



**PLEASE CHECK FOR CHANGE INFORMATION  
AT THE REAR OF THIS MANUAL.**

# **7704**

## **OSCILLOSCOPE**

### **INSTRUCTION MANUAL**

**Tektronix, Inc.**  
**P.O. Box 500**  
**Beaverton, Oregon 97077**

Serial Number \_\_\_\_\_



## **WARRANTY**

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

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Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

# SYSTEM SPECIFICATIONS

Your 7000-Series oscilloscope system will provide exceptional flexibility in operation with a wide variety of general and special purpose plug-in amplifiers and time bases. The Type number of a particular plug-in identifies it thus: the first digit (7) denotes the oscilloscope system (7000); the second character describes the use of the plug-in—A for amplifier, B for “real time” time base, J or K for spectrum analyzer, L for single-unit spectrum analyzer (a double-width plug-in). M for miscellaneous, S for sampling unit, and T for sampling time base. The third and fourth digits in the plug-in title are sequence numbers. The table following lists specifications that are dependent upon the system as a whole.

7000-SERIES OSCILLOSCOPE SYSTEM SPECIFICATION

Plug-In Unit	7500-Series			7700-Series		Vertical System Deflection Factor Accuracy*			SIG OUT		Horizontal System
	Probe	BW	T <sub>r</sub>	BW	T <sub>r</sub>	EXT CAL 0-50°C	INT CAL 15°-35°C	INT CAL 0-50°C	BW	T <sub>r</sub>	
7A11	Integral	90 MHz	3.9 ns	150 MHz	2.4 ns	2%	3%	4%	60 MHz	5.9 ns	Horizontal System bandwidth with 2 units of the same type operated X-Y with phase correction is 2 MHz for the 7500-Series, 3 MHz for the 7700-Series unless otherwise stated. Without phase correction the 7700-Series horizontal bandwidth upper 10% down point is 3 MHz; that of the 7500-Series is 5 MHz, unless otherwise indicated. X-Y phase shift with correction is 2° at 2 MHz for both Series unless otherwise stated.
7A12	None	75 MHz	4.7 ns	105 MHz	3.4 ns	2%	3%	4%	55 MHz	6.4 ns	
	P6053	75 MHz	4.7 ns	105 MHz	3.4 ns	3%	4%	5%	55 MHz	6.4 ns	
7A13	None	75 MHz	4.7 ns	100 MHz	3.5 ns	1 1/2%	2 1/2%	3 1/2%	55 MHz	6.4 ns	
	P6053	75 MHz	4.7 ns	100 MHz	3.5 ns	1 1/2%	2 1/2%	3 1/2%	55 MHz	6.4 ns	
7A14	P6021	45 MHz	7.8 ns	50 MHz	7.0 ns	2%	3%	4%	40 MHz	8.8 ns	
	P6022	75 MHz	4.7 ns	105 MHz	3.4 ns	2%	3%	4%	50 MHz	7.0 ns	
7A16	None	90 MHz	3.9 ns	150 MHz	2.4 ns	2%	3%	4%	60 MHz	5.9 ns	
	P6053	90 MHz	3.9 ns	150 MHz	2.4 ns	3%	4%	5%	60 MHz	5.9 ns	
7A22	None or	1.0 MHz	350 ns	1 MHz	350 ns	2%	3%	4%	1.0 MHz	350 ns	Both the 7700- and 7500-Series are specified as follows: Bandwidth with phase correction is 800 kHz; without phase correction bandwidth is 1 MHz ±10%; X-Y phase shift with phase correction is 1° at 100 kHz.
	Any	±10%	±9%	±10%	±9%				±10%	±9%	

\*Deflection Factor accuracy is checked as follows:

EXT CAL 0°C to 50°C, plug-in gain is set at a temperature within 10°C of operating temperature, using an external calibrator whose accuracy is within .25%.

INT CAL 15°C to 35°C, plug-in gain is set while operating within a temperature range of +15°C to +35°C, using the oscilloscope calibrator.

INT CAL 0°C to 50°C, plug-in gain is set using the oscilloscope calibrator (within 10°C of the operating temperature) in a temperature range between 0°C and +50°C.

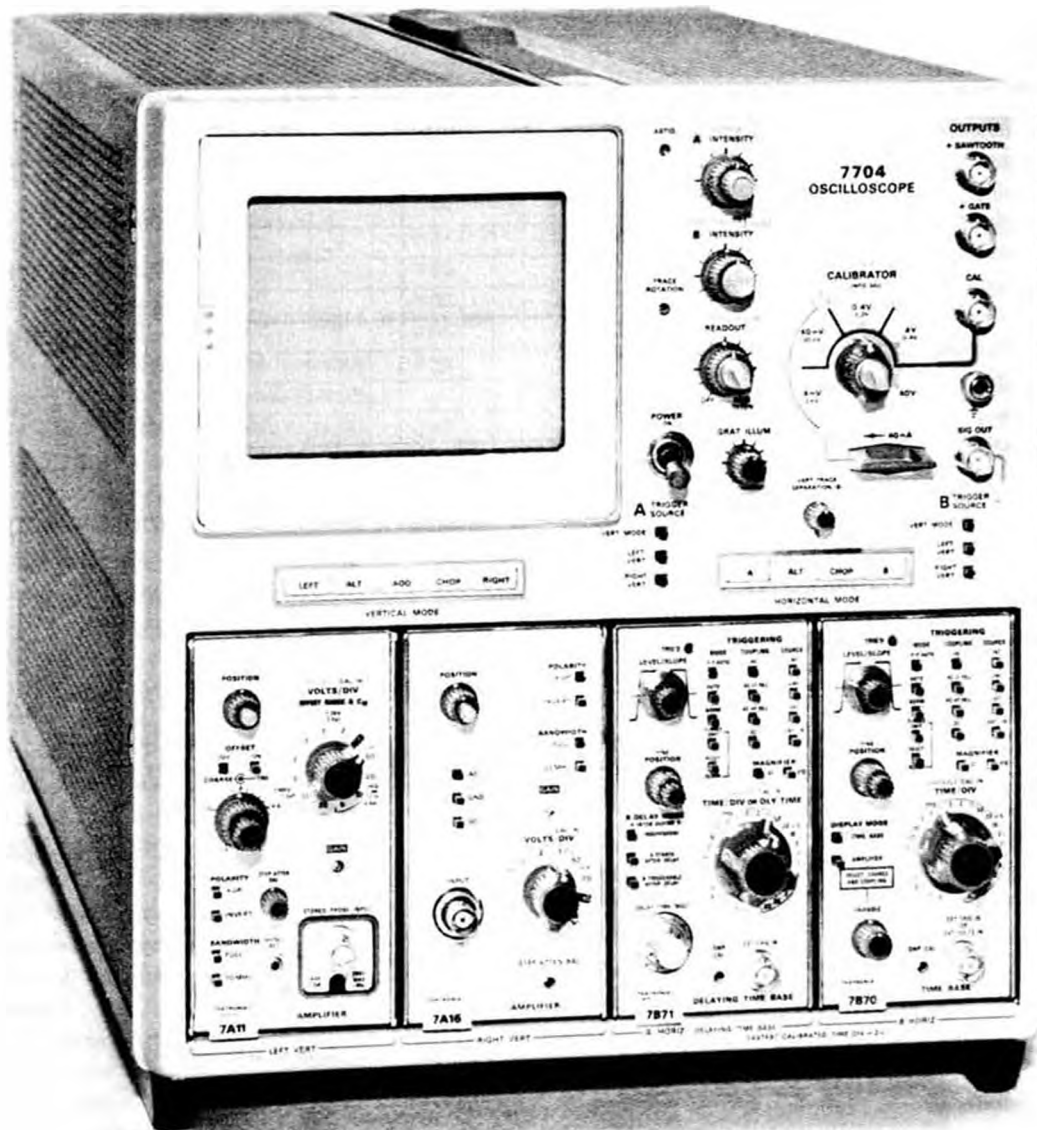


Fig. 1-1. 7704 Oscilloscope.

## PLUG-IN OPTIONS MAJOR CHARACTERISTICS AMPLIFIERS



Fig. 1. 7A11 FET Probe Wide Band Amplifier (All specifications at Probe tip).

### 7A11 FET Probe Wide Band Amplifier (All specifications at Probe tip)

Deflection Factor	5 mV/div to 20 V/div
Input Resistance	1 M $\Omega$ within 1%
Input Capacitance	2 to 6 pF depending on Volts/div setting
DC Offset	Up to 400 V referred to input

Attenuation via integral FET Probe and/or amplifier from X1 through X400 controlled automatically by Volts/div switch to prevent display from overscanning screen.

### 7A12 Dual Trace Wide Band Amplifier

Deflection Factor	5 mV/div to 5 V/div, pushbutton selected
Input Resistance	1 M $\Omega$ within 2%
Input Capacitance	24 pF within 1 pF for all deflection factors
DC Offset	Equivalent to at least 1000 div
Operating Modes	CH 1 Only, CH 2 Only, Chopped, Alternate and Added. Either channel can be inverted for differential measurements.

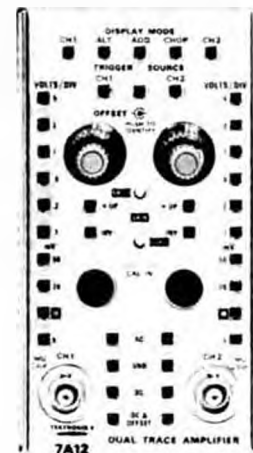


Fig. 2. 7A12 Dual Trace Wide Band Amplifier.

## AMPLIFIERS (Cont)

### 7A13 Differential Comparator & Differential Amplifier

Deflection Factor	1 mV/div to 5 V/div
Calibrated Comparison Voltages	0 to +10 Volts or 0 to -10 Volts
Input Resistance	1 M $\Omega$ within 0.15%
Input Capacitance	20 pF within 0.4 pF



Fig. 3. 7A13 Differential Comparator and Differential Amplifier.

### 7A14 Current Probe Amplifier

Deflection Factor	1 mA/div to 1 A/div
Input Connector	Special BNC connector senses type of probe in use and switches internal compensation circuit so no gain adjustment is needed.



Fig. 4. 7A14 Current Probe Amplifier.

### 7A16 Wide Band Amplifier

Deflection Factor	5 mV/div to 5 V/div
Input Resistance	1 M $\Omega$ within 2%
Input Capacitance	15 pF within 0.5 pF
Bandwidth	(See System Specification) Maintains full bandwidth capabilities of system over complete range of deflection factors



Fig. 5. 7A16 Wide Band Amplifier.

## AMPLIFIERS (Cont)

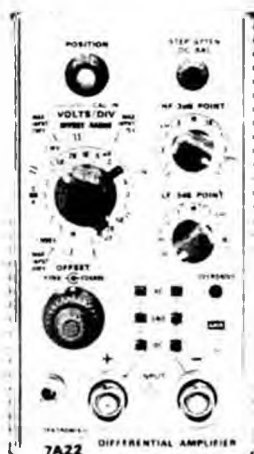


Fig. 6. 7A22 High-Gain Differential Amplifier.

### 7A22 High-Gain Differential Amplifier

Deflection Factor	10 $\mu$ V/div to 10 V/div
Input Resistance	1 M $\Omega$ within 1%
Input Capacitance	47 pF within 2.5 pF
Displayed Noise	16 $\mu$ V at 10 $\mu$ V/div at maximum bandwidth, tangentially measured.

## REAL TIME TIME BASES

### 7B50 Time Base

Sweep Rate	5 s/div to 50 ns/div (5 ns/div with X10 MAGNIFIER) in 25 calibrated steps
Triggering	To 100 MHz or vertical amplifier bandwidth, whichever is less. Sweep free runs providing bright baseline in the absence of adequate triggering signal in P-P AUTO and AUTO triggering modes
Internal Trigger Jitter	1 ns or less at 75 MHz
Display Mode	Time-Base for normal sweep operation. Amplifier for X-Y operation

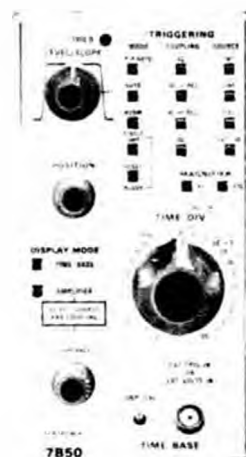


Fig. 7. 7B50 Time Base.

### 7B51 Delaying Time Base

Used singly in 7500-Series oscilloscope as conventional time base, or in combination with Type 7B50 as delaying sweep time base.

Sweep Rate and Triggering	Same as Type 7B50
Delay Time Multiplier Range	0 to 10 times the time/div setting
Accuracy	5 s/div to 1 s/div within 2% 0.5 s/div to 1 $\mu$ s/div within 1%.
Multiplier Incremental Linearity	Within 0.2%
Jitter	1 part or less in 50,000 of 10X the TIME/DIV setting



Fig. 8. 7B51 Delaying Time Base.



## REAL TIME TIME BASES (Cont)

### 7B70 Time Base

Sweep Rate	0.02 $\mu$ s/div to 5 s/div (2 ns/div with X10 MAGNIFIER) in 26 calibrated steps
Triggering	To 200 MHz or vertical amplifier bandwidth, whichever is less. Sweep free runs providing bright base line in the absence of adequate triggering signal in P-P AUTO and AUTO triggering modes.
Display Mode	Time-Base for normal sweep operation. Amplifier for X-Y operation and phase measurements.



Fig. 9. 7B70 Time Base.

### 7B71 Delaying Time Base

Used singly in 7700-Series oscilloscope as conventional time base, or in combination with Type 7B70 as delaying sweep time base.

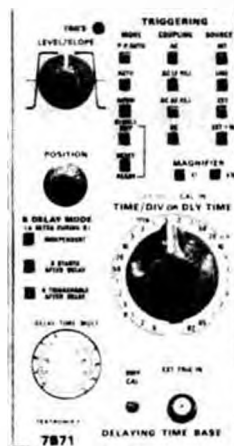


Fig. 10. 7B71 Delaying Time Base.

Sweep Rate and Triggering	Same as Type 7B70
Delay Time Multiplier Range	0 to 10 times TIME/DIV setting
Accuracy	5 s/div to 1 s/div within 2% 0.5 s/div to 1 $\mu$ s/div within 1%
Multiplier Incremental Linearity	within 0.2%
Jitter	1 part or less in 50,000 of 10X TIME/DIV setting.

## SAMPLING UNIT



Fig. 11. 7S11 Sampling Unit.

### 7S11 Sampling Unit

Single channel sampling unit accepting all Tektronix sampling heads. Vertical characteristics set by the sampling head in use.

DC Offset	$\pm 1$ volt
Units/Div	2 to 200
Polarity	Display normal or inverted
Output connectors	Offset & Vertical Signal

Internal Trigger circuits operate with sampling heads containing trigger pickoff circuitry. Will operate with a second 7S11 for dual-trace sampling, both controlled by a 7T11 Sampling Sweep Unit.

## SAMPLING SWEEP

### 7T11 Sampling Sweep Unit

Automatically provides equivalent time or real time sampling process. Random mode or sequential mode available during equivalent time sampling. Operates with one or two 7S11 Sampling Units.

Sweep Rates	Equivalent time, 5 $\mu$ s/Div to 10 ps/Div Real time, 5 ms/Div to 0.1 $\mu$ s/Div
Time Position Ranges	Equivalent time, 50 ns to 50 $\mu$ s Real time, 0.5 ms to 50 ms
Triggering	Internal (except with S-3 plug-in head) or External.
Modes	Frequency Range
Internal	DC to 500 MHz
External, 50 $\Omega$ Input	DC to 500 MHz
External, 1 M $\Omega$ Input	DC to 100 MHz
External, 50 $\Omega$ Input HF sync	500 MHz to 12.4 GHz
Frequency coverage	DC coupled through 12.4 GHz HF Sync
Sensitivity	5 mV to 2 V P-P (50 mV internal)
Dot Density	Variable, 50 to 1000 dots/Div



Fig. 12. 7T11 Sampling Sweep Unit.

## DELAY LINE

### 7M11 50 $\Omega$ Delay Line, Dual Channel

Signal Delay	75 ns, 30 ps or less time difference between channels
Risetime	175 ps or less
Attenuation	2X
Trigger Pickoff	Selectable from either channel

An accessory for sequential sampling systems without internal delay lines, or for random sampling systems operated at low signal repetition rates requiring a pretrigger.



Fig. 13. 7M11 50  $\Omega$  Delay Line, Dual channel.

## SAMPLING HEADS

### Signal Input Heads

#### S-1 Sampling Head

Input Resistance	50 $\Omega$
Risetime	350 ps
Random noise	less than 2 mV

#### S-2 Sampling Head

Input Resistance	50 $\Omega$
Risetime	50 ps
Random noise	Less than 6 mV

#### S-3 Sampling Head (with attached probe)

Input Resistance	100 k $\Omega$
Input Capacitance	2.3 pF
Risetime	350 ps
Random noise	Less than 3 mV

#### S-4 Sampling (3 mm input connector)

Input Resistance	50 $\Omega$
Risetime	25 ps
Random noise	Less than 5 mV

#### S-5 Sampling Head

Input Resistance	1 M $\Omega$
Risetime (with 10X probe)	1 ns
Noise	Less than 500 $\mu$ V

## Special Purpose Heads

#### S-50 Pulse Generator Head (3 mm output connector)

Pulse Risetime	25 ps
Pulse Amplitude	+400 mV
Pulse Duration	100 ns, with pre-trigger out

#### S-51 Trigger Countdown Head (3 mm input connector)

Trigger Countdown	1 to 18 GHz
Input Signal Voltage	100 mV P-P to 5 V P-P

# SECTION 1

## 7704 SPECIFICATION

*Change information, if any, affecting this section will be found at the rear of the manual.*

### Introduction

The Tektronix 7704 Oscilloscope is a solid-state, high-performance instrument designed for general-purpose applications. This instrument accepts Tektronix 7-series plug-in units to form a complete measurement system. The flexibility of this plug-in feature and the variety of plug-in units available allow the system to be used for many measurement applications.

The 7704 has four plug-in compartments. The left pair of plug-ins is connected to the vertical deflection system. The right pair is connected to the horizontal deflection system. Electronic switching between the plug-ins connected to each deflection system allows a dual-trace vertical display and/or a dual-sweep horizontal display. This instrument features regulated DC power supplies to assure that performance is not affected by variations in line voltage and frequency, or by changes in load due to the varying power requirements of the plug-in units. Maximum power consumption of this instrument is about 210 watts (60 hertz, 115-volt line).

The 7704 features a CRT with small spot size and high writing rate. Graticule area is 8 X 10 centimeters. Additionally, the instrument includes a readout system providing CRT display of alpha-numeric information from the plug-ins, including deflection factor, sweep rate and other encoded parameters.

This instrument will meet the electrical characteristics listed in Table 1-1 following complete calibration as given in Section 5. The performance check procedure given in Section 5 provides a convenient method of checking instrument performance without making internal checks or adjustments. The following electrical characteristics apply over a calibration interval of 1000 hours and an ambient temperature range of 0°C to +50°C, except as otherwise indicated. Warmup time for given accuracy is 20 minutes.

**NOTE**

*Many of the measurement capabilities of this instrument are determined by the choice of plug-in units. The following characteristics apply to the 7704 Oscilloscope only. See the system specification later in this section for characteristics of the complete system.*

**TABLE 1-1**  
**ELECTRICAL**

Characteristic	Performance	Characteristic	Performance
<b>VERTICAL DEFLECTION SYSTEM</b>		Isolation Between Vertical Compartments	At least 100:1 from DC to 150 megahertz.
Deflection Factor	Compatible with all 7-series plug-in units.	Chopped Mode	
Deflection Accuracy	Less than 1% difference between vertical compartments.	Repetition rate	One megahertz $\pm$ 20%.
Low-Frequency Linearity	0.1 division or less compression or expansion of a center-screen two-division signal when positioned to the top and bottom of the graticule area.	Time segment from each compartment	0.4 to 0.6 microsecond.
		Delay Line	Permits viewing of leading edge of triggering signal.

Characteristic	Performance
Difference in delay between compartments	0.2 nanosecond or less.
Vertical Display Modes (selected by front-panel VERTICAL MODE switch)	LEFT: Left vertical unit only. ALT: Dual-trace, alternate between vertical units. ADD: Added algebraically. CHOP: Dual-trace, chopped between vertical units. RIGHT: Right vertical unit only.
Trace Separation Range for Dual-Sweep Modes	B trace can be positioned +4 to +6 or -4 to -6 divisions from the A trace.

**TRIGGERING**

Trigger Source (selected by front-panel A TRIGGER SOURCE and B TRIGGER SOURCE switches)	VERT MODE: Determined by vertical mode. LEFT VERT: From left vertical unit only. RIGHT VERT: From right vertical unit only.
---	---

**HORIZONTAL DEFLECTION SYSTEM**

Deflection Factor	Compatible with all 7-series plug-in units.
Deflection Accuracy	Less than 1% difference between compartments.
Fastest Calibrated Sweep Rate	Two nanoseconds/division.
Phase Shift Between Vertical and Horizontal Deflection Systems (with five division peak-to-peak signal)	
Without phase correction	2° or less from DC to at least 35 kilohertz.
With phase correction	Adjustable to less than 2° from DC to two megahertz.

Characteristic	Performance
Chopped Mode	
Repetition rate	200 kilohertz $\pm$ 20%.
Time segment from each compartment	2.0 to 3.0 microseconds.
Horizontal Display Modes (selected by front-panel HORIZONTAL MODE switch)	A: A horizontal unit only. ALT: Dual-sweep, alternate between horizontal units. CHOP: Dual-sweep, chopped between horizontal units. B: B horizontal unit only.

**CALIBRATOR**

Wave Shape	Square wave.
Polarity	Positive going with baseline at zero volts.
Output Voltage (selected by front-panel CALIBRATOR switch)	
Open circuit	4 mV, 40 mV, 0.4 V, 4 V, 40 V.
Into 50 ohms	2 mV, 20 mV, 0.2 V, 0.4 V.
Output Current	40 milliamperes through current loop.
Amplitude Accuracy (Voltage and Current)	
+15°C to +35°C	Within 1%.
0°C to +50°C	Within 2%.
Repetition Rates (selected by front-panel RATE switch)	One kilohertz. One-half repetition rate of B Sweep gate. DC.
One-Kilohertz Accuracy (voltage and current)	
+15°C to +35°C	Within 0.25%.

Characteristic	Performance
0°C to +50°C	Within 0.5%.
Duty Cycle	50% $\pm$ 0.1%.
Risetime and Falltime 4 mV through 4 V and 40 mA	Less than 0.25 microsecond.
40 V	Less than two microseconds with 10 pF load.

## EXTERNAL Z-AXIS INPUTS

High Sensitivity Input Sensitivity	Two volts peak to peak provides trace modulation over full intensity range.
Useful input voltages versus repetition frequency	Two volts peak to peak, DC to two megahertz; reducing to 0.4 volt peak to peak at 20 megahertz
Polarity of operation	Positive-going signal decreases trace intensity; negative-going signal increases trace intensity.
Minimum pulse width that provides intensity modulation	30 nanoseconds at two volts.
Input Resistance at DC	500 ohms $\pm$ 10%.
Maximum input voltage	15 volts (DC + peak AC).
High Speed Input Sensitivity	60 volts peak to peak provides trace modulation over full intensity range.
Useful input voltage versus repetition frequency	60 volts peak to peak, DC to 100 megahertz.
Polarity of operation	Positive-going signal decreases trace intensity; negative-going signal increases trace intensity.

Characteristic	Performance
Minimum pulse width that provides intensity modulation	3.5 nanoseconds at 60 volts.
Input Resistance at DC	18 kilohms $\pm$ 20%.
Maximum input voltage	60 volts (DC + peak AC); 60 volts peak to peak AC.

## SIGNAL OUTPUTS

+Sawtooth Source (selected by internal Sweep switch)	A HORIZ time-base unit or B HORIZ time-base unit.
Polarity	Positive-going with baseline at zero volts $\pm$ 1 volt (into one megohm).
Output voltage Rate of rise Into 50 ohms	50 millivolts/unit of time $\pm$ 15%. <sup>1</sup>
Into one megohm	One volt/unit of time $\pm$ 10%. <sup>1</sup>
Peak voltage Into 50 ohms	Greater than 500 millivolts.
Into one megohm	Greater than 10 volts.
Output resistance	950 ohms $\pm$ 2%.
+Gate Source (selected by internal Gate switch)	A HORIZ time-base unit. B HORIZ time-base unit. Delaying time-base unit (in A HORIZ compartment).
Output voltage Into 50 ohms	0.5 volt $\pm$ 10%.
Into one megohm	10 volts $\pm$ 10%.
Risetime into 50 ohms	20 nanoseconds or less.

<sup>1</sup> Unit of time selected by time-base time/division switch.

Specification—7704

Characteristic	Performance
Output resistance	950 ohms $\pm 2\%$ .
Vertical Signal Output Source	Determined by B TRIGGER SOURCE switch.
Output voltage Into 50 ohms	25 millivolts/division of vertical deflection $\pm 25\%$ .
Into one meg-ohm	0.5 volt/division of vertical deflection $\pm 25\%$ .
Output resistance	950 ohms $\pm 2\%$ .

CHARACTER GENERATOR

Character Height (zeros)	0.25 to 0.4 division.
Word Location	See Fig. 2-7.

POWER SUPPLY

Line Voltage Range AC, RMS (Selected by Line Selector assembly on rear panel).	
115-volts nominal	90 to 136 volts.
230-volts nominal	180 to 272 volts.
Line Frequency	48 to 440 hertz.
Maximum Power Consumption	210 watts, 2.6 amperes at 60 hertz, 115-volt line.

CATHODE-RAY TUBE (CRT)

Graticule Type	Internal variable edge lighting.
Area	Eight divisions vertical by ten divisions horizontal. Each division equals one centimeter.
Phosphor	P31 standard.

Characteristic	Performance
Resolution	
Horizontal	At least 12 lines/division.
Vertical	At least 12 lines/division.
Geometry	0.1 division or less total bowing or tilt of a displayed horizontal or vertical line.
Beam Finder	Limits display within graticule area when actuated.
Photographic Writing Speed (without film fogging techniques)	
Tektronix C-51 Camera with f1.2 lens and 1:0.5 object-to-image ratio	At least 3300 centimeters/micro-second with Polaroid <sup>2</sup> Type 410 film (10,000 ASA) and P31 CRT phosphor.
Tektronix C-27 Camera with f1.3 lens and 1:0.5 object-to-image ratio	At least 2200 centimeters/micro-second with Polaroid Type 410 film (10,000 ASA) and P31 CRT phosphor.

TABLE 1-2  
ENVIRONMENTAL CHARACTERISTICS

Characteristic	Performance
NOTE	
<i>This instrument will meet the electrical characteristics given in Table 1-1 over the following environmental limits. Complete details on environmental test procedures, including failure criteria, etc., can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.</i>	
Temperature Range	
Operating	0°C to +50°C.
Non-operating	-55°C to +75°C.
Altitude	
Operating	15,000 feet.

<sup>2</sup>Registered trademark of the Polaroid Corporation.

Characteristic	Performance
Non-operating	Test limit 50,000 feet.
Electro-magnetic Interface (EMI) as tested in MIL-I-6181D (when equipped with option 3 only)	
Radiated interference	Interference radiated from the instrument under test within the given limits from 150 kilohertz to 1000 megahertz.
Conducted interference	Interference conducted out of the instrument under test through the power cord within the given limits from 150 kilohertz to 25 megahertz.
Transportation (packaged instrument, without plug-ins)	Qualifies under National Safe Transit Committee test procedure 1A, Category II.

**TABLE 1-3**  
**PHYSICAL**

Characteristic	Performance
Ventilation	Safe operating temperature is maintained by convection cooling. Automatic resetting thermal cutout protects instrument from overheating.
Warm-up Time	20 minutes for rated accuracy.
Finish	Anodized front panel. Blue-vinyl painted aluminum cabinet.
Overall Dimensions (measured at maximum points)	
Height	13.5 inches (34.2 centimeters).
Width	12.0 inches (30.5 centimeters).
Length	21.7 inches (35.1 centimeters).
Net Weight (instrument only)	42 pounds (19.1 kilograms).

## STANDARD ACCESSORIES

Standard accessories supplied with the 7704 are given in the Mechanical Parts List illustrations. For optional accessories available for use with this instrument, see the Tektronix, Inc. catalog.

## INSTRUMENT OPTIONS

### General

The following options are available for the 7704 and can be installed as part of the instrument when ordered, or they can be installed at a later time. Complete information on all options for this instrument is given in this manual. For further information on instrument options, see your Tektronix, Inc. catalog, or contact your local Tektronix Field Office or representative.

### Option 1

This option deletes the Readout System. Operation of the instrument is unchanged except that there is no alphanumeric display on the CRT and the READOUT control is non-functional. The Readout System can be added at any time by ordering the readout conversion kit.

### Option 2

The X-Y Delay Compensation Network can be added to the instrument 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 adjustable to less than 2° from DC to two megahertz.

### Option 3

With option 3 installed, the instrument will meet the EMI interference specifications given in Table 1-2.



# SECTION 2

## OPERATING INSTRUCTIONS

*Change information, if any, affecting this section will be found at the rear of the manual.*

### General

To effectively use the 7704, the operation and capabilities of the instrument must be known. This section describes the operation of the front- and rear-panel controls and connectors and gives first time and general operating information.

### PRELIMINARY INFORMATION

#### Operating Voltage

The 7704 can be operated from either a 115-volt or a 230-volt nominal line voltage source. The Line Selector assembly on the rear panel converts this instrument from one operating voltage to the other. This assembly also includes fuses to provide protection for the line-input portion of this instrument. Use the following procedure to obtain correct instrument operation from the line voltage available.

#### CAUTION

*This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single-phase, three-wire system.*

1. Disconnect the instrument from the power source.
2. Loosen the two captive screws which hold the cover onto the selector assembly; then pull to remove the cover.
3. To convert from 115-volts to 230-volts nominal line voltage, or vice versa, pull out the Selector switch bar (see Fig. 2-1) and plug it back into the remaining holes. Change the line-cord power plug to match the power-source receptacle or use a 115- to 230-volt adapter.

#### NOTE

*Color-coding of the cord conductors is as follows (in accordance with National Electrical Code):*

Line	Black
Neutral	White
Safety earth (ground)	Green

4. Re-install the cover and tighten the captive screws.

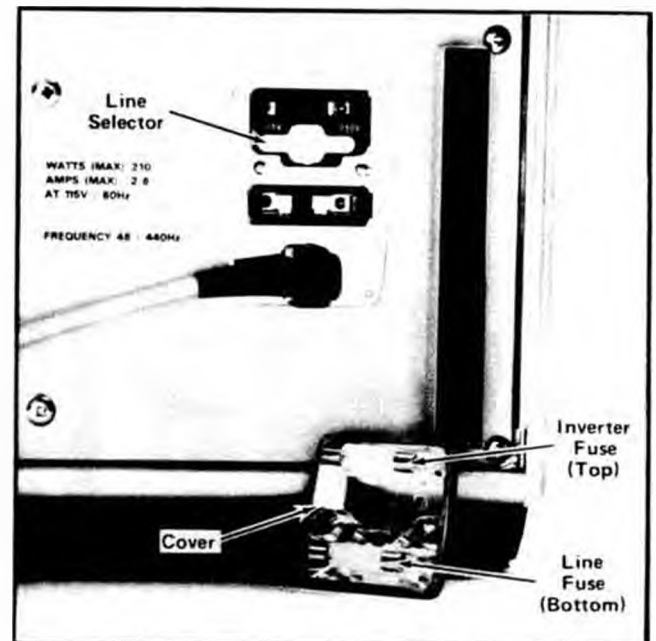
5. Before applying power to the instrument, check that the indicator tab on the switch bar is protruding through the correct hole for the desired nominal line voltage.

#### CAUTION

*This instrument may be damaged if operated with the Line Selector assembly set to incorrect positions for the line voltage applied.*

**TABLE 2-1**  
Regulating Ranges

Line Selector Switch Position	Regulating Range
115 V	90 to 136 volts
230 V	180 to 272 volts



**Fig. 2-1.** Line Selector assembly on rear panel (shown with cover removed).

## Operating Instructions—7704

The 7704 is designed to be used with a three-wire AC power system. If the three- to two-wire adapter is used to connect this instrument to a two-wire AC power system, be sure to connect the ground lead of the adapter to earth (ground). Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

The feet on the rear panel provide a convenient cord wrap to store the power cord when not in use (see Fig. 2-2).

### Operating Temperature

The 7704 can be operated where the ambient air temperature is between 0°C and +50°C. This instrument can be stored in ambient temperatures between -55°C and +75°C. After storage at temperatures beyond the operating limits, allow the chassis temperature to come within the operating limits before power is applied.

The 7704 is cooled by convection air flow through the instrument. Adequate clearance must be provided on all sides to allow heat to be dissipated from the instrument. Do not block or restrict the air flow through the holes in the cabinet. Maintain the clearance provided by the feet on the bottom and rear and allow about two inches clearance on the top, sides and rear (more if possible).

A thermal cutout in this instrument provides thermal protection and disconnects the power to the instrument if the internal temperature exceeds a safe operating level. Power is automatically restored when the temperature

returns to a safe level. Operation of this instrument in confined areas or in close proximity to heat-producing instruments may cause the thermal cutout to open more frequently.

### Operating Position

A bail-type stand is mounted on the bottom of this instrument. This stand permits the 7704 to be tilted up about 10° for more convenient viewing (see Fig. 2-3). In addition, the instrument may be operated on the rear feet if desired (maximum ambient air temperature limited to +40°C).

## PLUG-IN UNITS

### General

The 7704 is designed to accept up to four Tektronix 7-series plug-in units. This plug-in feature allows a variety of display combinations and also allows selection of bandwidth, sensitivity, display mode, etc. to meet the measurement requirements. In addition, it allows the oscilloscope system to be expanded to meet future measurement requirements. The overall capabilities of the resultant system is in large part determined by the characteristics of the plug-in selected. A list of the currently available plug-ins for this instrument along with their major specifications, is given in Section 1. For more complete information, see the current Tektronix, Inc. catalog.

### Installation

To install a plug-in unit into one of the plug-in compartments, align the slots in the top and bottom of the plug-in

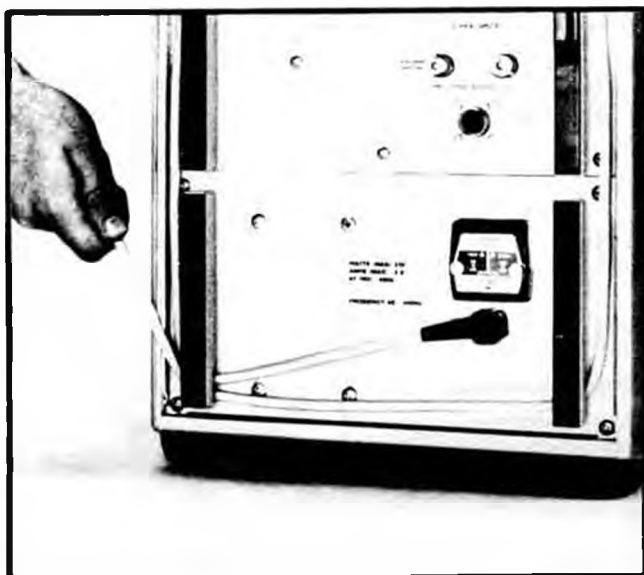


Fig. 2-2. Cord wrap provided on rear panel to store power cord.

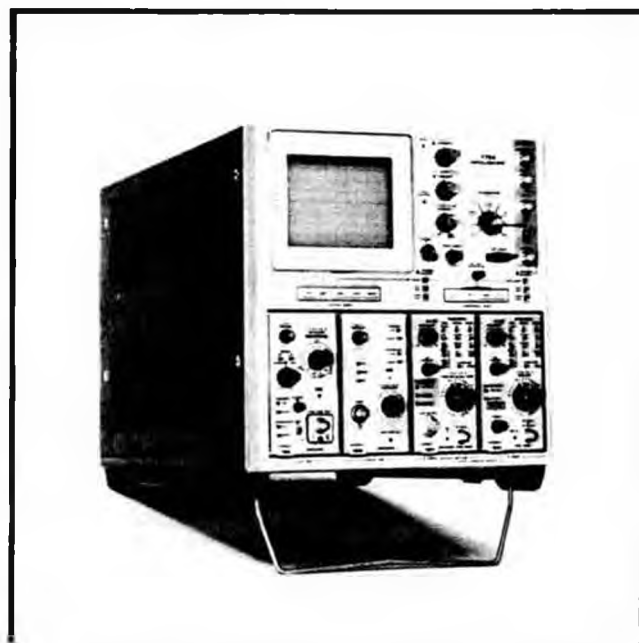


Fig. 2-3. Instrument positioned on bail-type stand.

with the associated guide rails in the plug-in compartment. Push the plug-in unit firmly into the plug-in compartment until it locks into place. To remove a plug-in, pull the release latch on the plug-in unit to disengage it and pull the unit out of the plug-in compartment. Plug-in units can be removed or installed without turning off the instrument power.

It is not necessary that all of the plug-in compartments be filled to operate the instrument; the only plug-ins needed are those required for the measurement to be made. However, at environmental extremes excess interference may be radiated into this instrument through the open plug-in compartments. Blank plug-in panels are available from Tektronix, Inc. to cover the unused compartments; order Tektronix Part No. 016-0155-00.

When the 7704 is calibrated in accordance with the calibration procedure given in this instruction manual, the vertical and horizontal gain are normalized. This allows calibrated plug-in units to be changed from one plug-in compartment to another without recalibration. However, the basic calibration of the individual plug-in units should be checked when they are installed in this system to verify their measurement accuracy. See the operating instructions section of the plug-in unit instruction manual for verification procedure.

The plug-in versatility of the 7704 allows a variety of display modes with many different plug-ins. Specific information for obtaining these displays is given under Display Combinations later in this section. However, the following information is provided here to aid in plug-in installation.

To produce a single-trace display, install a single-channel vertical unit (or dual-channel unit set for single-channel operation) in either of the vertical compartments. For dual-trace displays, either install a dual-channel vertical unit in one of the vertical compartments or install a single-channel vertical unit in each vertical compartment. A combination of a single-channel and dual-channel vertical unit allows a three-trace display; likewise, a combination of two dual-channel vertical units allows a four-trace display.

For single time-base displays, the time-base unit can be placed in either horizontal compartment. However, for dual time-base displays, other considerations must be taken into account. In the ALT position of the VERTICAL MODE switch and ALT or CHOP position of the HORIZONTAL MODE switch, the plug-ins in the LEFT VERT and B HORIZ compartments are displayed together and the RIGHT VERT and A HORIZ plug-ins are displayed together. Therefore, the vertical and horizontal plug-ins must be correctly mated if a special display is desired. If delayed sweep operation is desired, a delaying time-base unit must be installed in the A HORIZ (DELAYING TIME

BASE) compartment. Any compatible 7B-series plug-in can be used as a delayed time-base in the B HORIZ compartment.

X-Y displays can be obtained in two ways with the 7704 system. If a 7B-series time-base plug-in is available which has an amplifier feature, the X signal can be routed through one of the vertical units via the internal-trigger pickoff circuitry to the horizontal system. Then, the vertical signal (Y) is connected to the remaining vertical unit. Also, a 7A-series amplifier plug-in can be installed in one of the horizontal compartments for X-Y operation.

Special purpose plug-ins may have specific restrictions regarding the plug-in compartments in which they can be installed. This information will be given in the instruction manuals for these plug-ins.

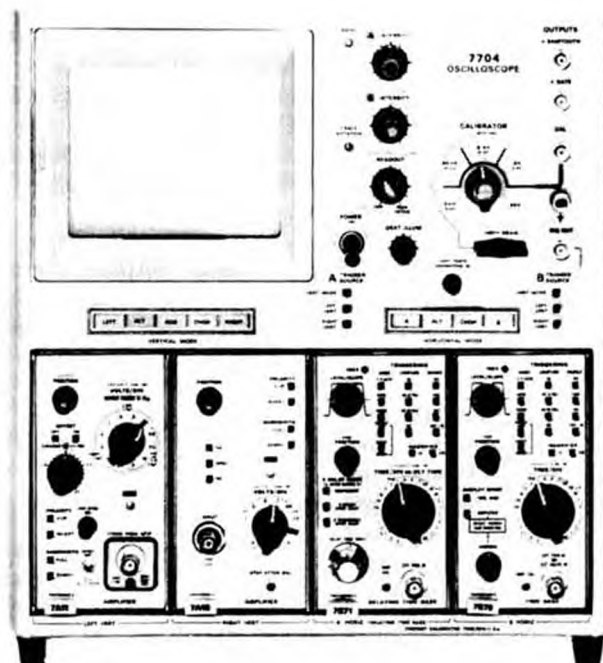
## CONTROLS AND CONNECTORS

### General

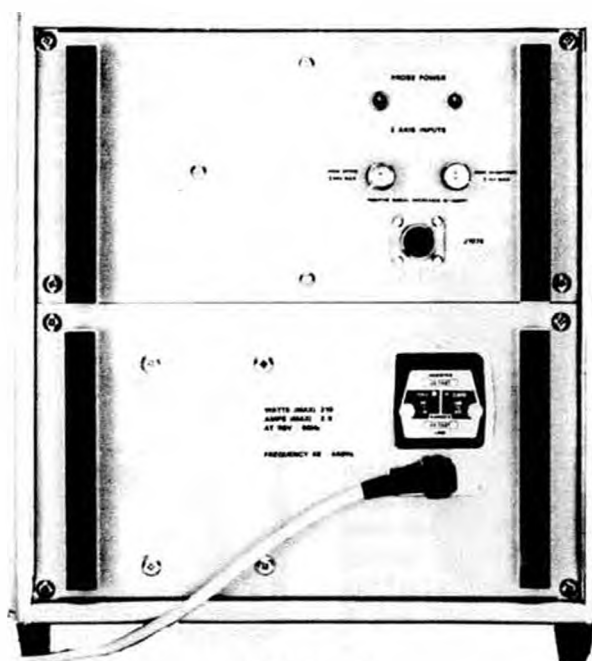
The major controls and connectors for operation of the 7704 are located on the front panel of the instrument. Several auxiliary functions are provided on the rear panel. Fig. 2-4 shows the front and rear panels of the 7704. To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each of these controls and connectors. A brief description of each control and connector is given here. More detailed operating information is given under General Operating Information.

### Cathode-Ray Tube (CRT)

ASTIG	Screwdriver adjustment used in conjunction with the FOCUS control to obtain a well-defined display. Does not require readjustment in normal use.
A INTENSITY	Controls brightness of the trace produced by the plug-in unit in the A HORIZ (DELAYING TIME BASE) compartment. Light behind the 'A' of A INTENSITY indicates when this control is operative. Control is inoperative (light off) when the A plug-in is not selected for display by the HORIZONTAL MODE switch or when the A HORIZ compartment is vacant.
FOCUS	Provides adjustment for optimum display definition.



A. Front panel



B. Rear panel

Fig. 2-4. Front- and rear-panel controls and connectors.

<b>B INTENSITY</b>	Controls brightness of the trace produced by the plug-in unit in the B HORIZ compartment. Light behind the 'B' of B INTENSITY indicates when the control is operative. Control is inoperative (light off) when the B plug-in is not selected for display by the HORIZONTAL MODE switch or when the B HORIZ compartment is vacant.	<b>CHOP:</b> Signals from plug-in units in both LEFT VERT and RIGHT VERT compartments are displayed. Display switched between vertical plug-ins at a one-megahertz repetition rate.
<b>BEAM FINDER (PULL LOCK)</b>	Compresses display within graticule area independent of display position or applied signals. Momentary actuation provided when button is pressed; display remains compressed when knob is pulled outward to lock it in the "find" position.	<b>ADD:</b> Signals from plug-in units in both LEFT VERT and RIGHT VERT compartments are algebraically added and the algebraic sum displayed on the CRT.
<b>READOUT</b>	Controls brightness of the readout portion of the CRT display. In the fully counterclockwise position, the Readout System is inoperative.	<b>ALT:</b> Signals from plug-in units in both LEFT VERT and RIGHT VERT compartments are displayed. Display switched between vertical plug-ins after each sweep except for delayed sweep operation. Then, the display is switched between vertical plug-ins after every second sweep. When the HORIZONTAL MODE switch is set to ALT or CHOP, sweep-slaving is provided.
<b>CONTROL ILLUM</b>	Controls illumination level of pushbutton switches on 7704 and the associated plug-ins.	<b>RIGHT:</b> Signal from plug-in unit in RIGHT VERT compartment is displayed.
	<b>OFF:</b> All pushbutton lights off. A and B INTENSITY lights remain at low intensity to provide a power-on indication.	<b>A TRIGGER SOURCE</b>
	<b>LOW:</b> All pushbuttons illuminated at low intensity.	Selects source of internal trigger signal for the time-base in the A HORIZ compartment.
	<b>HIGH:</b> Pushbuttons illuminated at maximum intensity.	<b>VERT MODE:</b> Trigger signal automatically follows the vertical display except in CHOP (vertical); then the trigger signal is the same as for ADD.
<b>TRACE ROTATION</b>	Screwdriver adjustment to align trace with horizontal graticule lines.	<b>LEFT VERT:</b> Trigger signal is obtained from plug-in unit in LEFT VERT compartment.
<b>GRAT ILLUM</b>	Controls graticule illumination.	<b>RIGHT VERT:</b> Trigger signal is obtained from plug-in unit in RIGHT VERT compartment.
<b>Mode Selectors</b>		<b>HORIZONTAL MODE</b>
<b>VERTICAL MODE</b>	Selects vertical mode of operation.	Selects horizontal mode of operation.
		<b>A:</b> Signal from plug-in unit in the A HORIZ compartment is displayed.
		<b>LEFT:</b> Signal from plug-in unit in LEFT VERT compartment is displayed.

	<p>ALT: Signals from plug-in units in both A HORIZ and B HORIZ compartments are displayed. Display switched between horizontal plug-ins at end of each sweep.</p> <p>CHOP: Signals from plug-in units in both A HORIZ and B HORIZ compartments are displayed. Display switched between horizontal plug-ins at a 0.2-megahertz repetition rate.</p> <p>B: Signal from plug-in unit in the B HORIZ compartment is displayed.</p>	<p>RATE</p> <p>Selects the mode and repetition rate of the output from the Calibrator.</p> <p>DC (current only): 40 milliampere DC current through current loop. No voltage at CAL connector.</p> <p>1 kHz: Calibrator operates at one-kilohertz rate. 40-milliampere square-wave current through current loop and square-wave voltage (amplitude determined by CALIBRATOR switch) at CAL connector.</p>
<p>B TRIGGER SOURCE</p>	<p>Selects source of internal trigger signal for the time-base in the B HORIZ compartment.</p> <p>VERT MODE: Trigger signal automatically follows the vertical display except in CHOP (vertical); then trigger signal is the same as for ADD.</p> <p>LEFT VERT: Trigger signal is obtained from plug-in unit in LEFT VERT compartment.</p> <p>RIGHT VERT: Trigger signal is obtained from plug-in unit in the RIGHT VERT compartment.</p>	<p>B GATE ÷ 2: Calibrator operates at one-half the repetition rate of the gate signal from the time-base unit in the B HORIZ compartment. 40-milliampere square-wave current through current loop and square-wave voltage (amplitude determined by CALIBRATOR switch) at CAL connector.</p> <p>DC (volts only): DC voltage available at CAL connector (amplitude determined by CALIBRATOR switch). No current through 40 mA current loop.</p>
<p>VERT TRACE SEPARATION (B)</p>	<p>Vertically positions the trace produced by the plug-in unit in the B HORIZ compartment up to four divisions with respect to the trace produced by the plug-in unit in the A HORIZ compartment.</p>	
<p>Calibrator</p>		<p>Outputs</p>
<p>CALIBRATOR</p>	<p>Selects amplitude of output at CAL connector. Outputs available from four millivolts to 40 volts into high-impedance load, in decade steps; or from two millivolts to 0.4 volts into 50-ohm load (output into 50 ohms shown in brackets on panel).</p>	<p>+ SAWTOOTH</p> <p>Positive-going sample of sawtooth signal. Internal switch allows selection of sawtooth from time-base in the A HORIZ compartment or the B HORIZ compartment.</p> <p>+ GATE</p> <p>Positive-going gate signal coincident with the respective sweep. Internal switch allows selection of one of three gate signals; A gate from time-base in A HORIZ compartment, B gate from time-base in B HORIZ compartment, or delayed gate from delaying time-base in A HORIZ compartment.</p> <p>CAL</p> <p>Provides positive-going calibrator output when voltage operation is selected (see calibrator RATE).</p>

40 mA Current Loop	Probe loop providing calibrator current output when current operation is selected (see calibrator RATE).
Ground (not labeled)	Binding post to establish common ground between the 7704 and any associated equipment.
SIG OUT	Provides output signal from the vertical plug-ins. Source of the output signal at the SIG OUT connector is selected by the B TRIGGER SOURCE switch (see B TRIGGER SOURCE for description of sources available).
<b>Rear Panel</b>	
Line Selector (not labeled)	Switching assembly to select the nominal operating voltage (115 or 230 volts). The assembly also includes the line input fuses.
PROBE POWER	Power source for active probe systems.
Z-AXIS INPUTS	Input connectors for intensity modulation of the CRT display.
	<b>HIGH SPEED:</b> Input connector for high-amplitude Z-axis signals; usable from DC to 100 MHz.
	<b>HIGH SENSITIVITY:</b> Input connector for low-amplitude Z-axis signals; usable for signals with repetition rates of DC to 10 megahertz; input voltage derating necessary between 2 and 10 megahertz.
J1075	Nine-pin connector which provides remote single-sweep reset and ready indication for the time-base units in the A HORIZ and B HORIZ compartments (with compatible time-base units only).
Cord Wrap (not labeled)	Feet on rear panel provide a cord wrap to store the power cord when not in use.

## FIRST-TIME OPERATION

### General

The following steps demonstrate the use of the controls and connectors of the 7704. It is recommended that this procedure be followed completely for familiarization with this instrument.

### Set-up Information

1. Set the front-panel controls as follows:

A INTENSITY	Counterclockwise
FOCUS	Midrange
B INTENSITY	Counterclockwise
BEAM FINDER	Released
READOUT	OFF
CONTROL ILLUM	OFF
GRAT ILLUM	Counterclockwise
POWER	Off
CALIBRATOR	4 V
RATE	1 kHz
VERTICAL MODE	LEFT
A TRIGGER SOURCE	VERT MODE
HORIZONTAL MODE	A
VERT TRACE	Midrange
SEPARATION (B)	
B TRIGGER SOURCE	VERT MODE

2. Connect the 7704 to a power source that meets the voltage and frequency requirements of this instrument. If the available line voltage is outside the limits of the Line Selector switch (on rear panel), see Operating Voltage in this section.

3. Insert Tektronix 7A-series amplifier units into both the LEFT VERT and RIGHT VERT compartments. Insert Tektronix 7B-series time-base units into both the A HORIZ and B HORIZ compartments.

4. Set the POWER switch to ON. Allow several minutes warmup so the instrument reaches a normal operating temperature before proceeding.

5. Set both vertical units for a vertical deflection factor of two volts/division and center the vertical position controls.

6. Set both time-base units for a sweep rate of 0.5 milliseconds/division in the auto, internal trigger mode.

7. Advance the A INTENSITY control until the trace is at the desired viewing level (near midrange).

8. Connect the CAL connector to the input of the left vertical unit with a BNC-to-BNC patch cord (supplied accessory).

9. Adjust the FOCUS control for a sharp, well-defined display over the entire trace length. (If focused display cannot be obtained, see Astigmatism Adjustment in this section.)

10. Disconnect the input signal and position the trace with the left vertical unit position control so it coincides with the center horizontal line of the graticule.

11. If the trace is not parallel with the center horizontal line, see Trace Alignment Adjustment in this section.

12. Rotate the GRAT ILLUM control throughout its range and notice that the graticule lines are illuminated as the control is turned clockwise (most obvious with tinted filter installed). Set control so graticule lines are illuminated as desired.

### Calibration Check

13. Connect the CAL connector to the input connectors of both vertical units with the BNC-to-BNC jumper leads.

14. The display should be two divisions in amplitude with five complete cycles shown horizontally. An incorrect display indicates that the plug-ins need to be recalibrated. See the instruction manual of the applicable unit for complete information.

### Vertical and Horizontal Mode

15. Notice that the position controls of only the left vertical unit and the A time-base unit have any effect on the displayed trace. Position the start of the trace to the left line of the graticule with the A time-base unit position control and move the trace to the upper half of the graticule with the left vertical unit position control.

16. Press the RIGHT button of the VERTICAL MODE switch. Also press the B button of the HORIZONTAL MODE switch. Advance the B INTENSITY control until the trace is at the desired viewing level (about midrange).

17. Notice that the position controls of only the right vertical unit and the B time-base unit have any effect on the displayed trace. Position the start of the trace to the left graticule line with the B time-base position control and move the display to the bottom half of the graticule with the right vertical unit position control.

18. Press the ALT button of the VERTICAL MODE switch. Notice that two traces are displayed on the CRT. The top trace is produced by the left vertical unit and the bottom trace is produced by the right vertical unit; the sweep for both traces is produced by the B time-base unit. Reduce the sweep rate of the B time-base unit to 50 milliseconds/division. Notice that the display alternates between the left and right vertical plug-ins after each sweep. Turn the B time-base sweep rate switch throughout its range. Notice that the display alternates between vertical units at all sweep rates.

19. Press the CHOP button of the VERTICAL MODE switch. Turn the B time-base unit sweep rate switch throughout its range. Notice that a dual trace display is presented at all sweep rates, but unlike ALT, both vertical units are displayed on each sweep on a time-sharing basis. Return the B time-base unit sweep rate switch to 0.5 millisecond/division.

20. Press the ADD button of the VERTICAL MODE switch. The display should be four divisions in amplitude. Notice that the position control of either vertical unit moves the display. Return the VERTICAL MODE switch to the LEFT position.

21. Press the ALT button of the HORIZONTAL MODE switch. Two displays should be presented on the CRT. If the displays overlap, adjust the VERT TRACE SEPARATION (B) control to position one trace to the bottom of the graticule area. Turn the sweep rate switches of both time-base units throughout their range. Notice that each time-base unit controls one of the displays independently of the other time-base unit. Also notice that when one of the time-base units is set to a slow sweep rate (below about 50 milliseconds/division) sweep alternation is evident. Only one of the traces is presented on the CRT at a time. Return the sweep rates of both time-base units to 0.5 millisecond/division. Adjust the A INTENSITY control. Notice that it changes the intensity of the trace produced by the A time-base unit only. Likewise, the B INTENSITY control changes the intensity of the trace produced by the B time-base unit only. Return both intensity controls to the desired level.

