auto, internal triggering at a sweep rate of one millisecond/division.

d. Connect the time-mark generator to the 7A19 with the 42-inch 50-ohm BNC cable.

e. Set the time-mark generator for one-millisecond markers. Set the deflection factor of the 7A19 so the markers are at least two divisions in amplitude.

f. Position the first marker to the farthest left line of the graticule.

g. Set the 7B92 sweep-calibration adjustment for one marker each major graticule division between the second and tenth lines (center eight divisions).

NOTE

Steps 26Ah and 26Ai check and adjust the 7904/7B92 high-frequency timing. If the timing is within, or can be adjusted within the given tolerances, omit step 26B and proceed to step 27. If the timing cannot be adjusted within the given tolerances, proceed to step 26B then repeat step 26A. If the tolerances still cannot be met, adjust the 7B92 High-Frequency Linearity and Timing as given in the 7B92 Service Manual.

√h. CHECK—Refer to the 7B92 Service Manual for checking high-frequency timing and linearity. Use the procedures and limits given for checking the four fastest sweep rates. If the given limits are met, omit the remainder of this step.

i. ADJUST—7B92 high-frequency timing and linearity for the four fastest sweep rates according to the procedure given in the 7B92 Service Manual.

j. Disconnect all test equipment and remove the plug-in units.

26B. Adjust Horizontal Amplifier High-Frequency Compensation (For Instrument SNB080000 and Above)

a. Install the 7B92 in the LEFT VERT compartment and the signal standardizer calibration fixture in the B HORIZ compartment.

b. Set the calibration-fixture Test switch to Vert or Horiz +Step Resp, and the Rep Rate switch to 1 MHz.

c. Set the 7B92 for auto, external triggering on the negative slope at a sweep rate of 200 nanoseconds/division.

d. Connect the calibration-fixture Trigger output to the 7B92 external trigger input with the 18-inch 50-ohm BNC cable.

e. Set the calibration-fixture Amplitude control for a three-division display. Horizontally center the display.

f. CHECK—CRT display for optimum square corner and flat top on displayed pulse. See Fig. 3-7 for typical response waveform. Check the leading edge of the pulse (circled portion of pulse shown in Fig. 3-7) for aberrations not to exceed +0.45 or −0.45 division with total peak-to-peak aberrations not to exceed 0.45 division.

g. ADJUST—High-frequency compensation as given in Table 3-3 for optimum square leading corner and flat top with minimum aberrations within limits given in step 26Bf. See Fig. 3-7 for typical response waveform. Adjust C928 and C948 equally and in the same direction.

TABLE 3-3

High-Frequency Compensation (Instrument SNB080000 and Above)

Adjustment	Primary Area of Pulse Affected
R876	Overall level
C905-R906	Top
C928-C948	Leading edge

h. INTERACTION—Check step 26A.

i. Disconnect all test equipment and remove the plug-in units.

For instruments above SNB080000 omit steps 27A and 27B and proceed to step 28.

26. Adjust Horizontal Amplifier Limit Centering (For Instrument SNB080000 and Below)

a. Remove the 7B92 and the signal standardizer calibration fixture and install the 7B70 in the B HORIZ compartment.

b. Set the 7B70 for auto, internal triggering at a sweep rate of ten milliseconds/division.

c. Set the 7B70 for free-running operation with the magnifier on.

d. Connect one 10X probe to each input of the test oscilloscope. Check the compensation of the probes.

e. Set both vertical channels of the test oscilloscope for a vertical deflection factor of 0.5 volt/division (five volts/division at probe tips) in the chop dual-trace mode.

f. Establish a ground reference for both channels of the test oscilloscope by either grounding the probe tips or setting the input coupling to ground; then position both traces to the center horizontal line of the graticule. Do not change the test oscilloscope position controls after establishing this ground reference.

g. Connect the probe tips to the horizontal deflection plate connectors of the 7904.

h. Set the test oscilloscope for DC input coupling (vertical channels) and a sweep rate of two milliseconds/division internally triggered from the signal on one channel only.

i. CHECK—The base line of the displayed triangular waveforms should be at the same DC level within one volt (0.2 division).

j. ADJUST—Limit Centering adjustment R876 to match the DC levels of both waveforms.

k. INTERACTION—If R876 is adjusted, check step 24.

l. Disconnect all test equipment.

√27A. Adjust High-Frequency Timing

a. Remove the 7B70 and install the 7B92 in the B HORIZ compartment.

NOTE

For optimum performance at fast sweep rates, install the 7B92 normally used with the 7904 being calibrated.

b. Set the VERTICAL MODE switch to LEFT.

c. Set the 7B92 for auto, internal triggering at a sweep rate of one millisecond/division.

d. Connect the time-mark generator to the 7A19 with the 42-inch 50-ohm BNC cable.

e. Set the time-mark generator for one-millisecond markers. Set the deflection factor of the 7A19 so the markers are at least two divisions in amplitude.

f. Position the first marker to the farthest left line of the graticule.

g. Set the 7B92 sweep-calibration adjustment for one marker each major graticule division between the second and tenth lines (center eight divisions).

NOTE

Parts h and i of this step check and adjust the 7904/7B92 high-frequency timing. If the timing is within, or can be adjusted within the given tolerances, omit step 27B and proceed to step 28. If the timing cannot be adjusted within the given tolerances, proceed to step 27B then repeat step 27A. If the tolerances still cannot be met, adjust the 7B92 High-Frequency Linearity and Timing as given in the 7B92 Calibration procedure.

√h. CHECK—Using Table 3-4 as a guide, check that the delayed-sweep accuracy over the center eight divisions is within the listed tolerances. Linearity over any two-division portion in the center eight divisions must be within 10%, or 0.2 division. (If checked outside the +15°C to +35°C temperature range, see the 7B92 Operators manual for correct tolerance.)

i. ADJUST—Using Table 3-4 as a guide, adjust the 7B92 adjustments for the delayed-sweep rates to be within the listed tolerances. Maintain the linearity over any two-division portion in the center eight divisions within 10%, or 0.2 division. See the 7B92 Service manual for location of the adjustments.

j. Disconnect all test equipment and remove the plug-in units.

TABLE 3-4

7904/7B92 High-Frequency Timing

7B92 Delayed-Sweep Rate	Time-Mark Generator Output	CRT Display	Tolerance Over Center Eight Divisions	7B92 Adjustment
20 ns/Division	20-nanosecond sinewave	one cycle/division	0.32 division	C449
2 ns/Division	2-nanosecond sinewave	one cycle/division	0.32 division	R244
1 ns/Division	2-nanosecond sinewave	one cycle/two divisions	0.32 division	R246
0.5 ns/Division	2-nanosecond sinewave	one cycle/four divisions	0.4 division	R567

27B. Adjust Horizontal Amplifier High-Frequency Compensation

a. Install the 7B92 in the LEFT VERT compartment and the signal standardizer calibration fixture in the B HORIZ compartment.

b. Set the calibration-fixture Test switch to Vert or Horiz +Step Resp, and the Rep Rate switch to 1 MHz.

c. Set the 7B92 for auto, external triggering on the negative slope at a sweep rate of 200 nanoseconds/division.

d. Connect the calibration-fixture Trigger output to the 7B92 external trigger input with the 18-inch 50-ohm BNC cable.

e. Set the calibration-fixture Amplitude control for a 1.5-division display. Horizontally center the display.

f. CHECK—CRT display for optimum square corner and flat top on displayed pulse. See Fig. 3-7 for typical response waveform. Check the leading edge of the pulse (circled portion of pulse shown in Fig. 3-7) for aberrations not to exceed +0.23 or −0.23 division with total peak-to-peak aberrations not to exceed 0.23 division.

g. ADJUST—High-frequency compensation as given in Table 3-5 for optimum square leading corner and flat top with minimum aberrations within limits given in part f. See Fig. 3-7 for typical response waveform. Adjust C955 and C925 equally and in the same direction.

TABLE 3-5

High-Frequency Compensation
(Instrument SNB080000 and Below)

Adjustment	Primary Area of Pulse Affected
R868	Overall level
C955-C925	Top
R898-C898	Leading edge

h. INTERACTION—Check step 27A.

i. Disconnect all test equpment and remove the plug-in units.

√28. Adjust X-Y Delay Compensation

a. Install the 7A15 plug-in units in the LEFT VERT and B HORIZ compartments.

b. Set both 7A15 units for a deflection factor of 10 millivolts/division with DC input coupling.

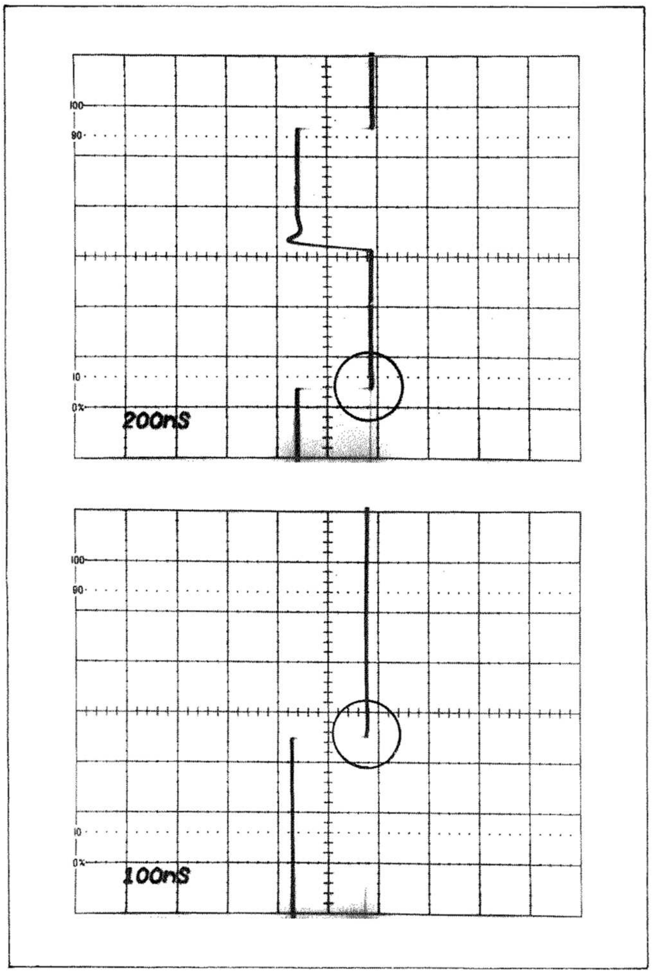


Fig. 3-7. Waveforms showing correct high-frequency compensation of horizontal amplifier at different sweep rates. Circle surrounds compensated portion of square waves.

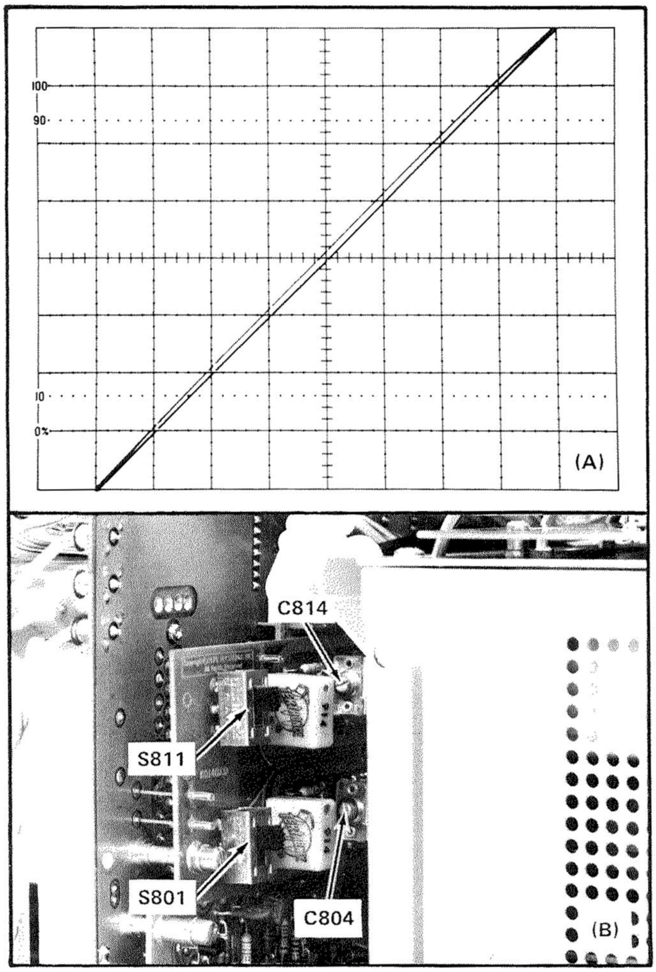


Fig. 3-8. (A) Typical display when checking X-Y delay compensation, (B) Location of phasing adjustments (X-Y Delay Compensation board).

c. If this instrument contains Option 2 (X-Y Delay Compensation board), set S801 and S811, the A and B Delay Disable switches (behind right side panel), to the Out (down) position.

d. Connect the low-frequency signal generator to the input of either 7A15 with the 42-inch 50-ohm BNC cable, 50-ohm BNC termination, and BNC T connector. Connect the output of the BNC T connector to the input of the other 7A15 with an 18-inch 50-ohm BNC cable.

e. Set the low-frequency generator for eight divisions of vertical and horizontal deflection at an output frequency of 35 kilohertz.

√f. CHECK—CRT lissajous display for an opening at the center vertical line of 0.28 division or less (indicates 2° or less phase shift; see Fig. 3-8A).

g. Remove the 7A15 from the B HORIZ compartment and install it in the A HORIZ compartment (leave signals connected).

h. Set the HORIZONTAL MODE switch to A.

√i. Repeat parts e and f.

j. Disconnect the 50-ohm termination from the BNC T connector. Connect the medium-frequency generator to the input of the BNC T connector with the five-nanosecond GR cable and the 50-ohm GR in-line termination.

NOTE

If this instrument does not contain Option 2, omit the remainder of this step; perform steps 29a, b, c, and then proceed with step 29i.

k. Set both internal Delay Disable switches to the In (up) position.

l. Set the medium-frequency generator for eight divisions of vertical and horizontal deflection at one megahertz.

√m. CHECK—CRT lissajous display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift).

n. ADJUST—A Phase Correction adjustment C804 (see Fig. 3-8B) for minimum opening of the display at the center vertical line.

o. Remove the 7A15 from the A HORIZ compartment and install it in the B HORIZ compartment (leave signals connected).

p. Set the HORIZONTAL MODE switch to B.

√q. CHECK—CRT lissajous display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift).

r. ADJUST—B Phase Correction adjustment C814 (see Fig. 3-8B) for minimum opening of the display at the center vertical line.

s. Disconnect the BNC T connector and the 18-inch cable.

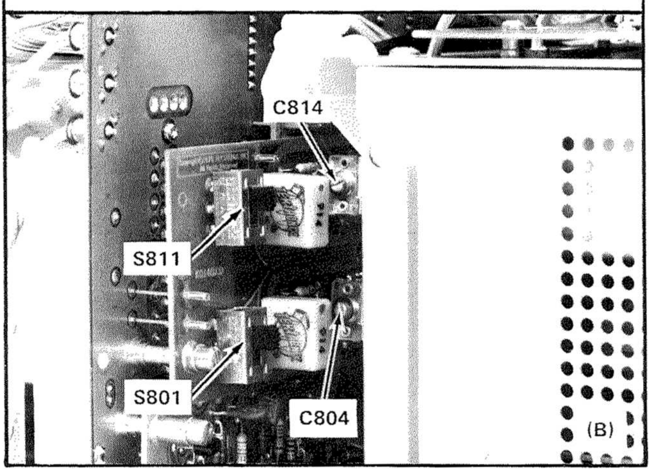


Fig. 3-8. (A) Typical display when checking X-Y delay compensation, (B) Location of phasing adjustments (X-Y Delay Compensation board).

CALIBRATOR AND OUTPUT SIGNALS CALIBRATION

Equipment Required	
1. Precision DC voltmeter	7. 10X probe
2. 7A19 plug-in unit	8. BNC post jack
3. 7A15 plug-in unit	9. 18-inch 50-ohm BNC cable
4. Time-mark generator	10. 42-inch 50-ohm BNC cable
5. 7B70 plug-in unit	11. Three-inch screwdriver
6. 7B92 plug-in unit	12. Low-capacitance screwdriver

Control Settings

Set the controls as given under Preliminary Control Settings.

Location of Adjustments

The calibrator and output signals adjustments are located on the Calibrator board (on right side of instrument). The location of these adjustments is shown in Fig. 3-9.

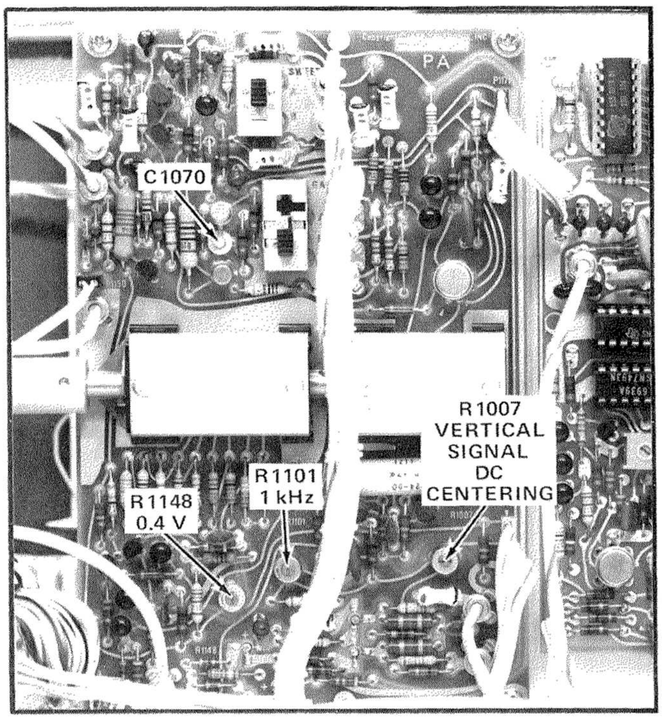


Fig. 3-9. Location of calibrator and output signals adjustments.

√30. Adjust Calibrator Output Voltage

a. Connect the precision DC voltmeter between the center contact of the CAL VOLTS connector (use BNC post jack) and chassis ground.

b. Change the following control settings:

CALIBRATOR	0.4 V
RATE	DC

√c. CHECK—Meter reading; 0.4 volt ±0.004 volt (within 0.008 volt if this measurement is made outside the +15°C to +35°C range).

d. ADJUST—0.4 V adjustment R1148 for a meter reading of exactly 0.4 volt.

e. Disconnect the precision DC voltmeter.

√31. Adjust Calibrator 1 kHz Repetition Rate

NOTE

If a frequency counter with an accuracy of at least 0.1% is available (such as TEKTRONIX 7D14 Digital Counter), it can be used to adjust Calibrator repetition rate.

a. Install the 7A19, 7A15, and 7B70 in the LEFT VERT, RIGHT VERT, and A HORIZ compartments respectively.

b. Set the VERTICAL MODE switch to ALT.

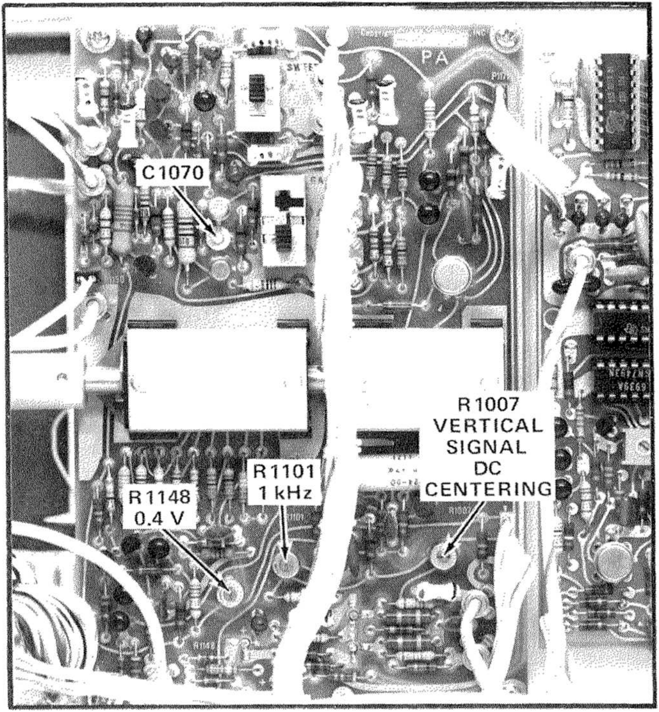


Fig. 3-9. Location of calibrator and output signals adjustments.

c. Connect the CAL VOLTS connector to the 7A15 with the 18-inch 50-ohm BNC cable.

d. Set the 7A15 for a deflection factor of 100 millivolts/division.

e. Connect the marker output of the time-mark generator to the 7A19 with the 42-inch 50-ohm BNC cable.

f. Set the time-mark generator for one-millisecond markers.

g. Set the deflection factor of the 7A19 so the markers are at least two divisions in amplitude.

h. Set the 7B70 for a stable display of both waveforms in the normal, internal triggering mode at a sweep rate of one millisecond/division.

i. Position the markers with the Position control of the 7A19 so the tips of the markers fall just below the bottom of the square wave.

j. ADJUST—1 kHz adjustment R1101 to align the leading edges of the calibrator square wave with the markers over the entire display area (preliminary adjustment).

k. Change the following control settings:

VERTICAL MODE	ADD
A TRIGGER SOURCE	RIGHT VERT

l. Set the 7B70 for a sweep rate of 0.2 millisecond/division.

m. ADJUST—1 kHz adjustment for minimum drift of the time markers across the calibrator square wave.

n. Set the A TRIGGER SOURCE switch to VERT MODE.

o. Adjust the 7B70 triggering so a triggered trace is presented only when the time markers occur during the positive portion of the calibrator square wave.

p. Set the 7B70 for AC low-frequency reject coupling at a sweep rate of 0.2 second/division.

√q. CHECK—The amount of time required for a time mark to drift across the positive level of the calibrator square wave, to the negative level and back to the positive level, must be at least 0.4 second (0.2 second if outside the +15°C to +35°C temperature range). This time can be measured directly from the display by observing the number of divisions that the marker moves across the display area before it returns to the positive level. If the above time is not met, repeat parts j through q.

r. Disconnect the time-mark generator.

√32. Check Calibrator B Gate ÷ 2 Repetition Rate

a. Change the following control settings:

VERTICAL MODE	RIGHT
RATE	B GATE ÷2

b. Install the 7B92 in the B HORIZ compartment.

c. Set the 7B70 for auto, AC-coupled triggering at a sweep rate of 0.5 millisecond/division.

d. Set the 7B92 for auto, external triggering at a sweep rate of 0.1 millisecond/division.

e. Connect the + GATE connector to the 7A19 with the 42-inch 50-ohm BNC cable.

f. Set the 7A15 for a deflection factor of 0.1 volt/division.

g. Set the GATE switch (behind right side panel) to B.

h. Set the VERTICAL MODE switch to CHOP.

√i. CHECK—CRT display for duration of one complete cycle of calibrator square wave equal to two cycles of B Gate waveform. (If necessary, adjust the triggering level of the 7B70 for a stable display.)

j. Disconnect the cable from the + GATE connector and the 7A19.

√33. Check Calibrator Risetime, Falltime, and Duty Cycle

a. Change the following control settings:

VERTICAL MODE	RIGHT
CALIBRATOR	4 V
RATE	1 kHz

b. Set the 7A15 for a deflection factor of 0.5 volt/division; then set the variable control for exactly six divisions of vertical deflection.

c. Set the 7B70 for a sweep rate of one millisecond/division.

d. Position the display so it is centered vertically on the graticule.

e. Set the 7B70 for a stable display triggered on the rising portion of the waveform at a sweep rate of 0.1 microsecond/division.

√f. CHECK—Displayed waveform for not more than 2.5 divisions between the 10% and 90% points (risetime 0.25 microsecond or less).

g. Set the 7B70 for a stable display triggered on the falling portion of the waveform.

√h. CHECK—Displayed waveform for not more than 2.5 divisions between the 90% and 10% points (falltime 0.25 microsecond or less).

i. Disconnect the cable between the CAL VOLTS connector and the 7A15 input.

j. Set the CALIBRATOR switch to 40 V.

k. Set the 7B70 for a sweep rate of one microsecond/division.

l. Connect the 10X probe to the input of the 7A15. Connect the probe tip to the center contact of the CAL VOLTS connector (use the BNC post jack).

m. Set the 7A15 for exactly six divisions of deflection (use variable control).

√n. CHECK—Displayed waveform for not more than two divisions between the 90% and 10% points (falltime two microseconds or less).

o. Set the 7B70 for a stable display triggered on the rising portion of the waveform.

√p. CHECK—Displayed waveform for not more than two divisions between the 10% and 90% points (risetime two microseconds or less).

q. Set the 7A15 for a calibrated deflection factor of two volts/division.

r. Set the 7B70 for auto, internal triggering at a sweep rate of 50 microseconds/division. Set the triggering controls so the display starts at the 50% point on the rising edge of the waveform.

s. Set the 7B70 X10 magnifier on. Then, position the display horizontally so the falling edge of the waveform aligns with the vertical center line.

t. Set the 7A15 to invert the display. (NOTE: The display is triggered on the opposite slope, even though the display appears the same.)

√u. CHECK—50% point on falling edge of the waveform now displayed is within 0.4 division of the center line (indicates duty cycle of 50% ±0.1%).

v. Disconnect the 10X probe.

√34. Check Sawtooth Output Signals

a. Connect the + SAWTOOTH connector to the 7A15 with the 18-inch 50-ohm BNC cable.

b. Set the 7A15 for a deflection factor of two volts/division with DC input coupling.

c. Set the 7B70 for a sweep rate of two milliseconds/division (X10 magnifier off).

d. Set the 7B92 for a free-running sweep at a sweep rate of 0.5 millisecond/division.

e. Set the Sweep switch (behind right side panel) to B.

√f. CHECK—CRT display for sawtooth waveform about five divisions in amplitude with a duration of at least 2.5 divisions.

g. Set the HORIZONTAL MODE switch to B.

h. Set the Sweep switch to A.

i. Set the 7B92 for auto triggering at a sweep rate of two milliseconds/division and the 7B70 for a free-running sweep at a sweep rate of 0.5 millisecond/division.

√j. CHECK—CRT display for sawtooth waveform about five divisions in amplitude with duration of at least 2.5 divisions.

√35. Check Gate Output Signals

a. Move the cable from the + SAWTOOTH connector to the + GATE connector.

b. Set the Gate switch (behind right side panel) to A.

√c. CHECK—CRT display for gate waveform five divisions ±0.5 division in amplitude with a duration of at least 2.5 divisions.

d. Set the HORIZONTAL MODE switch to A.

e. Set the Gate switch to B.

f. Remove the time-base units from the horizontal compartments; then, install the 7B92 in the A HORIZ compartment and the 7B70 in the B HORIZ compartment.

g. Set the 7B70 for auto triggering at a sweep rate of 2 milliseconds/division and the 7B92 for a free-running sweep at a sweep rate of 0.5 millisecond/division.

√h. CHECK—CRT display for gate waveform five dividions ±0.5 division in amplitude with a duration of at least 2.5 divisions.

36. Adjust Gate Output High-Frequency Compensation

a. Set the VERTICAL MODE switch to LEFT and GATE switch to A.

b. Disconnect the cable from the 7A15 and connect it to the 7A19.

c. Set the 7B70 for a free-running sweep at a sweep rate of 2 nanoseconds/division.

d. Set the 7A19 for a deflection factor of 0.1 volt/division; position the display so it is centered vertically.

e. CHECK—Displayed waveform for flat top and for not more than two divisions between the 10% and 90% points (risetime two nanoseconds or less).

f. ADJUST—C1070 for optimum square leading corner and flat top while maintaining a risetime of approximately two nanoseconds (use low-capacitance screwdriver to adjust variable capacitor).

g. Remove the cable.

37. Adjust Vertical Signal Centering

a. Change the following control settings:

A TRIGGER SOURCE	RIGHT VERT
B TRIGGER SOURCE	LEFT VERT
VERTICAL MODE	RIGHT

b. Remove the 7A19 from the LEFT VERT compartment.

c. Set the 7A15 for a deflection factor of one volt/division with DC input coupling.

d. Set the 7B70 for auto, internal triggering at a sweep rate of 10 microseconds/division.

e. Establish a zero-volt reference level at the center horizontal graticule line with the 7A15 Position control.

f. Connect the SIG OUT connector to the 7A15 with the 18-inch 50-ohm BNC cable.

g. CHECK—Display for DC level of zero volt within one division (0 volt ± one volt).

h. ADJUST—Vertical Signal DC Centering adjustment R1007 for a DC level of zero volt within one volt.

√38. Check Vertical Signal Output

a. Install the 7A19 in the LEFT VERT compartment.

b. Change the following control settings:

VERTICAL MODE	LEFT
CALIBRATOR	4 V 1 kHz

c. Set the 7A15 for a deflection factor of 0.5 volt/division and the 7B70 for auto triggering at a sweep rate of 0.5 millisecond/division.

d. Connect the CAL VOLTS connector to the 7A19 with the 42-inch 50-ohm BNC cable.

e. Set the 7A19 for a deflection factor of 0.1 volt/division and center the display vertically.

f. Set the VERTICAL MODE switch to CHOP.

√g. CHECK—CRT display for waveform four divisions within one division in amplitude.

h. Disconnect all test equipment and remove the plug-in units.

READOUT SYSTEM CALIBRATION

NOTE

If the Readout System was deleted from the instrument being calibrated (Option 1), omit this section of the procedure.

Equipment Required	
1. Amplifier plug-in unit	2. Time-base plug-in unit
	3. Three-inch screwdriver

Control Settings

Set the controls as given under Preliminary Control Settings.

Location of Adjustments

The location of the readout-system adjustments on the Readout System board is shown in Fig. 3-10B (right side of instrument).

39. Adjust Vertical Separation

a. Set the POWER switch to off and remove Q2225 from its socket on the Readout System board (see Fig. 3-10B).

b. Set the POWER switch to on.

c. Set the READOUT control for visible characters (all zeros).

d. CHECK—CRT display for two rows of zeros, 40 zeros to a row with no overlap. Total length of each row of characters should be between 9.5 and 10.5 divisions. There should be one zero or less to the right of the last graticule line, and one zero or less to the left of the first graticule line. The two rows of zeros should be located vertically in the middle of the top and bottom divisions of the graticule (see Fig. 3-10A).

NOTE

These tolerances are provided as guides to correct instrument operation and are not instrument specifications.

e. ADJUST—Vertical Separation adjustment R2291 to position the two rows of readout characters to the middle of the top and bottom divisions of the graticule.

NOTE

The Vertical Amplifier Centering adjustment must be correct before making this adjustment; see step 12.

f. Set the POWER switch to off and replace Q2225 in its socket; return the POWER switch to on.

40. Adjust Full Character Scan and Character Height

a. Install the amplifier unit in the RIGHT VERT compartment.

b. Set the amplifier unit for a deflection factor of 50 millivolts/division.

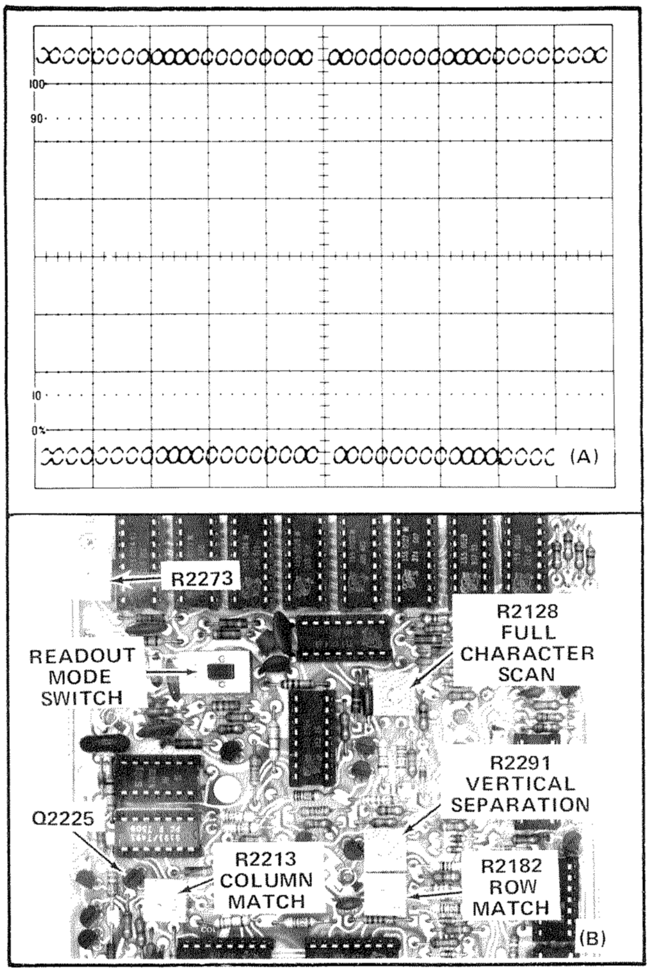


Fig. 3-10. (A) Readout display with Q2225 removed, (B) Location of Q2225 and readout adjustments (Readout System board).

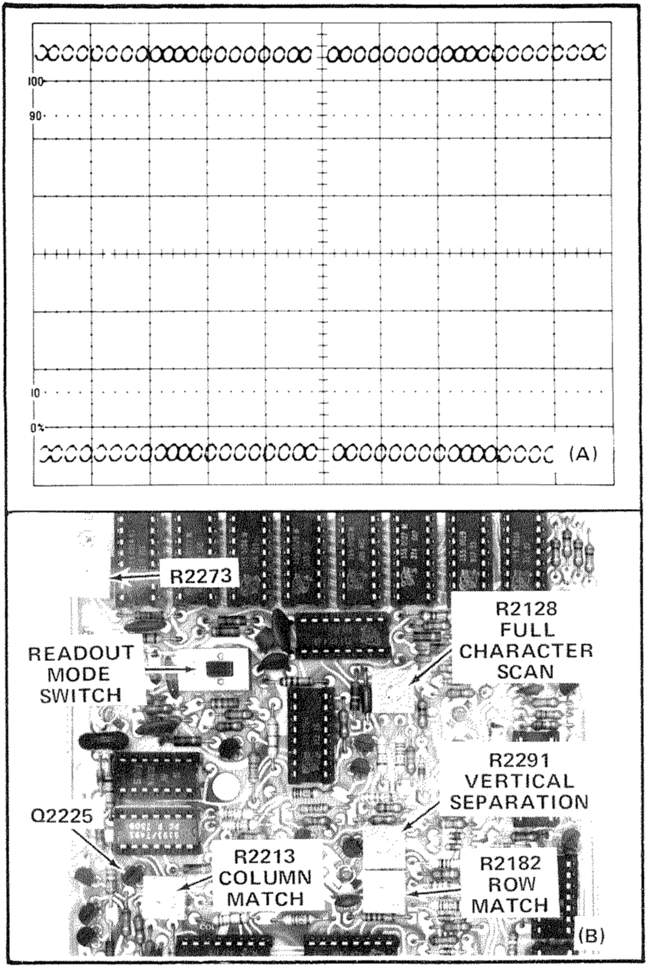


Fig. 3-10. (A) Readout display with Q2225 removed, (B) Location of Q2225 and readout adjustments (Readout System board).

c. CHECK—Displayed characters for completeness without overscanning (overscanning causes a bright dot to appear where the traces overlap).

d. ADJUST—Full Character Scan adjustment R2128 for fully scanned characters without overscanning. The m and the 5 will show the most change.

NOTE

For instruments below serial number B090000, omit part e and proceed to the next step.

e. ADJUST—Character Height adjustment R2273 for readout character size as desired.

41. Adjust Column Match and Row Match

a. Press and hold the amplifier unit trace-identify button.

b. CHECK—Readout display for correct indication of "IDENTIFY". If the readout display either blinks or is incorrect, adjustment is required.

c. ADJUST—Column Match adjustment R2213 and Row Match adjustment R2182 for correct readout of "IDENTIFY". Set these adjustments to the center of the adjustment range which provides correct readout indication. Release the amplifier unit trace-identify button.

42. Check Readout Modes

a. Install the time-base unit in the A HORIZ compartment.

b. Set the time-base unit for a free-running sweep.

c. Set the Readout Mode switch to F.R. (Free Run) and the Gate switch to A (Gate switch located on Output Signals board).

d. CHECK—Set the time-base unit for several sweep rates throughout its range. Check that the readout characters are presented on a free-run basis, independent of the sweep rate.

e. Set the Readout Mode switch to the Gate Trig'd position.

f. Set the time-base unit for a free-running sweep at a rate of 0.1 second/division.

g. CHECK—Readout characters are blanked out while the sweep is running, and are displayed immediately after the end of the sweep; each character encoded by the plug-in units is displayed only once for each sweep.

This completes the Calibration procedure for the 7904. Disconnect all test equipment and replace the side panels.

OPTION INFORMATION

Your instrument may be equipped with one or more options. This section describes those options, or directs the reader to where the option is documented.

			Pages
Option 1	W/O CRT Readout:	Described in this section.	1
Option 2	X-Y Delay Compensation:	Described in this section.	1
Option 3	EMI Modification:	Described in this section.	2
Option 4	Maximum Brightness CRT:	Described in this section.	1
Option 78	P11 Phosphor, CRT:	Described in this section.	1

OPTION 1

Without CRT Readout

This option deletes the Readout System. Operation of the instrument is unchanged except there is no alpha-numeric display on the CRT and the READOUT control is non-functional. The Readout board A18 has been replaced with DUMMY READOUT A26 to maintain continuity of the remaining circuitry. The components shown on Readout board photo 5-11 and schematic diagram 5 are not present in the Option 1 products. DUMMY READOUT board parts list information is located in this section.

Parts List Changes

DELETE:

A18	670-1900-00	B010000	B089999	Readout Circuit Board Assy.
	670-1900-02	B090000		Readout Circuit Board Assy.

ADD:

A26	670-2018-00			Dummy Readout Circuit Board Assy.

OPTION 1

Without READOUT Circuit Board Assembly

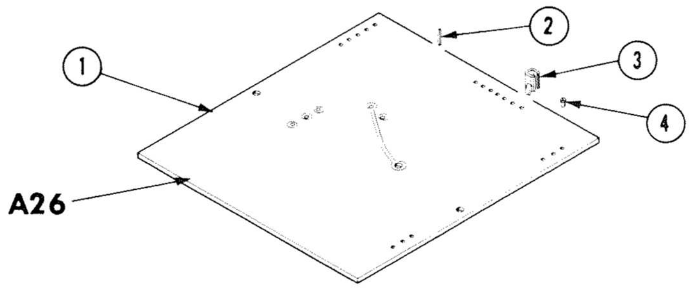


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	- - - - - - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY—DUMMY READOUT A26
	- - - - - - - - - -			-	circuit board assembly includes:
	388-2561-00			1	CIRCUIT BOARD
-2	131-0608-00			18	TERMINAL, pin, 0.365 inch long
-3	131-1003-00			6	RECEPTACLE, cable, coax
-4	136-0252-04			6	SOCKET, pin connector

STANDARD ACCESSORIES same as 7904

OPTION 2

X-Y Delay Compensation

This option adds a X-Y Delay Compensation network to equalize the signal delay between the vertical and horizontal deflection systems. When this network is installed and activated, the phase shift between the vertical and horizontal channels is less than 2° from DC to one megahertz. Option 2 calibration procedure is outlined in Section 3, Step 28 of this manual.

Parts List Changes

DELETE:		
A19	670-1634-00	Horizontal Interconnect Circuit Board Assembly
ADD:		
A17	670-1633-00	X-Y Delay Compensation Circuit Board Assembly

OPTION 2

X-Y Delay Compensation Network

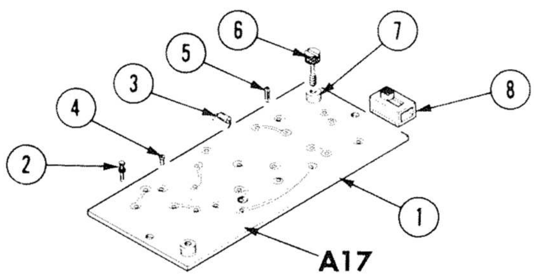


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	----------[1]			1	CIRCUIT BOARD ASSEMBLY—X-Y DELAY COMPENSATION A17
	----------			-	circuit board assembly includes:
	388-2196-00			1	CIRCUIT BOARD
-2	131-0285-00			4	CONNECTOR, terminal lug
-3	131-0566-00			1	LINK, terminal connecting
-4	136-0252-04			32	SOCKET, pin connector
-5	136-0263-00			15	SOCKET, pin connector, square
-6	211-0155-00			2	SCREW, 4-40 X 0.375 inch, knurled
-7	361-0301-00			2	SPACER, sleeve
-8	260-0723-00			2	SWITCH, slide

STANDARD ACCESSORIES same as 7904

OPTION 3

Electro-magnetic Interference (EMI) Modification

This option adds special shielding and equipment to the instrument for EMI protection when operated in most severe EMI environments. Also, in order to meet the EMI specifications, any unused plug-in compartment must be covered with an EMI shielded blank plug-in panel. One is required for each unused compartment. Order or use only Tektronix Part No. 016-0155-00 blank plug-in panel for this purpose.

Option 3 parts illustrations are located in this section. EMI Specifications may be found in Table 1-2 of the 7904 Operators manual.

OPTION 3

Electromagnetic Interference (EMI)

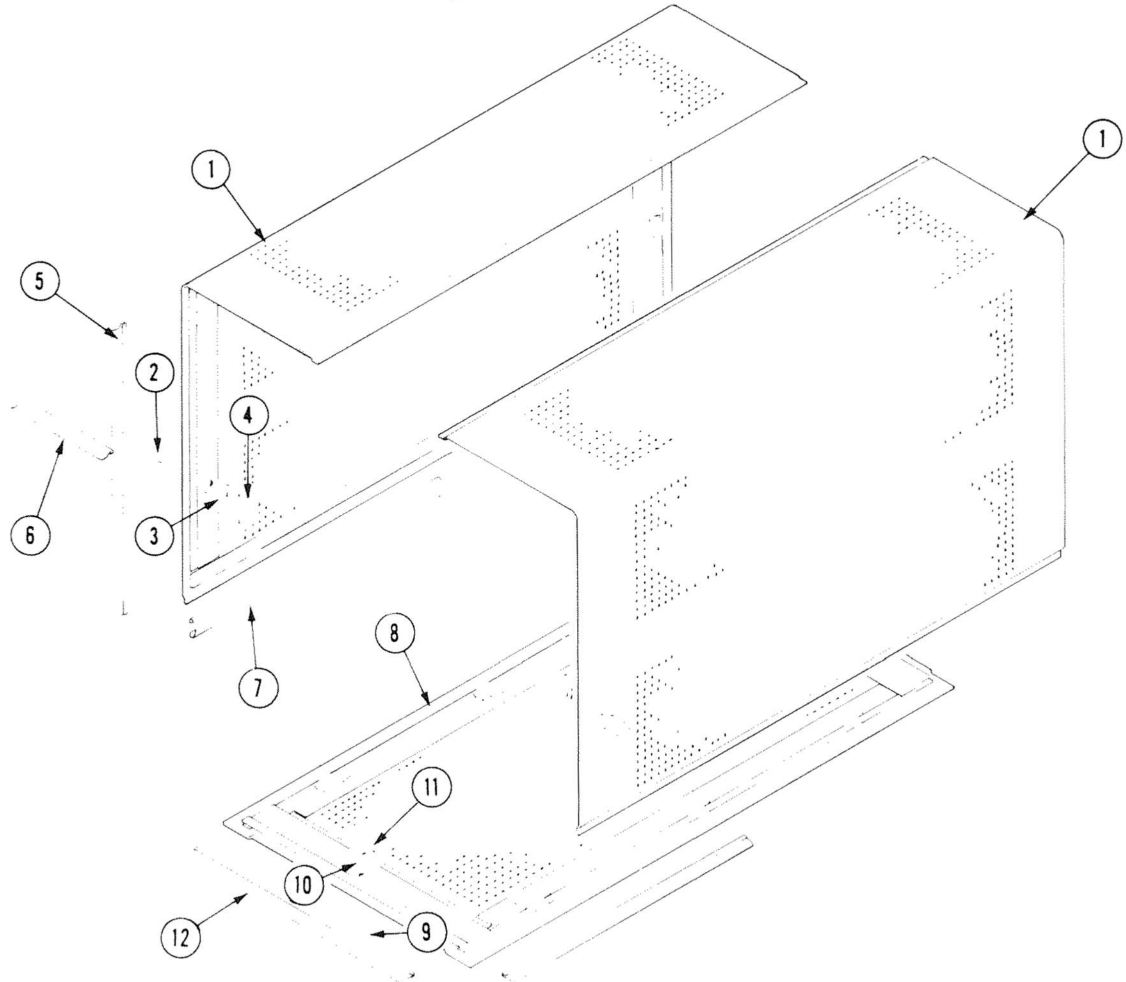


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	390-0123-00			2	CABINET SIDE
	- - - - - - - - - -			-	each cabinet side includes:
-2	214-0603-02			6	PIN, securing, w/spring
-3	386-1634-00			6	PLATE, INDEX, plastic
-4	386-1633-00			6	PLATE, locking
-5	348-0210-00			2	SHIELDING GASKET, 10.887 inches long
-6	348-0209-00			2	SHIELDING GASKET, 4.359 inches long
-7	348-0211-00			4	SHIELDING GASKET, 9.322 inches long
-8	390-0122-00			1	CABINET BOTTOM
	- - - - - - - - - -			-	cabinet bottom includes:
-9	214-0603-02			8	PIN, securing, w/spring
-10	386-1634-00			8	PLATE, index, plastic
-11	386-1633-00			8	PLATE, locking
-12	348-0212-00			6	SHIELDING GASKET, 9.10 inches long
	378-0603-00			1	FILTER, mesh, CRT

STANDARD ACCESSORIES same as 7904—also includes:

378-0625-00	1	FILTER, light, CRT
426-0514-00	1	FRAME, mask, plastic
016-0155-00	1	PLUG-IN PANEL, blank (OPTIONAL ONLY)

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OPTION 4

Maximum Brightness CRT

This option changes the standard CRT to a 4 x 5-cm type that provides maximum trace brightness and optimum photographic writing speed.

Parts List Changes

DELETE:		
V1725	154-0644-00	Standard 8 x 10-cm CRT, P31 phosphor.
	331-0245-00	Mask, CRT
ADD:		
V1725	154-0661-05	4 x 5-cm CRT, P31 phosphor
	154-0661-09	4 x 5-cm CRT, P11 phosphor
	331-0318-00	Mask, CRT (4 x 5)

After installation of the 4 x 5-cm CRT, perform calibration steps 4 thru 15 and steps 24 thru 27 as outlined in Section 3 of this manual.

OPTION 78

This option adds a Type P11 phosphor CRT to the instrument.

Parts List Changes

DELETE:		
V1725	154-0644-00	Standard 8 x 10-cm CRT, P31 phosphor
ADD:		
V1725	154-0644-04	8 x 10-cm CRT, P11 phosphor

After installation of the CRT, perform calibration steps 4 thru 15 and steps 24 thru 27 as outlined in Section 3 of this manual.

ELECTRICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable
AT	Attenuator, fixed or variable
B	Motor
BT	Battery
C	Capacitor, fixed or variable
Cer	Ceramic
CR	Diode, signal or rectifier
CRT	cathode-ray tube
DL	Delay line
DS	Indicating device (lamp)
Elect.	Electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
F	Fuse
FL	Filter
H	Heat dissipating device (heat sink, etc.)
HR	Heater
J	Connector, stationary portion
K	Relay
L	Inductor, fixed or variable
LR	Inductor/resistor combination
M	Meter
Q	Transistor or silicon-controlled rectifier
P	Connector, movable portion
PMC	Paper, metal cased
PT	paper, tubular
PTM	paper or plastic, tubular molded
R	Resistor, fixed or variable
RT	Thermistor
S	Switch
T	Transformer
TP	Test point
U	Assembly, inseparable or non-repairable
V	Electron tube
Var	Variable
VR	Voltage regulator (zener diode, etc.)
WW	wire-wound
Y	Crystal

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
A1	670-1642-00			PROBE POWER Circuit Board Assembly
A2	670-1623-00	B010100	B019999	MAIN INTERFACE Circuit Board Assembly
A2	670-1623-01	B020000		MAIN INTERFACE Circuit Board Assembly
A3	670-1637-00			FRONT PANEL INTERCONNECT Circuit Board Assembly
A4	670-1624-00	B010100	B079999	LOGIC Circuit Board Assembly
A4	670-1624-01	B080000		LOGIC Circuit Board Assembly
A5	670-1626-00	B010100	B099999	A TRIGGER SELECTOR Circuit Board Assembly
A5	670-1626-01	B100000		A TRIGGER SELECTOR Circuit Board Assembly
A6	670-1627-00	B010100	B099999	B TRIGGER SELECTOR Circuit Board Assembly
A6	670-1627-01	B100000		B TRIGGER SELECTOR Circuit Board Assembly
A7	670-1625-00	B010100	B019999	VERTICAL INTERFACE Circuit Board Assembly
A7	670-1625-01	B020000		VERTICAL INTERFACE Circuit Board Assembly
A8	670-1630-00	B010100	B019999	VERTICAL AMPLIFIER Circuit Board Assembly
A8	670-1630-01	B020000	B149999	VERTICAL AMPLIFIER Circuit Board Assembly
A8	670-1630-02	B150000		VERTICAL AMPLIFIER Circuit Board Assembly
A9	670-1632-00	B010100	B079999	MAIN HORIZONTAL AMPLIFIER Circuit Board Assembly
A9	670-1632-01	B080000		MAIN HORIZONTAL AMPLIFIER Circuit Board Assembly
A10	670-1635-00			CALIBRATOR-SIGNAL Circuit Board Assembly
A11	670-1610-00	B010100	B049999	POWER SUPPLY INVERTER Circuit Board Assembly
A11	670-1610-01	B050000		POWER SUPPLY INVERTER Circuit Board Assembly
A12	670-1612-00	B010100	B049999	CAP. RECTIFIER Circuit Board Assembly
A12	670-1612-01	B050000		CAP. RECTIFIER Circuit Board Assembly
A13	670-1611-00			LV REGULATOR Circuit Board Assembly
A14	670-1613-00			HIGH VOLTAGE Circuit Board Assembly
A15	670-1622-00			AUTO FOCUS Circuit Board Assembly
A16	670-1636-00			Z AXIS Circuit Board Assembly
A17	670-1633-00			X-Y DELAY COMPENSATION Circuit Board Assembly
A18	670-1900-00	B010100	B089999	READOUT SYSTEM Circuit Board Assembly
A18	670-1900-02	B090000	B109999	READOUT SYSTEM Circuit Board Assembly
A18	670-1900-03	B110000		READOUT SYSTEM Circuit Board Assembly
A19	670-1634-00			HORIZ INTERCONNECT Circuit Board Assembly
A20	670-1638-00			VERTICAL MODE SWITCH Circuit Board Assembly
A21	670-1639-00			HORIZONTAL MODE SWITCH Circuit Board Assembly

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLIES (cont)				
A22	670-1640-00			A TRIGGER SOURCE SWITCH Circuit Board Assembly
A23	670-1698-00	B010100	B019999	50 Ω FOLLOWER Circuit Board Assembly (2)
A23	670-1698-02	B020000		50 Ω FOLLOWER Circuit Board Assembly (2)
A24	670-1641-00			B TRIGGER SOURCE SWITCH Circuit Board Assembly
A25	670-0702-00			GRATICULE LIGHT Circuit Board Assembly
A26	670-2018-00			DUMMY READOUT Circuit Board Assembly
CAPACITORS				
C21	283-0003-00	B010100	B069999	0.01 μF, Cer, 150 V, +80-20%
C21	283-0024-00	B070000		0.1 μF, Cer, 30 V, +80-20%
C24	283-0003-00	B010100	B069999	0.01 μF, Cer, 150 V, +80-20%
C24	283-0024-00	B070000		0.1 μF, Cer, 30 V, +80-20%
C26	283-0067-00	XB100000		0.001 μF, Cer, 200 V, 10%
C27	283-0003-00	B010100	B069999X	0.01 μF, Cer, 150 V, +80-20%
C36	283-0067-00	XB100000		0.001 μF, Cer, 200 V, 10%
C60	290-0519-00			100 μF, Elect., 20 V, 20%
C62	290-0716-00			8.2 μF, Elect., 74 V, 20%
C64	290-0716-00			8.2 μF, Elect., 74 V, 20%
C66	290-0519-00			100 μF, Elect., 20 V, 20%
C68	290-0519-00			100 μF, Elect., 20 V, 20%
C94	283-0111-00			0.1 μF, Cer, 50 V
C95	283-0111-00			0.1 μF, Cer, 50 V
C96	283-0111-00			0.1 μF, Cer, 50 V
C213	283-0672-00			200 pF, Mica, 500 V, 1%
C216	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C218	281-0603-00			39 pF, Cer, 500 V, 5%
C224	281-0629-00			33 pF, Cer, 600 V, 5%
C227	281-0525-00			470 pF, Cer, 500 V, 20%
C228	281-0629-00			33 pF, Cer, 600 V, 5%
C231	281-0525-00			470 pF, Cer, 500 V, 20%
C233	281-0603-00			39 pF, Cer, 500 V, 5%
C234	283-0638-00			130 pF, Mica, 100 V, 1%
C246	283-0177-00			1 μF, Cer, 25 V, +80%-20%
C248	283-0000-00	B010100	B019999X	0.001 μF, Cer, 500 V, +100%-0%
C309	281-0603-00			39 pF, Cer, 500 V, 5%
C311	281-0603-00			39 pF, Cer, 500 V, 5%
C320	281-0523-00			100 pF, Cer, 350 V, 20%
C322	283-0000-00			0.001 μF, Cer, 500 V, +100%-0%
C324	283-0177-00			1 μF, Cer, 25 V, +80%-20%
C346	281-0603-00			39 pF, Cer, 500 V, 5%
C349	281-0523-00			100 pF, Cer, 350 V, 20%
C360	281-0589-00			170 pF, Cer, 500 V, 5%
C365	281-0589-00			170 pF, Cer, 500 V, 5%
C390	283-0177-00			1 μF, Cer, 25 V, +80%-20%
C393	290-0529-00			47 μF, Elect., 20 V, 20%
C394	283-0177-00			1 μF, Cer, 25 V, +80%-20%
C396	283-0177-00			1 μF, Cer, 25 V, +80%-20%
C510	283-0160-00			1.5 pF, Cer, 50 V, 10%

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)					
C512		283-0160-00			1.5 pF, Cer, 50 V, 10%
C514		283-0160-00			1.5 pF. Cer, 50 V, 10%
C516		283-0160-00			1.5 pF, Cer, 50 V, 10%
C521		283-0114-00			0.0015 pF, Cer, 200 V, 5%
C534		283-0114-00			0.0015 pF, Cer, 500 V, 5%
C536		283-0160-00			1.5 pF, (nominal value) Selected
C546		283-0157-00			7 pF, (nominal value) Selected
C552		283-0219-00			1500 pF, Cer, 50 V, 20%
C556		283-0219-00			1500 pF. Cer, 50 V, 20%
C560		283-0160-00			1.5 pF, Cer, 50 V, 20%
C562		283-0160-00			1.5 pF, Cer, 50 V, 10%
C564		283-0160-00			1.5 pF, Cer, 50 V, 10%
C565		283-0160-00			1.5 pF, Cer, 50 V, 10%
C571		283-0114-00			0.0015 µF, Cer, 200 V, 5%
C574		283-0114-00			0.0015 µF, Cer, 200 V, 5%
C586		283-0157-00			7 pF, (nominal value) Selected
C592		283-0219-00			0.0015 µF, Cer, 50 V, 20%
C596		283-0219-00			0.0015 µF, Cer, 50 V, 20%
C603		283-0160-00	B010100	B029999	1.5 pF, Cer, 50 V, 10%
C603		283-0160-00	B030000		1.5 pF, (nominal value) Selected
C606		283-0160-00	B010100	B029999	1.5 pF, Cer, 50 V, 10%
C606		283-0160-00	B030000		1.5 pF, (nominal value) Selected
C609		283-0160-00	B010100	B029999	1.5 pF, Cer, 50 V, 10%
C609		283-0160-00	B030000		1.5 pF, (nominal value) Selected
C612		283-0160-00	B010100	B029999	1.5 pF, Cer, 50 V, 10%
C612		283-0160-00	B030000		1.5 pF, (nominal value) Selected
C620		283-0187-00	XB020000	B069999	0.047 µF, Cer, 400 V, 10%
C620		283-0341-00	B070000		0.047 µF, Cer, 100 V, 10%
C623		283-0238-00	B010000	B019999	0.01 µF, Cer, 50 V, 10%
C623		283-0180-00	B020000		5600 pF, Cer, 200 V, 20%
C626		283-0203-00	XB020000		0.47 µF, Cer, 50 V, 20%
C629		283-0187-00	B010100	B019999	0.047 µF, Cer, 400 V, 10%
C629		283-0638-00	B020000		240 pF, (nominal value) Selected
C632		283-0203-00	XB020000		0.47 µF, Cer, 50 V, 20%
C635		283-0187-00	B010100	B019999	0.047 µF, Cer, 400 V, 10%
C635		281-0638-00	B020000		240 pF, (nominal value) Selected
C638		283-0187-00	XB020000	B069999	0.047 µF, Cer, 400 V, 10%
C638		283-0341-00	B070000		0.047 µF, Cer, 100 V, 10%
C641		283-0238-00	B010100	B019999	0.01 µF, Cer, 50 V, 10%
C641		283-0180-00	B020000		5600 pF, Cer, 200 V, 20%
C644		283-0160-00	XB100000		1.5 pF, (nom value), Selected
C645		283-0114-00			0.0015 µF, Cer, 200 V, 5%
C657		283-0185-00	XB010231		2.5 pF, Cer, 50 V, 5%
C658		281-0151-00			1-3 pF, Var, Cer, 100 V
C659		283-0185-00	XB010231		2.5 pF, Cer, 50 V, 5%
C662		281-0603-00			39 pF, Cer, 500 V, 5%
C663		281-0629-00	B010100	B010230	33 pF, Cer, 600 V, 5%
C663		281-0603-00	B010231		39 pF, Cer, 500 V, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C670	281-0536-00	B010100	B010230	1000 pF, Cer, 500 V, 10%
C670	281-0543-00	B010231		270 pF, Cer, 500 V, 10%
C672	281-0536-00	B010100	B010230	1000 pF, Cer, 500 V, 10%
C672	281-0543-00	B010231		270 pF, Cer, 500 V, 10%
C675	283-0160-00			1.5 pF, Cer, 50 V, 10%
C676	283-0181-00			1.8 pF, Cer, 100 V, 10%
C680	283-0181-00			1.8 pF, Cer, 100 V, 10%
C681	283-0160-00			1.5 pF, Cer, 50 V, 10%
C685	281-0543-00			270 pF, Cer, 500 V, 10%
C689	281-0543-00			270 pF, Cer, 500 V, 10%
C733	283-0160-00			1.5 pF, Cer, 50 V, 10%
C734	283-0181-00			1.8 pF, Cer, 100 V, 10%
C736	283-0160-00	XB130000		1.5 pF, (nominal value) Selected
C738	283-0181-00			1.8 pF, Cer, 100 V, 10%
C739	283-0160-00			1.5 pF, Cer, 50 V, 10%
C743	283-0128-00	B010100	B019999	100 pF, Cer, 500 V, 5%
C743	283-0128-00	B020000		100 pF, (nominal value) Selected
C745	283-0114-00			0.0015 μF, Cer, 200 V, 5%
C747	283-0239-00			0.022 μF, Cer, 50 V, 10%
C749	283-0203-00			0.47 μF, Cer, 50 V
C758	283-0197-00	B010100	B019999	470 pF, Cer, 100 V, 5%
C758	283-0047-00	B020000	B049999	270 pF, (nominal value) Selected
C758	283-0108-00	B050000		220 pF, Cer, 200 V, 10%
C760	283-0180-00			5600 pF, Cer, 200 V, 20%
C762	283-0211-00			0.1 μF, Cer, 200 V, 10%
C764	283-0212-00			2 μF, Cer, 50 V, 20%
C770	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C783	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C787	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C789	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C791	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C794	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C796	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C798	283-0001-00			0.005 μF, Cer, 500 V, +100%-0%
C803	283-0603-00			113 pF, Mica, 300 V, 1%
C804	281-0118-00			8-90 pF, Var, Mica
C806	283-0677-00			82 pF, Mica, 500 V, 1%
C807	283-0668-00			184 pF, Mica, 500 V, 1%
C808	283-0668-00			184 pF, Mica, 500 V, 1%
C809	283-0677-00			82 pF, Mica, 500 V, 1%
C813	283-0603-00			113 pF, Mica, 300 V, 1%
C814	281-0118-00			8-90 pF, Var, Mica
C816	283-0677-00			82 pF, Mica, 500 V, 1%
C817	283-0668-00			184 pF, Mica, 500 V, 1%

ELECTRICAL PARTS LIST (cont)

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C818	283-0668-00			184 pF, Mica, 500 V, 1%
C819	283-0677-00			82 pF, Mica, 500 V, 1%
C830	283-0000-00	B010100	B010319X	0.001 μF, Cer, 500 V, +100%-0%
C832	281-0658-00	B010100	B079999X	6.2 pF, (nominal value) Selected
C837	281-0505-00			12 pF, Cer, 500 V, 10%
C840	283-0000-00	B010100	B010319X	0.001 μF, Cer, 500 V, +100%-0%
C842	281-0658-00	B010100	B079999X	6.2 pF, (nominal value) Selected
C847	281-0505-00			12 pF, Cer, 500 V, 10%
C857	290-0522-00	B010100	B069999X	1 μF, Elect., 50 V, 20%
C867	290-0522-00	XB080000		1 μF, Elect., 50 V, 20%
C868	281-0523-00	B010100	B079999X	100 pF, (nominal value) Selected
C876	283-0615-00	XB080000		33 pF, Mica, 500 V, 5%
C877	283-0674-00	XB080000		85 pF, Mica, 500 V, 1%
C880	283-0615-00	XB080000		33 pF, Mica, 500 V, 5%
C897	283-0600-00	B010100	B079999X	43 pF, Mica, 500 V, 5%
C898	281-0092-00	B010100	B079999X	9-35 pF, Var, Cer
C905	283-0005-00	B010100	B079999	0.01 μF, Cer, 250 V, +100%-0%
C905	281-0092-00	B080000		9-35 pF, Var, Cer
C906	283-0211-00	B010100	B079999	0.1 μF, Cer, 200 V, 10%
C906	283-0616-00	B080000		75 pF, Mica, 500 V, 5%
C909	283-0211-00	B010100	B079999X	0.1 μF, Cer, 200 V, 10%
C912	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +80%-20%
C914	290-0522-00	B010100	B079999X	1 μF, Elect., 50 V, 20%
C915	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +90%-20%
C918	281-0064-00	B010100	B079999X	0.25-1.5 pF, Var, Tub.
C921	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +80%-20%
C923	290-0517-00	B010100	B079999X	6.8 μF, Elect., 25 V, 20%
C925[1]	281-0091-00	B010100	B079999X	2-8 pF, Var, Cer
C926[1]				
C928	281-0168-00	XB080000	B099999	1.3-5.4 pF, Var, Air, 250 V
C928	281-0153-00	B100000		1.7-10 pF, Var, Air, 250 V
C934	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +80-20%
C939	283-0211-00	B010100	B079999X	0.1 μF, Cer, 200 V, 10%
C940	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +80%-20%
C943	283-0003-00	XB080000		0.01 μF, Cer, 150 V, +80%-20%
C945[1]	283-0211-00	B010100	B079999X	0.1 μF, Cer, 200 V, 10%
C946[1]				
C948	281-0064-00	B010100	B079999	0.25-1.5 pF, Var, Tub.
C948	281-0168-00	B080000	B099999	1.3-5.4 pF, Var, Air, 250 V
C948	281-0153-00	B100000		1.7-10 pF, Var, Air, 250 V
C949	283-0211-00	B010100	B079999X	0.1 μF, Cer, 200 V, 10%
C953	290-0517-00	B010100	B079999X	6.8 μF, Elect., 35 V, 20%
C955	281-0091-00	B010100	B079999X	2-8 pF, Car, Cer
C990	290-0572-00	XB080000		0.1 μF, Elect., 50 V, 20%
C991	290-0135-00	B010100	B079999X	15 μF, Elect., 20 V, 20%
C992	290-0527-00	XB080000		15 μF, Elect., 20 V, 20%
C993	290-0135-00	B010100	B079999X	15 μF, Elect., 20 V, 20%

[1]Part of Circuit Board

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C994	290-0522-00	B010100	B079999	1 μF, Elect., 50 V, 20%
C994	290-0527-00	B080000		15 μF, Elect., 20 V, 20%
C995	283-0177-00	B010100	B079999X	1 μF, 25 V, +80%-20%
C996	290-0135-00	B010100	B079999	15 μF, Elect., 20 V, 20%
C996	290-0527-00	B080000		15 μF, Elect., 20 V, 20%
C997	283-0177-00	B010100	B079999X	1 μF, Cer, 25 V, +80%-20%
C998	283-0178-00	B010100	B079999	0.1 μF, Cer, 100 V, +80%-20%
C998	290-0572-00	B080000		0.1 μF, Elect., 50 V, 20%
C1001	281-0500-00			2.2 μF, Cer, 500 V, ±0.5 pF
C1008	283-0000-00			0.001 μF, Cer, 500 V, +100%-0%
C1026	290-0522-00			1 μF, Elect., 50 V, 20%
C1031	281-0547-00			2.7 pF, Cer, 500 V, 10%
C1033	281-0540-00			51 pF, Cer, 500 V, 5%
C1036	281-0547-00			2.7 pF, Cer, 500 V, 10%
C1038	281-0540-00			51 pF, Cer, 500 V, 5%
C1042	290-0522-00			1 μF, Elect., 50 V, 20%
C1046	290-0525-00	XB030000		4.7 μF, Elect., 50 V, 20%
C1049	281-0547-00			2.7 pF, Cer, 500 V, 10%
C1052	290-0522-00			1 μF, Elect., 50 V, 20%
C1055	290-0525-00	XB030000		4.7 μF, Elect., 50 V, 20%
C1056	281-0579-00			21 pF, Cer, 500 V, 5%
C1070	281-0123-00			5-25 pF, Var, Cer
C1104	283-0095-00			56 pF, Cer, 200 V, 10%
C1108	285-0824-00			0.047 μF, PTM, 100 V, 2%
C1114	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1125	283-0004-00			0.02 μF, Cer, 150 V
C1140	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1146	283-0000-00			0.001 μF, Cer, 500 V, +100%-0%
C1193	290-0522-00	B010100	B029999	1 μF, Elect., 50 V, 20%
C1193	290-0525-00	B030000		4.7 μF, Elect., 50 V, 20%
C1194	290-0523-00	B010100	B029999X	2.2 μF, Elect., 20 V, 20%
C1195	290-0525-00			4.7 μF, Elect., 50 V, 20%
C1197	290-0524-00	B010100	B029999	4.7 μF, Elect., 10 V, 20%
C1197	290-0525-00	B020000		4.7 μF, Elect., 50 V, 20%
C1201	283-0044-00	B010100	B010249	0.001 μF, Cer, 3000 V
C1201	283-0279-00	B010250		0.001 μF, Cer, 3000 V, 20%
C1203	283-0004-00	B010100	B010249	0.001 μF, Cer, 3000 V
C1203	283-0279-00	B010250		0.001 μF, Cer, 3000 V, 20%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C1205	283-0022-00			0.02 µF, Cer, 1400 V
C1206	283-0022-00			0.02 µF, Cer, 1400 V
C1216	290-0561-00	B010100	B029999	950 µF, Elect., 200 V, +50%-10%
C1216	290-0628-00	B030000		950 µF, Elect., 200 V, +50%-10%
C1217	290-0561-00	B010100	B029999	950 µF, Elect., 200 V, +50%-10%
C1217	290-0628-00	B030000		950 µF, Elect., 200 V, +50%-10%
C1219	283-0057-00			0.1 µF, Cer, 200 V, +80%-20%
C1227	283-0280-00			2200 pF, Cer, 2000 V, 10%
C1228	283-0280-00			2200 pF, Cer, 2000 V, 10%
C1229	285-0939-00			3 µF, PTM, 400 V, 5%
C1231	290-0395-00			4.7 µF, Elect., 50 V, 20%
C1235	283-0078-00			0.001 µF, Cer, 500 V, 20%
C1236	283-0280-00			2200 pF, Cer, 2000 V, 10%
C1237	285-0938-00			0.03 µF, PTM, 600 V, 5%
C1238	283-0279-00			0.001 µF, Cer, 3000 V, 20%
C1239	290-0395-00			4.7 µF, Elect., 50 V, 20%
C1242	283-0001-00			0.005 µF, Cer, 500 V
C1243	290-0159-00			2 µF, Elect., 150 V
C1245	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1249	290-0164-00			1 µF, Elect., 150 V
C1253	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1254	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1256	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1259	290-0523-00			2.2 µF, Elect., 20 V, 20%
C1264	290-0573-00			2.7 µF, Elect., 50 V, 20%
C1267	290-0523-00			2.2 µF, Elect., 20 V, 20%
C1275	283-0060-00			100 pF, Cer, 200 V, 5%
C1276	283-0060-00			100 pF, Cer, 200 V, 5%
C1277	290-0572-00			0.1 µF, Elect., 50 V, 20%
C1278	290-0572-00			0.1 µF, Elect., 50 V, 20%
C1285	283-0092-00			0.03 µF, Cer, 200 V, +80%-20%
C1291	283-0211-00	B010100	B029999X	0.1 µF, Cer, 200 V, 10%
C1298	283-0023-00			0.1 µF, Cer, 10 V, +80%-20%
C1300	283-0078-00			0.001 µF, Cer, 500 V, 20%
C1301	283-0078-00			0.001 µF, Cer, 500 V, 20%
C1302	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1313	290-0425-00			100 µF, Elect., 20 V, 20%
C1314	290-0529-00			47 µF, Elect., 20 V, 20%
C1316	290-0425-00			100 µF, Elect., 20 V, 20%
C1317	290-0519-00			100 µF, Elect., 20 V, 20%
C1318	290-0529-00	B010100	B029999	47 µF, Elect., 20 V, 20%
C1318	290-0519-00	B030000		100 µF, Elect., 20 V, 20%
C1326	283-0211-00	XB030000		0.1 µF, Cer, 200 V, 10%
C1328	290-0149-00	B010100	B010334	5 µF, Elect., 150 V
C1328	290-0582-00	B010335		5 µF, Elect., 150 V, +75%-10%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C1330	290-0149-00	B010100	B010334	5 μF, Elect., 150 V
C1330	290-0582-00	B010335		5 μF, Elect., 150 V, +75%-10%
C1331	283-0057-00			0.1 μF, Cer, 200 V, +80%-20%
C1350	290-0425-00			100 μF, Elect., 20 V, 20%
C1351	290-0425-00			100 μF, Elect., 20 V, 20%
C1353	290-0529-00			47 μF, Elect., 20 V, 20%
C1354	290-0529-00			47 μF, Elect., 20 V, 20%
C1358	290-0194-00			10 μF, Elect., 100 V
C1360	290-0716-00			8.2 μF, Elect.,74 V, 20%
C1362	290-0194-00			10 μF, Elect., 100 V
C1364	290-0716-00			8.2 μF, Elect.,74 V, 20%
C1371	290-0572-00			0.1 μF, Elect., 50 V, 20%
C1392	283-0057-00			0.1 μF, Elect., 200 V, +80%-20%
C1395	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1397	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1413	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1416	283-0047-00	B010100	B010144	270 pF, Cer, 500 V, 5%
C1416	283-0084-00	B010145		270 pF, Cer, 1000 V, 5%
C1436	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1441	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1451	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1463	283-0078-00	XB010200		0.001 μF, Cer, 500 V, 20%
C1481	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1495	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1506	283-0068-00			0.01 μF, Cer, 500 V, +100%-0%
C1511	290-0572-00			0.1 μF, Elect., 50 V, 20%
C1518	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1533	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1571	283-0128-00			100 pF, Cer, 500 V, 5%
C1605	283-0006-00			0.02 μF, Cer, 500 V, +80%-20%
C1606	283-0105-00			0.01 μF, Cer, 2000 V, +80%-20%
C1607	283-0105-00			0.01 μF, Cer, 2000 V, +80%-20%
C1608	283-0272-00			0.0068 μF, Cer, 4000 V, 30%
C1609	283-0272-00			0.0068 μF, Cer, 4000 V, 30%
C1612	283-0272-00			0.0068 μF, Cer, 4000 V, 30%
C1629	283-0000-00			0.001 μF, Cer, 500 V, +100%-0%
C1634	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1635	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1637	283-0000-00			0.001 μF, Cer, 500 V, +100%-0%
C1642	283-0271-00			0.001 μF, Cer, 4000 V, 20%
C1653	283-0079-00			0.01 μF, Cer, 250 V, 20%
C1654	283-0279-00			0.001 μF, Cer, 3000 V, 20%
C1656	283-0279-00			0.001 μF, Cer, 3000 V, 20%
C1657	283-0078-00			0.001 μF, Cer, 500 V, 20%
C1659	283-0279-00			0.001 μF, Cer, 3000 V, 20%
C1676	283-0092-00			0.03 μF, Cer, 200 V, +80%-20%
C1678	283-0271-00			0.001 μF, Cer, 4000 V, 20%
C1680	283-0271-00			0.001 μF, Cer, 4000 V, 20%
C1681	283-0104-00			2000 pF, Cer, 500 V, 5%
C1716	283-0272-00			0.0068 μF, Cer, 4000 V, 30%
C1727	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1729	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1733	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%
C1736	283-0003-00			0.01 μF, Cer, 150 V, +80%-20%

ELECTRIAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C1762	283-0001-00			0.005 µF, Cer, 500 V
C1765	283-0001-00			0.005 µF, Cer, 500 V
C1770	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1778	283-0271-00			0.001 µF, Cer, 4000 V, 20%
C1805	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1820	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1824	281-0609-00	XB130000		1 pF, Cer, 500 V, +/-0.1pF
C1829	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1841	281-0549-00	B010100	B129999	68 pF, Cer, 500 V, 10%
C1841	281-0550-00	B130000		120 pF, 500 V, 10%
C1842	281-0118-00			8-90 pF, Var, Mica
C1844	281-0637-00			91 pF, Cer, 500 V, 5%
C1846	281-0118-00			8-90 pF, Var, Mica
C1850	283-0178-00			0.1 µF, Cer, 100 V, +80%-20%
C1856	290-0149-00			5 µF, Elect., 150 V
C1857	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C1871	281-0092-00			9-35 pF, Var, Cer
C1873	281-0619-00			1.2 pF, Cer, 200 V, +/-0.1 pF
C1877	283-0003-00	B010100	B129999	0.01 µF, Cer, 150 V, +80%-20%
C1877	283-0000-00	B130000		0.001 µF, Cer, 500 V, +100%-0%
C1883	281-0627-00			1 pF, Cer, 600 V
C1884	283-0271-00			0.001 µF, Cer, 4000 V, 20%
C1890	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1892	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1893	290-0529-00	B010100	B129999	47 µF, Elect., 20 V, 20%
C1893	290-0539-00	B130000		47 µF, Elect., 20 V, 20%
C1894	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1895	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1896	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1897	290-0529-00	B010100	B129999	47 µF, Elect., 20 V, 20%
C1897	290-0539-00	B130000		47 µF, Elect., 20 V, 20%
C1898	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C1899	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C2101	283-0004-00			0.02 µF, Cer, 150 V
C2109	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C2112	283-0077-00			330 pF, Cer, 500 V, 5%
C2115	290-0534-00			1 µF, Elect., 35 V, 20%
C2117	290-0534-00			1 µF, Elect., 35 V, 20%
C2119	290-0534-00			1 µF, Elect., 35 V, 20%
C2121	283-0594-00			0.001 µF, Mica, 100 V, 1%
C2135	285-0698-00			0.0082 µF, PTM, 100 V, 5%
C2140	283-0103-00			180 pF, Cer, 500 V, 5%
C2144	281-0544-00			5.6 pF, Cer, 500 V, 10%
C2145	290-0534-00			1 µF, Elect., 35 V, 20%
C2155	283-0103-00			180 pF, Cer, 500 V, 5%
C2183	283-0032-00			470 pF, Cer, 500 V, 5%
C2185	283-0004-00			0.02 µF, Cer, 150 V
C2214	283-0032-00			470 pF, Cer, 500 V, 5%
C2242	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C2244	283-0004-00			0.02 µF, Cer, 150 V
C2255	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C2281	283-0054-00	XB120000		150 µF, Cer, 200 V, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES				
CR20	152-0141-02			Silicon, replaceable by 1N4152
CR23	152-0141-02			Silicon, replaceable by 1N4152
CR27	152-0141-02			Silicon, replaceable by 1N4152
CR28	152-0141-02			Silicon, replaceable by 1N4152
CR29	152-0141-02			Silicon, replaceable by 1N4152
CR34	152-0141-02			Silicon, replaceable by 1N4152
CR36	152-0141-02			Silicon, replaceable by 1N4152
CR40	152-0141-02			Silicon, replaceable by 1N4152
CR121	152-0423-00			Silicon, replaceable by MR1033B
CR122	152-0423-00			Silicon, replaceable by MR1033B
CR201	152-0141-02			Silicon, replaceable by 1N4152
CR202	152-0141-02			Silicon, replaceable by 1N4152
CR203	152-0141-02			Silicon, replaceable by 1N4152
CR204	152-0141-02			Silicon, replaceable by 1N4152
CR239	152-0141-02			Silicon, replaceable by 1N4152
CR240	152-0153-00			Silicon, replaceable by FD7003 or CD5574
CR241	152-0153-00			Silcion, replaceable by FD7003 or CD5574
CR248	152-0141-02			Silicon, replaceable by 1N4152
CR250	152-0141-02			Silicon, replaceable by 1N4152
CR251	152-0141-02			Silicon, replaceable by 1N4152
CR253	152-0141-02			Silicon, replaceable by 1N4152
CR254	152-0141-02			Silicon, replaceable by 1N4152
CR264	152-0141-02			Silicon, replaceable by 1N4152
CR265	152-0141-02			Silicon, replaceable by 1N4152
CR314	152-0141-02			Silicon, replaceable by 1N4152
CR343	152-0141-02			Silicon, replaceable by 1N4152
CR346	152-0141-02			Silicon, replaceable by 1N4152
CR349	152-0141-02			Silicon, replaceable by 1N4152
CR350	152-0141-02			Silicon, replaceable by 1N4152
CR360	152-0141-02			Silicon, replaceable by 1N4152
CR365	152-0141-02			Silicon, replaceable by 1N4152
CR420	152-0141-02			Silicon, replaceable by 1N4152
CR421	152-0141-02			Silicon, replaceable by 1N4152
CR422	152-0141-02			Silicon, replaceable by 1N4152
CR426	152-0141-02			Silicon, replaceable by 1N4152
CR440	152-0141-02			Silicon, replaceable by 1N4152
CR442	152-0141-02			Silicon, replaceable by 1N4152
CR447	152-0141-02			Silicon, replaceable by 1N4152
CR454	152-0141-02			Silicon, replaceable by 1N4152
CR456	152-0141-02			Silicon, replaceable by 1N4152
CR457	152-0141-02			Silicon, replaceable by 1N4152
CR458	152-0075-00			Germanium, replaceable by GD238 or ED48
CR460	152-0141-02			Silicon, replaceable by 1N4152
CR461	152-0141-02			Silicon, replaceable by 1N4152
CR465	152-0141-02			Silicon, replaceable by 1N4152
CR474	152-0141-02			Silicon, replaceable by 1N4152
CR479	152-0141-02			Silicon, replaceable by 1N4152
CR486	152-0141-02			Silicon, replaceable by 1N4152
CR489	152-0141-02			Silicon, replaceable by 1N4152
CR491	152-0075-00			Germanium, replaceable by GD238 or ED48
CR493	152-0141-02			Silicon, replaceable by 1N4152

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR494	152-0141-02			Silicon, replaceable by 1N4152
CR495	152-0141-02			Silicon, replaceable by 1N4152
CR503	152-0141-02			Silicon, replaceable by 1N4152
CR519	152-0141-02			Silicon, replaceable by 1N4152
CR569	152-0141-02			Silicon, replaceable by 1N4152
CR583	152-0141-02	B010100	B099999X	Silicon, replaceable by 1N4152
CR584	152-0141-02	B010100	B099999X	Silicon, replaceable by 1N4152
CR615	152-0141-02			Silicon, replaceable by 1N4152
CR787	152-0141-02	XB140000	B149999X	
CR801	152-0141-02			Silicon, replaceable by 1N4152
CR811	152-0141-02			Silicon, replaceable by 1N4152
CR863	152-0153-00	B010100	B079999X	Silicon, replaceable by FD7003 or CD5574
CR865	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR870	152-0153-00	B010100	B079999X	Silicon, replaceable by FD7003 or CD5574
CR873	152-0322-00	B010100	B079999X	Silicon, replaceable by A1108
CR874	152-0322-00	B010100	B079999X	Silicon, replaceable by A1108
CR883	152-0322-00	XB080000		Silicon, replaceable by A1108
CR887	152-0322-00	XB080000		Silicon, replaceable by A1108
CR888	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR889	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR893	152-0322-00	XB080000		Silicon, replaceable by A1108
CR896	152-0141-02	B010100	B079999X	Silicon, replaceable by 1N4152
CR897	152-0322-00	XB080000		Silicon, replaceable by A1108
CR898	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR899	152-0141-02			Silicon, replaceable by 1N4152
CR902	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR908	152-0141-02	XB080000		Silicon, replaceable by 1N4152
CR922	152-0061-00	B010100	B079999X	Silicon, replaceable by CD8393 or FDH2161
CR923	152-0061-00	B010100	B079999X	Silicon, replaceable by CD8393 or FDH2161
CR952	152-0061-00	B010100	B079999X	Silicon, replaceable by CD8393 or FDH2161
CR953	152-0061-00	B010100	B079999X	Silicon, replaceable by CD8393 or FDH2161
CR1022	152-0141-02			Silicon, replaceable by 1N4152
CR1024	152-0141-02			Silicon, replaceable by 1N4152
CR1042	152-0141-02			Silicon, replaceable by 1N4152
CR1044	152-0141-02			Silicon, replaceable by 1N4152
CR1081	152-0141-02			Silicon, replaceable by 1N4152
CR1086	152-0141-02	B010100	B010261	Silicon, replaceable by 1N4152
CR1086	152-0153-00	B010262		Silicon, replaceable by CD7003 or CD5574
CR1087	152-0141-02			Silicon, replaceable by 1N4152
CR1119	152-0025-00			Silicon, replaceable by 1N634
CR1129	152-0141-02			Silicon, replaceable by 1N4152
CR1215	152-0396-01			Silicon, selected from W603
CR1232	152-0107-00			Silicon, replaceable by TI60 or 1N647
CR1234	152-0400-00			Silicon, replaceable by 1N936
CR1238	152-0401-00			Silicon, replaceable by MPT32

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR1240	152-0107-00			Silicon, replaceable by TI60 or 1N647
CR1241	152-0400-00			Silicon, replaceable by 1N936
CR1242	152-0107-00			Silicon, replaceable by TI60 or 1N647
CR1244	152-0107-00			Silicon, replaceable by TI60 or 1N647
CR1249	152-0061-00			Silicon, replaceable by CD8393 or FDH2161
CR1251	152-0061-00			Silicon, replaceable by CD8393 or FDH2161
CR1252	152-0061-00			Silicon, replaceable by CD8393 or FDH2161
CR1253	152-0141-02			Silicon, replaceable by 1N4152
CR1256	152-0141-02			Silicon, replaceable by 1N4152
CR1259	152-0141-02			Silicon, replaceable by 1N4152
CR1280	152-0333-00			Silicon, replaceable by FDH6012
CR1281	152-0333-00			Silicon, replaceable by FDH6012
CR1282	152-0333-00			Silicon, replaceable by FDH6012
CR1283	152-0333-00			Silicon, replaceable by FDH6012
CR1288	152-0333-00			Silicon, replaceable by FDH6012
CR1289	152-0333-00			Silicon, replaceable by FDH6012
CR1290	152-0333-00			Silicon, replaceable by FDH6012
CR1291	152-0061-00	B010100	B029999X	Silicon, replaceable by CD8393 or FDH2161
CR1292	152-0061-00	XB010600	B029999X	Silicon, replaceable by CD8393 or FDH2161
CR1294	152-0141-02			Silicon, replaceable by 1N4152
CR1306	152-0141-02			Silicon, replaceable by 1N4152
CR1310	152-0397-00			Silicon, selected from MR880
CR1311	152-0502-00			Silicon, replaceable by MBD5300
CR1312	152-0502-00			Silicon, replaceable by MBD5300
CR1313	152-0397-00			Silicon, selected from MR880
CR1320	152-0413-00	B010100	B039999	Silicon, replaceable by MR814
CR1320[1]	153-0052-00	B040000		Silicon, matched set of 4
CR1321	152-0413-00	B010100	B039999	Silicon, replaceable by MR814
CR1321[1]	153-0052-00	B040000		Silicon, matched set of 4
CR1322	152-0413-00	B010100	B039999	Silicon, replaceable by MR880
CR1322[1]	153-0052-00	B040000		Silicon, matched set of 4
CR1323	152-0413-00	B010100	B039999	Silicon, replaceable by MR880
CR1323[1]	153-0052-00	B040000		Silicon, matched set of 4
CR1325	152-0061-00	XB030000		Silicon, replaceable by CD8393 or FDH2161
CR1326	152-0061-00	XB030000		Silicon, replaceable by CD8393 or FDH2161
CR1340	152-0413-00			Silicon, replaceable by MR814
CR1341	152-0413-00			Silicon, replaceable by MR814
CR1342	152-0413-00			Silicon, replaceable by MR814
CR1343	152-0413-00			Silicon, replaceable by MR814
CR1345	152-0397-00			Silicon, selected from MR880
CR1346	152-0397-00			Silicon, selected from MR880
CR1347	152-0397-00			Silicon, selected from MR880
CR1348	152-0397-00			Silicon, selected from MR880

CR1320, CR1321, CR1322 and CR1323 furnished as a unit S/N B040000-up.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR1376	152-0141-02			Silicon, replaceable by 1N4152
CR1378	152-0141-02			Silicon, replaceable by 1N4152
CR1402	152-0141-02			Silicon, replaceable by 1N4152
CR1410	152-0141-02			Silicon, replaceable by 1N4152
CR1429	152-0066-01			Silicon, replaceable by 1N3194
CR1431	152-0141-02			Silicon, replaceable by 1N4152
CR1439	152-0141-02			Silicon, replaceable by 1N4152
CR1445	152-0141-02			Silicon, replaceable by 1N4152
CR1459	152-0066-01			Silicon, replaceable by 1N3194
CR1468	152-0141-02			Silicon, replaceable by 1N4152
CR1469	152-0141-02			Silicon, replaceable by 1N4152
CR1482	152-0141-02			Silicon, replaceable by 1N4152
CR1483	152-0141-02			Silicon, replaceable by 1N4152
CR1489	152-0141-02			Silicon, replaceable by 1N4152
CR1499	152-0066-01			Silicon, replaceable by 1N3194
CR1502	152-0141-02			Silicon, replaceable by 1N4152
CR1503	152-0141-02			Silicon, replaceable by 1N4152
CR1506	152-0233-00			Silicon, replaceable by CD61128
CR1510	152-0141-02			Silicon, replaceable by 1N4152
CR1520	152-0141-02			Silicon, replaceable by 1N4152
CR1521	152-0141-02			Silicon, replaceable by 1N4152
CR1523	152-0141-02			Silicon, replaceable by 1N4152
CR1539	152-0066-01			Silicon, replaceable by 1N3194
CR1543	152-0075-00			Germanium, replaceable by GD238 or ED48
CR1549	152-0141-02			Silicon, replaceable by 1N4152
CR1576	152-0141-02			Silicon, replaceable by 1N4152
CR1589	152-0066-01			Silicon, selected from 1N3194
CR1607	152-0409-00			Silicon, replaceable by VG-12X
CR1608	152-0409-00			Silicon, replaceable by VG-12X
CR1625	152-0066-01			Silicon, selected from 1N3194
CR1632	152-0141-02			Silicon, replaceable by 1N4152
CR1635	152-0141-02			Silicon, replaceable by 1N4152
CR1638	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1639	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR1653	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1655	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1656	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1658	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1676	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1679	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1680	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1682	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1701	152-0242-00			Silicon, selected from 1N486A or replaceable by CD12691
CR1753	152-0141-02			Silicon, replaceable by 1N4152
CR1754	152-0141-02			Silicon, replaceable by 1N4152
CR1764	152-0141-02			Silicon, replaceable by 1N4152
CR1768	152-0066-01			Silicon, selected from 1N3194
CR1771	152-0141-02			Silicon, replaceable by 1N4152
CR1822	152-0141-02			Silicon, replaceable by 1N4152
CR1828	152-0141-02			Silicon, replaceable by 1N4152
CR1844	152-0141-02			Silicon, replaceable by 1N4152
CR1845	152-0141-02			Silicon, replaceable by 1N4152
CR1855	152-0141-02			Silicon, replaceable by 1N4152
CR1858	152-0233-00			Silicon, replaceable by CDG1128
CR1872	**152-0141-02**	**XB130000**		**Silicon, replaceable by 1N4152**
CR2124	**151-0141-02**			**Silicon, replaceable by 1N4152**
CR2125	152-0141-02			Silicon, replaceable by 1N4152
CR2127	152-0141-02			Silicon, replaceable by 1N4152
CR2140	152-0141-02			Silicon, replaceable by 1N4152
CR2141	152-0141-02			Silicon, replaceable by 1N4152
CR2142	152-0141-02			Silicon, replaceable by 1N4152
CR2145	152-0141-02			Silicon, replaceable by 1N4152
CR2146	152-0141-02			Silicon, replaceable by 1N4152
CR2156	152-0141-02			Silicon, replaceable by 1N4152
CR2157	152-0141-02			Silicon, replaceable by 1N4152
CR2162	152-0141-02			Silicon, replaceable by 1N4152
CR2163	152-0141-02			Silicon, replaceable by 1N4152
CR2166	152-0141-02			Silicon, replaceable by 1N4152
CR2167	152-0141-02			Silicon, replaceable by 1N4152
CR2170	152-0141-02			Silicon, replaceable by 1N4152
CR2171	152-0141-02			Silicon, replaceable by 1N4152
CR2174	152-0141-02			Silicon, replaceable by 1N4152
CR2175	152-0141-02			Silicon, replaceable by 1N4152
CR2192	152-0141-02			Silicon, replaceable by 1N4152
CR2193	152-0141-02			Silicon, replaceable by 1N4152
CR2196	152-0141-02			Silicon, replaceable by 1N4152
CR2198	152-0141-02			Silicon, replaceable by 1N4152
CR2226	152-0141-02			Silicon, replaceable by 1N4152
VR235	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
VR884	152-0306-00	XB080000	B099999	Zener, replaceable by 1N960B,0.4W,9.1V,5%
VR884	152-0611-00	B100000		Zener, 0.4W,9V,2%
VR894	152-0306-00	XB080000	B099999	Zener, replaceable by 1N960B,0.4W,9.1V,5%
VR894	152-0611-00	B100000		Zener, 0.4W,9V,2%

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ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
VR1246	152-0287-00			Zener, replaceable by 1N986B, 0.4 W, 100 V, 5%
VR1253	152-0149-00			Zener, replaceable by 1N961B, 0.4 W, 10 V, 5%
VR1279	152-0243-00	B010100	B069999	Zener, replaceable by 1N965B, 0.4 W, 15 V, 5%
VR1279	152-0304-00	B070000		Zener, replaceable by 1N986B, 0.4 W, 20 V, 5%
VR1297	152-0212-00			Zener, selected from 1N936, 0.5 W, 9 V, 5%
VR1401	152-0226-00			Zener, selected from 1N751A, 0.4 W, 5.1 V, 5%
VR1461	152-0226-00			Zener, selected from 1N751A, 0.4 W, 5.1 V, 5%
VR1501	152-0127-00			Zener, replaceable by 1N755A, 0.4 W, 7.5 V, 5%
VR1505	152-0212-00			Zener, selected from 1N936, 0.5 W, 9 V, 5%
VR1635	152-0255-00			Zener, replaceable by 1N978B, 0.4 W, 51 V, 5%
VR1701	152-0247-00			Zener, replaceable by 1N989B, 0.4 W, 150 V, 5%
VR2262	152-0405-00			Zener, replaceable by 1N5567B, 1 W, 15 V, 5%
VR2263	152-0405-00			Zener, replaceable by 1N5567B, 1 W, 15 V, 5%
VR2264	152-0405-00			Zener, replaceable by 1N5567B, 1 W, 15 V, 5%
DELAY LINE				
DL650	119-0318-00			Delay Line
BULBS				
DS100	150-0057-00			Incandescent, 7153AS15
DS102	150-0057-00			Incandescent, 7153AS15
DS104	150-0057-00			Incandescent, 7153AS15
DS106	150-0057-00			Incandescent, 7153AS15
DS108	150-0057-00			Incandescent, 7153AS15
DS110	150-0057-01			Incandescent, 7153AS15, selected
DS112	150-0057-01			Incandescent, 7153AS15, selected
DS114	150-0057-01			Incandescent, 7153AS15, selected
DS116	150-0057-00			Incandescent, 7153AS15, selected
DS120	150-0048-00			Incandescent, #683
DS122	150-0048-00			Incandescent, #683
DS452	150-0048-01			Incandescent, #683, selected
DS466	150-0048-01			Incandescent, #683, selected
DS469	150-0048-01			Incandescent, #683, selected
DS497	150-0048-01			Incandescent, #683, selected
DS505	150-0048-01			Incandescent, #683, selected
DS507	150-0048-01			Incandescent, #683, selected
DS1208	119-0181-00			Surge Voltage Protector
DS1213	119-0181-00			Surge Voltage Protector
DS1219	150-0035-00			Neon, AID-T, 0.3 mA
DS1552	150-0029-00			Incandescent, GE349
DS1553	150-0029-00			Incandescent, GE349
DS1554	150-0029-00			Incandescent, GE349
DS1663	150-0035-00	B010100	B029999X	Neon, AID-T, 0.3 mA
DS1664	150-0035-00	B010100	B029999X	Neon, AID-T, 0.3 mA
DS1687	150-0035-00			Neon, AID-T, 0.3 mA
DS1688	150-0035-00			Neon, AID-T, 0.3 mA
DS1718	150-0030-00			Neon, NE 2 V
DS1719	150-0030-00			Neon, NE 2 V
FUSES				
F1201	159-0082-00			15A, 1AG, fast-blo
F1200	159-0017-00			4A, 3AG, fast-blo
F1223	159-0021-00			2A, 3AG, fast-blo

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CONNECTORS				
J1	131-0767-05			Receptacle, electrical
J2	131-0767-05			Receptacle, electrical
J3	131-0767-03			Receptacle, electrical
J4	131-0767-04			Receptacle, electrical
J7	131-1003-00			Receptacle, coaxial cable
J8	131-1003-00			Receptacle, coaxial cable
J9	131-1003-00			Receptacle, coaxial cable
J17	131-1003-00			Receptacle, coaxial cable
J18	131-1003-00			Receptacle, coaxial cable
J19	131-1003-00			Receptacle, coaxial cable
J30	131-1003-00			Receptacle, coaxial cable
J35	131-1003-00			Receptacle, coaxial cable
J60	131-1003-00			Receptacle, coaxial cable
J64	131-1003-00			Receptacle, coaxial cable
J71	131-1003-00			Receptacle, coaxial cable
J75	131-1003-00			Receptacle, coaxial cable
J90	136-0089-00			Socket, 9 pin, chassis mounted
J92	131-1003-00			Receptacle, coaxial cable
J94	131-0771-00			Receptacle, electrical
J95	131-0771-00			Receptacle, electrical
J97	131-0955-00			Receptacle, electrical, BNC, female
J98	131-1003-00			Receptacle, coaxial, cable
J100	136-0454-00			Socket, circuit board
J110	136-0454-00			Socket, circuit board
J155	136-0454-00			Socket, circuit board
J195	136-0454-00			Socket, circuit board
J401	131-1003-00			Receptacle, coaxial cable
J402	131-0391-00			Receptacle, electrical
J403	131-0391-00			Receptacle, electrical
J405	131-1003-00			Receptacle, coaxial cable
J406	131-0391-00			Receptacle, electrical
J407	131-0391-00			Receptacle, electrical
J409	131-1003-00			Receptacle, coaxial cable
J410	131-0391-00			Receptacle, electrical
J411	131-0391-00			Receptacle, electrical
J413	131-1003-00			Receptacle, coaxial cable
J414	131-0391-00			Receptacle, electrical
J415	131-0391-00			Receptacle, electrical
J592	131-1003-00			Receptacle, coaxial cable
J596	131-1003-00			Receptacle, coaxial cable
J601/J602	103-0146-00	B010100	B019999X	Adapter, connector
J601	131-1003-00	XB020000		Receptacle, coaxial cable
J604/J605	103-0146-00	B010100	B019999X	Adapter, connector
J604	131-1003-00	XB020000		Receptacle, coaxial cable
J607/J608	103-0146-00	B010100	B019999X	Adapter, connector
J607	131-1003-00	XB020000		Receptacle, coaxial cable
J610/J611	103-0146-00	B010100	B019999X	Adapter, connector
J610	131-1003-00	XB020000		Receptacle, coaxial cable
J643	131-1003-00			Receptacle, coaxial cable
J645	131-1003-00			Receptacle, coaxial cable
J660	131-1003-00			Receptacle, coaxial cable
J661	131-1003-00			Receptacle, coaxial cable
J690	131-1003-00			Receptacle, coaxial cable
J704	131-1003-00			Receptacle, coaxial cable

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CONNECTORS (cont)				
J719	131-1003-00			Receptacle, coaxial cable
J848	131-1003-00			Receptacle, coaxial cable
J849	131-1003-00			Receptacle, coaxial cable
J850	131-1003-00	XB080000		Receptacle, coaxial cable
J851	131-1003-00	B010100	B079999X	Receptacle, coaxial cable
J853	131-1003-00	XB080000		Receptacle, coaxial cable
J854	131-1003-00			Receptacle, coaxial cable
J876	131-1003-00	B010100	B079999X	Receptacle, coaxial cable
J1000	131-1003-00			Receptacle, coaxial cable
J1002	131-1003-00			Receptacle, coaxial cable
J1028	131-1003-00			Receptacle, coaxial cable
J1030	131-1003-00			Receptacle, coaxial cable
J1035	131-1003-00			Receptacle, coaxial cable
J1058	131-1003-00			Receptacle, coaxial cable
J1060	131-1003-00			Receptacle, coaxial cable
J1064	131-1003-00			Receptacle, coaxial cable
J1075	131-1003-00			Receptacle, coaxial cable
J1088	131-1003-00			Receptacle, coaxial cable
J1168	131-1003-00			Receptacle, coaxial cable
J1740	131-1003-00			Receptacle, coaxial cable
J1801	131-1003-00			Receptacle, coaxial cable
J1802	131-1003-00			Receptacle, coaxial cable
J2132	131-1003-00			Receptacle, coaxial cable
J2138	131-1003-00			Receptacle, coaxial cable
J2139	131-1003-00			Receptacle, coaxial cable
J2192	131-1003-00			Receptacle, coaxial cable
J2296	131-1003-00			Receptacle, coaxial cable
J2299	131-1003-00			Receptacle, coaxial cable
P402	131-0582-00			Receptacle, electrical
P403	131-0582-00			Receptacle, electrical
P406	131-0582-00			Receptacle, electrical
P407	131-0582-00			Receptacle, electrical
P410	131-0582-00			Receptacle, electrical
P411	131-0582-00			Receptacle, electrical
P414	131-0582-00			Receptacle, electrical
P415	131-0582-00			Receptacle, electrical
P601	131-1161-00	B010100	B019999	Plug, electrical, 50 Ω
P601	{210-0774-00	B020000		Plug, electrical
	{210-0775-00	B020000		Plug, electrical
P602	131-0582-00	B010100	B019999X	Receptacle, electrical
P604	131-1161-00	B010100	B019999	Plug, electrical, 50 Ω
P604	{210-0774-00	B020000		Plug, electrical
	{210-0775-00	B020000		Plug, electrical
P605	131-0582-00	B010100	B019999X	Receptacle, electrical
P607	131-1161-00	B010100	B019999	Plug, electrical, 50 Ω
P607	{210-0774-00	B020000		Plug, electrical
	{210-0775-00	B020000		Plug, electrical
P608	131-0582-00	B010100	B019999X	Receptacle, electrical
P610	131-1161-00	B010100	B019999	Plug, electrical, 50 Ω
P610	{210-0774-00	B020000		Plug, electrical
	{210-0775-00	B020000		Plug, electrical
P611	131-0582-00	B010100	B019999X	Receptacle, electrical
RELAYS				
K802	148-0034-00			Armature, DPDT, 15V DC
K805	148-0034-00			Armature, DPDT, 15V DC
K815	148-0034-00			Armature, DPDT, 15V DC

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INDUCTORS				
L216	108-0245-00			3.9 µH
L224	108-0245-00			3.9 µH
L228	108-0245-00			3.9 µH
L390	108-0245-00			3.9 µH
L393	108-0245-00			3.9 µH
L394	108-0245-00			3.9 µH
L396	108-0245-00			3.9 µH
L660	108-0250-00	B010100	B010230	0.1 µH
L660	108-0369-00	B010231		0.12 µH
L661	108-0250-00	B010100	B010230	0.1 µH
L661	108-0369-00	B010231		0.12 µH
L667	108-0146-00	B010100	B010230	5 µH
L667	114-0220-00	B010231	B129999	1-3 µH, Var, Core 276-0568-00
L667	114-0222-00	B130000		2-6 µH, Var
L802	108-0719-00			805 nH
L805	108-0719-00			805 nH
L806	108-0718-00			1.76 µH
L807	108-0719-00			805 µH
L808	108-0719-00			805 µH
L809	108-0718-00			1.75 µH
L812	108-0719-00			805 nH
L815	108-0719-00			805 nH
L816	108-0718-00			1.75 µH
L817	108-0719-00			805 nH
L818	108-0719-00			805 nH
L819	108-0718-00			1.76 µH
L857	120-0382-00	B010100	B079999X	Toroid, 14 turns, single
L991	108-0245-00	B010100	B079999X	3.9 µH
L992	108-0245-00	XB080000		3.9 µH
L993	108-0245-00	B010100	B079999X	3.9 µH
L994	108-0245-00	XB080000		3.9 µH
L996	108-0245-00			3.9 µH
L1201} L1203	108-0686-00			116 µH
L1229	108-0681-00			140 µH
L1237	108-0678-00			1 mH
L1313	108-0679-00			12 µH
L1316	108-0679-00			12 µH
L1318	108-0554-00			5 µH
L1329	108-0646-00			80 µH
L1352	108-0680-00			27 µH
L1355	108-0680-00			27 µH
L1359	108-0646-00			80 µH
L1363	108-0646-00			80 µH
L1725	108-0544-00			Beam Rotation
L1730	108-0546-00	B010100	B029999	Y-Axis Alignment
L1730	108-0605-00	B030000		Y-Axis Alignment
L2283	108-0331-00			0.75 µH
LR232	108-0543-00			1.1 µH
LR268	108-0543-00			1.1 µH
LR278	108-0543-00			1.1 µH
LR288	108-0543-00			1.1 µH
LR780	108-0685-00			80 nH (wound on a 180 Ω, 1/4 W, 5% resistor)
LR784	108-0685-00			,0 nH (wound on a 180 Ω, 1/4 W, 5% resistor)
LR787	108-0330-00	XB030000		0.4 µH (wound on a 56 Ω, 1/4 W, 5% resistor)
LR789	108-0325-00			0.5 µH (wound on a 100 Ω, 1/4 W, 5% resistor)
LR791	108-0325-00			0.5 µH (wound on a 100 Ω, 1/4 W, 5% resistor)
LR794	108-0325-00			0.5 µH (wound on a 100 Ω, 1/4 W, 5% resistor)
LR796	108-0325-00			0.5 µH (wound on a 100 Ω, 1/4 W, 5% resistor)
LR798	108-0325-00			9.5 µH (wound on a 100 Ω, 1/4 W, 5% resistor)

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
METER				
M69	149-0030-00	B010100	B079999X	Elapsed Time
TRANSISTORS				
Q238	151-0198-00			Silicon, NPN, replaceable by MPS918
Q248	151-0192-00			Silicon, NPN, selected from MPS6521
Q260	151-0198-00			Silicon, NPN, selected from MPS6521
Q272	151-0198-00			Silicon, NPN, selected from MPS6521
Q275	151-0223-00			Silicon, NPN, replaceable by 2N4275
Q282	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q292	151-0192-00			Silicon, NPN, selected from MPS6521
Q296	151-0192-00			Silicon, NPN, selected from MPS6521
Q312	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q342	151-0192-00			Silicon, NPN, selected from MPS6521
Q347	151-0192-00			Silicon, NPN, selected from MPS6521
Q350	151-0216-00			Silicon, PNP, replaceable by MPS6523
Q352	151-1022-00			Silicon, FET, selected from 2N4392
Q362	151-0192-00			Silicon, NPN, selected from MPS6521
Q367	151-0192-00			Silicon, NPN, selected from MPS6521
Q428	151-0192-00			Silicon, NPN, selected from MPS6521
Q430	151-0192-00			Silicon, NPN, selected from MPS6521
Q466	151-0192-00			Silicon, NPN, selected from MPS6521
Q469	151-0192-00			Silicon, NPN, selected from MPS6521
Q472	151-0192-00			Silicon, NPN, selected from MPS6521
Q476	151-0192-00			Silicon, NPN, selected from MPS6521
Q484	151-0192-00			Silicon, NPN, selected form MPS6521
Q500	151-0192-00			Silicon, NPN, selected from MPS6521
Q506	151-0192-00			Silicon, NPN, selected from MPS6521
Q521	151-0192-00			Silicon, NPN, selected from MPS6521
Q542	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q544	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q571	151-0192-00			Silicon, NPN, selected from MPS6521
Q592	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q596	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q616	151-0192-00			Silicon, NPN, selected from MPS6521
Q617	151-0192-00			Silicon, NPN, selected from MPS6521
Q694	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q698	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q705	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q710	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q716	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q723	151-0302-00			Silicon, NPN, replaceable by 2N2222A
Q728	151-0302-00			Silicon, NPN, replaceable by 2N2222A
Q773	151-0302-00			Silicon, NPN, replaceable by 2N2222A
Q776	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q785	**151-0390-00**	**XB150000**		**Silicon, NPN, replaceable by MPS-U45**
Q786	**151-0126-00**	**XB150000**		**Silicon, NPN, replaceable by 2N2484**
Q859	151-0190-00	XB080000		Silicon, NPN, replaceable by 2N3904 or TE3904
Q864	151-0271-00	B010100	B079999X	Silicon, PNP, replaceable by SAB4113
Q869	151-0271-00	B010100	B079999X	Silicon, PNP, replaceable by SAB4113
Q879	151-0221-00	XB080000		Silicon, PNP, replaceable by 2N4258
Q881	151-0221-00	XB080000		Silicon, PNP, replaceable by 2N4258
Q882	151-0271-00	B010100	B079999X	Silicon, PNP, replaceable by SAB4113
Q886	151-0271-00	B010100	B079999X	Silicon, PNP, replaceable by SAB4113
Q887	151-0367-00	XB080000		Silicon, NPN, replaceable by SKA6516
Q889	151-0271-00	B010100	B079999	Silicon, PNP, replaceable by SAB4113
Q889	151-0221-00	B080000		Silicon, PNP, replaceable by 2N4258
Q892	151-0269-00	B010100	B079999X	Silicon, NPN, replaceable by SE3005
Q895	151-0271-00	B010100	B079999X	Silicon, PNP, replaceable by SAB4113
Q897	151-0221-00	XB080000		Silicon, PNP, replaceable by 2N4258

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS (cont)				
Q899	151-0367-00	XB080000		Silicon, NPN, replaceable by SKA6516
Q900	151-0269-00	B010100	B079999X	Silicon, NPN, replaceable by SE3005
Q901	151-0369-00	XB080000		Silicon, PNP, replaceable by SKA66664
Q902	151-0369-00	XB080000		Silicon, PNP, replaceable by SKA66664
Q908	151-0270-00	B010100	B079999X	Silicon, PNP, selected from 2N3495
Q909	151-0424-00	XB080000		Silicon, NPN, replaceable by 2N5769
Q912	151-0270-00	XB080000		Silicon, PNP, selected from 2N3495
Q914	151-0274-00	B010100	B079999X	Silicon, NPN, replaceable by 2N3501
Q920	151-0220-00	B010100	B079999X	Silicon, PNP, replaceable by 2N4122
Q922	151-0274-00	XB080000		Silicon, NPN, replaceable by 2N3501
Q925	151-0220-00	XB080000		Silicon, PNP, replaceable by 2N4122
Q932	151-0274-00	XB080000		Silicon, NPN, replaceable by 2N3501
Q938	151-0274-00	B010100	B079999X	Silicon, NPN, replaceable by 2N3501
Q942	151-0270-00	XB080000		Silicon, PNP, selected from 2N3495
Q944	151-0270-00	B010100	B079999X	Silicon, PNP, selected from 2N3495
Q945	151-0190-00	XB080000		Silicon, NPN, replaceable by 2N3904 or TE3904
Q950	151-0190-00	B010100	B079999X	Silicon, NPN, replaceable by 2N3904 or TE3904
Q1013	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q1016	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q1021	151-0294-00			Silicon, PNP, replaceable by MMT4261 or SKH1029
Q1042	151-0224-00			Silicon, NPN, replaceable by 2N3692
Q1046	151-0221-00			Silicon, PNP, replaceable by 2N4258
Q1052	151-0221-00			Silicon, PNP, replaceable by 2N4258
Q1069	151-0127-00			Silicon, NPN, selected from 2N2369
Q1073	151-0127-00			Silicon, NPN, selected from 2N2369
Q1084	151-0271-00			Silicon, PNP, replaceable by SAB4113
Q1103	151-0273-00			Silicon, NPN, selected from 2N5249
Q1111	151-0273-00			Silicon, NPN, selected from 2N5249
Q1116	151-0224-00			Silicon, NPN, replaceable by 2N3692
Q1118	151-0224-00			Silicon, NPN, replaceable by 2N3692
Q1128	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1131	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1135	151-0276-00			Silicon, PNP, replaceable by 2N5087
Q1137	151-0276-00			Silicon, PNP, replaceable by 2N5087
Q1140	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1234	151-0368-00			Silicon, NPN, replaceable by RCA61577
Q1241	151-0368-00			Silicon, NPN, replaceable by RCA61577
Q1246	151-0260-00			Silicon, NPN, replaceable by 2N5189 or 2N5859
Q1248	151-0519-00			Silicon, SCR, replaceable by 2N5063
Q1252	151-0302-00			Silicon, NPN, replaceable by 2N2222A
Q1254	151-0302-00			Silicon, NPN, replaceab by 2N2222A
Q1373	151-0216-00			Silicon, PNP, replaceable by MPS6523
Q1409A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1415	151-0292-00			Silicon, NPN, replaceable by A5T5058
Q1418	151-0228-00			Silicon, PNP, selected from 2N4888
Q1425	151-0136-00			Silicon, NPN, replaceable by 2N3053
Q1428	151-0349-00			Silicon, NPN, selected from MJE2801 or SJE924
Q1436A,B	151-0232-00			Silicon, replaceable by NS7348 or selected from 2N2919, dual
Q1445	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1451	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1455	151-0260-02			Silicon, NPN, replaceable by 2N5189 or 2N5859
Q1458	151-0349-00			Silicon, NPN, selected from MJE2801 or replaceable SJE924
Q1466A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS (cont)				
Q1485	151-0216-00			Silicon, PNP, replaceable by MPS6523
Q1489A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1496	151-0260-02			Silicon, NPN, replaceable by 2N5189 or 2N5859, checked
Q1498	151-0349-00			Silicon, NPN, selected from MJE2801 or replaceable by SJE924
Q1508A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1522	151-0228-00			Silicon, PNP, selected from 2N4888
Q1526	151-0302-00			Silicon, NPN, replaceable by 2N2222A
Q1534	151-0136-00			Silicon, NPN, replaceable by 2N3053
Q1538	151-0349-00			Silicon, NPN, selected from MJE2801 or replaceable by SJE924
Q1546	151-0192-00			Silicon, NPN, selected from MPS6521
Q1550	151-0324-00	B010100	B129999	Silicon, PNP, replaceable by MJE371
Q1550	151-0324-01	B130000		Silicon, PNP, replaceable by MJE371
Q1560A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1576A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1582	151-0192-00			Silicon, NPN, selected from MPS6521
Q1585	151-0260-00			Silicon, NPN, replaceable by 2N5189 or 2N5859
Q1588	151-0349-00			Silicon, NPN, selected from MJE2801 or replaceable by SJE924
Q1627	151-0228-00			Silicon, PNP, selected from 2N4888
Q1631	151-0279-00			Silicon, NPN, replaceable by SE7056
Q1755	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1757	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1765	151-0228-00			Silicon, PNP, selected from 2N4888
Q1769	151-0292-00			Silicon, NPN, replaceable by A5T5058
Q1805	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1808	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1815	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1824	151-0224-00	B010100	B081987	Silicon, NPN, replaceable by 2N3692
Q1824	151-0192-00	B081988		Silicon, NPN, selected from MPS6521
Q1827	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1834	151-0271-00			Silicon, PNP, replaceable by SAB4113
Q1836	151-0271-00			Silicon, PNP, replaceable by SAB4113
Q1838	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q1854	151-0270-00			Silicon, PNP, selected from 2N3495
Q1874	151-0224-00	B010100	B081987	Silicon, NPN, replaceable by 2N3692
Q1874	151-0192-00	B081988		Silicon, NPN, selected from MPS6521
Q1876	151-0274-00			Silicon, NPN, replaceable by 2N3501
Q2108	151-0223-00			Silicon, NPN, replaceable by 2N4275
Q2112	151-0221-00			Silicon, PNP, replaceable by 2N4258
Q2138	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q2153	151-0192-00			Silicon, NPN, selected from MPS6521
Q2159	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q2215A,B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q2223	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q2225	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q2229	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q2240	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q2287	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q2296	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q2299	151-0188-00			Silicon, PNP, replaceable by 2N3906

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS				
R1	315-0470-00			47 Ω, 1/4 W, 5%
R2	315-0470-00			47 Ω, 1/4 W, 5%
R4	315-0470-00			47 Ω, 1/4 W, 5%
R6	315-0470-00			47 Ω, 1/4 W, 5%
R8	315-0470-00			47 Ω, 1/4 W, 5%
R10	321-0260-00			4.99 kΩ, 1/8 W, 1%
R12	321-0260-00			4.99 kΩ, 1/8 W, 1%
R14	321-0260-00			4.99 kΩ, 1/8 W, 1%
R16	321-0260-00			4.99 kΩ, 1/8 W, 1%
R20	315-0105-00	B010100	B069999	1 MΩ, 1/4 W, 5%
R20	315-0104-00	B070000	B129999	100 kΩ, 1/4 W, 5%
R20	315-0105-00	B130000		1 MΩ, 1/4 W, 5%
R21	315-0334-00	B010100	B069999X	330 kΩ, 1/4 W, 5%
R23	315-0105-00	B010100	B069999	1 MΩ, 1/4 W, 5%
R23	315-0104-00	B070000		100 kΩ, 1/4 W, 5%
R24	315-0334-00	B010100	B069999X	330 kΩ, 1/4 W, 5%
R26	315-0151-00	B010100	B069999	150 Ω, 1/4 W, 5%
R26	315-0152-00	B070000		1.5 kΩ, 1/4 W, 5%
R27	315-0683-00	B010100	B069999	68 kΩ, 1/4 W, 5%
R27	315-0243-00	B070000		24 kΩ, 1/4 W, 5%
R31	321-0068-00			49.9 Ω, 1/8 W, 1%
R32	321-0068-00			49.9 Ω, 1/8 W, 1%
R34	315-0472-00			4.7 kΩ, 1/4 W, 5%
R36	321-0239-00			3.01 kΩ, 1/8 W, 1%
R37	321-0222-00			2 kΩ, 1/8 W, 1%
R40	321-0222-00			2 kΩ, 1/8 W, 1%
R42	321-0222-00			2 kΩ, 1/8 W, 1%
R44	321-0204-00			1.3 kΩ, 1/8 W, 1%
R46	321-0204-00			1.3 kΩ, 1/8 W, 1%
R48	321-0231-00			2.49 kΩ, 1/8 W, 1%
R50	321-0231-00			2.49 kΩ, 1/8 W, 1%
R52	321-0204-00			1.3 kΩ1 1/8 W, 1%
R54	321-0204-00			1.3 kΩ, 1/8 W, 1%
R56	321-0068-00			49.9 Ω, 1/8 W, 1%
R58	321-0068-00			49.9 Ω, 1/8 W, 1%
R69	315-0395-00	B010100	B079999X	3.9 MΩ, 1/4 W, 5%
R98	323-0160-00			453 Ω, 1/2 W, 5%
R201	315-0202-00			2 kΩ, 1/4 W, 5%
R202	315-0202-00			2 kΩ, 1/4 W, 5%
R204	315-0332-00			3.3 kΩ, 1/4 W, 5%
R206	315-0223-00			22 kΩ, 1/4 W, 5%
R207	321-0193-00			1 kΩ, 1/8 W, 1%
R209	315-0223-00			22 kΩ, 1/4 W, 5%
R210	321-0193-00			1 kΩ, 1/8 W, 1%
R212	321-0147-00			332 Ω, 1/8 W, 1%
R213	321-0239-00			3.01 kΩ, 1/8 W, 1%
R214	315-0912-00			9.1 kΩ, 1/4 W, 5%
R216	315-0101-00			100 Ω, 1/4 W, 5%
R218	315-0512-00			5.1 kΩ, 1/4 W, 5%
R219	315-0512-00			5.1 kΩ, 1/4 W, 5%
R220	315-0101-00			100 Ω, 1/4 W, 5%
R222	321-0306-00			15 kΩ, 1/8 W, 1%
R224	315-0271-00			270 Ω, 1/4 W, 5%
R225	315-0332-00			3.3 kΩ, 1/4 W, 5%
R228	315-0271-00			270 Ω, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R229	315-0332-00			3.3 kΩ, 1/4 W, 5%
R233	315-0752-00			7.5 kΩ, 1/4 W, 5%
R235	315-0682-00			6.8 kΩ, 1/4 W, 5%
R236	315-0303-00			30 kΩ, 1/4 W, 5%
R237	315-0512-00			5.1 kΩ, 1/4 W, 5%
R239	315-0242-00			2.4 kΩ, 1/4 W, 5%
R241	321-0328-00			25.5 kΩ, 1/8 W, 1%
R242	321-0224-00			2.1 kΩ, 1/8 W, 1%
R243	321-0226-00			2.21 kΩ, 1/8 W, 1%
R245	321-0222-00			2 kΩ, 1/8 W, 1%
R246	315-0151-00			150 Ω, 1/4 W, 5%
R248	321-0210-00			1.5 kΩ, 1/8 W, 1%
R249	315-0151-00			150 Ω, 1/4 W, 5%
R250	315-0361-00			360 Ω, 1/4 W, 5%
R260	315-0202-00			2 kΩ, 1/4 W, 5%
R261	315-0202-00			2 kΩ, 1/4 W, 5%
R263	315-0512-00			5.1 kΩ, 1/4 W, 5%
R265	315-0332-00			3.3 kΩ, 1/4 W, 5%
R266	315-0152-00			1.5 kΩ, 1/4 W, 5%
R269	315-0152-00			1.5 kΩ, 1/4 W, 5%
R271	315-0102-00			1 kΩ, 1/4 W, 5%
R275	315-0222-00			2.2 kΩ, 1/4 W, 5%
R279	315-0332-00			3.3 kΩ, 1/4 W, 5%
R280	315-0152-00			1.5 kΩ, 1/4 W, 5%
R281	315-0103-00			10 kΩ, 1/4 W, 5%
R289	315-0332-00			3.3 kΩ, 1/4 W, 5%
R290	315-0302-00			3 kΩ, 1/4 W, 5%
R291	315-0303-00			30 kΩ, 1/4 W, 5%
R294	315-0222-00			2.2 kΩ, 1/4 W, 5%
R296	315-0332-00			3.3 kΩ, 1/4 W, 5%
R298	315-0301-00			300 Ω, 1/4 W, 5%
R299	315-0102-00			1 kΩ, 1/4 W, 5%
R303	315-0102-00			1 kΩ, 1/4 W, 5%
R304	315-0201-00			200 Ω, 1/4 W, 5%
R306	315-0103-00			10 kΩ, 1/4 W, 5%
R308	315-0153-00			15 kΩ, 1/4 W, 5%
R309	315-0201-00			200 Ω, 1/4 W, 5%
R312	315-0751-00			750 Ω, 1/4 W, 5%
R313	315-0103-00			10 kΩ, 1/4 W, 5%
R315	315-0683-00			68 kΩ, 1/4 W, 5%
R320	315-0201-00			200 Ω, 1/4 W, 5%
R325	321-0205-00			1.33 kΩ, 1/8 W, 1%
R328	315-0622-00			6.2 kΩ, 1/4 W, 5%
R329	315-0622-00			6.2 kΩ, 1/4 W, 5%
R331	315-0472-00			4.7 kΩ, 1/4 W, 5%
R333[1]	311-1195-00			5 kΩ, Var
R335	321-0239-00			3.01 kΩ, 1/8 W, 1%
R337	321-0239-00			3.01 kΩ, 1/8 W, 1%
R339	311-0973-00			5 kΩ, Var
R340	315-0103-00			10 kΩ, 1/4 W, 5%

[1]Furnished as a unit with R1700.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R342	315-0821-00			820 Ω, 1/4 W, 5%
R344	315-0152-00			1.5 kΩ, 1/4 W, 5%
R346	315-0822-00			8.2 kΩ, 1/4 W, 5%
R347	315-0132-00			1.3 kΩ, 1/4 W, 5%
R349	315-0302-00			3 kΩ, 1/4 W, 5%
R350	315-0271-00			270 Ω, 1/4 W, 5%
R351	315-0102-00			1 kΩ, 1/4 W, 5%
R353	315-0152-00			1.5 kΩ, 1/4 W, 5%
R354	311-0310-00			5 kΩ, Var
R355	315-0152-00			1.5 kΩ, 1/4 W, 5%
R361	321-0288-00			9.76 kΩ, 1/8 W, 1%
R364	321-0246-00			3.57 kΩ, 1/8 W, 1%
R366	321-0288-00			9.76 kΩ, 1/8 W, 1%
R369	321-0246-00			3.57 kΩ, 1/8 W, 1%
R372	315-0100-00			10 Ω, 1/4 W, 5%
R396	315-0100-00			10 Ω, 1/4 W, 5%
R401	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R402	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R403	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R405	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R406	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R407	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R409	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R410	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R411	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R413	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R414	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R415	321-0022-01			16.5 Ω, 1/8 W, 1/2%
R423	315-0102-00			1 kΩ, 1/4 W, 5%
R424	315-0911-00			910 Ω, 1/4 W, 5%
R426	315-0911-00			910 Ω, 1/4 W, 5%
R428	315-0911-00			910 Ω, 1/4 W, 5%
R430	315-0102-00			1 kΩ, 1/4 W, 5%
R432	315-0752-00			7.5 kΩ, 1/4 W, 5%
R434	315-0122-00			1.2 kΩ, 1/4 W, 5%
R436	315-0911-00			910 Ω, 1/4 W, 5%
R438	315-0681-00			680 Ω, 1/4 W, 5%
R439	315-0681-00			680 Ω, 1/4 W, 5%
R445	315-0132-00			1.3 kΩ, 1/4 W, 5%
R447	315-0751-00			750 Ω, 1/4 W, 5%
R449	315-0102-00			1 kΩ, 1/4 W, 5%
R450	315-0302-00			3 kΩ, 1/4 W, 5%
R461	315-0332-00			3.3 kΩ, 1/4 W, 5%
R463	315-0512-00			5.1 kΩ, 1/4 W, 5%
R465	315-0202-00			2 kΩ, 1/4 W, 5%
R467	315-0102-00			1 kΩ, 1/4 W, 5%
R471	315-0433-00			43 kΩ, 1/4 W, 5%
R474	315-0303-00			30 kΩ, 1/4 W, 5%
R477	315-0103-00			10 kΩ, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R479	315-0102-00			1 kΩ, 1/4 W, 5%
R481	315-0302-00			3 kΩ, 1/4 W, 5%
R482	315-0433-00			43 kΩ, 1/4 W, 5%
R486	315-0303-00			30 kΩ, 1/4 W, 5%
R488	315-0392-00			3.9 kΩ, 1/4 W, 5%
R494	315-0112-00			1.1 kΩ, 1/4 W, 5%
R499	315-0202-00			2 kΩ, 1/4 W, 5%
R501	315-0512-00			5.1 kΩ, 1/4 W, 5%
R504	315-0102-00			1 kΩ, 1/4 W, 5%
R510	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R512	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R514	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R516	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R517	315-0222-00			2.2 kΩ, 1/4 W, 5%
R518	321-0150-00			357 Ω, 1/8 W, 1%
R519	321-0165-00			511 Ω, 1/8 W, 1%
R523	322-0189-00			909 Ω, 1/4 W, 1%
R525	321-0213-00			1.62 kΩ, 1/8 W, 1%
R526	321-0213-00			1.62 kΩ, 1/8 W, 1%
R527	321-0213-00			1.62 kΩ, 1/8 W, 1%
R528	321-0213-00			1.62 kΩ, 1/8 W, 1%
R529	321-0213-00			1.62 kΩ, 1/8 W, 1%
R530	321-0213-00			1.62 kΩ, 1/8 W, 1%
R531	321-0213-00			1.62 kΩ, 1/8 W, 1%
R532	321-0213-00			1.62 kΩ, 1/8 W, 1%
R534	321-0040-00			25.5 Ω, 1/8 W, 1%
R536	317-0082-00			82 Ω, (nominal value) Selected
R537	321-0069-00			51.1 Ω, 1/8 W, 1%
R538	323-0097-00			100 Ω, 1/2 W, 1%
R539	321-0032-00			21 Ω, 1/8 W, 1%
R540	321-0069-00			51.1 Ω, 1/8 W, 1%
R542	323-0163-00			487 Ω, 1/2 W, 1%
R543	311-1259-00			100 Ω, Var
R544	323-0163-00			487 Ω, 1/2 W, 1%
R545	321-0070-00			52.3 Ω, 1/8 W, 1%
R546	315-0101-00			100 Ω, (nominal value) Selected
R548	315-0101-00			100 Ω, 1/4 W, 5%
R549	311-1261-00			500 Ω, Var
R551	323-0193-00			1 kΩ, 1/2 W, 1%
R552	317-0201-00			200 Ω, 1/8 W, 5%
R553	321-0075-00			59 Ω, 1/8 W, 1%
R554	321-0164-00			499 Ω, 1/8 W, 1%
R556	317-0201-00			200 Ω, 1/8 W, 5%
R557	323-0193-00			1 kΩ, 1/2 W, 1%
R558	321-0075-00			59 Ω, 1/8 W, 1%
R559	321-0164-00			499 Ω, 1/8 W, 1%
R560	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R562	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R564	325-0117-00			52.1 Ω, 1/20 W, 1/2%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R566	325-0117-00			52.1 Ω, 1/20 W, 1/2%
R567	315-0222-00			2.2 kΩ, 1/4 W, 5%
R568	321-0150-00			357 Ω, 1/8 W, 1%
R569	321-0165-00			511 Ω, 1/8 W, 1%
R572A	Selected	B010100	B010246	
R572A	317-0620-00	B010247		62 Ω, 1/8 W, 5%
R572B	Selected	B010100	B010246	
R572B	317-0620-00	B010247		62 Ω, 1/8 W, 5%
R572C	Selected	B010100	B010246	
R572C	317-0620-00	B010247		62 Ω, 1/8 W, 5%
R572D	Selected	B010100	B010246	
R572D	317-0620-00	B010247		62 Ω, 1/8 W, 5%
R573	322-0189-00			909 Ω, 1/4 W, 1%
R574	321-0040-00			25.5 Ω, 1/8 W, 1%
R575	321-0213-00			1.62 kΩ, 1/8 W, 1%
R576	321-0213-00			1.62 kΩ, 1/8 W, 1%
R577	321-0213-00			1.62 kΩ, 1/8 W, 1%
R578	321-0213-00			1.62 kΩ, 1/8 W, 1%
R579	321-0213-00			1.62 kΩ, 1/8 W, 1%
R580	321-0213-00			1.62 kΩ, 1/8 W, 1%
R581	321-0213-00			1.62 kΩ, 1/8 W, 1%
R582	321-0213-00			1.62 kΩ, 1/8 W, 1%
R583	323-0158-00			432 Ω, 1/2 W, 1%
R584	323-0158-00			432 Ω, 1/2 W, 1%
R585	321-0070-00			52.3 Ω, 1/8 W, 1%
R586	315-0131-00			130 Ω, (nominal value) Selected
R587	311-0605-00			200 Ω, Var
R588	315-0101-00			100 Ω, 1/4 W, 5%
R586	311-1261-00			500 Ω, Var
R591	323-0193-00			1 kΩ, 1/2 W, 1%
R592	317-0201-00			200 Ω, 1/8 W, 5%
R593	321-0075-00			59 Ω, 1/8 W, 1%
R594	321-0164-00			499 Ω, 1/8 W, 1%
R596	317-0201-00			200 Ω, 1/8 W, 5%
R597	323-0193-00			1 kΩ, 1/2 W, 1%
R598	321-0075-00			59 Ω, 1/8 W, 1%
R599	321-0164-00			499 Ω, 1/8 W, 1%
R602	Selected			
R603	325-0044-00			100 Ω, 1/20 W, 1/2%
R605	Selected			
R606	325-0044-00			100 Ω, 1/20 W, 1/2%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R608	Selected			
R609	325-0044-00			100 Ω, 1/20 W, 1/2%
R611	Selected			
R612	325-0044-00			100 Ω, 1/20 W, 1/2%
R613	321-0150-00			357 Ω, 1/8 W, 1%
R614	321-0120-00			174 Ω, 1/8 W, 1%
R615	321-0147-00			332 Ω, 1/8 W, 1%
R616	321-0210-00			1.5 kΩ, 1/8 W, 1%
R618	315-0302-00			3 kΩ, 1/4 W, 5%
R619	322-0189-00			909 Ω, 1/4 W, 1%
R620	315-0751-00	XB020000		750 Ω, (nominal value) Selected
R621	321-0133-00			237 Ω, 1/8 W, 1%
R622	Selected			
R623	315-0102-00	B010100	B019999	1 kΩ, 1/4 W, 5%
R623	315-0431-00	B020000		430 Ω, (nominal value) Selected
R624	321-0133-00			237 Ω, 1/8 W, 1%
R625	323-0131-00			226 Ω, 1/2 W, 1%
R626	315-0751-00	XB020000		750 Ω, (nominal value) Selected
R627	321-0133-00			237 Ω, 1/8 W, 1%
R628	Selected			
R629	315-0911-00	B010100	B019999	910 Ω, 1/4 W, 5%
R629	315-0911-00	B020000		910 Ω, (nominal value) Selected
R630	321-0133-00			237 Ω, 1/8 W, 1%
R631	323-0131-00			226 Ω, 1/2 W,
R632	315-0102-00	XB020000		1 kΩ, (nominal value) Selected
R633	321-0133-00			237 Ω, 1/8 W, 1%
R634	Selected			
R635	315-0911-00	B010100	B019999	910 Ω, 1/4 W, 5%
R635	315-0911-00	B020000		910 Ω, (nominal value) Selected
R636	321-0133-00			237 Ω, 1/8 W, 1%
R637	323-0131-00			220 Ω, 1/2 W, 1%
R638	315-0102-00	XB020000		1 kΩ, (nominal value) Selected
R639	321-0133-00			237 Ω, 1/8 W, 1%
R640	Selected			
R641	315-0102-00	B010100	B019999	1 kΩ, 1/4 W, 5%
R641	315-0431-00	B020000		430 Ω, (nominal value) Selected
R642	321-0133-00			237 Ω, 1/8 W, 1%
R643	323-0131-00			226 Ω, 1/2 W, 1%
R644	317-0101-00	XB100000		100 Ω, (nominal value) Selected
R646	Selected			
R657	317-0270-00	XB010231		27 Ω, 1/8 W, 5%
R658	311-0605-00			200 Ω, Var
R659	317-0270-00	XB010231		27 Ω, 1/8 W, 5%
R660	324-0114-00			150 Ω, 1 W, 1%

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)					
R661		324-0114-00			150 Ω, 1 W, 1%
R662		321-0039-00			24.9 Ω, 1/8 W, 1%
R663		321-0039-00			24.9 Ω, 1/8 W, 1%
R667		315-0511-00	B010100	B010230	510 Ω, 1/4 W, 5%
R667		315-0561-00	B010231		560 Ω, 1/4 W, 5%
R668		315-0511-00	B010100	B010230	510 Ω, 1/4 W, 5%
R668		315-0561-00	B010231		560 Ω, 1/4 W, 5%
R670		317-0056-00	B010100	B010230	5.6 Ω, 1/8 W, 5%
R670		317-0047-00	B010231		4.7 Ω, 1/8 W, 1%
R672		317-0056-00	B010100	B010230	5.6 Ω, 1/8 W, 5%
R672		317-0047-00	B010231		4.7 Ω, 1/8 W, 5%
R676		317-0101-00			100 Ω, 1/8 W, 5%
R677		323-0069-00			51.1 Ω, 1/2 W, 1%
R679		323-0069-00			51.1 Ω, 1/2 W, 1%
R680		317-0101-00			100 Ω, 1/8 W, 5%
R682		323-0121-00			178 Ω, 1/2 W, 1%
R684		Selected			
R685		315-0820-00			82 Ω, 1/4 W, 5%
R686		315-0820-00			82 Ω, 1/4 W, 5%
R688		Selected			
R689		323-0121-00			178 Ω, 1/2 W, 1%
R691		321-0068-00			49.9 Ω, 1/8 W, 1%
R693		321-0126-00			200 Ω, 1/8 W, 1%
R694		315-0911-00			910 Ω, 1/4 W, 5%
R695		321-0058-00			39.2 Ω, 1/8 W, 1%
R697		321-0058-00			39.2 Ω, 1/8 W, 1%
R698		315-0510-00			51 Ω, 1/4 W, 5%
R700		315-0911-00			910 Ω, 1/4 W, 5%
R701		321-0126-00			200 Ω, 1/8 W, 1%
R703		315-0303-00			30 kΩ, 1/4 W, 5%
R704		315-0621-00			620 Ω, 1/4 W, 5%
R706		321-0237-00			2.87 kΩ, 1/8 W, 1%
R707		311-1259-00			100 Ω, Var
R708		321-0114-00			150 Ω, 1/8 W, 1%
R709		321-0114-00			150 Ω, 1/8 W, 1%
R711		321-0201-00			1.21 kΩ, 1/8 W, 1%
R712		311-0532-00			1.5 kΩ, Var
R713		321-0201-00			1.21 kΩ, 1/8 W, 1%
R715		321-0123-00			187 Ω, 1/8 W, 1%
R717		315-0301-00			300 Ω, 1/4 W, 5%
R718		321-0216-00			200 Ω, 1/8 W, 1%
R719		321-0191-00			953 Ω, 1/8 W, 1%
R721		315-0301-00			300 Ω, 1/4 W, 5%
R722		321-0117-00			162 Ω, 1/8 W, 1%

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ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
R724	323-0164-00			499 Ω, 1/2 W, 1%
R725	323-0164-00			499 Ω, 1/2 W, 1%
R727	321-0055-00			36.5 Ω, 1/8 W, 1%
R730	311-0622-01			100 Ω, Var
R731	307-0364-00			50 Ω, 1/8 W, 5%
R732	317-0470-00			47 Ω, 1/8 W, 5%
R733	**317-0470-00**	**XB130000**		**47 Ω, 1/8 W, 5%**
R734	317-0101-00	B010100	B029999	100 Ω, 1/8 W, 5%
R734	315-0101-00	B030000		100 Ω, 1/4 W, 5%
R736	**317-0101-00**	**XB130000**		**100 Ω, (nominal value) Selected**
R735	323-0069-00			51.1 Ω, 1/2 W, 1%
R737	323-0069-00			51.1 Ω, 1/2 W, 1%
R738	317-0101-00	B010100	B029999	100 Ω, 1/8 W, 5%
R738	315-0101-00	B030000		100 Ω, 1/4 W, 5%
R741	Selected			
R743	311-1261-00			500 Ω, Var
R745	315-0561-00	B010100	B019999	560 Ω, 1/4 W, 5%
R745	315-0471-00	B020000	B049999	470 Ω, (nominal value) Selected
R745	315-0561-00	B050000		560 Ω, 1/4 W, 5%
R747	315-0561-00	B010100	B019999	560 Ω, 1/4 W, 5%
R747	315-0471-00	B020000		470 Ω, (nominal value) Selected
R749	315-0471-00	B010100	B019999	470 Ω, 1/4 W, 5%
R749	311-1263-00	B020000	B020749	1 kΩ, Var
R749	311-0635-00	B020750		1 kΩ, Var
R753	323-0097-00			100 Ω, 1/2 W, 1%
R754	323-0097-00			100 Ω, 1/2 W, 1%
R756	Selected			
R758	311-1261-00			500 Ω, Var
R760	315-0391-00	B010100	B019999	390 Ω, 1/4 W, 5%
R760	315-0681-00	B020000	B049999	680 Ω, (nominal value) Selected
R760	315-0751-00	B050000		750 Ω, 1/4 W, 5%
R762	315-0561-00	B010100	B019999	560 Ω, 1/4 W, 5%
R762	315-0471-00	B020000		470 Ω, (nominal value) Selected
R764	311-1263-00	B010100	B019999	1 kΩ, Var
R764	311-1265-00	B020000		2 kΩ, Var
R767	323-0097-00			100 Ω, 1/2 W, 1%
R768	323-0097-00			100 Ω, 1/2 W, 1%
R770	308-0692-00			44 Ω, 3 W, WW, 1%
R771	323-0112-00			143 Ω, (nominal value) Selected
R775	315-0182-00			1.8 kΩ, 1/4 W, 5%
R778	315-0471-00			470 Ω, 1/4 W, 5%
R782A,B[1]	307-0292-XX			Thick film, hybrid
R783	**321-0324-00**	**XB150000**		**23.2 kΩ, 1/8 W, 1%**
R784	**321-0289-00**	**XB150000**		**10 kΩ, 1/8 W, 1%**
R785	**315-0472-00**	**XB150000**		**4.7 kΩ, 1/4 W, 5%**
R786	**315-0362-00**	**XB150000**		**3.6 kΩ, 1/4 W, 5%**
R787	315-0101-00	B010100	B029999X	100 Ω, 1/4 W, 5%
R788	**315-0103-00**	**XB140000**	**B149999X**	**10 kΩ, 1/4 W, 5%**
R790	323-0064-00			45.3 Ω, 1/2 W, 1%
R792	323-0064-00			45.3 Ω, 1/2 W, 1%
R795	323-0077-00			61.9 Ω, 1/2 W, 1%
R796	323-0145-00	B010100	B010230	316 Ω, 1/2 W, 1%
R796	323-0143-00	B010231		301 Ω, 1/2 W, 1%
R797	321-0063-00			44.2 Ω, 1/8 W, 1%
R799	308-0248-00			150 Ω, 5 W, WW, 1%
R802	321-0068-00			49.9 Ω, 1/8 W, 1%
R805	321-0068-00			49.9 Ω, 1/8 W, 1%

[1]R782A,B are part of the CRT assembly and are selected at the factory to match the impedance of the CRT Vertical Deflection Plates. R782A,B may be purchased separately.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTOR (cont)				
R812	321-0068-00			49.9 Ω, 1/8 W, 1%
R815	321-0068-00			49.9 Ω, 1/8 W, 1%
R821	321-1068-01			50.5 Ω, 1/8 W, 1/2%
R823	321-1068-01			50.5 Ω, 1/8 W, 1/2%
R825	321-1068-01			50.5 Ω, 1/8 W, 1/2%
R827	321-1068-01			50.5 Ω, 1/8 W, 1/2%
R830	315-0303-00	B010100	B010319X	30 kΩ, 1/4 W, 5%
R832	315-0201-00	B010100	B079999X	200 Ω, (nominal value) Selected
R835	321-0088-00			80.6 Ω, 1/8 W, 1%
R836	321-0088-00			80.6 Ω, 1/8 W, 1%
R837	323-0187-00			866 Ω, 1/2 W, 1%
R839	321-0218-00			1.82 kΩ, 1/8 W, 1%
R840	315-0303-00	B010100	B010319X	30 kΩ, 1/4 W, 5%
R842	315-0201-00	B010100	B079999X	200 Ω, (nominal value) Selected
R845	321-0088-00			80.6 Ω, 1/8 W, 1%
R846	321-0088-00			80.6 Ω, 1/8 W, 1%
R847	323-0187-00			866 Ω, 1/2 W, 1%
R850	315-0271-00	XB080000		270 Ω (nominal value) Selected
R851	322-0178-00	B010100	B079999	698 Ω, 1/4 W, 1%
R851	321-0245-00	B080000		3.48 kΩ, 1/8 W, 1%
R852	321-0071-00	B010100	B079999	53.6 Ω, 1/8 W, 1%
R852	321-0199-00	B080000		1.15 kΩ, 1/8 W, 1%
R853	322-0166-00	XB080000		523 Ω, 1/4 W, 1%
R854	321-0071-00	B010100	B079999	53.6 Ω, 1/8 W, 1%
R854	321-0074-00	B080000		57.6 Ω, 1/8 W, 1%
R855	322-0178-00	B010100	B079999X	698 Ω, 1/4 W, 5%
R856	321-0284-00	XB080000		8.87 kΩ, 1/8 W, 1%
R857	315-0432-00	B010100	B079999	4.3 kΩ, 1/4 W, 5%
R857	311-1228-00	B080000		10 kΩ, Var
R858	323-0151-00	B010100	B079999	365 Ω, 1/2 W, 1%
R858	321-0284-00	B080000		8.87 kΩ, 1/8 W, 1%
R859	311-1258-00	B010100	B079999X	50 Ω, Var
R860	321-0085-00	B010100	B079999	75 Ω, 1/8 W, 1%
R860	315-0222-00	B080000		2.2 kΩ, 1/4 W, 5%
R861	321-0085-00	B010100	B079999X	75 Ω, 1/8 W, 1%
R862	322-0187-00	XB080000		866 Ω, 1/4 W, 1%
R863	321-0233-00	B010100	B079999	2.61 kΩ, 1/8 W, 1%
R863	321-0084-00	B080000		73.2 Ω, 1/4 W, 1%
R864	317-0161-00	B010100	B029999	160 Ω, 1/8 W, 5%
R864	315-0161-00	B030000	B079999	160 Ω, 1/4 W, 5%
R864	321-0120-00	B080000		174 Ω, 1/8 W, 1%
R865	315-0162-00	XB080000		1.6 kΩ, 1/4 W, 5%
R866	321-0059-00	B010100	B079999X	40.2 Ω, 1/8 W, 1%
R867	311-1258-00	B010100	B079999	50 Ω, Var
R867	315-0100-00	B080000		10 Ω, 1/4 W, 5%
R868	311-1265-00	B010100	B079999	2 kΩ, Var
R868	315-0562-00	B080000		5.6 kΩ, 1/4 W, 5%
R869	317-0161-00	B010100	B029999	160 Ω, 1/8 W, 5%
R869	315-0161-00	B030000	B079999	160 Ω, 1/4 W, 5%
R869	323-0175-00	B080000		649 Ω, 1/2 W, 1%
R870	321-0233-00	B010100	B039999	2.61 kΩ, 1/8 W, 1%
R870	321-0241-00	B040000	B079999	3.16 kΩ, 1/8 W, 1%
R870	321-0127-00	B080000		205 Ω, 1/8 W, 1%
R871	Selected	B010100	B079999	
R871	311-1221-00	B080000		50 Ω, Var
R872	321-0127-00	XB080000		205 Ω, 1/8 W, 1%
R873	315-0152-00	B010100	B079999X	1.5 kΩ, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R874	315-0152-00	B010100	B079999	1.5 kΩ, 1/4 W, 5%
R874	321-0100-00	B080000		107 Ω, 1/8 W, 1%
R875	311-1221-00	XB080000		50 Ω, Var
R876	311-0634-00	B010100	B079999	500 Ω, Var
R876	311-0635-00	B080000		1 kΩ, Var
R877	311-1035-00	B010100	B079999	50 kΩ, Var
R877	315-0100-00	B080000		10 Ω, 1/4 W, 5%
R878	315-0752-00	B010100	B079999	7.5 kΩ, 1/4 W, 5%
R878	315-0301-00	B080000		300 Ω, 1/4 W, 5%
R879	322-0212-00	XB080000		1.58 kΩ, 1/4 W, 1%
R880	315-0101-00	B010100	B079999	100 Ω, 1/4 W, 5%
R880	315-0100-00	B080000		10 Ω, 1/4 W, 5%
R881	322-0184-00	B010100	B079999	806 Ω, 1/4 W, 5%
R881	315-0511-00	B080000		510 Ω, 1/4 W, 5%
R883	308-0393-00	B010100	B079999	1.6 kΩ, 3 W, WW, 5%
R883	315-0473-00	B080000		47 kΩ, 1/4 W, 5%
R884	315-0301-00	B010100	B070000	300 Ω, 1/4 W, 5%
R884	315-0101-00	B080000		100 Ω, 1/4 W, 5%
R885	315-0512-00	B010100	B079999	5.1 kΩ, 1/4 W, 5%
R885	322-0210-00	B080000		1.5 kΩ, 1/4 W, 1%
R886	321-0237-00	XB080000		2.87 kΩ, 1/8 W, 1%
R887	315-0101-00	B010100	B079999	100 Ω, 1/4 W, 5%
R887	301-0103-00	B080000		10 kΩ, 1/2 W, 5%
R888	322-0184-00	B010100	B079999	806 Ω, 1/4 W, 5%
R888	315-0151-00	B080000		150 Ω, 1/4 W, 5%
R889	315-0153-00	XB040000	B079999	15 kΩ, 1/4 W, 5%
R889	306-0332-00	B080000		3.3 kΩ, 2 W, 10%
R890	308-0393-00	B010100	B079999X	1.6 kΩ, 3 W, WW, 5%
R891	315-0330-00	B010100	B079999X	33 Ω, 1/4 W, 5%
R892	321-0335-00	XB080000		30.1 kΩ, 1/8 W, 1%
R893	315-0242-00	B010100	B079999	2.4 kΩ, 1/4 W, 5%
R893	315-0473-00	B080000		47 kΩ, 1/4 W, 5%
R894	317-0470-00	B010100	B029999	47 Ω, 1/8 W, 5%
R894	315-0470-00	B030000	B079999	47 Ω, 1/4 W, 5%
R894	315-0101-00	B080000		100 Ω, 1/4 W, 5%
R895	315-0152-00	B010100	B079999	1.5 kΩ, 1/4 W, 5%
R895	322-0210-00	B080000		1.5 kΩ, 1/4 W, 1%
R896	301-0683-00	B010100	B079999	68 kΩ, 1/2 W, 5%
R896	321-0237-00	B080000		2.87 kΩ, 1/8 W, 1%
R897	301-0103-00	XB080000		10 kΩ, 1/2 W, 5%
R898	311-1258-00	B010100	B079999	50 Ω, Var
R898	315-0151-00	B080000		150 Ω, 1/4 W, 5%
R899	315-0223-00	B010100	B079999	22 kΩ, 1/4 W, 5%
R899	306-0332-00	B080000		3.3 kΩ, 2 W, 10%
R901	315-0152-00	B010100	B079999	1.5 kΩ, 1/4 W, 5%
R901	315-0470-00	B080000		47 Ω, 1/4 W, 5%
R903	317-0470-00	B010100	B029999	47 Ω, 1/8 W, 5%
R903	315-0470-00	B030000	B079999	47 Ω, 1/4 W, 5%
R903	315-0162-00	B080000		1.6 kΩ, 1/4 W, 5%
R905	315-0432-00	B010100	B079999	4.3 kΩ, 1/4 W, 5%
R905	301-0822-00	B080000		8.2 kΩ, 1/2 W, 5%
R906	315-0100-00	B010100	B079999	10 Ω, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R906	311-0643-00	B080000		50 Ω, Var
R907	301-0822-00	XB080000		8.2 kΩ, 1/2 W, 5%
R908	315-0392-00	B010100	B079999	3.9 kΩ, 1/4 W, 5%
R908	315-0470-00	B080000		47 Ω, 1/4 W, 5%
R909	301-0333-00	B010100	B079999	33 kΩ, 1/2 W, 5%
R909	307-0103-00	B080000		2.7 Ω, 1/4 W, 5%
R910	315-0101-00	B010100	B079999	100 Ω, 1/4 W, 5%
R910	315-0332-00	B080000		3.3 kΩ, 1/4 W, 5%
R911	317-0470-00	B010100	B029999	47 Ω, 1/8 W, 5%
R911	315-0470-00	B030000	B079999X	47 Ω, 1/4 W, 5%
R912	317-0390-00	B010100	B029999	39 Ω, 1/8 W, 5%
R912	315-0390-00	B030000	B079999	39 Ω, 1/4 W, 5%
R912	307-0109-00	B080000		8.2 Ω, 1/4 W, 5%
R913	315-0432-00	XB080000		4.3 kΩ, 1/4 W, 5%
R914	315-0242-00	B010100	B079999	2.4 kΩ, 1/4 W, 5%
R914	315-0392-00	B080000		3.9 kΩ, 1/4 W, 5%
R915	315-0512-00	B010100	B079999	5.1 kΩ, 1/4 W, 5%
R915	301-0333-00	B080000		33 kΩ, 1/2 W, 5%
R917	315-0470-00	XB080000		47 Ω, 1/4 W, 5%
R918	322-0356-00	B010100	B079999X	49.9 kΩ, 1/4 W, 1%
R920	315-0751-00	B010100	B079999	750 Ω, 1/4 W, 5%
R920	315-0622-00	B080000		6.2 kΩ, 1/4 W, 5%
R921	315-0102-00	XB080000		1 kΩ, 1/4 W, 5%
R923	301-0751-00	B010100	B079999X	750 Ω, 1/2 W, 5%
R924	315-0100-00	XB080000		10 Ω, 1/4 W, 5%
R925	321-0260-00	B010100	B079999X	4.99 kΩ, 1/8 W, 1%
R926	322-0356-00	XB080000	B109999	49.9 kΩ, 1/4 W, 1%
R926	325-0176-00	B110000		49.9 kΩ, 1/4 W, 1%
R927	321-0260-00	XB080000		4.99 kΩ, 1/8 W, 1%
R928	315-0102-00	XB080000		1 kΩ, 1/4 W, 5%
R929	321-0260-00	XB080000		4.99 kΩ, 1/8 W, 1%
R933	315-0622-00	XB080000		6.2 kΩ, 1/4 W, 5%
R934	315-0102-00	XB080000		1 kΩ, 1/4 W, 5%
R937	315-0470-00	XB080000		47 Ω, 1/4 W, 5%
R938	315-0622-00	B010100	B079999X	6.2 kΩ, 1/4 W, 5%
R939	315-0102-00	B010100	B079999X	1 kΩ, 1/4 W, 5%
R940	301-0333-00	XB080000		33 kΩ, 1/2 W, 5%
R941	317-0470-00	B010100	B029999	47 Ω, 1/8 W, 5%
R941	315-0470-00	B030000	B079999	47 Ω, 1/4 W, 5%
R941	315-0392-00	B080000		3.9 kΩ, 1/4 W, 5%
R942	317-0390-00	B010100	B029999	39 Ω, 1/8 W, 5%
R942	315-0390-00	B030000	B079999	39 Ω, 1/4 W, 5%
R942	315-0432-00	B080000		4.3 kΩ, 1/4 W, 5%
R943	315-0100-00	XB080000		10 Ω, 1/4 W, 5%
R944	315-0392-00	B010100	B079999	3.9 kΩ, 1/4 W, 5%
R944	315-0100-00	B080000		10 Ω, 1/4 W, 5%
R945	301-0333-00	B010100	B079999X	33 kΩ, 1/2 W, 5%
R946	315-0362-00	B010100	B079999	3.6 kΩ, 1/4 W, 5%
R946	322-0356-00	B080000	B109999	49.9 kΩ, 1/4 W, 1%
R946	325-0176-00	B110000		49.9 kΩ, 1/4 W, 1%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R947	321-0339-00	XB080000		33.2 kΩ, 1/8 W, 1%
R948	322-0356-00	B010100	B079999	49.9 kΩ, 1/4 W, 1%
R948	315-0102-00	B080000		1 kΩ, 1/4 W, 5%
R949	315-0100-00	B010100	B079999	10 Ω, 1/4 W, 5%
R949	321-0260-00	B080000		4.99 kΩ, 1/8 W, 1%
R953	301-0751-00	B010100	B079999X	750 Ω, 1/2 W, 5%
R955	321-0260-00	B010100	B079999X	4.99 kΩ, 1/8 W, 1%
R990	315-0390-00	XB080000		39 Ω, 1/4 W, 5%
R998	315-0390-00			39 Ω, 1/4 W, 5%
R1001	315-0101-00			100 Ω, 1/4 W, 5%
R1003	321-0064-00			45.3 Ω, 1/8 W, 1%
R1005	321-0064-00			45.3 Ω, 1/8 W, 1%
R1007	311-1258-00			50 Ω, Var
R1008	315-0100-00			10 Ω, 1/4 W, 5%
R1010	301-0131-00			130 Ω, 1/2 W, 5%
R1012	301-0131-00			130 Ω, 1/2 W, 5%
R1014	321-0186-00			845 Ω, 1/8 W, 1%
R1015	321-0118-00			165 Ω, 1/8 W, 1%
R1018	315-0200-00			20 Ω, 1/4 W, 5%
R1020	315-0200-00			20 Ω, 1/4 W, 5%
R1021	315-0301-00			300 Ω, 1/4 W, 5%
R1022	321-0220-00			1.91 kΩ, 1/8 W, 1%
R1024	321-0220-00			1.91 kΩ, 1/8 W, 1%
R1026	307-0106-00			4.7 Ω, 1/4 W, 5%
R1031	315-0101-00			100 Ω, 1/4 W, 5%
R1033	315-0470-00			47 Ω, 1/4 W, 5%
R1036	315-0101-00			100 Ω, 1/4 W, 5%
R1038	315-0470-00			47 Ω, 1/4 W, 5%
R1040	321-0269-00			6.19 kΩ, 1/8 W, 1%
R1042	315-0682-00			6.8 kΩ, 1/4 W, 5%
R1044	323-0275-00			7.15 kΩ, 1/2 W, 1%
R1046	307-0103-00	XB030000		2.7 Ω, 1/4 W, 5%
R1049	321-0264-00			5.49 kΩ, 1/8 W, 1%
R1051	315-0132-00			1.3 kΩ, 1/4 W, 5%
R1052	321-0254-00			4.32 kΩ, 1/8 W, 1%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1054	315-0152-00			1.5 kΩ, 1/4 W, 5%
R1055	307-0103-00	XB030000		2.7 Ω, 1/4 W, 5%
R1056	317-0620-00	B010100	B029999	62 Ω, 1/8 W, 5%
R1056	315-0620-00	B030000		62 Ω, 1/4 W, 5%
R1057	321-0187-00			866 Ω, 1/8 W, 1%
R1061	321-0306-00			15 kΩ, 1/8 W, 1%
R1062	321-0133-00			237 Ω, 1/8 W, 1%
R1064	321-0133-00			237 Ω, 1/8 W, 1%
R1065	321-0306-00			15 kΩ, 1/8 W, 1%
R1067	315-0101-00			100 Ω, 1/4 W, 5%
R1069	315-0301-00			300 Ω, 1/4 W, 5%
R1070	317-0511-00	B010100	B029999	510 Ω, 1/8 W, 5%
R1070	315-0511-00	B030000		510 Ω, 1/4 W, 5%
R1071	321-0193-00			1 kΩ, 1/8 W, 1%
R1073	323-0143-00			301 Ω, 1/2 W, 1%
R1075	321-0126-00			200 Ω, 1/8 W, 1%
R1076	321-0289-00			10 kΩ, 1/8 W, 1%
R1077	315-0101-00			100 Ω, 1/4 W, 5%
R1079	315-0182-00			1.8 kΩ, 1/4 W, 5%
R1081	321-0180-00			732 Ω, 1/8 W, 1%
R1082	321-0226-00			2.21 kΩ, 1/8 W, 1%
R1084	315-0101-00			100 Ω, 1/4 W, 5%
R1087	321-0190-00			931 Ω, 1/8 W, 1%
R1101	311-1263-00			1 kΩ, Var
R1102	308-0647-00			2.7 kΩ, 3 W, WW, 1%
R1104	315-0272-00			2.7 kΩ, 1/4 W, 5%
R1106	315-0513-00			51 kΩ, 1/4 W, 5%
R1109	315-0623-00			62 kΩ, 1/4 W, 5%
R1112	315-0153-00			15 kΩ, 1/4 W, 5%
R1113	315-0202-00			2 kΩ, 1/4 W, 5%
R1116	315-0512-00			5.1 kΩ, 1/4 W, 5%
R1117	315-0102-00			1 kΩ, 1/4 W, 5%
R1120	321-0285-00			9.09 kΩ, 1/8 W, 1%
R1122	315-0302-00			3 kΩ, 1/4 W, 5%
R1124	315-0302-00			3 kΩ, 1/4 W, 5%
R1125	315-0560-00			56 Ω, 1/4 W, 5%
R1126	315-0511-00			510 Ω, 1/4 W, 5%
R1127	315-0513-00			51 kΩ, 1/4 W, 5%
R1129	315-0473-00			47 kΩ, 1/4 W, 5%
R1132	315-0183-00			18 kΩ, 1/4 W, 5%
R1134	315-0362-00			3.6 kΩ, 1/4 W, 5%
R1136	321-1188-06			898 Ω, 1/8 W, 1/4%
R1138	315-0112-00			1.1 kΩ, 1/4 W, 5%
R1140	315-0102-00			1 kΩ, 1/4 W, 5%
R1142	315-0103-00			10 kΩ, 1/4 W, 5%
R1144	321-0281-00			8.25 kΩ, 1/8 W, 1%
R1145	321-0820-06			42 kΩ, 1/8 W, 1/4%
R1146	315-0913-00			91 kΩ, 1/4 W, 5%
R1148	311-1273-00			200 kΩ, Var
R1150	321-0766-06			4.053 kΩ, 1/8 W, 1/4%
R1152	321-0068-00			49.9 Ω, 1/8 W, 1%
R1153	321-0815-07			4.1 kΩ, 1/8 W, 1/10%
R1155	321-0812-07			455 Ω, 1/8 W, 1/10%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1156	321-0811-07			56.3 Ω, 1/8 W, 1/10%
R1158	321-0813-07			495 Ω, 1/8 W, 1/10%
R1159	321-0810-07			55 Ω, 1/8 W, 1/10%
R1161	321-0816-07			5 kΩ, 1/8 W, 1/10%
R1162	321-1068-01			50.5 Ω, 1/8 W, 1/2%
R1201	302-0271-00			270 Ω, 1/2 W, 10%
R1203	302-0271-00			270 Ω, 1/2 W, 10%
R1205	304-0270-00			27 Ω, 1 W, 10%
R1208	304-0473-00	B010100	B049999	47 kΩ, 1 W, 10%
R1208	304-0104-00	B050000		100 kΩ, 1 W, 10%
R1209	307-0350-00			7.5 Ω, Thermal
R1210	303-0304-00			300 kΩ, 1 W, 5%
R1213	304-0473-00	B010100	B049999	47 kΩ, 1 W, 10%
R1213	304-0104-00	B050000		100 kΩ, 1 W, 10%
R1219	302-0565-00			5.6 MΩ, 1/2 W, 10%
R1221	304-0154-00			150 kΩ, 1 W, 10%
R1225	316-0471-00			470 Ω, 1/4 W, 10%
R1231	307-0057-00			5.1 Ω, 1/2 W, 5%
R1232	316-0220-00			22 Ω, 1/4 W, 10%
R1236	316-0103-00			10 kΩ, 1/4 W, 10%
R1239	307-0057-00			5.1 Ω, 1/2 W, 5%
R1240	316-0220-00			22 Ω, 1/4 W, 10%
R1242	315-0823-00	B010100	B049999	82 kΩ, 1/4 W, 5%
R1242	315-0753-00	B050000		75 kΩ, 1/4 W, 5%
R1243	316-0274-00			270 kΩ, 1/4 W, 10%
R1244	316-0270-00			27 Ω, 1/4 W, 10%
R1245	316-0101-00			100 Ω, 1/4 W, 10%
R1246	316-0561-00			560 Ω, 1/4 W, 10%
R1247	316-0684-00			680 kΩ, 1/4 W, 10%
R1248	302-0332-00			3.3 kΩ, 1/2 W, 10%
R1249	316-0101-00			100 Ω, 1/4 W, 10%
R1253	316-0473-00			47 kΩ, 1/4 W, 10%
R1256	316-0562-00			5.6 kΩ, 1/4 W, 10%
R1257	316-0223-00			22 kΩ, 1/4 W, 10%
R1259	316-0562-00			5.6 kΩ, 1/4 W, 10%
R1261	316-0104-00			100 kΩ, 1/4 W, 10%
R1267	316-0154-00			150 kΩ, 1/4 W, 10%
R1269	316-0224-00			220 kΩ, 1/4 W, 10%
R1270	316-0123-00			12 kΩ, 1/4 W, 10%
R1271	315-0201-00	B010100	B049999	200 Ω, 1/4 W, 5%
R1271	315-0431-00	B050000		430 Ω, 1/4 W, 5%
R1272	316-0470-00			47 Ω, 1/4 W, 10%
R1277	316-0560-00			56 Ω, 1/4 W, 10%
R1279	316-0331-00	B010100	B010467	330 Ω, 1/4 W, 10%
R1279	316-0181-00	B010468		180 Ω, 1/4 W, 5%
R1284	315-0471-00			470 Ω, 1/4 W, 5%
R1285	321-0313-00			17.8 kΩ, 1/8 W, 1%
R1286	315-0102-00			1 kΩ, 1/4 W, 5%
R1287	321-0005-00			11 Ω, 1/8 W, 1%
R1291	302-0683-00	B010100	B010467X	68 kΩ, 1/2 W, 10%
R1292	321-0425-00			261 kΩ, 1/8 W, 1%
R1293	311-1226-00			2.5 kΩ, Var
R1294	321-0283-00			8.66 kΩ, 1/8 W, 1%
R1296	321-0282-00			8.45 kΩ, 1/8 W, 1%
R1297	315-0102-00			1 kΩ, 1/4 W, 5%
R1300	321-0366-00			63.4 kΩ, 1/8 W, 1%
R1301	316-0153-00			15 kΩ, 1/4 W, 10%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1302	316-0103-00	B010100	B099999	10 kΩ, 1/4 W, 10%
R1302	315-0512-00	B100000		5.1 kΩ, 1/4 W, 5%
R1304	321-0286-00			9.31 kΩ, 1/8 W, 1%
R1305	321-0339-00			33.2 kΩ, 1/8 W, 1%
R1326	302-0563-00	XB030000		56 kΩ, 1/2 W, 10%
R1371	315-0304-00			300 kΩ, 1/4 W, 5%
R1373	315-0113-00			11 kΩ, 1/4 W, 5%
R1375	315-0362-00			3.6 kΩ, 1/4 W, 5%
R1376	315-0911-00			910 Ω, 1/4 W, 5%
R1378	316-0154-00			150 kΩ, 1/4 W, 10%
R1392	316-0100-00			10 Ω, 1/4 W, 10%
R1395	316-0220-00			22 kΩ, 1/4 W, 10%
R1397	316-0220-00			22 Ω, 1/4 W, 10%
R1401	316-0471-00			470 Ω, 1/4 W, 10%
R1402	316-0221-00			220 Ω, 1/4 W, 10%
R1404	316-0474-00			470 kΩ, 1/4 W, 10%
R1406	315-0183-00			18 kΩ, 1/4 W, 5%
R1408	316-0274-00			270 kΩ, 1/4 W, 10%
R1412	321-0924-07			40 kΩ, 1/8 W, 1%
R1413	321-0924-07			40 kΩ, 1/8 W, 1%
R1415	316-0823-00			82 kΩ, 1/4 W, 10%
R1416	316-0272-00			2.7 kΩ, 1/4 W, 10%
R1418	316-0472-00			4.7 kΩ, 1/4 W, 10%
R1420	315-0433-00			43 kΩ, 1/4 W, 5%
R1421	316-0823-00			82 kΩ, 1/4 W, 10%
R1422	315-0181-00			180 Ω, 1/4 W, 5%
R1424	316-0331-00			330 Ω, 1/4 W, 10%
R1428	308-0679-00			0.51 Ω, 2 W, WW, 5%
R1429	316-0471-00			470 Ω, 1/4 W, 10%
R1431	316-0683-00			68 kΩ, 1/4 W, 10%
R1432	316-0104-00			100 kΩ, 1/4 W, 10%
R1434	316-0334-00			330 kΩ, 1/4 W, 10%
R1436	316-0103-00			10 kΩ, 1/4 W, 10%
R1437	316-0274-00			270 kΩ, 1/4 W, 10%
R1440	321-0924-07			40 kΩ, 1/8 W, 1/10%
R1441	321-1296-07			12 kΩ, 1/8 W, 1/10%
R1443	315-0511-00			510 Ω, 1/4 W, 5%
R1444	315-0153-00			15 kΩ, 1/4 W, 5%
R1446	316-0333-00			33 kΩ, 1/4 W, 10%
R1448	315-0512-00			5.1 kΩ, 1/4 W, 5%
R1449	315-0101-00			100 Ω, 1/4 W, 5%
R1451	316-0103-00			10 kΩ, 1/4 W, 10%
R1453	316-0153-00			15 kΩ, 1/4 W, 10%
R1456	316-0681-00			680 Ω, 1/4 W, 10%
R1457	308-0701-00			0.12 Ω. 2 W, WW, 5%
R1459	316-0151-00			150 Ω, 1/4 W, 10%
R1461	316-0182-00			1.8 kΩ, 1/4 W, 10%
R1463	321-1296-07			12 kΩ, 1/8 W, 1/10%
R1464	321-0332-07			28 kΩ, 1/8 W, 1/10%
R1467	316-0184-00			180 kΩ, 1/4 W, 10%
R1480	316-0124-00			120 kΩ, 1/4 W, 10%
R1481	316-0471-00			470 Ω, 1/4 W, 10%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1485	316-0272-00			2.7 kΩ, 1/4 W, 10%
R1487	316-0222-00			2.2 kΩ, 1/4 W, 10%
R1490	302-0822-00			8.2 kΩ, 1/2 W, 10%
R1492	316-0273-00			27 kΩ, 1/4 W, 10%
R1493	315-0391-00			390 Ω, 1/4 W, 5%
R1495	316-0222-00			2.2 kΩ, 1/4 W, 10%
R1497	316-0681-00			680 Ω, 1/4 W, 10%
R1498	308-0701-00			0.12 Ω, 2 W, WW, 5%
R1499	316-0471-00			470 Ω, 1/4 W, 10%
R1502	316-0393-00			39 kΩ, 1/4 W, 10%
R1504	323-0264-00			5.49 kΩ, 1/2 W, 1%
R1506	315-0562-00			5.6 kΩ, 1/4 W, 5%
R1509	316-0224-00			220 kΩ, 1/4 W, 10%
R1512	321-0272-00			6.65 kΩ, 1/8 W, 1%
R1513	311-0635-00			1 kΩ, Var
R1514	321-0338-00			32.4 kΩ, 1/8 W, 1%
R1517	316-0125-00			1.2 MΩ, 1/4 W, 10%
R1518	316-0471-00			470 Ω, 1/4 W, 10%
R1522	316-0472-00			4.7 kΩ, 1/4 W, 10%
R1524	316-0102-00			1 kΩ, 1/4 W, 10%
R1528	316-0123-00			12 kΩ, 1/4 W, 10%
R1529	301-0123-00			12 kΩ, 1/2 W, 5%
R1531	315-0101-00			100 Ω, 1/4 W, 5%
R1533	316-0222-00			2.2 kΩ, 1/4 W, 10%
R1535	316-0331-00			330 Ω, 1/4 W, 10%
R1537	308-0703-00			1.8 Ω, 2 W, WW, 5%
R1539	316-0471-00			470 Ω, 1/4 W, 10%
R1541	311-0736-00			10 kΩ, Var
R1543	321-0289-00			10 kΩ, 1/8 W, 1%
R1544	316-0103-00			10 kΩ, 1/4 W, 10%
R1545	315-0243-00			24 kΩ, 1/4 W, 5%
R1548	315-0562-00			5.6 kΩ, 1/4 W, 5%
R1549	316-0221-00			220 Ω, 1/4 W, 10%
R1551	308-0702-00			0.33 Ω, 2 W, WW, 5%
R1562	316-0274-00			270 kΩ, 1/4 W, 10%
R1564	321-0924-07			40 kΩ, 1/8 W, 1/10%
R1565	321-0926-07			4 kΩ, 1/8 W, 1/10%
R1566	315-0622-00			6.2 kΩ, 1/4 W, 5%
R1567	316-0273-00			27 kΩ, 1/4 W, 10%
R1568	316-0473-00			47 kΩ, 1/4 W, 10%
R1570	316-0334-00			330 kΩ, 1/4 W, 10%
R1571	316-0103-00			10 kΩ, 1/4 W, 10%
R1573	315-0471-00			470 Ω, 1/4 W, 5%
R1574	315-0562-00			5.6 kΩ, 1/4 W, 5%
R1577	316-0223-00			22 kΩ, 1/4 W, 10%
R1579	315-0152-00			1.5 kΩ, 1/4 W, 5%
R1580	315-0750-00			75 Ω, 1/4 W, 5%
R1583	316-0103-00			10 kΩ, 1/4 W, 10%
R1586	316-0681-00			680 Ω, 1/4 W, 10%
R1587	308-0701-00			0.12 Ω, 2 W, WW, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1589	316-0470-00			47 Ω, 1/4 W, 10%
R1591	316-0470-00			47 Ω, 1/4 W, 10%
R1603	302-0152-00			1.5 kΩ, 1/2 W, 10%
R1604	315-0130-00			13 Ω, 1/4 W, 5%
R1605	315-0560-00			56 Ω, 1/4 W, 5%
R1609	316-0472-00			4.7 kΩ, 1/4 W, 10%
R1611	316-0472-00			4.7 kΩ, 1/4 W, 10%
R1612	316-0472-00			4.7 kΩ, 1/4 W, 10%
R1614	302-0331-00			330 Ω, 1/2 W, 10%
R1616	316-0471-00			470 Ω, 1/4 W, 10%
R1618	301-0135-00			1.3 MΩ, 1/2 W, 5%
R1619	301-0135-00			1.3 MΩ, 1/2 W, 5%
R1625	302-0563-00			56 kΩ, 1/2 W, 10%
R1627	316-0821-00			820 Ω, 1/4 W, 10%
R1629	316-0332-00			3.3 kΩ, 1/4 W, 10%
R1631	316-0150-00			15 Ω, 1/4 W, 10%
R1632	316-0681-00			680 Ω, 1/4 W, 10%
R1633	316-0331-00			330 Ω, 1/4 W, 10%
R1634	316-0392-00			3.9 kΩ, 1/4 W, 10%
R1635	315-0244-00			240 kΩ, 1/4 W, 5%
R1637	316-0474-00			470 kΩ, 1/4 W, 10%
R1640A,B	307-0290-01			Thick film
R1642	302-0102-00			1 kΩ, 1/2 W, 10%
R1651	301-0225-00			2.2 MΩ, 1/2 W, 5%
R1652	301-0225-00			2.2 MΩ, 1/2 W, 5%
R1658	302-0183-00			18 kΩ, 1/2 W, 10%
R1659	316-0226-00			22 MΩ, 1/4 W, 10%
R1661	302-0104-00			100 kΩ, 1/2 W, 10%
R1671	301-0305-00			3 MΩ, 1/2 W, 5%
R1672	301-0305-00			3 MΩ, 1/2 W, 5%
R1674	311-0644-01			20 kΩ, Var
R1675	315-0123-00			12 kΩ, 1/4 W, 5%
R1682	316-0183-00			18 kΩ, 1/4 W, 10%
R1684	316-0226-00			22 MΩ, 1/4 W, 10%
R1686	316-0104-00			100 kΩ, 1/4 W, 10%
R1690	316-0104-00			100 kΩ, 1/4 W, 10%
R1700[1]	311-1195-00			1 MΩ, Var
R1704	301-0105-00			1 MΩ, 1/2 W, 5%
R1705	301-0105-00			1 MΩ, 1/2 W, 5%
R1706	301-0105-00			1 MΩ, 1/2 W, 5%
R1707	301-0105-00			1 MΩ, 1/2 W, 5%
R1708	301-0105-00			1 MΩ, 1/2 W, 5%
R1709	301-0105-00			1 MΩ, 1/2 W, 5%
R1711	**311-0657-00**	**B010100**	**B129999**	**2 MΩ, Var**
R1711	**311-1720-00**	**B130000**		2 MΩ, Var
R1712	301-0205-00			2 MΩ, 1/2 W, 5%
R1713	301-0105-00			1 MΩ, 1/2 W, 5%
R1714	301-0105-00			1 MΩ, 1/2 W, 5%
R1716	315-0101-00			100 Ω, 1/4 W, 5%
R1717	315-0105-00			1 MΩ, 1/4 W, 5%
R1719	315-0105-00			1 MΩ, 1/4 W, 5%
R1725	311-0443-00			2.5 kΩ, Var