22. Press the CHOP button of the HORIZONTAL MODE switch. Notice that two traces are shown on the



CRT in a manner similar to the ALT display. Turn the sweep rate switches of both time-base units throughout their range. Notice that two traces are displayed on the CRT at all sweep rates. Also notice that when both time base units are set to a slow sweep rate (50 milliseconds/division or slower), both traces are visible on the CRT at the same time. Return the sweep rate switches of both time base units to 0.5 millisecond/division.

23. Set the CALIBRATOR switch to 0.4 V. Press the CHOP button of the VERTICAL MODE switch. Four traces should be displayed on the CRT. If not, adjust the vertical unit position controls and the VERT TRACE SEPARATION (B) control to position the four traces onto the viewing area. Adjust the position controls of the plug-in units to identify which traces are produced from each of the plug-in units (use identify feature of vertical unit, if available). Also, set one of the time-base units to a sweep rate of 1 millisecond/division. Notice that the vertical deflection produced by the LEFT VERT unit is displayed at the sweep rate of both the A HORIZ and B HORIZ time-base units and that the vertical deflection produced by the RIGHT VERT plug-in unit is also displayed at the sweep rate of both the A HORIZ and B HORIZ time-base units.

24. Press the ALT button of the HORIZONTAL MODE switch. Notice that the display is very similar to the display obtained in the previous step. The main difference in this display is that the sweeps are produced alternately by the time-base units (noticeable only at slow sweep rates).

25. Press the ALT button of the VERTICAL MODE switch. Set the CALIBRATOR switch to 4 V. Notice that only two traces are displayed on the CRT. Also notice that one of the traces is produced by the left vertical unit at the sweep rate of the B time-base unit and the other trace is produced by the right vertical unit at the sweep rate of the A time-base unit. This feature is called sweep-slaving, and is obtained only when the VERTICAL MODE switch is in the ALT position and the HORIZONTAL MODE switch is in either the ALT or the CHOP position.

## Triggering

26. Press the LEFT button of the VERTICAL MODE switch and the A button of the HORIZONTAL MODE switch. Center the display on the CRT with the left vertical unit position control. Disconnect the input signal from the right vertical unit input connector. Sequentially press all of the VERTICAL MODE switch buttons. Notice that a stable display is obtained in all positions of the VERTICAL MODE switch (straight line in RIGHT position).

27. Press the LEFT VERT button of the A TRIGGER SOURCE switch. Again, sequentially press all of the VER-

TICAL MODE buttons. Notice that the display is again stable in all positions, as in the previous step.

28. Press the RIGHT VERT button of the A TRIGGER SOURCE switch. Sequentially press all the VERTICAL MODE switch buttons and notice that a stable display cannot be obtained in any position. This is because there is no input signal connected to the right vertical unit.

29. The B TRIGGER SOURCE switch operates in a similar manner to the A TRIGGER SOURCE switch when the B time-base unit is selected for display.

## Control Illumination

30. Notice that only the light associated with the A INTENSITY control is illuminated. Sequentially press all the HORIZONTAL MODE switch buttons and notice the A or B INTENSITY lights; these intensity lights indicate which intensity control is active. These lights also provide an indication that the POWER switch is on. Set the CONTROL ILLUM switch to the LOW position. Notice that the selected pushbuttons of the 7704 and the plug-in units are illuminated.

31. Change the CONTROL ILLUM switch to the HIGH position. Notice that the selected pushbuttons of the 7704 and the plug-in units are illuminated at maximum intensity.

## Readout

32. Turn the READOUT control clockwise until a digital display is visible within the top or bottom division of the CRT. Change the deflection factor of the vertical unit that is selected for display. Notice that the readout display changes as the deflection factor is changed. Likewise, change the sweep rate of the time-base unit which is selected for display. Notice that the readout display for the time-base unit changes also as the sweep rate is changed.

33. Set the time-base unit for magnified operation. Notice that the readout display changes to indicate the correct magnified sweep rate. If a readout-coded X10 probe is available for use with the vertical unit, install it on the input connector of the vertical plug-in. Notice that the deflection factor indicated by the readout is increased by 10 times when the probe is added. Return the time-base unit to normal sweep operation and disconnect the probe.

34. Sequentially press all of the VERTICAL MODE switch buttons and the HORIZONTAL MODE buttons. Notice that the readout from a particular plug-in occupies a specific location on the display area. If any of the plug-in units is a dual-trace unit, notice that the readout for channel 2 appears within the lower division of the CRT.

## Beam Finder

35. Set the vertical deflection factor of the vertical plug-in which is displayed to 0.1 volt/division. Notice that a square wave display is not visible since the deflection exceeds the scan area of the CRT.

36. Press the BEAM FINDER button. Notice that the display is returned to the viewing area in compressed form. Release the BEAM FINDER switch and notice that the display again disappears from the viewing area. Pull the BEAM FINDER outward so it locks in the "find" position. Notice that the display is again returned to the viewing area in compressed form, but that in this position it remains on the viewing area as long as the BEAM FINDER switch is locked in the outward position.

37. With the BEAM FINDER switch locked in the outward position, increase the vertical and horizontal deflection factor until the display is reduced to about two divisions vertically and horizontally (when the time-base unit is in the time-base mode, change only the deflection factor of the vertical unit). Adjust the position controls of the displayed vertical unit and the time-base unit to center the compressed display about the center lines of the graticule. Press the BEAM FINDER switch in and release. Notice that the display remains within the viewing area.

## Calibrator

38. Set the RATE switch to the B GATE  $\div 2$  position. Press the A button of the HORIZONTAL MODE switch and set the B time-base unit for free-running operation. Change the sweep rate of the time-base unit in the B HORIZ compartment and notice that the repetition rate of the displayed signal changes as the sweep rate is changed. The repetition rate of the displayed signal is one-half the repetition rate of the gate signal produced by the B time-base unit (approximately 10 times the setting of the B sweep rate switch). Also notice that the amplitude of the square wave is adjustable with the CALIBRATOR switch.

39. Set the RATE switch to DC (volts only). Establish a ground reference level on the CRT (such as center horizontal line of graticule). Set the vertical unit for DC input coupling. Notice that the display is a straight line deflected from the ground reference line by the amount selected by the CALIBRATOR switch.

40. If a current-probe amplifier plug-in is available, the current function of the Calibrator can be demonstrated. Install the current-probe amplifier plug-in unit in the 7704 and press the VERTICAL MODE button which will display this unit. Set the RATE switch to the 1 kHz position. Connect the current probe to the 40 mA current loop (observe current direction shown by arrow). Set the deflection

factor of the current-probe amplifier to display several divisions of the calibrator waveform. Change the setting of the CALIBRATOR switch and notice that this has no effect on the current-amplifier display. Set the RATE switch to the B GATE  $\div 2$  position. Notice that the display is the same amplitude as obtained previously, but that the repetition rate is variable with the B HORIZ sweep rate switch. Change the RATE switch to the DC (volts only) position. Notice that there is no current through the current loop as shown by no deflection on the CRT. The DC (current only) function can be demonstrated only with a current-probe that is sensitive to DC current.

## Z-Axis Input

41. If an external signal is available (five volts peak-to-peak minimum), the function of the Z-AXIS INPUTS can be demonstrated. Remove the BNC caps from both Z-AXIS INPUTS (on rear panel). Connect the external signal to both the input connector of the displayed vertical unit and the HIGH SENSITIVITY connector. Set the sweep rate of the displayed time base to display about five cycles of the waveform. Adjust the amplitude of the signal generator until intensity modulation is visible on the display (change the vertical deflection factor as necessary to produce an on-screen display). The positive peaks of the waveform should be blanked out and the negative peaks intensified. Notice that the setting of the intensity controls determines the amount of intensity modulation that is visible.

42. Disconnect the external signal from the HIGH SENSITIVITY connector and reconnect it to the HIGH SPEED connector. Again increase the amplitude of the signal generator until trace modulation is apparent on the displayed waveform. Notice that a higher amplitude signal is necessary to produce trace modulation. Again, the positive peaks of the waveform should be blanked out and the negative peaks intensified. Also, notice that the setting of the intensity controls affects the amount of trace modulation. The major difference between these two methods of obtaining trace modulation is that the HIGH SENSITIVITY input is more sensitive, but that the HIGH SPEED input has a higher usable frequency range. Replace the BNC caps on both Z-AXIS INPUTS.

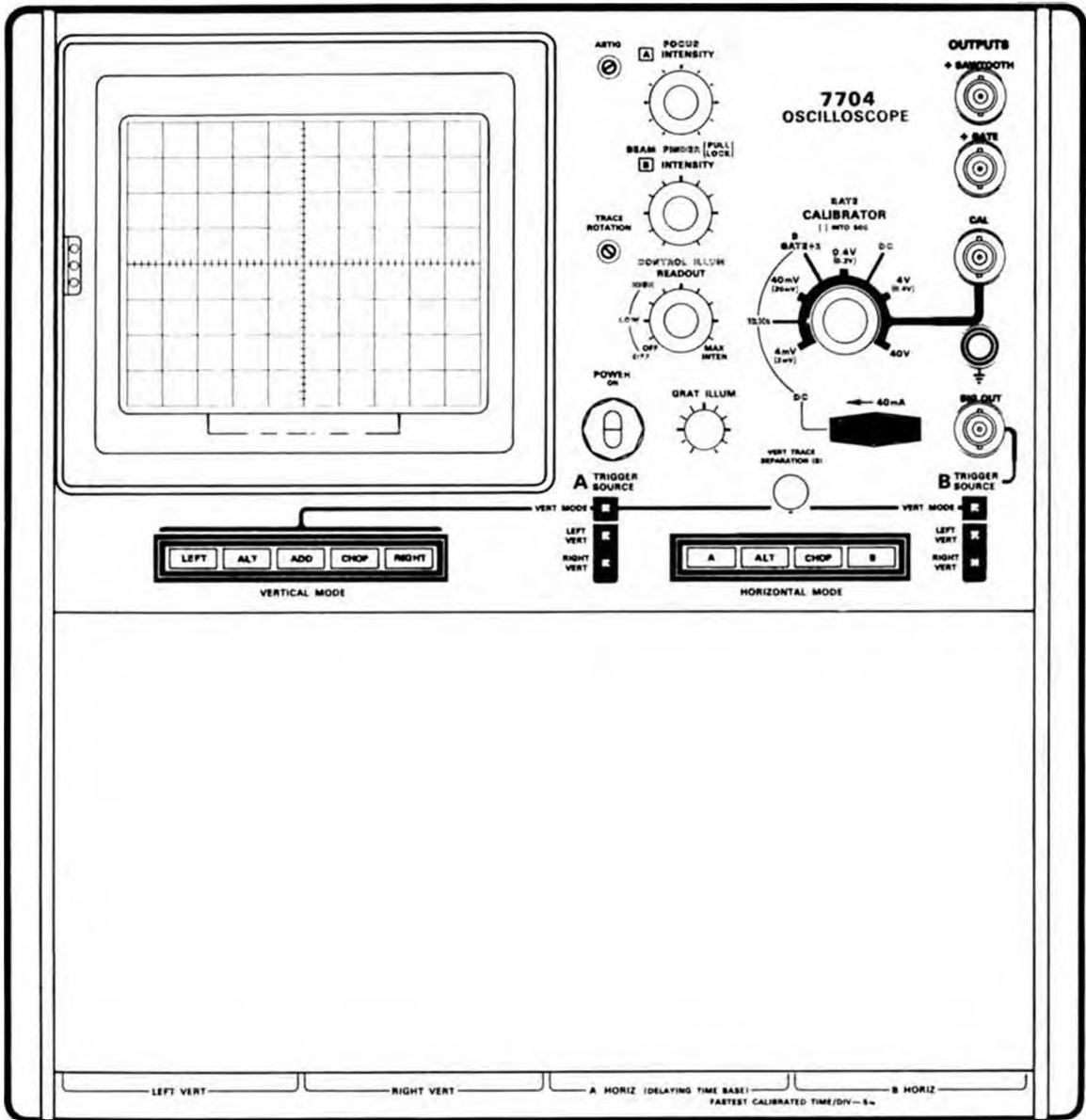
43. This completes the description of the basic operating procedure for the 7704. Instrument operations not explained here, or operations which need further explanation are discussed under General Operating Information.

## TEST SET-UP CHART

### General

Fig. 2-5 shows the front and rear panels of the 7704. This chart may be reproduced and used as a test-setup record for special measurements, applications or procedures, or it may be used as a training aid for familiarization with this instrument.

7704 TEST SET-UP CHART



REAR PANEL (not shown)

Line Selector—115 V ☐. 230 V ☐.

Connections (list connector and type of interconnecting lead or cable)

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Fig. 2-5.

## GENERAL OPERATING INFORMATION

### Simplified Operating Instructions

**General.** The following information is provided to aid in quickly obtaining the correct setting for the 7704 controls to present a display. The operator should be familiar with the complete function and operation of this instrument as described in this section before using this procedure. For detailed operating information for the plug-in units, see the instruction manuals for the applicable units.

**Single-Trace Display.** The following procedure will provide a display of a single-trace vertical unit against one time-base unit. For simplicity of explanation, the vertical unit is installed in the LEFT VERT compartment and the time-base unit is installed in the A HORIZ compartment. Other compartments can be used if the following procedure is changed accordingly.

1. Install a 7A-series vertical unit in the LEFT VERT compartment.

2. Press the LEFT button of the VERTICAL MODE switch.

3. Install a 7B-series time-base unit in the A HORIZ compartment.

4. Press the A button of the HORIZONTAL MODE switch.

5. Press the VERT MODE button of the A TRIGGER SOURCE switch.

6. Set the POWER switch to ON. Allow several minutes warmup.

7. Connect the signal to the input connector of the vertical unit.

8. Set the vertical unit for AC input coupling and calibrated deflection factors.

9. Set the time-base unit for peak-to-peak auto mode, internal triggering at a calibrated sweep rate of one millisecond/division.

10. Advance the A INTENSITY control until a display is visible (if display is not visible with A INTENSITY at

about midrange, press BEAM FINDER switch and adjust the vertical deflection factor until the display is reduced in size vertically; then center compressed display with vertical and horizontal position controls; release BEAM FINDER). Adjust FOCUS control for well-defined display.

11. Set the vertical deflection factor and vertical position control for a display which remains within the graticule area vertically.

12. If necessary, set the time-base triggering controls for a stable display.

13. Adjust the time base position control so the display begins at the left line of the graticule. Set the time-base sweep rate to display the desired number of cycles.

**Dual-Trace Display.** The following procedure will provide a display of two single-trace vertical units against one time-base unit.

1. Install 7A-series vertical units in both vertical plug-in compartments.

2. Press the LEFT button of the VERTICAL MODE switch.

3. Install a 7B-series time-base unit in the A HORIZ compartment.

4. Press the A button of the HORIZONTAL MODE switch.

5. Press the VERT MODE button of the A TRIGGER SOURCE switch.

6. Set the POWER switch to ON. Allow several minutes warmup.

7. Connect the signals to the input connectors of the vertical units.

8. Set the vertical units for AC input coupling and calibrated deflection factors.

9. Set the time-base unit for peak-to-peak auto mode, internal triggering at a sweep rate of one millisecond/division.

10. Advance the A INTENSITY control until a display is visible (if display is not visible with A INTENSITY at midrange, press BEAM FINDER switch and adjust vertical deflection factor until display is reduced in size vertically; then center compressed display with vertical and horizontal position controls; release BEAM FINDER). Set FOCUS control for well-defined display.

11. Set the left vertical unit deflection factor for a display about four divisions in amplitude. Adjust the vertical position control to move this display to the top of the graticule area.

12. Press the RIGHT button of the VERTICAL MODE switch.

13. Set the right vertical unit deflection factor for a display which is about four divisions in amplitude (if display cannot be located, use BEAM FINDER switch). Position this display to the bottom of the graticule area with the RIGHT VERT position control.

14. Press the ALT or CHOP button of the VERTICAL MODE switch. A dual-trace display of the signal from the LEFT VERT and RIGHT VERT plug-ins should be presented on the CRT. (For more information on choice of dual-trace mode, see Dual-Trace Displays in this section).

15. If necessary, adjust the time-base triggering controls for a stable display.

16. Adjust the time-base position control so the display begins at the left graticule line. Set the time-base sweep rate for the desired horizontal display.

**Dual-Sweep Display.** The following procedure will provide a dual-sweep display of a single-trace vertical unit against two time-base units.

1. Install a 7A-series vertical unit in the LEFT VERT compartment.

2. Press the LEFT button of the VERTICAL MODE switch.

3. Install 7B-series time-base units in both the A HORIZ and B HORIZ compartments.

4. Press the A button of the HORIZONTAL MODE switch.

5. Press the VERT MODE buttons of the A TRIGGER SOURCE and B TRIGGER SOURCE switches.

6. Set the POWER switch to ON. Allow several minutes warmup.

7. Connect the signal to the input connector of the vertical unit.

8. Set the vertical unit for AC input coupling and calibrated deflection factors.

9. Set both time-base units for peak-to-peak auto mode, internal triggering at a sweep rate of one millisecond/division.

10. Advance the A INTENSITY control until a display is visible (if display is not visible with A INTENSITY at midrange, press BEAM FINDER switch and adjust vertical deflection factor until display is reduced in size vertically; then center compressed display with vertical position control; release BEAM FINDER). Set FOCUS control for well-defined display.

11. Set the vertical unit for a display about four divisions in amplitude and move the display to the top of the graticule area with the vertical position controls.

12. If necessary, set the A time-base unit for stable triggering.

13. Set the A time-base sweep rate for the desired display.

14. Press the B button of the HORIZONTAL MODE switch.

15. Advance the B INTENSITY control until a display is visible (if display is not visible with B INTENSITY at midrange, press BEAM FINDER switch and adjust the vertical deflection factor until display is reduced in size vertically; then center compressed display with vertical position control; release BEAM FINDER).

16. If necessary, set the B time-base unit for stable triggering.

17. Set the B time-base unit sweep rate for the desired display.

18. Press the ALT or CHOP button of the HORIZONTAL MODE switch (see Dual-Sweep Displays in this section for further information on selecting sweep mode).

19. Adjust the VERT TRACE SEPARATION (B) control to position the trace produced by the B time-base unit with respect to the trace produced by the A time-base unit.

**Dual-Trace/Dual-Sweep Displays.** The following procedure will provide a dual-trace, dual-sweep display of two single-trace vertical units against two time-base units (four traces displayed on CRT).

1. Install 7A-series vertical units in both vertical compartments.

2. Press the LEFT button of the VERTICAL MODE switch.

3. Install 7B-series time-base units in both horizontal compartments.

4. Press the B button of the HORIZONTAL DISPLAY switch.

5. Press the VERT MODE buttons of the A TRIGGER SOURCE and B TRIGGER SOURCE switches.

6. Set the POWER switch to ON. Allow several minutes warmup.

7. Connect the signals to the input connectors of the vertical units.

8. Set the vertical units for AC input coupling and calibrated deflection factors.

9. Set both time-base units for peak-to-peak auto mode, internal triggering at a sweep rate of one millisecond/division.

10. Advance the B INTENSITY control until a display is visible (if display is not visible with B INTENSITY at midrange, press BEAM FINDER switch and adjust the LEFT VERT deflection factor until display is reduced in size vertically; then center compressed display with LEFT VERT position controls; release BEAM FINDER). Set FOCUS control for well-defined display.

11. Set the LEFT VERT deflection factor for a display which is about two divisions in amplitude and position the display to the top of the graticule area.

12. If necessary, adjust the B time-base unit triggering controls for a stable display.

13. Position the start of the trace to the left graticule line with the B time-base unit position control. Set the B time-base unit sweep rate for the desired display.

14. Press the RIGHT button of the VERTICAL MODE switch and the A button of the HORIZONTAL MODE switch.

15. Advance the A INTENSITY control until a display is visible (if display is not visible with A INTENSITY at midrange, press BEAM FINDER switch and adjust the RIGHT VERT deflection factor until display is reduced in size vertically; then center compressed display with RIGHT VERT position control; release BEAM FINDER).

16. Set the RIGHT VERT deflection factor for a display about two divisions in amplitude and position the display just below the center horizontal line of the graticule.

17. If necessary, adjust the A time-base unit triggering controls for a stable display.

18. Position the start of the trace to the left graticule line with the A time-base unit position control. Set the A time-base sweep rate for the desired display.

19. Press the ALT or CHOP button of the HORIZONTAL MODE switch.

20. If necessary, adjust the VERT TRACE SEPARATION (B) control to separate the two traces.

21. Press the CHOP button of the VERTICAL MODE switch.

22. Adjust the vertical position controls and the VERT TRACE SEPARATION (B) controls as necessary to obtain the desired display.

**Sweep-Slaving Display.** The following procedure will provide a dual-trace, dual-sweep display where the LEFT VERT unit is displayed only at the sweep rate of the B

time-base unit and the RIGHT VERT unit is displayed only at the sweep rate of the A time-base unit.

1. Follow steps 1 through 19 of the previous procedure for Dual-Trace/Dual-Sweep Displays.

2. Press the ALT button of the VERTICAL MODE switch.

3. If necessary, adjust the VERT TRACE SEPARATION (B) control to separate the two traces. The vertical deflection produced by the unit in the LEFT VERT compartment is displayed at the sweep rate of the time-base in the B HORIZ compartment, and the vertical deflection produced by the unit in the RIGHT VERT compartment is displayed at the sweep rate of the time-base in the A HORIZ compartment.

**Delayed-Sweep Display.** The following procedure will provide a delayed-sweep display of a single-trace vertical unit.

1. Follow the complete procedure given under Single-Trace Displays.

2. Be sure the time-base unit installed in the A HORIZ (DELAYING TIME BASE) compartment is a delaying time-base unit.

3. Install a 7B-series time-base unit in the B HORIZ compartment.

4. Follow the procedure given in the instruction manual for the delaying sweep time-base unit to obtain a delayed-sweep display.

5. Press the B button of the HORIZONTAL MODE switch and advance the B INTENSITY control until a display is visible. Only the delayed sweep is shown on this display.

6. Press the ALT or CHOP button of the HORIZONTAL MODE switch.

7. If necessary, adjust the VERT TRACE SEPARATION (B) control to separate the two traces. This display provides a simultaneous presentation of the delaying (A HORIZ) time-base unit and the delayed (B HORIZ) time-base unit.

**X-Y Display.** The following procedure will provide an X-Y display (one signal versus another rather than against time).

#### NOTE

*Some 7B-series time-base units have provisions for amplifier operation in the X-Y mode; see X-Y Operation in this section for details of operation in this manner.*

1. Install 7A-series amplifier units in both the LEFT VERT and the A HORIZ compartments.

2. Press the LEFT button of the VERTICAL MODE switch and the A button of the HORIZONTAL MODE switch.

3. Set the POWER switch to ON. Allow several minutes warmup.

4. Connect the X-signal to the amplifier unit in the A HORIZ compartment.

5. Connect the Y-signal to the amplifier unit in the LEFT VERT compartment.

6. Set both amplifier units for AC input coupling and calibrated deflection factors.

7. Advance the A INTENSITY control until a display is visible (if display is not visible, press BEAM FINDER switch and adjust the deflection factors of both amplifier units until display is reduced in size both vertically and horizontally; then center compressed display with the position controls; release BEAM FINDER).

8. Set the deflection factor of both amplifier units for the desired display and center the display with the position controls. The amplifier unit in the A HORIZ compartment controls the horizontal deflection and the unit in the LEFT VERT compartment controls the vertical deflection.

#### Intensity Controls

The 7704 has three separate intensity controls. The A INTENSITY control determines the brightness of the display produced by the plug-in in the A HORIZ compartment. Likewise, the B INTENSITY control determines the brightness of the display produced by the plug-in in the B

HORIZ compartment. The READOUT intensity control determines the brightness of only the readout portion of the CRT display.

The setting of the intensity controls may affect the correct focus of the display. Slight re-adjustment of the FOCUS control may be necessary when the intensity level is changed. To protect the CRT phosphor, do not turn the intensity controls higher than necessary to provide a satisfactory display. The light filters reduce the observed light output from the CRT. When using these filters, avoid advancing the intensity controls too high as the trace may become de-focused. When the highest intensity display is desired, remove the filters and use only the clear faceplate protector (permanently installed behind bezel). Apparent trace intensity can also be improved in such cases by reducing the ambient light or using a viewing hood. Also, be careful that the intensity controls are not set too high when changing the time-base unit sweep rates from a fast to a slow sweep rate, or when changing to the X-Y mode of operation. The instrument incorporates protection circuitry which automatically reduces the display intensity to a lower level when either of the time-base units is set to a slow sweep rate. This reduces the danger of damaging the CRT phosphor at these slower sweep rates.

### Astigmatism Adjustment

If a well-defined display cannot be obtained with the FOCUS control, adjust the ASTIG adjustment as follows:

#### NOTE

*To check for proper setting of the ASTIG adjustment, slowly turn the FOCUS control through the optimum setting. If the ASTIG adjustment is correctly set, the vertical and horizontal portions of the display will come into sharpest focus at the same position of the FOCUS control. This setting of the ASTIG adjustment should be correct for any display. However, it may be necessary to reset the FOCUS control slightly when the intensity of the display is changed.*

1. Connect the CAL connector to the input of the vertical unit with a BNC-to-BNC jumper lead.

2. Set the CALIBRATOR switch to 4 V and the RATE switch to 1 kHz. Adjust the vertical deflection factor to produce a two- or three-division display.

3. Set the time-base unit for a sweep rate of 0.2 millisecond/division.

4. Set the A INTENSITY control so the display is at normal intensity (about midrange).

5. Turn the FOCUS control fully counterclockwise and set the ASTIG adjustment to midrange.

6. Adjust the FOCUS control so the top and bottom of the displayed square wave are as thin as possible but not elongated.

7. Set the ASTIG adjustment so the top and bottom of the displayed square wave are as thin as possible.

8. Repeat parts 6 and 7 for the best overall focus.

### Trace Alignment Adjustment

If a free-running trace is not parallel with the horizontal graticule lines, set the TRACE ROTATION adjustment as follows: Position the trace to the center horizontal line and adjust the TRACE ROTATION adjustment so the trace is parallel with the horizontal graticule lines.

### Graticule

The graticule of the 7704 is internally marked on the faceplate of the CRT to provide accurate, no-parallax measurements. The graticule is divided into eight vertical and ten horizontal divisions. Each division is one centimeter square. In addition, each major division is divided into five minor divisions at the center vertical and horizontal lines. The vertical gain and horizontal timing of the plug-ins are calibrated to the graticule so accurate measurements can be made from the CRT. The illumination of the graticule lines can be varied with the GRAT ILLUM control.

Fig. 2-6 shows the graticule of the 7704 and defines the various measurement lines. The terminology defined here will be used in all discussions involving graticule measurements.

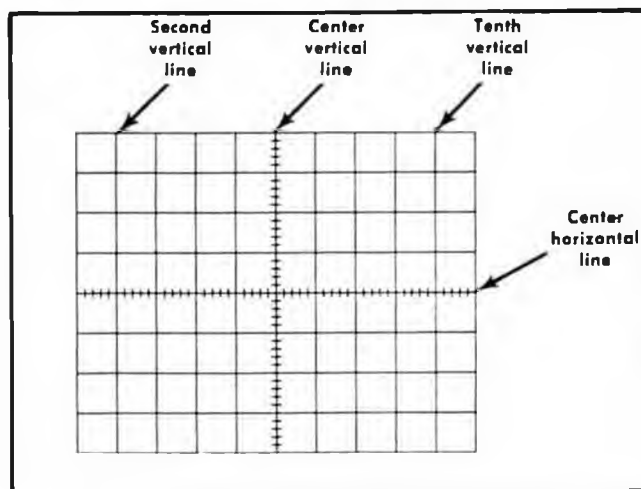


Fig. 2-6. Definition of measurement lines on 7704 graticule.



## Light Filter

The tinted filter provided with the 7704 minimizes light reflections from the face of the CRT to improve contrast when viewing the display under high ambient light conditions. This filter should be removed for waveform photographs or when viewing high writing rate displays. To remove the filter, pull outward on the bottom of the plastic CRT mask and remove it from the CRT. Remove the tinted filter (leave the metal light shield in place) and snap the plastic CRT mask back into place. A clear plastic faceplate protector is mounted between the CRT faceplate and the bezel. This faceplate protector should be left in place at all times to protect the CRT faceplate from scratches.

An optional mesh filter is available for use with the 7704. This filter provides shielding against radiated EMI (electro-magnetic interference) from the face of the CRT. It also serves as a light filter to make the trace more visible under high ambient light conditions. The mesh filter fits in place of the plastic CRT mask and the tinted filter. The filter can be ordered by Tektronix Part No. 378-0603-00.

## Beam Finder

The BEAM FINDER switch provides a means of locating a display which overscans the viewing area either vertically or horizontally. When the BEAM FINDER switch is pressed, the display is compressed within the graticule area. This switch can also be pulled outward to lock it in the beam-finder position. The latter feature is convenient when attempting to locate traces from more than one of the plug-in units in the 7704. Press the BEAM FINDER switch in to release it from the locked position. To locate and reposition an overscanned display, use the following procedure:

1. Press the BEAM FINDER switch in (or if desired, pull it outward to the lock position).
2. While the display is compressed, increase the vertical and horizontal deflection factors until the vertical deflection is reduced to about two divisions and the horizontal deflection is reduced to about four divisions (the horizontal deflection needs to be reduced only when in the X-Y mode of operation).
3. Adjust the vertical and horizontal position controls to center the display about the vertical and horizontal center lines of the graticule.
4. Release the BEAM FINDER switch; the display should remain within the viewing area.

## Control Illumination

The CONTROL ILLUM switch determines the illumination level of the pushbutton switches on the 7704 and

the associated plug-in units. This switch controls the illumination of only the pushbutton switches on the plug-in units and does not affect the intensity of lights which are used as function indicators (for example, it does not affect the illumination of the ready light on a time-base unit which has the single-sweep feature). In the OFF position all pushbutton lights on the 7704 and the associated plug-ins are off. The A and B INTENSITY lights remain on at low intensity to provide a power-on indication. In the LOW position the selected buttons are illuminated at low intensity. This is the recommended position for the CONTROL ILLUM switch, since it provides an adequate indication of switch position and also results in longest bulb life. The HIGH position provides maximum intensity for the pushbuttons and can be used so the selected switch is obvious even under high ambient light conditions.

### NOTE

*If the Readout System is not installed in this instrument (Option 1), disregard the following information. Also, the READOUT control has no effect upon instrument operation in this case.*

## Readout

The Readout System of the 7704 allows alphanumeric display of information on the CRT along with the analog waveform displays. The information displayed by the Readout System is obtained from the plug-in units which are installed in the plug-in compartments. The characters of the readout display are written by the CRT beam on a time-shared basis with the signal waveforms. However, the waveform display is interrupted for only about 20 microseconds for each character that is displayed. Only about 0.1% of total available display time (including retrace and holdoff time of time-base unit) is used to display each character.

The readout information from each plug-in is called a word. Up to eight words of readout information can be displayed on the 7704 CRT (two channels from each of the four plug-in compartments). The location at which each readout word is presented is fixed and is directly related to the plug-in unit and channel from which it originated. Figure 2-7 shows the area of the graticule where the readout from each plug-in unit and/or channel is displayed. Notice that the readout from channel 1 of each plug-in unit is displayed within the top division of the graticule and the readout from channel 2 is displayed directly below within the bottom division of the graticule. Only the readout from plug-ins and/or channels which are selected for display by the VERTICAL MODE or HORIZONTAL MODE switches, or by the mode switches of dual-channel plug-ins, appear in the readout display.

An "identify" feature is provided by the Readout System to link the readout word with the originating plug-in

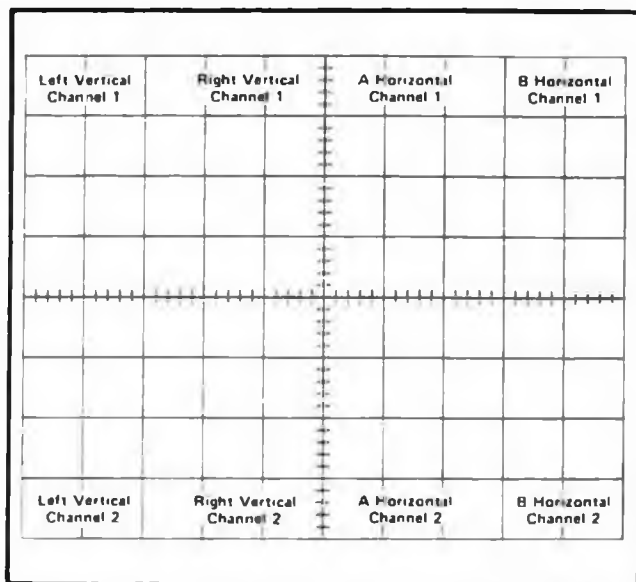


Fig. 2-7. Location of readout on the CRT identifying the originating plug-in and channel.

unit and channel (amplifier units only). When the "Identify" button of an amplifier unit is pressed, the word IDENTIFY appears in the readout location allocated to that plug-in and channel. Other readout words in the display remain unchanged. When the "Identify" button is released, the readout display from this plug-in channel is again displayed. Circuitry may also be provided in the amplifier unit which produces a noticeable change in the analog waveform display to also identify the associated trace when the "Identify" button is pressed; see the plug-in instruction manuals for details.

The READOUT control determines the intensity of only the readout portion of the display independent of the other traces. The Readout System is inoperative in the fully counterclockwise OFF position. This may be desirable when the top and bottom divisions of the graticule are to be used for waveform display, or when the trace interruptions necessary to display characters do not allow a satisfactory waveform display to be obtained.

### Vertical and Horizontal Mode Switch Logic

There are 20 possible combinations of VERTICAL MODE and HORIZONTAL MODE switch settings. The total possible number of display combinations is further multiplied by the variety of plug-in units available for use with this instrument (such as voltage amplifiers, current amplifiers, sampling units, etc.), the interchangeability of plug-ins (i.e., an amplifier or time-base unit can be installed in either of the vertical or horizontal compartments), or by the capabilities of the plug-in units which are used in this instrument (e.g., a dual-trace vertical unit can be used in either of the two single-channel modes, in either dual-trace mode or added algebraically; a delaying time base may be

used either for a normal sweep or for delayed sweep). Therefore, it is difficult to list all of the display combinations which can occur using the 7704 and the plug-in units which are available since the display combinations possible are dictated by the specific combination of plug-in units used. Table 2-2 lists the combination of VERTICAL MODE and HORIZONTAL MODE switch positions available and the type of display provided with each combination. For further information on operation in each position of the VERTICAL MODE and HORIZONTAL MODE switch positions, see the following sections on Vertical Mode and Horizontal Mode.

### Vertical Mode

**Left and Right Mode.** When the LEFT or RIGHT button of the VERTICAL MODE switch is pressed, only the signal from the plug-in unit in the selected compartment is displayed.

**Alternate Mode.** The ALT position of the VERTICAL MODE switch produces a display which alternates between the plug-in units in the LEFT VERT and RIGHT VERT compartments with each sweep of the CRT. Although the ALT mode can be used at all sweep rates, the CHOP mode provides a more satisfactory display at sweep rates below about 20 milliseconds/division. At these slower sweep rates, alternate-mode switching becomes visually perceptible.

The A and B TRIGGER SOURCE switches allow selection of the triggering for an alternate display. When these switches are set to the VERT MODE positions, each sweep is triggered by the signal being displayed on the CRT. This provides a stable display of two unrelated signals, but does not indicate the time relationship between the signals. In either the LEFT VERT or the RIGHT VERT positions, the two signals are displayed showing true time relationship. However, if the signals are not time related, the display from the plug-in which is not providing a trigger signal will be unstable on the CRT.

When the ALT vertical mode is selected and either the ALT or CHOP buttons of the HORIZONTAL MODE switch are pressed, the instrument operates in a sweep-slaving mode. Under this condition, the LEFT VERT unit is always displayed at the sweep rate of the time-base unit in the B HORIZ compartment and the RIGHT VERT unit is displayed at the sweep rate of the time-base unit in the A HORIZ compartment (non-delayed sweep only). This results in two displays that have completely independent vertical deflection and sweep rate which is equivalent to the display obtainable with a dual-beam oscilloscope. See Horizontal Mode for information on selection of either ALT or CHOP horizontal mode. If delayed-sweep operation is used under this condition, a different sequence of display occurs. First, the LEFT VERT unit is displayed at the sweep rate

TABLE 2-2  
Display Combinations<sup>1</sup>

VERTICAL MODE Switch Position	HORIZONTAL MODE Switch Position	Comments
LEFT	A	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	B	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	ALT	Two traces. Vertical deflection from single unit; horizontal deflection from both units.
	CHOP	Two traces. Vertical deflection from single unit; horizontal deflection from both units.
ALT	A	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	B	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	ALT	Two traces. Vertical deflection from both units; horizontal deflection from both units. Provides sweep-slaving between the LEFT VERT and B HORIZ plug-ins and the RIGHT VERT and A HORIZ plug-ins.
	CHOP	Two traces. Vertical deflection from both units; horizontal deflection from both units. Provides sweep-slaving between the LEFT VERT and B HORIZ plug-ins and the RIGHT VERT and A HORIZ plug-ins.
ADD	A	One trace. Vertical deflection is algebraic summation of both units; horizontal deflection from single unit.
	B	One trace. Vertical deflection is algebraic summation of both units; horizontal deflection from single unit.
	ALT	Two traces. Vertical deflection is algebraic summation of both units; horizontal deflection from both units.
	CHOP	Two traces. Vertical deflection is algebraic summation of both units; horizontal deflection from both units.
CHOP	A	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	B	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	ALT	Four traces. Vertical deflection from both units; horizontal deflection from both units.
	CHOP	Four traces. Vertical deflection from both units; horizontal deflection from both units.
RIGHT	A	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	B	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	ALT	Two traces. Vertical deflection from single unit; horizontal deflection from both units.
	CHOP	Two traces. Vertical deflection from single unit; horizontal deflection from both units.

<sup>1</sup> Combinations given for single-channel vertical and horizontal units only.

of the time-base unit in the A HORIZ compartment (delaying sweep) and then at the sweep rate of the time-base unit in the B HORIZ compartment (delayed sweep). The vertical display then shifts to the RIGHT VERT unit and it is displayed consecutively at the delaying and delayed sweep rate.

**Chopped Mode.** The CHOP position of the VERTICAL MODE switch produces a display which is electronically switched between channels at a one-megahertz rate. In general, the CHOP mode provides the best display at sweep rates slower than about 20 milliseconds/division or whenever dual-trace, single-shot phenomena are to be displayed. At faster sweep rates the chopped switching becomes apparent and may interfere with the display.

Correct internal triggering for the CHOP mode can be obtained in any of the three positions of the trigger source switches. When the A or B TRIGGER SOURCE switches are set to VERT MODE, the internal trigger signals from the vertical plug-ins are algebraically added and the time-base units are triggered from the resultant signal. Use of the LEFT VERT or RIGHT VERT trigger source positions triggers the time-base units on the internal trigger signal from the selected vertical unit only. This allows two time-related signals to be displayed showing true time relationship. However, if the signals are not time-related, the display from the channel which is not providing the trigger signal will appear unstable. The CHOP mode can be used to compare two single-shot, transient, or random signals which occur within the time interval determined by the time-base unit (ten times selected sweep rate). To provide correct triggering, the display which provides the trigger signal must precede the second display in time. Since the signals show true time relationship, time-difference measurements can be made from the display.

**Algebraic Addition.** The ADD position of the VERTICAL MODE switch can be used to display the sum or difference of two signals, for common-mode rejection to remove an undesired signal, or for DC offset (applying a DC voltage to one channel to offset the DC component of a signal on the other channel). The common-mode rejection ratio between the vertical plug-ins of the 7704 is greater than 10:1 at 150 megahertz. The rejection ratio increases to 100:1 at 20 megahertz.

The overall deflection on the CRT in the ADD mode is the resultant of the algebraic addition of the signals from the two vertical plug-in units. It is difficult to determine the voltage amplitude of the resultant display unless the amplitude of the signal applied to one of the plug-ins is known. This is particularly true when the vertical units are set to different deflection factors, since it is not obvious which portion of the display is a result of the signal applied to either plug-in unit. Also, the polarity and repetition rate of the applied signals enters into the calculation.

The following general precautions should be observed to provide the best display when using the ADD mode:

1. Do not exceed the input voltage rating of the plug-in units.
2. Do not apply large signals to the plug-in inputs. A good rule to follow is not to apply a signal which exceeds an equivalent of about eight times the vertical deflection factors. For example, with a vertical deflection factor of 0.5 volts/division, the voltage applied to that plug-in should not exceed four volts. Larger voltages may result in a distorted display.
3. To ensure the greatest dynamic range in the ADD mode, set the position controls of the plug-in units to a setting which would result in a mid-screen display if viewed in the LEFT or RIGHT positions of the VERTICAL MODE switch.
4. For similar response from each channel, set the plug-in units for the same input coupling.

## Horizontal Mode

**A and B.** When either the A or B button of the HORIZONTAL MODE switch is pressed, the display is presented at the sweep rate of only the selected time-base unit. Set the applicable intensity control and trigger source switch for the desired display.

**Alternate Mode.** The ALT position of the HORIZONTAL MODE switch produces a display which alternates between time-base units after each sweep on the CRT. Although the ALT horizontal mode can be used at all sweep rates, the CHOP horizontal mode provides a more satisfactory display at sweep rates below about 20 milliseconds/division. At slower sweep rates, the switching between the alternate-mode traces becomes apparent and may interfere with correct analysis of the display.

The A and B INTENSITY controls allow individual adjustment of the traces produced by the time-base units in the A HORIZ and B HORIZ compartments. Correct triggering of both time-base units is essential to obtaining the correct display in the ALT horizontal mode. If either of the time-base units does not receive a correct trigger, and therefore, does not produce a sweep, the other unit cannot produce a sweep either. This means that one time-base unit cannot begin its sweep until the previous unit has completed its entire display. This can be avoided if the time-base units are set for auto-mode triggering (sweep free runs if not correctly triggered). The A and B TRIGGER SOURCE switches allow individual selection of the trigger

source for the A HORIZ and B HORIZ time-base units. See the information on Trigger Source for complete operation of the A and B TRIGGER SOURCE switches. Also, see Vertical Trace Separation for information on positioning the B HORIZ display when in the ALT dual-sweep mode.

**Chopped Mode.** When the CHOP button of the HORIZONTAL MODE switch is pressed, the display is electronically switched between the two time-base units at a 200-kilohertz rate. In general, the CHOP horizontal mode provides the best display when either of the time-base units is set to a sweep rate slower than about 20 milliseconds/division. It also provides the best display when the two time-base units are set to widely varying sweep rates. In the CHOP horizontal mode, equal time segments are displayed from each of the time-base units. This provides a display which does not change greatly in intensity as the sweep rate of one of the time-base units is reduced (in contrast to ALT horizontal mode operation where the slowest trace tends to be the brightest).

The A and B INTENSITY controls allow individual adjustment of the intensity of the traces produced by the time-base units in the A HORIZ and B HORIZ compartments. Triggering is not as critical in the CHOP horizontal mode as in ALT since only the trace from the un-triggered time-base unit is missing from the display if one of the units is not triggered properly. The other trace will be presented in the normal manner. The A and B TRIGGER SOURCE switches allow individual selection of the trigger source for the A HORIZ and B HORIZ time-base units. See the information on Trigger Source. Also, see Vertical Trace Separation for information on positioning the trace produced by the B HORIZ unit in relation to the trace from the A HORIZ unit.

## Vertical Trace Separation

The VERT TRACE SEPARATION (B) control allows the trace produced by the B HORIZ plug-in to be positioned about four divisions above or below the trace produced by the plug-in unit in the A HORIZ compartment when one of the dual-sweep horizontal modes is selected. This control effectively operates as a vertical position control for dual-sweep operation. To use the control, first establish the desired position of the trace produced by the unit in the A HORIZ compartment. Then adjust the VERT TRACE SEPARATION (B) control to move the trace produced by the unit in the B HORIZ compartment away from the A HORIZ display. If any of the displays are larger than four divisions in amplitude, the displays can only be positioned so they do not directly overlap since each waveform cannot be positioned to a unique area of the CRT.

## Trigger Source

The A and B TRIGGER SOURCE switches allow selection of the internal trigger signals for the A HORIZ and B

HORIZ time-base units respectively. For most applications, these switches can be set to the VERT MODE positions. This position is the most convenient since the internal trigger signal is automatically switched as the VERTICAL MODE switch is changed or as the display is electronically switched between the LEFT VERT and RIGHT VERT plug-ins in the ALT position of the VERTICAL MODE switch. It also provides a usable trigger signal in the ADD or CHOP positions of the VERTICAL MODE switch, since the internal trigger signal in these modes is the algebraic sum of the signals applied to the vertical plug-in units. Therefore, the VERT MODE positions ensure that the time-base units receive a trigger signal regardless of the VERTICAL MODE switch setting without the need to change the trigger source selection. However, if correct triggering for the desired display is not obtained in the VERT MODE position, the trigger source for either the A HORIZ or B HORIZ time-base unit can be changed to obtain the trigger signal from either the LEFT VERT or RIGHT VERT plug-in. The internal trigger signal is obtained from the selected vertical compartment whether the plug-in in that compartment is selected for display on the CRT or not. If the internal trigger signal is obtained from one of the vertical units but the other vertical unit is selected for display, the internal trigger signal must be time-related to the displayed signal in order to obtain a triggered (stable) display.

## X-Y Operation

In some applications, it is desirable to display one signal versus another (X-Y) rather than against time (internal sweep). The flexibility of the plug-in units available for use with the 7704 provides a means for applying an external signal to the horizontal deflection system for this type of display. Some of the 7B-series time-base units can be operated as amplifiers in addition to their normal use as time-base generators. This feature allows an external signal to provide the horizontal deflection on the CRT. For most of the time-base units with the amplifier function, the X (horizontal) signal can be connected either to an external input connector on the time-base unit or it can be routed to the time-base unit through the internal triggering system (see time-base instruction manual for details). If the latter method is used, the A and B TRIGGER SOURCE switches must be set so that the X (horizontal) signal is obtained from one of the vertical units and the Y (vertical) signal is obtained from the other vertical unit. The advantages of using the internal trigger system to provide the X signal are that the attenuator switch of the amplifier unit providing the horizontal signal determines the horizontal deflection factor to allow full-range operation and the plug-in units do not have to be moved between compartments when X-Y operation is desired.

Another method of obtaining an X-Y display is to install an amplifier plug-in unit in one of the horizontal plug-in compartments (check amplifier unit gain as given in the plug-in instruction manual to obtain calibrated horizontal

deflection factors). This method provides the best X-Y display, particularly if two identical amplifier units are used, since both the X and Y input systems will have the same delay time, gain characteristics, input coupling, etc. For further information on obtaining X-Y displays see the plug-in unit manuals. Also, the reference books listed under Applications provide information on X-Y measurements and interpreting the resultant lissajous displays.

An optional X-Y delay compensation network is available for use with the 7704. This network provides close delay matching between the vertical and horizontal deflection systems up to two megahertz for use in X-Y applications which require precise phase measurement. The network can be added to the 7704 at any time. Order Tektronix Part No. 040-0529-00 from your local Tektronix Field Office or representative for a complete X-Y delay compensation network; installation instructions are included.

While the X-Y delay compensation network provides minimum phase shift between the X and Y portions of an X-Y display, it adds negative preshoot distortion and some corner rounding to fast step functions. An internal Delay Disable switch (see Fig. 2-8) is provided for both the A and B delay compensation networks to allow selection of either minimum phase-shift characteristics or optimum step response. When the Delay Disable switch is set to In (up), minimum phase-shift operation is provided as controlled by the plug-in units in the associated horizontal compartment. When set to the Out (down) position, the X-Y delay compensation network for the applicable horizontal compartment is disabled; the horizontal signal is connected to the horizontal deflection system with minimum distortion.

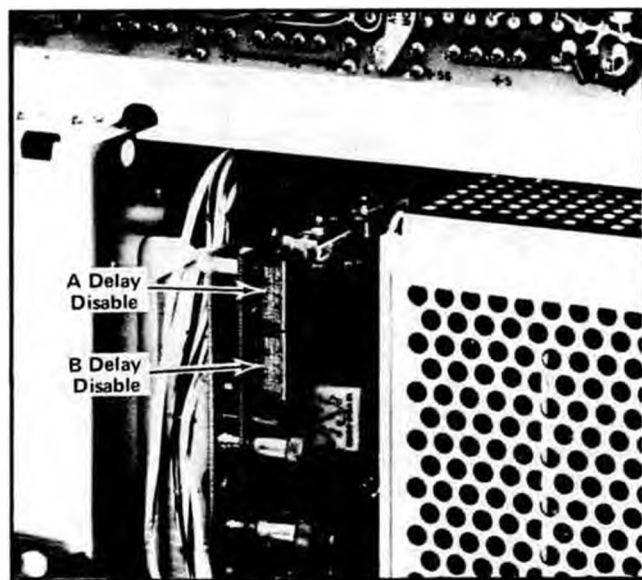


Fig. 2-8. Location of A and B Delay Disable switches (behind right side panel).

## Intensity Modulation

Intensity (Z-axis) modulation can be used to relate a third item of electrical phenomena to the vertical (Y-axis) and the horizontal (X-axis) coordinates without affecting the waveshape of the displayed signal. The Z-axis modulating signal applied to the CRT circuit changes the intensity of the displayed waveform to provide this type of display. "Gray scale" intensity modulation can be obtained by applying signals which do not completely blank the display. Large amplitude signals of the correct polarity will completely blank the display; the sharpest display is provided by signals with a fast rise and fall. The voltage amplitude required for visible trace modulation depends on the setting of the intensity controls.

Time markers applied to the Z-AXIS INPUTS provide a direct time reference on the display. With uncalibrated horizontal sweep or X-Y mode operation, the time markers provide a means of reading time directly from the display. However, if the markers are not time-related to the displayed waveform, a single-sweep display should be used (for internal sweep only) to provide a stable display.

Two modes of intensity modulation are provided in the 7704. The following discussions list the use and limitations of each mode.

**High Sensitivity Input.** The HIGH SENSITIVITY input (on rear panel) permits intensity modulation of the CRT display through the Z-Axis Amplifier circuit. A two-volt peak-to-peak signal will completely blank the display even at maximum intensity levels. Lower amplitude signals can be used to only change the trace brightness rather than completely blank the display. Negative-going modulating signals increase the display intensity and positive-going modulating signals decrease the display intensity. Bandwidth for this mode of intensity modulation is DC to 10 megahertz (input voltage derating necessary above two megahertz). The maximum input voltage in this mode should be limited to 15 volts (DC plus peak AC). Since this input is the most sensitive, it can be used for all applications requiring bandwidth of 10 megahertz or less. When the HIGH SENSITIVITY input is not in use, replace the BNC cap.

**High Speed Input.** Intensity modulation signals connected to the HIGH SPEED connector (on rear panel) are connected primarily to the cathode circuit of the CRT. A 60-volt peak-to-peak signal will provide complete blanking of the display even at maximum intensity settings. Negative-going modulating signals increase the display intensity and positive-going modulating signals decrease the display intensity. Bandwidth for this mode is DC to 100 megahertz. Maximum input voltage for signals connected to the HIGH SPEED input is 60 volts (DC plus peak AC). Replace the BNC cap when the HIGH SPEED input is not in use.

## Raster Display

A raster-type display can be used to effectively increase the apparent sweep length. For this type of display, the trace is deflected both vertically and horizontally by saw-tooth signals. This is accomplished in the 7704 by installing a 7B-series time-base unit in one of the vertical plug-in compartments. Normally, the time-base unit in the vertical compartment should be set to a slower sweep rate than the time-base unit in the horizontal compartment; the number of horizontal traces in the raster depends upon the ratio between the two sweep rates. Information can be displayed on the raster using several different methods. In the ADD position of the VERTICAL MODE switch, the signal from an amplifier unit can be algebraically added to the vertical deflection. With this method, the vertical signal amplitude on the CRT should not exceed the distance between the horizontal lines of the raster. Another method of displaying information on the raster is to use the Z-AXIS INPUTS to provide intensity modulation for the display. This type of raster display could be used to provide a television-type display. Complete information on operation using the Z-axis feature is given under Intensity Modulation.

To provide a stable raster display, both time-base units must be correctly triggered. Internal triggering is not provided for the time-base units when they are in the vertical compartments; external triggering must be used. Also, blanking is not provided from the time-base units when they are installed in a vertical compartment. To blank out the retrace portion from the time-base unit in the vertical compartment, special connections must be made from this time-base unit to the blanking network of the 7704.

## Calibrator

**General.** The internal calibrator of the 7704 provides a convenient signal source for checking basic vertical gain and sweep timing. The calibrator output signal is also very useful for adjusting probe compensation as described in the probe instruction manual. In addition, the calibrator can be used as a convenient signal source for application to external equipment.

**Voltage.** The calibrator provides accurate output voltages at the CAL connector from four millivolts to 40 volts in decade steps into high impedance loads. In addition, the positions from 4 mV to 4 V provide an output of two millivolts to 0.4 volts into 50 ohms (shown on front panel in brackets). The amplitude of the output voltage is selected by the CALIBRATOR switch. The output voltage is available at the front-panel CAL connector (note line connecting CALIBRATOR switch to output connector).

**Current.** The current loop provides a 40-milliampere output current which can be used to check and calibrate current-measuring probe systems. The current signal is ob-

tained by clipping the probe around the current loop. The arrow above the current loop indicates conventional current flow; i.e., from plus to minus.

**Repetition Rate.** The calibrator circuit uses frequency-stable components to maintain accurate frequency and constant duty cycle. Thus the calibrator can be used for checking the basic sweep timing of time-base units (one-kilohertz rate only). The RATE switch selects the repetition rate of the calibrator. Two positions of the RATE switch provide a square wave output signal both at the CAL connector and through the current loop. In the 1 kHz position, the repetition rate of the calibrator is one kilohertz; the voltage at the CAL connector is maximum when the current through the current loop is minimum, and vice versa. The B GATE  $\div 2$  position of the RATE switch provides a variable calibrator repetition rate. In this position, the repetition rate of the calibrator output signal is one-half the repetition rate of the gate signal produced by the time-base unit in the B HORIZ compartment (length of B gate is about ten times the setting of the B sweep rate switch). This position of the RATE switch allows selection of the repetition rate of the calibrator output signal by changing the sweep rate of the time-base unit in the B HORIZ compartment. The calibrator circuit maintains a constant 50% duty cycle on the output waveform regardless of the repetition rate (B time base free running). Like the 1 kHz position, the output voltage at the CAL connector is maximum when the current through the current loop is minimum, and vice versa.

Two positions of the RATE switch select DC operation. In the DC (current only) position, a constant 40 milli-ampere DC current is available through the current loop. There is no voltage output available at the CAL connector in this position. In the DC (volts only) position, positive DC voltage levels are available at the CAL connector; the amplitude of this DC voltage is determined by the setting of the CALIBRATOR switch. No current output is provided through the current loop under this condition.