[1]Furnished as a unit with R333.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1727	311-0613-00			100 kΩ, Var
R1730	311-1227-00			5 kΩ, Var
R1732	321-0271-00			6.49 kΩ, 1/8 W, 1%
R1733	311-0609-00			2 kΩ, Var
R1734	321-0310-00			16.5 kΩ, 1/8 W, 1%
R1736	311-1099-00			100 kΩ, Var
R1741	321-0306-00			15 kΩ, 1/8 W, 1%
R1743	321-0306-00			15 kΩ, 1/8 W, 1%
R1745	321-0322-00			22.1 kΩ, 1/8 W, 1%
R1746	321-0322-00			22.1 kΩ, 1/8 W, 1%
R1749	315-0203-00			20 kΩ, 1/4 W, 5%
R1751	311-0609-00			2 kΩ, Var
R1752	321-0227-00			2.26 kΩ, 1/8 W, 1%
R1753	315-0101-00			100 Ω, 1/4 W, 5%
R1754	321-0254-00			4.32 kΩ, 1/8 W, 1%
R1756	315-0102-00			1 kΩ, 1/4 W, 5%
R1757	311-1267-00			5 kΩ, Var
R1758	321-0334-00			29.4 kΩ, 1/8 W, 1%
R1759	321-0231-00			2.49 kΩ, 1/8 W, 1%
R1760	321-0410-00			182 kΩ, 1/8 W, 1%
R1762	321-0373-00			75 kΩ, 1/8 W, 1%
R1763	321-0260-00			4.99 kΩ, 1/8 W, 1%
R1765	321-0189-00	B010100	B129999	909 Ω, 1/8 W, 1%
R1765	**315-0132-00**	**B130000**		**1.3 kΩ, 1/4 W, 5%**
R1767	315-0473-00			47 kΩ, 1/4 W, 5%
R1770	315-0101-00			100 Ω, 1/4 W, 5%
R1772	315-0391-00			390 Ω, 1/4 W, 5%
R1774	315-0103-00			10 kΩ, 1/4 W, 5%
R1777	315-0104-00			100 kΩ, 1/4 W, 5%
R1778	315-0202-00			2 kΩ, 1/4 W, 5%
R1801	321-0066-00			47.5 Ω, 1/8 W, 1%
R1802	315-0510-00			51 Ω, 1/4 W, 5%
R1803	321-0193-00			1 kΩ, 1/8 W, 1%
R1805	315-0101-00			100 Ω, 1/4 W, 5%
R1806	321-0126-00			200 Ω, 1/8 W, 1%
R1808	321-0206-00			1.37 kΩ, 1/8 W, 1%
R1809	321-0126-00			200 Ω, 1/8 W, 1%
R1810	311-0635-00			1 kΩ, Var
R1812	321-0206-00			1.37 kΩ, 1/8 W, 1%
R1814	321-0126-00			200 Ω, 1/8 W, 1%
R1815	315-0101-00			100 Ω, 1/4 W, 5%
R1816	315-0561-00			560 Ω, 1/4 W, 5%
R1817	311-0978-00			250 Ω, Var
R1818	315-0271-00			270 Ω, 1/4 W, 5%
R1820	315-0272-00			2.7 kΩ, 1/4 W, 5%
R1822	323-0275-00			7.15 kΩ, 1/2 W, 1%
R1824	321-0193-00			1 kΩ, 1/8 W, 1%
R1825	315-0200-00	XB130000		20 Ω, **1/4 W, 5%**
R1827	315-0152-00			1.5 kΩ, 1/4 W, 5%
R1829	315-0100-00			10 Ω, 1/4 W, 5%
R1831	315-0681-00			680 Ω, 1/4 W, 5%
R1832	315-0302-00			3 kΩ, 1/4 W, 5%
R1833	315-0391-00			390 Ω, 1/4 W, 5%
R1838	315-0202-00			2 kΩ, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1839	315-0101-00			100 Ω, 1/4 W, 5%
R1842	311-0643-00			50 Ω, Var
R1844	311-0643-00	B010100	B129999	50 Ω, Var
R1844	311-0622-00	B130000		100 Ω, Var
R1846	315-0105-00			1 MΩ, 1/4 W, 5%
R1851	301-0472-00			4.7 kΩ, 1/2 W, 5%
R1852	301-0472-00			4.7 kΩ, 1/2 W, 5%
R1854	323-0256-00	B010100	B143999	4.53 kΩ, 1/2 W, 1%
R1854	303-0432-00	B144000		4.3 kΩ, 1 W, 5%
R1856	315-0510-00			51 Ω, 1/4 W, 5%
R1860	321-0347-00			40.2 kΩ, 1/8 W, 1%
R1861	321-0369-00	B010100	B129999	68.1 kΩ, 1/8 W, 1%
R1861	321-0367-00	B130000		64.9 kΩ, 1/8 W, 1%
R1871	321-0266-00			4.99 kΩ, 1/8 W, 1%
R1873	322-0356-00			49.9 kΩ, 1/4 W, 1%
R1877	317-0101-00	B010100	B029999	100 Ω, 1/8 W, 5%
R1877	315-0101-00	B030000	B129999	100 Ω, 1/4 W, 5%
R1877	321-0253-00	B130000		4.22 kΩ, 1/8 W, 1%
R1880	315-0103-00			10 kΩ, 1/4 W, 5%
R1883	315-0101-00			100 Ω, 1/4 W, 5%
R1887	315-0100-00			10 Ω, 1/4 W, 5%
R1894	307-0106-00			4.7 Ω, 1/4 W, 5%
R1897	307-0106-00			4.7 Ω, 1/4 W, 5%
R2101	315-0682-00			6.8 kΩ, 1/4 W, 5%
R2102	315-0103-00			10 kΩ, 1/4 W, 5%
R2104	315-0333-00			33 kΩ, 1/4 W, 5%
R2105	315-0153-00			15 kΩ, 1/4 W, 5%
R2107	315-0510-00			51 Ω, 1/4 W, 5%
R2108	315-0512-00			5.1 kΩ, 1/4 W, 5%
R2109	315-0221-00			220 Ω, 1/4 W, 5%
R2112	315-0102-00			1 kΩ, 1/4 W, 5%
R2113	315-0301-00			300 Ω, 1/4 W, 5%
R2122	315-0432-00			4.3 kΩ, 1/4 W, 5%
R2123[1]	315-0683-00			68 kΩ, 1/4 W, 5%
R2124[1]				
R2127	315-0302-00			3 kΩ, 1/4 W, 5%
R2128	311-1225-00	B010100	B109999	1 kΩ, Var
R2128	311-1263-00	B110000		1 kΩ, Var
R2129	315-0183-00			18 kΩ, 1/4 W, 5%
R2135	315-0393-00			39 kΩ, 1/4 W, 5%
R2137	315-0752-00			7.5 kΩ, 1/4 W, 5%
R2139	315-0242-00			2.4 kΩ, 1/4 W, 5%
R2144	315-0104-00			100 kΩ, 1/4 W, 5%
R2146	315-0152-00			1.5 kΩ, 1/4 W, 5%
R2148	315-0103-00			10 kΩ, 1/4 W, 5%
R2150	321-0407-00	B010100	B089999	169 kΩ, 1/8 W, 1%
R2150	321-0403-00	B090000		154 kΩ, 1/8 W, 1%
R2151	321-0372-00			73.2 kΩ, 1/8 W, 1%
R2153	315-0103-00			10 kΩ, 1/4 W, 5%
R2155	315-0512-00			5.1 kΩ, 1/4 W, 5%
R2158	315-0152-00			1.5 kΩ, 1/4 W, 5%
R2161	315-0102-00			1 kΩ, 1/4 W, 5%
R2162	315-0751-00			750 Ω, 1/4 W, 5%
R2163	315-0751-00			750 Ω, 1/4 W, 5%
R2165	315-0102-00			1 kΩ, 1/4 W, 5%
R2166	315-0751-00			750 Ω, 1/4 W, 5%
R2167	315-0751-00			750 Ω, 1/4 W, 5%

[1]Furnished as a unit with S122.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R2169	315-0102-00			1 kΩ, 1/4 W, 5%
R2170	315-0751-00			750 Ω, 1/4 W, 5%
R2171	315-0751-00			750 Ω, 1/4 W, 5%
R2173	315-0102-00			1 kΩ, 1/4 W, 5%
R2174	315-0751-00			750 Ω, 1/4 W, 5%
R2175	315-0751-00			750 Ω, 1/4 W, 5%
R2177	315-0511-00			510 Ω, 1/4 W, 5%
R2178	315-0511-00			510 Ω, 1/4 W, 5%
R2179	315-0511-00			510 Ω, 1/4 W, 5%
R2182	311-1225-00	B010100	B089999	1 kΩ, Var
R2182	321-0262-00	B090000		5.23 kΩ, 1/8 W, 5%
R2183	315-0472-00	B010100	B089999	4.7 kΩ, 1/4 W, 5%
R2183	311-1224-00	B090000		500 Ω, Var
R2191	315-0513-00			51 kΩ, 1/4 W, 5%
R2192	315-0133-00			13 kΩ, 1/4 W, 5%
R2193	315-0133-00			13 kΩ, 1/4 W, 5%
R2194	315-0753-00			75 kΩ, 1/4 W, 5%
R2196	321-0308-00			15.8 kΩ, 1/8 W, 1%
R2197	315-0513-00			51 kΩ, 1/4 W, 5%
R2198	321-0319-00			20.5 kΩ, 1/8 W, 1%
R2199	321-0335-00			30.1 kΩ, 1/8 W, 1%
R2201	315-0154-00			150 kΩ, 1/4 W, 5%
R2202	321-0335-00			30.1 kΩ, 1/8 W, 1%
R2203	321-0344-00			37.4 kΩ, 1/8 W, 1%
R2204	321-0335-00			30.1 kΩ, 1/8 W, 1%
R2206	315-0513-00			51 kΩ, 1/4 W, 5%
R2207	315-0154-00			150 kΩ, 1/4 W, 5%
R2208	321-0335-00			30.1 kΩ, 1/8 W, 1%
R2209	321-0335-00			30.1 kΩ, 1/8 W, 1%
R2211	315-0752-00			7.5 kΩ, 1/4 W, 5%
R2213	311-1225-00	B010100	B089999	1 kΩ, Var
R2213	321-0259-00	B090000		4.87 kΩ, 1/8 W, 1%
R2214	315-0432-00	B010100	B089999	4.3 kΩ, 1/4 W, 5%
R2214	311-1224-00	B090000		500 Ω, Var
R2215	315-0133-00			13 kΩ, 1/4 W, 5%
R2217	315-0124-00			120 kΩ, 1/4 W, 5%
R2219	315-0751-00			750 Ω, 1/4 W, 5%
R2220	321-0299-00			12.7 kΩ, 1/8 W, 1%
R2221	321-0212-00			1.58 kΩ, 1/8 W, 1%
R2226	315-0222-00			2.2 kΩ, 1/4 W, 5%
R2227	321-0266-00			6.04 kΩ, 1/8 W, 1%
R2229	321-0210-00			1.5 kΩ, 1/8 W, 1%
R2231	315-0303-00			30 kΩ, 1/4 W, 5%
R2235	315-0203-00			20 kΩ, 1/4 W, 5%
R2236	315-0203-00			20 kΩ, 1/4 W, 5%
R2237	315-0203-00			20 kΩ, 1/4 W, 5%
R2238	315-0203-00			20 kΩ, 1/4 W, 5%
R2241	321-0326-00			24.3 kΩ, 1/8 W, 1%
R2251	315-0102-00			1 kΩ, 1/4 W, 5%
R2252	315-0102-00			1 kΩ, 1/4 W, 5%
R2253	315-0102-00			1 kΩ, 1/4 W, 5%
R2254	315-0303-00	XB110000		30 kΩ, 1/4 W, 5%
R2261	315-0272-00			2.7 kΩ, 1/4 W, 5%
R2262	315-0102-00			1 kΩ, 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R2265	315-0512-00			5.1 kΩ, 1/4 W, 5%
R2266	315-0912-00			9.1 kΩ, 1/4 W, 5%
R2268	321-0296-00			11.8 kΩ, 1/8 W, 1%
R2273	311-1226-00	XB090000		2.5 kΩ, Var
R2274	321-0153-00			383 Ω, 1/8 W, 1%
R2275	321-0176-00	B010100	B089999	665 Ω, 1/8 W, 1%
R2275	321-0170-00	B090000		576 Ω, 1/8 W, 1%
R2276	315-0223-00			22 kΩ, 1/4 W, 5%
R2277	321-0250-00			3.92 kΩ, 1/8 W, 1%
R2278	315-0823-00	XB110000		82 kΩ, 1/4 W, 5%
R2279	321-0222-00			2 kΩ, 1/8 W, 1%
R2280	315-0823-00			82 kΩ, 1/4 W, 5%
R2281	315-0101-00	XB120000		100 Ω, 1/4 W, 5%
R2282	315-0332-00			3.3 kΩ, 1/4 W, 5%
R2283	315-0753-00	XB110000		75 kΩ, 1/4 W, 5%
R2284	321-0216-00			1.74 kΩ, 1/8 W, 1%
R2285	321-0245-00			3.48 kΩ, 1/8 W, 1%
R2286	321-0209-00			1.47 kΩ, 1/8 W, 1%
R2287	321-0199-00			1.15 kΩ, 1/8 W, 1%
R2288	321-0273-00			6.81 kΩ, 1/8 W, 1%
R2289	321-0193-00			1 kΩ, 1/8 W, 1%
R2291	311-1225-00			1 kΩ, Var
R2292	315-0132-00			1.3 kΩ, 1/4 W, 5%
R2293	321-0245-00			3.48 kΩ, 1/8 W, 1%
R2294	321-0255-00			4.42 kΩ, 1/8 W, 1%
R2295	321-0241-00			3.16 kΩ, 1/8 W, 1%
R2297	315-0152-00			1.5 kΩ, 1/4 W, 5%
R2298	315-0102-00			1 kΩ, 1/4 W, 5%
R2299	315-0511-00	B010100	B109999	510 Ω, 1/4 W, 5%
R2299	315-0431-00	B110000		430 Ω, 1/4 W, 5%
SWITCHES				
S100[1]	670-1638-00			Pushbutton, VERTICAL MODE
S110[1]	670-1639-00			Pushbutton, HORIZONTAL MODE
S122[2]	260-1138-00			Rotary, CONTROL ILLUM
S125[3]				Micro, BEAM FINDER
S455[1]	670-1640-00			Pushbutton, A TRIGGER SOURCE
S495[1]	670-1641-00			Pushbutton, B TRIGGER SOURCE
S801	260-0723-00			Slide, A DELAY DISABLE
S811	260-0723-00			Slide, B DELAY DISABLE
S1035	260-0723-00			Slide, SWEEP
S1065	260-0984-00			Slide, GATE
S1120	105-0293-00			Cam, RATE
S1150	105-0294-00			Cam, CALIBRATOR
S1200	260-1102-00	B010100	B069999	Toggle, POWER
S1200	260-1060-01	B070000		Togele, POWER
S1201	260-0879-00	B010100	B079999	Thermostatic, open 88.3 deg C, close 71.7 deg C
S1201	260-0638-00	B080000		Thermostatic, open 75 deg C, close 55 deg C
S1212[4]				
S2110	260-0723-00			Slide, READOUT MODE

[1]See Mechanical Parts List for replacement parts.
[2]Furnished as a unit with R2124.
[3]Furnished as a unit with R339.
[4]See Mechanical Parts List. Line Voltage Selector Body.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSFORMERS				
T1208	120-0636-00			Line Trigger
T1225	120-0743-00			Toroid, 13 turns bifilar
T1230	120-0744-00			Toroid, 5 windings
T1235	120-0747-00			Toroid, 55 turns single
T1310	120-0742-00			HV Power
HV MULTIPLIER				
U1615	152-0493-00			HV Multiplier
INTEGRATED CIRCUITS				
U215	155-0011-00			Monolithic, clock & chop blanking
U225	155-0010-00			Monolithic, chop divider & blanking
U265	155-0013-00			Monolithic, horiz. chop & alternate binary
U275	155-0013-00			Monolithic, horiz. chop & alternate binary
U285	155-0013-00			Monolithic, horiz. chop & alternate binary
U305	155-0009-00			Monolithic, horizontal lockout logic
U325	155-0012-00			Monolithic, Z-Axis logic & amplifier
U525	155-0060-00	B010100	B102899	Monolithic, vertical channel switch
U525	155-0060-01	B102900		Monolithic, vertical channel switch
U575	155-0060-00	B010100	B102899	Monolithic, vertical channel switch
U575	155-0060-01	B102900		Monolithic, vertical channel switch
U625[1]	155-0060-00			Monolithic, vertical channel switch
U685	155-0059-00			Monolithic, high frequency amplifier
U745	155-0065-00			Monolithic, out amplifier
U825	155-0022-00			Monolithic, channel switch
U1125	156-0012-00			Single 2 MHz J-K flip-flop, selected from 9923
U1275	155-0067-00	B010100	B010467	Monolithic, power supply regulator
U1275	155-0067-02	B010468		Monolithic, power supply regulator, checked
U1635	156-0067-00			Operational amplifier, replaceable by UA741C
U1745	155-0015-01			Monolithic, analog data switch
U2120	156-0043-00			Quad 2-input positive nor gate, replaceable by SN7402N
U2126	155-0021-00	B010100	B102882	Monolithic, timing generator
U2126	155-0021-00	B102883		Monolithic, timing generator
U2155	156-0043-00			Quad 2-input positive nor gate,replaceable by SN7402N
U2159	155-0017-00			Monolithic, 5 MHz decade counter
U2180	155-0015-01			Monolithic, analog data switch
U2185	155-0014-01			Monolithic, analog to decimal converter
U2190	155-0015-01			Monolithic, analog data switch
U2232	155-0018-00			Monolithic, zeros logic
U2244	155-0014-01			Monolithic, analog to decimal converter
U2250	156-0032-00			Single 10 MHz 1-&-3-bit binary ripple counter, replaceable by SN7493N
U2260	155-0019-00			Monolithic, decimal point and spacing
U2270	155-0023-00			Monolithic, character generator (numbers)
U2272	155-0024-00			Monolithic, character generator (symbols)
U2274	155-0025-00			Monolithic, character generator (prefixes)
U2276	155-0026-00			Monolithic, character generator (letters)
U2278	155-0027-00			Monolithic, character generator (letters 2)
U2284	155-0020-00			Monolithic, channel switching output assembly

[1]For replacement order 670-1625-01.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ELECTRON TUBE				
V1725	154-0644-00	B010100	B069999	CRT, Standard Phosphor
V1725	154-0644-05	B070000		CRT, Standard Phosphor

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

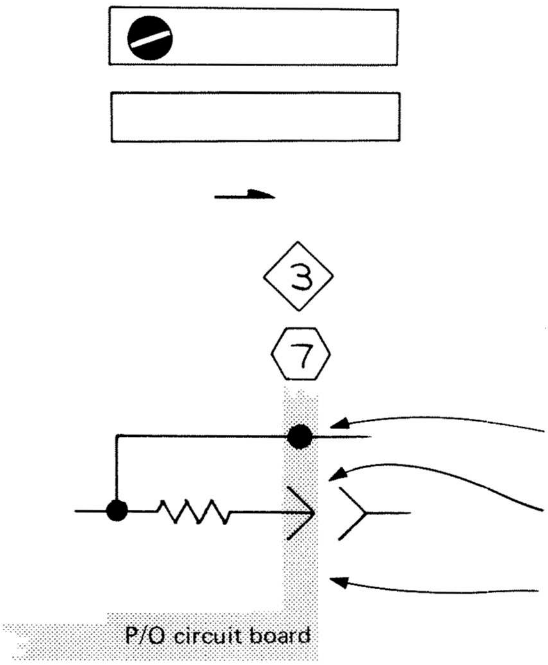
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors =	Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:



External Screwdriver adjustment.

External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

Connection soldered to circuit board.

Connection made to circuit board with interconnecting pin.

Blue tint encloses components located on circuit board.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc.)
AT	Attenuator, fixed or variable
B	Motor
BT	Battery
C	Capacitor, fixed or variable
CR	Diode, signal or rectifier
DL	Delay line
DS	Indicating device (lamp)
F	Fuse
FL	Filter
H	Heat dissipating device (heat sink, heat radiator, etc.)
HR	Heater
J	Connector, stationary portion
K	Relay
L	Inductor, fixed or variable
LR	Inductor/resistor combination
M	Meter
Q	Transistor or silicon-controlled rectifier
P	Connector, movable portion
R	Resistor, fixed or variable
RT	Thermistor
S	Switch
T	Transformer
TP	Test point
U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
V	Electron tube
VR	Voltage regulator (zener diode, etc.)
Y	Crystal

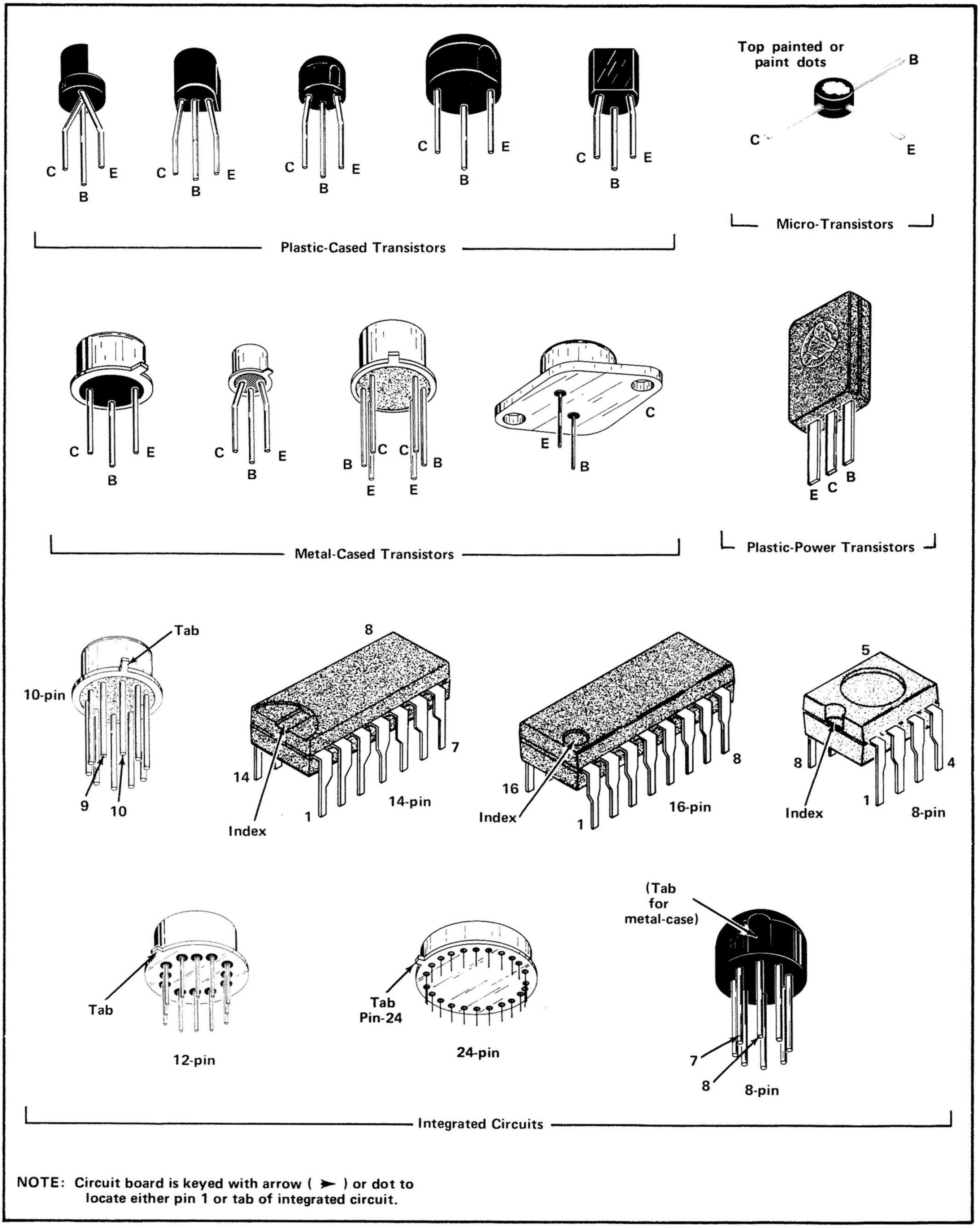


Fig. 5-1. Electrode configuration for semiconductors in this instrument.

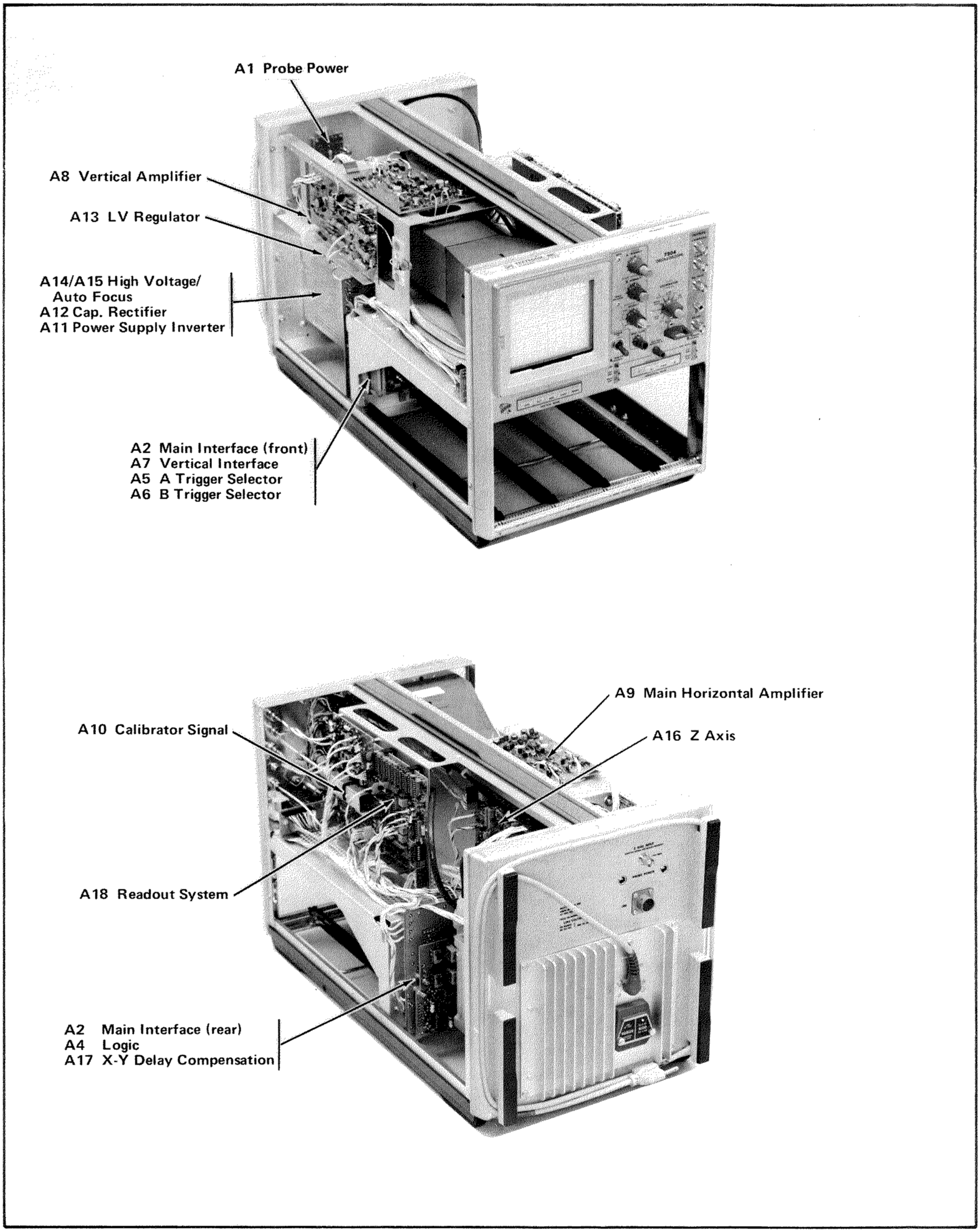
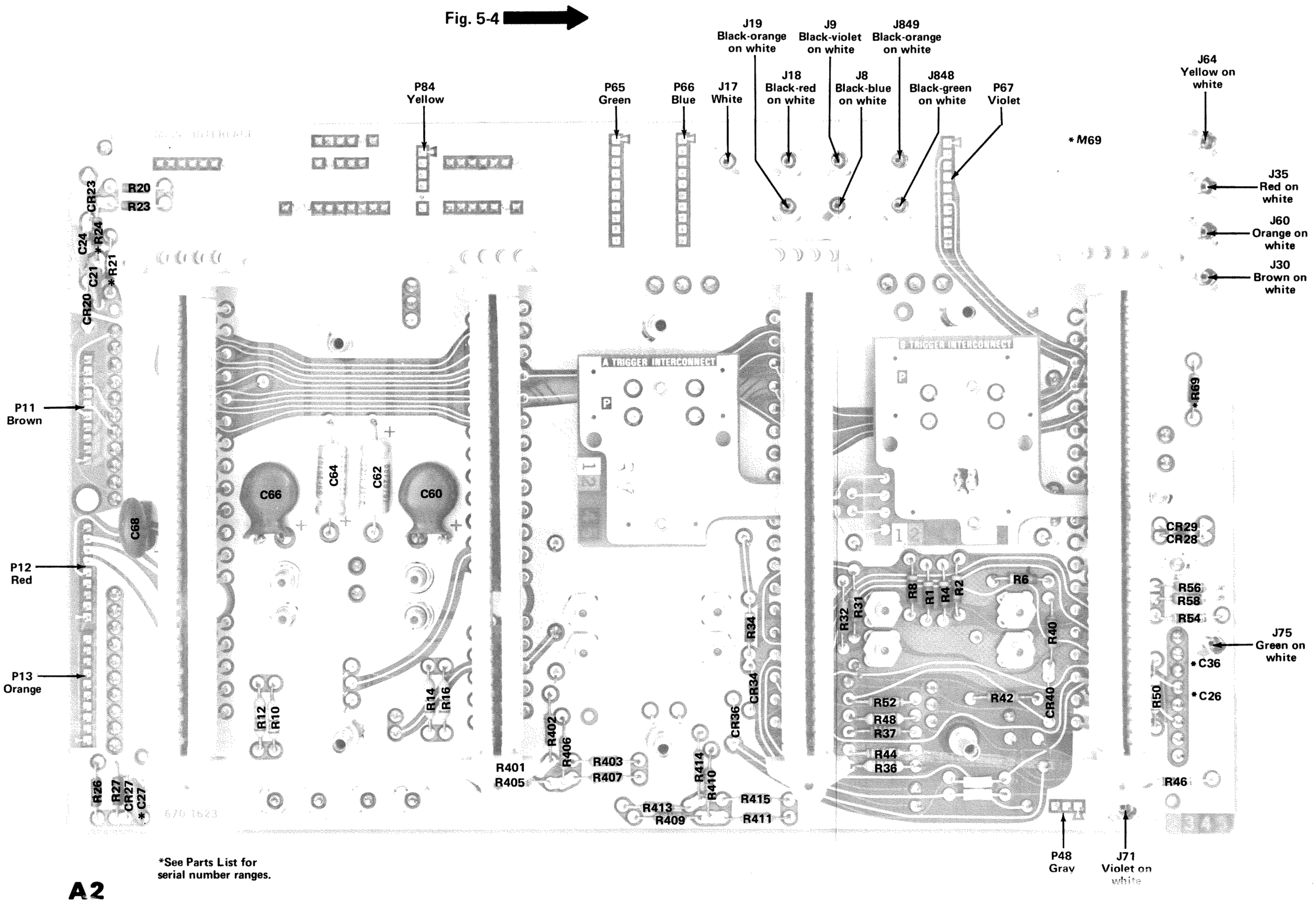


Fig. 5-2. Location of circuit boards in the 7904.



*See Parts List for serial number ranges.

A2

Fig. 5-3. Main Interface circuit board (front view).

A2

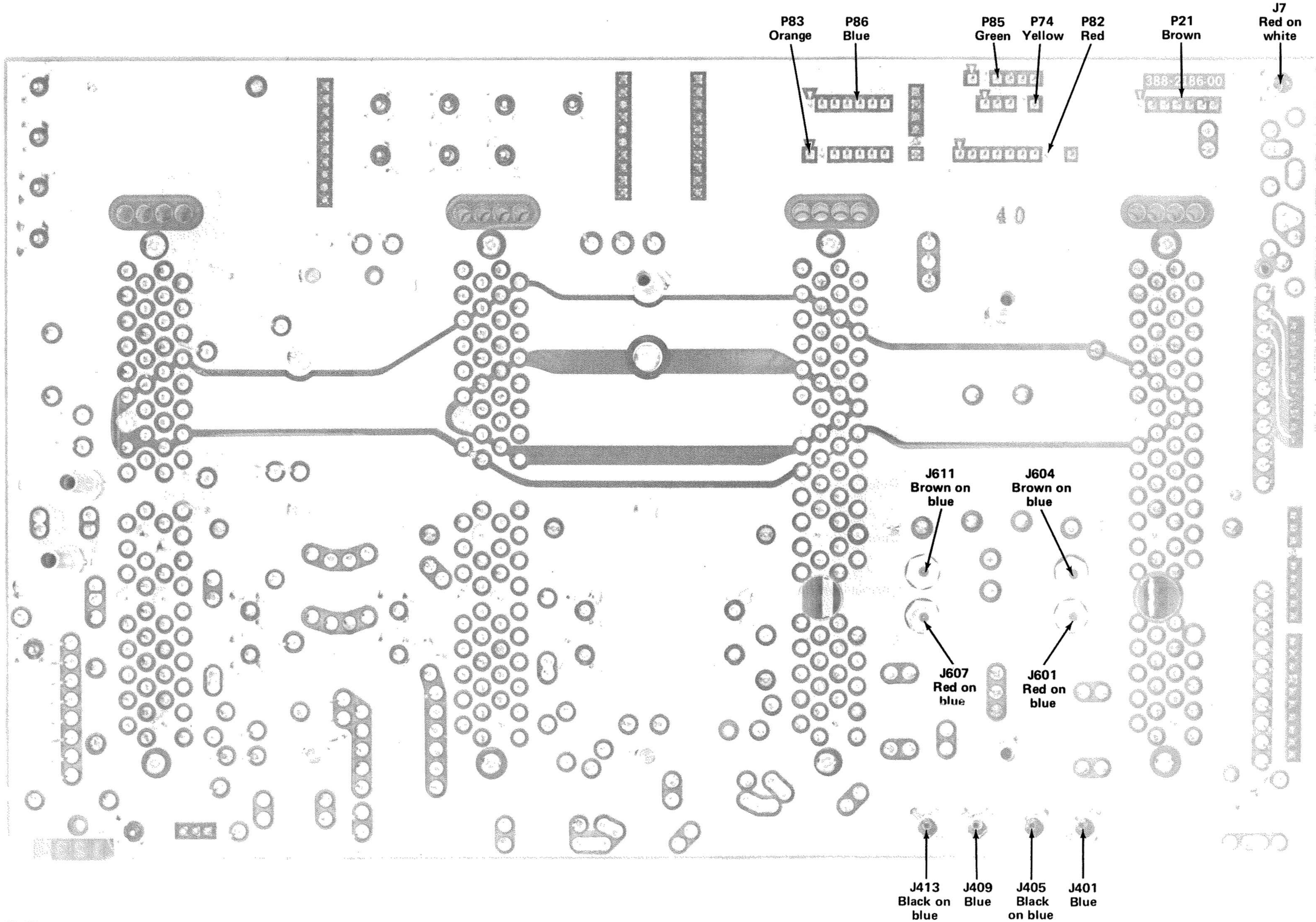


Fig. 5-4. Main Interface circuit board (rear view).

Ⓐ

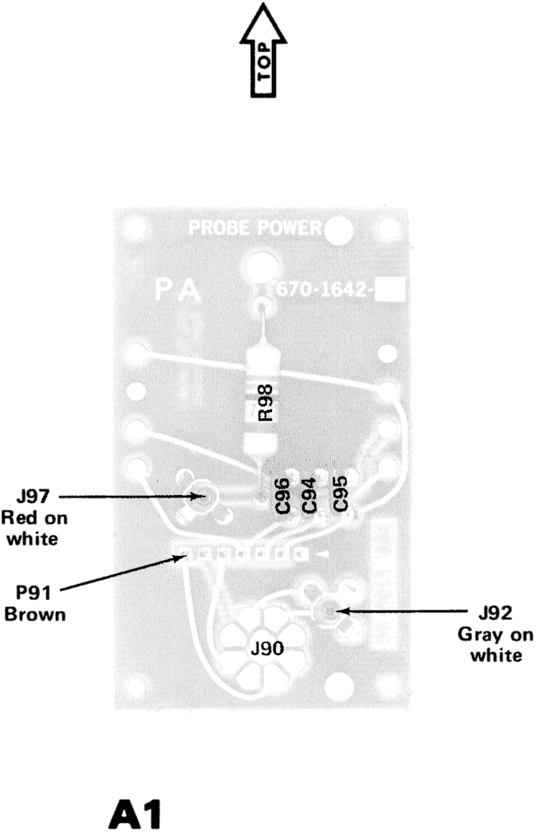
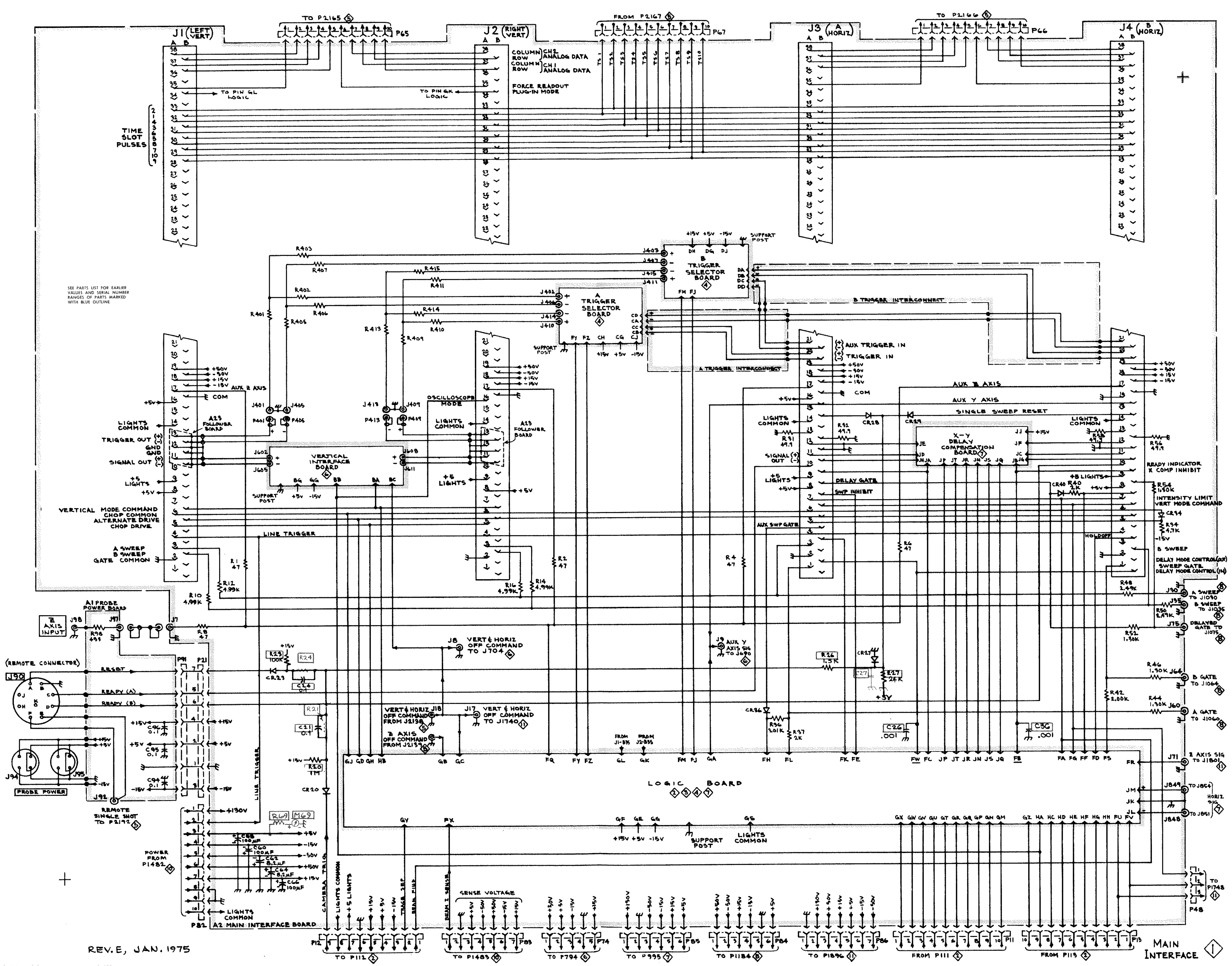


Fig. 5-5. Probe Power circuit board.