**Wave Shape.** The square-wave output signal of the calibrator can be used as a reference wave shape when checking or adjusting the compensation of passive, high-resistance probes. Since the square-wave output from the calibrator has a flat top, any distortion in the displayed waveform is due to the probe compensation.

## Signal Outputs

**+ Sawtooth.** The + SAWTOOTH connector provides a positive-going sample of the sawtooth signal from the time-base units in the horizontal plug-in compartments. The internal Sweep switch (located behind right side panel; see Figure 2-9) allows the output sawtooth to be selected from the time-base unit in either the A HORIZ or B HORIZ compartments. Rate of rise of the sawtooth output signal is

about 50 millivolts/unit of time into a 50-ohm load or about one volt/unit of time into a one-megohm load. Unit of time is determined by the time-base time/division switch (e.g., if time/division switch is set to one millisecond/division, a unit of time is one millisecond; at five milliseconds/division, a unit of time is five milliseconds). The peak output voltage is greater than 500 millivolts into a 50-ohm load or greater than 10 volts into a one-megohm load.

**+ Gate.** The + GATE output connector provides a positive-going rectangular output pulse from the time-base units in the horizontal plug-in compartments. The Gate switch (located behind the right side panel; see Fig. 2-9) allows the output signal to be selected from the time-base unit in the A HORIZ compartment, B HORIZ compartment, or the delayed gate from a delaying time-base unit in the A HORIZ compartment. Duration of the gate output signal is the same as the duration of the respective sweep or, in the case of the delayed gate, it starts at the end of the delay period and lasts until the end of the sweep from the delaying time-base unit. Amplitude of the output signal at the + GATE connector is about 0.5 volts into 50 ohms or about 10 volts into one megohm.

**Vertical Signal.** The SIG OUT connector provides a sample of the vertical deflection signal. The source of the output signal at this connector is determined by the B TRIGGER SOURCE switch (notice line connecting SIG OUT connector to B TRIGGER SOURCE switch). In the VERT MODE position of the B TRIGGER SOURCE switch, the output signal is determined by the setting of the VERTICAL MODE switch. The output signal in the LEFT and RIGHT positions of the VERTICAL MODE switch is obtained only from the selected vertical unit. In the ALT position of the VERTICAL MODE switch, the output sig-



Fig. 2-9. Location of Sweep and Gate switches (behind right side panel).



nal at the SIG OUT connector switches between vertical units along with the CRT display. However, the vertical output signal in the CHOP position is a composite signal and is the same as obtained in the ADD position due to the requirements of the triggering system. The LEFT VERT and RIGHT VERT positions of the B TRIGGER SOURCE switch provide the vertical output signal only from the selected vertical unit even when it is not selected for display. The output voltage into a 50 ohm load is about 25 millivolts/division of CRT display and about 0.5 volts/division of display into a one-megohm load. The bandwidth of the output signal is determined by the vertical plug-in unit which is used (see Systems Specification given in Section 1).

Probe Power Connectors

The two PROBE POWER connectors on the rear panel of this instrument provide operating power for active probe systems. It is not recommended that these connectors be used as a power source for applications other than the compatible probes or other accessories which are specifically designed for use with this system.

Remote Connector

The nine-terminal connector J1075 on the rear panel of the 7704 provides input for remote operation of the instrument and the associated plug-in units. Table 2-3 lists the function of each terminal of J1075. The mating connector for J1075 is Tektronix Part No. 134-0049-00 (one mating connector supplied as standard accessory). The methods of obtaining remote single-sweep reset and ready indication are given under Remote Single-Sweep Reset. Notice that there are several blank terminals on J1075. These terminals can be used for special remote applications.

Remote Single-Sweep Reset

Remote single-sweep reset operation can be provided to 7B-series time-base units with compatible features through rear-panel connector J1075. The remote single-sweep reset actuation can be obtained from either an active system (pulse generator, logic circuit, etc.) or a passive system (switch or relay). Input requirements for remote single-sweep reset operation are: Closure to ground (–5 volts to –0.5 volts provides actuation) at 10 milliamperes maximum current; minimum pulse width of 10 microseconds at 50% amplitude points; 15 volts maximum input voltage.

Fig. 2-10 shows a typical passive system to provide remote single-sweep reset operation. The remote ready lights are optional and can be used with an active or passive system whenever it is necessary to provide an indication at the remote location that reset has occurred.

Applications

The 7704 Oscilloscope and its associated plug-in units provide a very flexible measurement system. The capabilities of the overall system depend mainly upon the plug-ins that are chosen for use with this instrument. Specific applications for the individual plug-in units are described in the plug-in unit manuals. The overall system can also be used for many applications which are not described in detail either in this manual or in the manuals for the individual plug-in units. Contact your local Tektronix Field Office or representative for assistance in making specific measurements with this instrument.

TABLE 2-3

Remote Connections

J1075 Terminal	Function
A	Remote single-sweep reset (A and B HORIZ)
B	Chassis ground
C	Remote ready indicator (A HORIZ)
D	Remote ready indicator (B HORIZ)
E	No connection
F	No connection
H	No connection
J	No connection
K	No connection

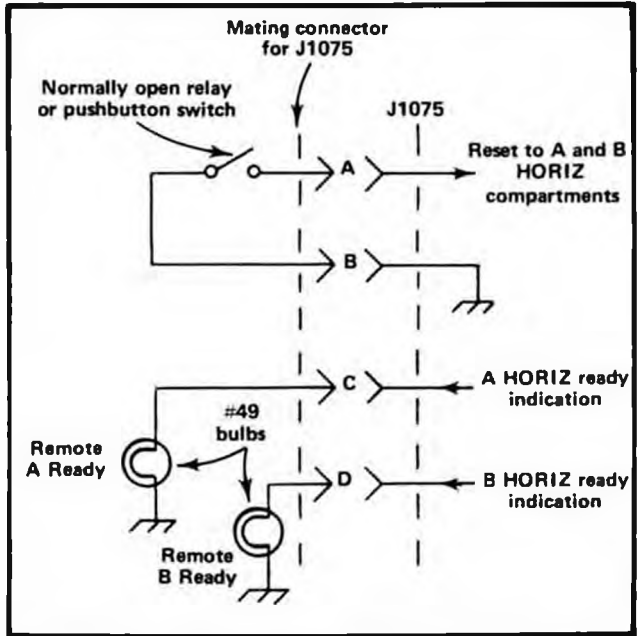


Fig. 2-10. Typical circuit for remote single-sweep reset operation.



The following books describe oscilloscope measurement techniques which can be adapted for use with this instrument.

Harley Carter, "An Introduction to the Cathode Ray Oscilloscope", Phillips Technical Library, Cleaver-Hume Press Ltd., London, 1960.

J. Czech, "Oscilloscope Measuring Techniques", Phillips Technical Library, Springer-Verlag, New York, 1965.

Robert G. Middleton, "Scope Waveform Analysis", Howard W. Sams & Co. Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1963.

Robert G. Middleton and L. Donald Payne, "Using the Oscilloscope in Industrial Electronics", Howard W. Sams & Co. Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1961.

John F. Rider and Seymour D. Uslan, "Encyclopedia of Cathode-Ray Oscilloscopes and Their Uses", John F. Rider Publisher Inc., New York, 1959.

John F. Rider, "Obtaining and Interpreting Test Scope Traces", John F. Rider Publisher Inc., New York, 1959.

Rufus P. Turner, "Practical Oscilloscope Handbook", Volumes 1 and 2, John F. Rider Publisher Inc., New York, 1964.

# SECTION 3

## CIRCUIT DESCRIPTION

*Change information, if any, affecting this section will be found at the rear of the manual.*

### Introduction

This section of the manual contains a description of the circuitry used in the 7704 Oscilloscope. The description begins with a discussion of the instrument using the basic block diagram shown in Fig. 3-1. Then, each circuit is described in detail using detailed block diagrams to show the interconnections between the stages in each major circuit and the relationship of the front-panel controls to the individual stages.

A complete block diagram is located in the Diagrams section at the back of this manual. This block diagram shows the overall relationship between all of the circuits. Complete schematics of each circuit are also given in the Diagrams section. Refer to these diagrams throughout the following circuit description for electrical values and relationship.

### BLOCK DIAGRAM

#### General

The following discussion is provided to aid in understanding the overall concept of the 7704 before the individual circuits are discussed in detail. A basic block diagram of the 7704 is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block represents a major circuit within the instrument. The number on each block refers to the complete circuit diagram which is located at the rear of this manual.

Vertical signals to be displayed on the CRT are applied to the Vertical Interface circuit from both vertical plug-in compartments. The Vertical Interface circuit determines whether the signal from the left and/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 Interface circuit from both horizontal plug-in compartments. The X-Y Delay Compensation net-

work (optional feature) provides a delay for the horizontal (X) portion of an X-Y display to match the delay of the vertical (Y) signal due to the delay line. The Horizontal Channel Switch determines whether the signal from the A and/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 Trigger Selector circuit. This circuit selects the trigger signal which is connected to the horizontal plug-in units. It also provides the drive signal for the Output Signals circuit to provide an output which is a sample of the vertical signal. The Output Signals circuit also provides a sawtooth output signal and a gate output signal. The Calibrator circuit produces a square-wave output with accurate amplitude which can be used to check the calibration of this instrument and the compensation of probes. The repetition rate of the output signal is selectable; either DC, one kilohertz, or one-half the B gate. This signal is available as a voltage at the CAL connector and 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 output signals automatically determine the correct instrument operation in relation to the plug-ins installed and/or selected, plug-in control settings, and 7704 control settings. The Z-Axis Amplifier circuit provides the drive signal to control the CRT intensity level through the CRT Circuit. The CRT Circuit produces the voltages and contains the controls necessary for operation of the cathode-ray tube.

The Low-Voltage Power Supply circuit provides the power necessary for operation of this instrument. This voltage is connected to all circuits within the instrument. The Controls and Cabling circuit shows the switching logic of the front-panel controls. It also includes the rear-panel Remote connector and the output connectors to supply power to active probe systems.

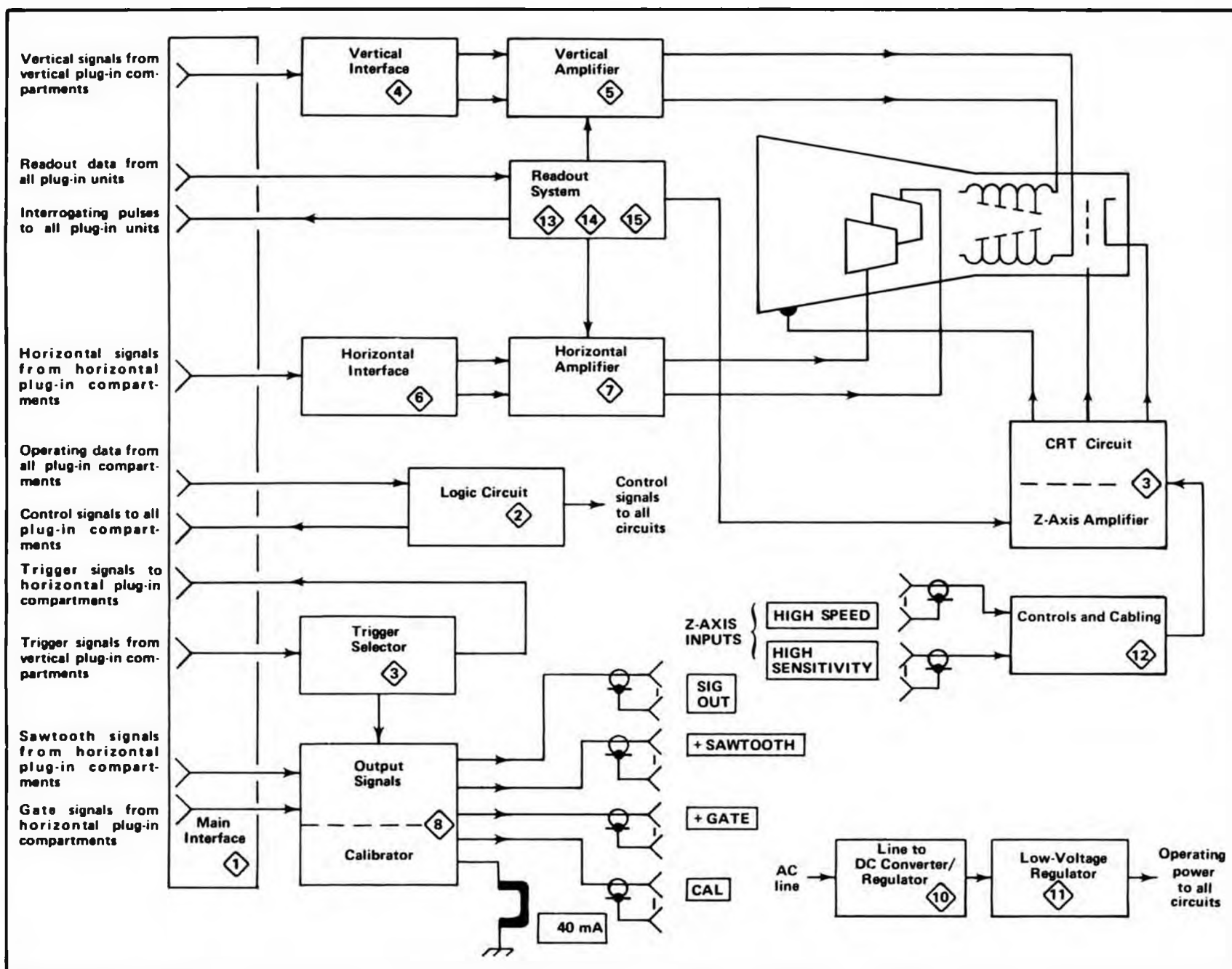


Fig. 3-1. Basic block diagram of the 7704 Oscilloscope.

## CIRCUIT OPERATION

### General

This section provides a detailed description of the electrical operation and relationship of the circuits in the 7704. The theory of operation for circuits unique to this instrument is described in detail in this discussion. Circuits which are commonly used in the electronics industry are not described in detail. If more information is desired on these commonly used circuits, refer to the following textbooks:

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

Cathode-Ray Tubes, Tektronix Part No. 062-0852-01.

Oscilloscope Trigger Circuits, Tektronix Part No. 062-1056-00.

Power Supply Circuits, Tektronix Part No. 062-0888-01.

Sweep Generator Circuits, Tektronix Part No. 062-1098-00.

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 following circuit analysis is written around the detailed block diagrams which 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

### General

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 No. 062-1030-00.

Robert C. Baron and Albert T. Piccirilli, "Digital Logic and Computer Operations", 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 within the 7704 which use digital techniques is described using the graphic symbols set forth in military standard MIL-STD-806B. Table 3-1 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 will be described in the circuit description for the applicable device.

### 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 state. 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, "Display B Command" means that the B Time-Base unit will be displayed when this line is HI or true. Likewise, the line labeled "X-Compensation Inhibit" means that the X-Compensation function is inhibited or disabled 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 which are of importance 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 3-1.

Non-Digital Devices

It should be noted that not all of the integrated circuit devices in this instrument are digital logic devices. The function of non-digital devices will be described individually using operating waveforms or other techniques to illustrate their function.

MAIN INTERFACE

General

Diagram 1 shows the plug-in interface and the interconnections between the plug-in compartments, circuit boards, etc. of this instrument. The circuitry shown on this diagram associated with Q24 and Q28 is described in connection with the Trigger Selector circuit.

LOGIC CIRCUIT

General

The Logic Circuit develops control signals for use in other circuits within this instrument. These output signals automatically determine the correct instrument operation in relation to the plug-ins installed and/or selected, plug-in control settings, and 7704 control settings. A block diagram of the Logic Circuit is shown in Fig. 3-2. This diagram shows the source of the input control signals, the output signals produced by this stage, and the basic interconnections between blocks. The interconnections shown are intended only to indicate inter-relation between blocks and

TABLE 3-1  
Basic Logic Reference

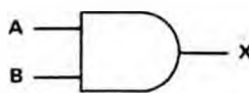
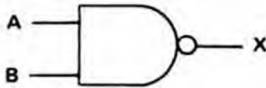

Device	Symbol	Description	Input/Output Table																		
AND gate		A device with two or more inputs and one output. The output of the AND gate is HI if and only if all of the inputs are at the HI state.	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>X</th></tr><tr><td>LO</td><td>LO</td><td>LO</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>HI</td></tr></table>	Input		Output	A	B	X	LO	LO	LO	LO	HI	LO	HI	LO	LO	HI	HI	HI
Input		Output																			
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.	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>X</th></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>HI</td></tr><tr><td>HI</td><td>HI</td><td>LO</td></tr></table>	Input		Output	A	B	X	LO	LO	HI	LO	HI	HI	HI	LO	HI	HI	HI	LO
Input		Output																			
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.	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>X</th></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>HI</td></tr><tr><td>HI</td><td>HI</td><td>HI</td></tr></table>	Input		Output	A	B	X	LO	LO	LO	LO	HI	HI	HI	LO	HI	HI	HI	HI
Input		Output																			
A	B	X																			
LO	LO	LO																			
LO	HI	HI																			
HI	LO	HI																			
HI	HI	HI																			

TABLE 3-1 (cont.)  
Basic Logic Reference


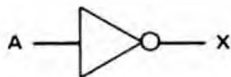





Device	Symbol	Description	Input/Output Table																		
NOR gate		A device with two or more inputs and one output. The output of the NOR gate is LO if one or more of the inputs are at the HI state.	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>X</th></tr>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

TABLE 3-1 (cont.)

## Basic Logic Reference

Device	Symbol	Description	Input/Output Table																																																																								
Triggered (toggle) Flip-Flop		A bistable device with one input and two outputs which changes output states from one stable state to the other stable state with each trigger (either or both outputs may be used). 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.	<table><tr><th colspan="2">Input</th><th colspan="2">Output</th></tr><tr><th>Condition before trigger pulse</th><th></th><th>Condition after trigger pulse</th><th></th></tr><tr><td>X</td><td><math>\bar{X}</math></td><td>X</td><td><math>\bar{X}</math></td></tr><tr><td>LO</td><td>HI</td><td>HI</td><td>LO</td></tr><tr><td>HI</td><td>LO</td><td>LO</td><td>HI</td></tr></table>	Input		Output		Condition before trigger pulse		Condition after trigger pulse		X	$\bar{X}$	X	$\bar{X}$	LO	HI	HI	LO	HI	LO	LO	HI																																																				
Input		Output																																																																									
Condition before trigger pulse		Condition after trigger pulse																																																																									
X	$\bar{X}$	X	$\bar{X}$																																																																								
LO	HI	HI	LO																																																																								
HI	LO	LO	HI																																																																								
Set-Clear (J-K) Flip-Flop		A bistable device with two inputs and two outputs which changes output states in response to the states at the inputs (either or both outputs may be used). The outputs are complementary (i.e., when one output is HI the other is LO).	<table><tr><th colspan="2">Input</th><th colspan="2">Output</th></tr><tr><th>A</th><th>B</th><th>X</th><th><math>\bar{X}</math></th></tr><tr><td>LO</td><td>LO</td><td colspan="2">No change</td></tr><tr><td>LO</td><td>HI</td><td>LO</td><td>HI</td></tr><tr><td>HI</td><td>LO</td><td>HI</td><td>LO</td></tr><tr><td>HI</td><td>HI</td><td colspan="2">Changes state</td></tr></table>	Input		Output		A	B	X	$\bar{X}$	LO	LO	No change		LO	HI	LO	HI	HI	LO	HI	LO	HI	HI	Changes state																																																	
Input		Output																																																																									
A	B	X	$\bar{X}$																																																																								
LO	LO	No change																																																																									
LO	HI	LO	HI																																																																								
HI	LO	HI	LO																																																																								
HI	HI	Changes state																																																																									
Triggered Set-Clear (J-K) Flip-Flop	<p>Without direct inputs</p> <p>With direct inputs</p>	<p>A bistable device with three or more inputs and two outputs (either or both inputs may be used). When triggered, the output changes states 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.</p> <p>For devices with direct-set (<math>S_D</math>) or direct-clear (<math>C_D</math>) 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.</p>	<table><tr><th colspan="4">Input</th><th colspan="2">Output</th></tr><tr><th>A</th><th>B</th><th><math>C^1</math></th><th><math>D^1</math></th><th>X</th><th><math>\bar{X}</math></th></tr><tr><td colspan="6">Conditions for triggered operation (output condition after trigger pulse)</td></tr><tr><td>LO</td><td>LO</td><td>LO</td><td>LO</td><td colspan="2">No change</td></tr><tr><td>LO</td><td>HI</td><td>LO</td><td>LO</td><td>LO</td><td>HI</td></tr><tr><td>HI</td><td>LO</td><td>LO</td><td>LO</td><td>HI</td><td>LO</td></tr><tr><td>HI</td><td>HI</td><td>LO</td><td>LO</td><td colspan="2" rowspan="2">Changes state</td></tr><tr><td colspan="6">Conditions for direct-set, direct-clear operation</td></tr><tr><td><math>\Phi</math></td><td><math>\Phi</math></td><td>LO</td><td>LO</td><td colspan="2">No change</td></tr><tr><td><math>\Phi</math></td><td><math>\Phi</math></td><td>LO</td><td>HI</td><td>LO</td><td>HI</td></tr><tr><td><math>\Phi</math></td><td><math>\Phi</math></td><td>HI</td><td>LO</td><td>HI</td><td>LO</td></tr><tr><td><math>\Phi</math></td><td><math>\Phi</math></td><td>HI</td><td>HI</td><td colspan="2">Undefined</td></tr></table> <p><math>\Phi</math> = Has no effect in this case</p> <p><sup>1</sup> Applies only with direct inputs.</p>	Input				Output		A	B	$C^1$	$D^1$	X	$\bar{X}$	Conditions for triggered operation (output condition after trigger pulse)						LO	LO	LO	LO	No change		LO	HI	LO	LO	LO	HI	HI	LO	LO	LO	HI	LO	HI	HI	LO	LO	Changes state		Conditions for direct-set, direct-clear operation						$\Phi$	$\Phi$	LO	LO	No change		$\Phi$	$\Phi$	LO	HI	LO	HI	$\Phi$	$\Phi$	HI	LO	HI	LO	$\Phi$	$\Phi$	HI	HI	Undefined	
Input				Output																																																																							
A	B	$C^1$	$D^1$	X	$\bar{X}$																																																																						
Conditions for triggered operation (output condition after trigger pulse)																																																																											
LO	LO	LO	LO	No change																																																																							
LO	HI	LO	LO	LO	HI																																																																						
HI	LO	LO	LO	HI	LO																																																																						
HI	HI	LO	LO	Changes state																																																																							
Conditions for direct-set, direct-clear operation																																																																											
$\Phi$	$\Phi$	LO	LO	No change																																																																							
$\Phi$	$\Phi$	LO	HI	LO	HI																																																																						
$\Phi$	$\Phi$	HI	LO	HI	LO																																																																						
$\Phi$	$\Phi$	HI	HI	Undefined																																																																							

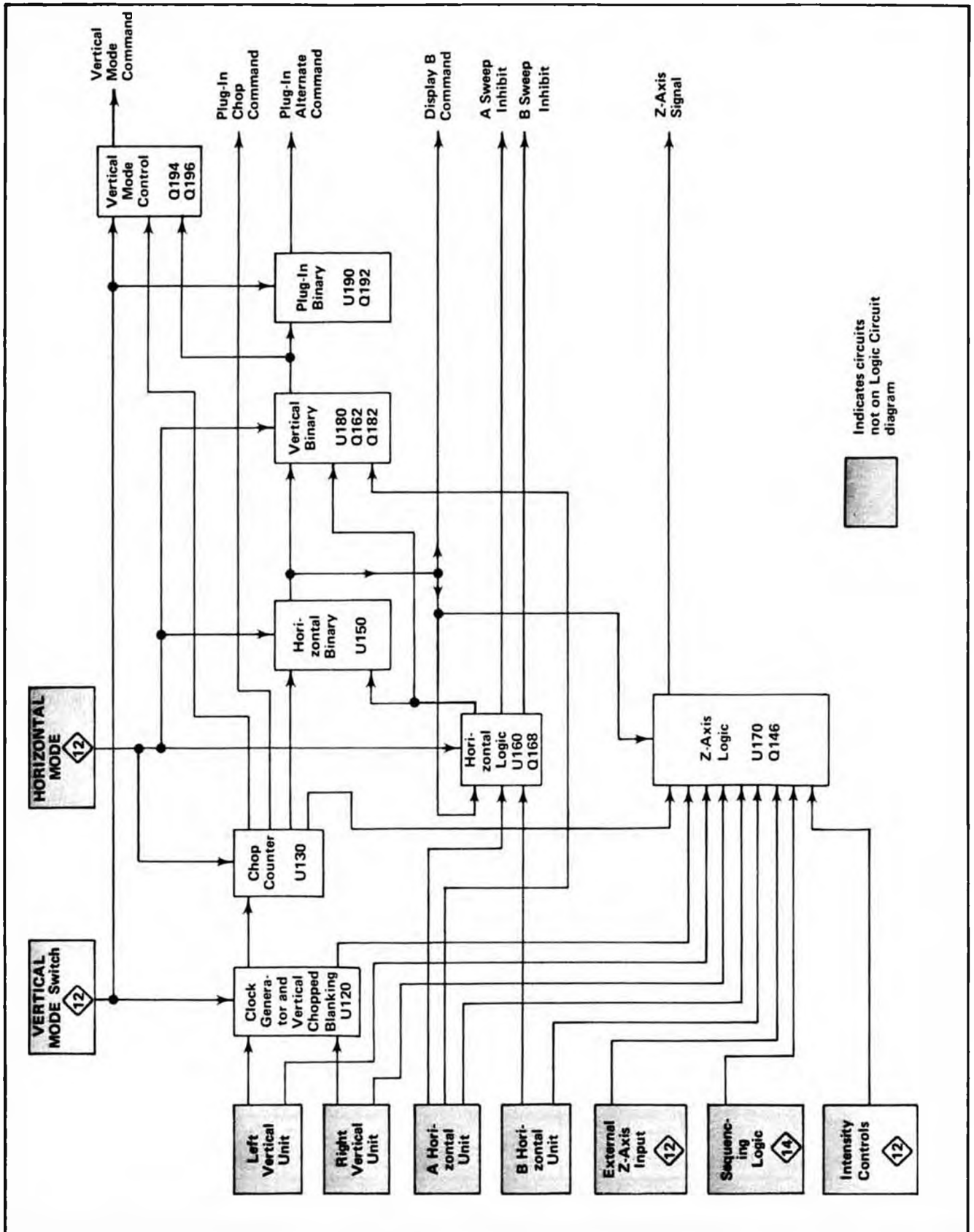


Fig. 3-2. Block diagram of Logic Circuit.



do not indicate a direct connection or that only a single connection is made between the given blocks. Details of the inter-relation between stages in this circuit are given in the circuit description which follows. A schematic of this circuit is shown on diagram 2 at the rear of this manual.

This circuit description for the Logic Circuit is written with the approach that each of the integrated circuits and its associated discrete components comprises an individual stage as shown by the block diagram (Fig. 3-2). The operation of each of these stages is discussed relating the input signals and/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 which are of importance to perform the prescribed function of an individual stage.

## Horizontal Logic

**General.** The Horizontal Logic stage performs three separate logic functions. These functions are; A Sweep Inhibit, B Sweep Inhibit and Alternate Pulse Generator. Fig. 3-3 identifies the three individual stages and the input and output terminals associated with each. Notice that some of the input levels are used in several or all of the individual stages.

**A Sweep Inhibit.** The A Sweep Inhibit stage produces an output level at pin 14 which determines if the A Time-Base unit can produce a sweep. If this level is HI, the A Time-Base unit is locked out (disabled) so it cannot produce a sweep. If the level is LO, the A Time-Base unit is enabled and can produce a sweep when triggered.

Only two combinations of input conditions produce an A Sweep Inhibit level (HI); if any one of the prescribed conditions is not met, the A Sweep Inhibit level is LO to enable the A Time-Base unit. These conditions are:

1. Pin 1 HI—HORIZONTAL MODE switch set to ALT.

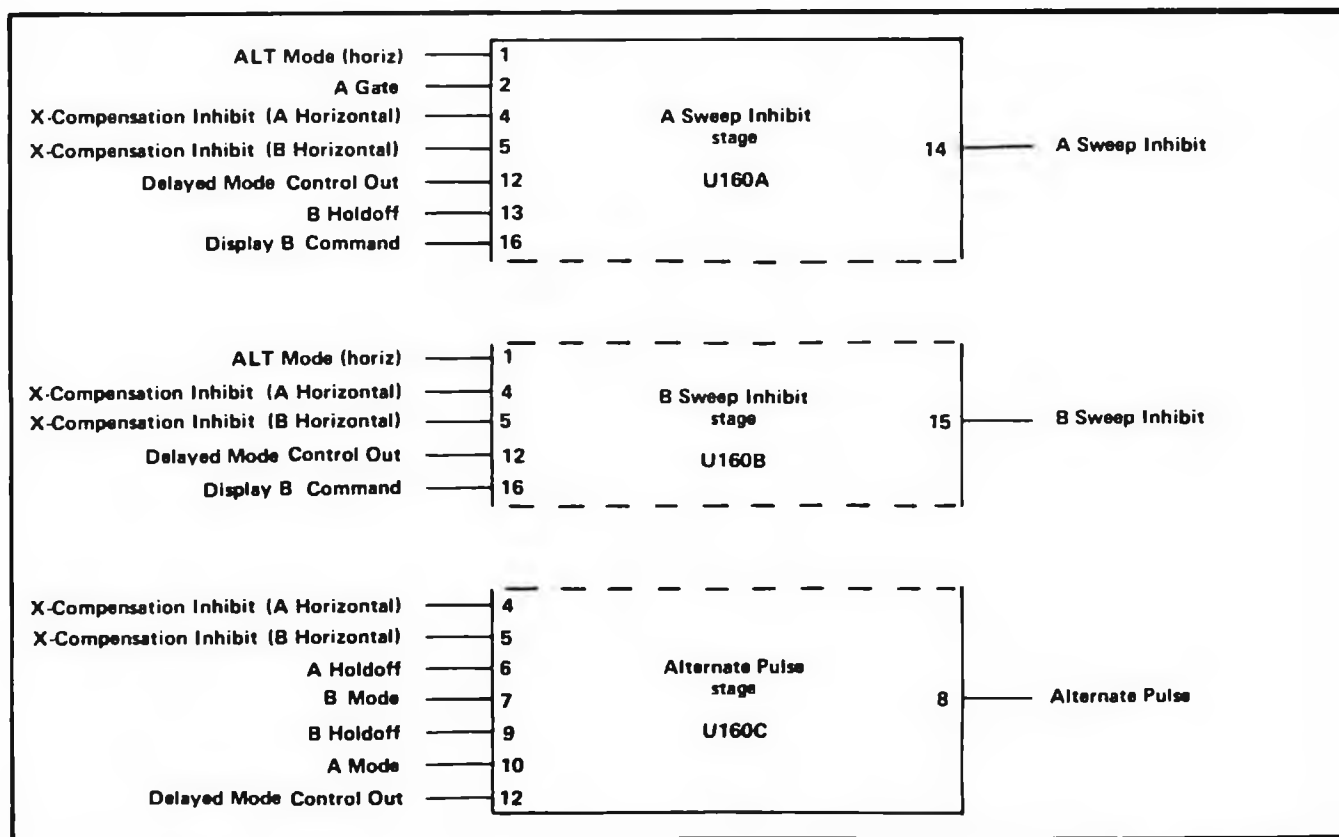


Fig. 3-3. Breakdown of separate stages within Horizontal Logic (U160) showing inputs and outputs for each stage.

Pin 4 HI—A Horizontal unit operated in time-base mode.

Pin 5 HI—B Horizontal unit operated in time-base mode.

Pin 12 LO—A Time-Base unit in independent (non-delayed) mode.

Pin 16 HI—B Sweep unit is being displayed in the horizontal-alternate mode.

2. Pin 2 LO—A Time-Base unit is not already producing a sweep.

Pin 12 HI—A Time-Base unit in delayed mode.

Pin 13 HI—B Time-Base unit has just completed a sweep and is in holdoff condition.

The first combination disables the A Sweep while the B Sweep is being displayed in the horizontal ALT 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 the B Sweep can complete its holdoff before the next A Sweep begins.

A logic diagram for the A Sweep Inhibit stage is shown in Fig. 3-4A. A table of input/output combinations for this stage is shown in Fig. 3-4B. This table shows the level at each input for the two combinations that produce a HI output level.

**B Sweep Inhibit.** The B Sweep Inhibit stage produces an output level at pin 15 of U160B which determines if the B Time-Base unit can produce a sweep. A HI level at this pin disables the B Sweep and a LO level provides an enabling level to the B Time-Base unit. The output at pin 15 is HI only under one set of input conditions. These conditions are:

Pin 1 HI—HORIZONTAL MODE switch set to ALT.

Pin 4 HI—A Horizontal unit operated in time-base mode.

Pin 5 HI—B Horizontal unit operated in time-base mode.

Pin 12 LO—A Time-Base unit in independent (non-delayed) mode.

Pin 16 LO—A Sweep is being displayed in the horizontal-alternate mode.

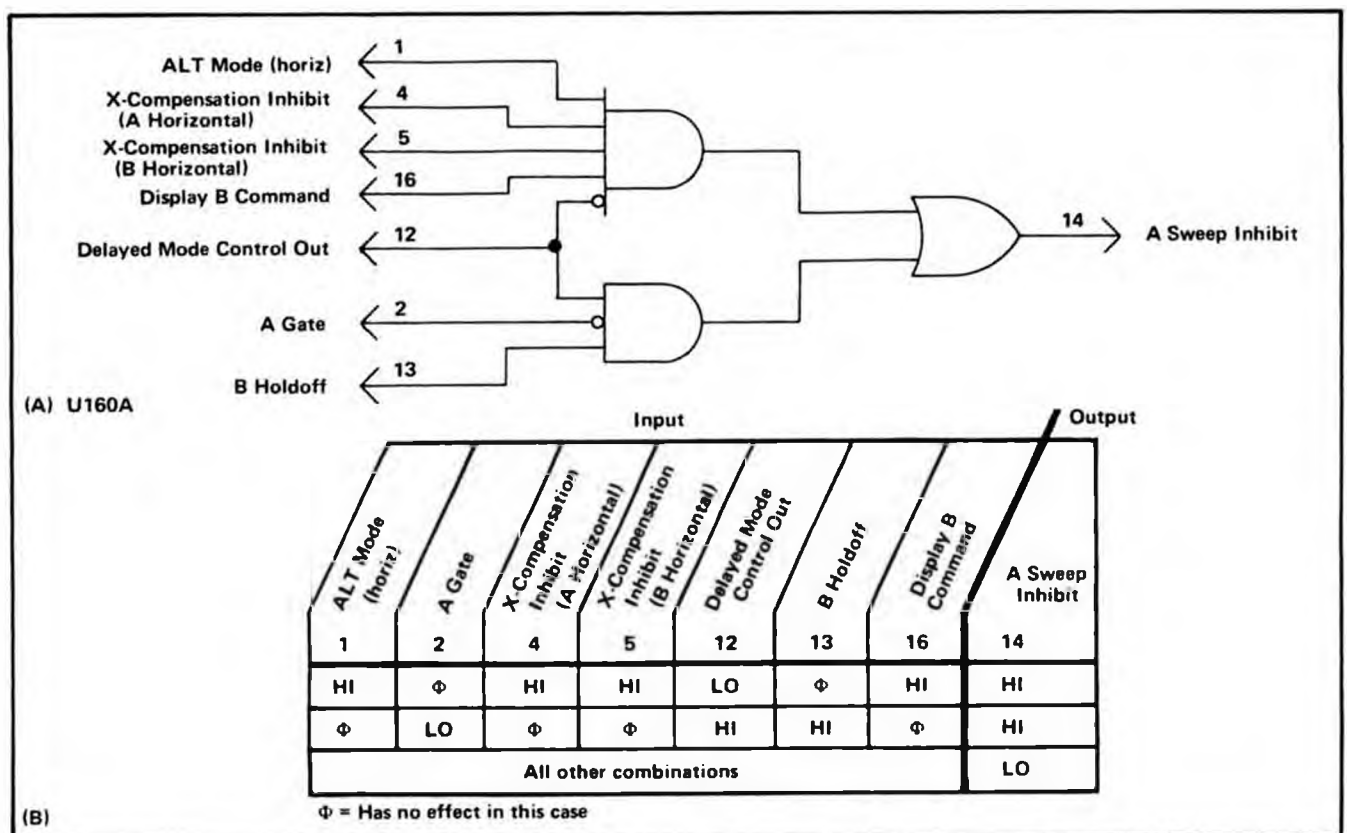


Fig. 3-4. (A) Logic diagram for A Sweep Inhibit stage, (B) Table of input/output combinations for A Sweep Inhibit stage.

These conditions disable the B Sweep while the A Sweep is being displayed in the horizontal ALT mode (both units must be in time-base mode) if non-delayed sweep is used. For any other combination of input conditions, the B Sweep Inhibit level at pin 15 is LO. However, the inhibit 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.

Fig. 3-5A shows the logic diagram of the B Sweep Inhibit stage. The gate connected to the output of this stage is a phantom-OR gate located on the Main Interface diagram (a phantom-OR gate performs the OR-logic function merely by interconnection of the two signals). An input/output table for the B Sweep Inhibit stage is shown in Fig. 3-5B.

**Alternate Pulse Generator.** The third function performed by U160 is to produce alternate pulses for use by the horizontal and vertical alternate systems. The conditions that exist at the inputs to the Alternate Pulse Generator stage determine which time base provides the Alternate Pulse. The Alternate Pulse is a positive-going pulse (falling edge only used by following-stages) which is coincident with the

leading edge of the holdoff gate from the time-base units. The holdoff gate is produced at the end of the sweep by the respective time-base unit, and differentiated by either C165 or C166 to provide a positive-going pulse to pins 6 or 9. The Alternate Pulse is produced at the end of either the A Sweep or the B Sweep, or both, depending upon the operating conditions. The following discussions describe the operation of the Alternate Pulse Generator stage in relation to various combinations of input conditions that can occur.

1. A (ONLY) MODE

The Alternate Pulse is produced only at the end of the A Sweep when the HORIZONTAL MODE switch is set to the A position. The input conditions are:

- Pin 4 HI—A Horizontal unit operated in time-base mode.
- Pin 6 HI—Holdoff pulse produced at end of A Sweep.
- Pin 7 LO—HORIZONTAL MODE switch set to any position except B.
- Pin 10 HI—HORIZONTAL MODE switch set to A.

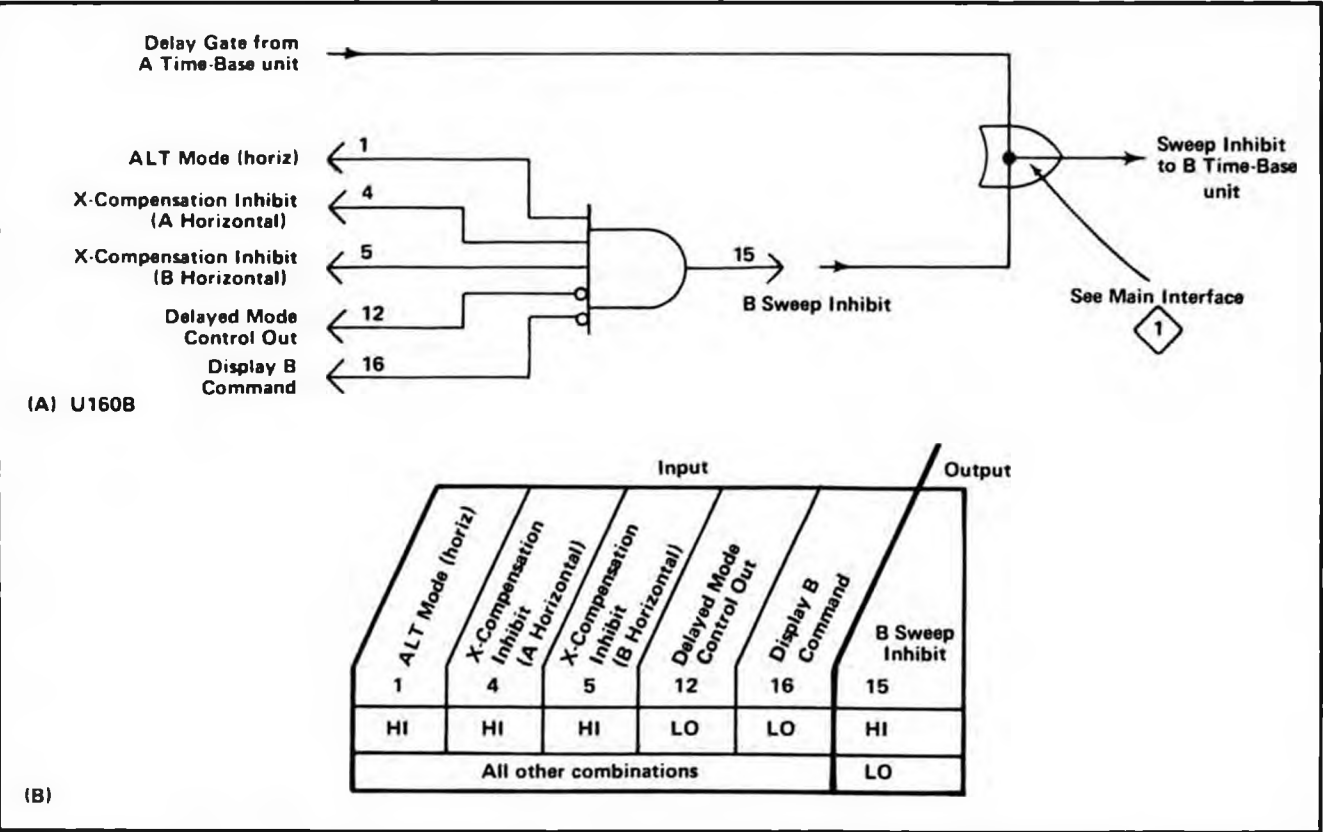


Fig. 3-5. (A) Logic diagram for B Sweep Inhibit stage, (B) Table of input/output combinations for B Sweep Inhibit stage.

## 2. B (ONLY) MODE—NON-DELAYED

In the B position of the HORIZONTAL MODE switch, the Alternate Pulse is produced only at the end of the B Sweep (A Time-Base must be in independent mode). The input conditions are:

Pin 5 HI—B Horizontal unit operated in time-base mode.

Pin 7 HI—HORIZONTAL MODE switch set to B.

Pin 9 HI—Holdoff pulse produced at end of B Sweep.

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

Pin 12 LO—A Time-Base unit in independent (non-delayed) mode.

## 3. ALTERNATE OR CHOPPED OPERATION—NON-DELAYED

When the HORIZONTAL MODE switch is set to ALT or CHOP (A Time-Base unit must be in independent mode), an Alternate Pulse is produced at the end of each sweep. For example, an Alternate Pulse is produced first 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. The input conditions for this mode of operation are:

Pin 4 HI—A Horizontal unit operated in time-base mode.

Pin 5 HI—B Horizontal unit operated in time-base mode.

Pin 6 HI—Holdoff pulse produced at end of A Sweep<sup>1</sup>

Pin 7 LO—HORIZONTAL MODE switch set to any position except B.

Pin 9 HI—Holdoff pulse produced at end of B Sweep<sup>1</sup>.

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

Pin 12 LO—A Time-Base unit in independent (non-delayed) mode.

## 4. DELAYED SWEEP

When the A Time-Base unit is set for delayed operation, the operation of the stage 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 whenever it is displayed. The input conditions for this mode of operation are:

Pin 4 HI—A Horizontal unit operated in time-base mode.

Pin 5 HI—B Horizontal unit operated in time-base mode.

Pin 6 HI—Holdoff pulse produced at end of A Sweep.

Pin 12 HI—A Time-Base unit in delayed mode.

## 5. VERTICAL UNIT IN HORIZONTAL COMPARTMENT

When a vertical 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 vertical units are installed in both horizontal plug-in compartments, an Alternate Pulse is not produced under normal operating conditions since there are no time-base units to produce a holdoff pulse.

### NOTE

*The conditions of the Alternate Pulse Generator with vertical units in both horizontal plug-in compartments are such that an Alternate Pulse could be produced if positive-going pulses are applied to pins 6 and 9. Although not used for normal operation, this mode may be used in special purpose plug-ins.*

## 6. ONE TIME-BASE REMOVED

If either time-base unit is removed from its compartment and the compartment is left vacant, an Alternate Pulse can not be produced. Although the input levels to the Alternate Pulse Generator stage will allow an output pulse to be produced by the remaining time-base unit, further operation is prevented by the A or B Sweep Inhibit stages.

A logic diagram for the Alternate Pulse Generator stage is shown in Fig. 3-6A. Note the resistors shown connected to pins 6 and 9 of U160C. These resistors, which are internal to the device, hold the level 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 from the respective time base. Fig. 3-6B shows an input/output table for the Alternate Pulse Generator stage.

## 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 hori-

<sup>1</sup>Simultaneous HI at pins 6 and 9 are not required; a HI at either input produces an Alternate Pulse if other conditions are met.

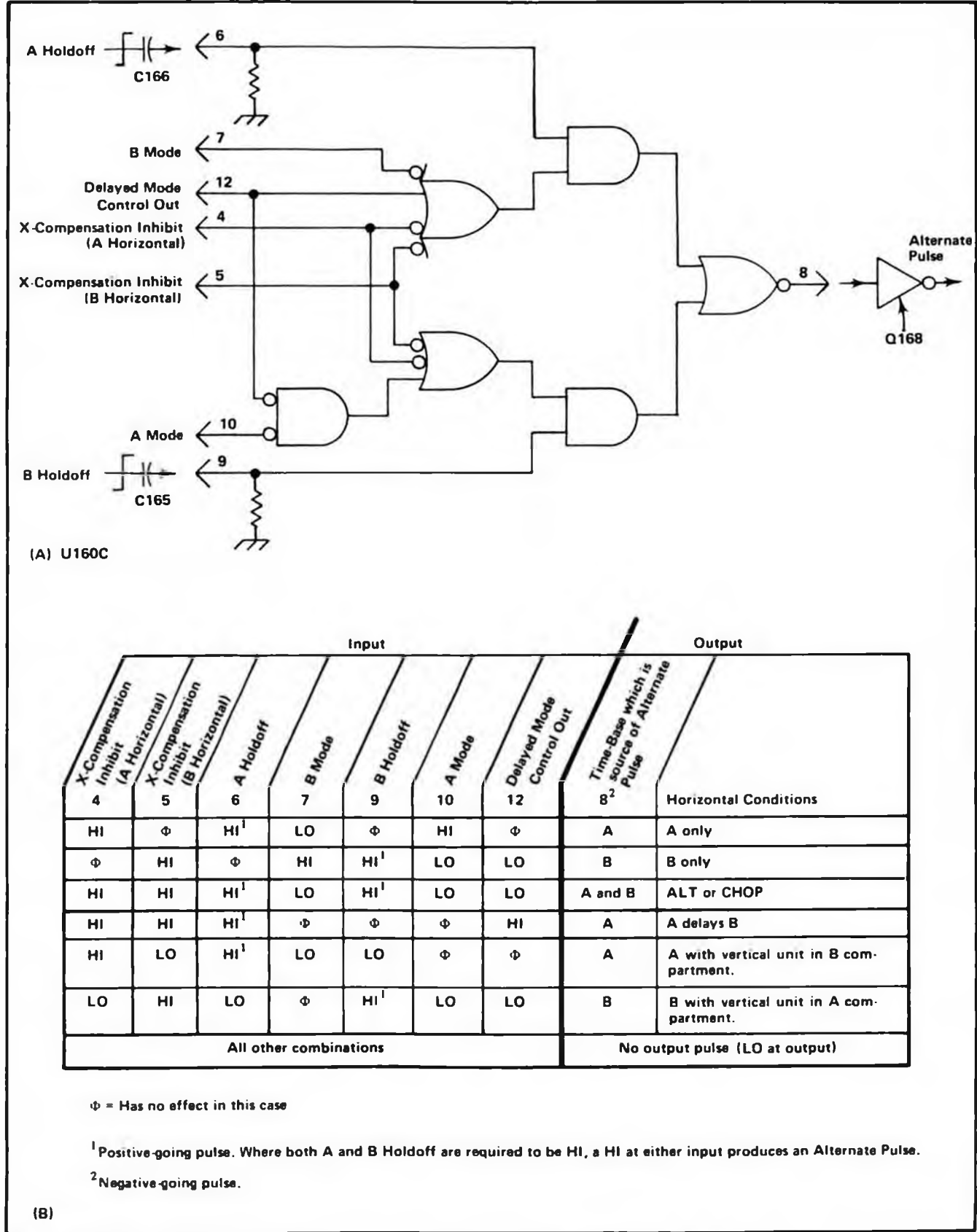


Fig. 3-6. (A) Logic diagram for Alternate Pulse Generator stage, (B) Table of input/output combinations for the Alternate Pulse Generator stage.

zontal display. The Vertical Chopped Blanking, Horizontal Chopped Blanking and Readout Blanking 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.

Fig. 3-7 identifies the inputs to the Z-Axis Logic circuit. 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 0 to 4 milliamperes and is determined by the applicable current source to control the output current at pin 8.

The Vertical Chopped Blanking connected to pin 6, and the Horizontal Chopped Blanking connected to both pins 6 and 7 through CR145-CR146, 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 signal is connected to pin 6 of U170 directly from pin 4 of U120. The Horizontal Chopped Blanking signal is connected to U170 from pin 4 of U130 through LR134, Q146 and CR145-CR146 (see diagram 2). Notice that this signal is connected to the collector of Q146. This transistor is normally operating in the saturated condition and the HI Horizontal Chopped Blanking level from U130 is the collector source voltage. When the Horizontal Chopped Blanking level goes LO, the current through Q146 drops to produce a corresponding LO level at its emitter. This level is connected to both pins 6 and 7 of U170 through CR145 and CR146.

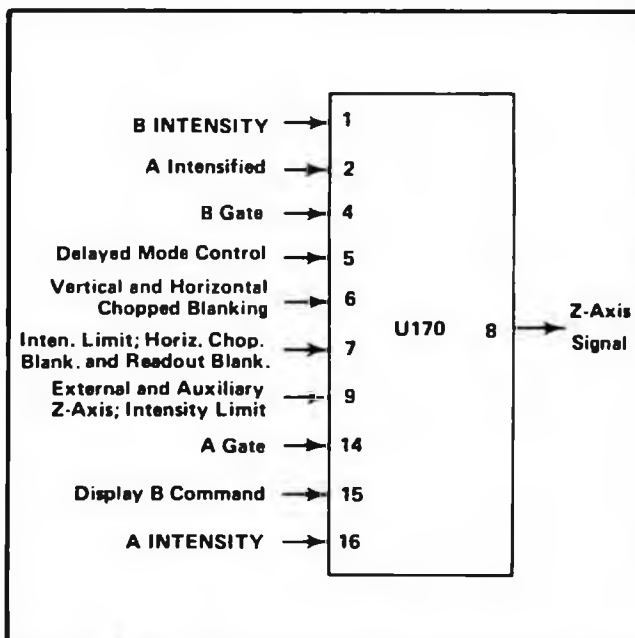


Fig. 3-7. Input and output pins for Z-Axis Logic stage.

Q146 also controls the levels at pins 6 and 7 for readout displays. The Z-Axis Logic OFF Command from the Readout Circuit is connected to the base of Q146 through VR148 and R147. This level is normally HI so Q146 operates as controlled by the Horizontal Chopped Blanking 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 Q146 through VR148 with very little voltage attenuation. Q146 is reverse-biased to produce a LO level at its emitter. This level is coupled to pins 6 and 7 of U170 through CR145 and CR146 to block the Z-Axis Logic output current during the readout display (intensity of readout display determined by a separate Readout Intensity level connected directly to the Z-Axis Amplifier; see CRT Circuit description). Diode CR147 clamps the emitter of Q146 at about  $-0.6$  volts when this transistor is off.

The Intensity Limit input at pins 7 and 9 provides protection for the CRT phosphor at slow sweep rates or when the BEAM FINDER switch is actuated. For conditions that do not require limiting, about 2.5 milliamperes is connected to pins 7 and 9. This current is established by resistors R140-R141-R142-R143-R144-R145-R175. When either of the time-base units is set to a sweep rate which requires intensity limiting, the junction of R143-R144-R145 is connected to ground in the time-base unit. This drops the current level at pins 7 and 9 to about 1.0 milliamperes to limit the output current from this stage. Limiting the output current of this stage in turn limits the maximum trace intensity for all CRT displays whenever either of the time-base units is set to a sweep rate that requires intensity limiting. The Max Intensity adjustment R140 is set to provide optimum writing rate on the CRT when the INTENSITY controls are set fully clockwise.

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 level goes HI indicating that the B Sweep is being displayed, the A INTENSITY current is blocked. The current from the A INTENSITY control (see diagram 12) is connected to pin 16 through R176.