J1 (LEFT VERT)
J2 (RIGHT VERT)
J3 (A HORIZ)
J4 (B HORIZ)
TO P2165
FROM P2167
TO P2166
TIME SLOT PULSES
B TRIGGER SELECTOR BOARD
A TRIGGER SELECTOR BOARD
VERTICAL INTERFACE BOARD
X-Y DELAY COMPENSATION BOARD
LOGIC BOARD
A1 PROBE POWER BOARD
A2 MAIN INTERFACE BOARD
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE
REV. E, JAN. 1975
MAIN INTERFACE

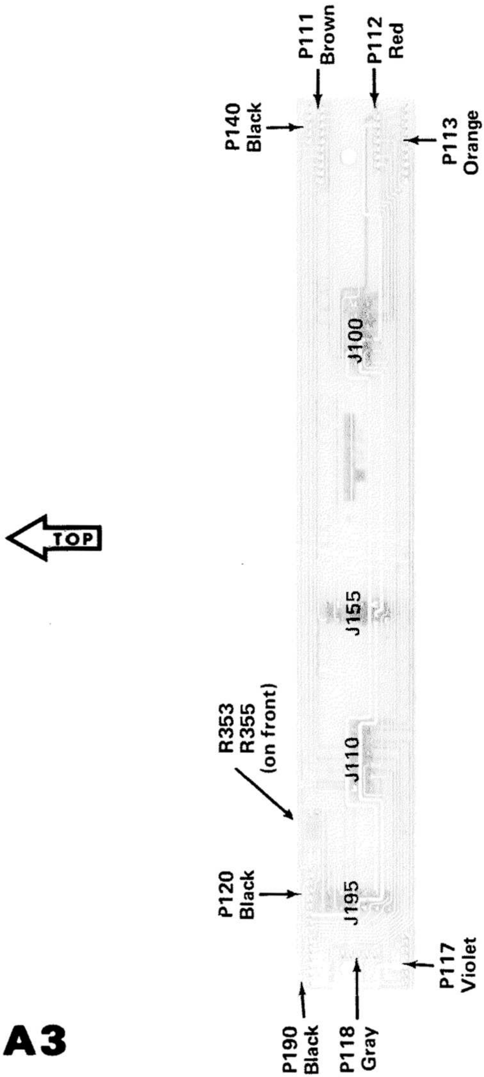
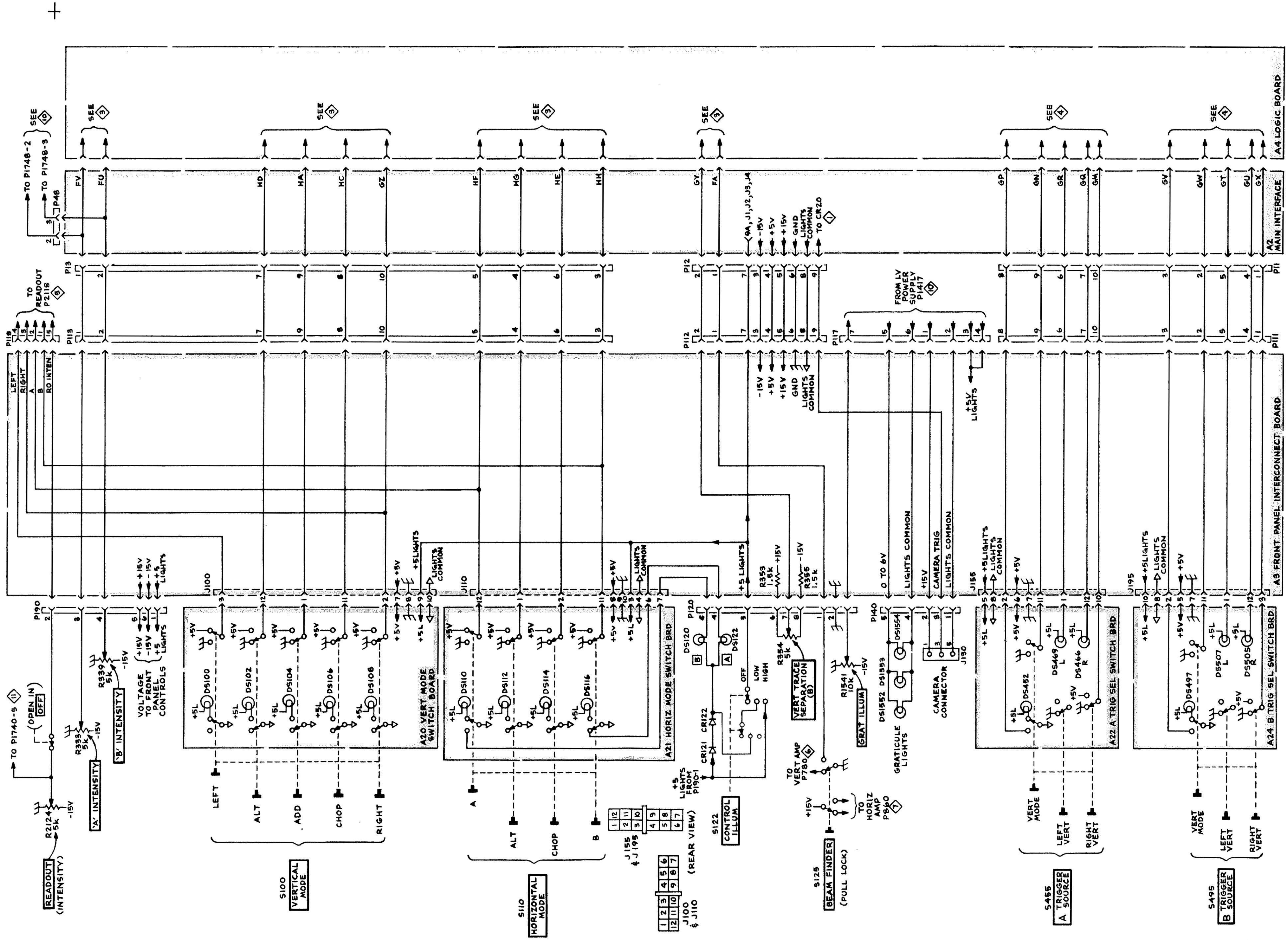


Fig. 5-6. Front Panel Interconnect circuit board (rear view).



7904

FRONT PANEL INTERCONNECT (2)

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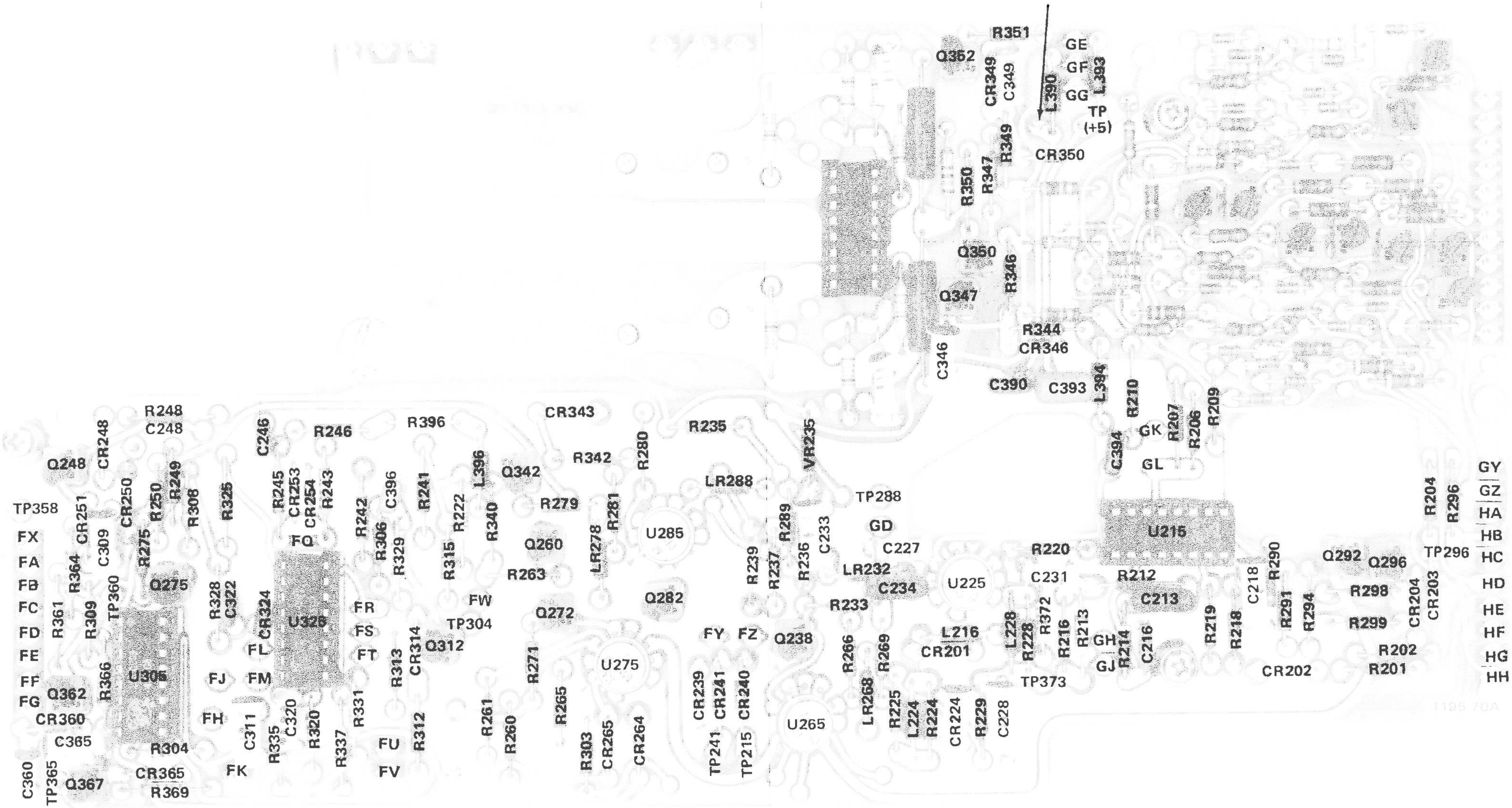
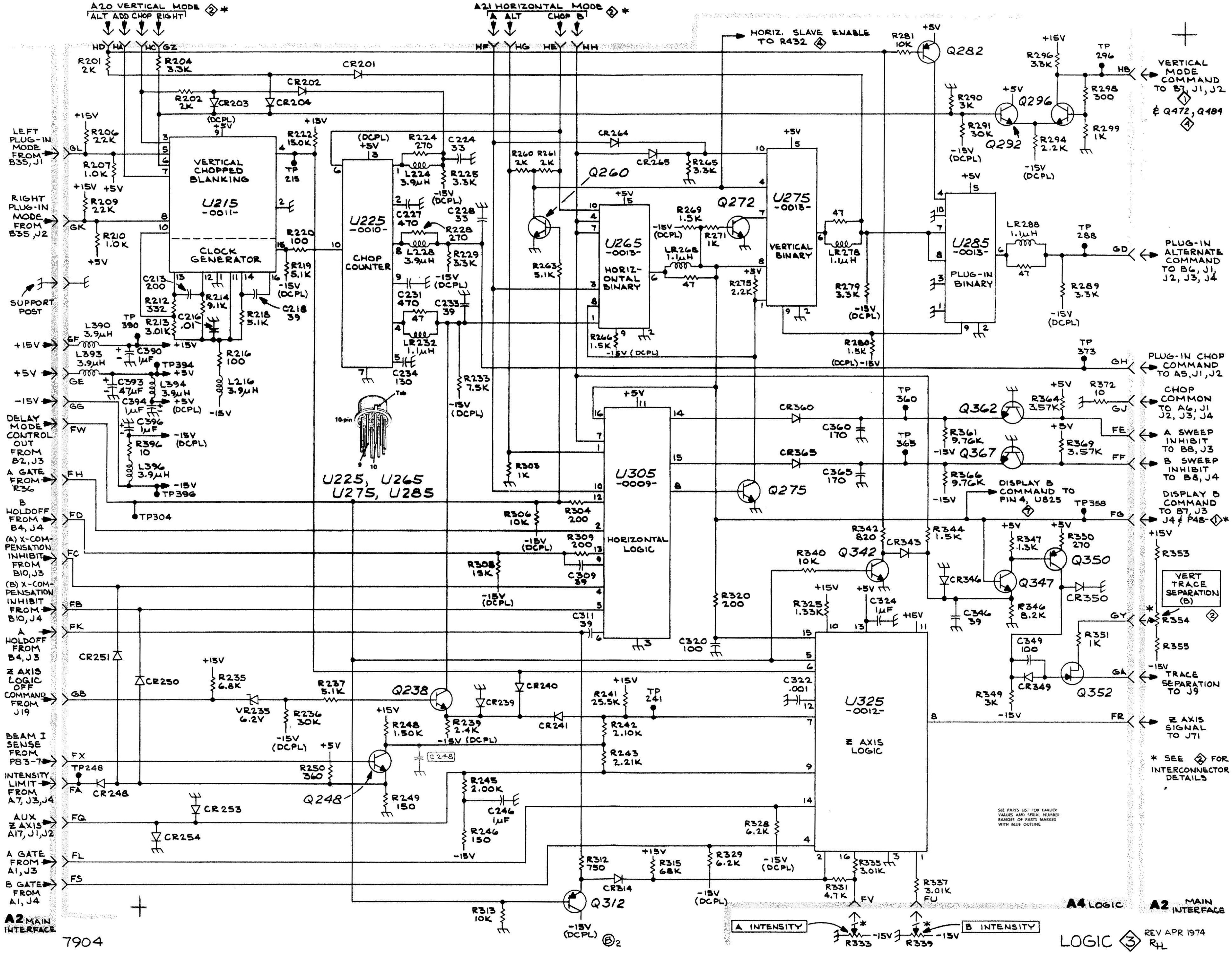


A4

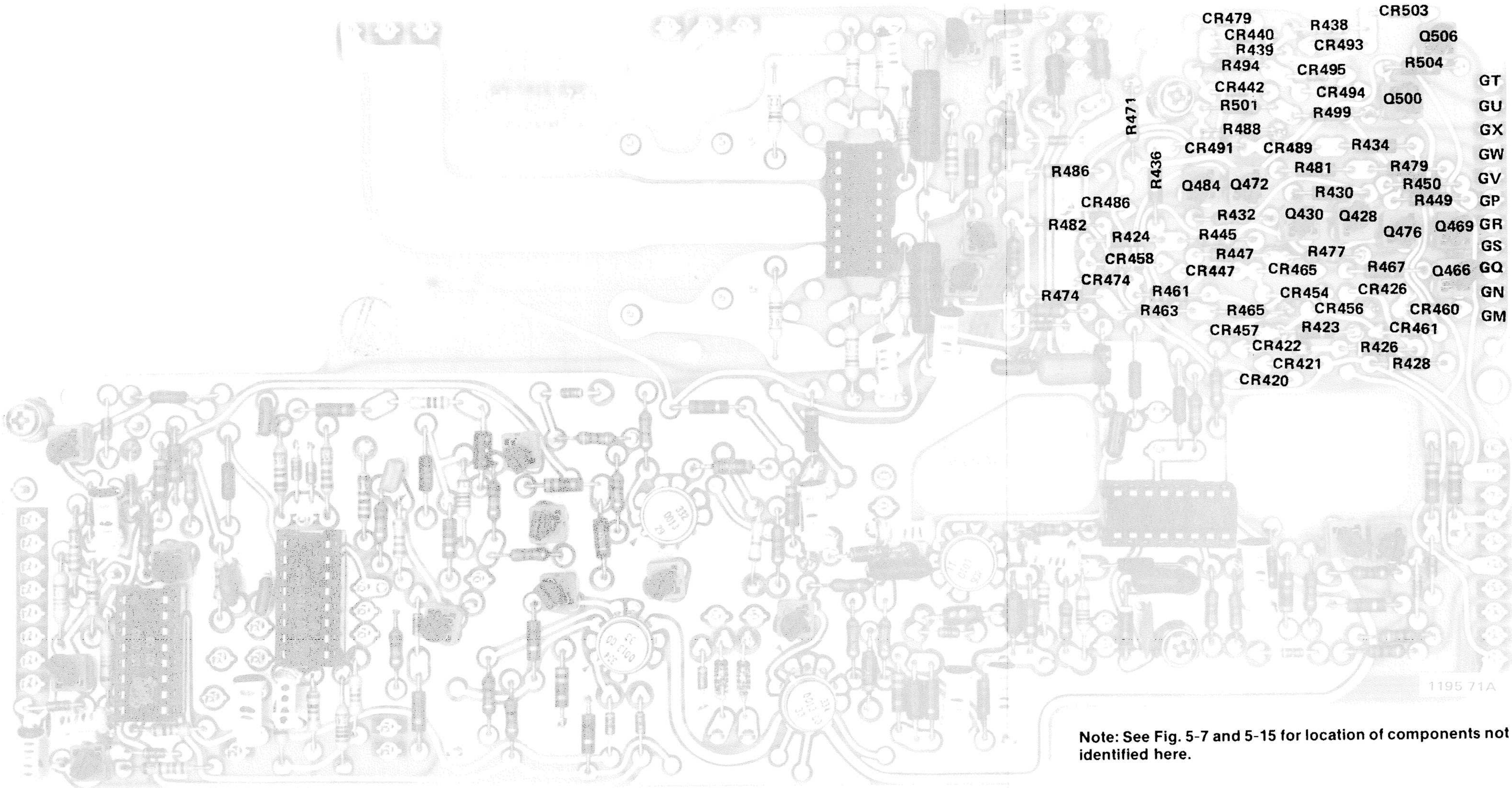
Fig. 5-7. Partial Logic circuit board.

Rev. C, Aug 1974



A20 VERTICAL MODE ② *
ALT ADD CHOP RIGHT
A21 HORIZONTAL MODE ② *
A ALT CHOP B
HD HA HC GZ
HF HG HE HH
HORIZ. SLAVE ENABLE TO R432 ④
R201 2K
R204 3.3K
CR201
CR202
R202 2K
CR203
CR204
R281 10K
Q282
R296 3.3K
TP 296
VERTICAL MODE COMMAND TO B7, J1, J2 ① & Q472, Q484 ④
R290 3K
Q296
R298 300
R291 30K
Q292
R294 2.2K
R299 1K
LEFT PLUG-IN MODE FROM B35, J1
GL
R206 22K
R207 1.0K
RIGHT PLUG-IN MODE FROM B35, J2
GK
R209 22K
R210 1.0K
VERTICAL CHOPPED BLANKING
U215 -0011-
CLOCK GENERATOR
TP 215
R222 15.0K
R224 270
C224 33
L224 3.9µH
R225 3.3K
U225 -0010-
CHOP COUNTER
C227 470
R228 270
L228 3.9µH
C228 33
R229 3.3K
R220 100
R219 5.1K
C213 200
R212 332
R214 9.1K
R218 5.1K
C218 39
R213 3.01K
C216 .01
C231 470
C233 39
L232 1.1µH
C234 130
R216 100
L216 3.9µH
R233 7.5K
10-pin
Tab
U225, U265
U275, U285
CR264
CR265
R260 2K
R261 2K
R265 3.3K
Q260
Q272
U265 -0013-
HORIZONTAL BINARY
R269 1.5K
R271 1K
LR268 1.1µH
R263 5.1K
R266 1.5K
R275 2.2K
U275 -0013-
VERTICAL BINARY
LR278 1.1µH
R279 3.3K
R280 1.5K
U285 -0013-
PLUG-IN BINARY
LR288 1.1µH
TP 288
R289 3.3K
GD
PLUG-IN ALTERNATE COMMAND TO B6, J1, J2, J3, J4
SUPPORT POST
TP 390
L390 3.9µH
GF
C390 1µF
L393 3.9µH
TP394
GE
C393 47µF
L394 3.9µH
C394 1µF
GG
DELAY MODE CONTROL OUT FROM B2, J3
FW
C396 1µF
R396 10
L396 3.9µH
TP396
A GATE FROM R36
FH
TP304
B HOLDOFF FROM B4, J4
FD
(A) X-COMPENSATION INHIBIT FROM B10, J3
FC
(B) X-COMPENSATION INHIBIT FROM B10, J4
FB
A HOLDOFF FROM B4, J3
FK
TP 373
GH
PLUG-IN CHOP COMMAND TO A5, J1, J2
R303 1K
R306 10K
R304 200
R309 200
C309 39
R308 15K
C311 39
U305 -0009-
HORIZONTAL LOGIC
CR360
TP 360
C360 170
R361 9.76K
Q362
R364 3.57K
R372 10
GJ
CHOP COMMON TO A6, J1, J2, J3, J4
FE
A SWEEP INHIBIT TO B8, J3
CR365
TP 365
C365 170
R366 9.76K
Q367
R369 3.57K
FF
B SWEEP INHIBIT TO B8, J4
Q275
DISPLAY B COMMAND TO PIN 4, U825 ⑦
TP358
FG
DISPLAY B COMMAND TO B7, J3, J4 & P48 ① *
R342 820
CR343
R344 1.5K
R340 10K
Q342
R347 1.3K
R350 270
Q350
Q347
CR346
CR350
R353
VERT TRACE SEPARATION (B)
R320 200
R325 1.33K
C324 1µF
C346 39
R346 8.2K
GY
R354
R355
C320 100
C349 100
R351 1K
CR349
Q352
R349 3K
GA
TRACE SEPARATION TO J9
Z AXIS LOGIC OFF COMMAND FROM J19
GB
CR251
CR250
R235 6.8K
VR235 6.2V
R236 30K
R237 5.1K
Q238
CR239
CR240
CR241
R239 2.4K
R241 25.5K
TP 241
C322 .001
R242 2.10K
R243 2.21K
U325 -0012-
Z AXIS LOGIC
FR
Z AXIS SIGNAL TO J71
BEAM I SENSE FROM P83-7
FX
TP248
R248 1.50K
C248
R250 360
Q248
INTENSITY LIMIT FROM A7, J3, J4
FA
CR248
R249 150
R245 2.00K
C246 1µF
R246 150
AUX Z AXIS A17, J1, J2
FQ
CR253
CR254
R328 6.2K
* SEE ② FOR INTERCONNECTOR DETAILS
A GATE FROM A1, J3
FL
B GATE FROM A1, J4
FS
R312 750
CR314
R315 68K
R329 6.2K
R335 3.01K
R331 4.7K
R337 3.01K
FV
FU
Q312
R313 10K
A INTENSITY
R333
B INTENSITY
R339
A2 MAIN INTERFACE
A4 LOGIC
A2 MAIN INTERFACE
7904
LOGIC ③
REV APR 1974

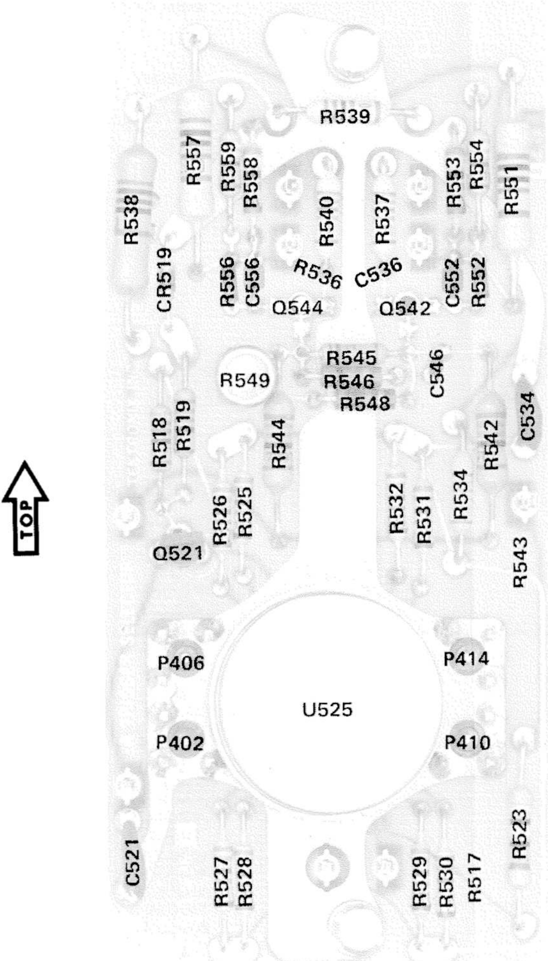
FIG. 5-9 & 5-10



Note: See Fig. 5-7 and 5-15 for location of components not identified here.

A4

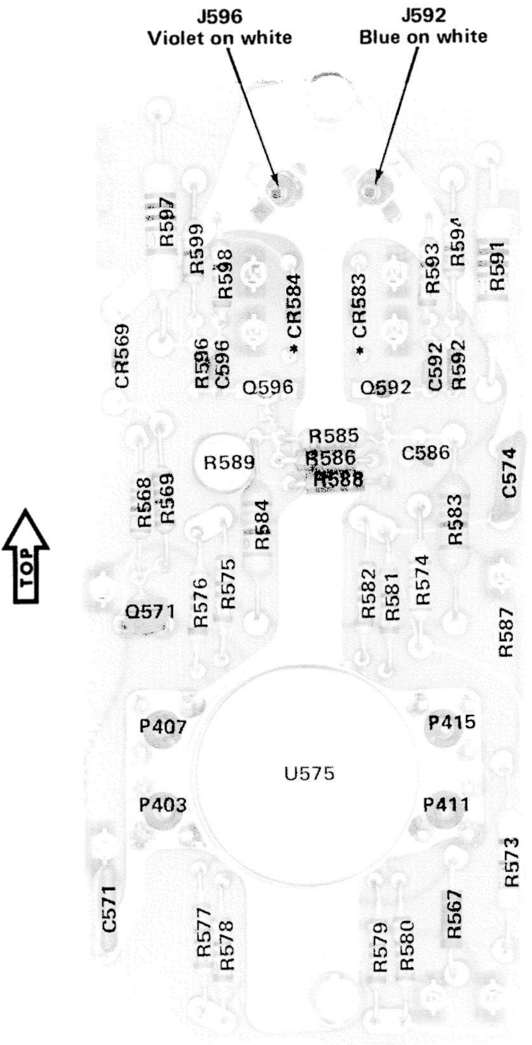
Fig. 5-8. Partial Logic circuit board.



NOTE: C510-R510, C512-R512, C514-R514, C516-R516, and R517 mounted on back of board.

A5

Fig. 5-9. A Trigger Selector circuit board.



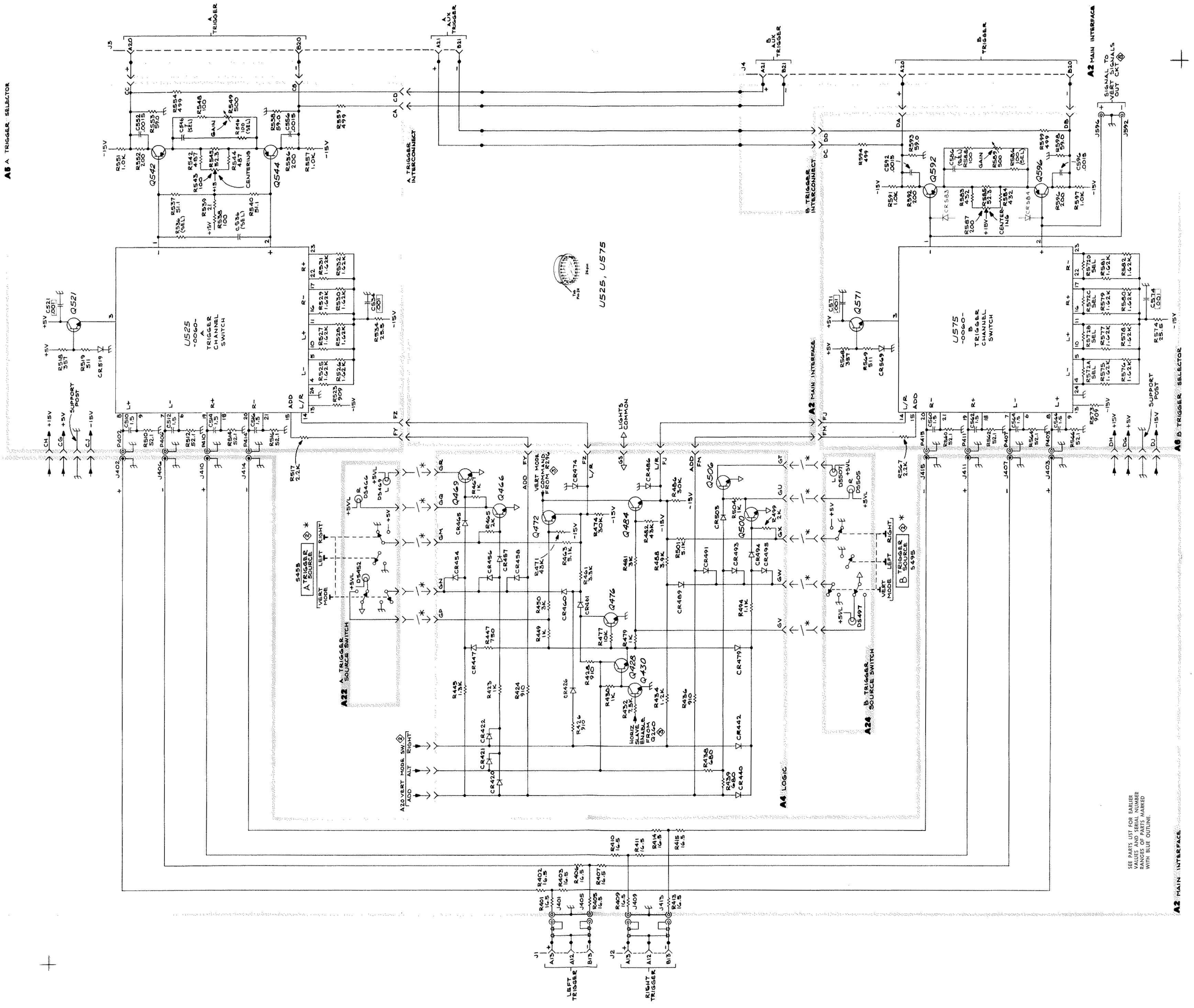
NOTE: C560-R560, C562-R562, C564-R564 and C566-R566 mounted on back of board.

A6

***See Parts List for serial number ranges.**

REV. APR 1974

Fig. 5-10. B Trigger Selector circuit board.



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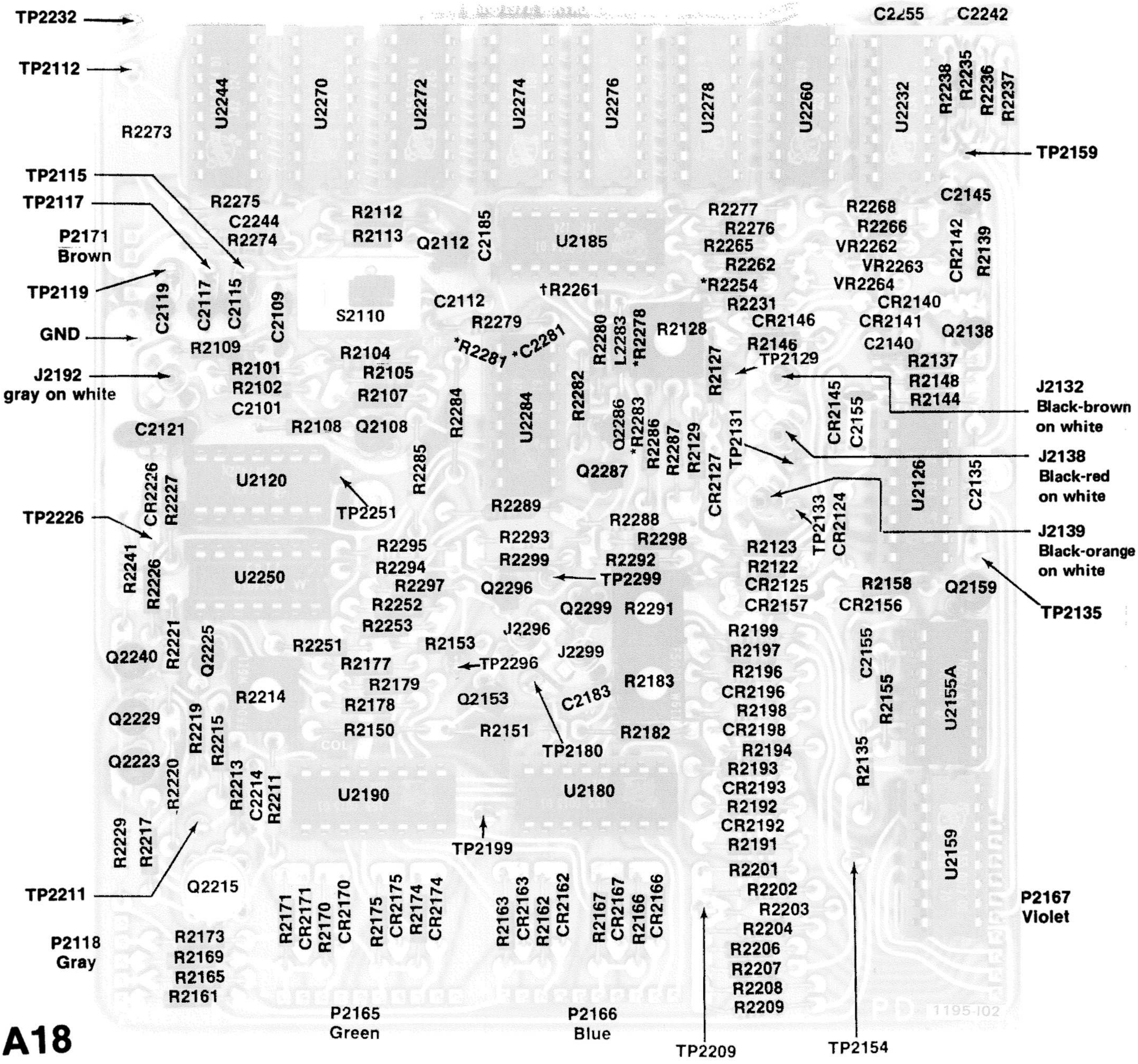
TRIGGER SELECTOR ④ REV APR 1974

FIG. 5-11B



NOTE: Black on white cable to J2296.
White cable to J2299

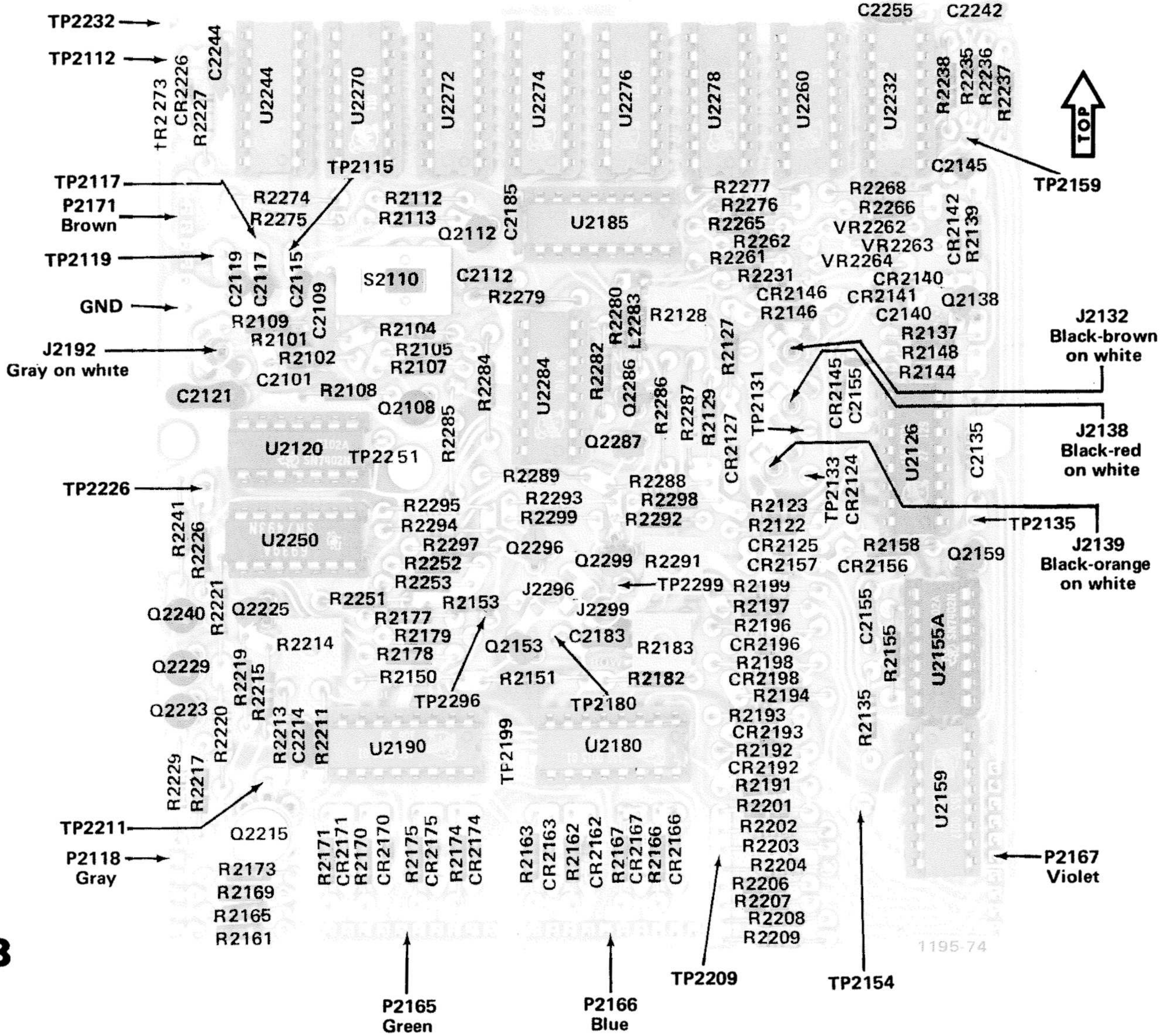
† R2261 relocated SN BII0000

*See Parts List for serial number ranges.

Fig. 5-11A. Readout system circuit board, SN B090000—up

REV. B, JAN. 1975

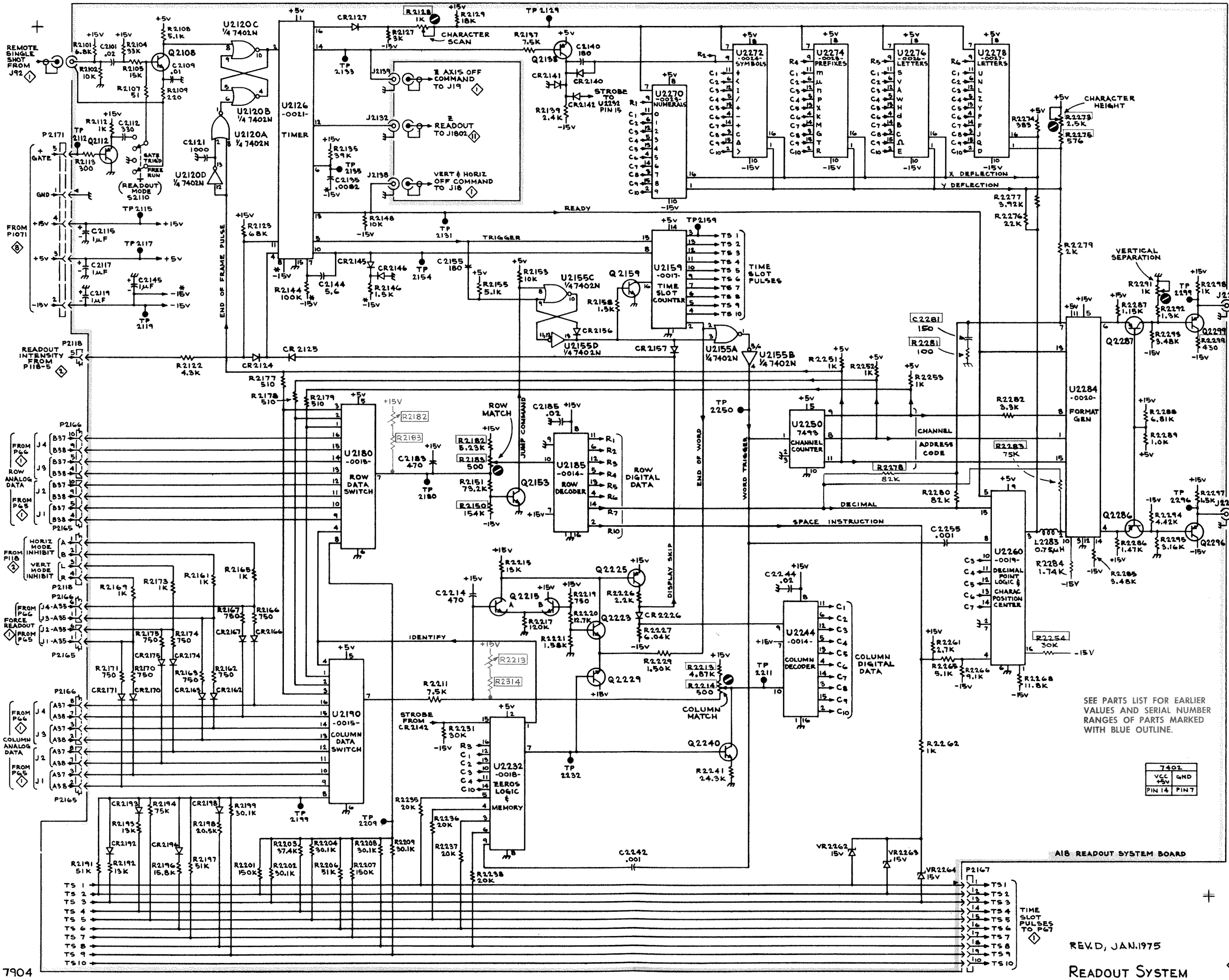
A18



NOTE: Black on white cable to J2296. White cable to J2299.

†Character Height (Variable)

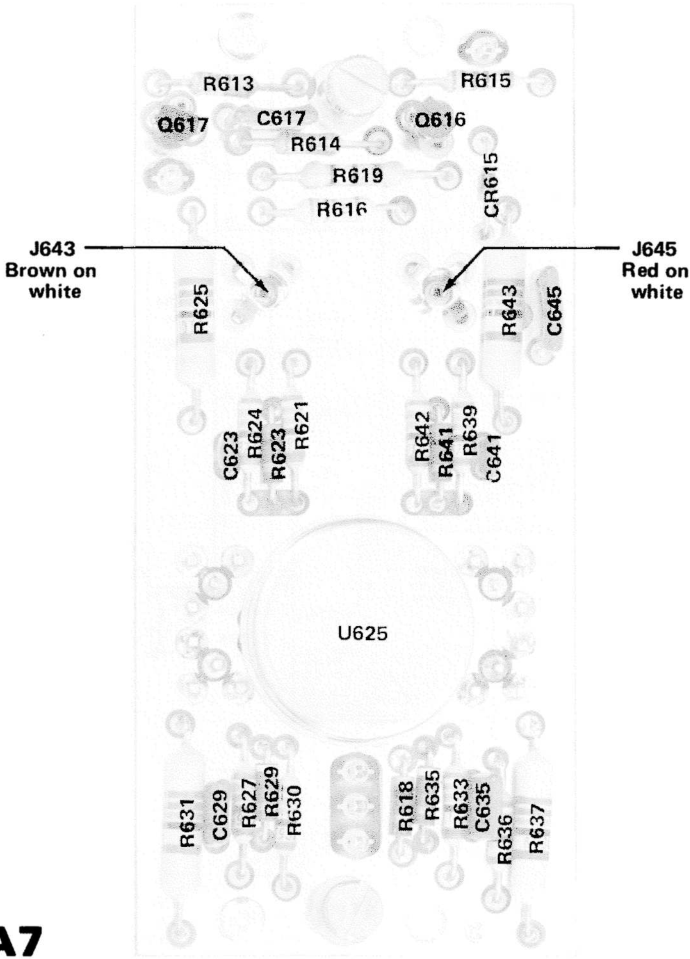
Fig. 5-11B. Readout system circuit board below SN B090000.



7904

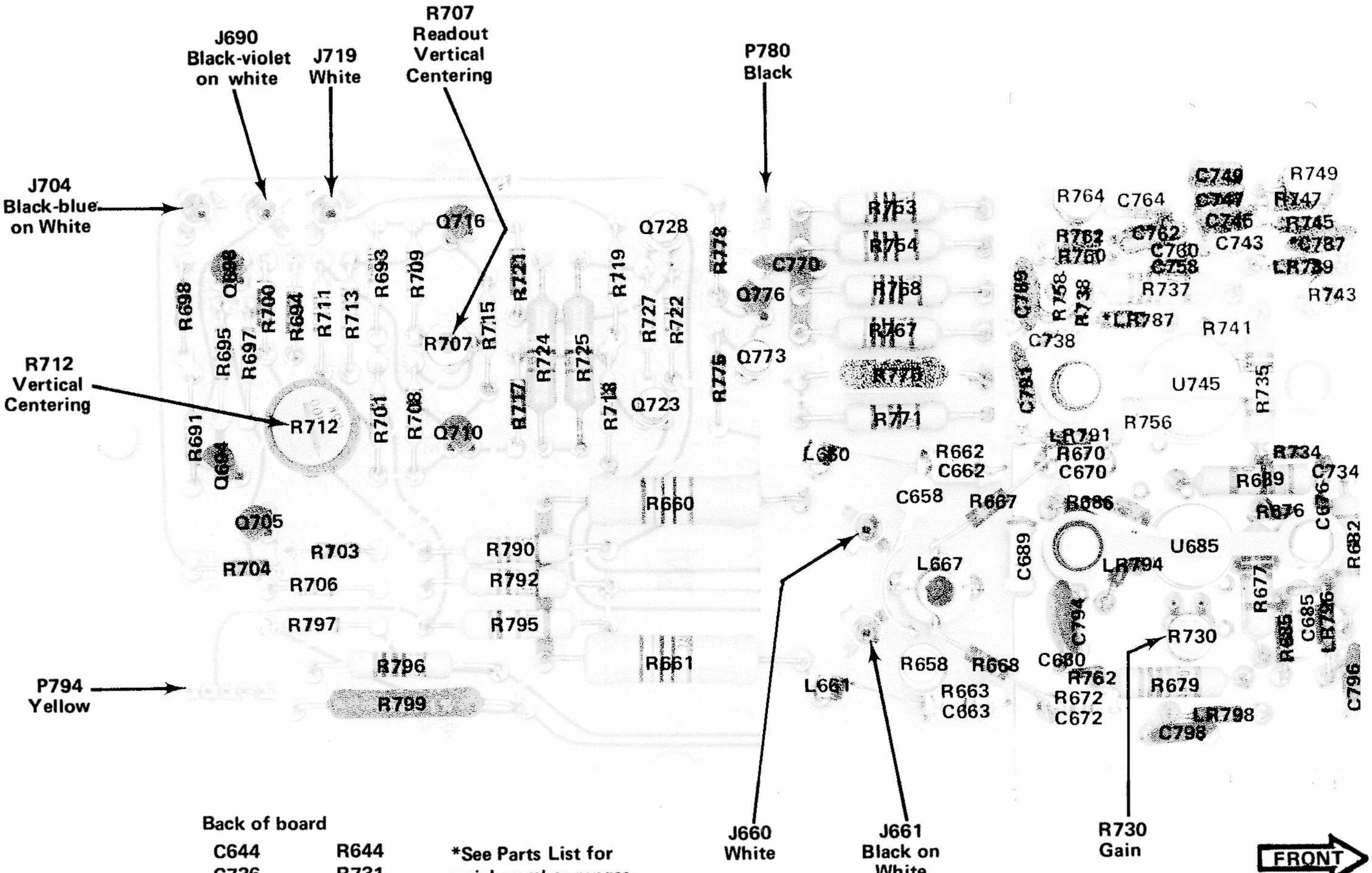
READOUT SYSTEM

Fig. 5-13



A7

Fig. 5-12. Vertical Interface circuit board.



Back of board

C644	R644
C736	R731
C787	R733
*CR787	R736
LR787	*R788

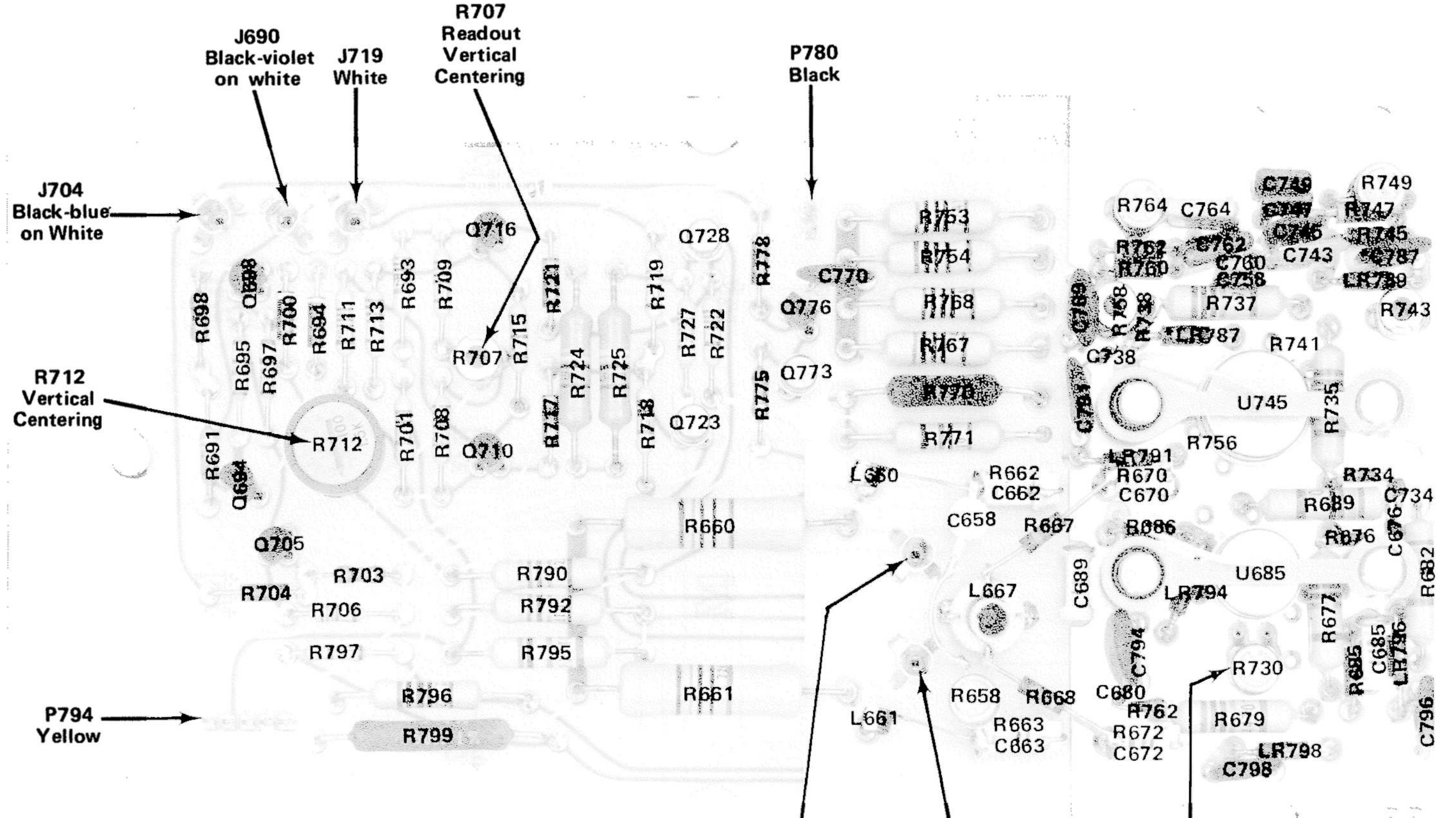
*See Parts List for serial number ranges.

A8

Fig. 5-13A. Vertical Amplifier circuit board, SN B020000-up.

REV. C, JAN. 1975

1195-76



Back of board

C644	R644
C736	R731
C787	R733
*CR787	R736
LR787	*R788

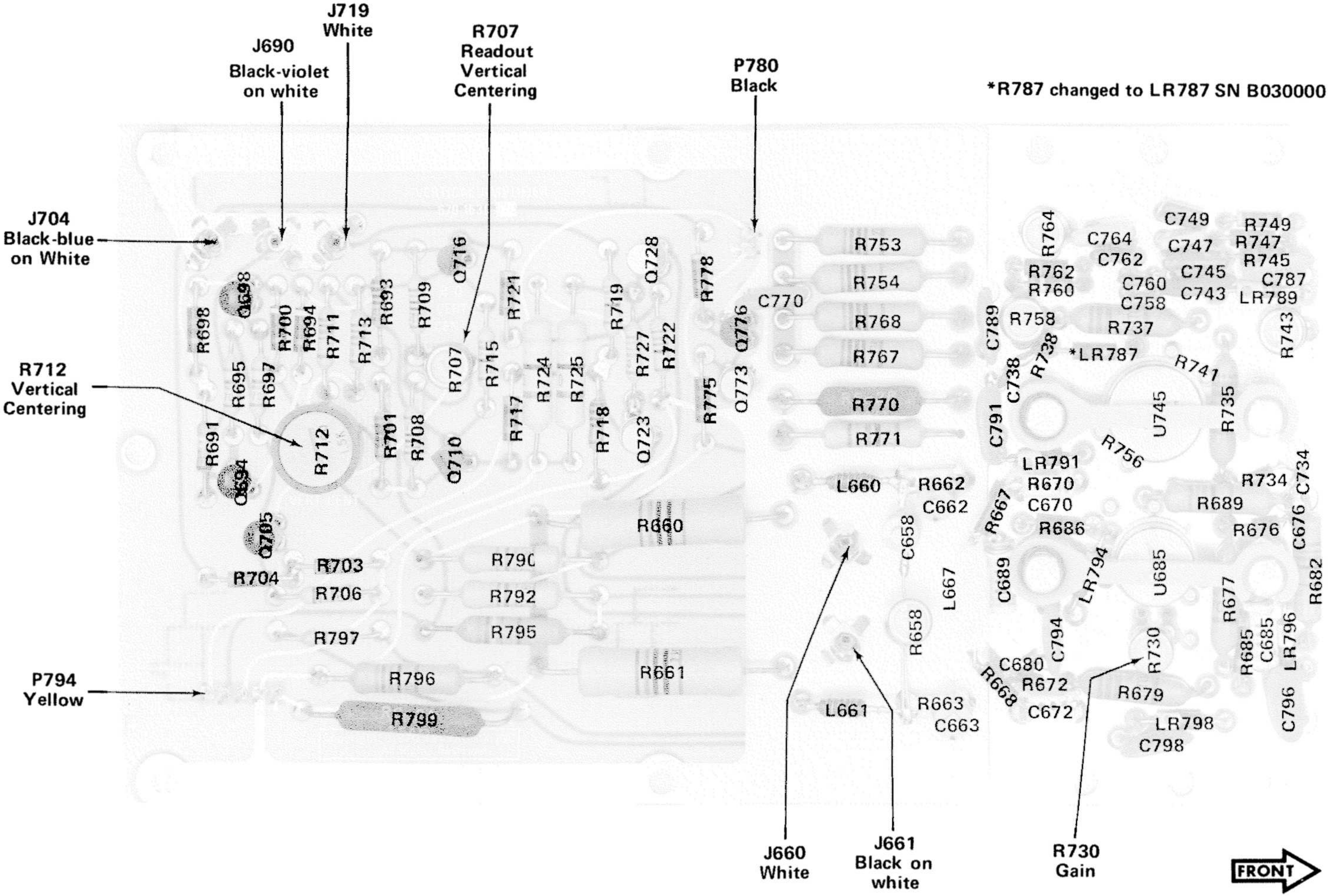
*See Parts List for serial number ranges.