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 the portion of the A sweep which will be displayed in the delayed mode. The A Intensified current is supplied to pin 2 of U170 from the A INTENSITY control through R178. 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

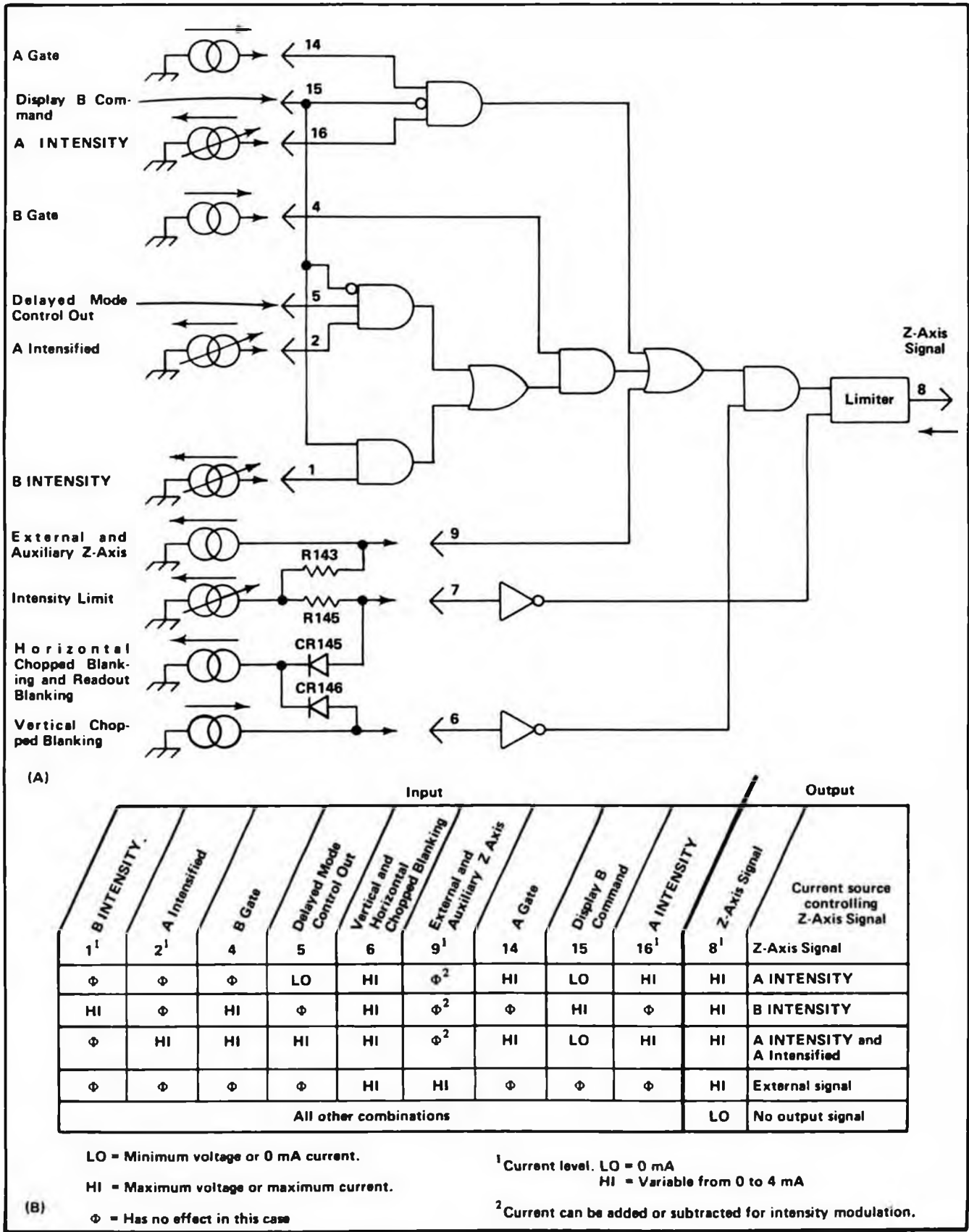


Fig. 3-8. (A) Logic diagram for Z-Axis Logic circuit, (B) Table of input/output combinations for Z-Axis Logic circuit.

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 Delayed 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 (see diagram 12) is connected to the Z-Axis Logic stage through R179.

The current level established by the intensity controls can be altered by the External and Auxiliary Z-Axis current level at pin 9. The current at this pin can come from the Z AXIS INPUT connectors on the rear panel through R112 or from any of the plug-in compartments through R110, R111, R113, or R114. 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 connectors 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 CR175 and CR176 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 connectors.

Fig. 3-8A 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. 3-8B.

## Horizontal Binary

The Horizontal Binary stage produces the Display B Command to determine which horizontal unit is to be displayed on the CRT. When this level is HI, the B Horizontal unit is displayed and when it is LO, the A Horizontal unit is displayed. The Display B Command is used in the following stages within the Logic Circuit: Horizontal Logic (A and B Lockout), Z-Axis Logic, and Vertical Binary. In addition, it is connected to the following circuits elsewhere in the instrument to indicate which horizontal unit is to be displayed: Main Interface circuit (A and B Horizontal plug-in compartments), Vertical Interface circuit (for trace separation) and Horizontal Interface circuit (for horizontal channel selection). Fig. 3-9 identifies the function of the input pins for this stage. The following discussions describe the operation of the Horizontal Binary stage in each position of the HORIZONTAL MODE switch.

### 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 Horizontal unit is to be displayed. The levels at pins

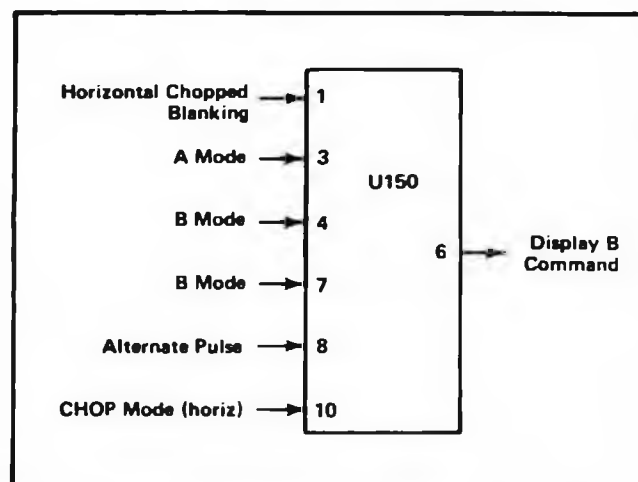


Fig. 3-9. Input and output pins for Horizontal Binary stage.

3, 4, 7 and 10 are determined by the HORIZONTAL MODE switch (see diagram 12). 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, for U150 either pin 3, pins 4 and 7 (notice that pins 4 and 7 are tied together at U150), or pin 10 can be HI and the two unselected lines from the HORIZONTAL MODE switch remain LO. The input conditions for A horizontal mode operation are:

Pin 3 HI—HORIZONTAL MODE switch set to A.

Pin 4 and 7 LO—HORIZONTAL MODE switch set to any position except B.

Pin 10 LO—HORIZONTAL MODE switch set to any position except CHOP.

### 2. B MODE

Selecting the B horizontal mode provides a HI Display B Command to all circuits. The input conditions are:

Pin 3 LO—HORIZONTAL MODE switch set to any position except A.

Pin 4 and 7 HI—HORIZONTAL MODE switch set to B.

Pin 10 LO—HORIZONTAL MODE switch set to any position except CHOP.

### 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 which switches between the A and B Horizontal 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 (see Chop Counter stage for further information on this pulse)



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Each time the Horizontal Chopped Blanking Pulse at pin 1 drops LO, the output at pin 6 switches to the opposite state. The input conditions which cause the output to change states are:

Pin 1 LO—Horizontal Chopped Blanking pulse generated by Chop Counter stage goes negative.

Pin 3 LO—HORIZONTAL MODE switch set to any position except A.

Pin 4 and 7 LO—HORIZONTAL MODE switch set to any position except B.

Pin 10 HI—HORIZONTAL MODE switch set to CHOP.

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

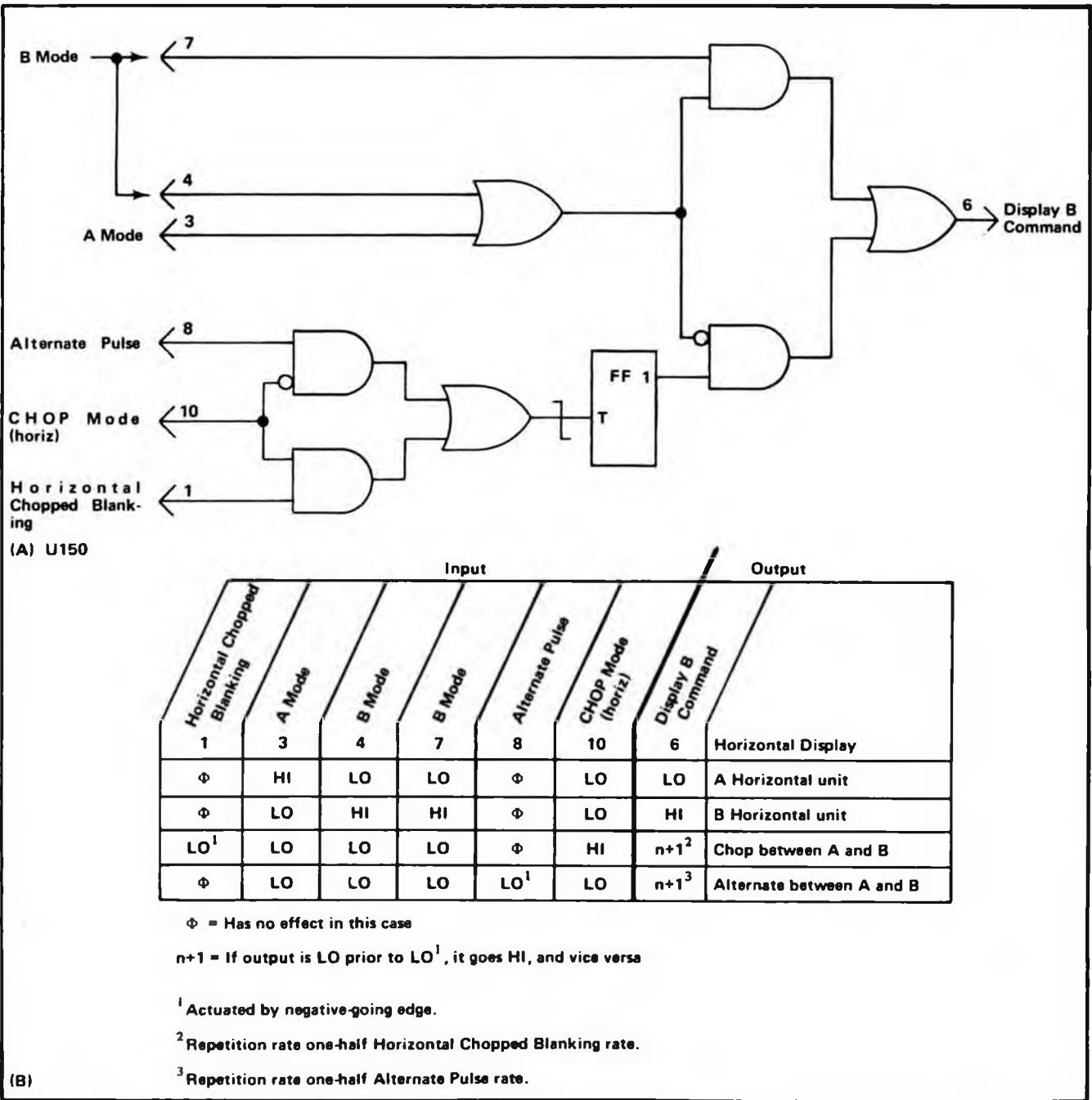


Fig. 3-10. (A) Logic diagram for Horizontal Binary stage, (B) Table of input/output combinations for the Horizontal Binary stage.

Logic stage. Repetition rate of the Display B Command in this mode is one-half the repetition rate of the Alternate Pulse. The input conditions which cause the output to change states are:

Pin 3 LO—HORIZONTAL MODE switch set to any position except A.

Pin 4 and 7 LO—HORIZONTAL MODE switch set to any position except B.

Pin 8 LO—Alternate Pulse generated by Horizontal Logic stage goes negative.

Pin 10 LO—HORIZONTAL MODE switch set to any position except CHOP.

Fig. 3-10A shows a logic diagram of the Horizontal Binary stage. An input/output table showing the conditions for each position of the HORIZONTAL MODE switch is shown in Fig. 3-10B.

### 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 Vertical unit is displayed and when it is LO, the Left Vertical 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 sweep-slaving operation in the ALT position of the VERTICAL MODE switch and the ALT or CHOP positions of the HORIZONTAL MODE switch whereby the Left Vertical unit is always displayed at the sweep rate of the B Time-Base unit and the Right Vertical unit at the sweep rate of the A Time-Base unit.

When the A Time-Base unit is set to the delayed 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) and 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 Control. It is also connected to the following circuits elsewhere in the instrument to indicate which vertical unit is to be displayed (through Vertical Mode Control stage; ALT vertical mode only): Main Interface circuit (Left and Right Vertical plug-in compartments and trigger selection circuitry) and Vertical Interface circuit.

Fig. 3-11 identifies the function of the input pins for the Vertical Binary stage. This stage uses the same type of

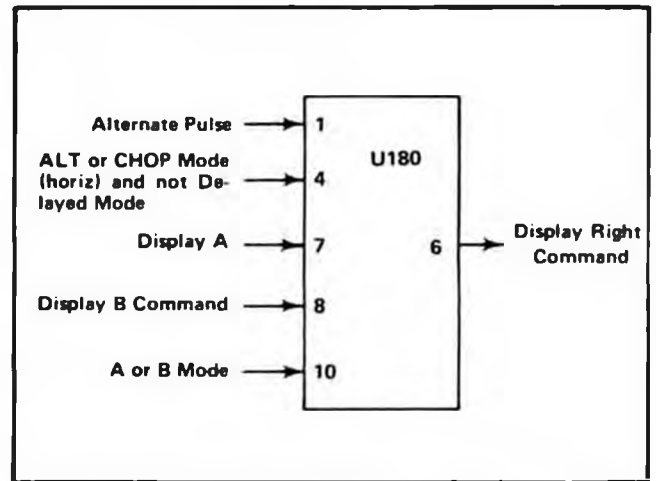


Fig. 3-11. Input and output pins for Vertical Binary stage.

integrated circuit 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. 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 U180 is always controlled by the HORIZONTAL MODE switch as described here, this level determines the Vertical Mode Control level at the collector of Q196 only in the ALT position of the VERTICAL MODE switch due to AND gate CR183-CR184. 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.

#### 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 Vertical unit is always displayed at the sweep rate of the A Time-Base unit and the Left Vertical unit at the sweep rate of the B Time-Base unit (sweep slaving). The input conditions to provide a HI output level so that the

Right Vertical 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.

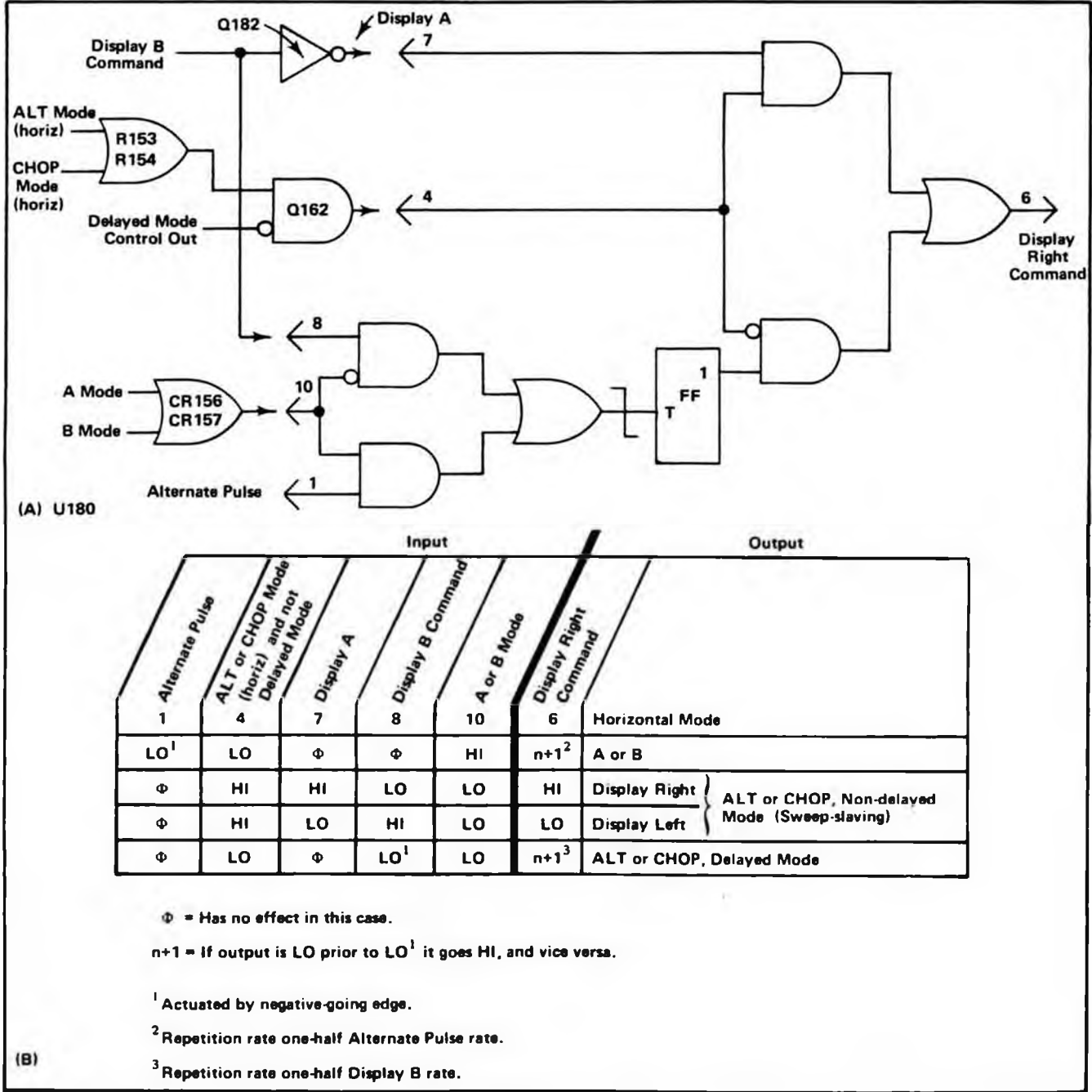


Fig. 3-12. (A) Logic diagram for Vertical Binary stage, (B) Table of input/output combinations for the Vertical Binary stage.

The input conditions to provide a LO output level so the Left Vertical 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 which is one-half the repetition rate of the Display B Command. The resultant CRT display allows the Right Vertical unit to be displayed first against the A Sweep (delaying) and then against the B Sweep (delayed). Then the display switches to the Left Vertical unit and it 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. 3-12A. 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. 3-12B.

### Plug-In Binary

The Plug-In Binary stage produces the Display Channel 2 Command to provide a Plug-In Alternate Command to dual-trace vertical units. Fig. 3-13 identifies the function of the input pins for the Plug-In Binary stage. This stage uses the same type of integrated circuit as the Horizontal Binary and Vertical Binary stages.

When the Display Channel 2 Command level is HI and the vertical plug-ins are 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 Display Channel 2 Command is determined by the setting of the VERTICAL

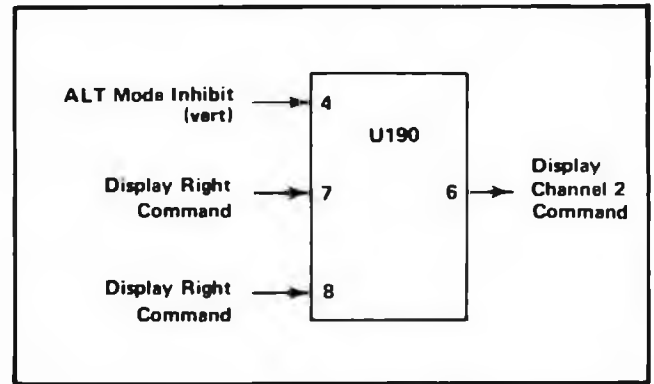


Fig. 3-13. Input and output pins for Plug-In Binary stage.

MODE switch. For all positions except ALT, the Display Channel 2 Command is the same as the Display Right Command from the Vertical Binary stage. Since the Display Right Command was 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 slaving 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 and Display B Command HI).

The input conditions to provide a HI output level so that Channel 2 of the plug-in 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 and Display B Command LO).

The Display Channel 2 Command switches from HI to LO as the Display B Command from the Horizontal Binary stage switches from LO to HI, and vice versa.

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 or both 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 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 Vertical unit at sweep rate of B Time-Base unit, 2. Channel 1 of Right Vertical unit at sweep rate of A Time-Base unit, 3. Channel 2 of Left Vertical unit at sweep rate of B Time-Base unit, 4. Channel 2 of Right Vertical unit at sweep rate of A Time-Base unit. Notice that under these conditions, both channels of the Left Vertical unit are displayed at the B Sweep rate and that both channels of the Right Vertical 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.

Fig. 3-14A shows a logic diagram of the Plug-In Binary stage. An input/output table for this stage is given in Fig. 3-14B.

### Clock Generator

One half of integrated circuit U120 along with the external components shown in Fig. 3-15A make up the Clock Generator stage. R1, Q1, Q2 and Q3 represent an equivalent circuit which is contained within U120A. This circuit

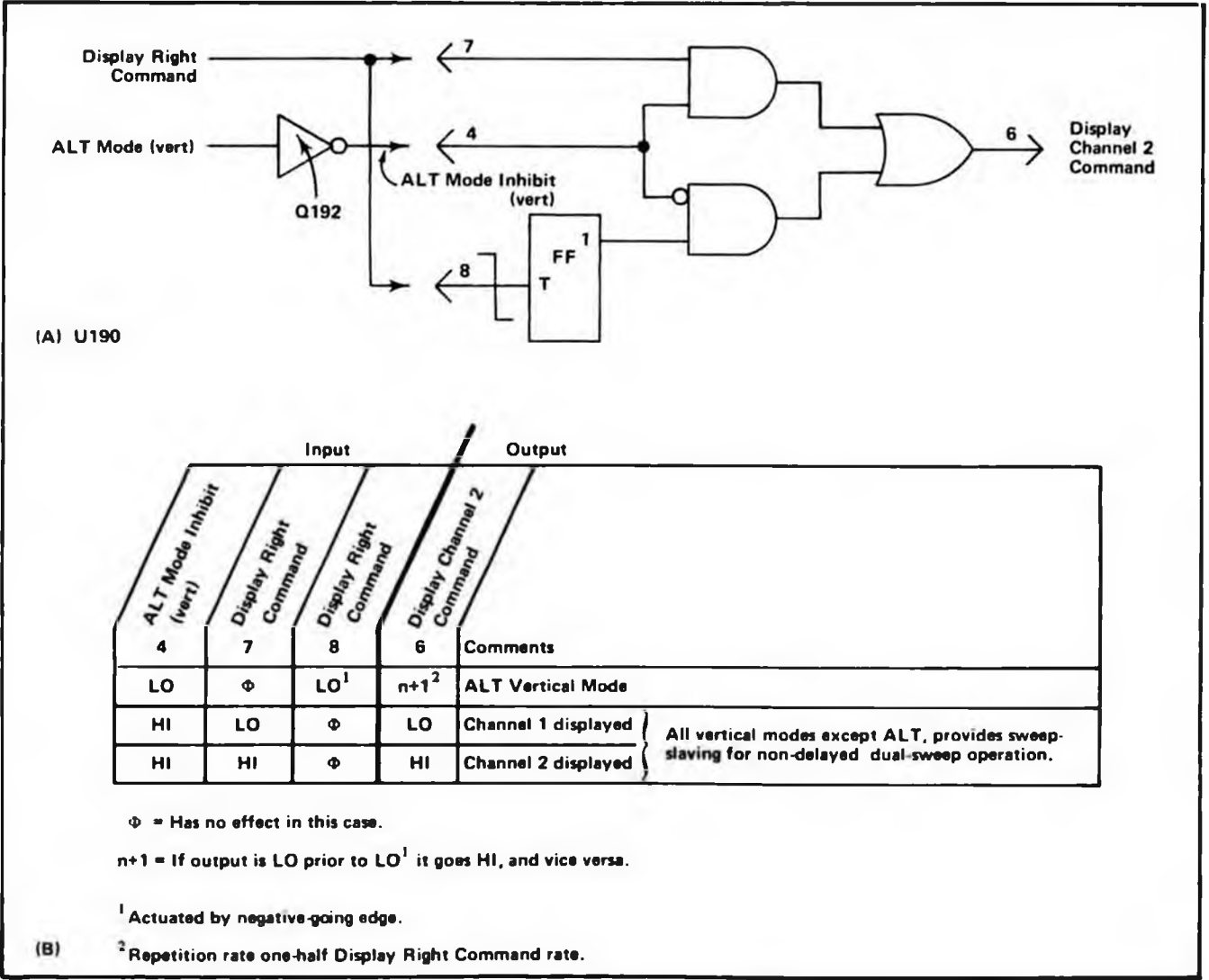


Fig. 3-14. (A) Logic diagram for Plug-In Binary stage, (B) Table of input/output combinations for the Plug-In Binary stage.

along with discrete components C117-R116-R117-R118 comprise a two-megahertz free-running oscillator to provide a timing signal (clock) for vertical, horizontal, and plug-in chopping.

The stage operates as follows: Assume that Q2 is conducting and Q1 is off. The collector current of Q2 produces a voltage drop across R1 which holds Q1 off. This negative level at the collector of Q2 is also connected to pin 14 through Q3 (see waveforms in Fig. 3-15B at time  $T_0$ ). Since there is no current through Q1, C117 begins to charge towards -15 volts through R116-R117. The emitter of Q1 goes negative as C117 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 C117 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, C117 can begin to discharge through R118. The emitter level of Q2 follows the discharge of C117 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, C117 begins to charge through R116-R117 to start the second cycle.

Two outputs are provided from this oscillator. The Delay Ramp signal from the junction of R116-R117 is connected to the Vertical Chopped Blanking stage. This signal has the same waveshape as shown by the waveform at pin 13 with its slope determined by the divider ratio between R116-R117. A square-wave output is provided at pin 14. The frequency of this square wave is determined by the overall RC relationship between C117-R116-R117-R118, and its duty cycle is determined by the ratio of R116-R117 to R118.

The square wave at pin 14 is connected to pin 16 through C119. C119, along with the internal resistance of U120A, 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 which is also part of U120A. The output at pin 15 is a

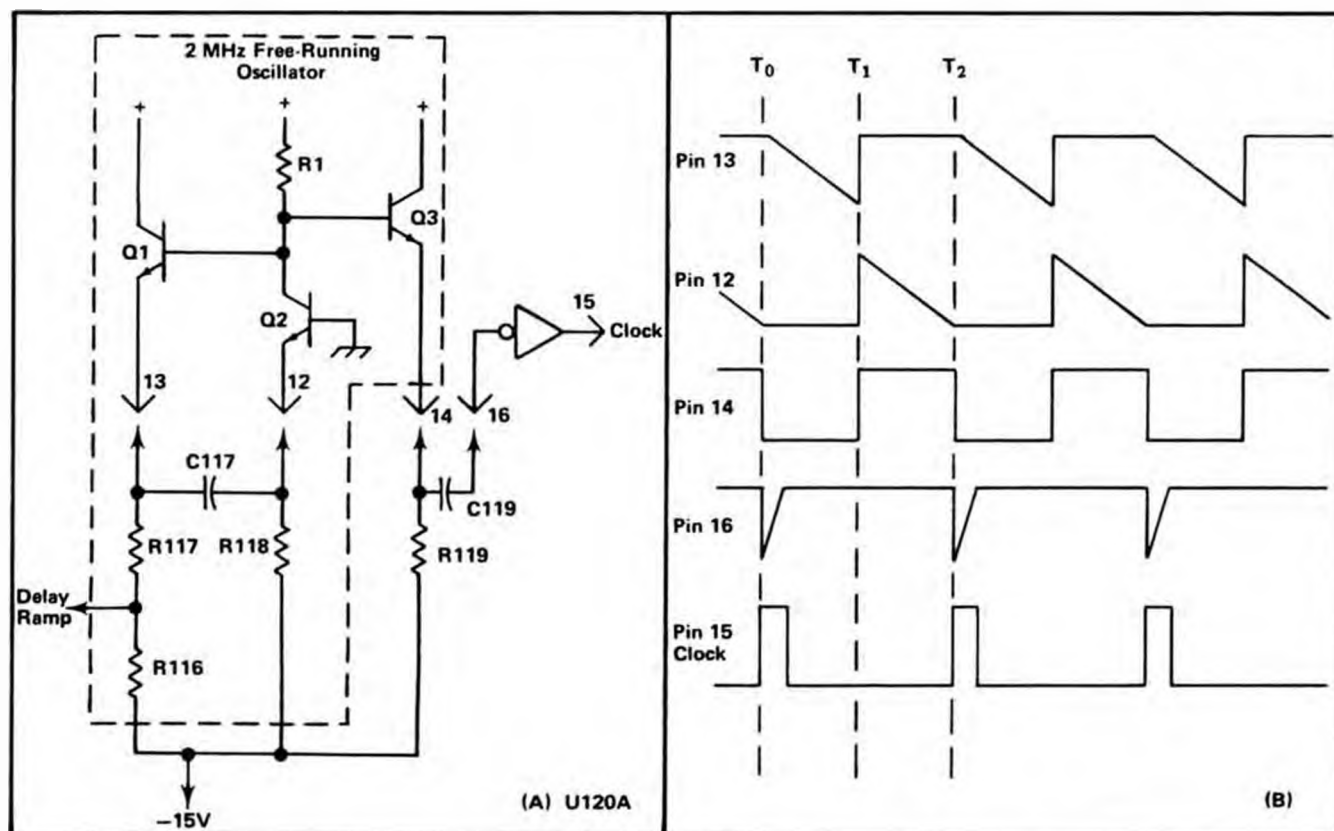


Fig. 3-15. (A) Diagram of Clock Generator stage, (B) Idealized waveforms for Clock Generator stage.

positive-going Clock pulse at a repetition rate of about two megahertz.

## Vertical Chopped Blanking

The Vertical Chopped Blanking stage is made up of the remaining half of integrated circuit U120. This stage determines if Vertical 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 always two megahertz as determined by the Clock Generator stage.

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. 3-16B). 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 Blanking pulse output level changes to the LO state. This signal remains LO until the Delay Ramp goes HI again. Notice the delay between the leading edge of the Clock pulse generated by U120A and the leading edge of the Vertical Chopped Blanking pulses (see Fig. 3-16B). The amount of delay between the leading edges of these pulses is determined by the slope of 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 discussion for more information).

Whenever this instrument is turned on, Vertical Chopped Blanking pulses are being produced at a two-megahertz rate. However, these pulses are available as an output at pin 4 only when the remaining inputs to U120B are at the correct levels. The following discussions give the operating conditions which produce Vertical Chopped Blanking pulses to blank the CRT during vertical chopping. Fig. 3-16A identifies the function of the pins of U120B.

### 1. CHOP VERTICAL MODE

When the VERTICAL MODE switch is set to CHOP, Vertical Chopped Blanking pulses are available at pin 4 at all times. The input conditions necessary are:

Pin 3 HI—VERTICAL MODE switch set to CHOP.

Pin 7 LO—VERTICAL MODE switch set to any position except ADD.

Pin 10 LO—Delay Ramp more negative than about zero volts.

### 2. LEFT VERTICAL UNIT SET FOR CHOPPED MODE

If the Left Vertical unit is set for chopped operation, the setting of the VERTICAL MODE switch determines whether Vertical Chopped Blanking pulses are available. If the VERTICAL MODE switch is set to the CHOP position, conditions are as described in #1 above. Operation in the ADD position of the VERTICAL MODE switch is given

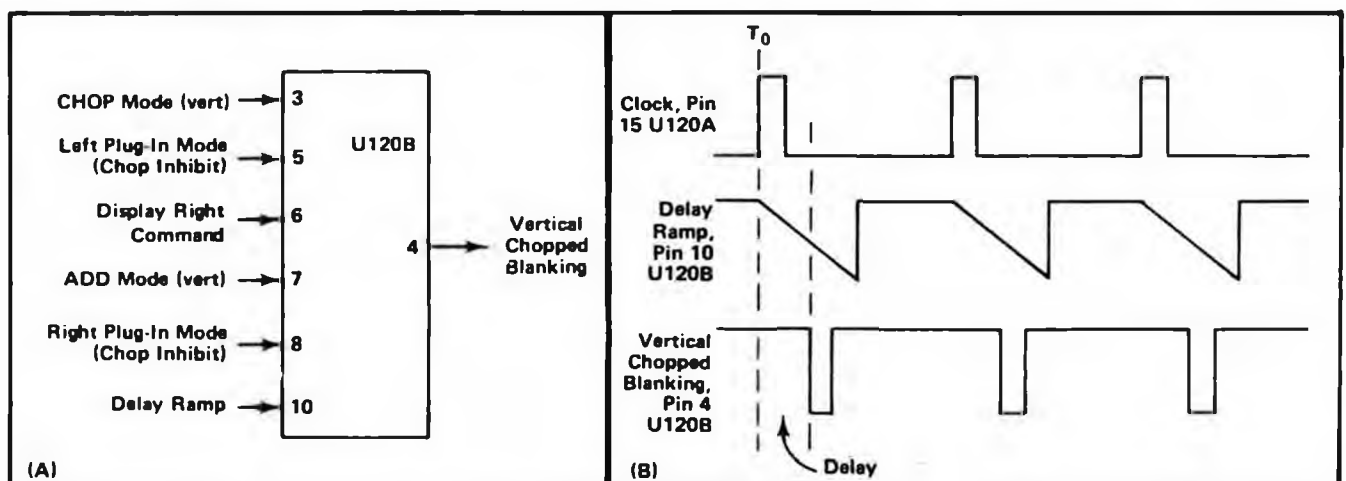


Fig. 3-16. (A) Input and output pins for Vertical Chopped Blanking stage, (B) Idealized waveforms for Vertical Chopped Blanking stage.

later. For the LEFT position of the VERTICAL MODE switch or when the Left Vertical unit is to be displayed in the ALT mode, Vertical Chopped Blanking pulses are available at all times (two-megahertz rate). The input conditions are:

Pin 3 LO—VERTICAL MODE switch set to any position except CHOP.

Pin 5 LO—Left Vertical unit set to chopped mode.

Pin 6 LO—Left Vertical unit to be displayed (Display Right Command LO).

Pin 7 LO—VERTICAL MODE switch set to any position except ADD.

Pin 10 LO—Delay Ramp more negative than about zero volts.

Notice that the Display Right Command at pin 6 must be LO for output pulses to be available at pin 4. This means that when the VERTICAL MODE switch is set to ALT, Vertical Chopped Blanking pulses will be produced only during the time that the Left Vertical unit is to be displayed (unless Right Vertical unit is also set for chopped operation).

### 3. RIGHT VERTICAL UNIT SET FOR CHOPPED OPERATION

If the Right Vertical unit is set for the chopped mode, operation is the same as described above for the Left Vertical unit except that Vertical Chopped Blanking pulses are produced when the VERTICAL MODE switch is set to RIGHT or when the Display Right Command is HI in the ALT mode. The input conditions are:

Pin 3 LO—VERTICAL MODE switch set to any position except CHOP.

Pin 6 HI—Right Vertical unit to be displayed (Display Right Command HI).

Pin 7 LO—VERTICAL MODE switch set to any position except ADD.

Pin 8 LO—Right Vertical unit set to chopped mode.

Pin 10 LO—Delay Ramp more negative than about zero volts.

### 4. ADD VERTICAL MODE

When the VERTICAL MODE switch is in the ADD position and either or both of the vertical units are operating in the chopped mode, Vertical Chopped Blanking pulses must

be available to block out the transition between the traces of the vertical units. The input conditions are:

Pin 3 LO—VERTICAL MODE switch set to any position except CHOP.

Pin 5 LO—Left Vertical unit set to chopped mode (can be HI if pin 8 is LO).

Pin 7 HI—VERTICAL MODE switch set to ADD.

Pin 8 LO—Right Vertical unit set to chopped mode (can be HI if pin 5 is LO).

Pin 10 LO—Delay Ramp more negative than about zero volts.

Fig. 3-17A shows a logic diagram of the Vertical Chopped Blanking stage. Notice the comparator block on this diagram (one input connected to pin 10). The output of this comparator is determined by the relationship between the levels at its inputs. If pin 10 is more positive (HI) than the grounded input, the output is HI also; if it is more negative (LO), the output is LO. An input/output table for this stage is given in Fig. 3-17B.

### Chop Counter

The Chop Counter stage 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 stage are identified in Fig. 3-18A. Idealized waveforms showing the timing relationship between the input and output signals for this stage are shown in Fig. 3-18B.

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 Vertical 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. 3-18B 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



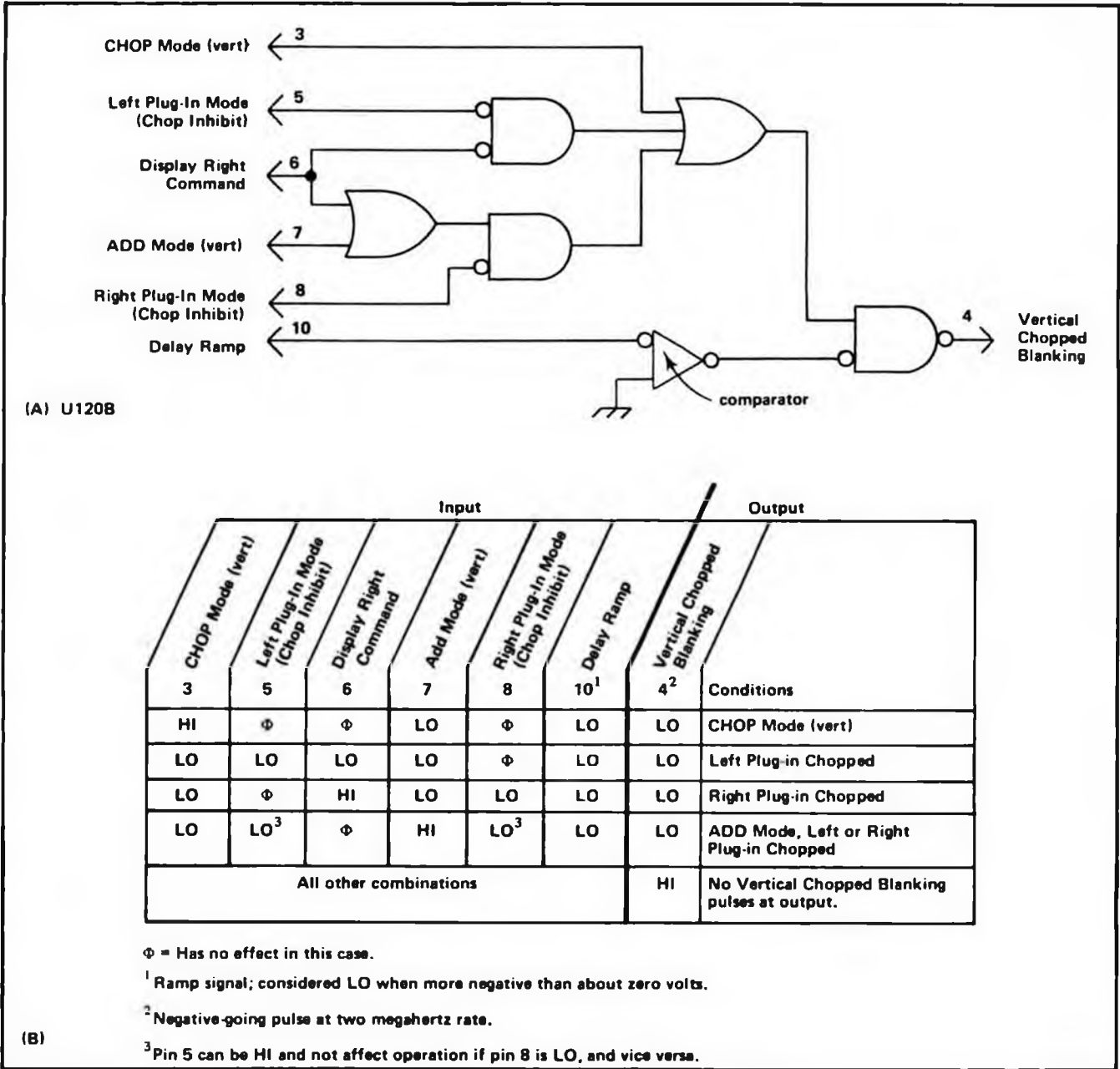


Fig. 3-17. (A) Logic diagram for Vertical Chopped Blanking stage, (B) Table of input/output combinations for Vertical Chopped Blanking stage.

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. 3-18B), a HI level is applied to pin 6. This stage continues to produce outputs at pins 1 and 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. However, this change does not appear at pin 4 immediately due to a delay network in the circuit. The

delay is necessary so the Horizontal Chopped Blanking coincides with the Vertical Chopped Blanking produced by U120A and the switching between the displayed signals (compare bottom two waveforms of Fig. 3-18B; 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 more time for the display to switch between horizontal units than between vertical units. During the time that the level

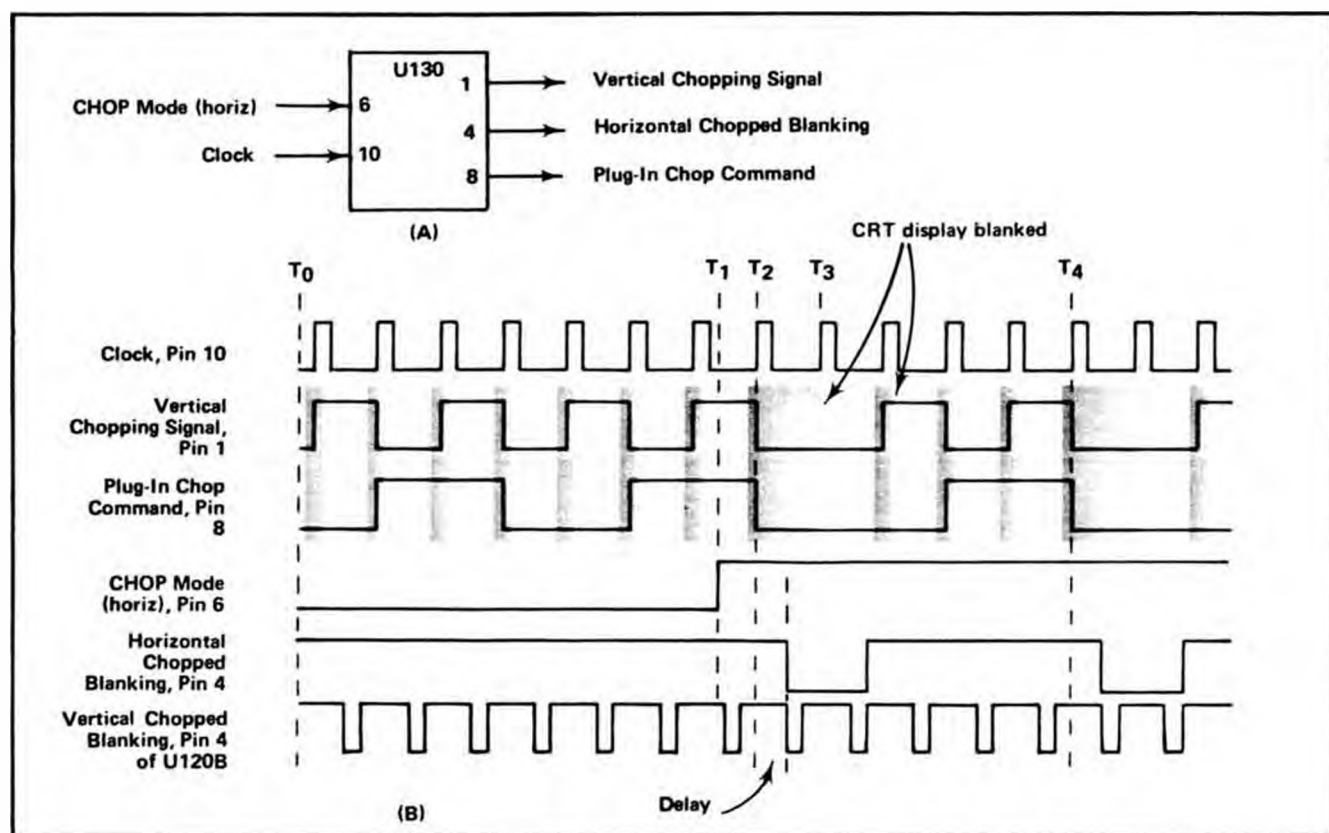


Fig. 3-18. (A) Input and output pins for Chop Counter stage, (B) Idealized waveforms for Chop Counter stage.

at pin 4 is LO, the CRT is blanked and the Vertical Chopped Signal and the Plug-in Chop Command cannot change levels. The Clock pulse at T<sub>3</sub> 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 trigger 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<sub>4</sub>) both outputs are again at their HI level. The fourth Clock pulse at T<sub>4</sub> 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. 3-18B) 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 U130 is connected to the Vertical Mode Logic stage (see following description) through L138-R138. This signal is HI when the Right Vertical unit is to be displayed and it is LO when the Left Vertical 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 L136-R136 via the Main Interface board. When this signal is HI, Channel 2 of the plug-in units can be displayed and when this level is LO, Channel 1 can be displayed. The Horizontal Chopped Blanking signal at pin 4 is connected through LR134 to the Horizontal Binary stage U150, and to the Z-Axis Logic stage U170 by way of Q146. 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 time-base units.

A logic diagram of the Chop Counter stage is shown in Fig. 3-19. Details of operation for the flip flops (FF) are shown in Table 3-1 at the front of this section. Use the waveforms given in Fig. 3-18B along with this diagram.

### Vertical Mode Logic

The Vertical Mode Logic stage made up of discrete components CR128-CR139, CR183-CR184, and Q194-Q196.

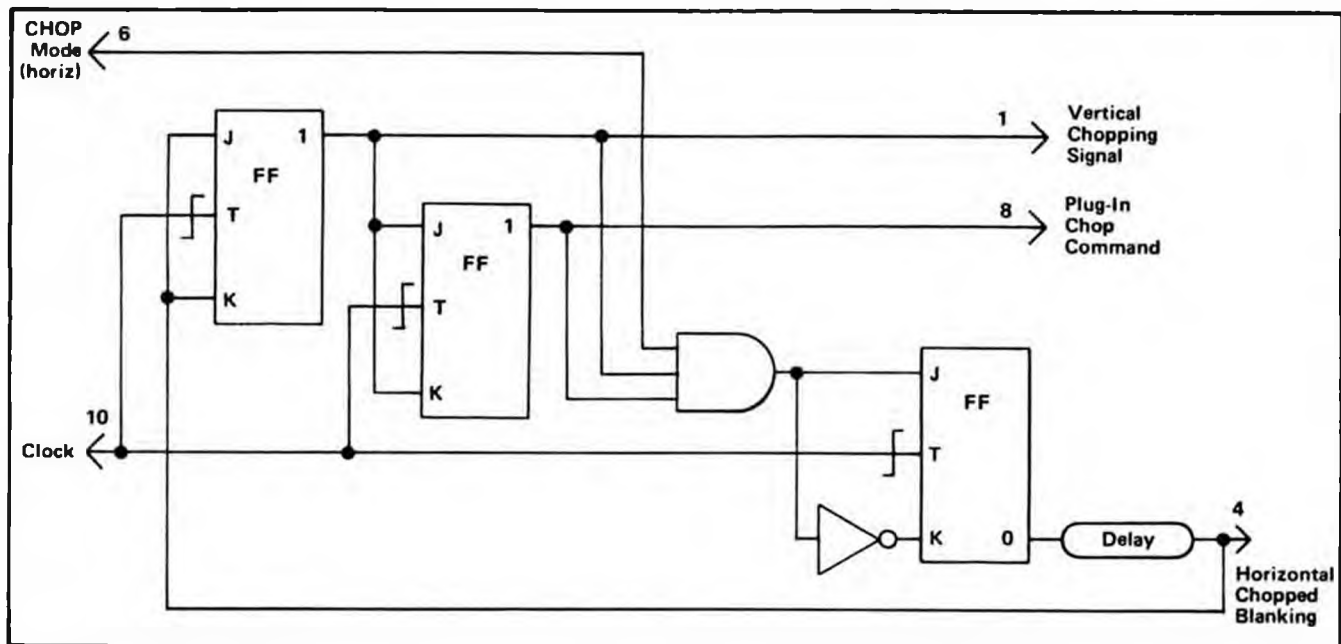


Fig. 3-19. Logic diagram of Chop Counter stage.

These components develop the Vertical Mode Command which is connected to the Main Interface circuit (vertical plug-in compartments and trigger selection circuitry) and the Vertical Interface circuit to indicate which vertical unit is to be displayed. When this output level is HI, the Right Vertical unit is displayed and when it is LO, the Left Vertical unit is displayed.

The VERTICAL MODE switch located on diagram 12 provides control levels to this stage. This switch provides a 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 used on this schematic). 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 Q194 through R127. This forward biases Q194 and the positive-going level at its emitter is connected to the emitter of Q196. The collector of Q196 goes HI to indicate that the Right Vertical unit is to be displayed. For the CHOP position of the VERTICAL MODE switch, a HI level is applied to the anodes of CR128-CR139 through R128. Both diodes are forward biased so that the Vertical Chopping Signal from pin 1 of U130 can pass to the base of Q194. This signal switches between the HI and LO levels at a one-megahertz rate and it produces a corresponding Vertical Mode Command output at the collector of Q196. When the output is HI, the Right Vertical unit is displayed and when it switches to LO, the Left Vertical unit is displayed.

In the ALT position of the VERTICAL MODE switch, a HI level is applied to the anodes of CR183-CR184 through R183. These diodes are forward biased so the Display Right Command from pin 6 of the Vertical Binary stage can pass to the base of Q194 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 selected line from the VERTICAL MODE switch 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 Q194 remains LO to produce a LO Vertical Mode Control output level at the collector of Q196.

A logic diagram of the Vertical Mode Logic stage is shown in Fig. 3-20. The discrete components which make up each logic function are identified.

## TRIGGER SELECTOR

### General

The Trigger Selector circuit determines the trigger signal which is connected to the A and B Time-Base units as controlled by the A TRIGGER SOURCE and B TRIGGER SOURCE switches. This circuit also provides the drive signal for the Vertical Signal Amplifier circuit as controlled by

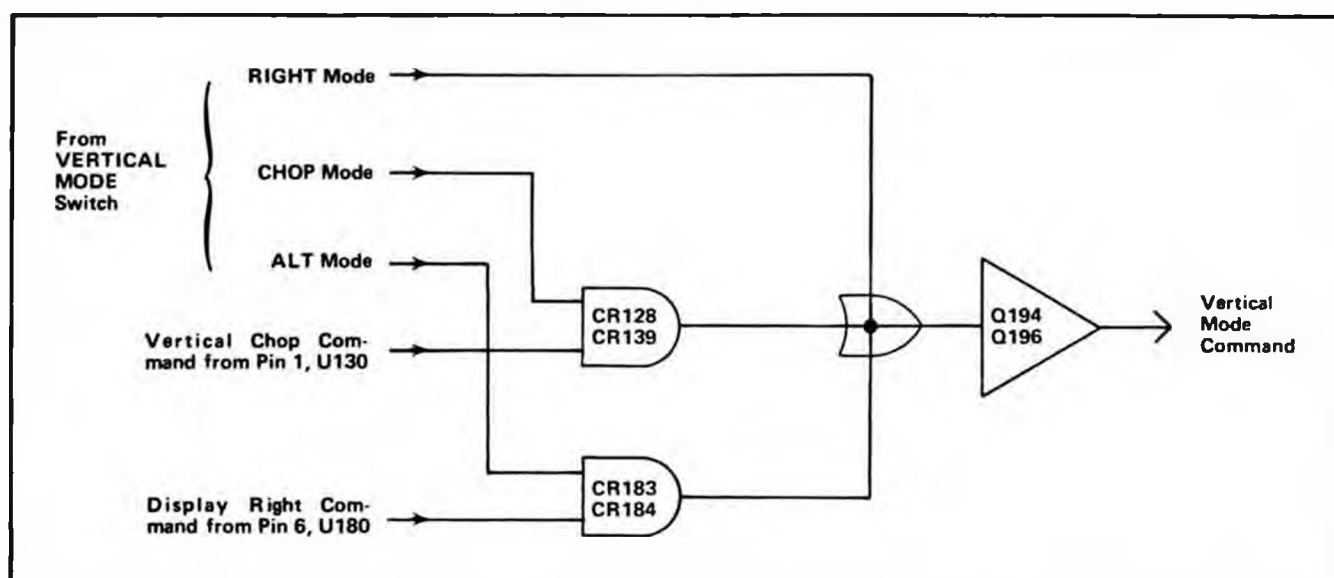


Fig. 3-20. Logic diagram of Vertical Mode Logic stage.

the B TRIGGER SOURCE switch. Fig. 3-21 shows a detailed block diagram of the Trigger Selector circuit along with a simplified diagram of all the circuitry involved in selection of the trigger source. A schematic of the Trigger Selector circuit is shown on diagram 3 at the rear of this manual. Also see diagrams 1 and 12 for the trigger selection circuitry not shown on diagram 3.

### Trigger Mode and ADD Signals

**General.** The circuitry shown on the left side of the simplified diagram in Fig. 3-21 determines the operation of the A and B Trigger Channel Switch stages. The A TRIGGER SOURCE switch S1011 controls the A Trigger Channel Switch U304 through Q24; the B TRIGGER SOURCE switch S1001 controls the B Trigger Channel Switch U324 through Q28. When the front-panel A or B TRIGGER SOURCE switches are set to the VERT MODE positions, the setting of the VERTICAL MODE switch determines the trigger selection. In the LEFT VERT or RIGHT VERT positions, the trigger signal is obtained from the indicated vertical unit. The following discussions give detailed operation in each position of the A and B TRIGGER SOURCE switches. It is written assuming that both of these switches are set to the same position. However, the A and B TRIGGER SOURCE switches operate independently to control the operation of the A and B Trigger Channel Switch stages respectively, to select the trigger output signal for the associated time-base unit.

**VERT MODE.** In the VERT MODE position of either the A or B TRIGGER SOURCE switch, the setting of the VERTICAL MODE switch determines the operation of the A and B Trigger Channel Switch stages (A TRIGGER

SOURCE, B TRIGGER SOURCE and VERTICAL MODE switches shown on diagram 12). In the LEFT position of the VERTICAL MODE switch, the bases of Q24 or Q28 (see Main Interface schematic) are connected to ground through the ALT and RIGHT sections of S1021, CR1022 and CR1027, and S1001 or S1011. This holds Q24 or Q28 reverse biased to provide a LO level to pin 4 of U304 and U324 (see Fig. 3-22).

When the VERTICAL MODE switch is set to ALT, +5 volts is applied to the bases of Q24 or Q28 through CR1022 and S1001 or S1011. Q24 and Q28 are forward biased and their emitter level is determined by the Vertical Mode Signal from the Logic Circuit applied to their collectors. This signal switches between the HI level (Right Vertical unit to be displayed) and the LO level (Left Vertical unit to be displayed) at the end of each sweep. When the Vertical Mode Signal is HI, it provides a positive collector voltage to Q24 and Q28. Q24 and Q28 are saturated due to CR1022, and their emitter levels are very near the collector level. This provides a HI output level to the Trigger Channel Switch stages. As the Vertical Mode Signal goes LO, the collector supply for Q24 and Q28 also goes negative. Q24 and Q28 remain saturated and the output again follows the collector level to supply a LO output level to U304 and U324.

For ADD and CHOP vertical mode operation, +5 volts is connected to pin 14 of U304 and U324 through CR1021 or CR1023 and S1001 or S1011. At the same time, the base of Q24 or Q28 is held LO by the ground connection through the ALT and RIGHT sections of S1021 so the level at pin 4 of the Trigger Channel Switches is LO also (produces an ADD mode in Trigger Channel Switches; see

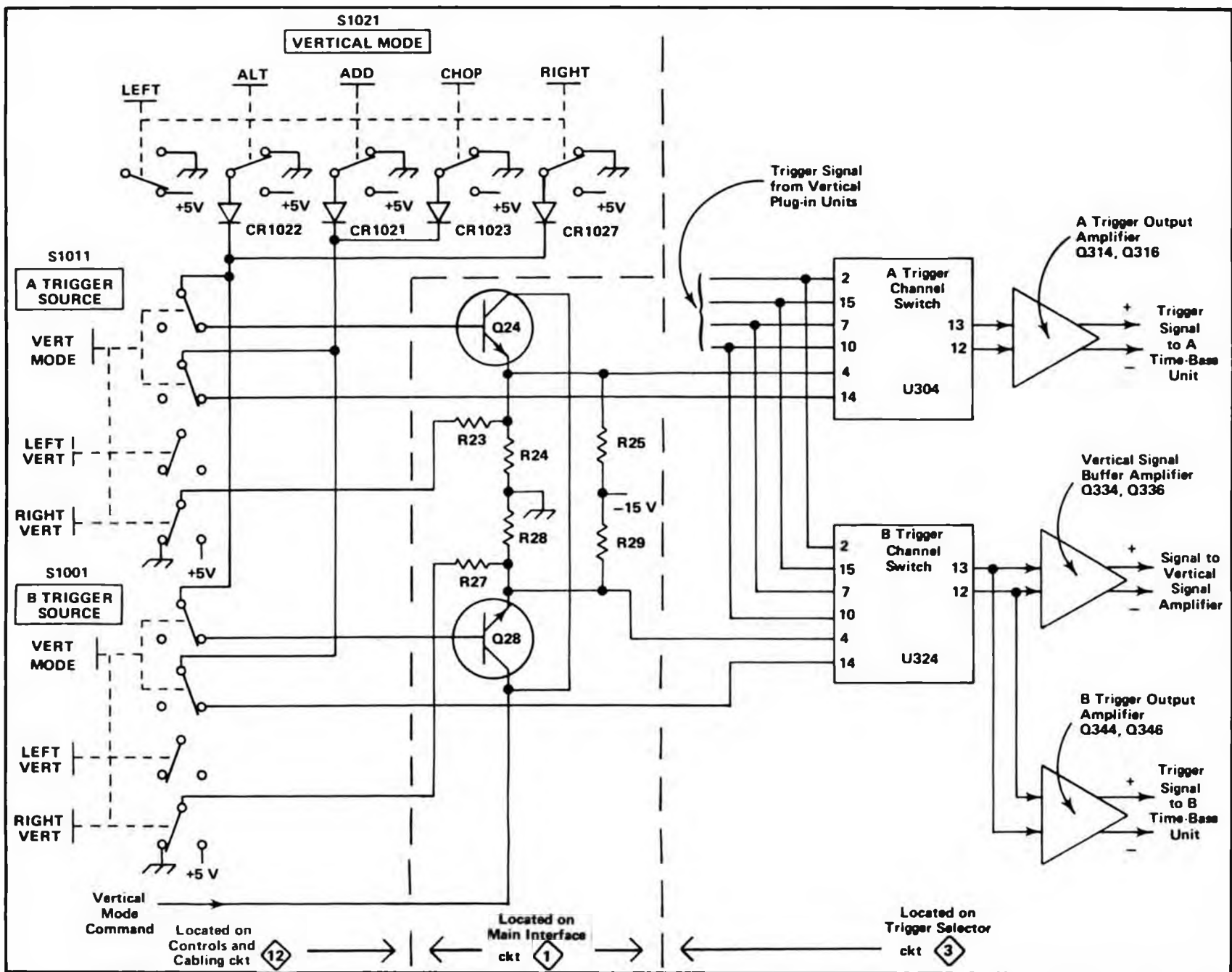


Fig. 3-21. Simplified schematic of trigger selector circuitry.

VERTICAL MODE switch positions		A and B TRIGGER SOURCE switch positions	
		VERT MODE	
VERTICAL MODE switch positions	LEFT	LO (Left Vertical)	↑
	ALT	Switches from LO to HI, and vice versa, at end of each sweep (both; follows display)	↑
	ADD	LO at pin 4 of U304 and U324, HI at pin 14 <sup>1</sup> (both; added algebraically)	LO (Left Vertical)    HI (Right Vertical)
	CHOP		
	RIGHT	HI (Right Vertical)	↓

<sup>1</sup>Pin 14 LO for all other conditions.

Fig. 3-22. Input levels at pin 4 of U304 and U324 (source of triggering signal is shown in parenthesis).

description of these circuits which follows). In the RIGHT position of the VERTICAL MODE switch, +5 volts is connected to the bases of Q24 or Q28 through CR1027 and S1001 or S1011 to forward bias these transistors. The Vertical Mode Signal connected to the collectors of Q24 and Q28 is also HI in this mode and a HI output level is produced at the emitters of Q24 or Q28.

**LEFT VERT.** When the LEFT VERT trigger source is selected, the VERTICAL MODE switch is disconnected from the trigger selector circuitry. Now, the ground connection through the RIGHT VERT section of S1001 or S1011 establishes a LO output level at the emitters of Q24 and Q28.

**RIGHT VERT.** In the RIGHT VERT position of the A or B TRIGGER SOURCE switches, +5 volts is connected to the emitters of Q24 and Q28 through S1011-R23 or S1001-R27. This produces a HI output level to the A and B Trigger Channel Switch stages.

### A and B Trigger Channel Switch

The A and B Trigger Channel Switch stages determine which input signal provides the trigger signal to the time-base units as controlled by the trigger mode and ADD signals from the trigger selection circuitry. Resistors R301-R321 and R302-R322 establish the input resistance of this stage and provide a load for the trigger output of the

Left and Right Vertical plug-in units. Resistors R303-R304-R305 and R307-R308-R309 establish the operating levels for the A Trigger Channel Switch; R303-R305 and R307-R309 set the current gain for each channel. Resistors R323-R324-R325 and R327-R328-R329 establish the operating levels for the B Trigger Channel Switch; R323-R325 and R327-R329 set the current gain for each channel. These stages are made up primarily of integrated circuits U304 and U324. An input/output table for U304 and U324 is shown in Fig. 3-23. U304-U324 provide a high impedance differential input for the trigger signal from the Left Vertical unit at pins 2 and 15 and for the trigger signal from the Right Vertical unit at pins 7 and 10. The output signal at pins 12 and 13 is a differential signal. 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 bias to the stages which follow as the A or B TRIGGER SOURCE switches or the VERTICAL MODE switch are changed.

When the level at pin 4 is LO (see Trigger Mode and ADD Signals discussion and Fig. 3-23), the trigger signal from the Left Vertical unit passes to the output while the trigger signal from the Right Vertical unit is blocked. A HI level at pin 4 connects the trigger signal from the Right Vertical unit to the output and the trigger signal from the Left Vertical unit is blocked. For VERT MODE operation in the ALT position of the VERT MODE switch, the level at pin 4 switches between the LO and HI level at a rate determined by the Vertical Binary stage (see Logic Circuit description). This action obtains the trigger signal from the Left Vertical unit when the Left Vertical unit is being displayed and from the Right Vertical unit when this unit is being displayed.

Input		Output
Trigger Mode Signal	Trigger ADD	Trigger Output Signal
4	14	12, 13
LO	LO	Left trigger signal
HI	LO	Right Trigger signal
LO	HI	Both (added algebraically)

Fig. 3-23. Input/output table of A and B Trigger Channel Switch stages.

When the level at pin 4 is LO and the level at pin 14 is HI, the trigger signal from both the Left and Right Vertical units passes to the output pins. This condition occurs only when the A or B TRIGGER SOURCE switches are set to VERT MODE and the VERTICAL MODE switch is set to either ADD or CHOP. Under this operating mode, the trigger output signal is the algebraic sum of the trigger input signals from the Left and Right Vertical units to prevent triggering on the vertical chopping transition or only on one signal of an added display.

### A Trigger Output Amplifier

The trigger output signal at pins 12 and 13 of the A Trigger Channel Switch is connected to the emitters of common-base amplifier Q314-Q316 through R311-R312. These transistors provide a low-resistance load for the A Trigger Channel Switch while providing a high output impedance to the circuits which follow. The signal at the collectors of Q314 and Q316 is connected to the A Horizontal unit via the Main Interface circuit. The A Horizontal unit provides a 50-ohm differential load for this stage. If it is removed from its compartment, the voltage-swing at the collectors of Q314-Q316 will increase substantially.

### Vertical Signal Buffer Amplifier

The trigger output signal at pins 12 and 13 of the B Trigger Channel Switch is connected to the emitters of common-base amplifier Q334-Q336. The output signal at the collectors of Q334 and Q336 is connected to the Vertical Signal Amplifier (see Output Signals and Calibrator description) through R337 and R338. R339 provides a differential output resistance of about 100 ohms.

### B Trigger Output Amplifier

The signal at pins 12 and 13 of the B Trigger Channel Switch is also connected to the bases of Q344-Q346 to provide the internal trigger signal for the B Horizontal unit (via the Main Interface circuit). This stage provides isolation between the B Horizontal unit and the Vertical Signal Buffer Amplifier stage. The B Horizontal unit provides a 50-ohm differential load for this stage. If it is removed from its compartment, the collector load for Q344-Q346 changes and the voltage swing at their collectors increases. The action of this stage prevents this change from affecting the Vertical Signal Buffer Amplifier stage. CR342-CR346 clamp the collectors of Q344 and Q346 at about +0.6 volts

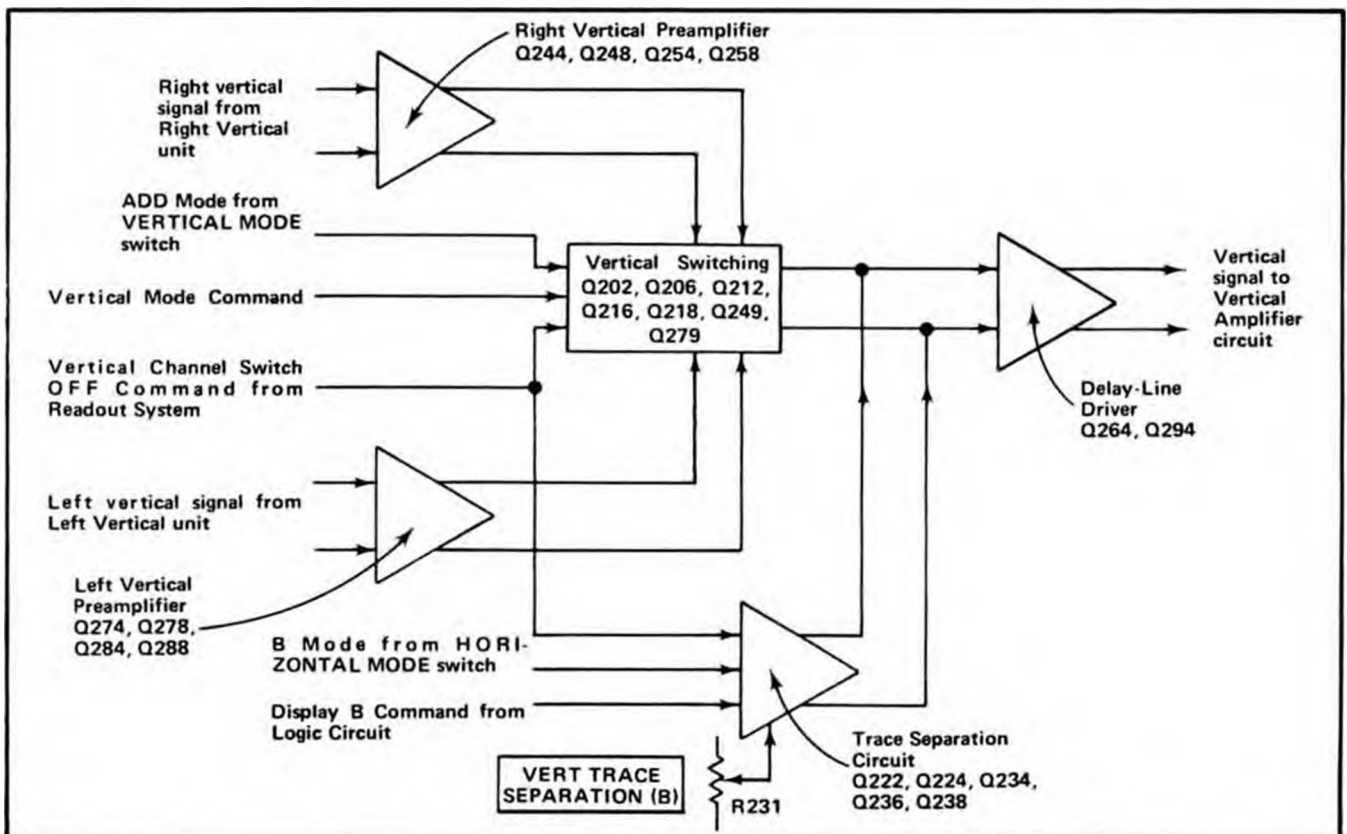


Fig. 3-24. Vertical Interface detailed block diagram.



to prevent these transistors from saturating under this no-load condition.

## VERTICAL INTERFACE

### General

The Vertical Interface circuit selects the vertical deflection signal from the output of the Left Vertical and/or the Right Vertical plug-in unit. This stage also accepts an input from the Readout System to block the vertical signal while readout information is displayed on the CRT. In addition, this stage contains the Trace Separation Circuit to shift the vertical position of the B-Sweep portion of a dual-sweep display. Fig. 3-24 shows a detailed block diagram of the Vertical Interface circuit. A schematic of this circuit is shown on diagram 4 at the rear of this manual.

### Vertical Switching

Transistors Q202-Q206 and Q212-Q216 form differential amplifiers which determine if the signal from the left vertical plug-in or the right vertical plug-in, or both, provides the vertical deflection signal to the Vertical Amplifier. Transistor Q218 provides a constant voltage source of about  $-8.7$  volts for the collector circuits of Q202-Q206 and Q212-Q216. The operation of this stage is controlled by the Vertical Mode Command, the ADD Mode signal and the Vertical Channel Switch OFF Command. Fig. 3-25 shows an input/output table for the overall Vertical Interface circuit to show the output signal for the applicable input conditions.

Input			Output
Vertical Mode Command	ADD Mode (Vert)	Vertical Channel Switch OFF Command	Output signal
LO	LO	LO	Left vertical signal
HI	LO	LO	Right vertical signal
LO	HI	LO	Both (added algebraically)
$\Phi$	$\Phi$	HI	Neither (blocked by Readout System)

$\Phi$  = Has no effect in this case

Fig. 3-25. Input/output table for Vertical Interface circuit.

When the VERTICAL MODE switch is set to LEFT, the Vertical Mode Command is LO. This level allows the bases of Q202 and Q212 to go negative so that these transistors are forward biased. The resulting positive-going change at the collectors of Q202 and Q212 produce different results for the Left and Right Vertical Preamplifier stages. The positive-going signal at the collector of Q212 is connected to the bases of the series transistors Q278-Q288 in the Left Vertical Preamplifier stage through R212. At the same time, the other transistor in this differential amplifier, Q216, is reverse biased. The negative level at its collector reverse biases Q279 and the shunt diodes CR279-CR289. As a result, the signal from the Left Vertical plug-in can pass to the Delay-Line Driver stage. The positive-going change at the collector of Q202 forward biases transistor Q249 and shunt diodes CR249-CR259 in the Right Vertical Preamplifier stage. Q206 is reverse biased and the negative level at its collector holds the series transistors Q248-Q258 reverse biased to block the signal from the Right Vertical plug-in. Instead, the signal is shunted through CR249-CR259 and Q249 to the junction of R262-R292. This arrangement provides a constant DC current to the Delay-Line Driver stage as the VERTICAL MODE switch is changed by providing a signal current either through the applicable series transistors or an equivalent DC current through the shunt diodes via R262-R292.

In the RIGHT position of the VERTICAL MODE switch, the Vertical Mode Command is HI. Now, diodes CR200 and CR209 are forward biased and the positive signal at the base of Q202-Q212 reverse biases these transistors. The previous conditions are now reversed. The collector of Q212 is negative so that series transistors Q278-Q288 are reverse biased. At the same time Q216 is forward biased to hold Q279 and the shunt diodes CR279-CR289 forward biased also. This action blocks the signal from the Left Vertical plug-in unit. On the Right Vertical side of the circuit, the negative level at the collector of Q202 reverse biases Q249 and shunt diodes CR249-CR259. The positive level at the collector of Q206 forward biases the series transistors Q248-Q258 to allow the signal from the Right Vertical plug-in unit to pass to the Delay-Line Driver stage.

For either the ALT or CHOP position of the VERTICAL MODE switch, the Vertical Mode Command switches between the LO and HI levels at a rate determined by either the Chop Counter or the Vertical Binary stages (see Logic Circuit description). This action allows the signal from the Left Vertical unit to be displayed when the Vertical Mode Command is LO and the signal from the Right Vertical unit is displayed when the Vertical Mode Command is HI.

When ADD vertical mode operation is selected, a HI Vertical Mode Command level is applied to the base of Q202 through R200. The level at the collector of Q202 goes negative to reverse bias the Right Vertical shunt diodes and the positive level at the collector of Q206 forward



biases the series transistors to allow the Right Vertical signal to pass to the Delay-Line Driver stage. At the same time, the Vertical Mode Command level is LO as determined by the Vertical Mode Control stage in the Logic Circuit. This allows Q212 to conduct to forward bias the Left Vertical series transistors; the shunt diodes are reverse biased by the negative level at the collector of Q216. Therefore, the signal from the Left Vertical plug-in unit can pass to the Delay-Line Driver stage. Now, the signal from both vertical units is algebraically added by the Delay-Line Driver stage and the resultant signal determines the vertical deflection.

The Vertical Channel Switch OFF Command from the Readout System has final control over the output signal from this stage. Quiescently, this signal is LO and the signal from the selected vertical unit can pass to the Delay-Line Driver stage. However, when the Readout System is ready to display readout information, the Vertical Channel Switch OFF Command goes HI. Transistor Q212 is reverse biased through CR210 and Q206 is reverse biased through R208. This reverse biases the series transistors Q248-Q258 and Q278-Q288 to block the signal from both vertical units. At the same time the remaining transistor in each differential amplifier is forward biased to shunt the vertical signal. Therefore, the signal from neither plug-in unit is displayed on the CRT and the CRT deflection is determined by the Readout System.

### **Left Vertical Preamplifier**

The vertical signal from the Left Vertical plug-in unit is connected to the Left Vertical Preamplifier stage by way of the strip lines on the Vertical Interconnect board. These strip lines provide an impedance of 50 ohms. The applied signal is amplified by transistors Q274-Q284. C274-C282-R274-R284 in the emitter circuit of Q274-Q284 provide high-frequency compensation; C274-R274 are variable to provide high-frequency response adjustment for this stage. The Left Vertical Centering adjustment R277 balances the quiescent DC levels at the output of the Left Vertical Preamplifier stage so the trace from the Left Vertical unit is displayed at the center of the CRT when the inputs to this stage are at the same potential. Transistors Q278-Q288 operate along with the Vertical Switching stage to determine if the Left Vertical signal is displayed on the CRT.

### **Right Vertical Preamplifier**

The components in the Right Vertical Preamplifier stage serve the same function as the corresponding components in the Left Vertical Preamplifier stage. The only difference between the two circuits is the presence of the Right Vertical Gain adjustment, R242, in this circuit. The overall gain of the Vertical Amplifier circuit is set when the Left Vertical signal is displayed. The right Vertical Gain adjustment compensates for any differences in gain between the Right

Vertical Preamplifier stage and the Left Vertical Preamplifier stage. Gain is controlled by changing the emitter degeneration between transistors Q244-Q254.

### **Trace Separation Circuit**

The Trace Separation Circuit provides a variable positioning voltage to offset the B Sweep display when operated in either the ALT or CHOP dual-sweep modes (horizontal). The display B Command from the Logic Circuit controls the operation of this stage through Q234. When the B Sweep is being displayed (for ALT or CHOP horizontal operation), the Display B Command is HI to forward bias Q234. The collector of Q234 goes negative to reverse bias shunt diodes CR233-CR234. Under this condition, the VERT TRACE SEPARATION (B) control determines the bias at the base of transistors Q236-Q238 through R230-R232 and the series diodes CR230-CR232. The output current at the collectors of Q236-Q238 is connected to the Delay-Line Driver stage through R261-R291 to offset the B Sweep display up to about four divisions above or below the A Sweep display. This prevents a confusing display when using dual-sweep operation, as the A and B Sweeps would be displayed on top of each other without this feature.

When the Display B Command is LO (A Sweep displayed), Q234 is reverse biased and the shunt diodes CR233-CR234 are forward biased through R233. This applies a DC bias of about +5.1 volts to the bases of transistors Q236-Q238 to provide a quiescent DC output current from this stage to the Delay-Line Driver stage. Since the series diodes CR230-CR232 are reverse biased, the VERT TRACE SEPARATION (B) control is disconnected while the A Sweep is being displayed.

Two other signals also control the current through this stage. When the HORIZONTAL MODE switch is set to B (only), a HI level is connected to the base of Q224 through CR224 and R224. This forward biases Q224 and, since Q224-Q234 share emitter resistor R227, transistor Q234 is reverse biased even though the Display B Command at its base is HI for this mode. Therefore, the VERT TRACE SEPARATION (B) control has no effect. The Vertical Channel Switch OFF Command from the Readout System is connected to the base of Q222 through R221. This signal is quiescently LO so that Q222 is conducting through R222 to hold Q224 reverse biased by way of R223 (except when HORIZONTAL MODE switch is in B position described above). When the Readout System is ready to display readout information, the Vertical Channel Switch OFF Command goes HI to reverse bias Q222. The base of Q224 goes positive through R222-R223 and it is forward biased. Now, Q224 controls conduction and Q234 is off to disconnect the VERT TRACE SEPARATION (B) control. The output of this stage goes to its quiescent DC level so that the Readout System has full control of the trace position (see Readout System description for more information).

## Delay-Line Driver

Output of the Left Vertical Preamplifier and the Right Vertical Preamplifier stages, along with any positioning current from the Trace Separation Circuit, is connected to the bases of Q264-Q294. This stage provides amplification for the selected signal as well as providing a reverse termination for the delay line. Diodes CR264-CR295 decrease the feedback resistance for Q264-Q294 as the signal is deflected towards the edges of the display area. This action reduces the gain of the stage to compensate for the inherent expansion characteristic of the CRT. The output signal from the Delay-Line Driver stage is connected to the Vertical Amplifier circuit through C266-R266 and C296-R296.

## VERTICAL AMPLIFIER

### General

The 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. Fig. 3-26 shows a detailed block diagram of the Vertical Amplifier circuit. A schematic of this circuit is shown on diagram 5 at the rear of this manual.

### Delay Line

The Delay Line DL400 provides approximately 120 nanoseconds 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 about 50 ohms per side, or about 100 ohms differentially. It is of the coaxial type which does not produce preshoot or phase distortion in the CRT display.

### Buffer Amplifier

The Buffer Amplifier stage Q412-Q416 provides a low input impedance for the Vertical Amplifier circuit to permit accurate delay-line termination. C401-R401 and C408-R408 provide the forward termination for the delay line. The output signal from the Buffer Amplifier stage is connected to the First Push-Pull Amplifier stage through C411-R411-VR411 and C417-R417-VR417. Zener diodes VR411 and VR417 limit the voltage swing across R411 and R417 to keep Q412 and Q416 out of saturation. R405 and the operating bias of Q412-Q416 provide compensation for thermal distortion produced in Q470-Q476.

For readout displays, the Y-signal from the Readout System is connected to the emitter of Q412 through R402. Since the signal from the vertical units is blocked in the Vertical Interface circuit, the readout signal provides the only vertical deflection. Although this signal is connected to the base of Q412 as a single-ended signal, it is converted to a push-pull signal in the following stages.

### First Push-Pull Amplifier

Q434-Q442 and Q436-Q444 are connected as a push-pull cascode amplifier stage. The network C426-L421-

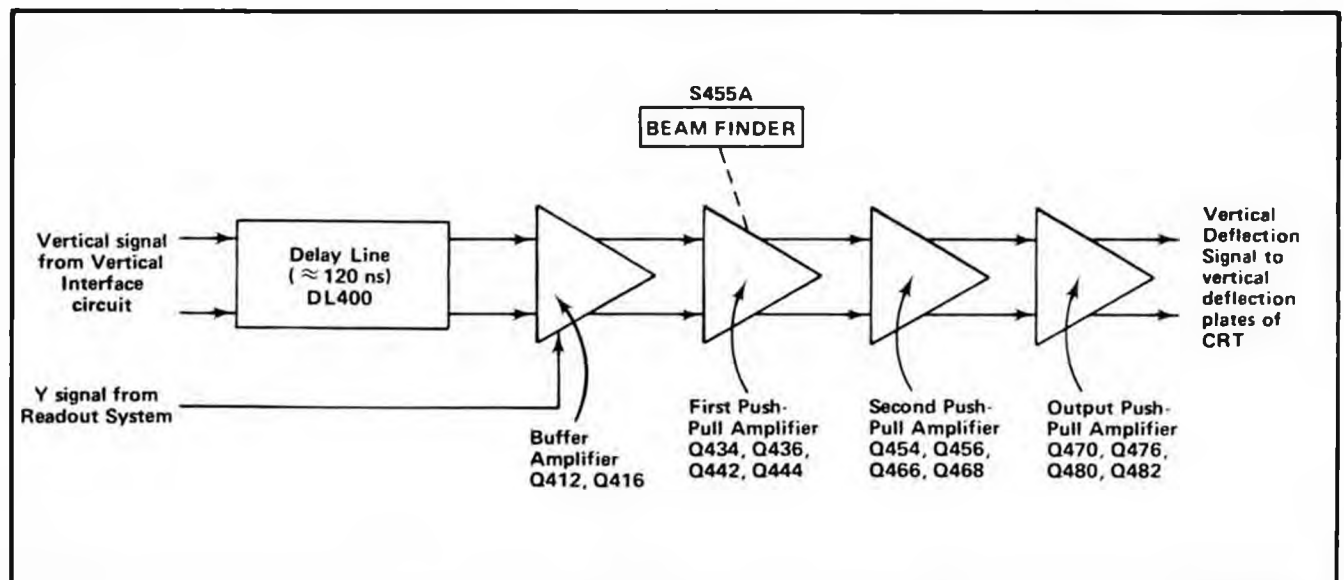


Fig. 3-26. Vertical Amplifier detailed block diagram.

L422-L423-R420-R421-R422-R423-R424-R425-R426 provides compensation for the delay line. R421-R422-R423 in this network are adjustable to provide mid-frequency compensation. C430-R430, connected between the emitters of Q434-Q436 provide high-frequency compensation adjustment for this stage. The network CR431-CR432-RT433 provides thermal compensation for this stage. As the temperature increases, the resistance of RT433 decreases and the capacitance of varactors CR431-CR432 increases. The output signals at the collectors of Q434-Q436 are connected to the common-base transistors Q442-Q444 through C435-R435-R436 and C438-R437-R438. The low input resistance of the Q442-Q444 common-base transistors allows this stage to provide maximum high-frequency performance. The Vertical Centering adjustment R443 balances the quiescent DC levels in the Vertical Amplifier circuit so the trace is displayed at the center of the CRT when the inputs to this circuit are at the same potential. The output signal from the First Push-Pull Amplifier stage is connected to the next stage through C447-L447 and C448-L448. Zener diode VR449 establishes a collector source voltage of about  $-6.2$  volts for Q442-Q444.

## Second Push-Pull Amplifier

The Second Push-Pull Amplifier, Q454-Q466 and Q456-Q468 operates in the same manner as the previous stage. The main difference between the stages is the compensation networks and the BEAM FINDER switch located in this circuit. C458-R458 in the emitter circuit of Q454-Q456 provides adjustable high-frequency compensation for this stage.

The BEAM FINDER switch S455A switches the emitter current source for Q454-Q456 to provide the beam finder function. Normally, the emitter current for Q454-Q456 is supplied through S455A-L455. However, when S455A is pressed in, the current source through L452 is interrupted and the only emitter-current source for Q454-Q456 is through R451. This limits the dynamic range of this stage by limiting its current, so the display is compressed vertically within the graticule area. The BEAM FINDER switch can also be pulled out to lock it in the "find" position to aid in locating the traces of several plug-in units.

The signal at the collectors of Q454-Q456 is connected to the common-base transistors Q466-Q468 through C460-R460-R461-R462 and C465-R463-R464-R465. Transformer T466 reduces the common-mode signal components in the push-pull signal applied to the following stages. The output signal from this stage at the collectors of Q466-Q468 is connected to the Output Push-Pull Amplifier through VR467-VR469 and LC networks C470-L470 and C471-L471. VR467-VR469 provide DC voltage matching without appreciable current loss. The Vertical Gain adjustment R468 sets the resistance between the bases of Q470-Q476 in the following stage to control the current

gain of this stage. This adjustment sets the overall gain of the Vertical Amplifier stage.

## Output Push-Pull Amplifier

Q470-Q480 and Q476-Q482 operate in the same manner as the previous stages to provide amplification for the vertical deflection signal. The output signal from this stage provides the vertical deflection on the CRT. C472 and thermistor RT472 provide frequency compensation to maintain high-frequency response with temperature changes. Thermistor RT480 and R480 provide gain compensation with changes in temperature. The output signal is connected to the vertical deflection plates of the CRT through buffer transistors Q480-Q482. A distributed deflection plate system is used in this instrument for maximum frequency response and sensitivity. The output signal at the collectors of Q480-Q482 is connected to the integral inductors in the CRT and then to the deflection-plate termination network C483-L481-L483-R483-R485 and C484-L482-L484-R484-R487. As the signal passes through the integral inductors 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 plates. Inductors L483-L484 and capacitors C483-C484 are adjusted to minimize signal reflections by providing the correct termination for the vertical deflection plate structure.

## HORIZONTAL INTERFACE

### General

The Horizontal Interface circuit is made up of the X-Y Delay Compensation Network and the Horizontal Channel Switch stage. The X-Y Delay Compensation Network provides a delay for the horizontal (X) 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 Horizontal and/or the B Horizontal plug-in unit. Fig. 3-27 shows a detailed block diagram of this circuit. A schematic of this circuit is shown on diagram 6 at the rear of this manual.

### X-Y Delay Compensation

**Time-Base Operation.** When the plug-in unit installed in the A or B horizontal 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 X Compensation Inhibit command is HI and relays K50-K60 or K70-K80 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.

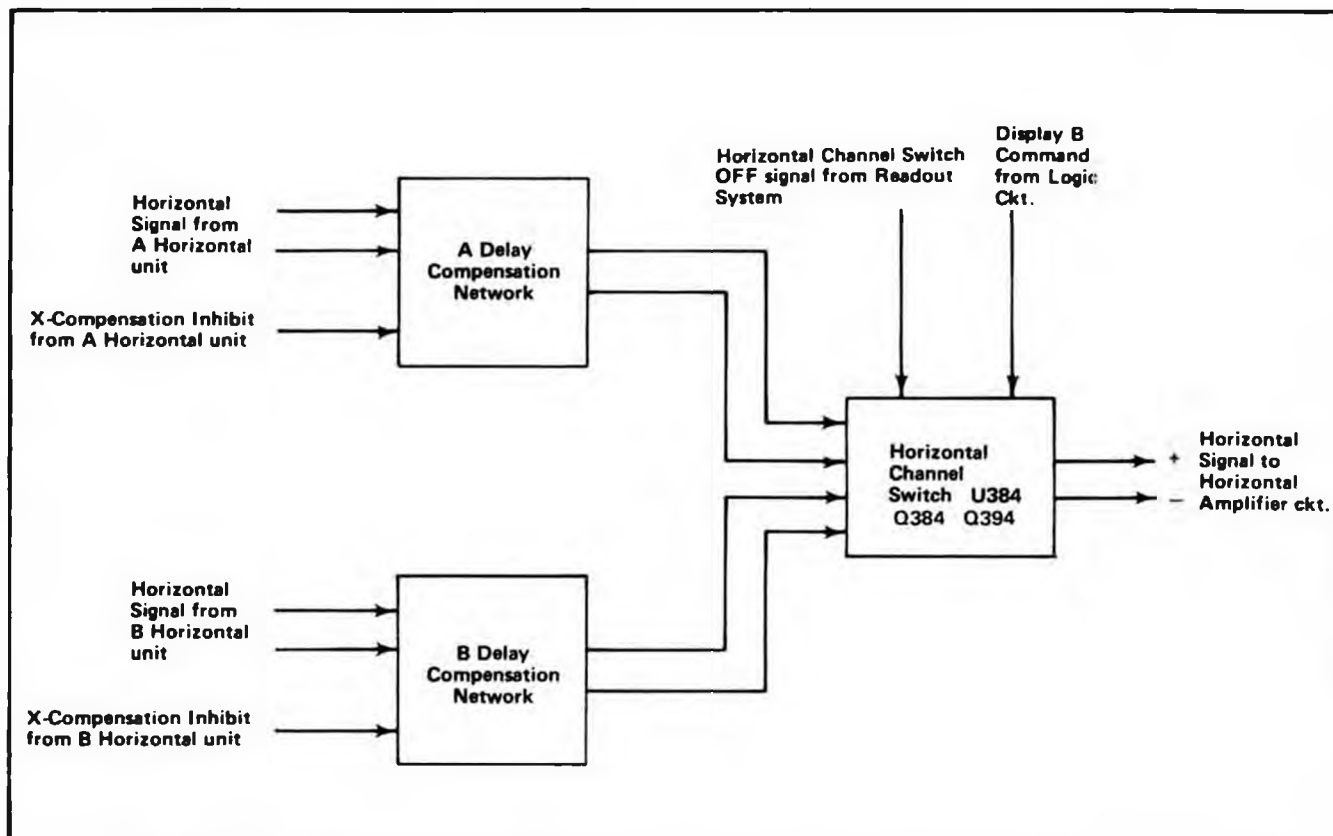


Fig. 3-27. Horizontal Interface detailed block diagram.

**X-Y Operation.** If the time-base unit installed in the A or B horizontal compartment is operated as an amplifier or if a vertical unit is installed in a horizontal compartment, the X Compensation Inhibit command to the applicable Delay Compensation Network drops to the LO level (zero volts). This provides an actuating level to relays K50-K60 or K70-K80 to connect the Delay Compensation Network into the circuit. For example, if the X Compensation Inhibit command from the A Horizontal Unit goes LO, K50 and K60 close to route the A Horizontal Signal through the A Delay Compensation Network. Diodes CR50 and CR70 shunt the voltage produced across the relays when the actuating level is removed. LR networks L51-R51 and L61-R61 along with capacitors C53 and C55 provide a constant input impedance. The LC network made up of C56-C58-C66-C68-L55-L56-L65-L66 provides a fixed delay from DC to about two megahertz to provide minimum phase shift between the X and Y portions of the CRT display. C55 is adjusted to match the horizontal delay to the vertical delay up to at least two megahertz.

The Delay Compensation Network normally produces negative preshoot distortion along with some corner rounding of fast step functions. The A Delay Disable switch S50 allows selection of a display with either minimum phase-shift characteristics or optimum step response. When

this switch is set to Out (down), the X Compensation Inhibit command from the A Horizontal Unit is disconnected from relays K50-K60. Now, the signal from the A Horizontal 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 stage by the Horizontal Interconnect board.

### Horizontal Channel Switch

The Horizontal Channel Switch determines which input signal provides the horizontal signal to the Horizontal Amplifier circuit as controlled by the Horizontal Mode Signal from the Logic Circuit. Resistors R352-R354 and R356-R358 establish the input resistance of this stage and provide a load for the A and B Horizontal units. Resistors R363-R365-R367 and R373-R375-R377 establish the operating levels for this stage. R363-R365 and R373-R375 set the current gain for each channel. C361-R361 and C371-R371 provide frequency compensation.

Input		Output
Display B Command	Horizontal Channel Switch OFF	Output signal
4	6	12, 13
LO	LO	A horizontal signal
HI	LO	B horizontal signal
$\Phi$	HI	Neither (blocked by Readout System)

$\Phi$  = Has no effect in this case

Fig. 3-28. Input/output table for Horizontal Channel Switch.

This stage is made up primarily of integrated circuit U364 which is the same type as used for the Trigger Channel Switch stage. An input/output table for U364 is shown in Fig. 3-28. U364 provides a high-impedance differential input for the signal from the A Horizontal unit at pins 2 and 15 and the signal from the B Horizontal unit at pins 7 and 10. The output signal at pins 12 and 13 is a differential signal which is connected to the 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.

When the HORIZONTAL MODE switch is set to A, the level at pin 4 is LO. This level allows the signal from the A Horizontal unit to pass to the output while the signal from the B Horizontal unit is blocked. In the B position of the HORIZONTAL MODE switch, the level at pin 4 is HI. Now, the signal from the B Horizontal unit is connected to the output while the signal from the A Horizontal unit is blocked.

For ALT or CHOP positions of the HORIZONTAL MODE switch, the Horizontal Mode Signal at pin 4 switches between the LO and HI levels at a rate determined by the Horizontal Binary stage in the Logic Circuit. This action allows the signals from the A Horizontal unit to be displayed when the Horizontal Mode Signal is LO and the signal from the B Horizontal Unit is displayed when the Horizontal Mode Signal is HI.

The Horizontal Channel Switch 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.

The output signal at pins 12 and 13 is connected to the Horizontal Amplifier circuit through Q384-Q394. Resistors R381-R383 and R391-R393 establish the correct operating DC levels for U364. Buffer amplifier Q384-Q394 provides a low load impedance for U364 as well as providing DC voltage matching between the Horizontal Interface and Horizontal Amplifier circuits.

## HORIZONTAL AMPLIFIER

### General

The Horizontal Amplifier circuit amplifies the push-pull horizontal deflection signal from the Horizontal Interface circuit and connects it 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. Fig. 3-29 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.

### Input Amplifier

The horizontal signal from the Horizontal Interface circuit is connected to the bases of Q526 and Q536. The Input Amplifier is driven from an equivalent 100-ohm source. The resistive network R521-R522-R524-R531-R532-R533-RT534 between the emitters of Q526-Q536 controls the emitter degeneration of this stage to perform several functions. Horizontal Gain adjustment R522 is variable to determine the amount of emitter degeneration between Q526-Q536 to set the overall gain of the Horizontal Amplifier circuit. Thermistor RT534 provides thermal gain compensation for this circuit. As the temperature increases, the resistance of RT534 decreases resulting in less emitter degeneration between Q526-Q536. Therefore, the overall gain of this stage increases to compensate for the opposite characteristic of the transistors in the Horizontal Amplifier circuit.

Transistor Q514 is normally supplying current to the emitters of Q526-Q536 through R521-R531. However, when the BEAM FINDER switch is actuated, Q514 is no longer forward biased so that the current supplied to R521-R531 is determined only by R515. This results in less current to Q526-Q536 so their dynamic range is limited. When the BEAM FINDER switch S455B is actuated, a ground level is also connected to the Logic Circuit to pro-

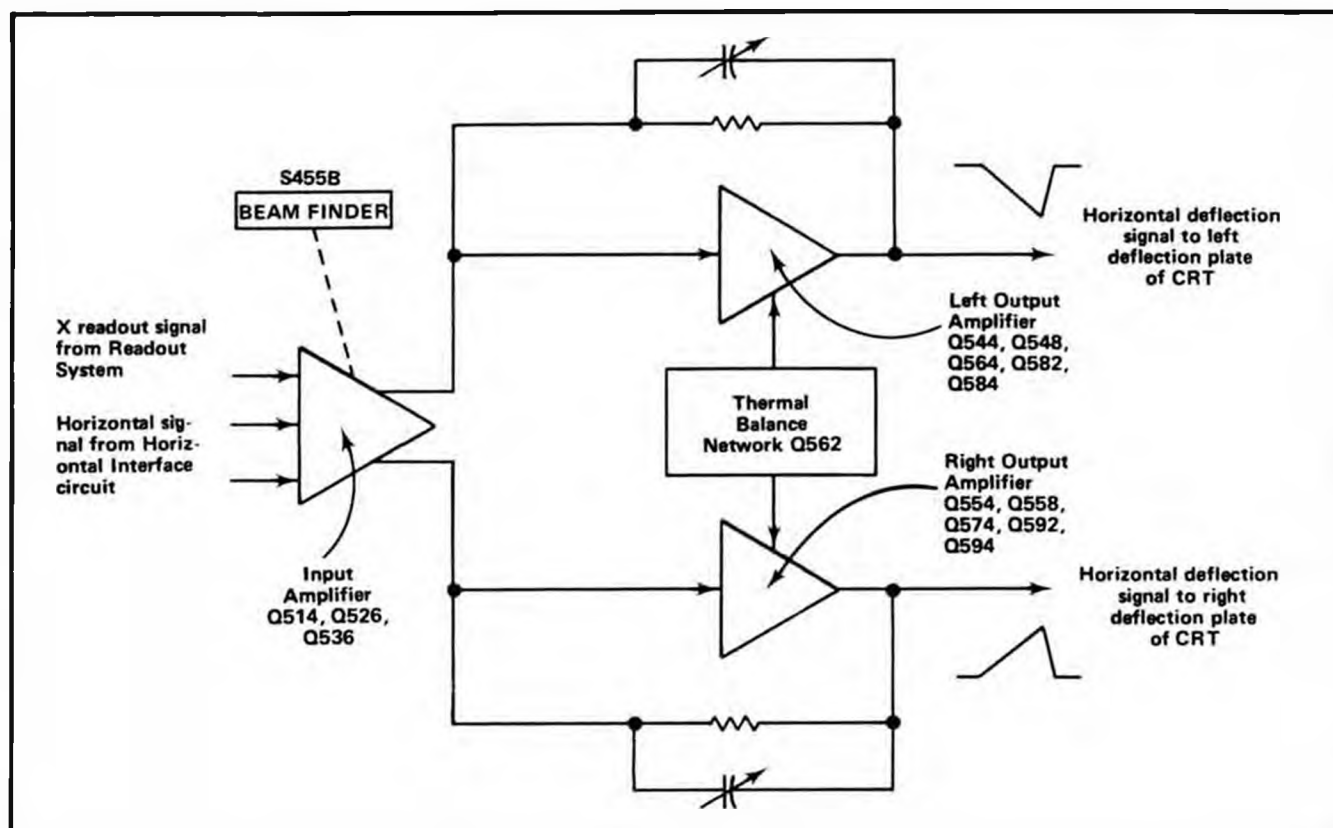


Fig. 3-29. Horizontal Amplifier detailed block diagram.

vide an intensity limit. This action prevents damage to the CRT phosphor when the display is compressed.

The Horizontal Centering adjustment R529 provides adjustment for differential unbalance in the Horizontal Amplifier circuit and the CRT. The network CR528-CR538-CR544-CR554 limits the input to the next stages so they always operate within their dynamic range and are not overdriven by excessive current from the Input Amplifier stage. Since the output signal from the Input Amplifier stage is a current signal, very little voltage change occurs across the limiting network. With horizontal deflection signals which produce an on-screen display, CR544 and CR554 remain forward biased and CR528-CR538 are reverse biased. However, if high-amplitude horizontal deflection signals are applied to this circuit as a result of sweep magnification or high-amplitude external horizontal signals, either CR544 or CR554 is reverse biased, depending on the polarity of the overdrive signal. This results in a sufficient voltage change at the anode of either CR528 or CR538 to forward bias it. The shunt diodes provide a current path for the signal current to limit the current change at the bases of Q544-Q554 during the overdrive condition.

For readout displays, the X readout signal from the Readout System is connected to the base of Q526 through

R525. The signal from the A HORIZ and B HORIZ units is blocked in the Horizontal Interface circuit so the only horizontal deflection is provided by the Readout System. Q526 and Q536 operate as a paraphase amplifier to convert the single-ended readout signal at the base of Q526 to a push-pull signal at the collectors of both Q526 and Q536. For instruments which are not equipped with a Readout System, R525 is connected to ground at the chassis where the Readout System is normally mounted.

### Left Output Amplifier

Transistors Q544, Q548, Q584, Q582, and Q564 are connected as a current-driven feedback amplifier. The input current is converted to a voltage output signal to drive the left horizontal deflection plate of the CRT. Input transistor Q544, an NPN transistor, responds best to positive-going input signals. The signal at the collector of Q544 is connected to the emitters of output transistors Q582-Q584 through two parallel paths. High-frequency signals are connected through capacitor C544. Low-frequency signals are connected to the output transistors through R544-Q548-R549. The output transistors Q582 and Q584 are connected in the complementary configuration to provide less resistive loading at the output. The output signal at the collector of Q582-Q584 is connected to the left deflection plate of the CRT through L589-R589.

Negative DC feedback is provided from the collectors of Q582-Q584 to the base of Q544 through feedback network R569-Q564-R563. Emitter follower Q564 in the feedback network provides current gain for the feedback signal. With this configuration, the input impedance of the Left Output Amplifier is low since the feedback network beyond the emitter followers is effectively reduced in impedance as far as the input signal is concerned. Variable capacitor C569 adjusts the transient response of the feedback network to provide good linearity at fast sweep rates. C568-R568 provide adjustment for correct high-frequency gain versus frequency response in the amplifier.

### Right Output Amplifier

Basic operation of the Right Output Amplifier stage is the same as just described for the Left Output Amplifier stage. Notice that the input transistor in this stage is complementary to the corresponding transistor in the Left Output Amplifier stage. Therefore, this stage provides the best response to negative-going input signals. C579 provides linearity adjustment for the Right Output Amplifier at fast sweep rates. The output signal at the collectors of Q592-Q594 is connected to the right deflection plate of the CRT through L599-R599.

### Thermal Balance Network

Q562 provides thermal balance for the Horizontal Amplifier circuit. The Thermal Balance adjustment R571 sets the bias on Q562 and thereby determines the operating voltage for Q544-Q554. This adjustment provides DC shift in the CRT display and reduces low-frequency signal cross talk. Diode CR562 provides reverse-voltage breakdown protection for Q562 when the instrument is first turned on. Diodes CR560 and CR570 establish the operating bias for Q544-Q554.

## OUTPUT SIGNALS AND CALIBRATOR

### General

The Output Signals and Calibrator circuit provides output signals to the connectors located in the OUTPUTS 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. Fig. 3-30 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 Channel Switch (see Trigger Selector description for more information) is connected to the bases of differential amplifier Q684-Q694. Resistors R681-R692 establish an input resis-

tance of about 50 ohms for this stage. The amplified signal at the collectors of Q684 and Q694 is connected to buffer amplifier Q686-Q696 through RC networks C686-R686 and C695-R695. These networks provide thermal balance for this stage. The single-ended signal at the collector of Q686 is connected to the front-panel SIG OUT connector J699. The signal at the collector of Q696 is connected to ground. CR696 and CR699 protect this stage if high-level voltages are accidentally applied to the SIG OUT connector. CR696 provides protection from positive voltages and CR699 provides protection from negative voltages.

### Sawtooth Amplifier

The sawtooth signals from the A Time-Base unit and the B Time-Base unit are both connected to the Sawtooth Amplifier stage through series resistors R32 and R34 respectively (on Main Interface board). The Sweep switch S666 (located on Output Signals board) determines which sawtooth signal provides the output signal. The other sawtooth signal is terminated by R667 to provide a similar load to the signal source. Transistors Q670, Q672 and Q675 comprise an inverting feedback amplifier. Gain of this stage is about two as determined by the ratio of feedback resistor R678 to the input resistance made up of R669 and either R32 or R34, depending on which sawtooth source is selected. The signal at the collector of Q675 is connected to the front-panel + SAWTOOTH connector J679 through R679. RC network C675-R675 provides frequency response stabilization for this stage. Diode CR674 provides protection from high-level positive voltages inadvertently connected to the output connector by providing a current path to the +15-volt supply through the collector-base junction of Q675. When CR674 is forward biased it clamps the base of Q675 at this level. CR676 provides protection from high-level negative voltages at the + SAWTOOTH connector by clamping the output if it attempts to go more negative than about -15.6 volts.

### Gate Amplifier

The output signal at the front-panel + GATE connector J618 is selected from three input gate signals by Gate switch S607 (located on Output Signals board). In the A position, the A Gate signal from the A Time-Base unit is connected to the base of emitter-follower Q607 through R607. The base of Q608 is connected to ground by S607 in this position so it operates as a common-base stage. Q607 provides a high input impedance for the stage while the emitter coupling between Q607-Q608 provides temperature compensation. Operation is the same in the B position of S607 except that the B Gate signal from the B Time-Base unit provides the input signal. In the Dly'd position, S607 connects the base of Q607 to ground through R607 and disconnects both the A and B Gate signals. Now, the Delayed Gate signal from the delaying time base (in A HORIZ compartment) can pass to the base of Q608 through R602. Q608 inverts this negative-going input signal



so the gate output signals at the + GATE connector are all positive going.

The input gate signal selected by S607 is connected to the emitter of Q615 through C612-R612. Diode CR614 provides temperature compensation of Q615. The signal at the collector of Q615 is connected to the + GATE connector through CR615 and R617. CR615 protects Q615 if a high-level positive voltage is applied to the + GATE connec-

tor and CR616 clamps the output at about  $-0.6$  volt if a negative signal is applied to this connector.

### B Gate Amplifier

The B Gate signal from the B Time-Base unit is connected to the base of Q610 through R610. Q610 amplifies and inverts the B Gate signal to provide a negative-going gate signal to the Calibrator circuit for B GATE operation

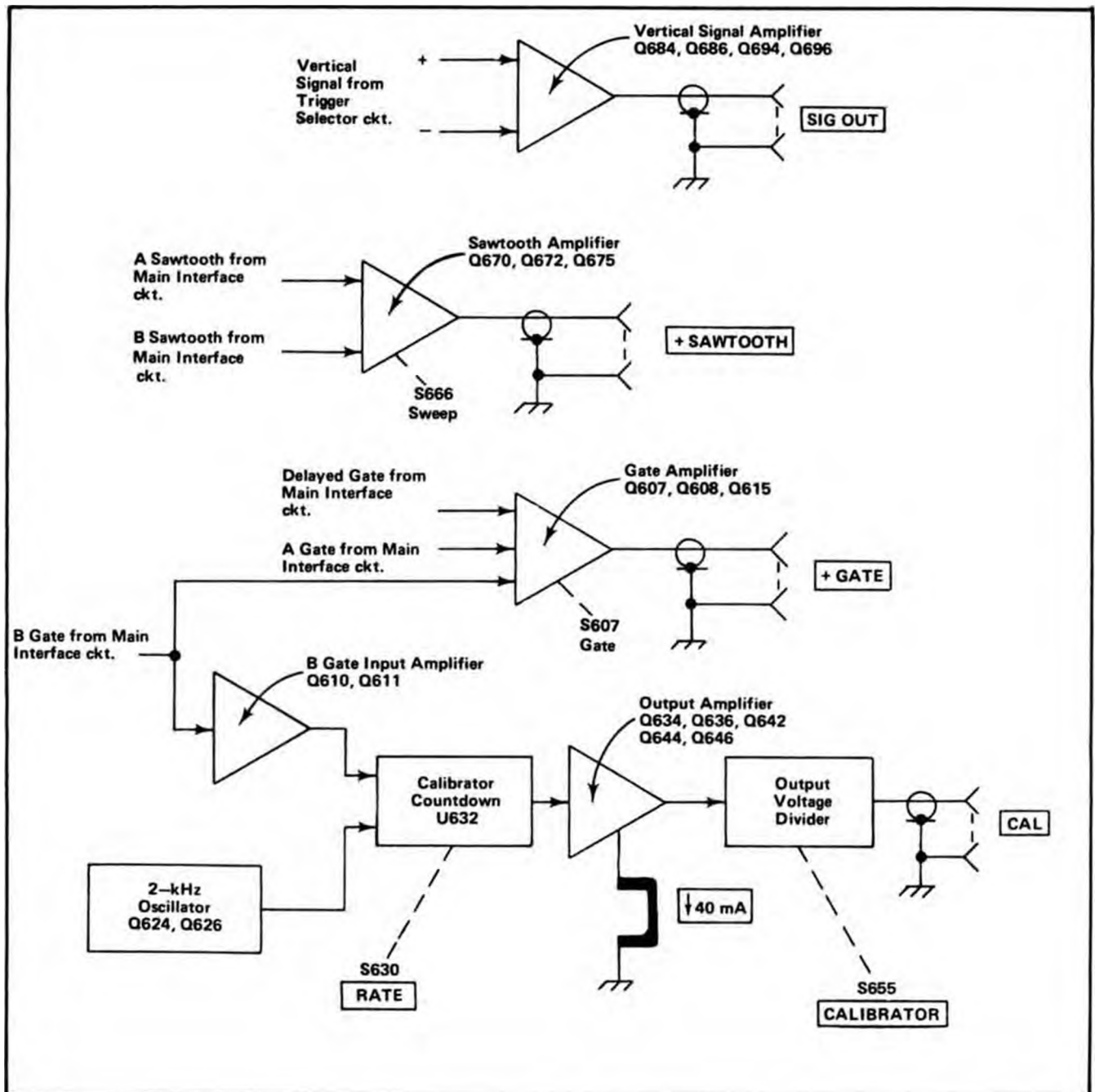


Fig. 3-30. Output Signals and Calibrator detailed block diagram.



of the Calibrator. Q611 provides temperature compensation for this stage.

Calibrator

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

**2-kHz Oscillator.** Q624 and Q626 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 Q624 is conducting and Q626 is off. The collector current of Q624 through R624-R625 produces a voltage level which holds the base of Q626 low. This keeps Q626 turned off and since there is no current through it, its collector goes positive to produce the positive portion of the square wave. At the same time, C621 begins to charge toward -50 volts through R627. The emitter of Q626 goes negative also as C621 charges until it reaches a level about 0.6 volt more negative than the level at its base. Then, Q626 is forward biased and its emitter rapidly rises positive. Since C621 cannot change its charge instantaneously, the sudden change in voltage at the emitter of Q626 pulls the emitter of Q624 positive also to reverse bias it. The current through Q626 produces a voltage drop at its collector to produce the negative portion of the square wave.

Now, conditions are reversed. Since Q624 is reverse biased, there is no current through it. Therefore, C621 can begin to discharge through R621. The emitter level of Q624 follows the discharge of C621 until it reaches about -0.6 volt. Then, Q624 is forward biased and its collector drops negative to reverse bias Q626. This interrupts the current through Q626 and its collector goes positive again to complete the square wave. Once again, C621 begins to charge through R627 to start the second cycle. The signal produced at the collector of Q626 is a two-kilohertz square wave. C628 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, R625, sets this stage so an accurate one-kilohertz square-wave is produced at the output of the Calibrator circuit.