A8

Fig. 5-13A. Vertical Amplifier circuit board, SN B020000-up.

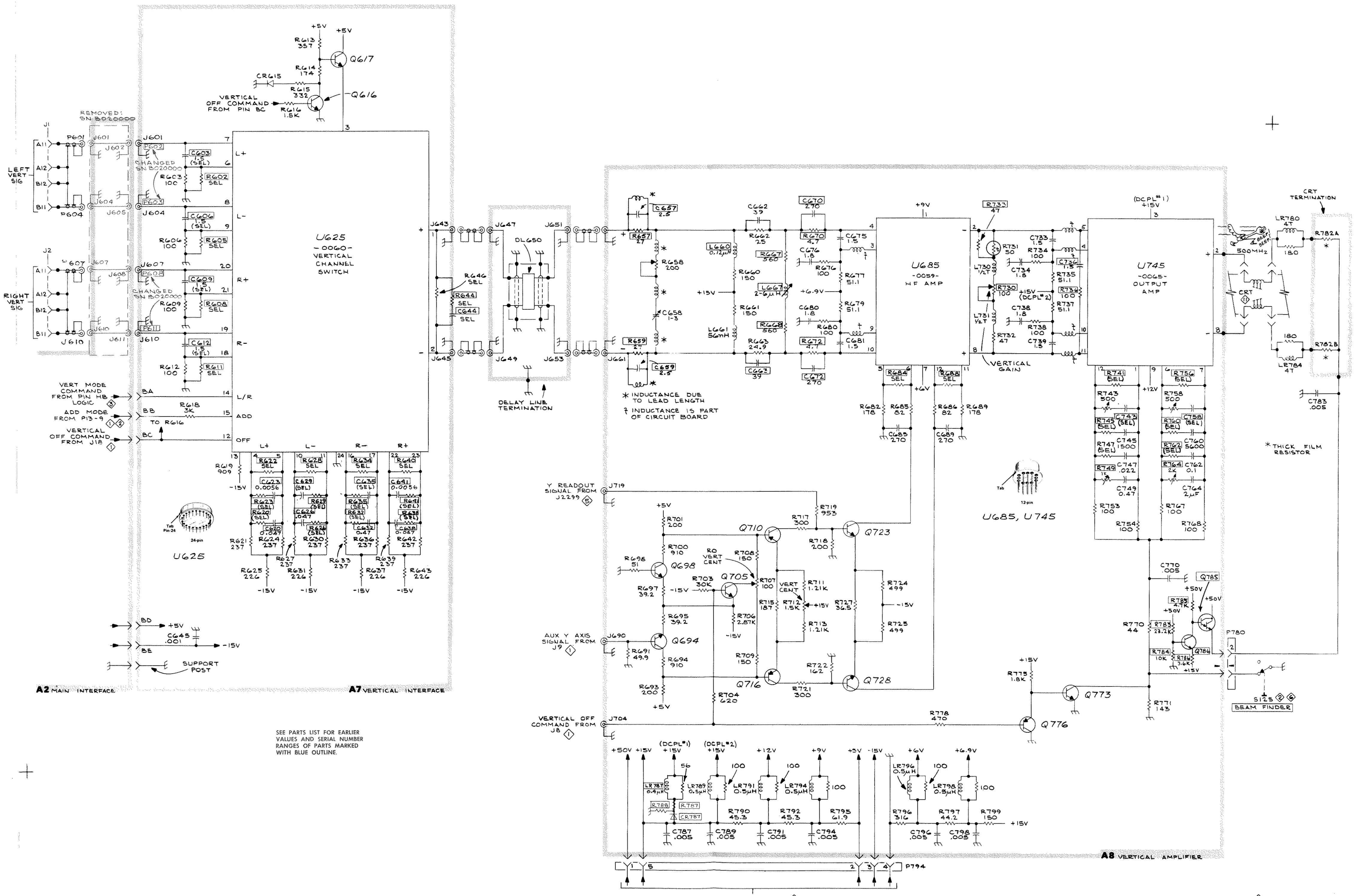
REV. C, JAN. 1975

1195-76



A8

Fig. 5-13B. Vertical Amplifier circuit board, below SN B020000.

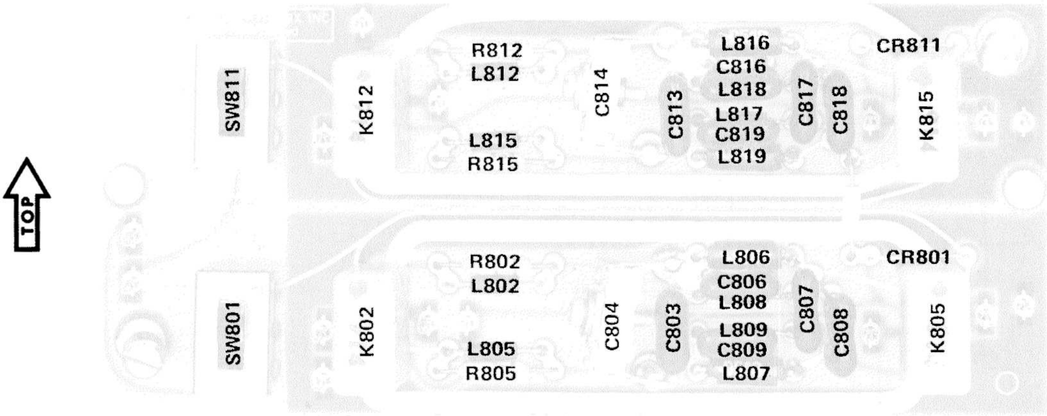


7904

REV.E, JAN. 1975

VERTICAL AMPLIFIER 6

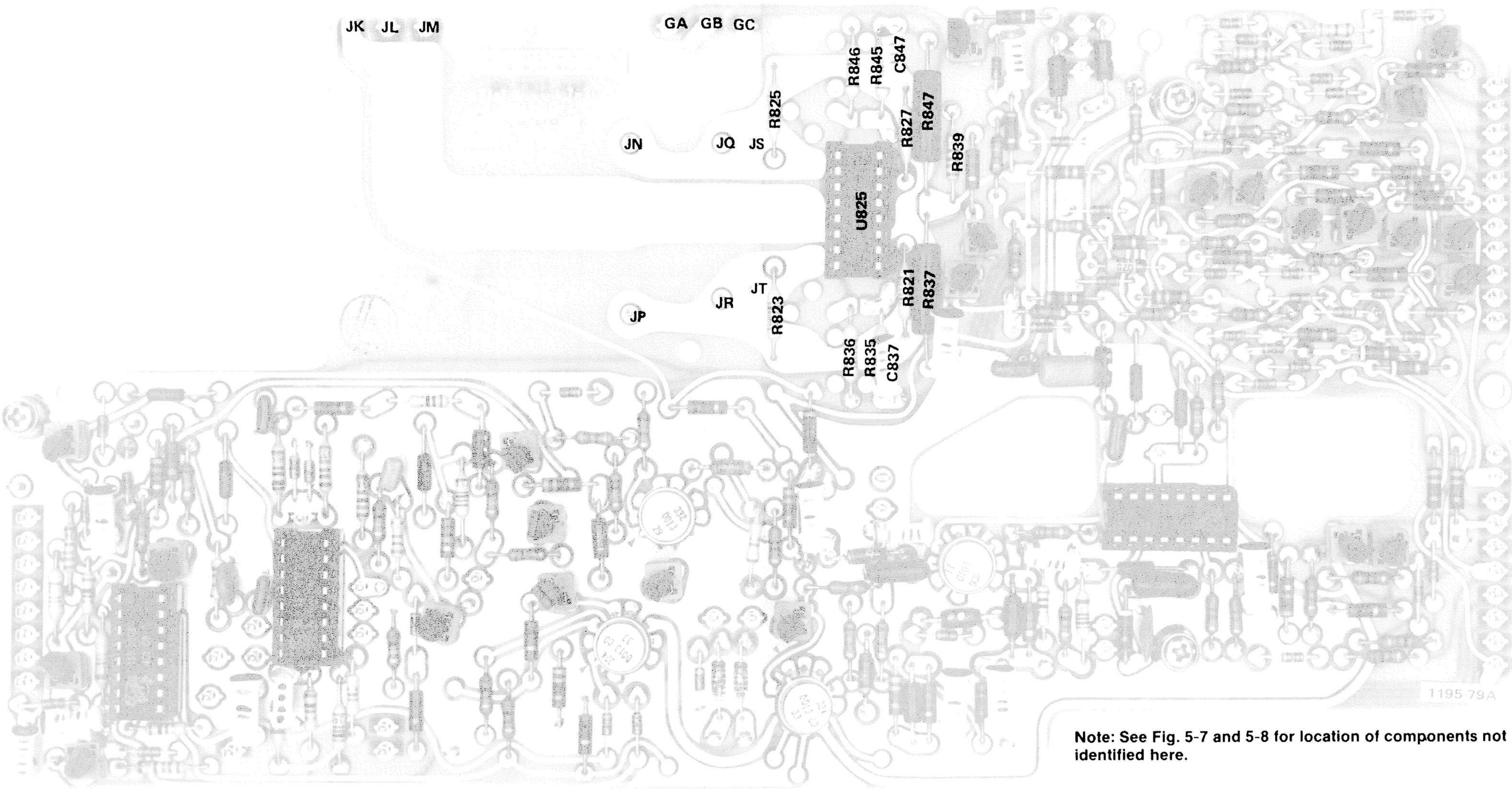
Fig. 5-15



A17

Fig. 5-14. X-Y Delay Compensation (Option 2) circuit board.

Ⓐ



Note: See Fig. 5-7 and 5-8 for location of components not identified here.

Fig. 5-15. Partial Logic circuit board.

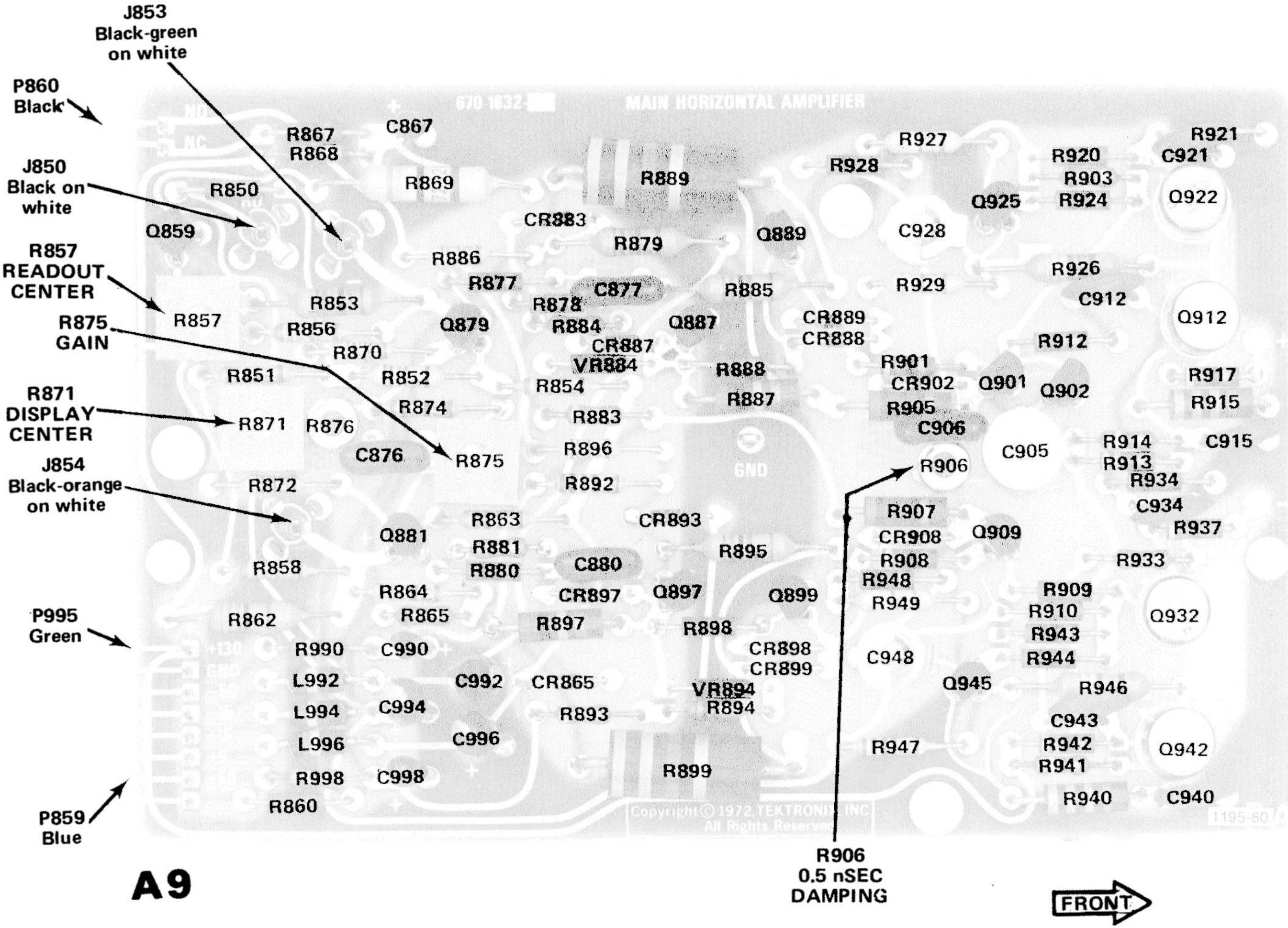
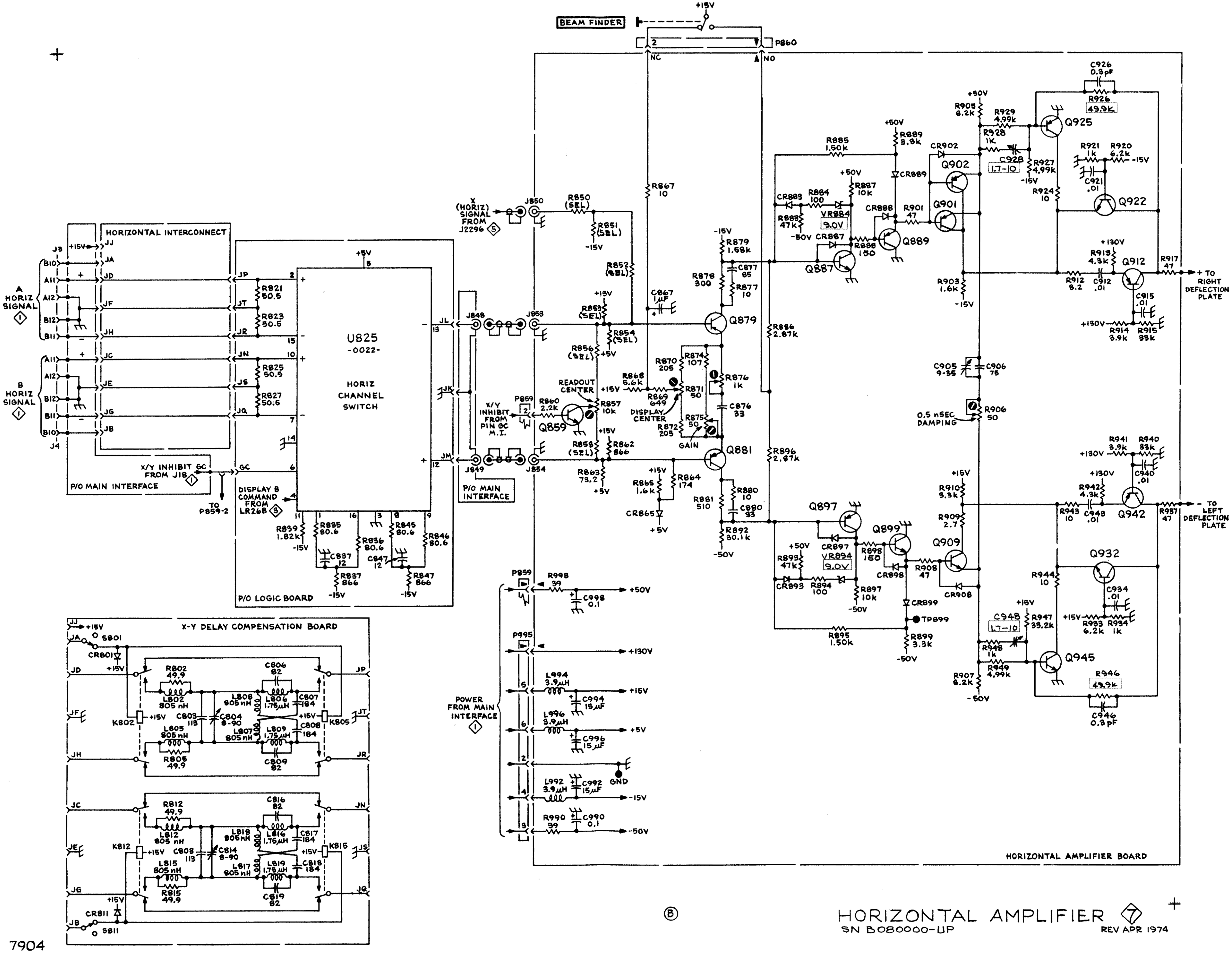


Fig. 5-16A. Main Horizontal Amplifier circuit board, SN B080000-up.

REV. B, AUG 1974

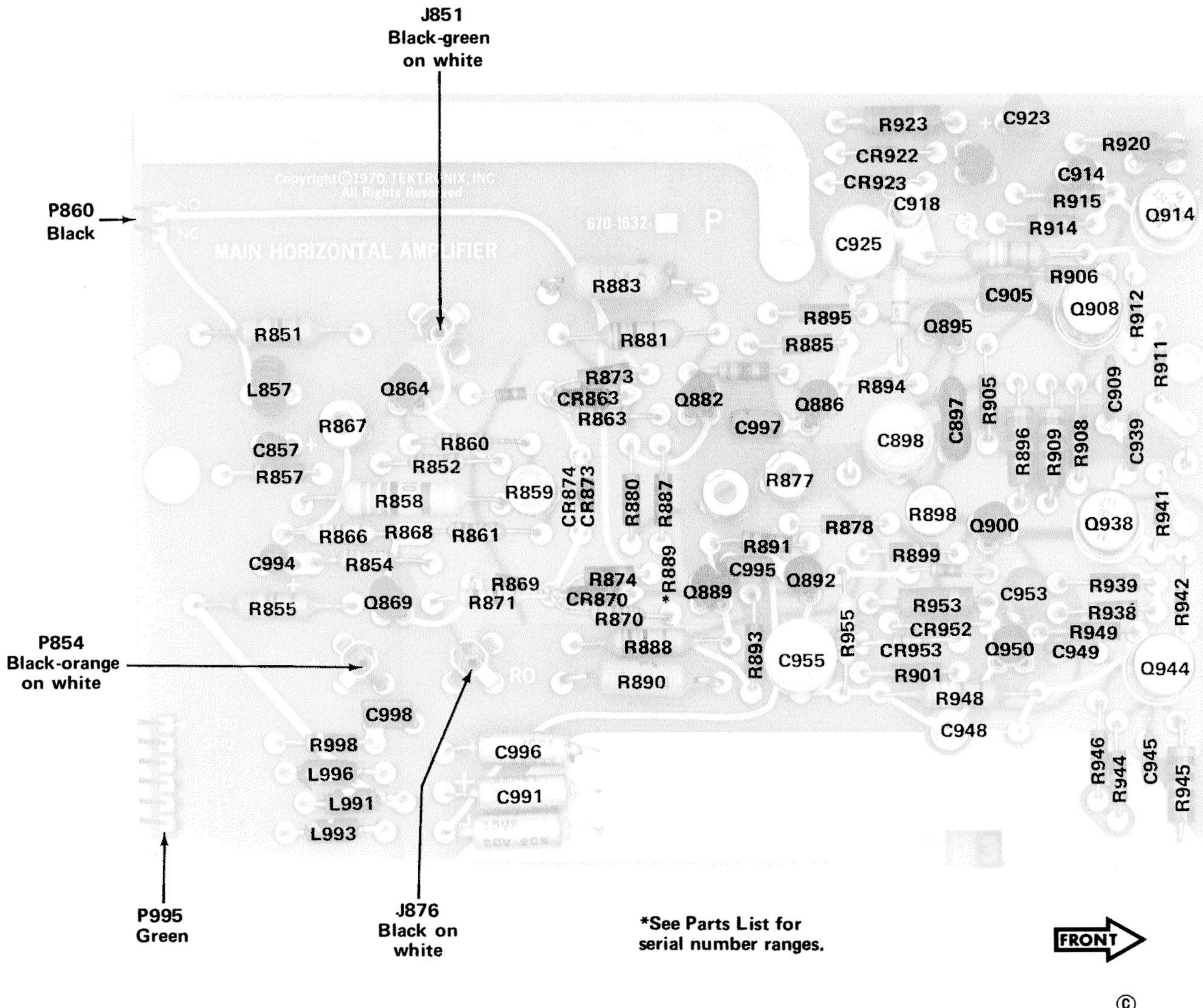


HORIZONTAL AMPLIFIER 7

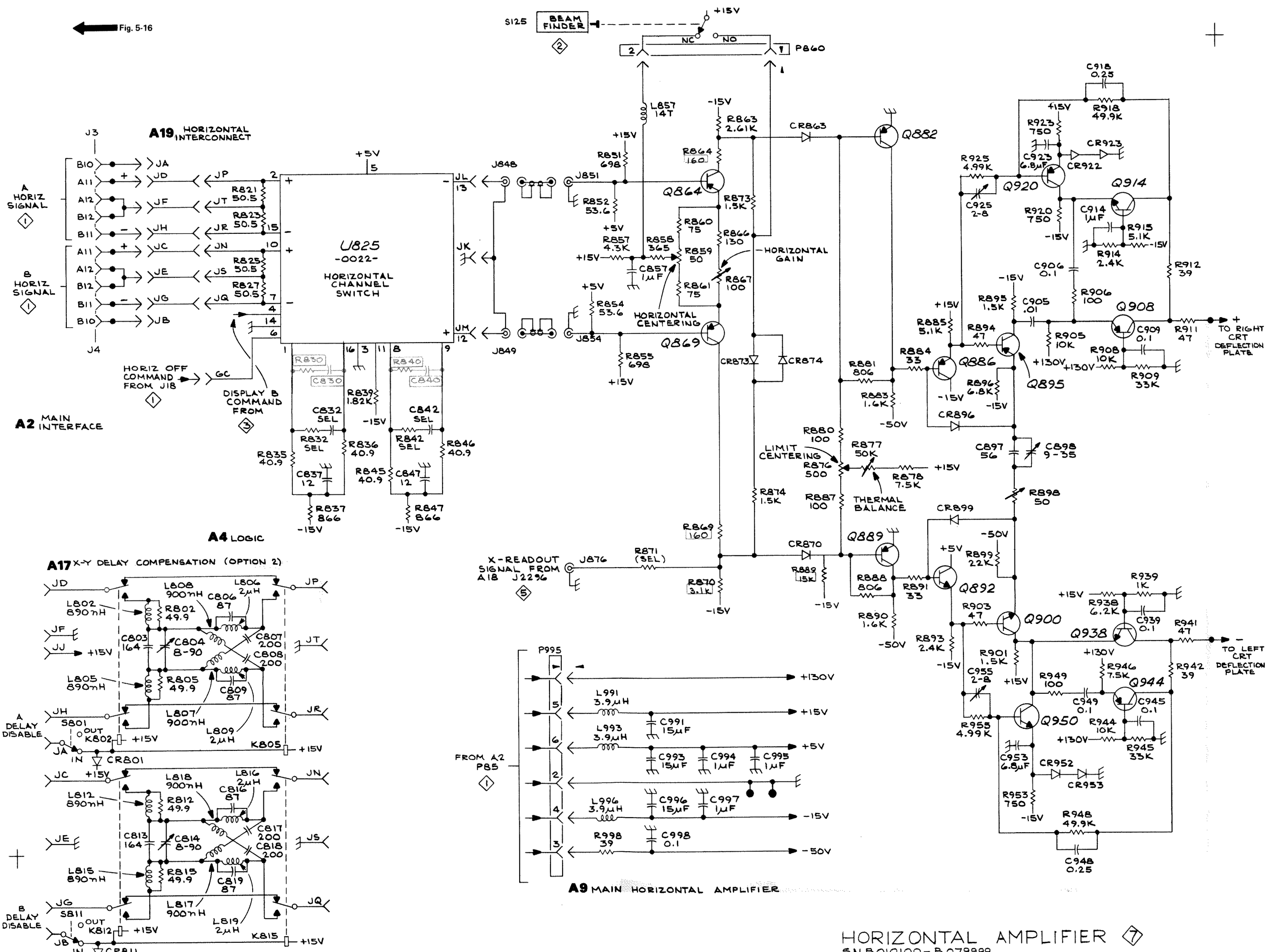
SN B080000-UP

REV APR 1974

7904



A9 Fig. 5-16B. Main Horizontal Amplifier circuit board, below SN B080000.



HORIZONTAL AMPLIFIER ⑦

SN B010100-B079999

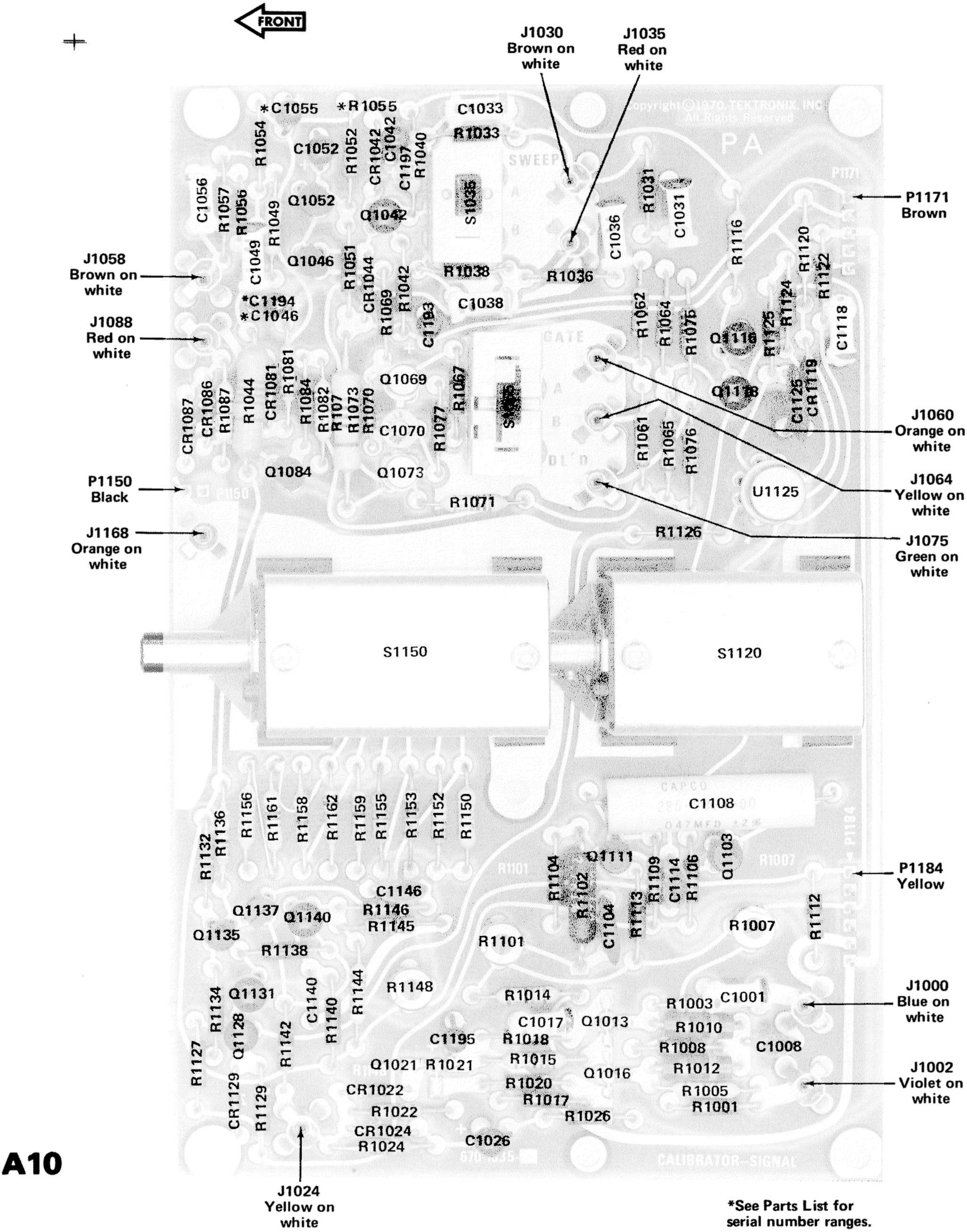
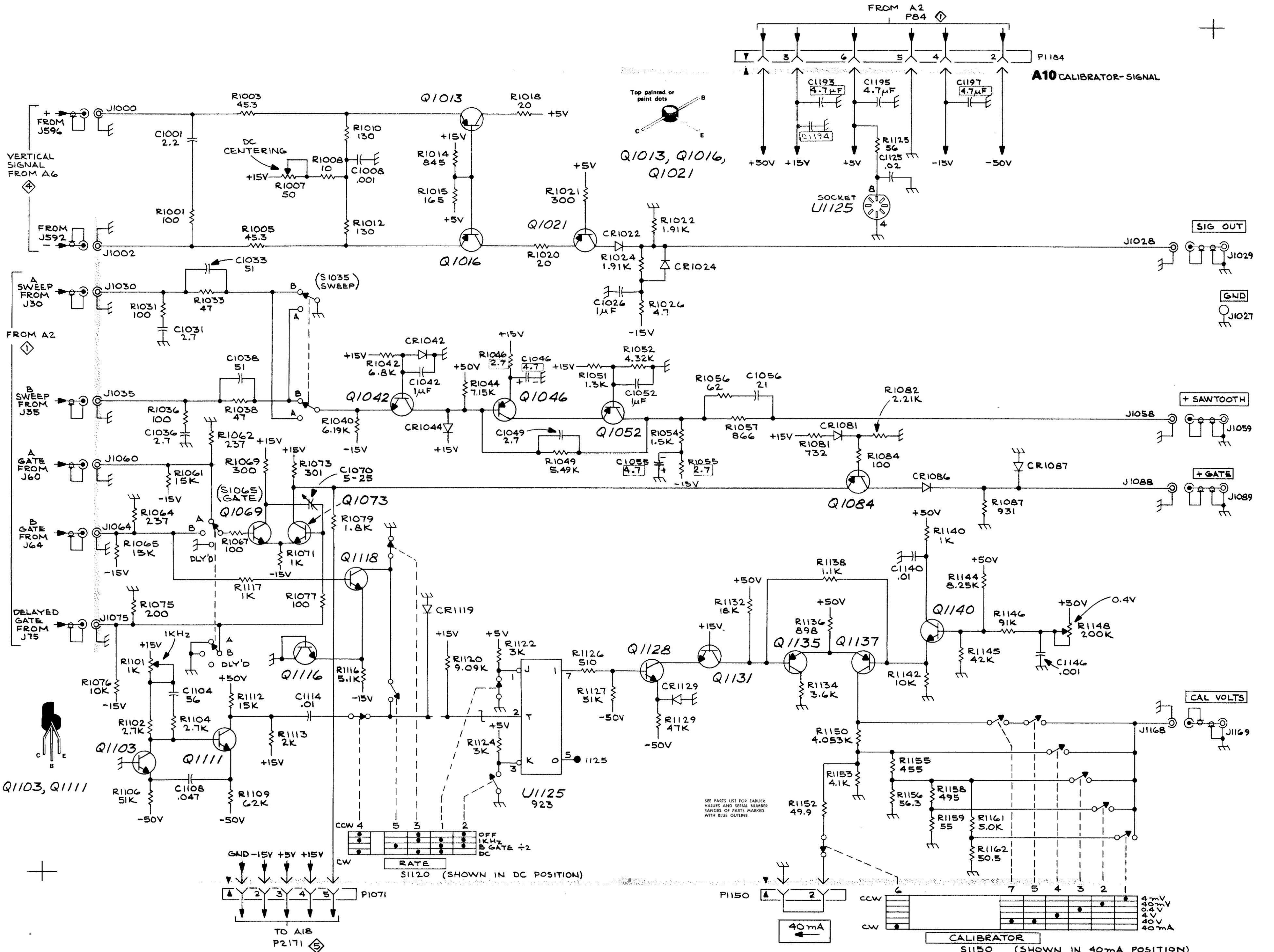


Fig. 5-17. Calibrator-Signal circuit board.

©



7904

OUTPUT SIGNALS AND CALIBRATOR ⑧

RL 1072

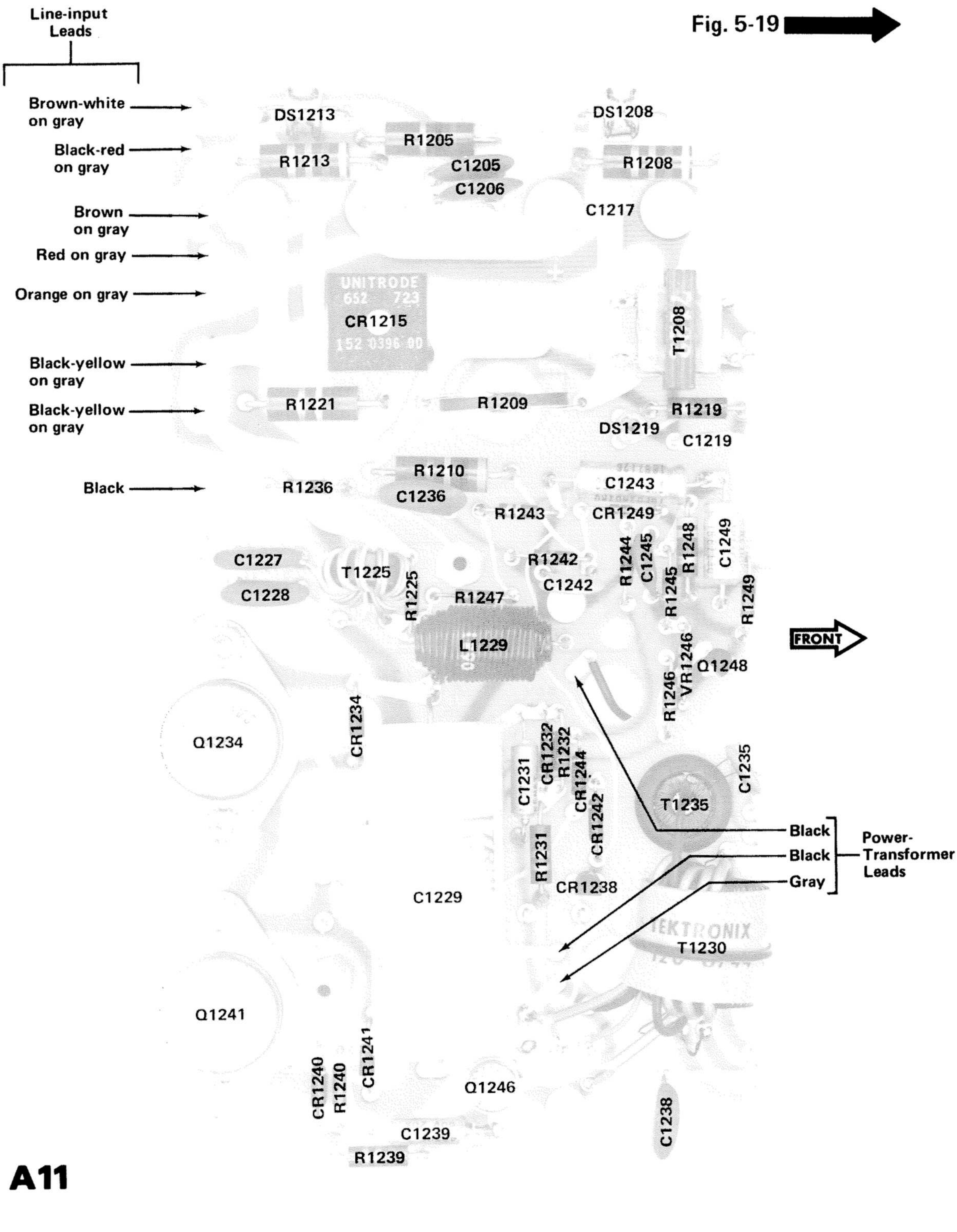
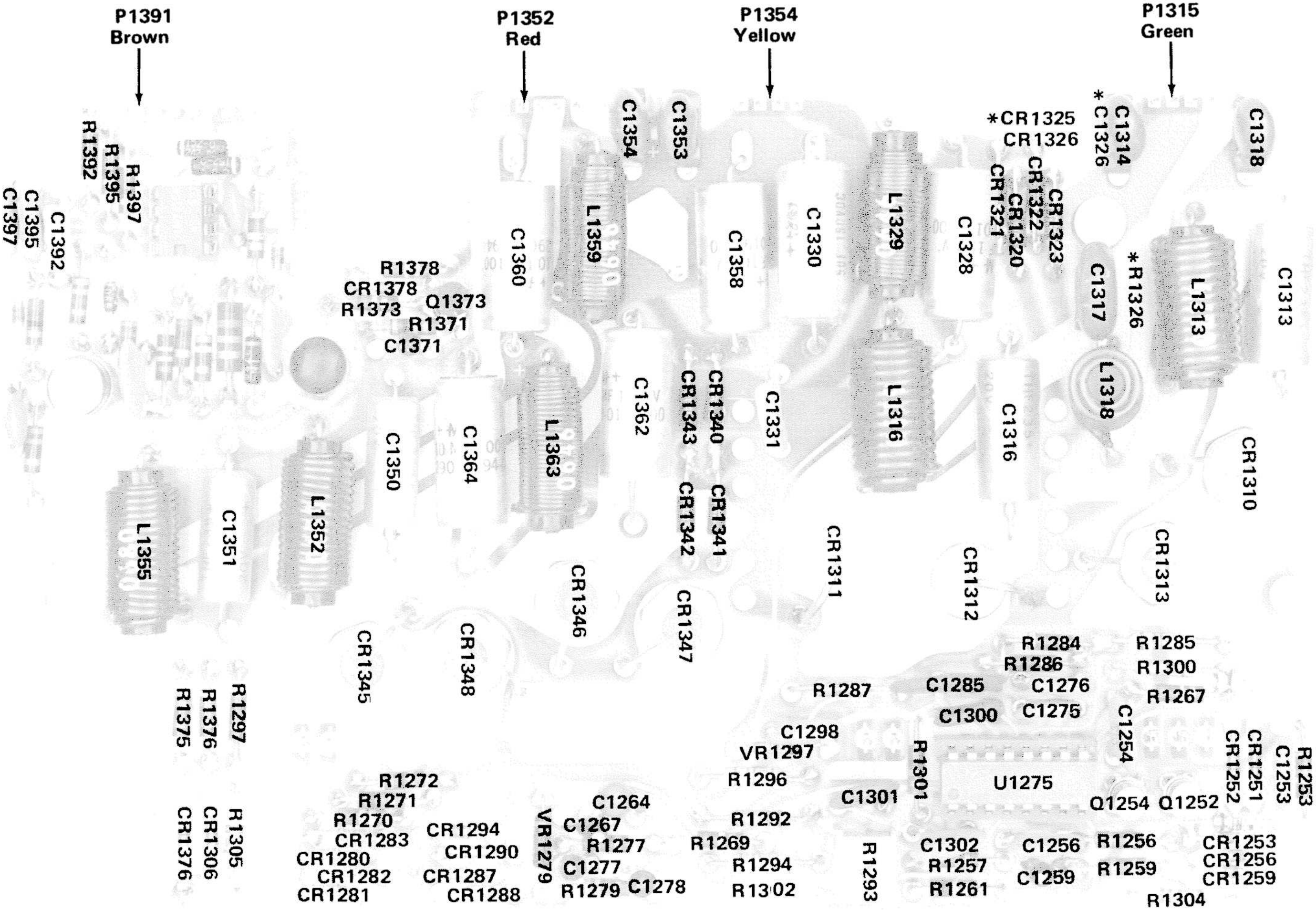


Fig. 5-18. Power Supply Inverter circuit board.

Ⓐ

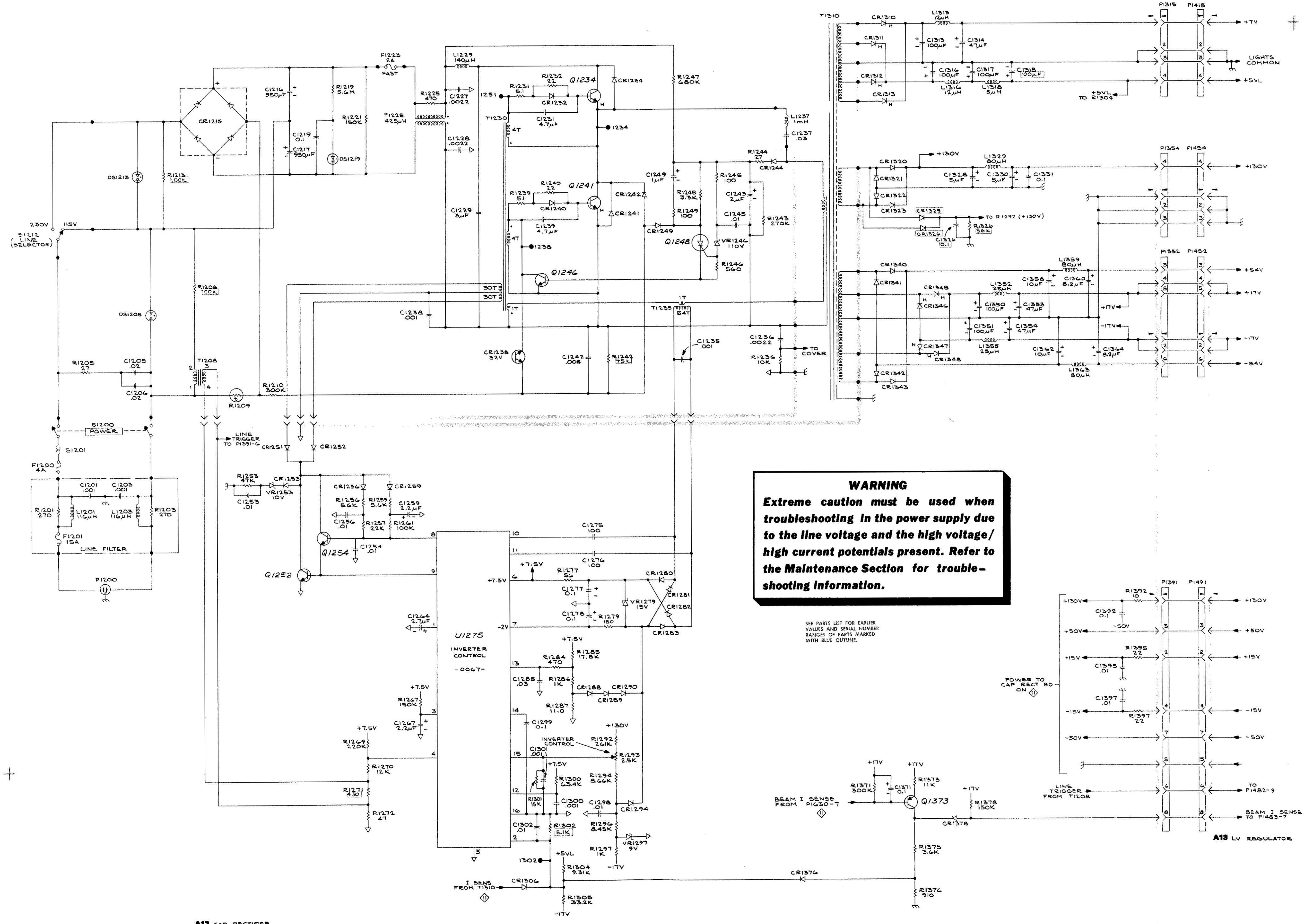


NOTE: See Fig. 5-21 for location of components not identified here.

*See Parts List for serial number ranges.

Fig. 5-19. Partial Cap. Rectifier circuit board.

REV. APR 1974



WARNING

Extreme caution must be used when troubleshooting in the power supply due to the line voltage and the high voltage/high current potentials present. Refer to the Maintenance Section for troubleshooting information.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

7904

CONVERTER / RECTIFIERS (9) REV APR 1974

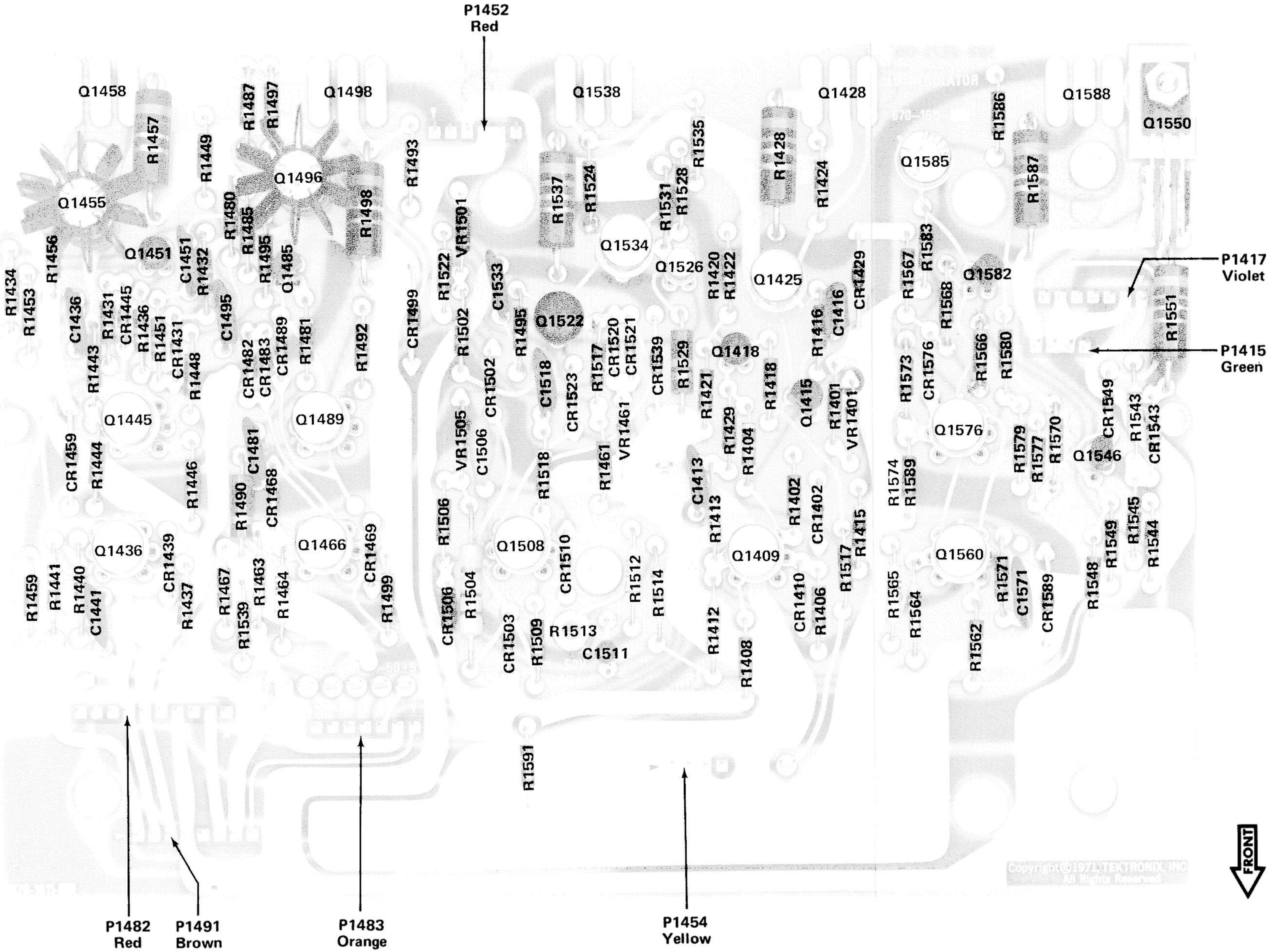
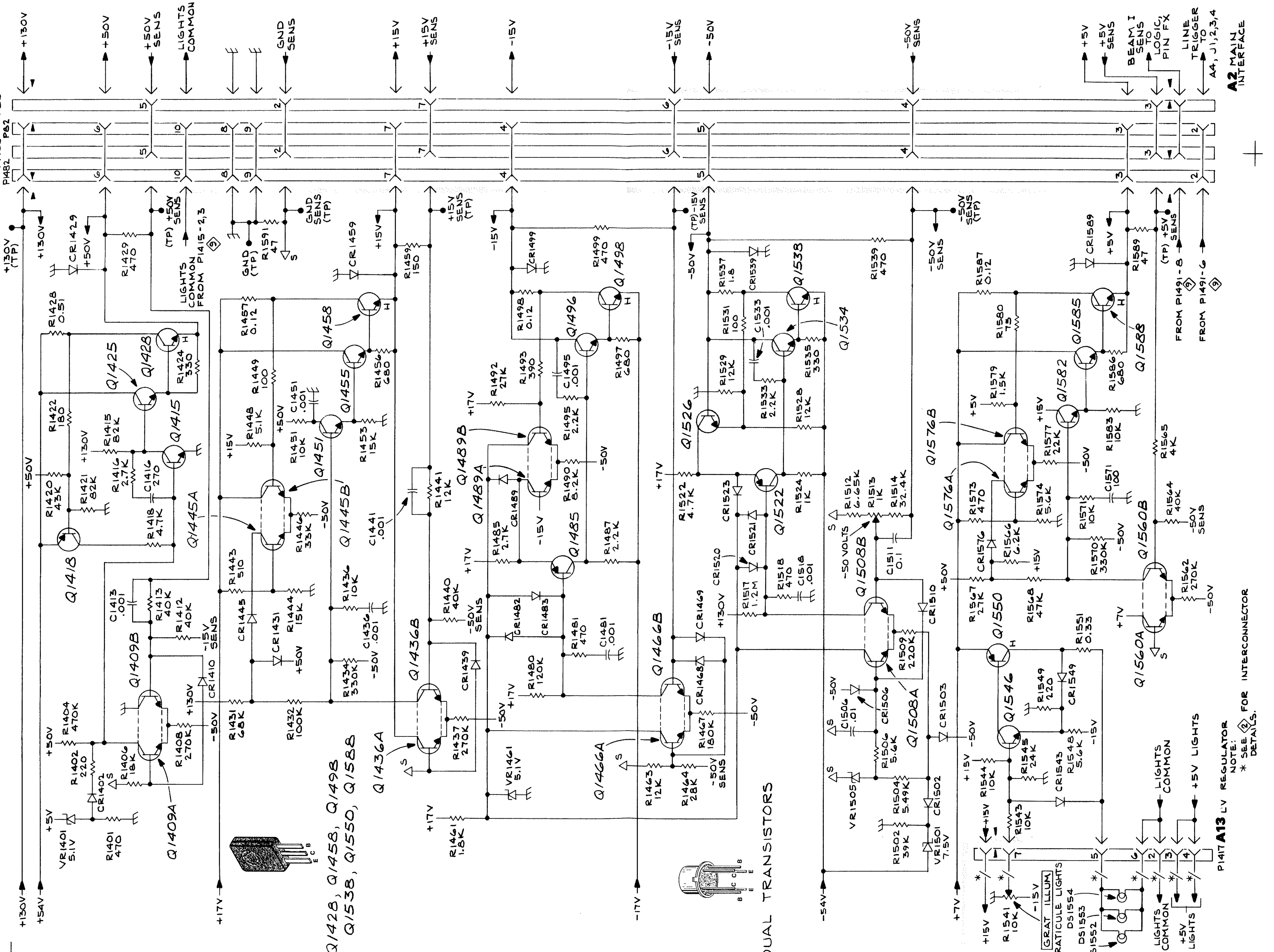


Fig. 5-20. LV Regulator circuit board.

REV. APR 1974



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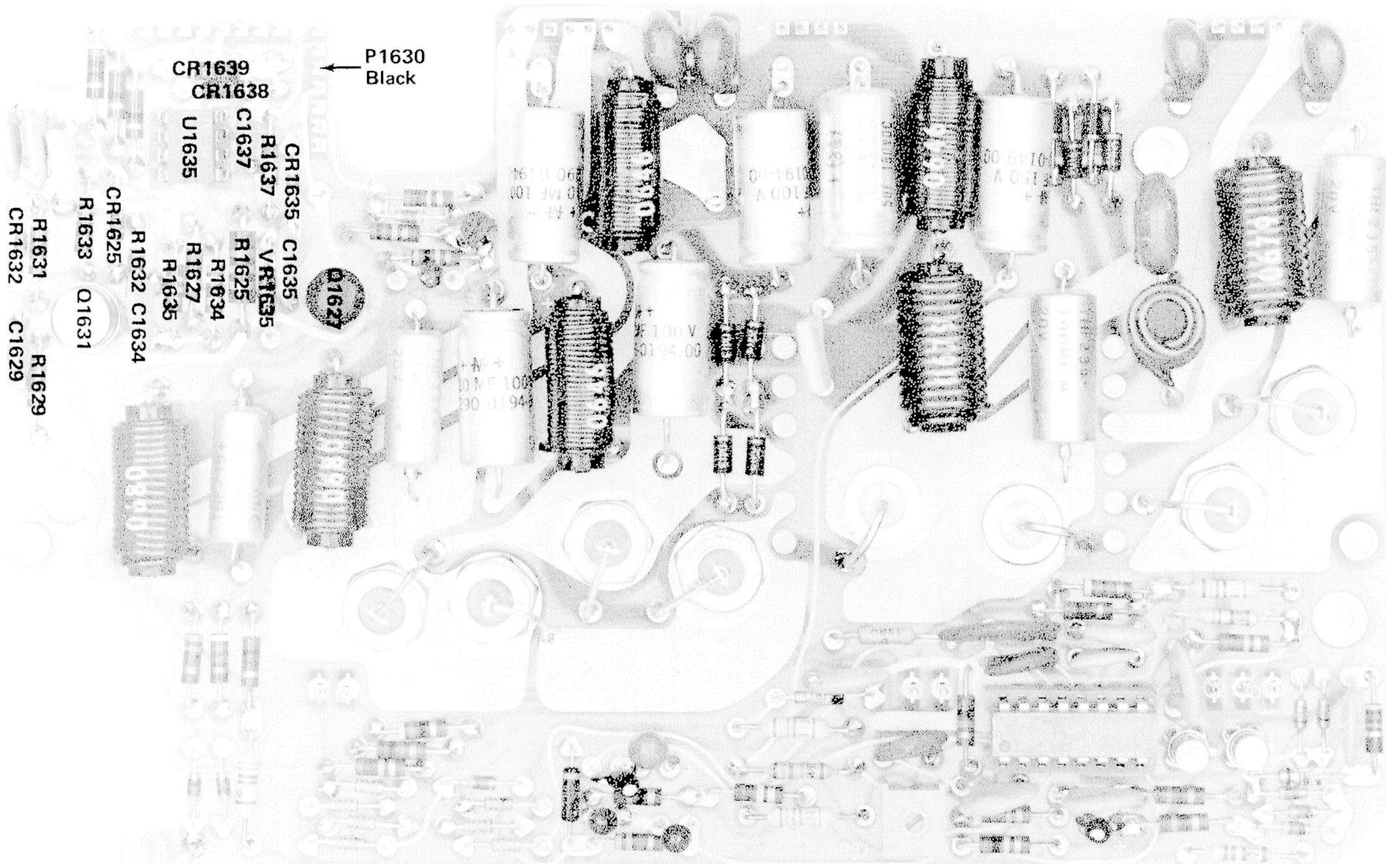
LOW-VOLTAGE REGULATORS ⑩

1171 RH

Fig. 5-22, 5-23 & 5-24



NOTE: See Fig. 5-19 for location of components not identified here.