**Calibrator Countdown.** Integrated circuit U632 is a triggered set-clear (J-K) flip-flop. An input/output table for this device is shown in Fig. 3-31. The calibrator RATE switch S630 determines the operating mode of U632 and also

Input		Output
3	1	Condition at pin 7 after trigger pulse
LO	LO	Output changes state with each trigger pulse
LO	HI	HI
HI	LO	LO
HI	HI	No change

Fig. 3-31. Input/output table for U632.

selects the source of its trigger signal. S630 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 (current only) positions (contacts on diagram shown in this position), a LO level is applied to the 'J' input (pin 3) and a HI level is applied to the 'K' input (pin 1). The next negative-going trigger from the 2-kHz Oscillator stage switches the output at pin 7 to its HI level (see input/output table). The output at pin 7 remains at the HI level as long as the RATE switch remains in this position.

For the 1 kHz position, all contacts except 5 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 S630 so that U632 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 which is one-half the B Gate repetition rate. For DC (volts only) operation, the 'K' input is held LO and the 'J' input is held HI. The negative-going trigger pulse, furnished by the 2-kHz Oscillator stage, switches the level at pin 7 to LO where it remains until the RATE switch is changed.

**Output Amplifier.** Transistors Q642 and Q644 are connected as a comparator with the reference level at the base of Q644 determined by network R638-R647-R648-R649-Q646. This network establishes a voltage level at the base of Q644 which results in 8.88 milliamperes collector current through Q644 when it is on. The 0.4 V adjustment R649 is set in the 0.4 V position of the CALIBRATOR switch to provide accurate calibrator output voltages at the CAL connector J650. Resistors R640-R641 and R642 form a cur-

rent divider to determine the current through the front-panel 40 mA current loop L642 when Q642 is conducting. The 40 mA adjustment R640 is set so eight milliamperes flows through R642 and the current loop. 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 Q634 through R634. Q634 acts as a switch to control the current through Q636, and the output of Q636 controls the conduction of comparator Q642-Q644. When DC (current only) operation is selected by the calibrator RATE switch, a HI level is applied to the base of Q634 and it is forward biased. This allows current to flow through Q636 and the resultant voltage drop across R636 forward biases Q642. The collector current of Q642 produces an equivalent 40 milliamperes DC current (eight milliamperes through five turns) in the probe loop. At the same time, Q644 is off and there is no current through the Output Voltage Divider so there is no output at the CAL connector. Conditions are reversed for DC (volts only) operation. A LO level is applied to Q634 to cut it off. Therefore, there is no current through Q636 and the base of Q642 rises positive to cut it off also. Now, the collector current of Q644 produces a voltage drop across the Output Voltage Divider to provide a DC voltage output at the CAL connector. Since Q642 is off, there is no current through the current loop under this condition.

For the 1 kHz and B GATE  $\div 2$  positions, the base of Q634 varies between the LO and HI levels at the rate selected by the calibrator RATE switch. When the base of Q634 is LO, Q642 is off and Q644 is conducting. This produces an output voltage at the CAL connector but no current through the current loop as for DC (volts only) operation. When the level at the base of Q634 is switched to HI, Q644 conducts and Q646 is reverse biased. Now, current flows through the current loop and the voltage level at the CAL connector drops to zero as for DC (current only) operation. Notice that the current and voltage output of the calibrator are out of phase; the current through the current loop is at maximum when the voltage output at the CAL connector is minimum, and vice versa.

**Output Voltage Divider.** The collector current of Q644 in the Output Amplifier stage is applied across the voltage divider made up of resistors R652 through R659. 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. The output resistance in the 40 V position is about 15 kilohms as determined by R651 and the equivalent resistance of divider network R652-R659. This means that a 1.5 megohm load will produce about 1% error in output voltage; error increases as the load resistance decreases. The CALIBRATOR switch S655 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 resistance into a 50-ohm load (notice that 40 V position lists no output into 50 ohms and should not be used in this manner). S655 is a cam-type switch and the dots on the contact-closure chart (see diagram 8) indicate when the associated contact is closed.

## CRT CIRCUIT

### General

The CRT Circuit produces the high-voltage potentials and provides the control circuits necessary for the operation of the cathode-ray tube (CRT). This circuit also includes the Z-Axis Amplifier stage to set the intensity of the CRT display. Fig. 3-32 shows a detailed block diagram of the CRT Circuit. A schematic of this circuit is shown on diagram 9 at the rear of this manual.

### Z-Axis Amplifier

**General.** The Z-Axis Amplifier stage is a current driven, shunt-feedback amplifier with a voltage output. The output voltage provides the drive signal to control the CRT intensity level through the Control-Grid Supply. Details of operation for the individual stages within this circuit follow.

**Turn-On Delay.** Transistors Q706, Q708, and Q712 provide a delay for the CRT Circuit to prevent it from coming into operation until the other circuits within the instrument have reached operating levels. When the instrument is turned on, C711 begins to charge through R711-R709-R712. However, since C711 is completely discharged when the instrument is turned on, the base of Q712 is at  $-15$  volts. As C711 charges, it pulls the base of Q712 positive and its emitter follows. C711 continues to charge until the emitter level of Q712 reaches about  $+50$  volts (Q712 saturated). The emitter voltage of Q712 supplies the positive voltage for the feedback divider in the High-Voltage Regulator stage. The delay provided by the charging of C711 prevents CRT beam current for about four seconds. This protects the CRT phosphor from damage due to a high-intensity display as the instrument is first turned on.

The current flow through R709 as C711 charges also forward biases transistor Q708. This holds Q706 reverse biased so that it is not supplying current to Input Amplifier Q704. The result of this reduction in current to Q704 is that the Z-Axis Amplifier output remains at its low level regardless of the input from either the Z-Axis Logic stage or the Readout System. When C711 reaches full charge, the current flow through R709 ceases and Q708 is reverse biased. Q706 is now forward biased and it supplies about four milliamperes of bias current to Q704. Diode CR708 protects Q708 as C711 discharges when the instrument is turned off.

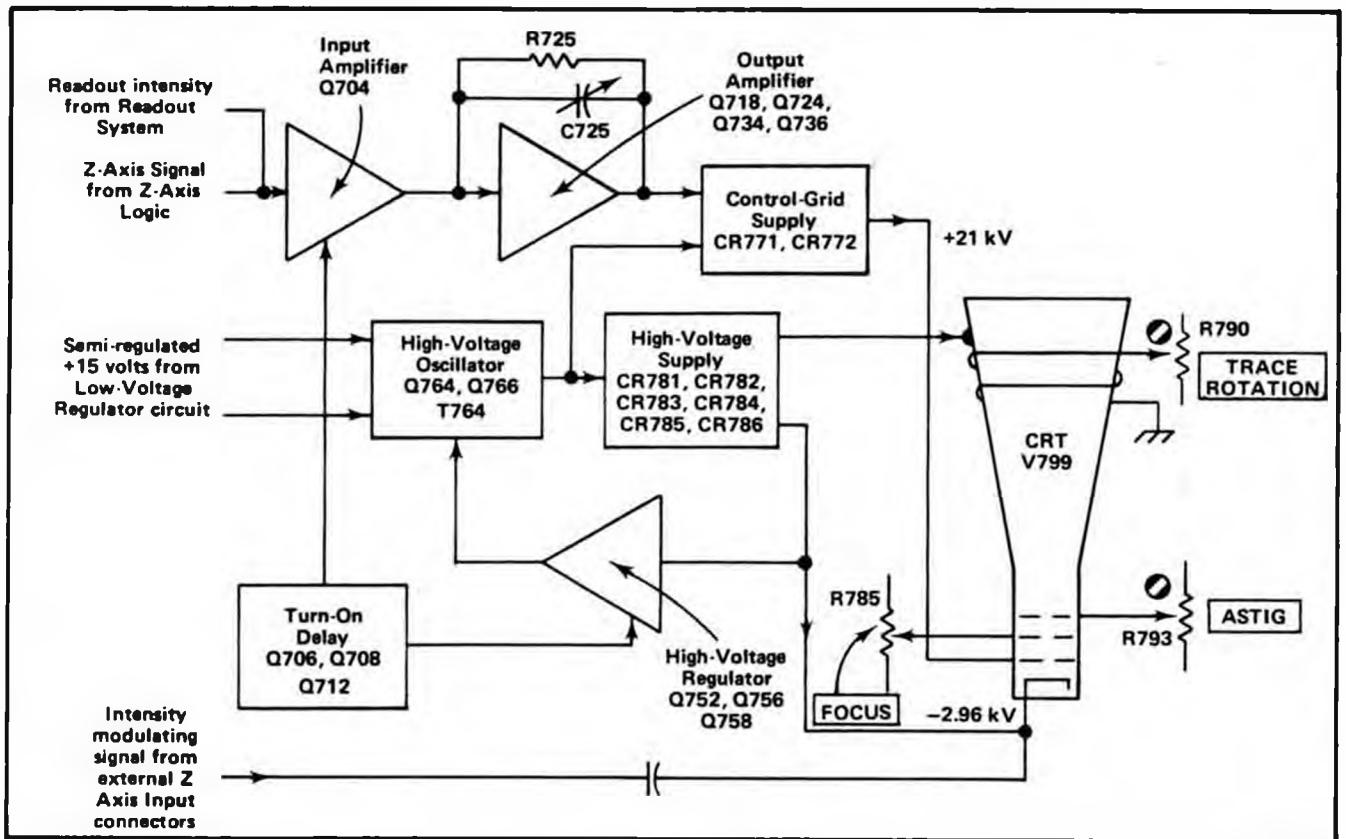


Fig. 3-32. CRT Circuit detailed block diagram.

**Input Amplifier.** Transistor Q704 is a common-base amplifier to establish a low input impedance for the Z-Axis Amplifier. The operating bias of Q704 is established by Q706 as described in the previous paragraph. The output level of this stage is determined by the input current from either of two circuits. For normal operation, the Z-Axis Signal from the Logic Circuit sets the input current as determined by the front-panel A and B INTENSITY controls, the chopped blanking logic, or an external signal connected to either of the rear-panel Z-Axis inputs (see Logic Circuit description for details). For readout displays, the Z-Axis Signal is blocked in the Logic Circuit. Now, the input current is provided from the Readout System as determined by the READOUT intensity control on the front panel.

**Output Amplifier.** The output stage is a shunt-feedback operational amplifier with feedback connected from the output to the input through C732-R732. The output voltage is determined by the input current multiplied by the feedback resistor and is expressed by the formula:  $E_{out} = I_{in} \times R_{fb}$  where R732 is  $R_{fb}$ . The signal current change at the base of Q704 for maximum intensity is about four milliamperes. The maximum output voltage change is set for 64 volts (about 4 mA  $\times$  15.4 k $\Omega$ ). AC feedback is provided from the output to the base of Q718 by C732. This capacitor is adjusted for optimum step response to provide a fast-rise unblanking gate output signal with mini-

mum overshoot or ringing. Otherwise, the CRT display would vary in intensity level following sudden changes in blanking.

The signal from the Input Amplifier stage is amplified by Q718-Q724. Variable resistor R719 in the collector circuit of Q718 provides transient response adjustment for this stage. The signal at the collector of Q724 is connected to the base of transistor Q732 through C730 and to the base of Q734 through R722-C723-R723. These transistors are connected as a collector-coupled complementary amplifier to provide a linear, fast output signal while consuming minimum quiescent power. Q734 maintains the low-frequency response of the input signal and provides a fast falling edge on the output signal. Only the fast-changing portions of the input signal are coupled to the base of Q732 through C730. Since Q732 is a PNP-type transistor, it responds faster to negative-going changes at its base than to positive-going changes. This action provides a fast rising edge on the output signal (fast falling edge provided by Q734, an NPN-type transistor). The signal at the collectors of Q732-Q734 is connected to the Control Grid Supply stage through R735-R736.

Diodes CR718, CR734 and CR735 provide protection for the Z-Axis Amplifier circuit. CR735 protects this stage from damage due to high-voltage surges connected back

into this circuit from the high-voltage supply. CR734 protects Q734 by clamping its base at  $-0.6$  volt if Q724 fails or is removed from its socket while the instrument is on. CR718 protects Q718 against excess reverse base-emitter voltage.

### High-Voltage Oscillator

Unregulated voltage for operation of the high-voltage supply is provided from the semi-regulated  $+15$  volts in the Low-Voltage Regulator circuit. The starting bias current for the High-Voltage Oscillator is supplied from the positive side of the  $+15$  volt input through R759. As the High-Voltage Oscillator begins to operate, the emitter of Q758 goes negative and further bias current is available through CR759 from the negative side of the semi-regulated  $+15$  volts. This configuration provides a controlled starting current for the High-Voltage Oscillator at turn-on and at the same time allows the High-Voltage Regulator stage to control the current of the High-Voltage Oscillator to regulate the output level after the stage reaches operating potential.

Q764-Q766 and the associated circuitry comprise the High-Voltage Oscillator to drive the high-voltage transformer T764. When the instrument is turned on, starting current is supplied to the bases of both Q764 and Q766. Both transistors are forward biased, and they both attempt to come into conduction. However, since the transistors will not have identical characteristics (even though they are of the same type), one transistor conducts more heavily than the other. For purposes of this explanation, assume that Q764 conducts more heavily. The collector current of Q764 produces a corresponding current increase in the base-feedback winding of T764 to further increase the bias on Q764. At the same time, the voltage developed across the base-feedback winding connected to Q766 reverse biases it. As long as the collector current of Q764 continues to increase, a voltage is induced into the base-feedback windings of T764 which holds Q764 forward biased. However, when the collector current of Q764 stabilizes, the magnetic field built up in T764 begins to collapse. This induces an opposite current into the base windings which reverse biases Q764, but forward biases Q766. When the induced voltage at the base of Q766 exceeds the bias set by Q758, Q766 is forward biased and the amplified current at its collector adds to the current flowing through T764 due to the collapsing field. Then as the current through T764 stabilizes again, the magnetic field around it once more begins to collapse. This induces a voltage into the base windings which forward biases Q764 and reverse biases Q766 to start another cycle.

The signal produced across the primary of T764 is a sine wave at a frequency of 35 to 45 kilohertz. C764-L764 shape the signal in the primary of T764 to improve regulation of the high-voltage supply. The amplitude of the oscillations in the primary of T764 is controlled by the High-Voltage Regulator stage to set the total accelerating poten-

tial for the CRT. Filter network C762-L762 decouples high peak operating currents from the  $+15$ -Volt Supply.

### High-Voltage Regulator

A sample of the secondary voltage from T764 is connected to the High-Voltage Regulator stage through divider R740-R741-R742. Q752 and Q756 are connected as an error amplifier to sense any change in the voltage level at the base of Q752. The  $-15$ -Volt Supply, connected to the emitter of Q752 through R753-R755, and the  $+50$  volts connected to R740 from the emitter of Q712 provide the reference level for this stage. High Voltage adjustment R743 sets the quiescent level at the base of Q752 to a level which establishes a  $-2.96$  kV operating potential at the CRT cathode. CR747 protects Q752 from excessive reverse emitter-base voltage.

Regulation occurs as follows: If the output voltage at the  $-2960$  V test points starts to go positive (less negative), a sample of this positive-going change is connected to the base of Q752. Both Q752 and Q756 are forward biased by this positive change which in turn increases the conduction of Q758. This results in a greater bias current delivered to the bases of Q764-Q766 through Q758. Now, the bases of both Q764 and Q766 are biased closer to their conduction level so that the feedback voltage induced into their base-feedback windings produces a larger collector current. This results in a larger induced voltage in the secondary of T764 to produce a more negative level at the  $-2960$  V test point to correct the original error. In a similar manner, the circuit compensates for output changes in a negative direction. Since the amplitude of the voltage induced into the secondary of T764 also determines the output level of the positive High-Voltage Supply and the Control-Grid Supply, the total high voltage output is regulated by sampling the output of the negative High-Voltage Supply.

### High-Voltage Supplies

The high-voltage transformer T764 has three output windings. One winding provides filament voltage for the cathode-ray tube. Two high-voltage windings provide the negative and positive accelerating potential for the CRT and provide the bias voltage for the control grid. All of these outputs are regulated by the High-Voltage Regulator stage to maintain a constant output voltage as previously described.

Positive accelerating potential for the CRT anode is supplied by voltage quintupler C782-C783-C784-C785-C786-CR782-CR783-CR784-CR785-CR786. This rectified voltage is filtered by C787-R786-R787 to provide an output of about  $+21$  kilovolts. All of these components are included in an encapsulated assembly. The negative accelerating potential for the CRT cathode is also obtained from the same secondary winding. Half-wave recti-

fier CR781 provides an output voltage of about  $-2.96$  kilovolts which is connected to the CRT cathode through L781 and L788. The cathode and filament are connected together through L788 to prevent cathode-to-filament breakdown due to a large difference in potential between these CRT elements. Neon bulbs DS781 and DS785 protect L781 and L788 if the CRT cathode is shorted to chassis ground. Diode CR780 and neon bulb DS780 protect the  $+50$ -Volt Supply from damage under this condition. A sample of the negative accelerating voltage is connected to the High-Voltage Regulator stage to maintain a regulated high-voltage output.

Half-wave rectifier CR772 provides a negative voltage for the control grid of the CRT. Output level of this supply is set by the CRT Grid Bias adjustment R739. Rectifier CR771 provides rectified low-potential voltage to R739 so that it can perform its function without being enclosed in the high-voltage compartment. Neon bulbs DS786-DS787-DS788 protect the CRT by limiting the voltage difference between the cathode and control grid to a maximum of about 165 volts. The unblanking gate from the Z-Axis Amplifier circuit is connected to the positive side of this circuit. As the unblanking gate level changes, it shifts the overall supply level to change the bias on the CRT to control the intensity of the display.

High speed intensity modulating signals from the rear panel Z Axis Inputs are applied to the CRT cathode through C790-C791-R788. This signal changes the CRT bias, and thereby the intensity of the display, by changing the level of the cathode. RC divider C1056-C1057-R1056-R1057 provides a cross-over network between the HIGH SPEED and HIGH SENSITIVITY inputs. The HIGH SENSITIVITY connector provides an input for low-frequency, low-amplitude intensity modulating signals. This signal is connected to the Z Axis Logic stage through R1060 (see Logic Circuit description for further information).

### CRT Control Circuits

Focus of the CRT display is determined by the FOCUS control R785. This control is part of divider R782-R783-R785-R744-VR786 between the negative high-voltage supply and ground. Therefore, the voltage applied to the focus grid is more positive (less negative) than the voltage on either the control grid or cathode. The ASTIG adjustment R793, which is used in conjunction with the FOCUS control to obtain a well-defined display, varies the positive level on the astigmatism grid. Geom adjustment R792 varies the positive level on the horizontal deflection plate shield to control the overall geometry of the display.

Two adjustments control the trace alignment by varying the magnetic field around the CRT. Y Axis adjustment

R795 controls the current through L795 which affects the CRT beam after vertical deflection but before horizontal deflection. Therefore, it affects only the vertical (Y) components of the display. The TRACE ROTATION adjustment R790 controls the current through L790 and affects both the vertical and horizontal rotation of the beam.

## LINE TO DC CONVERTER/REGULATOR

### General

The Line to DC Converter/Regulator circuit provides the operating power for this instrument from an AC line voltage source. This circuit also includes the Line Selector assembly to allow selection of the nominal operating voltage for the instrument. Figure 3-33 shows a detailed block diagram of the Line to DC Converter/Regulator circuit. A schematic of this circuit is shown on diagram 10 at the rear of this manual.

### Line Input

Power is applied to this circuit through Line fuse F800, EMI (electro-magnetic interference) filter FL801, POWER switch S800 and thermal cutout S801. The EMI filter is made up of C800-C801-C803-L800-L801-T800. This filter is designed primarily to filter out the 25 kilohertz interference originating within this circuit. L800-L801 provide differential and common-mode inductance; T800 provides additional common-mode inductance. C803 along with the differential inductance of L800-L801 provides differential EMI filtering. R803 provides differential resonance damping for C803-L800-L801. R804 provides a discharge path for C803 when the POWER switch is turned off. Common-mode EMI filtering is provided by C800-C801 along with the common-mode inductance of T800. R801 provides common-mode resonance damping for C800-C801-T800.

Thermal cutout S801 provides thermal protection for this instrument. If the internal temperature of the instrument exceeds a safe operating level, S801 opens to interrupt the applied power. When the temperature returns to a safe level, S801 automatically closes to re-apply the power.

The Line Selector switch S810 allows this instrument to operate from either a 115-volt nominal line or a 230-volt nominal line. In the 115 V position, rectifier CR810 operates as a full-wave doubler along with capacitors C813-C814. For 230 V operation, S810 connects rectifier CR810 in the bridge configuration. Under this condition, C813-C814 operate as series energy-storage capacitors. With this configuration, the output voltage from the Line Input stage to the Inverter stage is about the same for either 115-volt or 230-volt operation.

C810-L810 and C811-L811 form a 25 kilohertz filter to provide further EMI filtering. Thermistors RT810 and

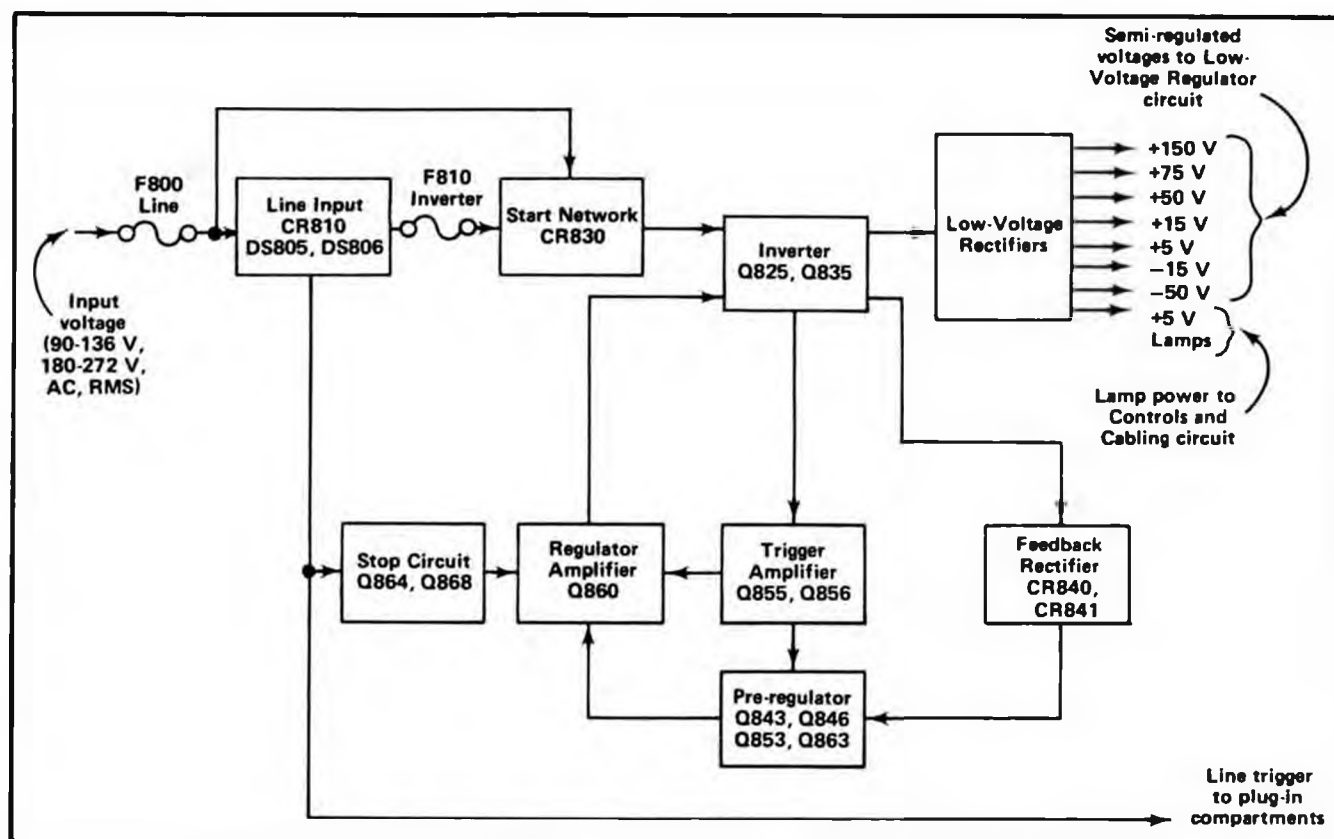


Fig. 3-33. Detailed block diagram of Line to DC Converter/Regulator circuit.

RT811 limit the surge current demanded by the power supply when it is first turned on. After the instrument is in operation, the resistance of the thermistors drops so that they have little power loss and have little effect on the operation of this stage. The stored charge on C813 and C814 limits the surge current if the POWER switch is quickly turned off and back to ON after the resistance of the thermistors has dropped to their low value. The discharge of capacitors C813-C814 is controlled by R813, and it is so designed that the discharge time constant of C813-C814-R813 is about equal to the thermal time constant of RT810-RT811. This arrangement provides surge-current limiting for the Line Input stage at all times. Since C813-C814 discharge slowly, dangerous potentials can exist across these capacitors for several minutes after the POWER switch is turned off. C812-DS812-R812 form a relaxation oscillator to indicate the presence of voltage across C813-C814. Neon bulb DS812 will blink until the potential across these capacitors drops to about 100 volts.

The rectified output voltage from this stage is connected to the Inverter stage through Inverter fuse F810. This fuse protects the Inverter stage if it demands too much current due to a malfunction.

DS805 and DS806 are surge voltage protectors. When the Line Selector switch is in the 115 V position, only

DS805 is connected across the line input. If a peak voltage surge in excess of about 230 volts is present on the line, DS805 will break down and demand high current. This excess current will quickly open Line fuse F800 to interrupt the input power before the circuit can be damaged. In the 230 V position, DS805 and DS806 are connected in series across the line input to provide surge voltage protection for peak voltage surges in excess of 460 volts.

Transformer T805 provides a sample of the line voltage to the plug-in connectors in the Main Interface circuit for internal triggering at line frequencies or for other applications. In the 115 V position of S810, the line input voltage is connected across the primary of T805 and R805. For the 230 V position, the line voltage is connected across the primary of T805 and R805-R806 in series. This arrangement provides an output voltage of about one volt RMS for either nominal line voltage. The line trigger signal is also connected to the Stop Circuit to provide an indication of the presence of line voltage at the input to this circuit.

### Start Network

Rectified DC power for the Inverter stage is supplied through EMI filter C820-C821-C822-T820. C820-C822-T820 provide common-mode filtering and C821

provides differential filtering. Resistors R820 and R821 provide common-mode and differential resonance damping respectively. The positive input voltage is connected directly to the power transformer T870. The negative input voltage provides the negative reference for the Inverter stage; the negative voltage to the power transformer is determined by the Inverter stage.

The input line voltage to this instrument is connected across divider R823-R824. This voltage charges C824 on each half cycle. Trigger diode CR830 conducts when the charge on C824 reaches about 32 volts to provide a turn-on trigger current to transistor Q835 through C835. This current allows the Inverter stage to start operation. After the Inverter stage is operating, the recurrent waveform at the collector of Q835 keeps C824 discharged through CR831.

### Inverter

A simplified schematic of the Inverter stage is shown in Fig. 3-34. After the circuit has been placed into operation by the start circuit, the LC circuit C1-L1 oscillates at its resonant frequency. The resulting current through the one-turn winding of T1 induces a bias current into the base circuit of either Q1 or Q2, depending on the polarity. The 1:4 turns ratio of T1 results in a current in the transistor base circuits which is one-fourth the current in the one-turn feedback winding. Since the current in the feedback winding must flow through the conducting transistor, the transistors operate at a forced beta of four. A sine-wave current is produced across the primary of power transformer T2; the voltage is a square wave with a peak-to-peak amplitude equal to the input DC voltage. The voltage induced into the secondary of T2 is rectified by diodes CR1

and CR2, filtered by capacitor C2 and applied across load R2.

Refer to the complete Line to DC Converter/Regulator diagram. The LC circuit is made up of C870 and L870. After the circuit has been started by the Start Network as discussed previously, C870-L870 resonate at a frequency of 25 kilohertz. The feedback to the base circuits of Q825-Q835 through T825 alternately turns Q825 and Q835 on. These transistors operate at a forced beta of four due to the turns ratio of T825, and their output current sustains resonance in C870-L870. The 60-turn center-tapped winding of T825 is used to delay the turn-on of Q825 or Q835 to provide pre-regulation of the voltage in the primary of T870. This operation will be discussed in more detail under Pre-Regulator.

Diodes CR828 and CR838 provide reverse conduction paths across Q825 and Q835 respectively, when these transistors are held off for pre-regulation purposes. Inductors L826-L836 minimize turn-on losses in the transistors by reducing the voltage on Q825-Q835 during their turn-on interval. CR826-R826 and CR836-R836 protect Q825 or Q835 from excessive voltage due to stored energy in the associated inductors when the transistors are turned off. Diodes CR825 and CR835 aid in the turn off of the associated transistors by connecting the collector potential back to the base of each transistor. This feedback does not turn the transistor off but removes the excess base current to reduce the turn-off time when the current from feedback transformer T825 reverses. The networks C825-R825 and C835-R835 develop voltage biases in response to the average base currents of Q825 and Q835 which help to hold Q825 and Q835 in cutoff during their respective off intervals.

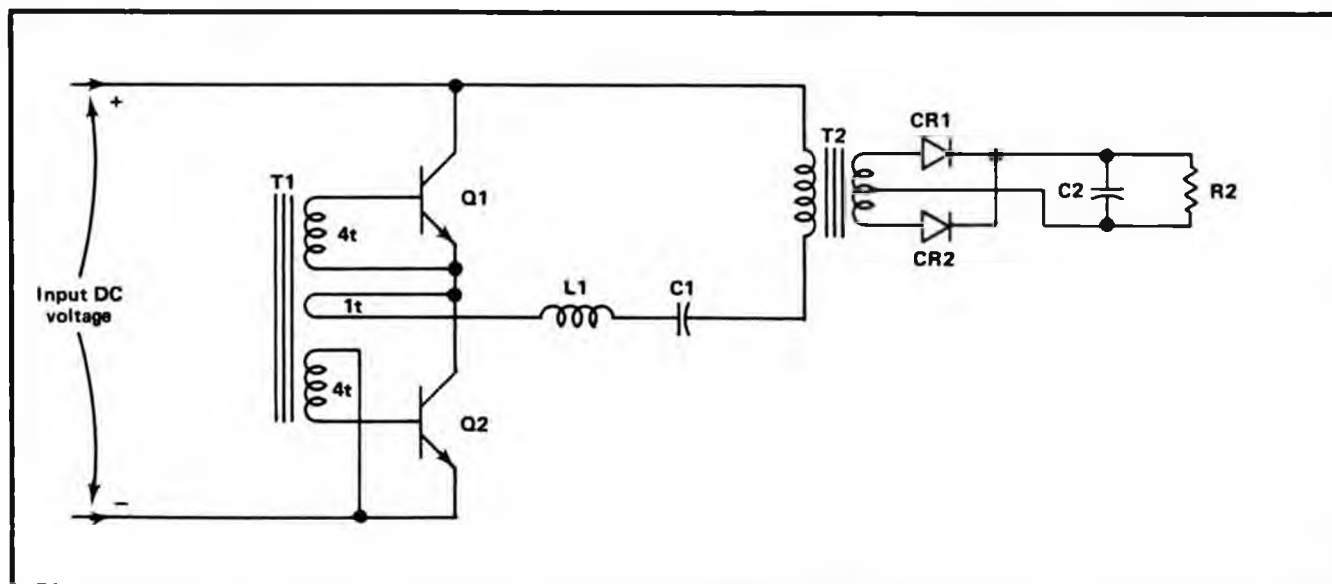


Fig. 3-34. Simplified schematic of Inverter stage.



### Trigger Amplifier

The primary current of power transformer T870 also flows through the one-turn primary winding of T839. The voltage induced into the secondary of T839 is differentiated by C855-R855 and C856-R856 and connected to the bases of Q855 and Q856. Notice that the differentiated signal at the bases of these transistors is opposite in polarity and this polarity changes on each half-cycle of the induced voltage. Therefore, on each half-cycle the transistor which receives a positive-going pulse at its base is momentarily forward biased. This results in a negative-going pulse at the collector of one of the transistors which is connected to the Pre-Regulator multivibrator.

CR857 and CR858 rectify the voltage in the secondary of T839. Under normal conditions, the rectified voltage developed across C858-R858 is not sufficient to forward bias CR859. However, if excess current is demanded from the Inverter stage, the current through the primary of T839 increases to result in a larger current in its secondary. This results in a larger voltage drop across R858 and, when it is sufficient to forward bias CR859, Q860 in the Regulator Amplifier circuit is turned on to limit the output current of the Inverter stage.

### Feedback Rectifier

Diodes CR840 and CR841 form a center-tapped full-wave rectifier. The rectified output of these diodes is filtered by C840-R840 to provide a feedback voltage of about +16 volts to the Pre-Regulator stage. The exact output level depends upon the voltage applied to transformer T870. This feedback is used to provide pre-regulation of the output voltages of T870.

### Pre-Regulator

Q853 and Q863 form a monostable multivibrator. The circuit conditions are such that Q863 is the conducting transistor in the stable state. When a negative-going trigger pulse is received from the Trigger Amplifier stage, Q863 turns off and Q853 turns on. The amount of time that Q853 remains in conduction is determined by the recharge time of C852. This time is, in turn, determined by Q843-Q846 and the feedback voltage from the Feedback Rectifier. Q843 and Q846 are connected as a comparator. Zener diode VR848 sets a level of about +9 volts at the base of Q846. The output voltage of the Feedback Rectifier stage is connected across divider R842-R843-R844. The +75 Volts adjustment R843 in this divider is adjustable to set the output voltage of the supply. If the feedback voltage from the Feedback Rectifier stage should increase after R843 has been adjusted properly, the collector current of Q843 will decrease. Therefore, C852 will recharge more slowly and Q863 will remain off for a longer period of time (further explanation of regulation will be given under Regulator Amplifier, which follows). Likewise, if the feedback

voltage decreases, the collector current of Q843 increases and C852 recharges more rapidly so that Q863 is off for a shorter period of time.

### Regulator Amplifier

The actual pre-regulation of the voltages produced by this circuit is controlled by transistor Q860. This transistor is connected so that it is always on when Q863 is off (note exceptions for current limiting and Stop Circuit operation). Therefore, when the multivibrator Q853-Q863 has been triggered so that Q863 is off, Q860 is on. The collector of Q860 drops negative and it conducts current away from the secondary of T825 through CR823 and CR824. Due to the turns ratio of T825, this action does not allow any current from the feedback winding to reach the base windings of either Q825 or Q835. As a result, the inverter transistors remain off as long as Q860 is on and they do not conduct current through the primary of T870. When the Pre-Regulator multivibrator resets so that Q863 is again conducting, Q860 turns off. Then, it does not conduct any current from T825 and the feedback current reaches the base windings of this transformer. Now the Inverter transistors operate as described previously. By controlling the amount of time that Q860 is in conduction, the voltage that is delivered to the power transformer T870 can be controlled. The amount of time that Q860 conducts is controlled by comparator Q843-Q846 and the feedback voltage as described under Pre-Regulator.

The network C860-CR860-R860-R861 in the collector circuit of Q860 protects this transistor from excess voltage at its collector when it is turned off. C858-CR857-CR858-CR859-R858 in the Trigger Amplifier stage, provide a current limiting network to protect the supply when excess current is demanded from the Inverter stage. When this condition occurs, the base of Q860 is pulled positive so that it conducts and limits the output current of the supply as long as excess current is flowing through the primary of T839.

### Stop Circuit

Transistors Q864 and Q868 provide a circuit to stop the operation of the Inverter circuit when the POWER switch is turned off or the line voltage is disconnected from this instrument. When the POWER switch is turned on and line voltage is available, the line triggers from transformer T805 in the Line Input stage are connected to the base of Q868 through R868. Each time a trigger pulse is received, Q868 conducts and the collector of Q868 goes negative to discharge C867. However, when there are no line triggers at the base of Q868, C867 begins to charge towards the feedback voltage through R867. As it charges, the base of Q864 is pulled positive to a level where it conducts. Then, the emitter of Q864 pulls the base of Q860 positive also to bring it into conduction. With Q860 conducting, the Inverter stage oscillation stops.



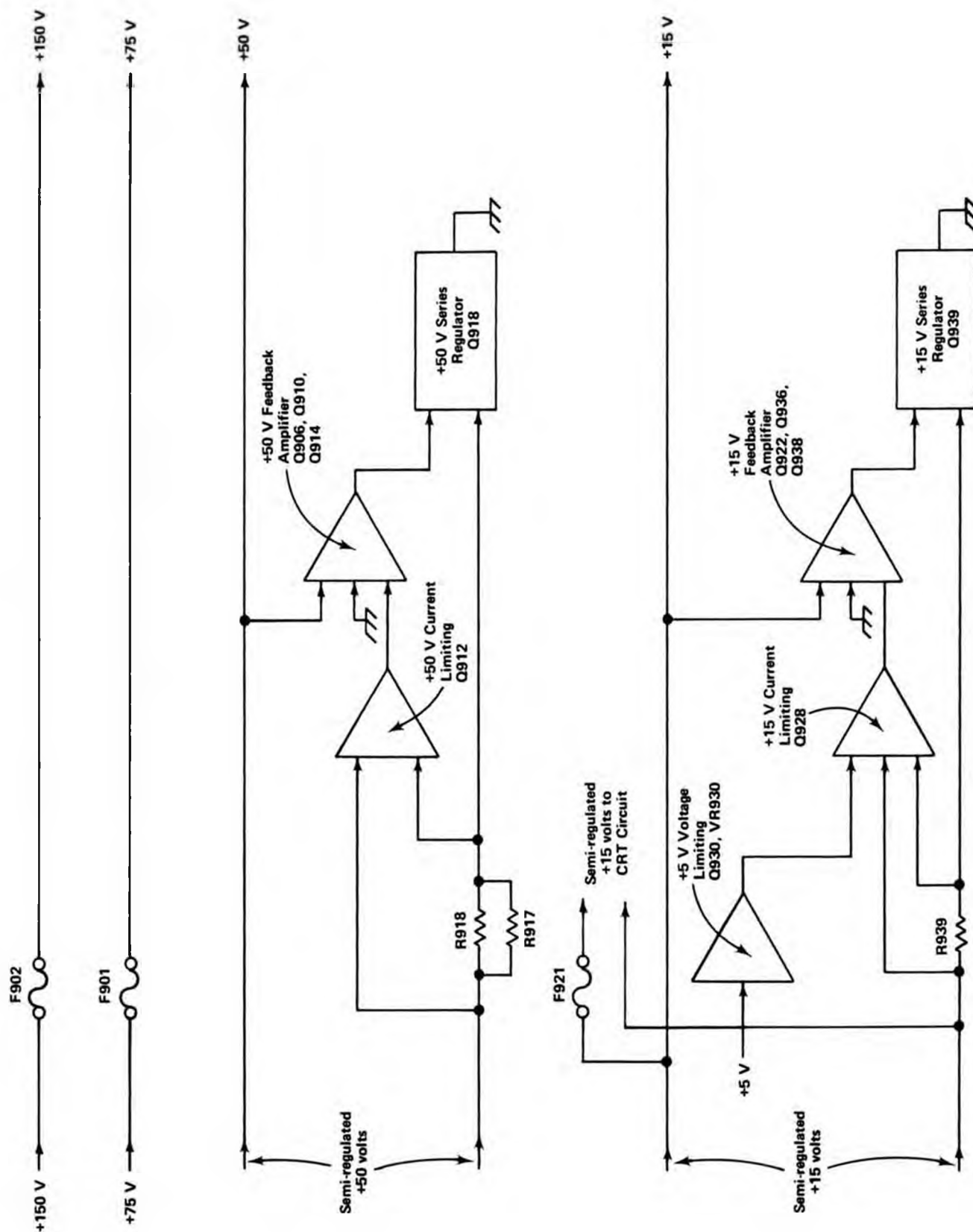


Fig. 3-35. Detailed block diagram of Low-Voltage Regulator circuit.

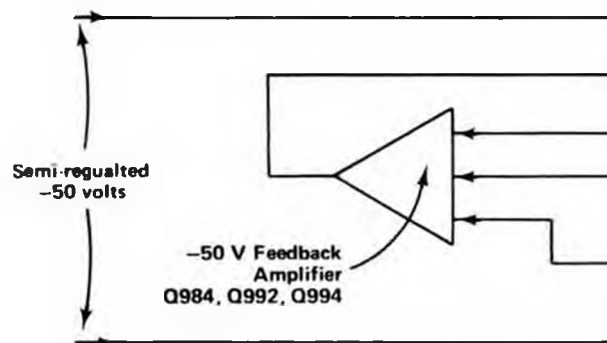
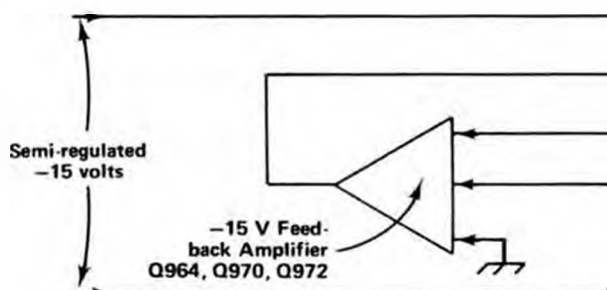
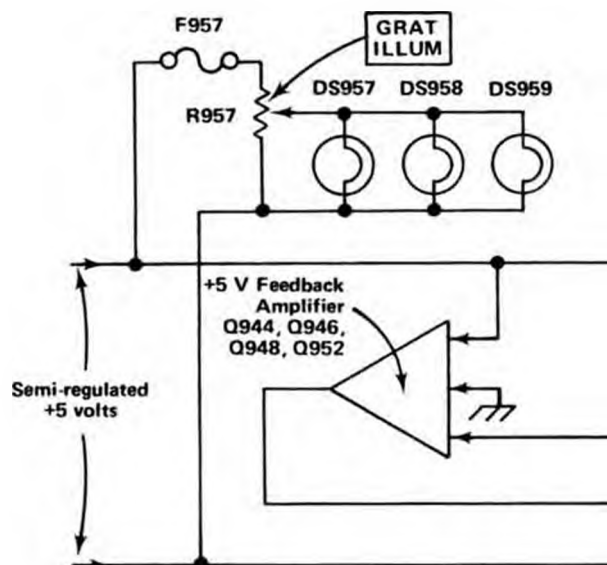
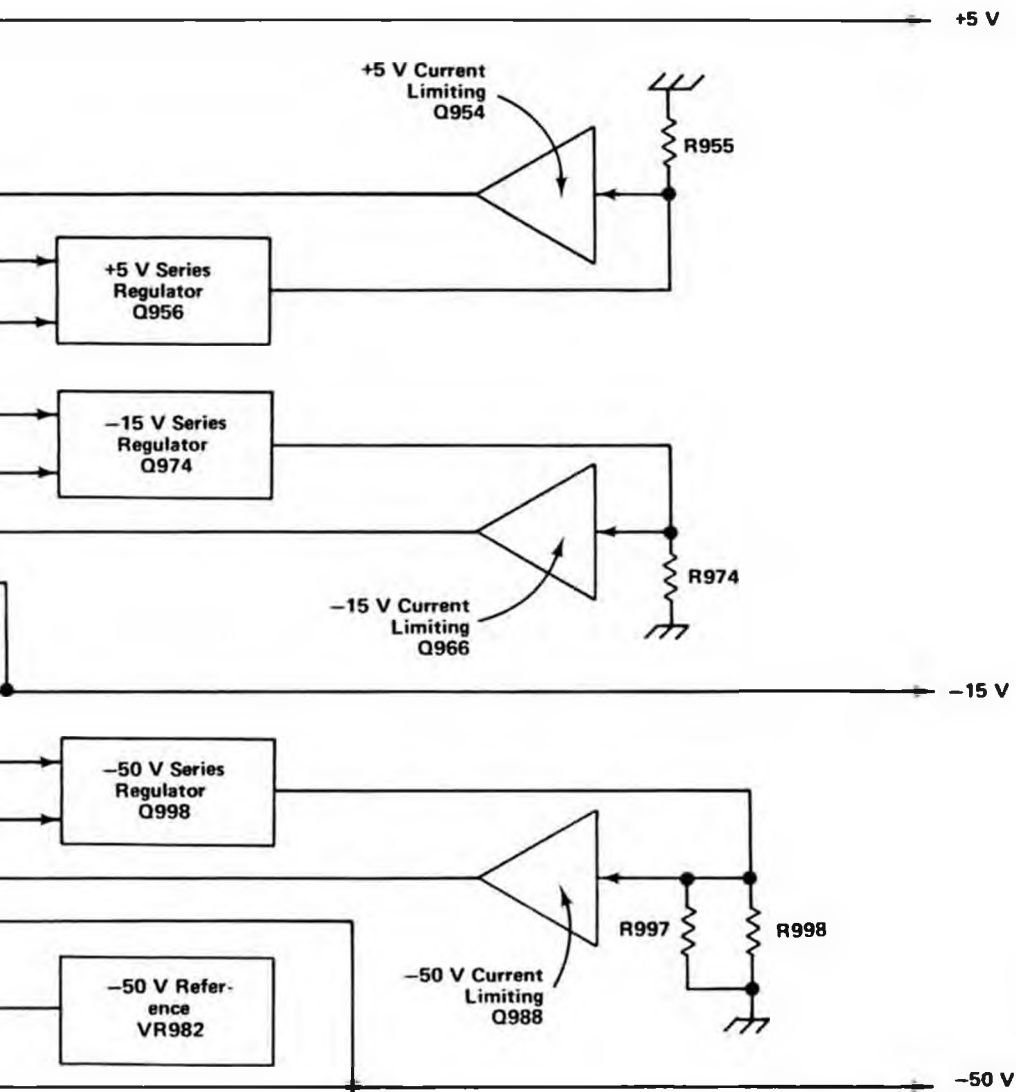


Fig. 3-35. (cont'd).



## Low-Voltage Rectifiers

The rectifiers and the associated filter components in the secondaries of T870 provide rectified, pre-regulated voltages for operation of this instrument or for re-regulation by the Low Voltage Regulator circuit for connection to the plug-in compartments. Zener diode VR876 and silicon-controlled rectifier Q876, connected from the +150 Volt output to ground, provide over-voltage protection for this circuit. If the output voltage across this secondary of T870 increases to about 180 volts, VR876 conducts to turn on Q876. This effectively shorts across this winding of T870 and demands high current from the circuit. This high current demand in the secondary of T870 results in Inverter fuse F810 opening to interrupt the power to the Inverter stage.

## LOW-VOLTAGE REGULATOR

### General

The Low-Voltage Regulator circuit contains five regulated supplies. Electronic regulation provides stable, low-ripple output voltages from the semi-regulated input voltages from the Line to DC Converter/Regulator circuit. Each supply contains a short-protection circuit to prevent instrument damage if a supply is inadvertently shorted to ground or to another supply. Fig. 3-35 shows a detailed block diagram of the Low-Voltage Regulator circuit. A schematic of this circuit is shown on diagram 11 at the rear of this manual.

### —50-Volt Supply

The following discussion includes the description of the —50 V Series Regulator, —50 V Feedback Amplifier, —50 V Reference and —50 V Current Limiting stages. Since these stages are closely related in the production of the —50-volt regulated output voltage, their operation is most easily understood when discussed as a unit.

The semi-regulated —50 volts from the Line to DC Converter/Regulator circuit provides the unregulated voltage source for this supply. Transistors Q984, Q992, Q994 and Q998 operate as a feedback stabilized regulator circuit to maintain a constant —50-volt output level. Q984 is connected as a differential amplifier to compare the feedback voltage at the base of Q984B against the reference voltage at the base of Q984A. The error output at the collector of Q984A reflects the difference, if any, between the two inputs. The change in error output level at the collector of Q984A is always in the same direction as the change in the feedback input at the base of Q984B (in phase).

Zener diode VR982 sets a reference level of about —9 volts at the base of Q984A. A sample of the output voltage from this supply is connected to the base of Q984B

through divider R985-R986-R987. R986 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. Fig. 3-36 illustrates the reason for this configuration. The inherent resistance of the interconnecting wire between the output of the —50-Volt Supply and the load produces a voltage drop which is equal to the output current multiplied by the resistance of the interconnecting wire. Even though the resistance of the wire is small, it results in a substantial voltage drop due to the high output current of this supply. Therefore, if the feedback voltage were obtained ahead of this drop, the voltage at the load might not maintain close regulation. However, the —50 V Sense configuration overcomes this problem since it obtains the feedback voltage from a point as close as practical to the load. Since the current in the —50 V Sense line is small and constant, the feedback voltage is an accurate sample of the voltage applied to the load.

Regulation occurs as follows: If the output level of this supply decreases (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 R985-R986-R987 decreases also. This results in a more positive feedback level at the base of Q984B than established by the —50 V Reference stage at the base of Q984A. Since the transistor with the more positive base controls the conduction of the differential amplifier, the output current at the collector of Q984A decreases. This decrease in output from Q984A allows more current to flow through Q992 and Q994 to result in increased conduction of the —50 V Series Regulator Q998. The load current increases and the output voltage of this supply also increases (more negative). As a result, the feedback voltage from the —50 V Sense line increases and the base of Q984B returns to the same level as the base of Q984A. Similarly, if the output level of this supply increases (more negative), the output current of Q984A increases. The feedback through Q992 and Q994 reduces the conduction of the —50 V Series Regulator to decrease the output voltage of this supply. C990-R990 and C992-R992 stabilize the feedback network.

The —50 Volts adjustment R986 determines the divider ratio to the base of Q984B and thereby determines the feedback voltage. This adjustment sets the output level of the supply in the following manner: If R986 is adjusted so the voltage at its variable arm goes less negative (closer to ground), this appears as an error signal at the base of Q984B. In the same manner as described previously, this positive-going change at the feedback input of the differential amplifier increases the conduction of the —50 V Series Regulator to produce more current through the load and thereby increase the output voltage of this supply. This places more voltage across divider R985-R986-R987 and the divider action returns the base of Q984B to about —9 volts. Notice that the feedback action of this supply forces a change in the output level which always returns the base of Q984B to the same level as the base of Q984A. In this

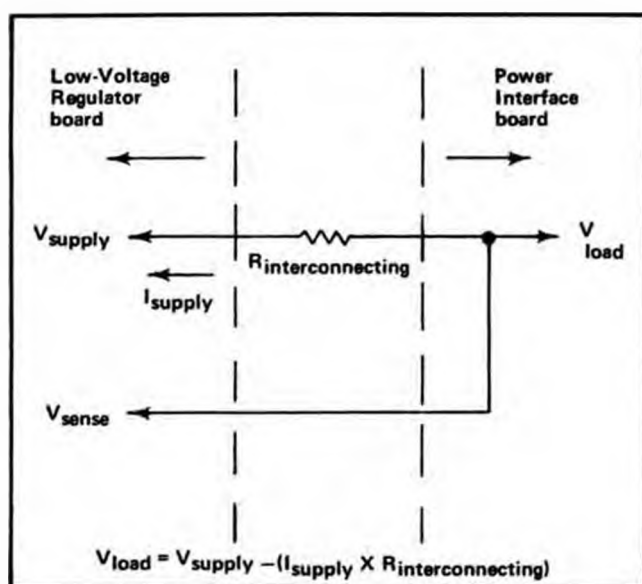


Fig. 3-36. Schematic illustrating voltage drop between power-supply output and load due to resistance of interconnecting wire.

manner, the output level of the  $-50$ -Volt Supply can be set to exactly  $-50$  volts by correct adjustment of R986.

The  $-50$  V Current Limiting stage Q988 protects the  $-50$ -Volt Supply if excess current is demanded from this supply. Since the ground return for the  $-50$ -Volt Supply is through R997-R998, all current from the  $-50$ -Volt Supply must flow through these resistors. Transistor Q988 senses the voltage drop across R997-R998. Under normal operation, there is about 0.3-volt drop across R997-R998 which is not sufficient to forward bias Q988. 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 R997-R998 increases until it is sufficient to forward bias Q988. The collector current of Q988 results in a reduction of current through Q992 and Q994 to limit the conduction of Q998. As the output voltage of this supply decreases due to the current limiting, the level of the positive semi-regulated voltage increases. More current flows through R988-R989 to increase the voltage drop across R989. As a result, the bias on Q998 increases so the Series Regulator supplies less current. This current limiting protects Q998 from damage due to excess power dissipation.

Several protection diodes are also included in this circuit. CR981 prevents the output of this supply from going more positive than about +0.6 volt if it is shorted to a positive supply. CR984 protects Q984A from reverse-voltage breakdown. CR991 protects transistor Q994 by disconnecting the +50-Volt Supply if it is more negative than the base of Q994, such as when the instrument is turned on, or if the +50-Volt Supply is shorted to a less positive supply. CR994 protects Q994 from reverse-voltage breakdown.

### $-15$ -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 R962-R963 between ground and the  $-50$  V Sense voltage. The divider ratio of R962-R963 sets a level of  $-15$  volts at the base of Q964A. 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 Q964B as an error signal. The output voltage is regulated in the same manner as described for the  $-50$ -Volt Supply. Diode CR972 insures a conduction path between the collector of  $-15$  V Current Limiting transistor Q966 and the  $-15$  V Series Regulator Q974 when current limiting is required. CR961 limits the output of this supply from going more positive than about +0.6 volts when it is shorted to one of the positive supplies. Diodes CR964 and CR965 provide reverse-voltage protection for transistors Q964A and Q964B respectively.

### +5-Volt Supply

Basic operation of the +5 V Series Regulator and +5 V Current Limiting stages are the same as described for the previous supplies. The +5 V Feedback Amplifier operates in the same manner as described previously except that Q948 provides inversion in the feedback path to assure correct operation of this circuit. The reference level for this supply is established by the ground connection at the base of Q944. Feedback voltage to the base of Q946 is provided by divider R946-R947 between the +5 V Sense line and the  $-50$  V Sense line. The divider ratio of R946-R947 is 10:1 so that the base of Q946 is at zero volts when the supply is operating properly. 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 Q946 as an error signal. The output voltage is regulated in the manner described previously for the  $-50$ -Volt Supply. Diode CR941 limits the output of this supply to about  $-0.6$  volt if it is shorted to one of the negative supplies. Diode CR942 provides a current path to limit the output of the +5-Volt Supply to about +7.6 volts if this supply is shorted to the +50-Volt Supply. Diode CR948 establishes a level of about +0.6 volt at the emitter of Q948. CR949 along with the forward drop across the base-emitter junction of Q948 establishes sufficient voltage drop for correct operation of the +5 V Current Limiting stage Q954.

The output of this supply is connected across the GRAT ILLUM control R957 through fuse F957. R957 controls the current through the graticule illumination lights DS957, DS958, DS959 to change the illumination of the graticule lines. Fuse F957 protects the +5-Volt Supply if a short-circuit condition occurs in the graticule light network.

The elapsed-time meter M941 is connected to the +5-volt output. This meter records the amount of time that this instrument has been operating. R941 establishes the

## Circuit Description—7704

current through M941 which determines the rate at which the meter records time.