A12

Fig. 5-21. Partial Cap. Rectifier circuit board.

Ⓐ

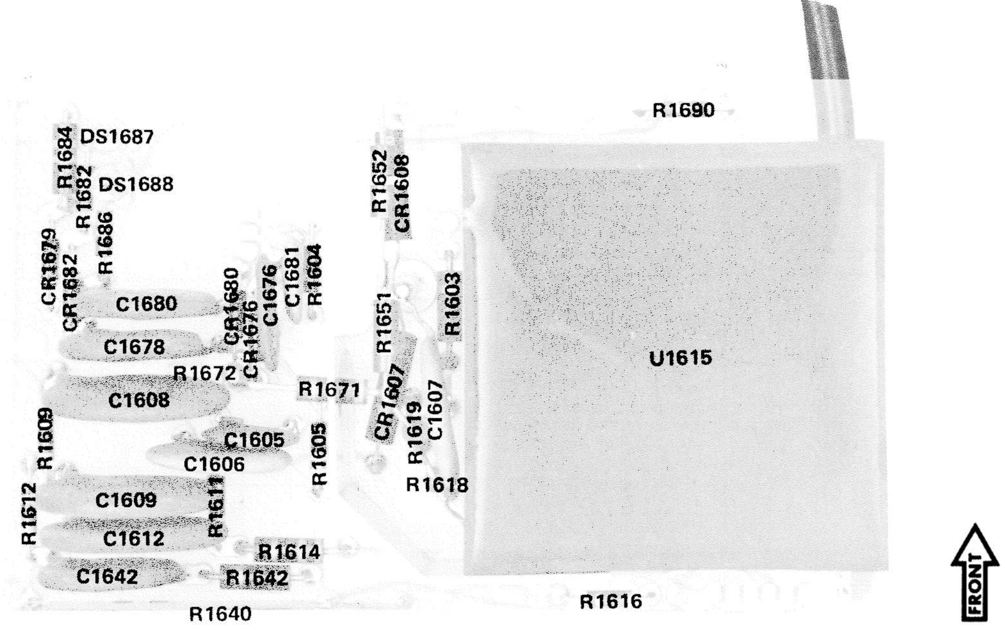
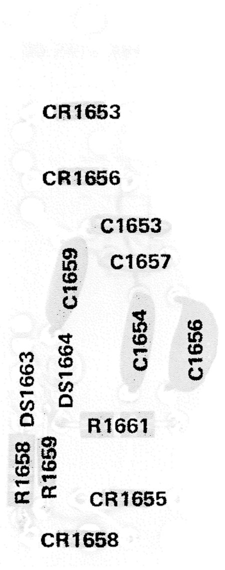


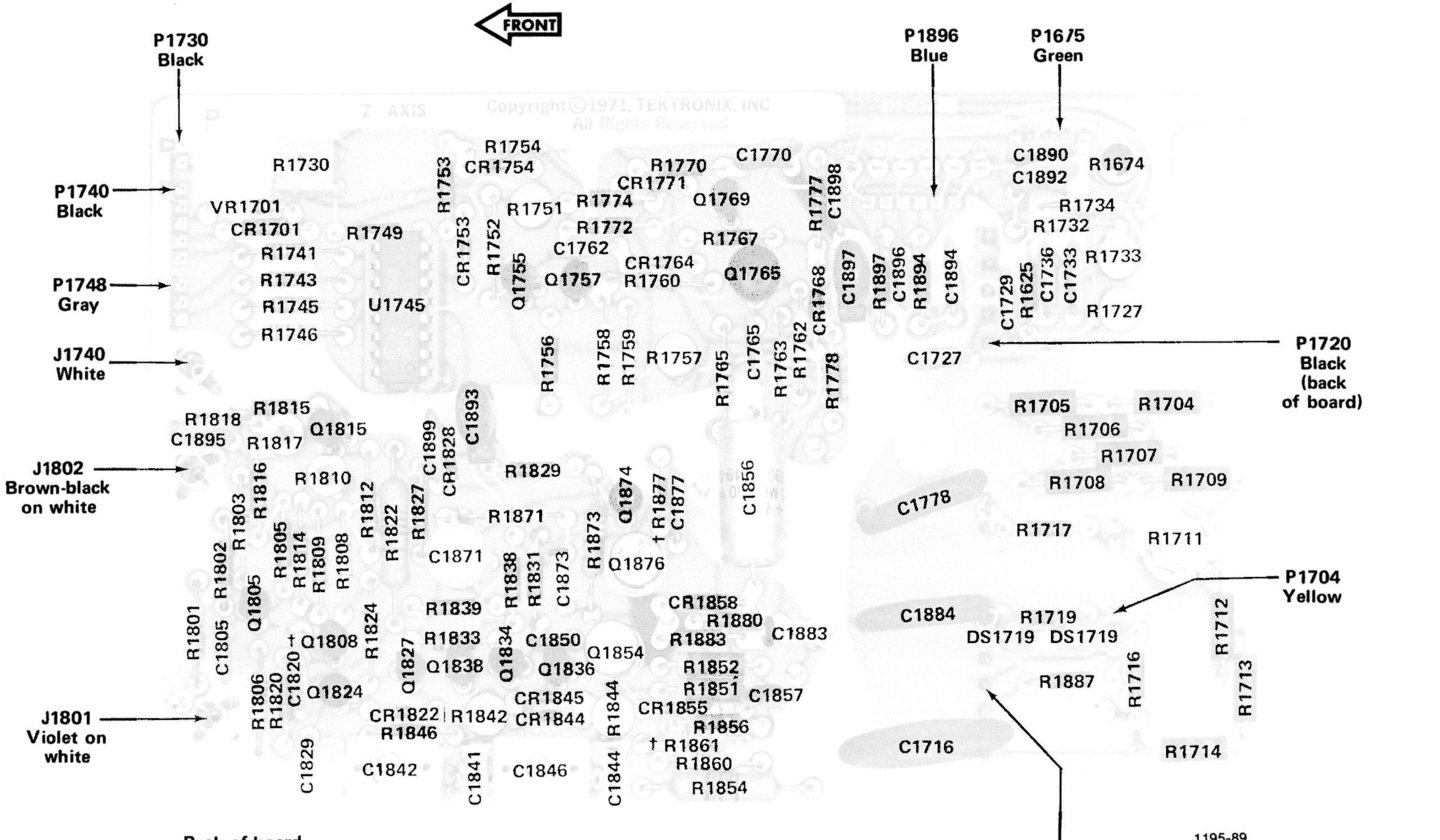
Fig. 5-22. High Voltage circuit board.

A14



A15

Fig. 5-23. Auto Focus circuit board.



Back of board

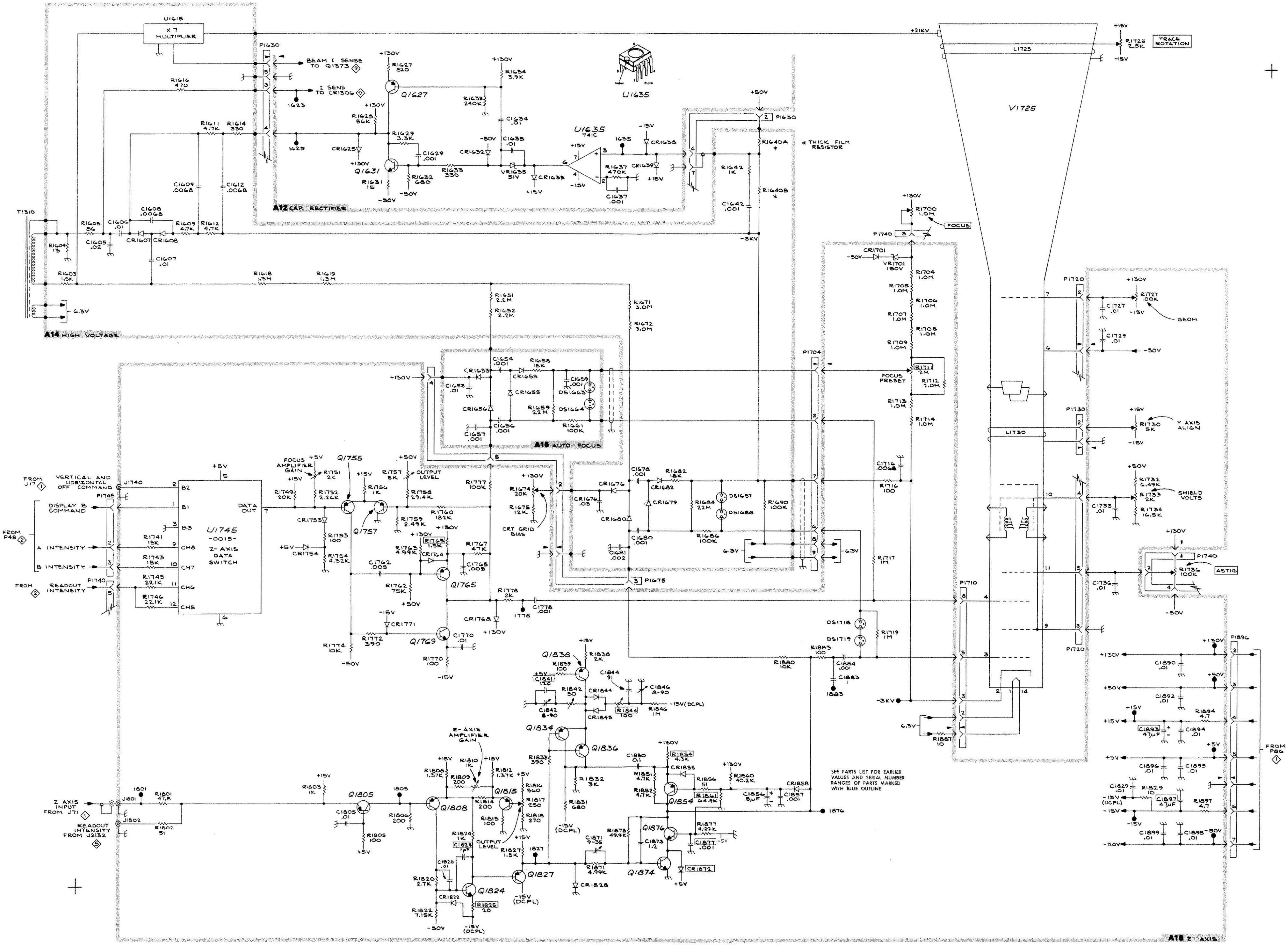
*CR1872	*R1832
Q1824	R1861
*R1825	R1877

*See Parts List for serial number ranges.

†Removed from front to back.

A16

Fig. 5-24. Z Axis circuit board.


A14 HIGH VOLTAGE
A12 CAP. RECTIFIER
A15 AUTO FOCUS
A16 Z AXIS
U1615 X7 MULTIPLIER
BEAM I SENSE TO Q1373
I SENS TO CR1306
U1635 741C
*THICK FILM RESISTOR
V1725
TRACE ROTATION
FOCUS
FOCUS PRESET
GEOM
Y AXIS ALIGN
SHIELD VOLTS
ASTIG
U1745 -0015- Z-AXIS DATA SWITCH
VERTICAL AND HORIZONTAL OFF COMMAND
DISPLAY B COMMAND
A INTENSITY
B INTENSITY
READOUT INTENSITY
FOCUS AMPLIFIER GAIN
OUTPUT LEVEL
CRT GRID BIAS
Z-AXIS AMPLIFIER GAIN
Z AXIS INPUT FROM J71
READOUT INTENSITY FROM J2132
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
FROM P86

SECTION 6 MECHANICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

FIGURE 1 FRONT & CRT

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-1	426-0514-00			1	FRAME, mask, plastic
-2	378-0625-00			1	FILTER, light, CRT
-3	331-0258-03			1	MASK, CRT
-4	204-0380-00			1	BODY, terminal, plastic
-5	131-0765-00			3	TERMINAL, feed-thru
-6	200-0939-01			1	BEZEL, CRT
	- - - - - -			-	mounting hardware: (not included w/bezel)
-7	212-0023-00			4	SCREW, 8-32 x 0.375 inch, PHS
	131-1022-00			2	CONTACT, electrical, grounding (not shown)
-8	337-1159-00			1	SHIELD, implosion
-9	366-1146-00			1	KNOB, gray--FOCUS
	- - - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-10	366-1164-00			2	KNOB, charcoal--A INTENSITY & READOUT
	- - - - - -			-	each knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-11	366-1163-00			2	KNOB, gray--CONTROL ILLUM & RATE
	- - - - - -			-	each knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-12	366-1165-00			1	KNOB, charcoal--CALIBRATOR
	- - - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-13	366-1122-00			1	KNOB, gray--BEAM FINDER
	- - - - - -			-	knob includes:
	213-0246-00			1	SETSCREW, 5-40 x 0.093 inch, HSS
-14	366-1120-00			1	KNOB, charcoal--B INTENSITY
	- - - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-15	366-1189-00			1	KNOB, charcoal--GRAT ILLUM
	- - - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-16	366-0392-02			1	KNOB, charcoal--VERT TRACE SEPARATION (B)
	129-0053-00			1	BINDING POST ASSEMBLY
	- - - - - -			-	binding post assembly includes:
-17	200-0103-00			1	NUT, plain knurled, 0.375 inch OD
-18	355-0507-00			1	STEM, binding post
	- - - - - -			-	mounting hardware: (not included w/binding post assembly)
-19	210-0455-00			1	NUT, hex., 0.25-28 x 0.375 inch
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD

FIGURE 1 FRONT & CRT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-20	333-1482-00			1	PANEL, front
	------			-	mounting hardware: (not included w/panel)
-21	211-0091-00			2	SCREW, 2-56 x 0.875 inch, PHS
-22	358-0301-02			2	BUSHING, sleeve, front panel trim
-23	378-0635-01			1	LENS, indicator light (A)
-24	378-0635-02			1	LENS, indicator light (B)
-25	------			2	RESISTOR, variable
	------			-	mounting hardware for each: (not included w/resistor)
-26	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-27	260-1138-00			1	SWITCH, rotary--READOUT
	------			-	mounting hardware: (not included w/switch)
-28	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-29	260-1102-00	B010100	B069999	1	SWITCH, toggle--POWER
	260-1060-01	B070000		1	SWITCH, toggle--POWER
	------			-	mounting hardware: (not included w/switch)
-30	210-0473-00			1	NUT, dodecagon, 0.469-32 x 0.634 inch
-31	210-0902-00			1	WASHER, flat, 0.47 ID x 0.656 inch OD
	354-0055-00			1	RING, locking
-32	210-0414-00			1	NUT, hex., 0.468-32 x 0.563 inch
-33	------			1	RESISTOR, variable
	------			-	mounting hardware: (not included w/resistor)
-34	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-35	361-0143-00			1	SPACER, ring, threaded, 0.281 ID x 0.562 inch OD
-36	200-0984-00			1	BEZEL, plastic, 5 button switch
-37	200-0983-00			1	BEZEL, plastic, 4 button switch
-38	358-0029-00			1	BUSHING, 0.375-32 x 0.50 inch
	------			-	mounting hardware: (not included w/bushing)
-39	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-40	119-0199-00			1	CURRENT LOOP
	------			-	mounting hardware: (not included w/current loop)
-41	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-42	134-0119-00			1	PLUG, hole, plastic
-43	348-0204-00			2	SHIELDING-GASKET, 10.632 inches long
-44	351-0202-00			4	GUIDE, plug-in, upper
	------			-	mounting hardware for each: (not included w/guide)
-45	211-0038-00			2	SCREW, 4-40 x 0.312 inch, 100° csk, FHS

FIGURE 1 FRONT & CRT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-46	131-0818-00			4	CONNECTOR, receptacle, BNC, w/hardware
-47	210-0774-00			4	EYELET, metallic, 0.245 inch long
-48	210-0775-00			4	EYELET, metallic, 0.230 inch long
-49	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	213-0020-00			1	SETSCREW, 6-32 x 0.125 inch, HSS
-50	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-51	358-0409-00			1	BUSHING, 0.25-32 x 0.207 inch
-52	210-0471-00			1	NUT, hex., 0.25-32 x 0.312 inch
-53	200-0935-00			2	CAP, neon, plastic
-54	331-0262-00			2	DIFFUSER, light
-55	352-0157-00			2	HOLDER, neon
-56	129-0318-00			2	POST, plastic, 2.17 inches long
	- - - - - -			-	mounting hardware for each: (not included w/post)
-57	211-0538-00			1	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-58	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--FRONT PANEL INTERCONNECT A3
	- - - - - -			-	circuit board assembly includes:
-59	131-0608-00			61	TERMINAL, pin, 0.365 inch long
-60	136-0454-00			4	SOCKET, 6/12 contact
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-61	211-0558-00			2	SCREW, plastic, 6-32 x 0.250 inch, BHS
-62	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY, switch--A TRIG SOURCE A22
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-63	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-64	352-0195-00			1	HOLDER, plastic
-65	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY, switch--B TRIG SOURCE A24
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-66	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-67	352-0195-00			1	HOLDER, plastic
-68	348-0216-00			1	SHIELDING-GASKET, electrical
-69	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--GRATICULE LIGHT A25
	- - - - - -			-	circuit board assembly includes:
-70	378-0614-00			1	REFLECTOR, light
	- - - - - -			-	mounting hardware: (not included w/reflector)
-71	211-0062-00			2	SCREW, 2-56 x 0.312 inch, RHS
-72	344-0179-00			2	CLIP, reflector

[1]Refer to Electrical Parts List for part number.

FIGURE 1 FRONT & CRT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-73	210-0759-00			3	EYELET
-74	210-0957-00			3	WASHER, flat, 0.062 ID x 0.125 inch OD
-75	131-0704-00[1]			3	CONTACT, 0.70 inch long
-76	- - - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY, switch--HORIZONTAL MODE A21
	- - - - - - -			-	circuit board assembly includes:
-77	352-0174-00			4	LAMPHOLDER
-78	337-1156-00			1	SHIELD, electrical
-79	366-1109-06			1	PUSHBUTTON--A
-80	366-1109-02			1	PUSHBUTTON--ALT
-81	366-1109-04			1	PUSHBUTTON--CHOP
-82	366-1109-07			1	PUSHBUTTON--B
-83	380-0168-00			1	HOUSING, front, plastic
	- - - - - - -			-	mounting hardware: (not included w/housing)
-84	211-0125-00			3	SCREW, 1-72 x 0.25 inch, PHS
	- - - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-85	211-0511-00			2	SCREW, 6-32 x 0.50 inch, PHS
-86	407-0700-00			1	BRACKET, switch
-87	- - - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY, switch--VERTICAL MODE A20
	- - - - - - -			-	circuit board assembly includes:
-88	352-0174-00			5	LAMPHOLDER
-89	337-1157-00			1	SHIELD, electrical
-90	366-1109-01			1	PUSHBUTTON--LEFT
-91	366-1109-02			1	PUSHBUTTON--ALT
-92	366-1109-03			1	PUSHBUTTON--ADD
-93	366-1109-04			1	PUSHBUTTON--CHOP
-94	366-1109-05			1	PUSHBUTTON--RIGHT
-95	380-0147-00			1	HOUSING, front, plastic
	- - - - - - -			-	mounting hardware: (not included w/housing)
-96	211-0125-00			3	SCREW, 1-72 x 0.25 inch, PHS
	- - - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-97	211-0511-00			2	SCREW, 6-32 x 0.50 inch, PHS
-98	407-0701-00			1	BRACKET, switch
-99	331-0245-00			1	MASK, CRT
-100	- - - - - - -			1	COIL
-101	214-0291-00			1	CONTACT, spring
	- - - - - - -			-	mounting hardware: (not included w/contact)
-102	211-0007-00			1	SCREW, 4-40 x 0.188 inch, PHS
-103	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
-104	348-0055-00			2	GROMMET, plastic, 0.25 inch diameter
-105	195-0093-00			1	LEAD SET, CRT deflection
	- - - - - - -			-	lead set includes:
	131-0049-00			2	CONNECTOR, cable, CRT
	131-1119-00			4	CONNECTOR, contact

[1] Refer to Electrical Parts List for part number.

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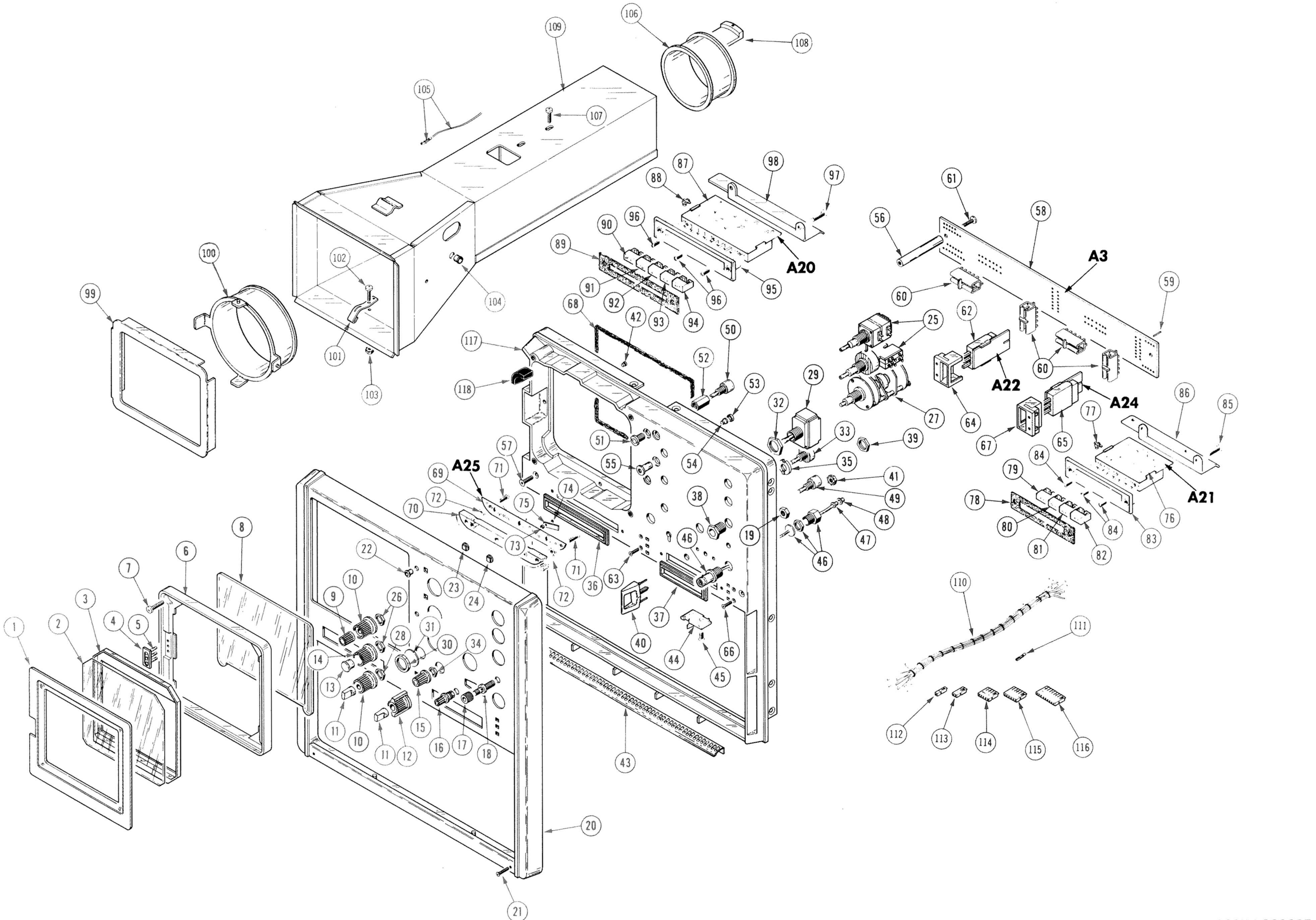
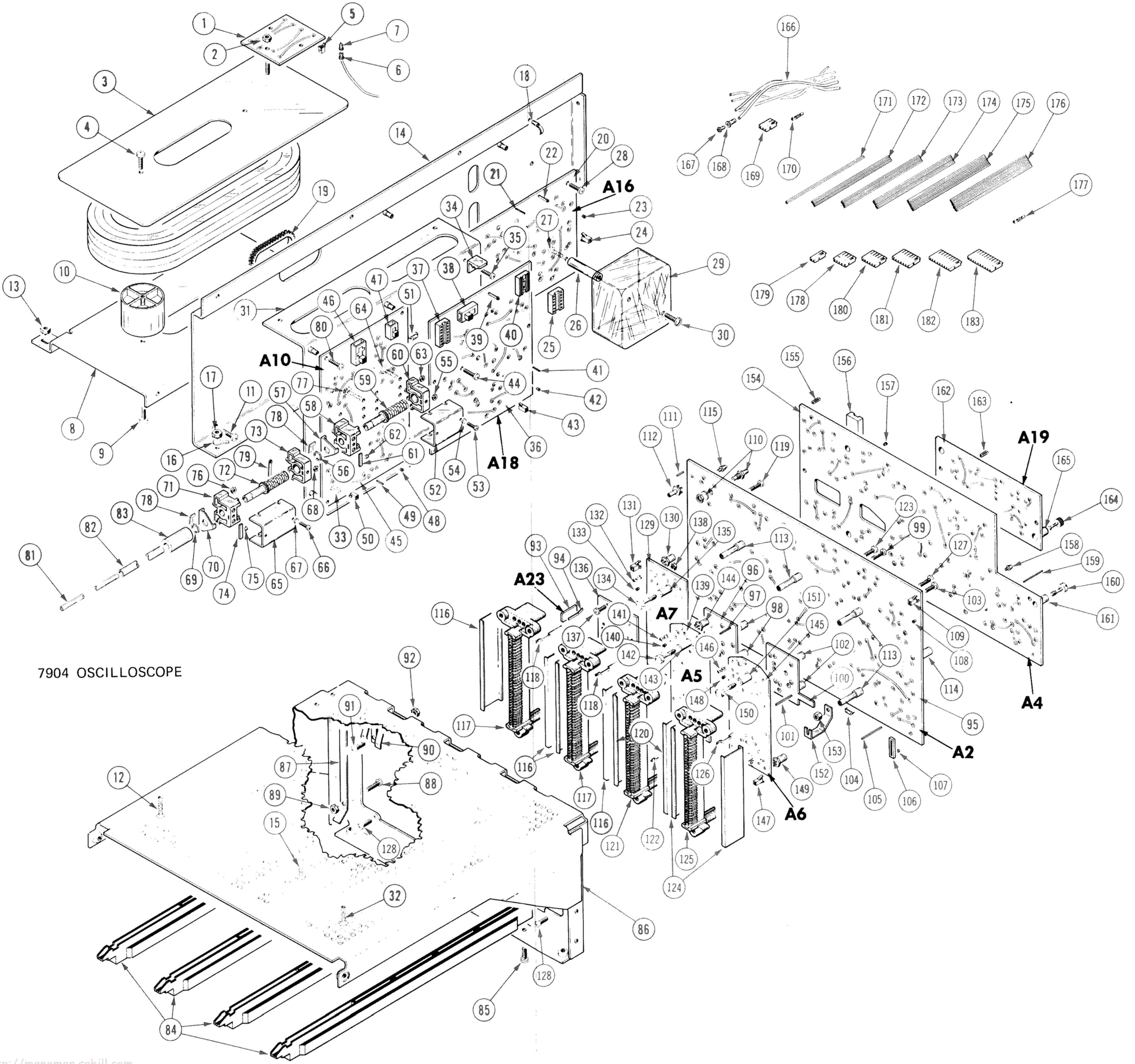
FIGURE 1 FRONT & CRT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-106	-------			1	COIL
	-------			-	mounting hardware: (not included w/coil)
-107	213-0138-00			2	SCREW, thread forming: 4-40 x 0.188 inch, PHS
-108	343-0217-00			1	CLAMP, coil
	210-0201-00	XB060000		1	TERMINAL, lug
	211-0007-00	XB060000		1	SCREW, 4-40 x 0.188 inch, PHS
	210-0586-00	XB060000		1	NUT, keps, 4-40 x 0.25 inch
-109	337-1460-00			1	SHIELD, CRT
-110	179-1689-00			1	WIRING HARNESS, front panel
	-------			-	wiring harness includes:
-111	131-0707-00			23	CONNECTOR, terminal
-112	352-0171-00			1	HOLDER, terminal connector, 1 wire (black)
-113	352-0169-00			1	HOLDER, terminal connector, 2 wire (black)
-114	352-0163-00			1	HOLDER, terminal connector, 5 wire (black)
-115	352-0164-00			1	HOLDER, terminal connector, 6 wire (black)
-116	352-0167-00			1	HOLDER, terminal connector, 9 wire (black)
-117	426-0442-10			1	FRAME-PANEL, cabinet front
	-------			-	frame-panel includes:
-118	386-1517-00			4	SUPPORT, CRT, front
	354-0345-00			1	RING, ornamental


A3
A20
A21
A22
A24
A25



7904 OSCILLOSCOPE

FIGURE 2 PLUG-IN HOUSING & DELAY LINE

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-	119-0318-00			1	DELAY LINE ASSEMBLY
	- - - - - -			-	delay line assembly includes:
-1	388-2194-00			1	CIRCUIT BOARD, termination
	- - - - - -			-	mounting hardware: (not included w/circuit board)
-2	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
-3	200-1265-00			1	COVER, top
	- - - - - -			-	mounting hardware: (not included w/cover)
-4	213-0041-00			2	SCREW, thread forming, 6-32 x 0.375 inch, THS
-5	131-1003-00			4	RECEPTACLE, cable, coax
-6	210-0775-00			8	EYELET, metallic, 0.23 inch long
-7	210-0774-00			8	EYELET, metallic, 0.218 inch long
-8	200-1264-00			1	COVER, bottom
	- - - - - -			-	mounting hardware: (not included w/cover)
-9	213-0041-00			2	SCREW, thread forming, 6-32 x 0.375 inch, THS
-10	129-0325-00			2	POST, plastic, 1.165 inches long
	- - - - - -			-	mounting hardware: (not included w/delay line assembly)
-11	211-0538-00			2	SCREW, 6-32 x 0.312 inch, PHS
-12	211-0541-00			2	SCREW, 6-32 x 0.25 inch, 100° csk, FHS
-13	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-14	441-1021-00			1	CHASSIS, z axis
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0510-00			3	SCREW, 6-32 x 0.375 inch, PHS (not shown)
-15	211-0538-00			5	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-16	210-0202-00			1	LUG, solder, SE #6
-17	210-0457-00			7	NUT, keps, 6-32 x 0.312 inch
-18	343-0213-00			2	CLAMP, cable
-19	255-0334-00			in	PLASTIC CHANNEL, 4.562 inches long
-20	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--Z AXIS A16
	- - - - - -			-	circuit board assembly includes:
-21	131-0589-00			10	TERMINAL, pin, 0.46 inch long
	131-0608-00			28	TERMINAL, pin, 0.365 inch long
-22	214-0579-00			14	PIN, test point
-23	136-0252-04	B010100	B123889	48	SOCKET, pin connector, 0.181 inch long (square)
	136-0252-04	**B123890**		**3**	**SOCKET, pin connector, 0.181 inch long (square)**
	136-0220-00	**B123890**		**12**	**SOCKET, plug-in, 3 pin**
	136-0183-00	**B123890**		**3**	**SOCKET, plug-in, 3 pin**
-24	131-1003-00			3	RECEPTACLE, cable, coax
-25	136-0260-02			1	SOCKET, integrated circuit, 16 pin
-26	385-0017-00			2	ROD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/rod)
-27	211-0558-00			1	SCREW, plastic, 6-32 x 0.25 inch, PHS
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-28	211-0008-00			4	SCREW, 4-40 x 0.25 inch, PHS

[1] Refer to Electrical Parts List for part number.

FIGURE 2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
2-29	337-1511-00			1	SHIELD, mechanical
	------			-	mounting hardware: (not included w/shield)
-30	211-0558-00			2	SCREW, plastic, 6-32 x 0.25 inch, PHS
-31	441-1029-00			1	CHASSIS, cal sig output
	------			-	mounting hardware: (not included w/chassis)
-32	211-0538-00			4	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-33	210-0457-00			4	NUT, keps, 6-32 x 0.312 inch
-34	344-0133-00			4	CLIP, circuit board
	------			-	mounting hardware for each: (not included w/clip)
-35	213-0138-00			1	SCREW, thread forming, 4-40 x 0.188 inch, PHS
-36	------[1]			1	CIRCUIT BOARD ASSEMBLY--READOUT SYSTEM A18
	------			-	circuit board assembly includes:
-37	136-0260-02			14	SOCKET, integrated circuit, 16 pin
-38	260-0723-00			1	SWITCH, slide
-39	214-0579-00			18	PIN, test point
-40	136-0269-02			3	SOCKET, integrated circuit, 14 pin
-41	131-0608-00			39	TERMINAL, pin, 0.365 inch long
-42	136-0252-04	B010100	B089999	46	SOCKET, connector pin
	136-0252-04	B090000	B123889	40	SOCKET, connector pin
	136-0235-00	B090000		1	SOCKET, transistor, 6 pin
	136-0220-00	B123890		13	. SOCKET, plug-in: 3 pin
-43	131-1003-00			6	RECEPTACLE, cable, coax
	------			-	mounting hardware:(not included w/circuit board assy)
-44	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-45	------			1	CIRCUIT BOARD ASSEMBLY--CALIBRATOR-SIGNAL A10
	------			-	circuit board assembly includes:
-46	260-0984-00			1	SWITCH, slide, triple
-47	260-0723-00			1	SWITCH, slide, double
-48	136-0252-04	B010100	B123889	65	SOCKET, connector pin
	136-0252-04	B123890		12	SOCKET, connector pin
	136-0220-00	B123890		15	SOCKET, plug-in: 3 pin
	136-0237-00	B123890		1	SOKCET, plug-in: 8 pin
-49	131-0590-00			46	TERMINAL, pin, 0.71 inch long
	131-0608-00			13	TERMINAL, pin, 0.365 inch long
-50	131-1003-00			11	RECEPTACLE, cable, coax
-51	131-0566-00			3	LINK, terminal connecting
	105-0293-00			1	ACTUATOR ASSEMBLY--CAL RATE
	------			-	actuator assembly includes:
-52	200-1032-00			1	COVER, cam switch
	------			-	mounting hardware: (not included w/cover)
-53	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-54	210-0001-00			2	WASHER, lock, internal, #2
-55	210-0405-00			1	NUT, hex., 2-56 x 0.187 inch

[1]Refer to Electrical Parts List for part number.

FIGURE 2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-56	354-0219-00			1	RING, retaining
-57	407-0714-00			1	BRACKET
-58	401-0058-00			1	BEARING, front
-59	105-0190-00			1	DRUM, cam
-60	401-0061-00			1	BEARING, rear
-61	214-1126-00[1]			-	SPRING, flat, gold
	214-1126-01[1]			-	SPRING, flat, green
	214-1126-02[1]			-	SPRING, flat, red
-62	214-1127-00			1	ROLLER, detent
-63	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-	mounting hardware: (not included w/actuator assembly)
-64	211-0166-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
	105-0294-00			1	ACTUATOR ASSEMBLY--CAL VOLTAGE
	- - - - - -			-	actuator assembly includes:
-65	200-1033-00			1	COVER, cam
	- - - - - -			-	mounting hardware: (not included w/cover)
-66	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-67	210-0001-00			2	WASHER, lock, internal, #2
-68	210-0405-00			1	NUT, hex., 2-56 x 0.187 inch
-69	354-0219-00			1	RING, retaining
-70	407-0714-00			1	BRACKET
-71	401-0058-00			1	BEARING, front
-72	105-0191-00			1	DRUM, cam
-73	401-0061-00			1	BEARING, rear
-74	214-1126-00[1]			-	SPRING, flat, gold
	214-1126-01[1]			-	SPRING, flat, green
	214-1126-02[1]			-	SPRING, flat, red
-75	214-1127-00			1	ROLLER, detent
-76	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-	mounting hardware: (not included w/actuator assembly)
-77	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-78	131-0840-00			2	CONTACT, electrical, grounding
-79	131-0604-00			12	CONTACT-POST ASSEMBLY
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-80	211-0008-00			5	SCREW, 4-40 x 0.25 inch, PHS
-81	384-0173-00			1	ROD, extension, 6.438 inches long
	- - - - - -			-	mounting hardware: (not included w/rod)
	213-0075-00			1	SETSCREW, 4-40 x 0.093 inch, HSS (not shown)
-82	384-1123-00			1	SHAFT, extension, 3.625 inches long
-83	376-0007-00			1	COUPLING
	- - - - - -			-	coupling includes:
	213-0005-00			2	SETSCREW, 8-32 x 0.125 inch, HSS (not shown)

[1]Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-84	351-0181-03			4	GUIDE, plug-in
	- - - - - -			-	mounting hardware for each: (not included w/guide)
-85	213-0104-00			1	SCREW, thread forming, 6-32 x 0.375 inch, THS
	213-0229-00			1	SCREW, thread forming, 6-32 x 0.375 inch, FHS (not shown)
-86	380-0253-00			1	HOUSING, plug-in
	- - - - - -			-	mounting hardware: (not included w/housing)
	212-0023-00			2	SCREW, 8-32 x 0.375 inch, PHS (not shown)
	212-0040-00			2	SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch, (not shown)
-87	131-0800-00			2	CONTACT, electrical, side
	- - - - - -			-	mounting hardware for each: (not included w/contact)
-88	211-0008-00			2	SCREW, 4-40 x 0.125 inch, PHS
-89	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-90	131-0799-00			3	CONTACT, electrical
	- - - - - -			-	mounting hardware for each: (not included w/contact)
-91	211-0008-00			1	SCREW, 4-40 x 0.125 inch, PHS
-92	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
	672-0031-00	B010100	B019999	1	MAIN INTERFACE ASSEMBLY
	672-0031-01	B020000		1	MAIN INTERFACE ASSEMBLY
	- - - - - -			-	main interface assembly includes:
-93	- - - - - -[1]			2	CIRCUIT BOARD ASSEMBLY--50 Ω FOLLOWER A23
	- - - - - -			-	each circuit board assembly includes:
-94	131-1149-00			6	CONTACT, electrical
	131-1161-00	B010100	B019999X	4	CONNECTOR, male, 50 Ω
	210-0774-00	B010100	B019999	2	EYELET, 0.23 inch
	210-0774-00	B020000		6	EYELET, 0.23 inch
	210-0775-00	B010100	B019999	2	EYELET, 0.218 inch
	210-0775-00	B020000		6	EYELET, 0.218 inch
-95	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--MAIN INTERFACE A2
	- - - - - -			-	circuit board assembly includes:
-96	388-2191-01			1	CIRCUIT BOARD
	- - - - - -			-	circuit board includes:
-97	131-0787-00			4	PIN, terminal
-98	351-0213-00			2	GUIDE-POST, lock
	- - - - - -			-	mounting hardware: (not included w/circuit board)
-99	211-0121-00			2	SCREW, 4-40 x 0.438 inch, PHS
-100	388-2192-01			1	CIRCUIT BOARD
	- - - - - -			-	circuit board includes:
-101	131-0787-00			4	PIN,terminal
-102	351-0213-00			2	GUIDE-POST, lock
	- - - - - -			-	mounting hardware: (not included w/circuit board)
-103	211-0121-00			2	SCREW, 4-40 x 0.438 inch, PHS

[1] Refer to Electrical Parts List for part number.

FIGURE2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-104	131-0566-00			2	LINK, terminal connecting
-105	131-0595-00			3	TERMINAL, pin, 1.37 inches long
-106	------	B010100	B079999X	1	METER, elapsed-time
-107	166-0292-00	B010100	B079999X	2	SLEEVE, support, plastic, 0.155 inch diameter
-108	136-0252-00			13	SOCKET, pin
-109	131-1003-00			13	RECEPTACLE, cable, coax
-110	103-0146-00			4	ADAPTER, connector, 50 Ω jack w/hardware
-111	131-0590-00			53	TERMINAL, pin, 0.79 inch long
	131-0592-00			21	TERMINAL, pin, 0.885 inch long
	131-0608-00			125	TERMINAL, pin, 0.365 inch long
-112	131-0391-00			12	CONNECTOR, receptacle, 50 Ω coax
-113	351-0227-00			6	GUIDE-POST, lock, 0.84 inch long
-114	351-0185-00			3	GUIDE-POST, lock, 0.65 inch long
	351-0188-00			2	GUIDE-POST, lock, 0.65 inch long
-115	386-1557-00			5	SUPPORT, circuit board
	131-0767-05			2	CONNECTOR, receptacle
	------			-	each connector includes:
-116	200-0950-00			2	COVER, plastic
-117	204-0365-02			1	BODY, plastic
-118	131-0726-00			35	CONTACT, electrical (straight)
	131-0727-00			35	CONTACT, electrical (offset)
	------			-	mounting hardware for each: (not included w/connector)
-119	213-0232-00			2	SCREW, thread forming, 2-56 x 0.312 inch, PHS
	131-0767-04			1	CONNECTOR, receptacle, 76 contact
	------			-	connector includes:
-120	200-0950-00			2	COVER, plastic
-121	204-0365-00			1	BODY, plastic
-122	131-0726-00			35	CONTACT, electrical (straight)
	131-0727-00			35	CONTACT, electrical (offset)
	131-0899-00			6	CONTACT, electrical (short tail)
	------			-	mounting hardware: (not included w/connector)
-123	213-0232-00			2	SCREW, thread forming, 4-40 x 0.375 inch, PHS
	131-0767-03			1	CONNECTOR, receptacle, 76 contact
	------			-	connector includes:
-124	200-0950-00			2	COVER, plastic
-125	204-0365-02			1	BODY, plastic
-126	131-0726-00	B010100	B059999	34	CONTACT, electrical (straight)
	131-0726-00	B060000		31	CONTACT, straight
	131-0727-00	B010100	B059999	34	CONTACT, electrical (offset)
	131-0727-00	B060000		31	CONTACT, electrical,(offset)
	131-0899-00			4	CONTACT, electrical (short tail)
	------			-	mounting hardware (not included w/connector)
-127	213-0232-00			2	SCREW, thread forming, 2-56 x 0.312 inch, PHS
	------			-	mounting hardware: (not included w/main interface assembly)
-128	213-0263-00			12	SCREW, thread forming, 4-40 x 0.375 inch, PHS
-129	------[1]			1	CIRCUIT BOARD ASSEMBLY--VERTICAL INTERFACE A7
	------			-	circuit board assembly includes:
-130	131-0582-00	B010100	B019999	4	CONNECTOR, receptacle
-131	131-1003-00	B010100	B019999	2	RECEPTACLE, cable, coax
	131-1003-00	B020000		6	CONNECTOR, receptacle
-132	136-0263-03			5	SOCKET, pin terminal
-133	136-0252-00	B010100	B019999	24	SOCKET, pin connector, 0.145 inch long
	136-0252-00	B020000		28	SOCKET, pin connector, 0.145 inch long

[1] Refer to Electrical Parts List for part number.

FIGURE 2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
	136-0252-04	B010100	B12389	6	SOCKET, pin connector, 0
	136-0220-00	B123890		2	SOCKET, plug-in: 3 pin
-134	211-0155-00			2	SCREW, 4-40 x 0.375 inch, knurled
-135	361-0238-00			2	SPACER, sleeve
-136	214-1690-00			1	HEATSINK
	- - - - - -			-	mounting hardware: (not included w/heatsink)
-137	211-0008-00			2	SCREW, 4-40 x 0.25 inch, PHS
-138	210-0586-00	B010100	B029999	2	NUT, keps, 4-40 x 0.25 inch
	210-0586-00	B030000		1	NUT, keps, 4-40 x 0.25 inch
	210-0599-00	B030000		1	NUT, 4-40 x 0.25 inch OD
	210-1002-00	B030000		1	WASHER, flat, 0.125 ID x 0.25 inch OD
	343-0342-01	B030000		1	HOLD-DOWN, integrated circuit
	- - - - - -			-	mounting hardware: (not included w/hold-down)
	210-0599-00			1	NUT, 4-40 x 0.25 inch OD
	210-1002-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-139	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--A TRIGGER SELECTOR A5
-140	136-0252-00			24	SOCKET, pin connector, 0.145 inch long
	136-0252-04	B010100	B123889	3	SOCKET, pin connector, 0.181 inch long (square)
	136-0220-00	B123890		1	SOCKET, plug-in: 3 pin
-141	136-0263-03			9	SOCKET, pin terminal
-142	211-0155-00			2	SCREW, 4-40 x 0.375 inch , knurled
-143	361-0238-00			2	SPACER, sleeve
-144	131-0582-00			4	CONNECTOR. receptacle
-145	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--B TRIGGER SELECTOR A6
-146	136-0263-03			9	SOCKET, pin terminal
-147	131-1003-00			2	RECEPTACLE, cable, coaxial
-148	136-0252-00			24	SOCKET, pin connector, 0.145 inch long
	136-0252-01			2	SOKCET, pin connector, 0.178 inch long
	136-0252-04	B010100	B123889	3	SOCKET, pin connector, 0.181 inch long (square)
	136-0220-00	B123890		1	SOCKET, plug-in: 3 pin
-149	131-0582-00			4	CONNECTOR, receptacle
-150	211-0155-00			2	SCREW, 4-40 x 0.375 inch, knurled
-151	361-0238-00			2	SPACER, sleeve
-152	131-0805-00			3	LINK, terminal connector
	- - - - - -			-	mounting hardware for each: (not included w/link)
-153	220-0561-00			1	NUT, hex., 10-32 x 0.25 inch
-154	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--LOGIC A4
	136-0241-00	XB020000		4	SOCKET, (I.C. - 10 pin)
-155	136-0263-00			50	SOCKET, pin terminal
-156	136-0260-01			4	SOCKET, integrated circuit, 16 pin
-157	136-0252-04	B010100	B019999	97	SOCKET, pin connector, 0.181 inch long (square)
	136-0252-04	B020000	B123889	57	SOCKET, pin connector, 0.181 inch long (square)
	136-0220-00	B123890		24	SOCKET, plug-in: 3 pin
-158	386-1556-00			1	SUPPROT, circuit board
-159	131-0787-00			6	TERMINAL, pin, 0.64 inch long
-160	211-0155-00			3	SCREW, 4-40 x 0.375 inch, knurled
-161	361-0238-00			3	SPACER, sleeve
-162	- - - - - -[1]			1	CIRCUIT BOARD ASSEMLBY--HORIZ INTERCONNECT A19
-163	136-0263-03			12	SOCKET, pin terminal
-164	211-0155-00			2	SCREW, 4-40 x 0.375 inch, knurled
-165	361-0301-00			2	SPACER, sleeve

[1]Refer to Electrical Parts List for part number.

FIGURE 2 PLUG-IN HOUSING & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-166	179-1690-00	B010100	B079999	1	WIRING HARNESS, main
	179-1690-01	B080000		1	WIRING HARNESS, main
	- - - - - -			-	wiring harness includes:
-167	210-0774-00			40	EYELET, 0.23 inch
-168	210-0775-00			40	EYELET, 0.218 inch
-169	352-0161-08			2	HOLDER, terminal connector, 3 wire (gray)
-170	131-0707-00			6	CONNECTOR, terminal
-171	175-0825-00			in	WIRE, electrical, 2 wire ribbon, 6 inches long
-172	175-0828-00			in	WIRE, electrical, 5 ribbon, 12.50 inches long
	175-0860-00			in	WIRE, electrical, 5 ribbon, 22 gauge, 9.75 inches long
-173	175-0859-00			in	WIRE, electrical, 6 wire ribbon, 23.75 inches long
-174	175-0858-00			in	WIRE, electrical, 7 wire ribbon, 50 inches long
-175	175-0832-00			in	WIRE, electrical, 9 wire ribbon, 14.50 inches long
-176	175-0833-00			in	WIRE, electrical, 10 wire ribbon, 53.75 inches long
	175-0855-00			in	WIRE, electrical, 10 wire ribbon, 22 guage, 10 inches long
-177	131-0707-00			258	CONNECTOR, terminal
-178	352-0163-00			1	HOLDER, terminal connector, 5 wire (black)
	352-0163-01			2	HOLDER, terminal connector, 5 wire (brown)
	352-0163-04			2	HOLDER, terminal connector, 5 wire (yellow)
	352-0163-08			2	HOLDER, terminal connector, 5 wire (gray)
-179	352-0169-00			1	HOLDER, terminal connector, 2 wire (black)
-180	352-0164-04			2	HOLDER, terminal connector, 6 wire (yellow)
	352-0164-05			2	HOLDER, terminal connector, 6 wire (green)
-181	352-0165-01			2	HOLDER, terminal connector, 7 wire (brown)
	352-0165-03			2	HOLDER, terminal connector, 7 wire (orange)
	352-0165-06			2	HOLDER, terminal connector, 7 wire (blue)
	352-0165-07			2	HOLDER, terminal connector, 7 wire (purple)
-182	352-0167-02			2	HOLDER, terminal connector, 9 wire (red)
-183	352-0168-01			2	HOLDER, terminal connector, 10 wire (brown)
	352-0168-03			2	HOLDER, terminal connector, 10 wire (orange)
	352-0168-05			2	HOLDER, terminal connector, 10 wire (green)
	352-0168-06			2	HOLDER, terminal connector, 10 wire (blue)
	352-0168-07			2	HOLDER, terminal connector, 10 wire (purple)

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
3-	620-0461-00			1	POWER SUPPLY
	------			-	power supply includes:
-1	214-1623-00			1	HEATSINK
	------			-	mounting hardware: (not included w/heatsink)
-2	211-0504-00			4	SCREW, 6-32 x 0.25 inch, PHS
-3	------			5	TRANSISTOR
	------			-	mounting hardware for each: (not included w/transistor)
-4	210-0071-00			1	WASHER, spring tension
-5	342-0136-00			1	WASHER, insulator
-6	211-0578-00			1	SCREW, 6-32 x 0.438 inch, PHS
	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
-7	161-0033-06			1	CABLE ASSEMBLY, power
	------			-	mounting hardware: (not included w/cable assembly)
-8	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
	210-0012-00			1	WASHER, lock, internal, 0.375 ID x 0.50 inch OD
-9	210-0202-00			2	LUG, solder, SE #6
	------			-	mounting hardware for each: (not included w/lug)
-10	211-0507-00			1	SCREW, 6-32 x 0.312 inch, PHS
-11	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
-12	------			-	THERMO CUTOUT
	------			-	mounting hardware: (not included w/thermo cutout)
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-15	210-0006-00			2	WASHER, lock, internal, 0.146 ID x 0.283 inch OD
-16	200-0763-04			1	COVER, line voltage-selector
	------			-	cover includes:
-17	352-0102-00			2	HOLDER, fuse
	------			-	mounting hardware for each: (not included w/holder)
-18	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-19	204-0278-01			1	BODY, line voltage-selector
	------			-	mounting hardware: (not included w/body)
-20	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-21	------			2	TRANSISTOR
	------			-	mounting hardware for each: (not included w/transistor)
-22	386-0979-00			1	PLATE, mica
-23	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-24	342-0104-00			1	INSULATOR, plate
-25	342-0103-00			1	INSULATOR, block
	------			-	mounting hardware: (not included w/insulator)
-26	213-0041-00			2	SCREW, thread forming, 6-32 x 0.375 inch, THS
-27	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
-28	214-1625-00			1	SPRING, flat, 2 inches long
-29	337-1551-00			1	SHIELD, electrical
	------			-	mounting hardware: (not included w/shield)
-30	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-31	348-0055-00			1	GROMMET, plastic, 0.25 inch diameter
-32	- - - - - - -			1	COIL
	- - - - - - -			-	mounting hardware: (not included w/coil)
-33	213-0138-00			1	SCREW, thread forming, 4-40 x 0.188 inch, PHS
-34	210-0201-00			1	LUG, solder, SE #4
	- - - - - - -			-	mounting hardware: (not included w/lug)
-35	211-0007-00			1	SCREW, 4-40 x 0.25 inch, PHS
-36	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
-37	131-0022-00			1	CONNECTOR, terminal, tie point
	- - - - - - -			-	mounting hardware: (not included w/connector)
-38	211-0007-00			1	SCREW, 4-40 x 0.25 inch, PHS
-39	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
-40	441-1019-00			1	CHASSIS
	- - - - - - -			-	mounting hardware: (not included w/chassis)
-41	211-0504-00			4	SCREW, 6-32 x 0.25 inch, PHS
-42	211-0008-00			2	SCREW, 4-40 x 0.25 inch, PHS
	211-0007-00			2	SCREW, 4-40 x 0.188 inch, PHS
-43	- - - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--LOW VOLTAGE REGULATOR A13
	- - - - - - -			-	circuit board assembly includes:
-44	131-0608-00			63	TERMINAL, pin, 0.365 inch long
-45	136-0252-04	B010100	B123889	87	SOCKET, pin connector
	136-0183-00	B123890		7	SOCKET, plug-in: 3 pin
	136-0220-00	B123890		6	SOCKET, plug-in: 3 pin
	136-0235-00	B123890		8	SOCKET, plug-in: 3 pin
-46	214-0579-00			8	PIN, test point
-47	136-0183-00			2	SOCKET, transistor, 3 pin
-48	- - - - - - -			1	TRANSISTOR, w/hardware
	- - - - - - -			-	mounting hardware: (not included w/transistor)
-49	211-0121-00			1	SCREW, 4-40 x 0.438 inch, PHS
-50	210-0551-00			1	NUT, hex., 4-40 x 0.25 inch
	- - - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-51	211-0007-00			5	SCREW, 4-40 x 0.25 inch, PHS
-52	407-0964-00	B010100	B010344	1	BRACKET, capacitor
	407-0964-01	B010345		1	BRACKET, capacitor
	- - - - - - -			-	mounting hardware: (not included w/bracket)
-53	211-0504-00			4	SCREW, 6-32 x 0.25 inch, PHS
-54	- - - - - - -			2	CAPACITOR
	- - - - - - -			-	mounting hardware for each: (not included w/capacitor)
-55	212-0518-00			4	SCREW, 10-32 x 0.312 inch, PHS
-56	337-1491-00			1	SHIELD, circuit board
	- - - - - - -			-	shield includes:
-57	344-0118-00			2	CLIP, capacitor mounting
-58	210-0623-00			2	RIVET
	- - - - - - -			-	mounting hardware: (not included w/shield)
-59	211-0008-00			3	SCREW, 4-40 x 0.25 inch, PHS

[1] Refer to Electrical Parts List for part number.