### +15-Volt Supply

The semi-regulated voltage applied to the +15-Volt Supply is connected to the High-Voltage Oscillator stage in the CRT Circuit through F921. This fuse protects the +15-Volt Supply from damage due to failures in the High-Voltage Oscillator stage. The +15 V Series Regulator and +15 V Current Limiting stages operate in the same manner as described for the previous supplies. The +15 V Feedback Amplifier stage is connected in the inverting configuration. The ground connection at the base of Q922A provides the reference for this supply. Feedback voltage to the base of Q922B is provided through divider R925-R926 between the +15 V Sense line and the -50 V Sense line. The divider ratio of R925-R926 sets the base of Q922B to zero volts. Any change in the output level of the +15-Volt Supply appears at the base of Q922B as an error signal. This results in an opposite change at the collector of Q922B which is connected to the base of Q936 through zener diode VR927. This diode provides voltage shifting between Q922B and Q936. The change at the base of Q936 is connected to the +15 V Series Regulator stage through Q938 to correct the error in the output voltage.

Diodes CR922 and CR924 provide reverse-voltage breakdown protection for transistors Q922A and Q922B respectively. Diode CR923 protects Q922B against negative voltages when the +15-Volt Supply is shorted to ground. CR938 provides a connection between the +15 V Current Limiting stage and the +15 V Series Regulator stage when current limiting is required. Diode CR935 disconnects the emitter circuit of Q936 from the -50-Volt Supply when the -50-Volt Supply is shorted to a positive supply.

The +5 V Voltage Limiting stage provides protection for the light bulbs and integrated circuits which are powered from the +5-Volt Supply. The output of the +5-Volt Supply is connected across zener diode VR930 through R929 and R930. Under normal conditions, Q930 does not conduct. However, if the output of the +5-Volt Supply rises positive due to a short to the +15-Volt Supply, the base of Q930 is clamped at about +5.1 volts by zener diode VR930. As the output voltage of the +5-Volt Supply increases to about +5.7 volts, Q930 is forward biased and its collector current turns on the +15 V Current Limiting stage through R931. This limits the output of the +15-Volt Supply to about +5.7 volts.

### +50-Volt Supply

Operation of the +50 V Series Regulator and the +50 V Current Limiting stages are the same as described previously for the other supplies. The +50 V Feedback Amplifier operates in the same manner as described previously except that

Q910 provides inversion in the feedback path to provide correct operation of this circuit. Reference voltage for this supply is established by the ground connection at the base of Q906A. Feedback voltage to the base of Q906B is provided by divider R907-R908 between the +50 V Sense line and -50 V Sense line. The divider ratio of R907-R908 sets the base level of Q906B to ground level when the output of this supply is correct. The protection diodes in this circuit operate similarly to the other supplies.

### +75- and +150-Volt Supply

The +75-Volt and +150-Volt levels produced by the Line to DC Converter/Regulator circuit are connected to fuses F901 and F902, respectively, in this circuit. These fuses protect the Line to DC Converter/Regulator circuit if the output of these supplies is shorted.

## CONTROLS AND CABLING

### General

Diagram 12 shows the front-panel switches and controls of the 7704 and the interconnections between these controls and the circuits within this instrument. To use the cabling diagram, note the number on the wire at the point where an individual wire joins the cable. Then follow the cable around until a break-out is found with the same number. This will be the source/location of the desired wire.

### Switch Logic

The VERTICAL MODE and HORIZONTAL MODE switches determine the operating mode of the Vertical Interface and Horizontal Interface circuits respectively. Each of these switches is designed so that it is self-canceling; (i.e., only one button can be pressed at a time). Specific operation of these switches is described in connection with the circuits that they control.

The A TRIGGER SOURCE and B TRIGGER SOURCE switches control the operation of the Trigger Selector circuit. These switches are also self-canceling so that only one of the buttons can be pressed at a time. Operation of these switches is discussed in connection with the Trigger Selector circuit.

### Indicator Lights

The indicator lights shown in connection with the VERTICAL MODE and HORIZONTAL MODE switches indicate which mode has been selected. When one of the buttons of these switches is pressed, it completes the circuit between the associated bulb and the lamp-common line. Notice that a separate bulb is used for each mode switch position. Bulbs DS1035 and DS1037, located by the B

INTENSITY and A INTENSITY controls respectively, are actuated by the HORIZONTAL MODE switch to indicate which of the intensity controls is active for the selected horizontal mode. The selected button of the A TRIGGER SOURCE and B TRIGGER SOURCE switches is also illuminated to indicate the trigger source. Notice that only one bulb is associated with each of the trigger source switches. The source switches are mechanically designed so that the button which is pressed receives light from the bulb, but the remaining buttons remain un-illuminated.

The CONTROL ILLUM switch S1040B determines the illumination level of the pushbutton switches on the 7704 and the associated plug-in units. In the HIGH position of this switch, the lamp power from the Low-Voltage Power Supply circuit is connected directly to the light bulbs. In the LOW position, the lamp power is connected to the bulbs through diodes CR1040 and CR1041. The forward drop across these diodes reduces the current available to the bulbs so that they operate at a lower intensity level. In the OFF position, the lamp power to all of the pushbutton switches is disconnected. However, lamp power is still provided to the bulbs associated with the A and B INTENSITY controls through CR1040 and CR1041 to provide an indication that the POWER switch is ON. Fuse F1040 protects the +5-Volt Lamp Supply if the lamp power circuit is shorted to ground.

This diagram also shows the wiring for the Camera Power Connector on the CRT bezel, the rear panel PROBE POWER connector J1080-J1085, and the Remote connector J1075.

## READOUT SYSTEM

### Introduction to Readout System

**General.** The Readout System in the 7704 provides alphanumeric 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. Schematics for the total Readout System are shown on diagrams 13, 14 and 15 at the rear of this manual.

The definitions of several terms must be clearly understood to follow this description of the Readout System. These are:

**Character**—A character is a single number, letter, or symbol which is 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 7704 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. Fig. 3-37 shows one complete frame (simulated readout) and the position at which each of the eight words is displayed.

**Column**—One of the vertical lines in the Character Selection Matrix (see Fig. 3-38). Columns C-0 (column zero) to C-10 (column 10) can be addressed in the 7704 system.

**Row**—One of the horizontal lines in the Character Selection Matrix (Fig. 3-38). Rows R-1 (row 1) to R-10 (row 10) can be addressed in the 7704 system.

**Time-slot**—A location in a pulse train. In the 7704 Readout System, the pulse train consists of 10 negative-going pulses. Each of these time-slots is assigned a number between one and ten. For example, the first time-slot is TS-1.

**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 7704 CRT. The position of each word is fixed and is directly related to the plug-in unit from which it originated. Fig. 3-37 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

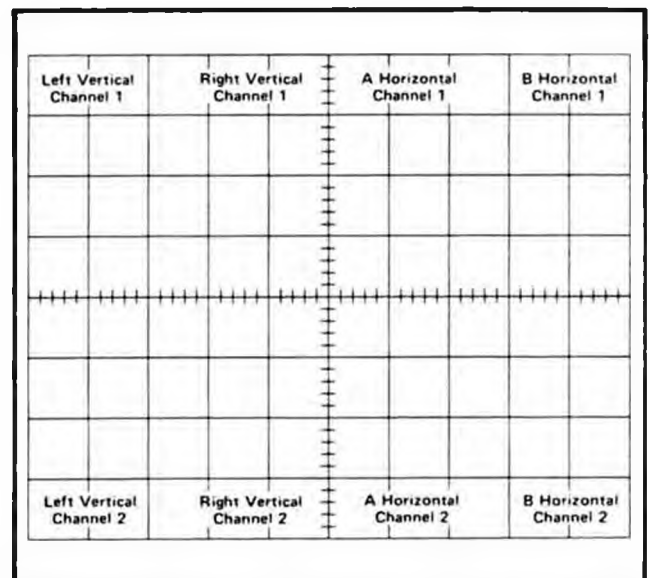


Fig. 3-37. Location of readout words on the CRT identifying the originating plug-in and channel (one complete frame shown, simulated readout).

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	SKIP* ↑ ↓	0	1	2	3	4	5	6	7	8	9
R-2	0.1		/	<	I	/	+	—	+	C	Δ	>
R-3	0.2		Add* one zero	Add* two zeros	Reduce* prefix	Reduce* prefix and add one zero						IDENTIFY*
R-4	0.3		<i>m</i>	<i>μ</i>	<i>n</i>	<i>p</i>	<i>X</i>	<i>K</i>	<i>M</i>	<i>G</i>	<i>T</i>	<i>R</i>
R-5	0.4		<i>S</i>	<i>V</i>	<i>A</i>	<i>W</i>	<i>H</i>	<i>d</i>	<i>B</i>	<i>c</i>	<i>Ω</i>	<i>E</i>
R-6	0.5		<i>U</i>	<i>N</i>	<i>L</i>	<i>Z</i>	<i>Y</i>	<i>P</i>	<i>F</i>	<i>J</i>	<i>Q</i>	<i>D</i>
R-7	0.6				Decimal* point location #3	Decimal* point location #4	Decimal* point location #5	Decimal* point location #6	Decimal* point location #7			
R-8	0.7											
R-9	0.8											
R-10	0.9		Add Space In Display*									

Fig. 3-38. Character Selection Matrix for 7704 Readout System.



Unused locations. Available for future expansion of Readout System

\* Operational address.



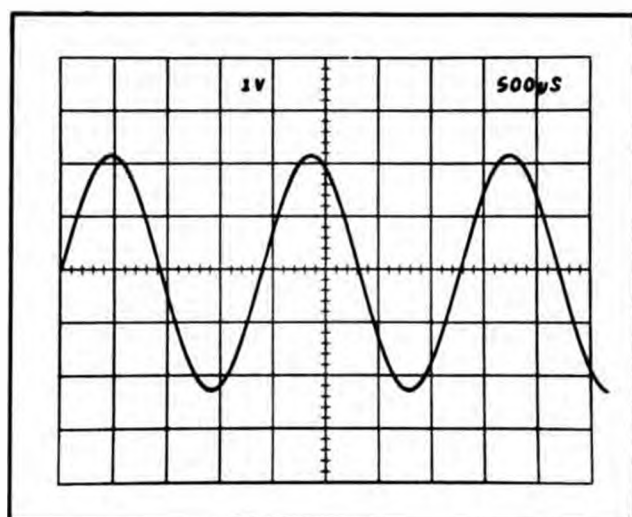


Fig. 3-39. Typical readout display where only channel 1 of the Right Vertical and B Horizontal units are displayed.

is displayed directly below within the bottom division. Fig. 3-39 shows a typical display where only channel 1 of the Right Vertical and B Horizontal units are 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. 3-38. Any one of the 50 separate characters can be addressed and displayed on the CRT. In addition, 12 operational addresses are provided for special instructions to the Readout System. The unused locations in the Matrix (shaded areas) 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. 3-40. 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 will be given later.

The key block in the Readout System is the Timer stage. This stage produces the basic signals which 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 Timing stage for further information). This stage also produces control signals for other stages within this circuit and interrupt signals to the Vertical Interface and Horizontal Interface circuits, CRT Circuit, and Z-Axis Logic stage 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 that there is a pulse on only one of the 10 lines during any 250 microsecond timing period. When the Time-Slot Counter stage has completed 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 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 which range from zero to one milliamper (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. 3-38. The standard format in which information is encoded onto the output lines is given in Table 3-2 (special purpose plug-in units may have their own format for readout; these special formats will be defined in the manuals for these units);

TABLE 3-2

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	1-2-5 scaling.
TS-5	Not encoded by plug-in unit. Left blank to allow addition of zeros by Readout System.
TS-6	
TS-7	
TS-8	Defines the prefix which modifies the units of measurement.
TS-9	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.
TS-10	

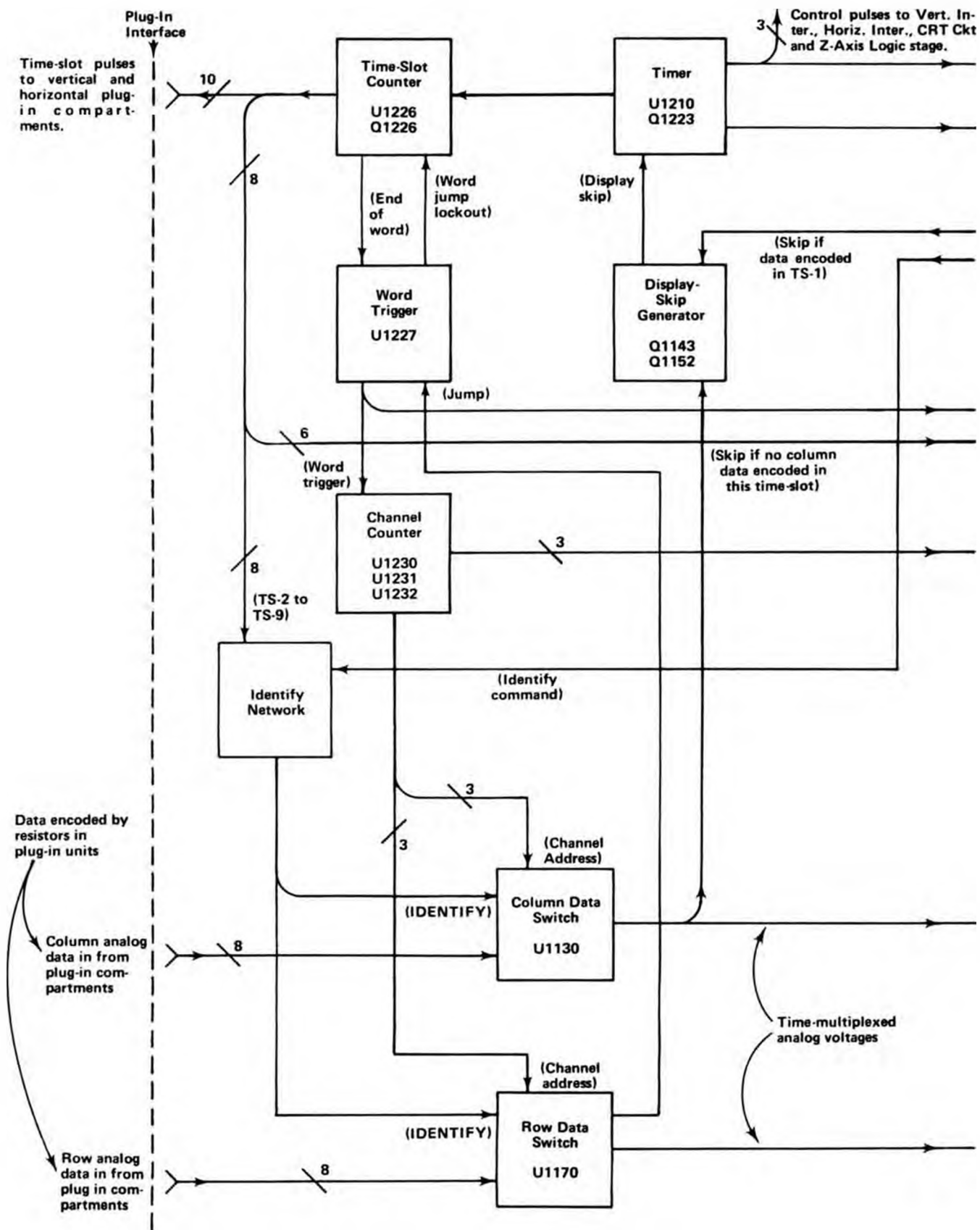


Fig. 3-40. Detailed block diagram of Readout System.

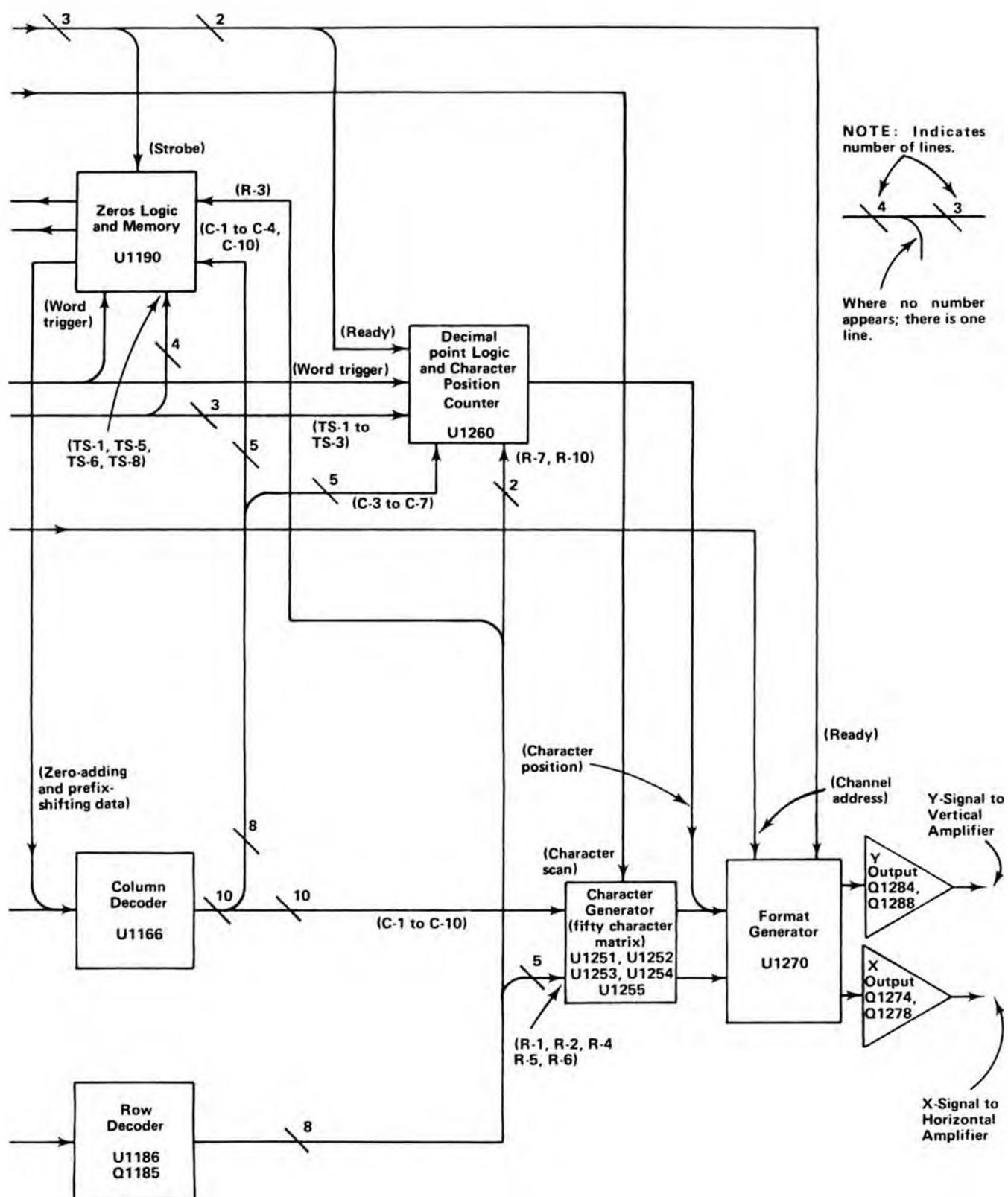


Fig. 3-40. (cont'd).

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 single time-multiplexed analog voltage output which contains 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 which 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 which normally interrupt the CRT display and present a character.

The analog output of the Column Data Switch and Row Data Switch are connected to the Column Decoder and Row Decoder stages respectively. These stages sense the 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 to C-10 (column 1 to 10) which correspond to the column information encoded by the plug-in unit. Likewise, the outputs of the Row Decoder stage are identified as R-1 to R-10 (row 1 to 10) which correspond to the row information encoded by the plug-in unit. 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. However, 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 there is no display during this time slot (as defined by Standard Readout Format; see Table 3-2). When time-slots 5, 6 and 8 occur, the memory is addressed and any information stored there during time-slot 1 is transferred out and connected to the input of the Column Decoder stage to modify the analog data during the applicable time-slot.

Another operation of the Zeros Logic and Memory stage is to produce 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 stage produces the characters which are displayed on the CRT. Any of the 50 characters shown on the Character Selection Matrix of Fig. 3-37 can be addressed by proper selection of the column and row current. 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 how many characters have been 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 encoded information in time-slot 2 (normal/invert) or time-slot 3 (cal/uncal) which precedes 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 row 7 and columns 3 through 7 (see Character Selection Matrix for location of these 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 which is associated with the plug-in and channel originating the word (see Fig. 3-36). 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-output signals are connected to the Horizontal Amplifier and Vertical Amplifier through the Horizontal Output and Vertical Output stages respectively.

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 Decoder stage.

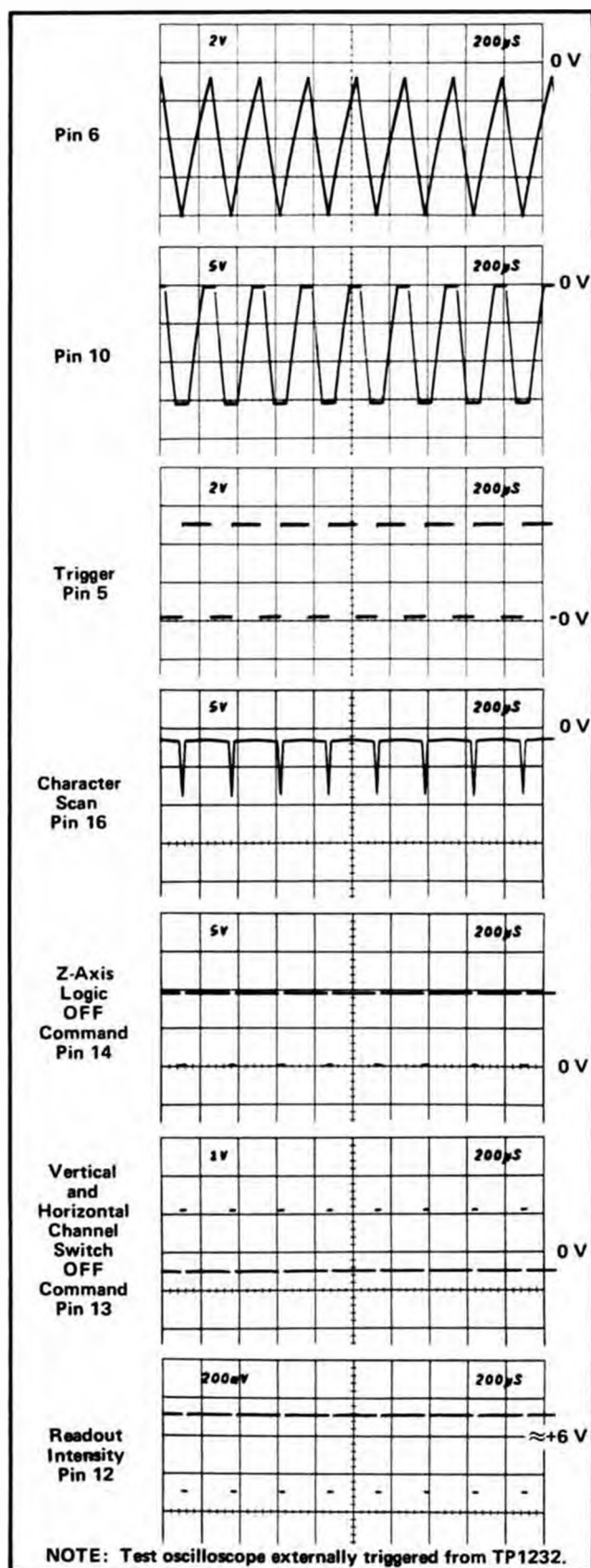


Fig. 3-41. Output waveforms of Timer stage.

## Circuit Analysis of Readout System

The following analysis of the Readout System discusses the operation of each stage in detail. Complete schematics of the Readout System are shown on diagrams 13, 14 and 15 at the rear of this manual.

### Timer

The Timer stage U1210 establishes the timing sequence for all circuits within the Readout System. This stage produces seven time-related output waveforms (see Fig. 3-41). 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 C1214-R1214. The triangle waveform is clipped and amplified by U1210 to form the trapezoidal output signal at pin 10. The amplitude of this output signal is exactly 15 volts as determined by U1210 (exact amplitude necessary to accurately encode data; 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 very important to the correct operation of the Readout System (see expanded waveforms in Fig. 3-42). 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 2) to blank the CRT before the display is switched to the Readout System. It also produces the Strobe pulse through R1221, Q1223 and CR1224 to signal other stages within the Readout System to begin the sequence necessary to produce a character. The collector level of Q1223 is also connected to Character Generator #2, U1252, through C1222-CR1222. This activates U1252 during the quiescent period of the Strobe pulse (collector of Q1223 negative) and diverts the output current of the Row Decoder stage U1186 to row 2. The purpose of this configuration is to prevent the Zeros Logic and Memory stage U1190 from storing incorrect data during the quiescent period of the Strobe pulse. When the Strobe pulse goes positive, CR1222 is reverse biased to disconnect Q1223 from U1252 and allow the Row Decoder stage to operate in the normal manner.

The next signal to be produced is the Vertical/Horizontal Channel Switch OFF Command at pin 13. This positive-going signal disconnects the plug-in signals in the vertical and horizontal deflection systems so the plug-ins do not control the position of the CRT beam. The Ready signal derived from this output is connected to the Decimal Point Logic and Character Position Counter stage and the Format Generator stage (see diagram 15). The Readout Intensity output at pin 12 is produced next. This current is connected to the Z-Axis Intensity circuit to unblank the

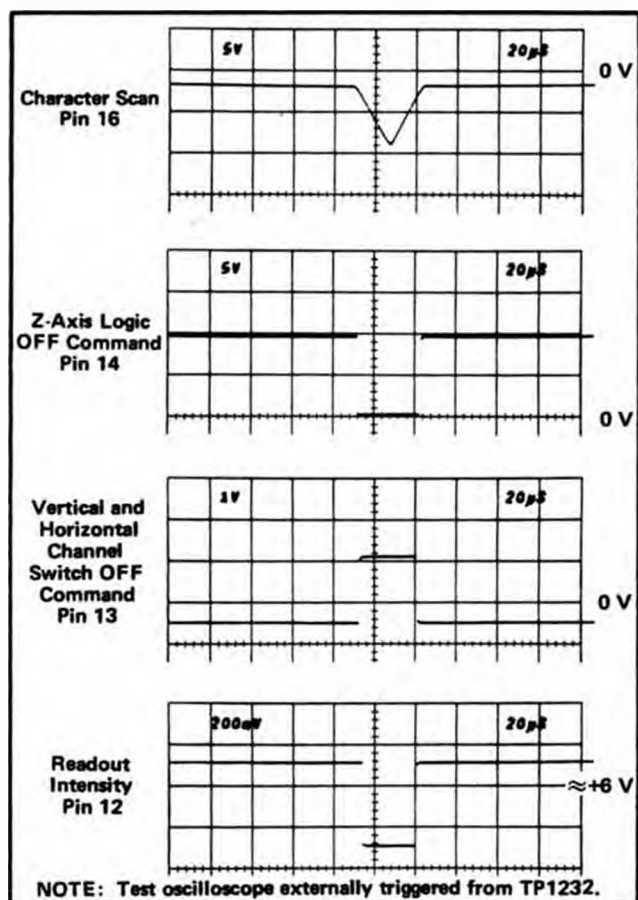


Fig. 3-42. Detail of output at pins 12, 13, 14 and 16 of U1210.

CRT to the level determined by the READOUT intensity control R1040. The Character Scan ramp at pin 16 started to go negative before this timing sequence began. However, character-generation does not start until the readout intensity level has been established. The triangular Character Scan ramp runs negatively from about  $-2$  volts to about  $-8.5$  volts and then returns back to the original level. This waveform provides the scanning signal for the Character Generator stages (see diagram 15). The Character Scan adjustment R1217 sets the DC level of the Character Scan ramp to provide 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 which 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 U1210 through CR1207 from the Display-Skip Generator stage (diagram 14). This signal causes the Timer stage to shorten its period of operation to about 210 microseconds. The waveforms shown in Fig. 3-43 show the operation of the Timer stage when the Display-Skip condition

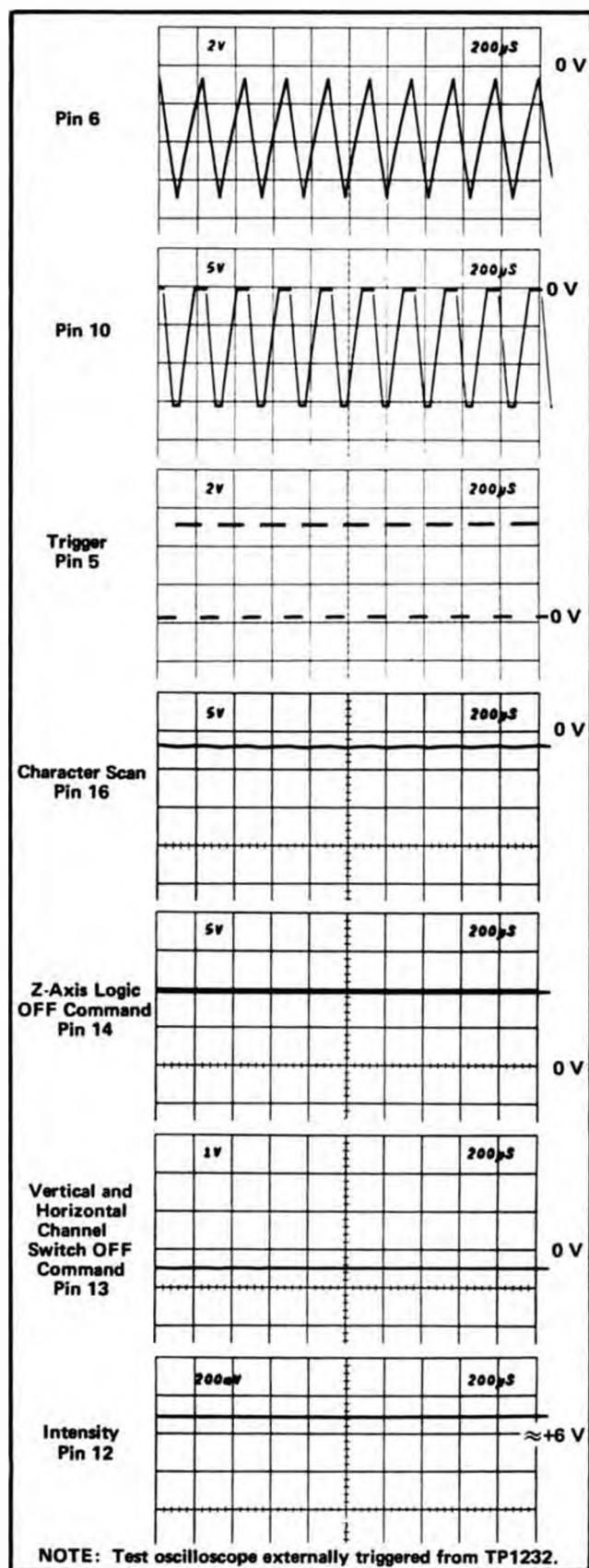


Fig. 3-43. Timer stage operation when Display-Skip condition occurs.



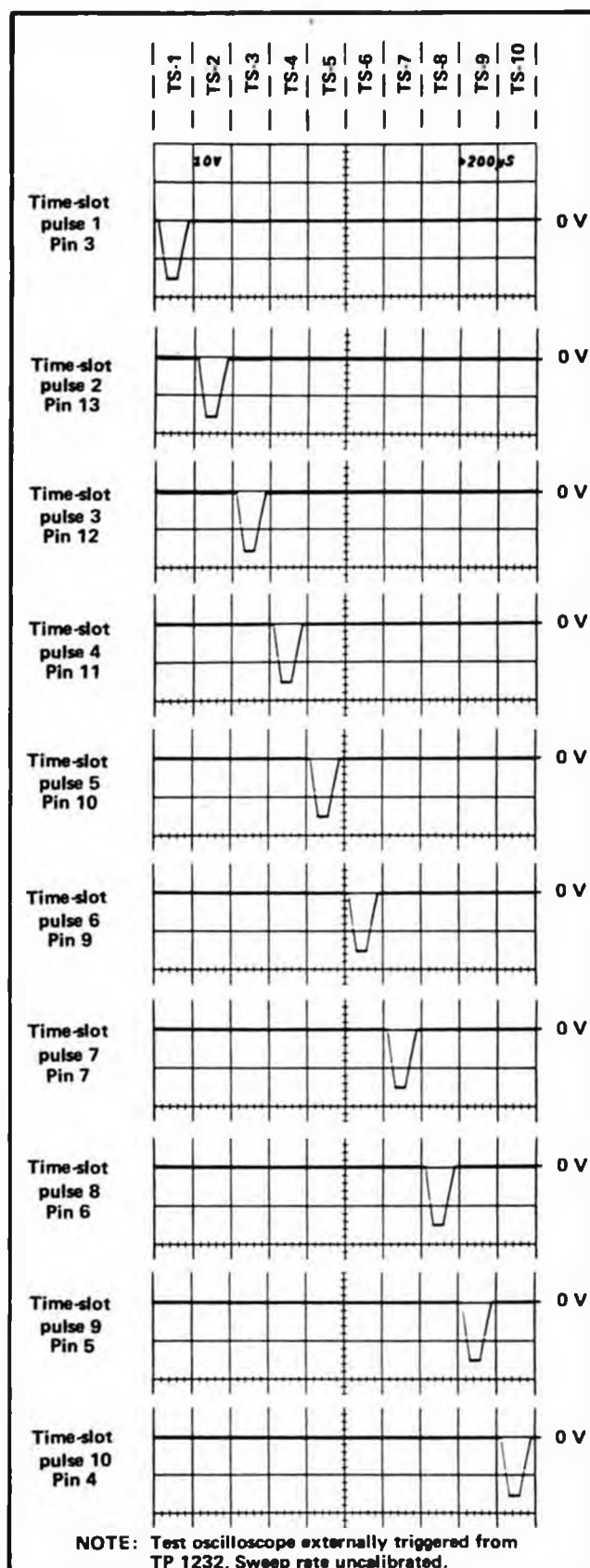


Fig. 3-44. Time relationship of the time-slot (TS) pulses produced by U1226.

occurs for all positions in a word. Notice that there is no output at pin 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 READOUT intensity control R1040 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 R1040 is turned fully counterclockwise, switch S1040A opens. This interrupts the current to pin 11 of U1210 and at the same time allows a positive voltage to be applied to pin 4 through R1206 and CR1206. This 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

The Time-Slot Counter stage U1226 is a sequential switch which directs the trapezoidal waveform input at pin 8 to one of its ten output lines. These time-slot pulses obtain the data for the Readout System from the plug-in units. The Trigger pulse at pin 15 switches the Time-Slot Counter to the next output line; the output signal is sequenced from time-slot 1 through time-slot 10. Fig. 3-44 shows the time-relationship of the time-slot pulses. Notice that only one of the lines carries a time-slot pulse at any given time. When time-slot 10 is completed, an 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.

Pin 16 is a reset input for the Time-Slot Counter stage. 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 signal is received by U1227A (see following discussion).

### Word Trigger

The Word Trigger stage is made up of 4 two-input NOR gates in U1227. The End-of-Word pulse produced by the Time-Slot Counter stage produces a HI level at pin 1 of U1227C. This level is inverted by U1227D to provide a negative-going advance pulse to the Channel Counter stage.

An output is also produced from U1227D when a Jump signal is received at pin 8 of U1227A. This condition can

occur during any time-slot. U1227A and U1227B are connected as a bistable flip-flop. The positive-going Jump signal at pin 8 of U1227A produces a LO level at pin 10 (see Row Decoder for further information on origin of the Jump signal). This LO level is inverted by U1227B to produce a HI level at pin 13 which allows pin 9 of U1227A to be pulled HI through R1227. The flip-flop has now been set to its HI state where it remains until reset, even though the Jump signal at pin 8 returns to its LO level. The HI output level at pin 13 turns on Q1226 through R1226 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 U1227 is reset. When the next Trigger pulse is received at pin 15, the Time-Slot Counter does not advance to the next output line (time-slot 2) but produces an output on the time-slot 1 line. A HI level is also applied to pin 4 of the Timer stage through CR1208 and CR1207. This HI level causes the Timer stage to operate in the display-skip mode so that a character is not generated.

Although this Trigger pulse was not recognized by the Time-Slot Counter stage, it does reset the Word Trigger stage through C1227. This produces a LO level at pin 13 of

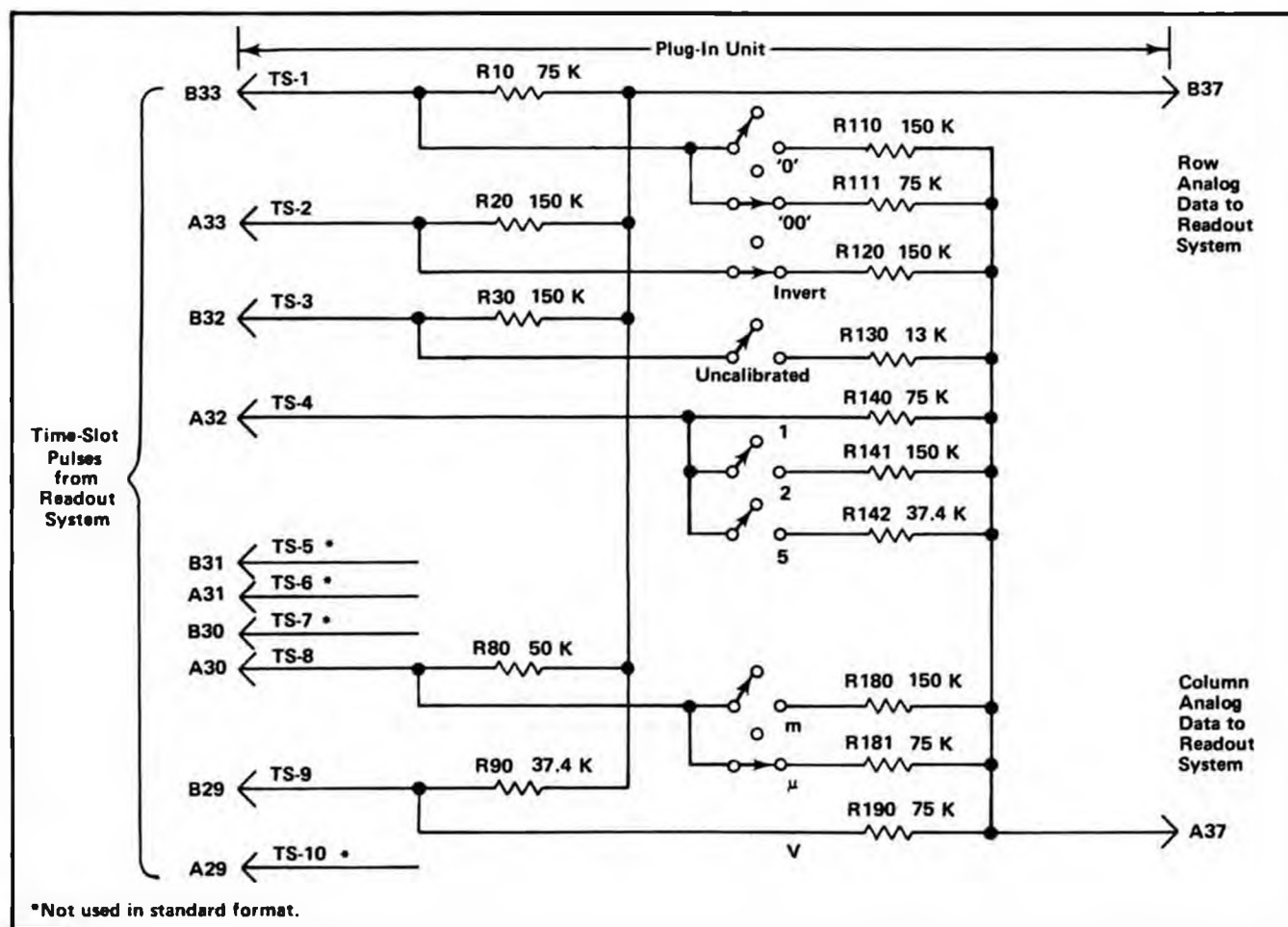
U1227B which enables the Time-Slot Counter and Timer stages for the next time-slot pulse. At the same time, the negative-going edge produced as U1227B switches output states is connected to pin 2 of U1227C. This results in a negative-going Word Trigger output at pin 4 of U1227D to advance the Channel Counter to the next word.

## Channel Counter

The Channel Counter stage made up of integrated circuits U1230, U1231 and U1232 is a binary counter which produces the Channel Address Code for the Column Decoder and Row Decoder stages (diagram 14) and the Format Generator stage (diagram 15). This code instructs these stages to sequentially select and display the eight channels of data from the plug-ins. The input channel which is displayed with each combination of the Channel Address Code is given in the discussion for the applicable stages.

## Encoding the Data

Data is conveyed from the plug-in unit to the Readout System in the form of an analog code having up to 11



**Fig. 3-45. Typical encoding scheme for voltage-sensing plug-in unit. Coding shown for deflection factor of 100 microvolts.**



current levels (from zero to one milliampere in 100 microampere steps). The characters which can be selected by the encoded data are shown on the Character Selection Matrix (see Fig. 3-38). Each character requires two currents to define it; these currents are identified as the column current and the row current which correspond to the column and row of the matrix. The column and row data is encoded by resistive programming in the plug-in units. Figure 3-45 shows a typical encoding scheme 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 3-2 for Standard Readout Format). The amplitude of the time-slot pulses 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. 3-45 resistors R10 through R90 control the row analog data which is connected back to the Readout System. These resistors are of fixed value and define the format in which the information will be presented by the Readout System. Fig. 3-46A shows an idealized output current waveform of row analog data which results from the 10 time-slot pulses. Each of the steps 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 shown in Figure 3-38. 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. 3-45 indicates a 100 microvolt sensitivity with the display inverted and calibrated vertical deflection factors. This results in the idealized output current waveforms shown in Fig. 3-46B 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 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. R130 is not connected to the time-slot 3 line since the vertical deflection factors are calibrated. Therefore, there is no column current output during this time-slot and there is 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

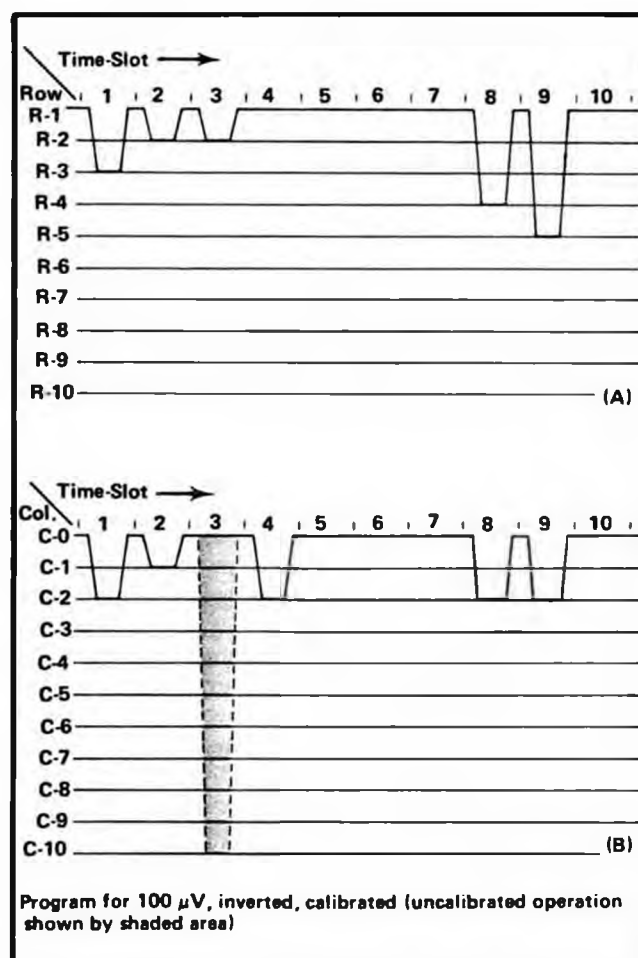


Fig. 3-46. Idealized current waveforms of: (A) Row analog data, (B) Column analog data.

this time-slot and 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  $\mu$  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 output. These resistors encode three 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  $\downarrow 100 \mu V$ .

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 lines. This encodes 10 units of column

current (see shaded area in time-slot 3 of the waveform shown in Fig. 3-46B). 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 say  $\downarrow > 100 \mu\text{V}$ . In a similar manner, the other switches can change the encoded data for the column output and thereby change the readout display. For information on decoding this information, see the descriptions which follow.

The column analog data encoded by the plug-in can be modified by attenuator probes connected to the input connectors of vertical 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 resistor which results in additional column current. For example, if a 10X attenuator probe is connected to a plug-in with the coding for 100 microvolts as shown in Fig. 3-45, an additional unit of current is added to the column analog data during time-slot 1. Since two units of current were encoded by R111 (see Fig. 3-45), 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 reduced. Since this instruction occurs in the same time-slot which 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 reduced to 1 mV (readout program produced by plug-in same as for previous example).

Likewise, if a 100X readout-coded probe is connected to the input of the plug-in unit, the column current during time-slot 1 will be increased two units for a total of four units of column current. This addresses an instruction in the Character Selection Matrix which reduces the prefix and adds one zero to the display. The resultant CRT readout with the previous program is 10 mV.

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; 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 readout data from the plug-in units is connected to the Column and Row Data Switch stages in the Readout

System. 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 U1130 and the Row Data Switch U1170 receive the Channel Address Code from the Channel Counter stage. This binary code directs the Column Data Switch and the Row Data Switch as to which channel should be the source of the readout data. Table 3-3 gives the eight combinations of the channel-address code and the resultant channel which is selected with each combination. These stages have nine inputs and provide a single 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 and the ninth input comes from a special data-encoding network composed of resistors R1131 through R1138 and R1171 through R1178 (see Zeros Logic and Memory description for further information on ninth channel).

TABLE 3-3  
Channel Address Code to  
Column and Row Decoder Stages

Pin 1 U1190 "Identify" Command	Pin 5 U1232	Pin 5 U1231	Pin 5 U1230	Channel Selected
HI	HI	HI	HI	Channel 1 Left Vertical
HI	HI	HI	LO	Channel 2 Left Vertical
HI	HI	LO	HI	Channel 1 Right Vertical
HI	HI	LO	LO	Channel 2 Right Vertical
HI	LO	HI	HI	Channel 1 A Horizontal
HI	LO	HI	LO	Channel 2 A Horizontal
HI	LO	LO	HI	Channel 1 B Horizontal
HI	LO	LO	LO	Channel 2 B Horizontal
LO	$\Phi$	$\Phi$	$\Phi$	IDENTIFY

$\Phi$  = Has no effect in this case.

In addition to the data inputs from the plug-ins, channel-inhibit inputs are provided from each of the plug-in units. The channel inhibit lines are LO only when the associated plug-in unit has been selected for display. When a plug-in unit is not selected, the respective line is HI which forward

biases the associated diode CR1112, CR1113, CR1117, CR1118, CR1122, CR1123, CR1127, or CR1128 to bypass the encoded data from this plug-in. However, since it may be desired to display information from special-purpose plug-ins even though they do not produce a normal display on the CRT, a feature is provided to over-ride the channel inhibit. This is done by applying a LO input to the associated forcing over-ride 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 switches.

### Display-Skip Generator

The Display-Skip Generator stage, Q1143-Q1150 Q1152-Q1155, 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 which should result in a CRT display. The base of Q1143B is fixed at about +14.25 volts by divider R1146-R1147-R1148. Quiescently, there is about 100 microamperes of current flowing through R1141 from Q1163 and the Zeros Logic and Memory stage (purpose of this quiescent current will be discussed in connection with the Zeros Logic and Memory stage). This current biases Q1143A so its base is at about +14.5 volts in the absence of column data. Therefore, since Q1143A and Q1143B are connected as a comparator, Q1143A will remain on unless its base is pulled more negative than about +14.25 volts. The analog data output from the Column Data Switch produces a 0.5-volt change for each unit of column current that has been encoded by the plug-in. Therefore, whenever any information appears at the output of the Column Data Switch, the base of Q1143A is pulled more negative than the base of Q1143B, resulting in a negative (LO) Display-Skip output to the Timer stage through Q1155. Recall that a LO was necessary at the skip input of the Timer stage so that the Timer stage could perform the complete sequence necessary to display a character.

Q1150-Q1152 also provide display-skip action. The End-of-Word level that is connected to their emitters through R1152 is LO only during time-slot 1. This means that these transistors are only enabled during this time-slot period. These transistors allow the Zeros Logic and Memory stage to generate a display-skip signal when information has been stored in memory which is not to be displayed on the CRT (further information given under Zeros Logic and Memory discussion).

### Column and Row Decoder

The Column Decoder stage U1166 and Row Decoder stage U1186 sense the magnitude of the analog voltages at their inputs and produce a binary output on one of ten lines corresponding to the column or row data which was encoded by the plug-in. 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 to determine the size of the character which will be displayed on the CRT. This size is fixed by the value of R1156. When a display-skip signal is present (collector of Q1155 HI), pin 9 is pulled HI through CR1155. 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 stage made up of Q1185 and its associated components is a Row 13 detector which 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 13 (thirteen units of row current; 1.3 milliamperes) is encoded, the base of Q1185 is pulled negative enough so that this transistor is reverse biased to produce a HI Jump output at its collector. This Jump command is connected to the Word Trigger stage (diagram 12) to advance the Channel Counter stage to the next word.

### Zeros Logic and Memory

The Zeros Logic and Memory stage U1190 stores data encoded by the plug-ins 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 it can store the encoded data. A block representation of the memory sequence is shown in Fig. 3-47. Typical output waveforms for the five possible input conditions that can occur are shown in Fig. 3-48. When time-slot 1 occurs, a store command is given to all of the memories. If the plug-in unit encoded data for column 1, 2, 3, 4 and 10 during time-slot 1, the appropriate memory (or memories) is set. Notice that row 3 information from the Row Decoder stage must also be present at pin 16 for data to be stored in the memory of U1190. If data was encoded during time-slot 1, a negative-going output is produced at pin 7 as the memories are being set. This negative-going pulse is connected to the base of Q1152 in the Display-Skip Generator stage to produce a Display-Skip output. Since the information that was encoded during time-slot 1 was only provided to set the memories and was 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 stage through Q1163 to add one unit of current at the input of the Column Decoder stage. This

produces a zero after the character displayed on the CRT 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 which again results in a column 1 output from the Column Decoder stage 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 reduced or left at the value which was encoded. If data has been encoded which calls for a reduction 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 stage. Notice on the Character Selection Matrix of Fig. 3-38 that a reduction of one column when row 4 is programmed results in a one unit reduction of the prefix. For example, with the 100  $\mu$ V program shown in Fig. 3-45, if the data received from the plug-in called for a reduction 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 R1141 that was provided by Q1163 (see Display-Skip Generator) allows the prefix to be reduced 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 stage 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 stage produces a negative-going output pulse at pin 1 which switches the Column Data Switch and Row Data Switch stages to the ninth channel. Then, time-slot pulses 2 through 9 encode an output current through resistors R1131-R1138 for column data and R1171-R1178 for row data. This provides the currents necessary to display the word IDENTIFY on the CRT in the word position allotted to the channel which originated the Identify command. After completion of this

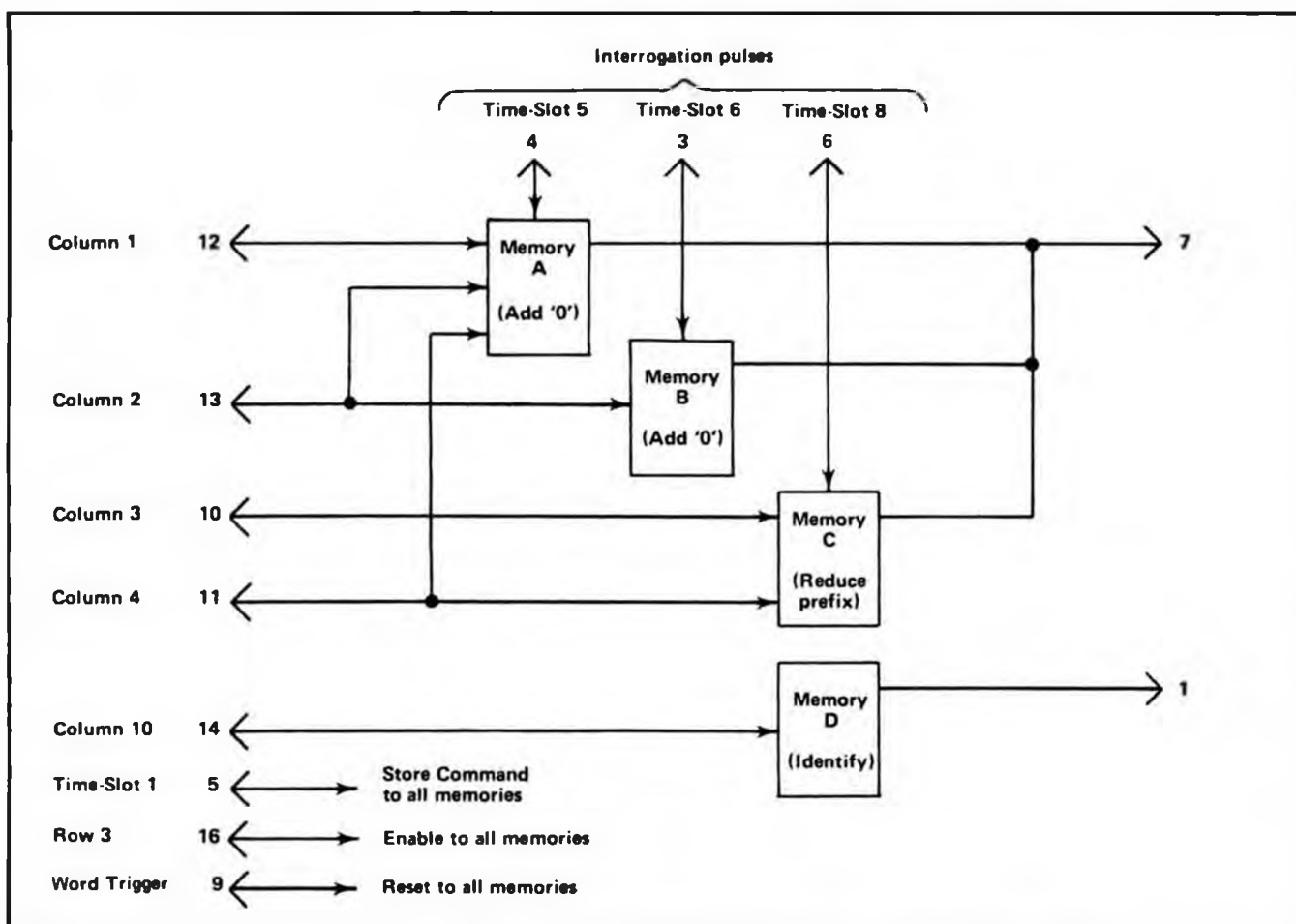


Fig. 3-47. Block representation of memory sequence in U1190.