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-60	344-0230-00			1	CLIP, spring tension
-61	220-0623-00			1	NUT BLOCK
	------			-	mounting hardware: (not included w/nut block)
-62	211-0504-00			3	SCREW, 6-32 x 0.25 inch, PHS
-63	337-1490-00			1	SHIELD, circuit board
	------			-	mounting hardware: (not included w/shield)
-64	211-0040-00			2	SCREW, plastic, 4-40 x 0.25 inch, BHS
-65	------[1]			1	CIRCUIT BOARD ASSEMBLY--POWER SUPPLY INVERTER A11
	------			-	circuit board assembly includes:
-66	348-0023-00			6	FOOT, plastic
-67	131-0591-00			7	TERMINAL, pin, 0.835 inch long
-68	136-0254-01			4	SOCKET, pin connector
-69	214-0579-00			3	PIN, test point
-70	348-0005-00			1	GROMMET
-71	355-0518-02			4	STUD, self-lock
-72	129-0323-00			2	POST, hex., 1 inch long
	------			-	mounting hardware for each: (not included w/post)
-73	211-0097-00			1	SCREW, 4-40 x 0.312 inch, PHS
	------			-	mounting hardware: (not included w/circuit board assembly)
-74	211-0008-00			2	SCREW, 4-40 x 0.25 inch PHS
-75	214-1624-00			1	HEATSINK-SHIELD
-76	348-0291-00			1	PAD, cushion
	672-0030-00			1	HIGH VOLTAGE & AUTO FOCUS ASSEMBLY
	------			-	high voltage & auto focus assembly includes:
-77	------			1	DIODE
	------			-	mounting hardware: (not included w/diode)
-78	210-0409-00			2	NUT, hex., 8-32 x 0.312 inch
-79	------[1]			1	CIRCUIT BOARD ASSEMBLY--HIGH VOLTAGE A14
	------			-	circuit board assembly includes:
-80	131-0809-00			1	TERMINAL, stud
	------			-	mounting hardware: (not included w/terminal)
-81	211-0007-00			1	SCREW, 4-40 x 0.188 inch, PHS
-82	337-1492-00			1	SHIELD, circuit board
	------			-	mounting hardware: (not included w/circuit board assembly)
-83	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-84	------[1]			1	CIRCUIT BOARD ASSEMBLY--AUTO FOCUS A15
	------			-	circuit board assembly includes:
	------			-	mounting hardware: (not included w/circuit board assembly)
-85	343-0088-00			2	CLAMP, cable, plastic

[1]Refer to Electrical Parts List for part number.

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-86	348-0023-00			2	FOOT, plastic
-87	343-0088-00			1	CLAMP, cable, plastic
-88	131-0707-00			17	CONNECTOR, terminal
-89	175-0860-00			in	WIRE, electrical, 5 wire ribbon, 24 inches
-90	175-1278-00			in	WIRE, electrical, 4 wire ribbon, 15 inches
-91	175-1279-00			in	WIRE, electrical, 2 wire ribbon, 17.50 inches
-92	352-0163-05			1	HOLDER, terminal connector, 5 wire (green)
-93	352-0165-04			1	HOLDER, terminal connector, 7 wire (yellow)
-94	352-0167-04			1	HOLDER, terminal connector, 9 wire (yellow)
-95	337-1487-00			1	SHIELD, HV supply (box)
	- - - - - -			-	mounting hardware: (not included w/shield)
-96	211-0008-00			4	SCREW, 4-40 x 0.25 inch, PHS
-97	386-1556-00			4	SUPPORT, plastic, circuit board
-98	348-0055-00			2	GROMMET, plastic, 0.25 inch diameter
-99	342-0105-00			1	INSULATOR
-100	252-0562-00			in	PLASTIC CHANNEL, 1.67 inches long
	- - - - - -			1	TRANSFORMER (not shown)
	- - - - - -			-	transformer includes:
-101	386-2041-00			2	SUPPORT, transformer
-102	344-0231-00			2	CLIP, transformer
-103	200-1263-00	B010100	B119999	1	COVER, right side
	200-1263-01	B120000		1	COVER, right side
	- - - - - -			-	mounting hardware: (not included w/cover)
-104	211-0504-00			1	SCREW, 6-32 x 0.25 inch, PHS
-105	200-1262-00	B010100	B119999	1	COVER, left side
	200-1262-02	B120000		1	COVER, left side
	- - - - - -			-	mounting hardware: (not included w/cover)
	211-0504-00			1	SCREW, 6-32 x 0.25 inch, PHS (not shown)
-106	351-0279-00			2	GUIDE, shoe
-107	200-1261-00			1	COVER, bottom & front
	- - - - - -			-	mounting hardware: (not included w/cover)
-108	211-0504-00			6	SCREW, 6-32 x 0.25 inch, PHS
-109	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--CAP RECTIFIER A12
	- - - - - -			-	circuit board assembly includes:
-110	136-0263-03			7	SOCKET, terminal pin
-111	136-0252-04	B010100	B123889	15	SOCKET, pin connector
	136-0220-00	B123890		3	SOCKET, plug-in, 3 pin
	136-0183-00	B123890			SOCKET, plug-in, 3 pin
-112	131-0608-00			29	TERMINAL, pin, 0.365 inch long
-113	214-0579-00			4	PIN, test point
-114	- - - - - -			6	DIODE
	- - - - - -			-	mounting hardware for each: (not included w/diode)
-115	210-0410-00			1	NUT, hex., 10-32 x 0.312 inch
-116	210-0056-00			1	WASHER, lock, split, 0.195 ID x 0.32 inch OD
-117	210-1003-00			1	WASHER, flat, 0.20 ID x 0.438 inch OD
-118	136-0260-02			1	SOCKET, integrated circuit, 16 pin
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-119	211-0008-00			4	SCREW, 4-40 x 0.25 inch, PHS

[1]Refer to Electrical Parts List for part number.

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
3-120	131-0707-00			64	CONNECTOR, terminal
-121	175-0857-00			in	WIRE, electrical, 8 wire ribbon, 2.75 inches
-122	175-0859-00			in	WIRE, electrical, 6 wire ribbon, 6.50 inches
-123	175-0861-00			in	WIRE, electrical, 4 wire ribbon, 8 inches
-124	352-0162-05			2	HOLDER, terminal connector, 4 wire (green)
	352-0162-04			2	HOLDER, terminal connector, 4 wire (yellow)
-125	352-0164-02			2	HOLDER, terminal connector, 6 wire (red)
-126	352-0166-01			2	HOLDER, terminal connector, 8 wire (brown)
	- - - - - -			-	mounting hardware: (not included w/power supply)
-127	212-0023-00			4	SCREW, 8-32 x 0.375 inch, PHS
-128	333-1484-00			1	PANEL, rear
-129	348-0225-00			2	PAD, cabinet foot
-130	348-0224-00			2	FOOT, cabinet, rear
	- - - - - -			-	mounting hardware for each: (not included w/foot)
-131	212-0020-00			2	SCREW, 8-32 x 1 inch, PHS
-132	211-0538-00			2	NUT, keps, 10-32 x 0.375 inch
-133	386-2060-00			1	SUB-PANEL, rear
	346-0045-00			1	STRAP, connector cover (not shown)
-134	200-0991-00	B010100	B029999	1	COVER, connector, BNC
	200-0678-00	B030000		1	COVER, connector, BNC, non shorting
-135	131-0955-00			1	CONNECTOR, receptacle, electrical, BNC, female, w/hardware
-136	131-0771-00			2	CONNECTOR, receptacle, 4 contact
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-137	210-0012-00			1	WASHER, lock, internal, 0.375 ID x 0.50 inch OD
-138	220-0551-00			1	NUT, hex., 9 mm thread, 0.437 inch
-139	136-0089-00			1	SOCKET, 9 pin, w/female insert
	- - - - - -			-	mounting hardware: (not included w/socket)
-140	211-0097-00			4	SCREW, 4-40 x 0.312 inch, PHS
-141	210-0586-00			4	NUT, keps, 4-40 x 0.25 inch
-142	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--PROBE POWER A1
	- - - - - -			-	circuit board assembly includes:
-143	136-0252-04			2	SOCKET, pin connector
-144	131-1003-00			2	RECEPTACLE, cable, coax
-145	131-0608-00			9	TERMINAL, pin, 0.365 inch long
-146	386-1557-00			4	SUPPORT, plastic, circuit board
	210-0201-00	XB060000		1	TERMINAL, LUG, SE #4
	211-0007-00	XB060000		1	SCREW, 4-40 x 0.188 inch, PHS
-147	441-1020-00			1	CHASSIS, vertical & horizontal amplifier circuits boards
	- - - - - -			-	mounting hardware: (not included w/chassis)
-148	211-0538-00			2	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-149	211-0101-00			2	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
	211-0504-00			2	SCREW, 6-32 x 0.25 inch, PHS (not shown)
-150	210-0457-00			4	NUT, keps, 6-32 x 0.312 inch
-151	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
	210-0803-00	XB010125		4	WASHER, flat, 0.15 ID x 0.375 inch OD

[1] Refer to Electrical Parts List for part number.

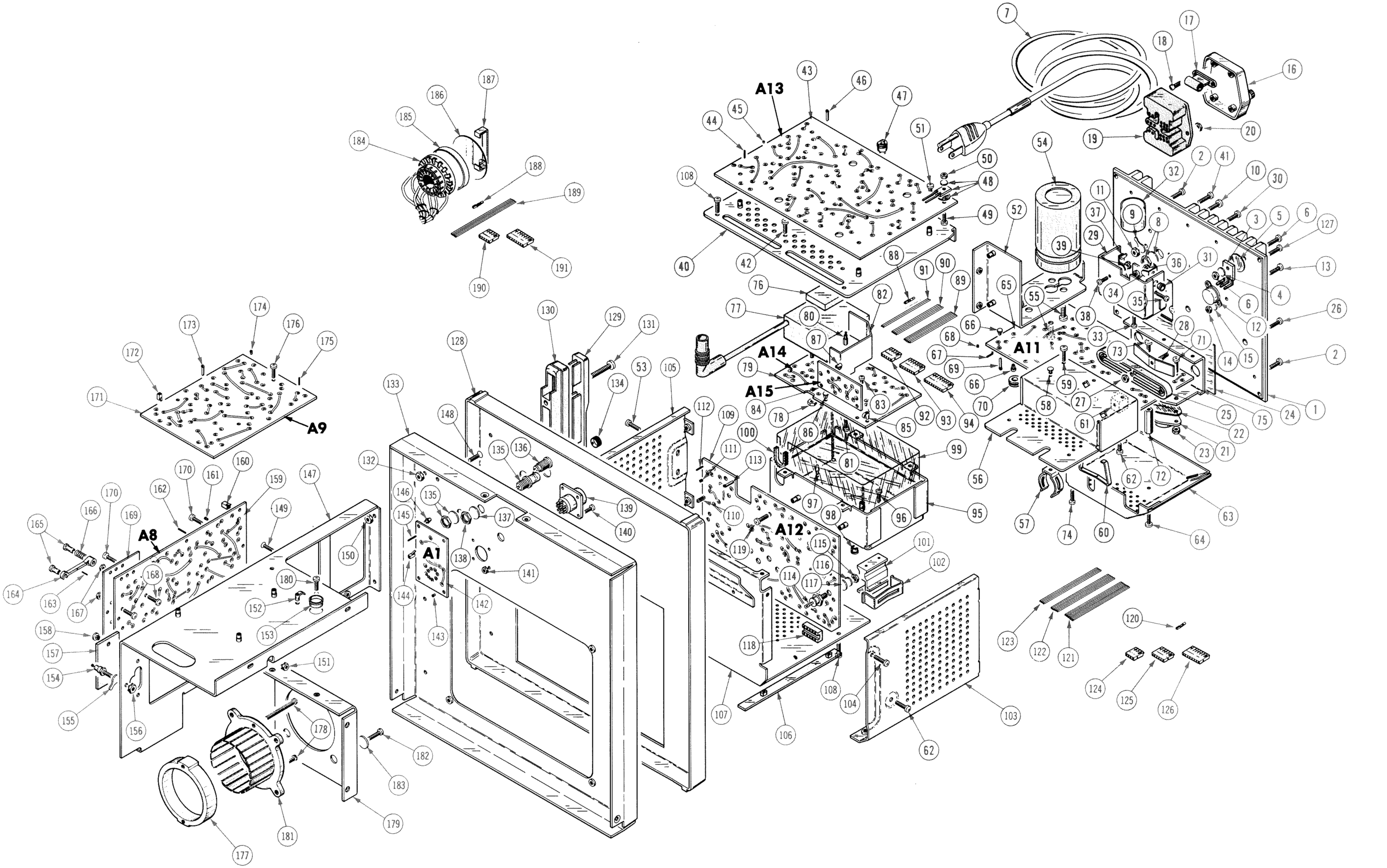
FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
3-152	343-0089-00			1	CLAMP, cable, plastic
-153	348-0063-00			1	GROMMET, plastic, 0.50 inch diameter
-154	129-0006-00			1	POST, connecting
	- - - - - -			-	mounting hardware: (not included w/post)
-155	210-0202-00			1	LUG, solder, SE #6
-156	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-157	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-158	210-0784-00	B010100	B010120	2	RIVET, press-mount
	211-0507-00	B010121	B079999	2	SCREW, 6-32 x 0.312 inch, PHS
	211-0511-00	B080000		2	SCREW, 6-32 x 0.50 inch, PHS
	166-0107-00	XB080000		2	TUBE, spacing, 0.18 ID x 0.25 ID x 0.219 inch long
	211-0511-00	B080000		2	SCREW,6-32 x 0.50 inch, PHS
	166-0107-00	XB080000		2	TUBE, spacing, 0.18 ID x 0.25 ID x 0.219 inch long
	210-0894-00	B010121		2	WASHER, plastic, 0.19 ID x 0.438 inch OD
-159	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--VERTICAL AMPLIFIER A8
	- - - - - -			-	circuit board assembly includes:
-160	131-1003-00			5	RECEPTACLE, cable coax
-161	136-0252-01			26	SOCKET, pin connector
	136-0252-04	B010100	B123889	27	SOCKET, pin connector, square
	136-0220-00	B123890		9	SOCKET, plug-in, 3 pin
-162	131-0608-00			7	TERMINAL, pin, 0.365 inch long
-163	210-0627-00			2	RIVET
-164	343-0097-00			2	CLAMP
	- - - - - -			-	mounting hardware for each: (not included w/clamp)
-165	210-0599-00			2	NUT, sleeve
-166	214-0368-00			2	SPRING, helical compression
-167	210-0551-00			2	NUT, hex., 4-40 x 0.25 inch
-168	211-0097-00			2	SCREW, 4-40 x 0.312 inch, PHS
-169	214-1683-00	B010100	B019999	1	HEATSINK
	214-1683-01	B020000		1	HEATSINK
	210-0698-00	XB154160		1	RIVET
	- - - - - -			-	mounting hardware:(not included with ckt board assy)
-170	211-0008-00			8	SCREW, 4-40 x 0.25 inch, PHS
-171	- - - - - -[1]			1	CIRCUIT BOARD ASSEMBLY--MAIN HORIZ AMP A9
	- - - - - -			-	circuit board assembly includes:
-172	131-1003-00			3	RECEPTACLE, cable, coax
-173	214-0579-00			2	PIN, test point
-174	136-0252-04	B010100	B079999	45	SOCKET, pin connector
	136-0252-04	B080000	B123889	48	SOCKET, pin connector
	136-0183-00	B123890		4	SOCKET, plug-in, 3 pin
	136-0220-00	B123890		12	SOCKET, plug-in, 3 pin
-175	131-0589-00	B010100	B079999	8	TERMINAL, pin, 0.46 inch long
	131-0589-00	B080000		10	TERMINAL, pin, 0.46 inch long
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-176	211-0008-00			3	SCREW, 4-40 x 0.25 inch, PHS
-177	354-0347-00			1	RING, clamp, CRT
	- - - - - -			-	mounting hardware: (not included w/ring)
-178	211-0170-00			2	SCREW, 4-40 x 2.75 inches, PHS

[1]Refer to Electrical Parts List for part nember.

FIGURE 3 REAR & LOW VOLTAGE POWER SUPPLY (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
3-179	407-0975-00			1	BRACKET, CRT shield
	- - - - - -			-	mounting hardware: (not included w/bracket)
-180	211-0504-00			2	SCREW, 6-32 x 0.25 inch, PHS
-181	343-0205-00	B010100	B010144	1	RETAINER, CRT
	343-0205-01	B010145		1	RETAINER, CRT
	- - - - - -			-	mounting hardware: (not included w/retainer)
-182	211-0507-00			4	SCREW, 6-32 x 0.312 inch, PHS
-183	210-0949-00			4	WASHER, flat, 0.046 ID x 0.50 inch OD
	136-0477-00			1	ASSEMBLY, CRT socket
	- - - - - -			-	assembly includes:
-184	136-0304-02			1	SOCKET, CRT
-185	200-0917-01			1	COVER, CRT socket
-186	343-0254-00			1	CLAMP, CRT socket
-187	367-0117-00			1	HANDLE, CRT socket
-188	131-0621-00			10	CONNECTOR, terminal
-189	175-0860-00			ft	WIRE, electrical, 5 wire ribbon, 0.458 foot long
-190	352-0201-00			1	HOLDER, terminal connector, 5 wire (black)
-191	352-0204-00			1	HOLDER, terminal connector, 8 wire (black)
	176-0045-00			ft	BRAIDED, wire, #24 0.125 ft lg
	210-0201-00			1	LUG, terminal, solder type 450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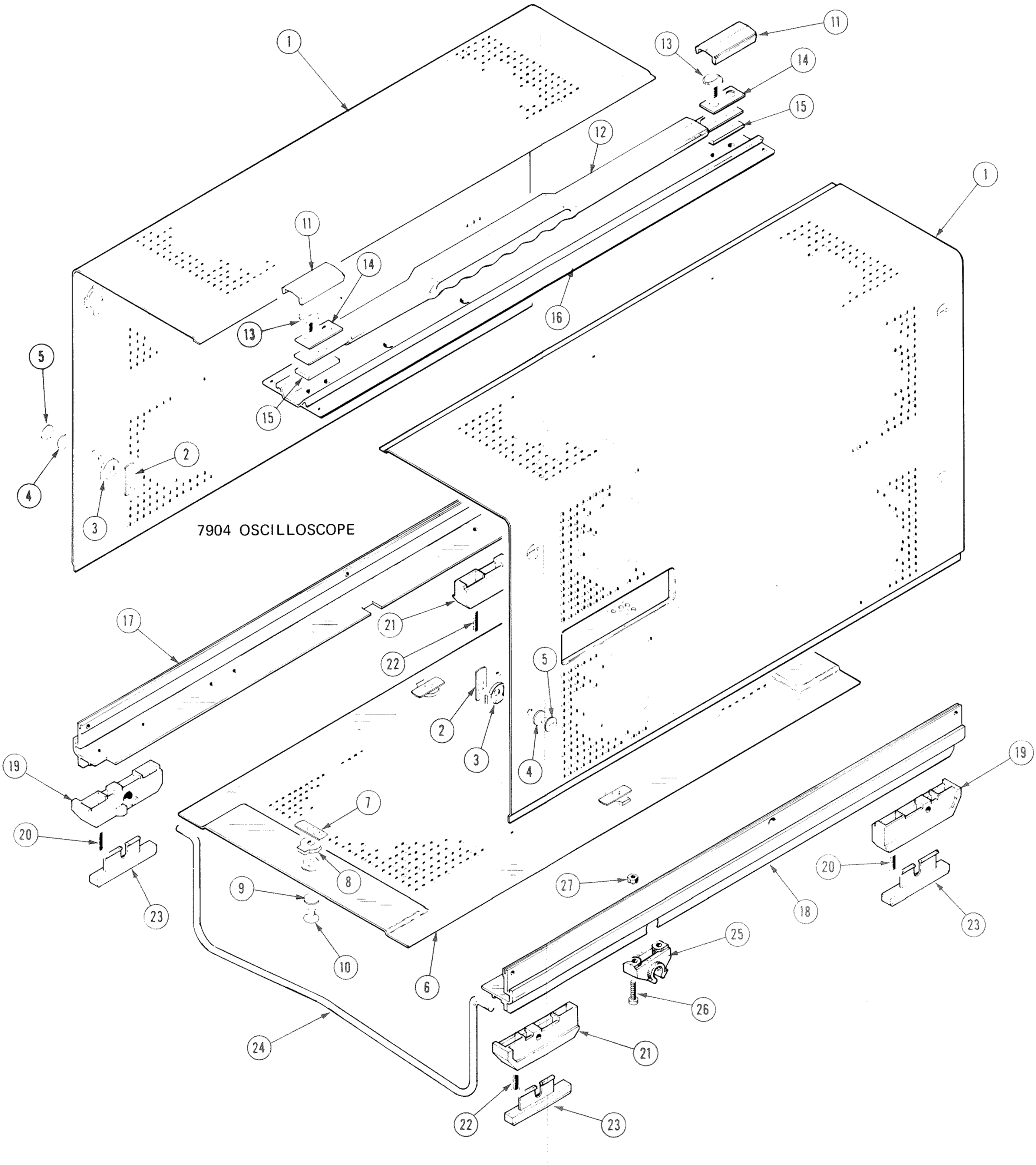
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FIGURE 4 CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
4-1	390-0086-00			2	CABINET SIDE
	- - - - - - -			-	each cabinet side includes:
	214-0812-00			4	LATCH ASSEMBLY
	- - - - - - -			-	each latch assembly includes:
-2	386-0226-00			1	PLATE, locking
-3	386-0227-00			1	PLATE, index, plastic
-4	214-0604-00			1	SPRING
-5	214-0603-01			1	PIN, securing
-6	390-0085-00			1	CABINET BOTTOM
	- - - - - - -			-	cabinet bottom includes:
	214-0812-00			8	LATCH ASSEMBLY
	- - - - - - -			-	each latch assembly includes:
-7	386-0226-00			1	PLATE, locking
-8	386-0227-00			1	PLATE, index, plastic
-9	214-0604-00			1	SPRING
-10	214-0603-01			1	PIN, securing
-11	200-0973-00			2	COVER, handle, plastic
-12	367-0108-00			1	HANDLE, carrying
	- - - - - - -			-	mounting hardware: (not included w/handle)
-13	213-0211-00			4	SCREW, 10-32 x 0.512 inch, FHS
-14	386-1624-00			2	PLATE, spacer
-15	386-1623-00			2	PLATE, spacer
-16	426-0848-00			1	FRAME SECTION, cabinet
	- - - - - - -			-	mounting hardware: (not included w/frame section)
	212-0040-00			4	SCREW, 8-32 x 0.375 inch, 100° csk, FHS, (not shown)
	210-0458-00			4	NUT, keps, 8-32 x 0.344 inch (not shown)
-17	426-0797-00			1	FRAME SECTION, cabinet, lower left
	- - - - - - -			-	mounting hardware: (not included w/frame section)
	212-0040-00			2	SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch (not shown)
	212-0070-00			2	SCREW, 8-32 x 0.312 inch, 100° csk, FHS (not shown)
-18	426-0810-00			1	FRAME SECTION, cabinet, lower right
	- - - - - - -			-	mounting hardware: (not included w/frame section)
	212-0040-00			2	SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch (not shown)
	212-0070-00			2	SCREW, 8-32 x 0.312 inch, 100° csk, FHS (not shown)
-19	348-0180-00			2	FOOT, cabinet, left front & right rear
	- - - - - - -			-	mounting hardware for each: (not included w/foot)
-20	211-0513-00			2	SCREW, 6-32 x 0.625 inch, PHS
-21	348-0181-00			2	FOOT, cabinet, right front & left rear
	- - - - - - -			-	mounting hardware for each: (not included w/foot)
-22	211-0513-00			2	SCREW, 6-32 x 0.625 inch, PHS
-23	348-0182-00			4	PAD, cabinet foot
-24	348-0193-00			1	FLIP-STAND, cabinet
-25	343-0256-00			2	RETAINER, block
	- - - - - - -			-	mounting hardware for each: (not included w/retainer)
-26	212-0091-00			2	SCREW, 8-32 x 0.625 inch, Fil HS
-27	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch

STANDARD ACCESSORIES

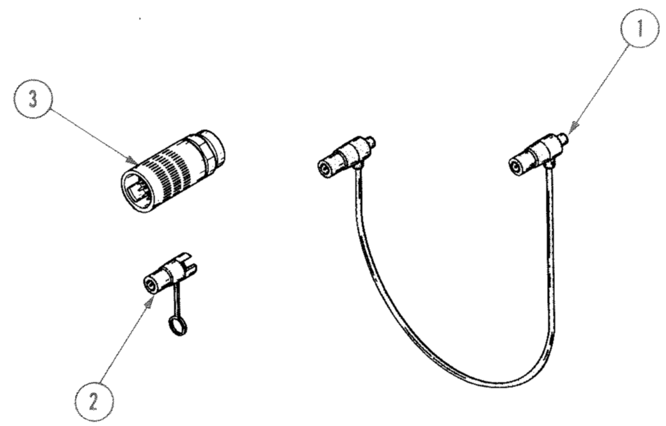


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
1	012-0087-00			2	PATCH CORD, BNC-BNC, 18 inches long		
2	012-0092-00			1	JACK, BNC-post		
3	134-0049-00			1	PLUG, 9-pin, w/male insert		
	070-1399-00			1	MANUAL, operators(not shown)		
	070-1195-02			1	MANUAL, service(not shown)		

CARTON ASSEMBLY
(Part No. 065-0162-00)

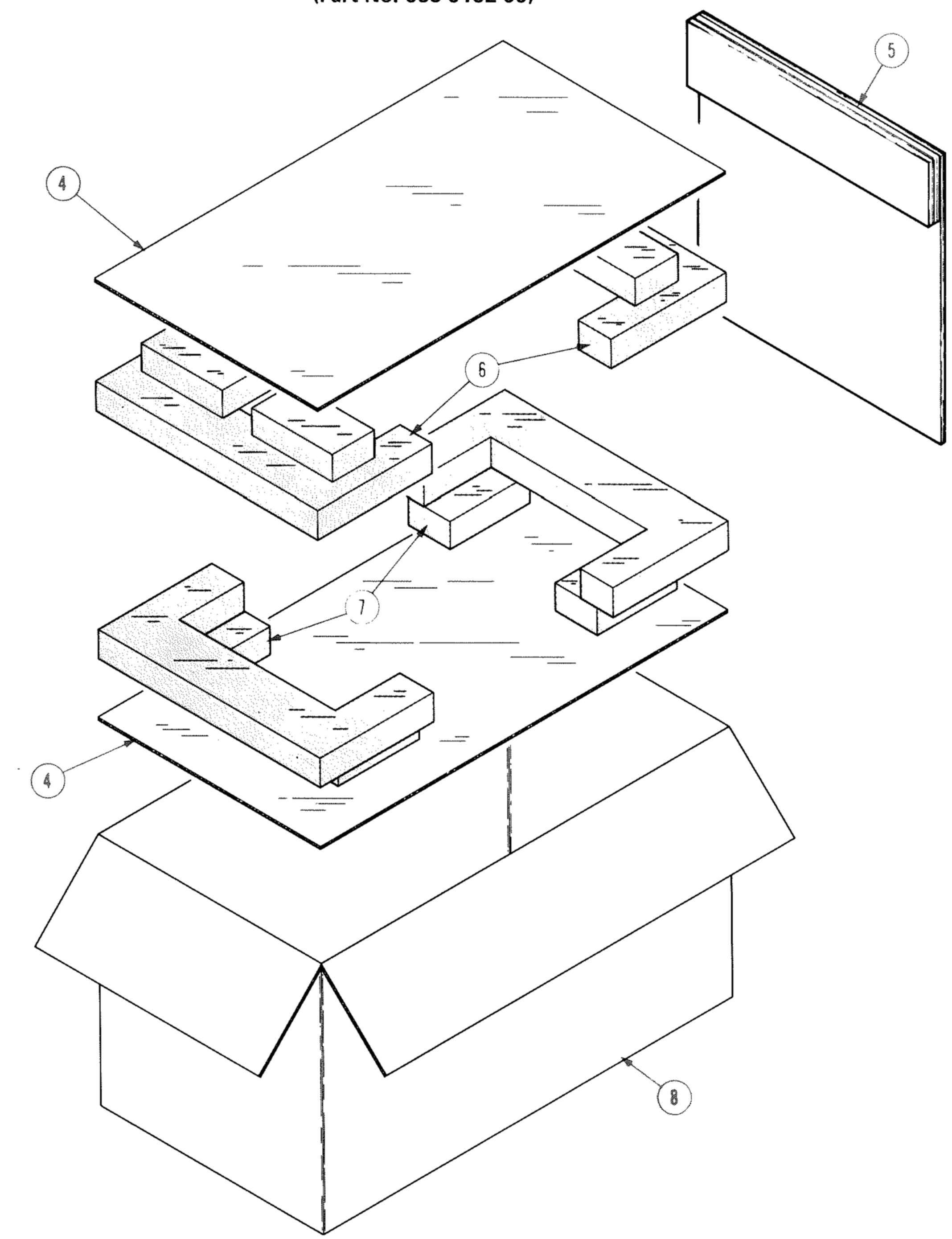


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
	065-0162-00			1	CARTON ASSEMBLY		
	----- -----			-	. carton assembly includes:		
4	004-1120-00			1	. PAD SET, 2 piece		
5	004-1118-00			1	. PAD SET, 1 piece		
	004-1084-00			1	. PAD SET, 3 piece, front & rear		
6	004-0293-00			1	. FRAME, top		
7	004-0292-00			1	. FRAME, bottom		
8	004-0751-00			1	. CARTON		

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

product modification

040-0605-03

R7903, 7904

READOUT CONVERSION

For TEKTRONIX® R7903 and 7904 Option 1* Oscilloscopes

All Serial Numbers

Modification kit PN 040-0605-03 contains parts and instructions to install a Readout circuit board which provides an alpha-numeric display of the Vertical and Horizontal deflection factors and other plug-in encoded information. The readout is displayed on the CRT, written by the CRT beam, on a time-shared basis with the analog waveform display.

* Without Readout Feature

8-11-75
Supersedes 040-0605-02

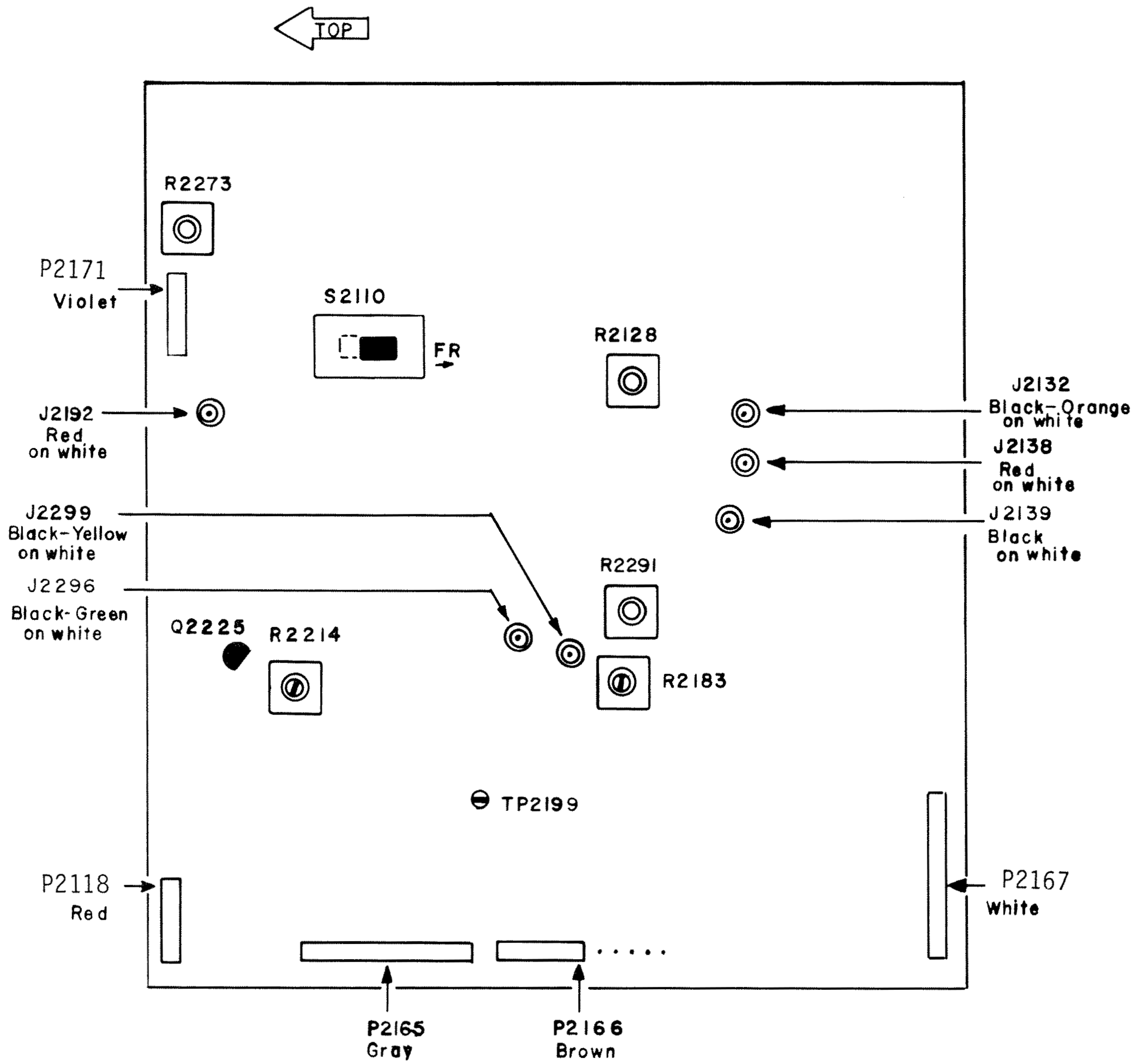

TOP
R2273
P2171
Violet
S2110
FR
R2128
J2132
Black-Orange
on white
J2192
Red
on white
J2138
Red
on white
J2299
Black-Yellow
on white
J2139
Black
on white
R2291
J2296
Black-Green
on white
Q2225
R2214
R2183
TP2199
P2118
Red
P2167
White
P2165
Gray
P2166
Brown

FIG. 1A

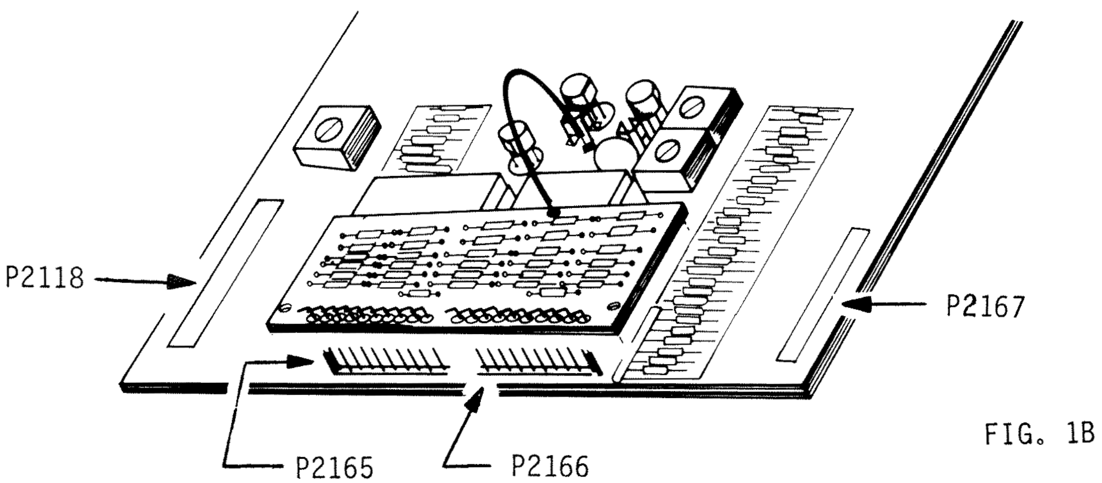

P2118
P2167
P2165
P2166

FIG. 1B

PARTS INCLUDED IN MODIFICATION KIT

Quantity	Part Number	Description
1 ea	672-0572-00	Circuit Board Readout

INSTRUCTIONS:

A. R7903 - REFER TO FIG. 1A & 1B.

( ) 1. Remove the top dust cover from the instrument.

( ) 2. Remove the four screws holding the power supply assembly to the rear of the instrument. Slide out the power assembly.

( ) 3. Remove the dummy readout board, held with one screw in the upper center of the board. (A spacer is also fastened to a mounting screw and is to be used when installing the readout board.)

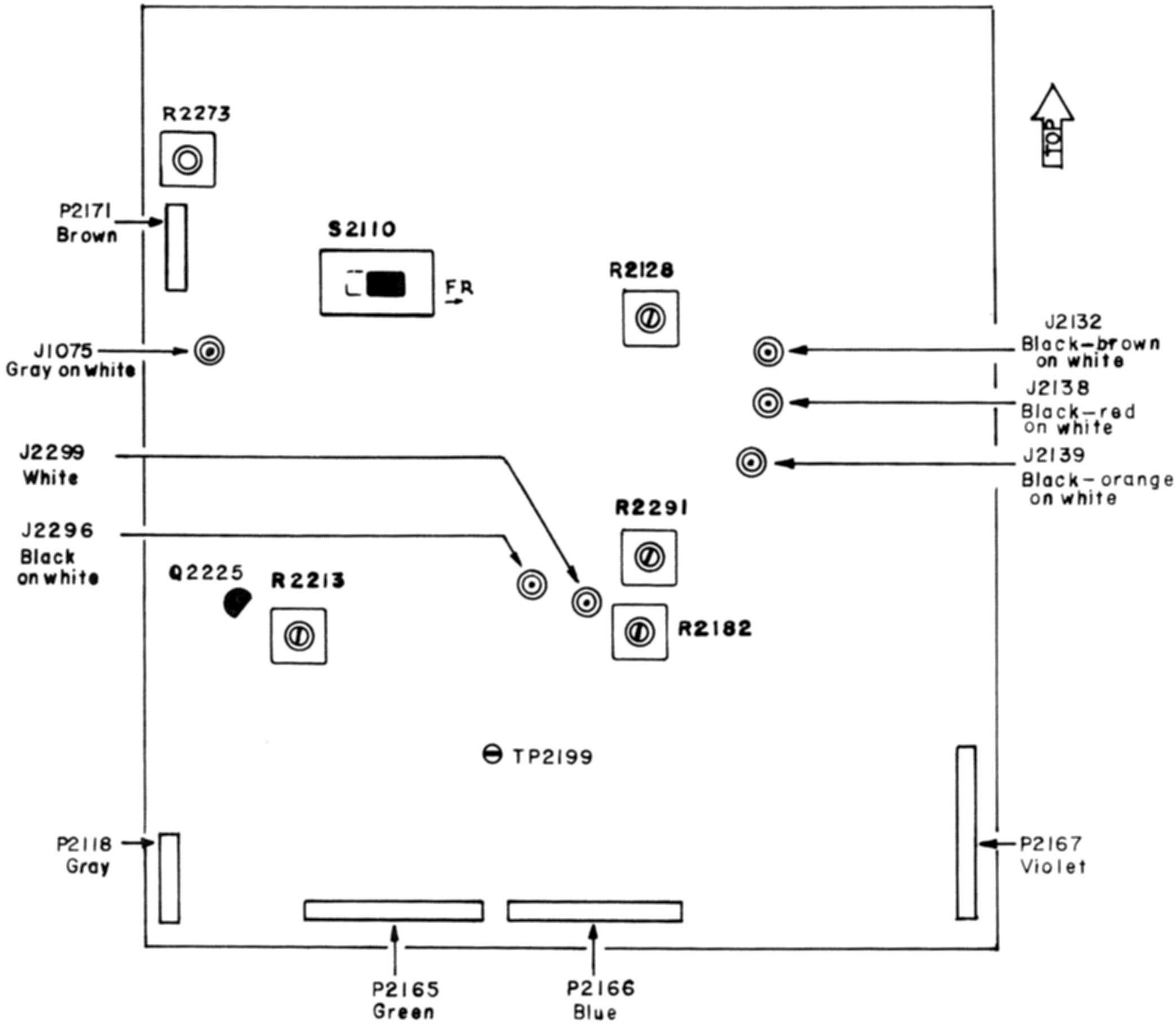
( ) 4. Remove the cable wires from the dummy board and then install them on the Readout System circuit board from the kit, as shown in Fig. 1.

( ) 5. Lay the Readout board on the top of the instrument with a piece of cardboard or other insulating material between.

( ) 6. Using the attached procedure, make the necessary calibration adjustments to insure correct readout operation.

( ) 7. Insert the Readout board in the Support channels and secure with the screw and spacer removed from the dummy board.

( ) 8. Replace power supply assembly and top cover.



READOUT SYSTEM CIRCUIT BOARD

FIG. 2A

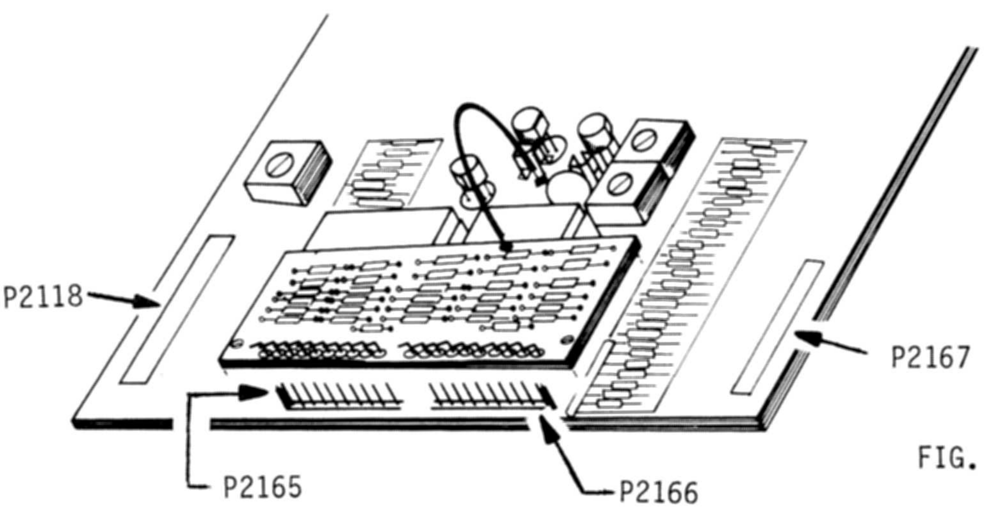


FIG. 2B

B. 7904 - REFER TO FIG. 2A & 2B

( ) 1. Remove the right side cover from the instrument.

( ) 2. Replace the dummy Readout circuit board with the Readout System circuit board assembly from the kit. (Use the mounting screw removed from the dummy board.) Refer to Fig. 2 below for cable connections.

( ) 3. Using the attached procedure, make the necessary calibration adjustments to insure correct readout operation.

( ) 4. Replace side cover.

READOUT SYSTEM CALIBRATION

Refer to Fig.2A for the location of the adjustments.

( ) 1. Remove all plug-ins from the Oscilloscope Main Frame.

( ) 2. Turn instrument on and allow 20 minutes warm-up time.

( ) 3. Remove Q2225 from its socket on the Readout System circuit board.

( ) 4. Install a Type 7B92 plug-in in the HORIZ compartment.

( ) 5. Set the 7B92 for AUTO, EXTERNAL TRIGGERING at a sweep rate of one millisecond/division. Set S2110 (Readout Mode switch) to FR.

( ) 6. Set the A INTENSITY control for a visible display.

( ) 7. Set the READOUT intensity control for a visible display of readout characters at the top and bottom of the display area.

( ) 8. Set the VERTICAL MODE switch to ALT.

( ) 9. CHECK - Displayed readout characters should be equally spaced above and below the center horizontal graticule line and the alternating traces should be within 0.5 division of the center graticule line.

( ) 10. ADJUST - Vertical centering adjustment R712 for equal spacing of the alternating traces from the graticule center line. (If the alternating traces appear as a single trace, adjust R712 to position the trace to the center line.) Adjust Readout Vertical centering R707 for equal spacing of the display readout characters from the graticule center line. Repeat the adjustments until no interaction is noted.

( ) 11. ADJUST - Vertical separation adjustment R2291 to position the two rows of readout characters to the middle of the top and bottom divisions of the graticule.

> NOTE: Readout Vertical Centering adjustment must be correct before making this adjustment; see Step 10. Readjust if necessary. Some interaction may occur.

( ) ADJUST - Character size R2273, as needed.

( ) 12. Remove the 7B92 plug-in.

( ) 13. CHECK - CRT display for two rows of zeros, 40 zeros to a row with no overlap. Total length of each row of characters should be between 9.5 and 10.5 divisions. Character height should be 0.25 to 0.5 division. There should be one zero or less to the right of the last graticule line, and one zero or less to the left of the first graticule line. The two rows of zeros should be located vertically in the middle of the top and bottom divisions of the graticule.

NOTE: These tolerances are provided as guides to correct instrument operation and are not instrument specifications.

( ) 14. Set the POWER switch to OFF and replace Q2225 in its socket; return the POWER switch to ON.

( ) 15. Install a Type 7A15 in the LEFT VERT compt. (Set MODE Sw. to LEFT)

( ) 16. Set the 7A15 for a deflection factor of 50 millivolts/division.

( ) 17. CHECK - Display characters for completness.

( ) 18. ADJUST - Full character Scan adjustment R2128 for fully scanned characters. The m and the 5 will show the most change.

( ) 19. Install the 7B92 in the HORIZ compartment.

( ) 20. Set the 7B92 for auto triggering.

( ) 21. Set the Gate Switch to A (Gate switch located on Calibrator-Signal circuit board).

( ) 22. CHECK - Turn the 7B92 time/division switch throughout its complete range. Check that the readout characters are present on a free-run basis, independent of the sweep rate.

( ) 23. Set S2110 (Readout Mode switch) to Gate Trig'd.

( ) 24. Set the 7B92 for a sweep rate of 0.1 second/division.

( ) 25. CHECK - Readout characters are blanked out while the sweep is running, and are displayed immediately after the end of the sweep; each character encoded by the plug-in units is displayed only once for each sweep.

( ) 26. Return the Readout Mode switch to Free Run-Remote.

NOTE: Two methods of adjustment follow. If digital plug-in units such as the TEKTRONIX Type 7D13 or 7D14 are to be used in this instrument, parts 27 through 35 must be used to insure correct readout operation. However, with other types of plug-in units, the alternate procedure given in parts a through c will provide correct operation in most cases.

( ) 27. Set the CALIBRATOR switch to 0.4V.

( ) 28. Connect the calibrator signal to TP2199 with an 18 inch BNC cable, BNC to clip-lead adapter, 0.1μF, 25volts capacitor, and a 10 kilohm 5% resistor, in given order. The resistor can either be temporarily soldered in place or a mini-alligator clip can be added to the resistor to clip it in place.

( ) 29. Press and hold the Identify button on the 7A15.

( ) 30. CHECK - Readout display for correct indication of "IDENTIFY". If the readout display either blinks or is incorrect, adjustment is required.

( ) 31. ADJUST - Column Match adjustment R2213 (R2214) for correct readout indication. Set R2213 (R2214) to the center of the adjustment range which provides correct readout indication. Release the Identify button.

( ) 32. Disconnect the 10 kilohm resistor and reconnect it to TP2209.

( ) 33. Press and hold the Identify button on the 7A15.

( ) 34. CHECK - Readout display for correct indication of "IDENTIFY". If the readout display either blinks or is incorrect, adjustment is required.

( ) 35. ADJUST - Row Match adjustment R2182 (R2183) for correct readout indication. Set R2182 (R2183) to the center of the adjustment range which provides correct readout indication. Release the Identify button and disconnect the 10 kilohm resistor.

ALTERNATE PROCEDURE

a. Press and hold the Identify button on the 7A15.

b. CHECK - Readout display for correct indication of "IDENTIFY".

c. ADJUST - Column Match adjustment R2213 (R2214) and Row Match adjustment R2182 (R2183) for correct readout indication. Set these adjustments to the center of the adjustment range which provides correct readout indication. Release the Identify button.

ADDENDUM TO THE FOLLOWING READOUT CONVERSION 040 KITS:

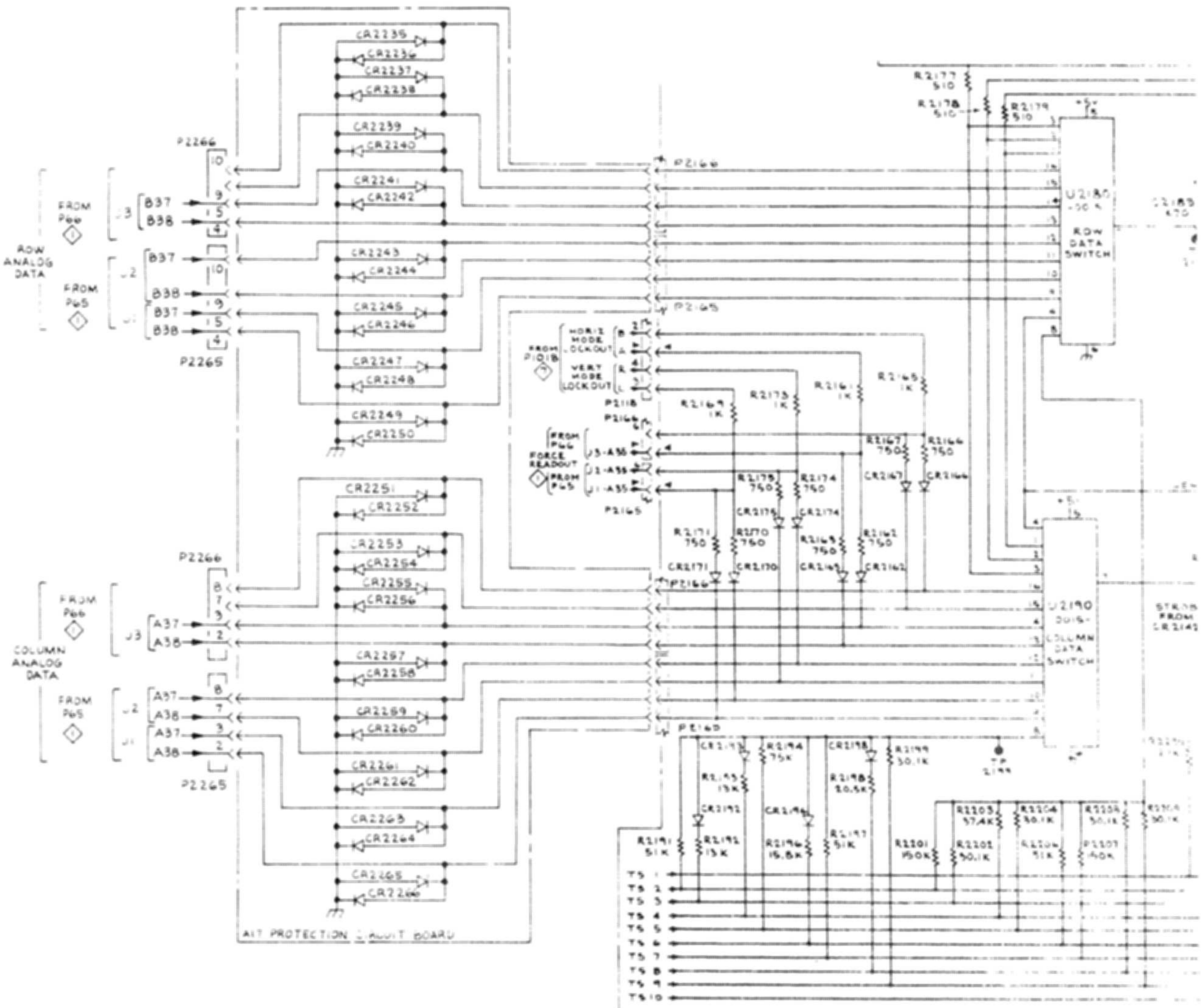
040-0605-03	040-0675-02
040-0654-02	040-0676-02
040-0655-02	040-0748-01
040-0656-02	040-0759-01
040-0674-02	

Readout Protection circuit diodes CR2235 through CR2266 (32 diodes) are all 152-0333-00 silicon diodes.

Note: In those 7000 series instruments that have only three plug-in compartments, the following eight diodes are not used:

CR2235, CR2236, CR2237, CR2238, CR2251, CR2252, CR2253, CR2254

The schematic is for a three plug-in compartment instrument. The eight diodes listed above connect to J4 pins B37, B38, A37 and A38, respectively.



1-28-76