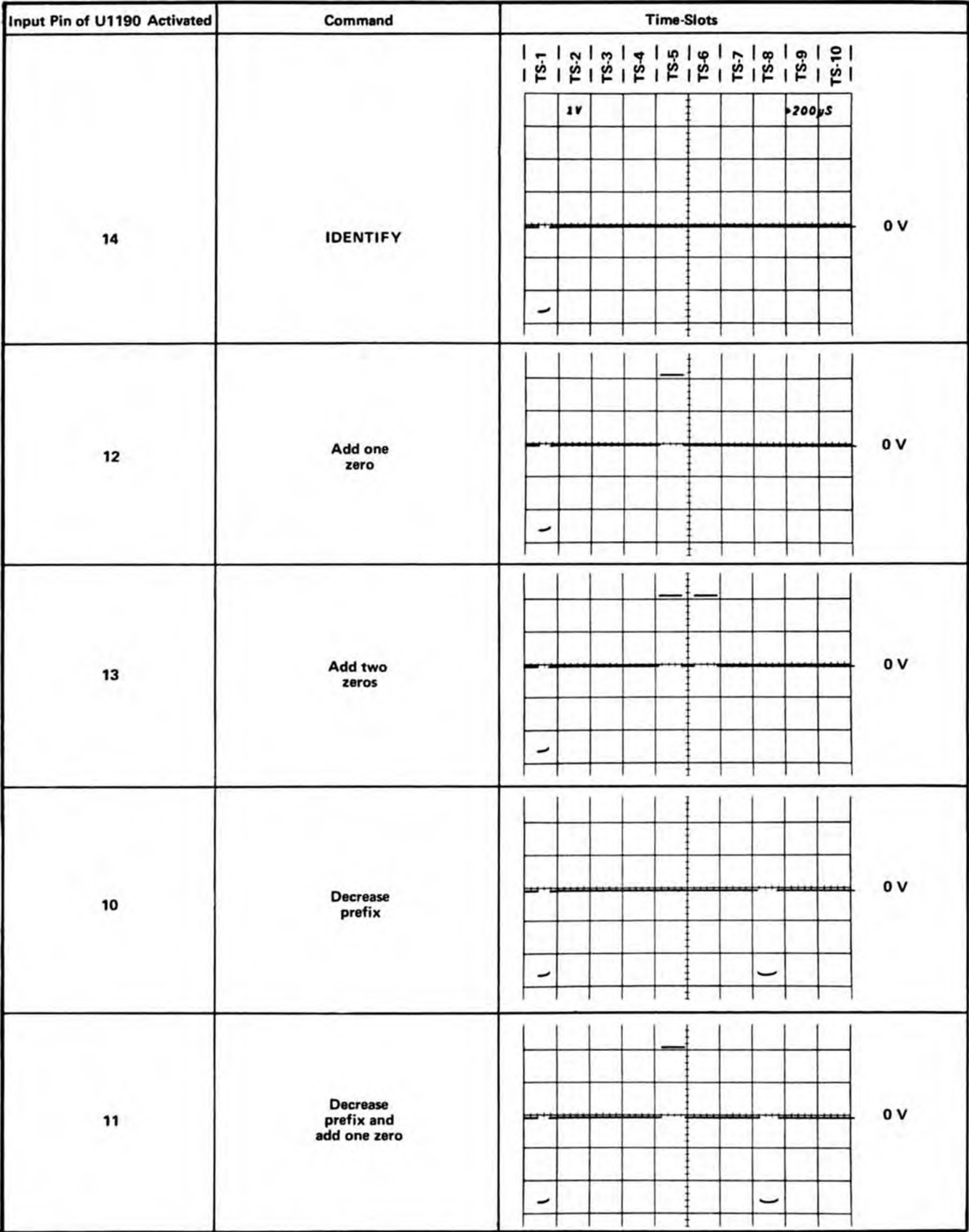


Fig. 3-48. Typical output waveforms for Zeros Logic and Memory stage operation (at pin 7 of U1190).

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 U1190 through C1190. At the end of each word of readout information, this pulse goes low. This erases the four memories in the Zeros Logic and Memory stage in preparation for the data to be received from the next channel.

### Character Generators

The Character Generator stage consists of five similar integrated circuits U1251-U1255 which produce the X (horizontal) and Y (vertical) outputs at pins 16 and 1 respectively to produce the character displayed on the CRT. Each integrated circuit can produce 10 individual characters. For example, U1251 which is designated as the "Numerals" Character Generator can produce the numerals 0 through 9 shown in row 1 of the Character Selection Matrix (Fig. 3-38). U1252 can produce the symbols shown in row 2 of the Character Selection Matrix and U1253 produces the prefixes and some letters of the alphabet which are used as prefixes in row 4. U1254 and U1255 produce the remaining letters of the alphabet shown in rows 5 and 6 of the Character Selection Matrix. All of these stages receive the column digital data from the Column Decoder stage U1166. However, only one of the character generators receives row data at a particular time. Therefore, only the stage which receives both row and column data is enabled. For example, if column 2 is encoded by the plug-in, the five Character Generators are enabled so that either a 1, <,  $\mu$ , V, or an N can be produced. However, if at the same time row 4 has also been encoded by the plug-in, only the Prefix Character Generator U1253 will produce an output to result in a  $\mu$  displayed on the screen. This integrated circuit provides current outputs to the Format Generator stage which produce the selected character on the CRT. In a similar manner, any of the 50 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

The Decimal Point Logic and Character Position Counter stage U1260 performs two functions. The first function is to produce a staircase current which is added 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 produced one character space to the right. This stage can also be advanced when a Space instruction is encoded by the plug-in unit so that a space is left between the displayed characters on the CRT. Row 10 information from the Row Decoder stage is connected to

pin 4 of U1260 through R1265. 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.

Time-slot pulses 1, 2, and 3 are also connected to pin 4 of U1260 through VR1260, VR1261, and VR1262 respectively and R1260, R1265. 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 which is displayed during time-slot 4 (1-2-5 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 by the plug-in. The Word Trigger pulse connected to pin 8 of U1260 through C1267 returns 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 as encoded by the plug-in units. When row 7 is encoded in coincidence with columns 3 through 7 (usually encoded during time-slot 1), a decimal point is placed at one of the five locations on the CRT identified in row 7 of the Character Selection Matrix (Fig. 3-38). This instruction refers to the decimal point location in relation to the total number of characters that can be displayed on the CRT (see Fig. 3-49). For example, if column 3 and row 7 are encoded during time-slot 1, the system is instructed to place a decimal point in

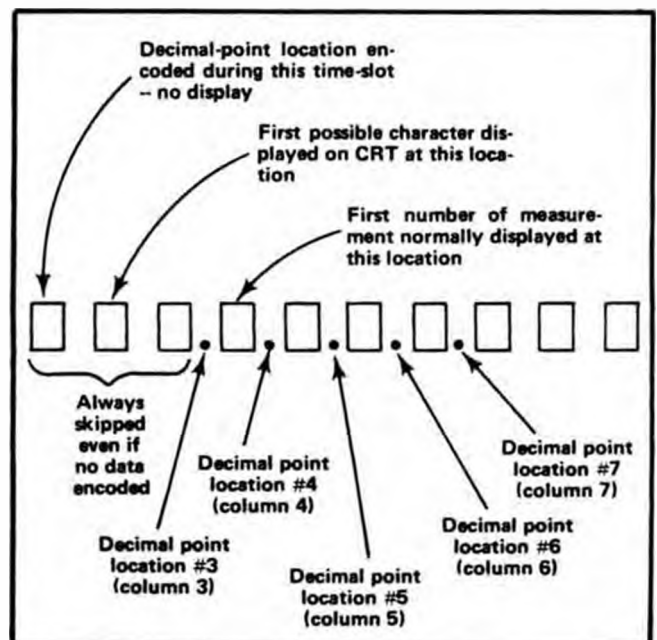


Fig. 3-49. Readout word relating 10 possible character locations to the decimal point instructions that can be encoded, and the resultant CRT display.

location #3. As shown in Fig. 3-49, this displays a decimal point before the third character that can be displayed on the CRT (first three time-slots produce a space whether data is encoded or not; see previous paragraph). The simultaneous application of row 7 data to the Y-input of the Format Generator stage through R1269 raises the decimal point so it appears between the displayed characters.

When decimal-point data is encoded, the CRT is unblanked so a readout display is presented. However, since row 7 does not activate any of the five Character Generators, the CRT beam is not deflected but instead remains in a fixed position to display a decimal point between the characters along the bottom line of the readout word. After the decimal point is produced in the addressed location, the 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 the Format Generator stage U1270. The Channel Address Code from the Channel Counter stage is also connected to pins 1, 8 and 15 of this stage. The Channel Address Code adds current to the X and Y signals to deflect the CRT beam to the area of the CRT which is associated with the plug-in channel that originated the information (see Fig. 3-37). The Channel Address Code and the resultant word positions are shown in Table 3-4. In addition, the character position current from the Decimal Point Logic and Character Position stage is added to the X (horizontal) input signal to space the characters horizontally on the CRT (see previous discussion). The Ready signal at pin 13 activates this stage so it can produce an output at the same time that the Timer stage produces the signal to disconnect the plug-in signals from the vertical and horizontal deflection systems.

### Y-Output Amplifier

The Y-output signal at pin 6 of U1270 is connected to the Y-Output Amplifier Q1284-Q1288. This stage provides a low impedance load for the Format Generator while pro-

TABLE 3-4

Channel Address Code to  
Format Generator Stage

Pin 7 U1232	Pin 7 U1231	Pin 5 U1230	Channel Displayed
LO	LO	HI	Channel 1 Left Vertical
LO	LO	LO	Channel 2 Left Vertical
LO	HI	HI	Channel 1 Right Vertical
LO	HI	LO	Channel 2 Right Vertical
HI	LO	HI	Channel 1 A Horizontal
HI	LO	LO	Channel 2 A Horizontal
HI	HI	HI	Channel 1 B Horizontal
HI	HI	LO	Channel 2 B Horizontal

viding isolation between the Readout System and the Vertical Amplifier. The Vertical Separation adjustment R1285 changes the gain of this stage to control the vertical separation between the words displayed at the top and bottom of the graticule area.

### X-Output Amplifier

The X-Output Amplifier Q1274-Q1278 operates similarly to the Y-Output Amplifier to provide the horizontal deflection from the readout signal available at pin 4 of U1270. The gain of this stage is fixed by the values of the resistors in the circuit.

### Display Sequence

Fig. 3-50 shows a flow chart for the Readout System. This chart illustrates the sequence of events which occurs in the Readout System each time a character is generated and displayed on the CRT.



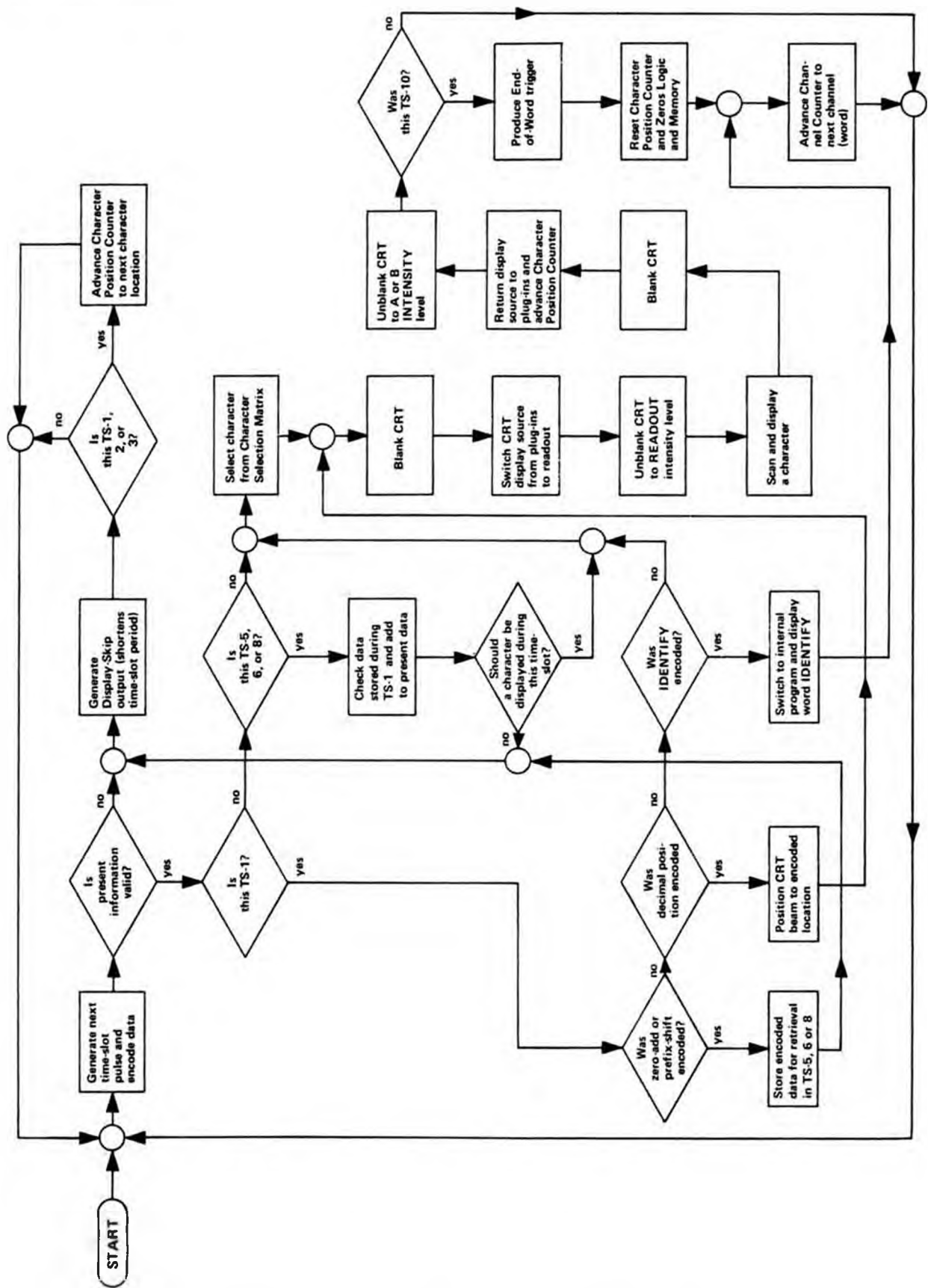
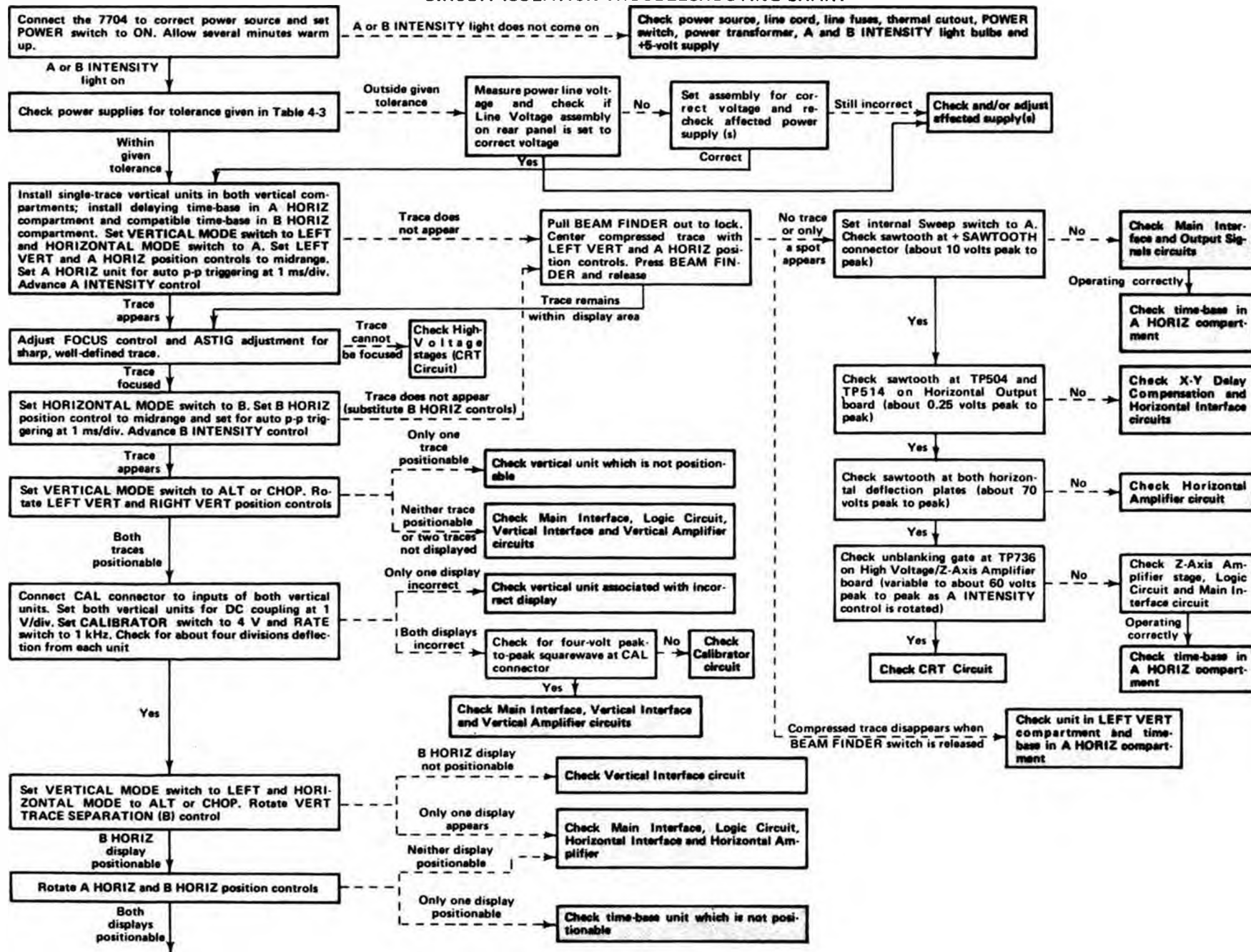


Fig. 3-50. Flow chart for character generation by the Readout System.



**Maintenance--7704**



# SECTION 4

## MAINTENANCE

*Change information, if any, affecting this section will be found at the rear of the manual.*

### Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the 7704.

### 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 7704 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 held in place with eight 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.

### Swing-Down Chassis

A swing-down chassis on the right side of this instrument provides access to the Calibrator, Horizontal Output and High Voltage/Z-Axis Amplifier circuit boards and the high-voltage compartment. This chassis is held in place by three captive securing screws. Be sure these securing screws are tightened firmly before the right side panel is replaced.

### Power-Unit Removal

The power-unit can be slid out of the rear of the 7704 to gain better access to the Logic, Vertical Switching and X-Y Delay Compensation circuit boards, CRT socket and for power-unit maintenance. To remove the power unit, first lower the swing-down chassis. Then, remove the four screws (see Fig. 4-1) 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 cable so it does not catch on other parts

of the instrument). The power-unit remains connected to the rest of the instrument so that it can be operated in this position for maintenance purposes. Reverse this procedure when replacing the power-unit; be careful not to pinch the power cable 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 Troubleshooting the Power Supply for troubleshooting information, and Access to Components in Power Unit for information on how to remove the protective cover/shield on the power unit.*

## 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 7704 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

### Cleaning

**General.** The 7704 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.*

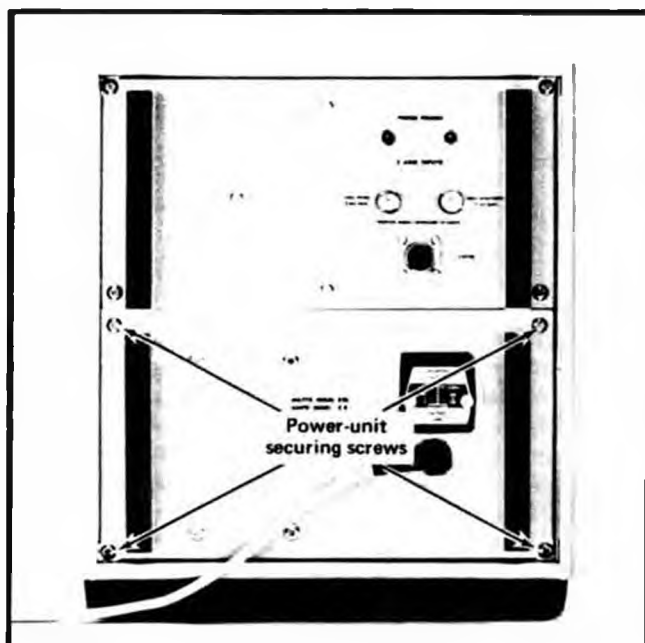


Fig. 4-1. Securing screws for power unit (rear of instrument).

**Exterior.** Loose dust accumulated on the outside of the 7704 can be removed with a soft cloth or small paint brush. The paint 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 #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 paint 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 7704 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 7704 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, replace-

ment 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.

An elapsed-time meter is installed on the Low-Voltage Regulator circuit board (on right side of instrument). This meter provides a full-scale indication of 5,000 hours of operating time and can be used to indicate when recalibration is necessary. Each minor division on this meter indicates 250 hours of operation. When the elapsed-time meter reaches 5,000 hours (full scale), it should be replaced.

## TROUBLESHOOTING

### Introduction

The following information is provided to facilitate troubleshooting of the 7704. 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. See the Circuit Description section for complete information.

### Troubleshooting Aids

**Diagrams.** Complete circuit diagrams are given on fold-out pages in the Diagrams section. The component number and electrical value of each component in this instrument are shown on the diagrams. Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the 7704 and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams. The portions of the circuit mounted on circuit boards are enclosed with blue lines.

**Cam-type Switch Contact Identification.** Switches shown on the diagrams are coded to indicate the position of the contact in the complete switch assembly counting from the front, or mounting end of the switch, toward the rear. The contact closure chart given on the diagrams indicates when each contact is closed.

**Circuit Boards.** Figs. 4-9 through 4-26 show the circuit boards used in the 7704. Fig. 4-8 shows the location of each board within the instrument. Each electrical component on the boards is identified by its circuit number. The circuit boards are also outlined on the diagrams with a blue line. These pictures, used along with the diagrams, aid in locating the components mounted on the circuit boards.

**Wiring Color-Code.** All insulated wire and cable used in the 7704 is color-coded to facilitate circuit tracing. Table 4-2 gives the wiring color-code used in this instrument.

**TABLE 4-1**  
Component Numbers

Component numbers on diagrams	Diagram number	Circuit
1-49	1	Main Interface
100-199	2	Logic Circuit
300-349	3	Trigger Selector
200-299	4	Vertical Interface
400-499	5	Vertical Amplifier
50-99	6	Horizontal Interface
350-399		
500-599	7	Horizontal Amplifier
600-699	8	Output Signals and Calibrator
700-799	9	CRT Circuit
800-899	10	Line to DC Converter/Regulator
900-999	11	Low-Voltage Regulator
1000-1099	12	Controls and Cabling
1200-1249	13	Sequencing Logic
1100-1199	14	Data Collection
1250-1299	15	Character Generators and Output

**TABLE 4-2**  
WIRING COLOR CODE

Supply or Function	Background Color	Stripe <sup>1</sup>
–50 volt	Violet	Brown
–15 volt	Violet	Black
+5 volt	Red	Black
+15 volt	Red	Brown
+50 volt	Red	Orange
+75 volt	Red	Yellow
+150 volt	Red	Green
Chassis ground	Black <sup>2</sup>	Footnote 3
Safety ground	Green	Yellow
AC (internal)	Gray <sup>2</sup>	Footnote 4
Bulb filaments	Brown	Footnote 4
Signal leads	White <sup>2</sup>	Footnote 4

<sup>1</sup> If more than one stripe appears on lead, extra stripes are for lead identification only (for circuit tracing).

<sup>2</sup> See WARNING note concerning power-cord color code.

<sup>3</sup> White stripe indicates floating (signal) ground.

<sup>4</sup> All stripes for lead identification only (for circuit tracing).

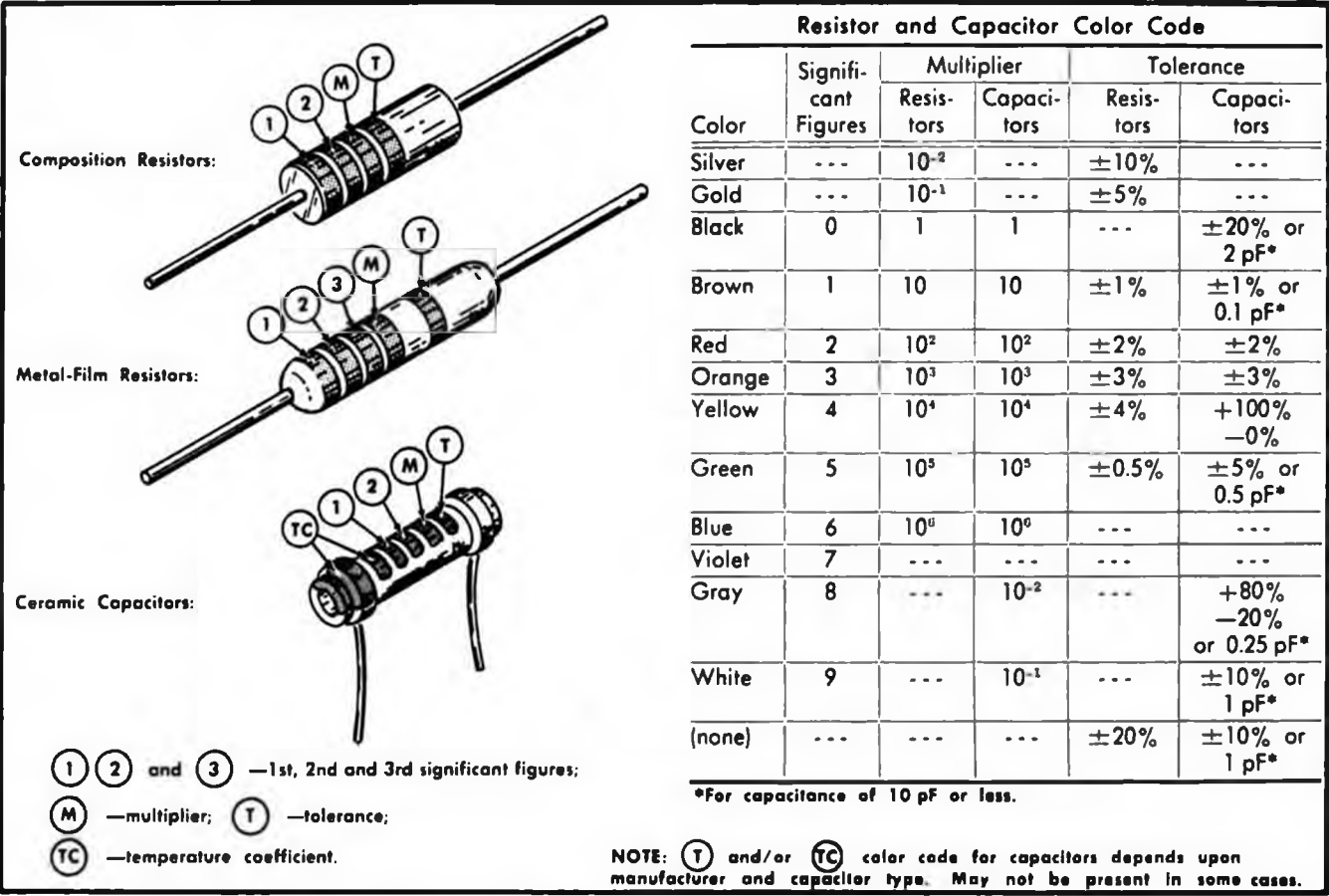


Fig. 4-2. Color-code for resistors and ceramic capacitors.

**WARNING**

This color code applies to leads within the 7704 only.  
Color code of the AC power cord is:

- Black
- White
- Green
- Line
- Neutral
- Safety earth (ground)

**Resistor Color-Code.** In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the 7704. The resistance values of wire-wound resistors are printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color-coded on the components with EIA color-code (some metal-film resistors may have the value printed on the body). The color-code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 4-2). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

**Capacitor Marking.** The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the 7704 are color-coded in picofarads using a modified EIA code (see Fig. 4-2).

**Diode Color-Code.** 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-coded 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.

**Semiconductor Lead Configuration.** Fig. 4-3 shows the lead configuration for the semiconductors used in this instrument. This view is as seen from the bottom of the semiconductors.

**Troubleshooting Equipment**

The following equipment is useful for troubleshooting the 7704.

1. Transistor Tester

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

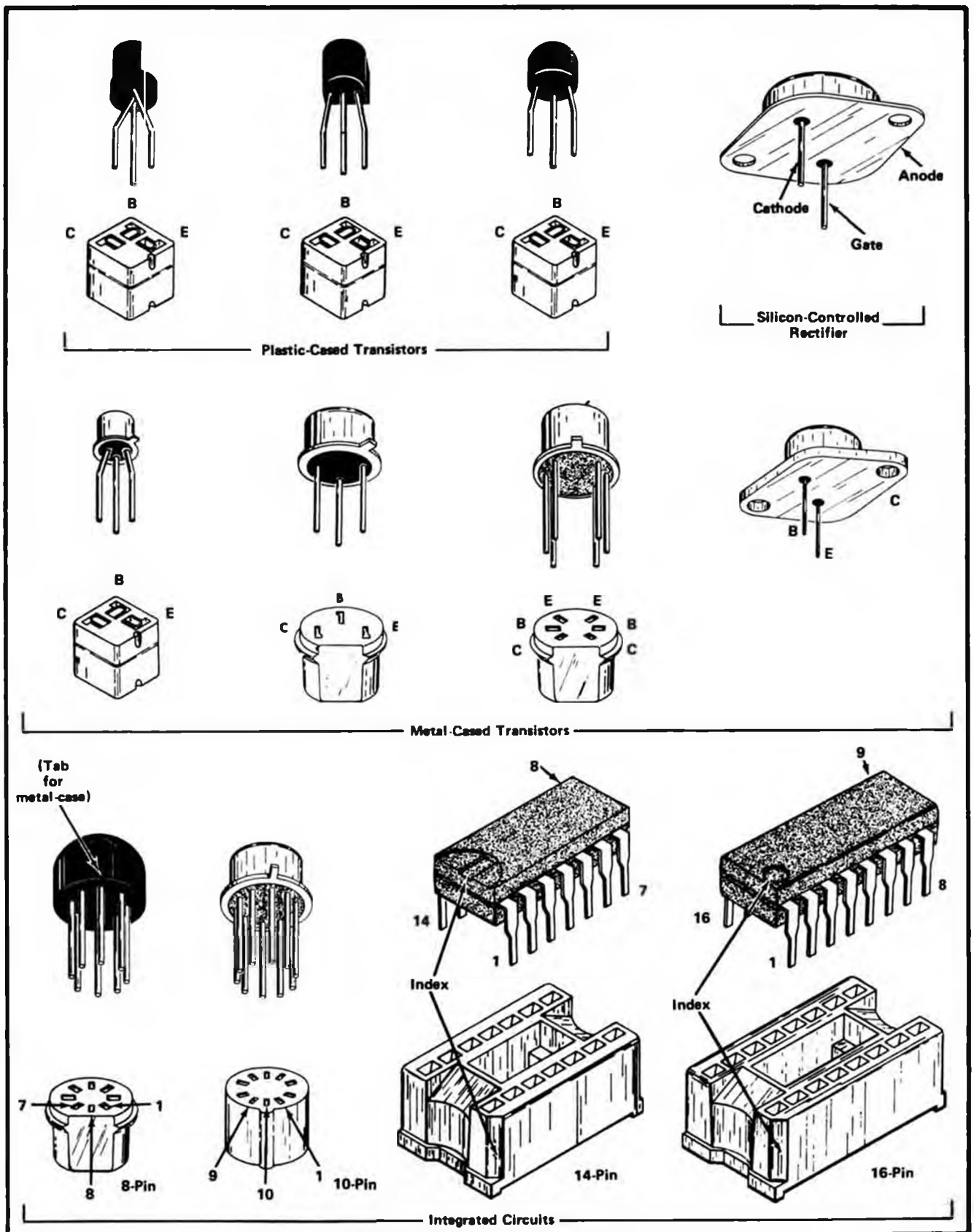


Fig. 4-3. Electrode configuration for semiconductors in this instrument.

## Maintenance—7704

**Purpose:** To test the semiconductors used in this instrument.

**Recommended type:** Tektronix Type 576 Transistor-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 50 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 7504 Oscilloscope with 7A16 Amplifier, 7A14 Current Probe Amplifier, and 7B50 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 7704 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 Metered 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 Operating Instructions section.

**2. Check Associated Equipment.** Before proceeding with troubleshooting of the 7704, 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 7704 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 high voltage supplies) 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.

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 4-3 lists the tolerances of the power supplies in this instrument. These voltages are measured between the power-supply test points (on Low-Voltage Regulator board) to the ground test point on this board. See Fig. 4-4 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.

#### NOTE

*See the specific information on Troubleshooting the Power Supply in this section for further information.*

Fig. 4-5 provides a guide for locating a defective circuit. Start from the top of the chart and perform the given

TABLE 4-3

Power Supply Tolerance and Ripple  
(referenced to TPGND)

Power Supply	Test point (see Fig. 4-4)	Tolerance	Maximum ripple (peak-to-peak)
-50 volt	TP -50	$\pm 0.10$ volts	5 millivolts
-15 volt	TP -15	$\pm 0.75$ volts	2 millivolts
+5 volt	TP +5	$\pm 0.15$ volts	2 millivolts
+15 volt	TP +15	$\pm 0.30$ volts	2 millivolts
+50 volt	TP +50	$\pm 0.60$ volts	5 millivolts
+75 volt	TP +75	$\pm 2.25$ volts	200 millivolts
+150 volt	TP +150	$\pm 6.0$ volts	300 millivolts

checks on the left side of the page until a step is found which does not produce the indicated results. Further checks and/or the circuit in which the trouble is probably located are listed to the right of this step. This chart does not include checks for all possible defects; use steps 6 and 7 or the Special Troubleshooting Information in such cases.

After the defective circuit has been located, proceed with steps 6 and 7 to locate the defective component(s).

**6. Check Voltages and Waveforms.** Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

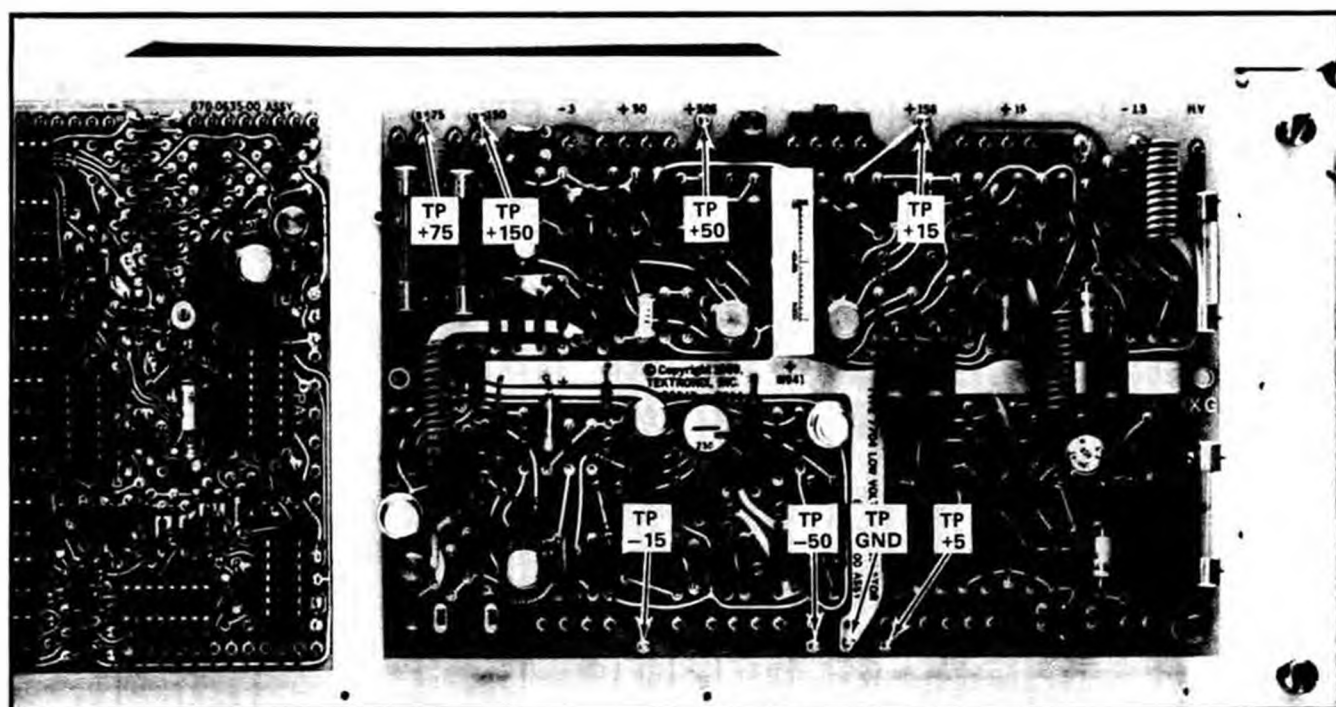


Fig. 4-4. Location of power-supply test points on Low-Voltage Regulator board.



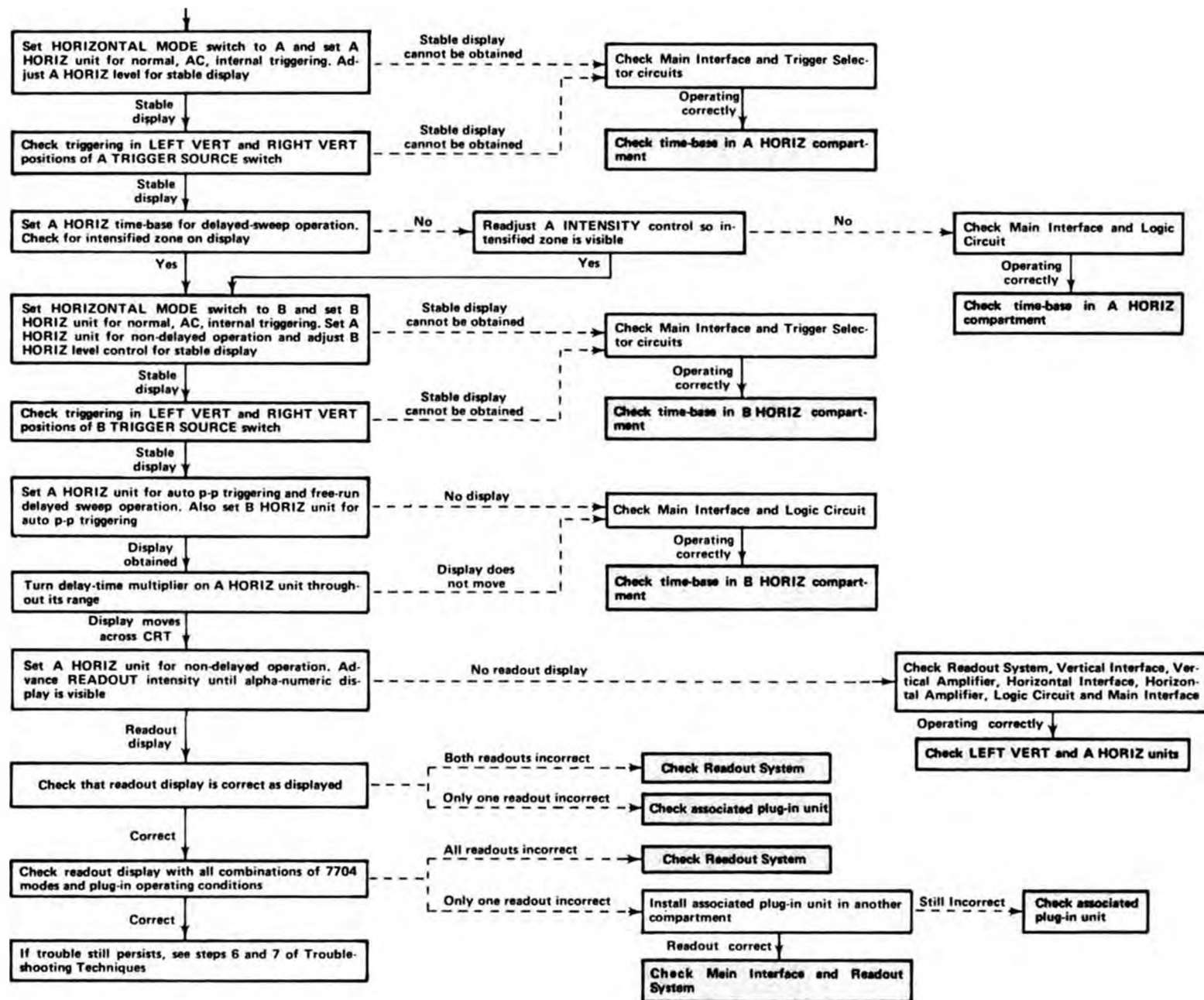


Fig. 4-5. Troubleshooting chart for 7704.

**NOTE**

*Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first diagram page.*

**7. Check Individual Components.** The following procedures describe methods of checking individual components in the 7704. 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 most effectively be 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.

Integrated circuits can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of the circuit description is essential to troubleshooting circuits using integrated circuits. In addition, operating waveforms, logic levels and other operating information for the integrated circuits are given in the Circuit Description section. Use care when checking voltages and waveforms around the integrated circuits so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin integrated circuits is with an integrated-circuit test clip. This device also doubles as an integrated-circuit extraction tool.

**B. DIODES.**

A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of between 800 millivolts and 3 volts, the resistance should be very high in one direction and very low when the meter leads are reversed.

**CAUTION**

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

**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.

**Special Troubleshooting Information**

**General.** The following information provides a step-by-step procedure to aid in the troubleshooting of some of the more complex circuits and/or systems in the 7704. A thorough understanding of the circuit operation is essential before troubleshooting in these areas. Read the applicable portions of the Circuit Description in Section 3 before proceeding with troubleshooting. This troubleshooting procedure refers to the diagrams, operating voltages, and waveforms given in Section 7. Specifications for the troubleshooting equipment referred to in these procedures are given earlier in this section under Troubleshooting Equipment.

**Troubleshooting the Power Supply.** The following procedure gives a guide to troubleshooting the Power Supply of the 7704.

**WARNING**

*Line AC and stored DC potentials are present inside the power-unit. The stored DC remains long after the instrument is disconnected from the power source. Read the following instructions completely before attempting maintenance with the power-unit cover removed.*

## 1. Isolating the Trouble

- 1.1 Inspect the Line Selector assembly on the rear panel of the instrument to verify that the switch is in the correct position for the applied line voltage.
- 1.2 Verify that the applied line voltage and frequency are within the specified limits.
- 1.3 Set the POWER switch to the off position and remove the cover from the Line Selector assembly on the rear panel.
- 1.4 Inspect the fuses in the Line Selector assembly cover. If either fuse is open, install a new fuse of the correct value (see Table 4-4). Replace the Line Selector cover.
  - 1.4.1 If the LINE fuse is open, do steps 3.1 – 3.9 inclusive; then go directly to step 4.1.
  - 1.4.2 If the INVERTER fuse is open, do steps 3.1 – 3.9 inclusive; then go directly to step 5.1.
- 1.5 If neither fuse is open, remove all plug-in units from the instrument and set the following front-panel controls:
 

CONTROL ILLUM	LOW
GRAT ILLUM	Fully clockwise
- 1.6 Set POWER switch to ON.
  - 1.6.1 If instrument comes on and stays on (front-panel lights stay on), proceed to step 2.1.
  - 1.6.2 If instrument does not come on or does not stay on, do steps 3.3 – 3.9 inclusive; then go directly to step 5.1.

## 2. Low-Voltage Regulator Check

- 2.1 Set the POWER switch to the off position and remove the right side cover from the instrument.
- 2.2 Inspect the Low-Voltage Regulator board for any visible signs of failure. Check the fuses on this board and the +5-Volt Lamps fuse F1040 to be sure they are good.
- 2.3 Set the POWER switch to ON. Then, measure the output of each supply between the designated test point (see Fig. 4-4) and the ground test point with the voltmeter. Tolerance for each supply is given in Table 4-3.

### NOTE

*The +75- and +150-volt outputs are derived directly from the Line to DC Converter/Regulator circuit and*

*are not regulated on the Low-Voltage Regulator board. If either of these supplies is out of tolerance, the trouble is probably in the Inverter stage. Do steps 3.1 – 3.9 inclusive; then go directly to step 5.1.*

- 2.4 If all supplies are proportionately low, do steps 3.1 – 3.9 inclusive; then go directly to step 4.1.
- 2.5 If one supply is noticeably lower than the rest, check for an overload condition on this supply. An overload may cause a supply to operate in a current limiting mode which will reduce its output voltage. If no overload is apparent, check the semi-regulated voltage reaching the applicable regulator stage from the Line to DC Converter/Regulator circuit. This can best be done by lowering the swing-down chassis and measuring the input voltage between the inter-connecting pin which connects the power-unit to the Low-Voltage Regulator board (see diagram for correct pin) and the power-supply test point. For example, the semi-regulated voltage for the +5-Volt Supply is measured between pin SW and TP+5S. Typical values for the semi-regulated voltage are given on the diagrams.
  - 2.5.1 If the semi-regulated voltage measures low, do steps 3.1 – 3.9 inclusive; then go directly to step 5.5.
  - 2.5.2 If the semi-regulated voltage is correct but the output of the supply remains high or low, make the following checks:
    - 2.5.2.1 Measure the voltage between the semi-regulated input voltage interconnecting pin and TP GND (e.g., note voltage at pin SW). Compare the results to the voltages given on the diagrams.
    - 2.5.2.2 If above check does not locate the fault, check the applicable regulator circuit using the voltages given on the diagrams.

## 3. Test Set-Up for Troubleshooting the Line to DC Converter/Regulator Circuit

- 3.1 Remove all plug-in units from the instrument.
- 3.2 Set the following front-panel controls:
 

CONTROL ILLUM	LOW
GRAT ILLUM	Fully counterclockwise
POWER	Off
- 3.3 Connect the isolation transformer to a grounded power outlet. If the isolation transformer has a power switch, set it to the off position. Isolation

transformer must have a three-wire power cord, plug, and receptacle.

- 3.4 Connect the autotransformer to the power receptacle of the isolation transformer. Set the power switch of the autotransformer to off and set the output-voltage control so it will provide an output of about 115 volts.
- 3.5 Connect the 7704 line cord to the autotransformer power receptacle. Be sure that the 7704 POWER switch is off.
- 3.6 Remove the four screws from the lower portion of the rear panel and slide the power-unit out of the instrument.
- 3.7 Verify that a ground connection exists from the chassis of the power-unit to the third-wire ground at the input to the isolation transformer.

**WARNING**

*The primary storage capacitors, C813 and C814, remain charged with high voltage DC for several minutes after the line power is disconnected. When this stored voltage exceeds about 80 volts, a neon bulb located on the Line Input board flashes.*

- 3.8 Locate the neon warning bulb on the Line Input board (right side of power-unit when facing rear panel). Wait at least two minutes after the bulb has stopped flashing before proceeding.
- 3.9 Remove the four screws which hold the cover on the power-unit and remove the cover.

**CAUTION**

*Do not short circuit the primary storage capacitors C813 and C814 as they will be damaged by this action. If manual discharge is necessary at any time, use a 1.5 k $\Omega$ , two-watt insulated resistor. USE EXTREME CAUTION. Allow at least one minute for the current-limiting thermistors to cool before turning on the POWER switch if the capacitors have been manually discharged. Do not leave the external bleeder resistor connected across the capacitors when the POWER switch is ON.*

4. Check Line Input Stage and Primary Storage Capacitors

- 4.1 Be sure that steps 3.1 — 3.9 have been performed.
- 4.2 Locate the Line Input board and inspect the components for any visible signs of failure.
- 4.3 Remove the cover from the Line Selector assembly on the rear panel and remove the INVERTER fuse. Leave the LINE fuse in place and re-install the Line

Selector cover. (Notice on the diagrams that this allows the Line Input stage to operate without supplying power to the Inverter stage.)

- 4.4 Remove the plastic cover shielding the primary storage capacitors C813 and C814.
- 4.5 Set the power switch of the isolation transformer to on. Then, set the power switch of the autotransformer to on. Finally, set the 7704 POWER switch to ON.
- 4.6 Set the voltmeter to a scale that will measure at least 400 volts DC. Connect the voltmeter between the positive side of C813 and the negative side of C814 (notice that these capacitors are connected in series by the strap between the negative side of C813 and the positive side of C814). This voltage should be between 220 and 370 volts DC; the exact voltage depends upon the line input voltage.
- 4.7 Set the 7704 POWER switch to the off position and unplug the power cord from the autotransformer. Observe the neon warning bulb on the Line Input board. Wait at least two minutes after the bulb has stopped flashing before proceeding.

**CAUTION**

*With the voltmeter still connected across C813 and C814, check that these capacitors have fully discharged (voltmeter reading zero volts) before making ohmmeter measurements in the Line Input stage.*

- 4.8 If the voltage measured in step 4.6 was lower than 220 volts, check the Line Input stage for defective components.
- 4.9 When the defective component is located, replace it using the replacement procedures given in this section. Then, repeat steps 4.1 — 4.8.
- 4.10 If the voltage measurement in step 4.6 is within the given limits, disconnect the voltmeter and replace the plastic cover over C813 and C814. Then, remove the cover from the Line Selector assembly and replace the INVERTER fuse. Reinstall the Line Selector cover. This completes the checks in the Line Input stage.

5. Check Remaining Circuits in the Line to DC Converter/Regulator Circuit

- 5.1 Be sure that steps 3.1 — 3.9 have been performed.

**NOTE**

*If a defective component is located in the following checks, proceed to steps 5.13 — 5.14 before re-assembling the power-unit. The checks given in these steps will insure that the Inverter stage is working correctly.*

5.2 Remove the cover from the Line Selector assembly. This opens the DC path between the Line Input stage and the Inverter stage to allow ohmmeter measurements to be made within the Inverter stage.

5.3 Use the following procedure to check the power-handling components in the Inverter stage.

5.3.1 Connect the positive lead of the ohmmeter to TP826 and the negative lead to TP836 (both test points on Inverter board). Set the ohmmeter to a scale of R X 10 k or higher. Typical resistance readings between these test points should be between 10 and 50 megohms. If the reading falls below about two megohms, check the following components for reverse breakdown characteristics with a curve tracer: CR825, CR826, CR828 and Q825. Minimum reverse breakdown characteristics for these components should be 400 volts.

5.3.2 Connect the positive lead of the ohmmeter to TP836 and the negative lead to TP820. Repeat the check as given in the previous step. Components to check if the reading falls below two megohms are: CR835, CR836, CR838 and Q835. Disconnect the ohmmeter.

5.4 Check the LINE and INVERTER fuses to be sure they are good. If not, replace the fuses and reinstall the Line Selector assembly cover.

#### NOTE

*The next seven steps will get the Inverter stage operating at low line voltage and low output voltage with the pre-regulator circuitry disabled. This will allow waveform checks and output voltage measurements even though an overload condition may exist.*

5.5 Remove Q860 from its socket. This disables the pre-regulator circuit.

5.6 Connect the voltmeter between TP+75V and TPGND on the Rectifier board. Use the 75 volt, or higher, scale.

#### CAUTION

*TP820 is normally elevated about 100 volts above chassis ground. However, when the isolation transformer is used as given in this procedure, TP820 can be grounded without danger or damage to the power supply.*

5.7 Connect the 10X probe to the test oscilloscope. Then, connect the probe ground clip to TP820.

5.8 Connect the probe tip to TP836 on the Inverter board. Be sure that the test oscilloscope is properly grounded by the three-wire power cord before proceeding. Set the test oscilloscope for a vertical deflection of 5 volts/division (50 volts/division at probe tip) at a sweep rate of 10 microseconds/division with AC internal triggering in the automatic trigger mode.

5.9 Set the output voltage of the autotransformer to zero volts.

5.10 Set the power switch of the isolation transformer to on. Then set the power switch of the autotransformer to on. Finally, set the 7704 POWER switch to ON.

5.11 **Read this step completely before proceeding.** Slowly increase the output of the autotransformer until a waveform appears on the test oscilloscope. Then, quickly reduce the autotransformer setting to keep the voltage, as measured by the voltmeter, below 75 volts. **Do not allow the voltage at TP+75V to exceed 75 volts.** Notice that the Inverter stage will continue to operate with an input voltage as low as one-half the level required to start it. Decreasing the input voltage as described after the Inverter stage has started reduces the possibility of opening the INVERTER fuse if an overload condition exists.

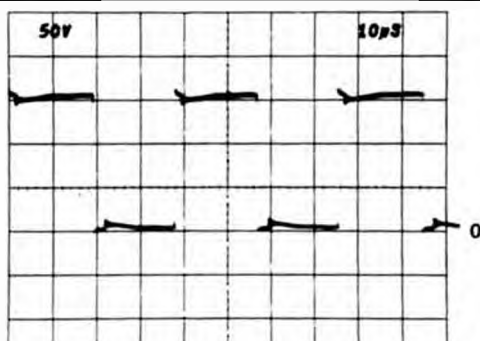
#### NOTE

*The next three steps determine if the Inverter stage and power transformer primary circuit are malfunctioning, or if an overload condition exists in the transformer secondary.*

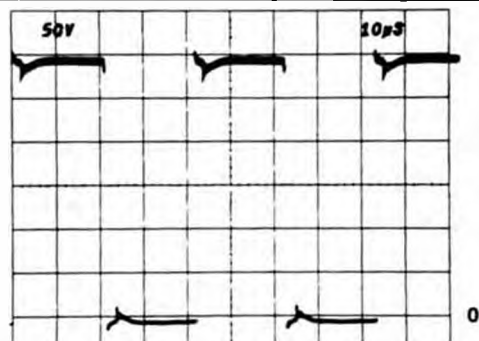
5.12 Examine the waveform on the test oscilloscope and compare to the waveform shown in Fig. 4-6A and 4-6B. The waveform should be a square wave with a peak-to-peak amplitude equal to the DC voltage stored in the primary storage capacitors.

5.13 Install the current-probe amplifier in the test oscilloscope and connect the current probe to its input. Set the current-probe amplifier for a vertical deflection of one ampere/division at a sweep rate of 10 microseconds/division. Connect the current-probe tip around the wire (gray with red stripe) which connects interconnecting pin NE on the Line Input board to point PC on the Inverter board (connect probe around lead at upper left corner of Inverter board). This wire carries the Inverter supply current.

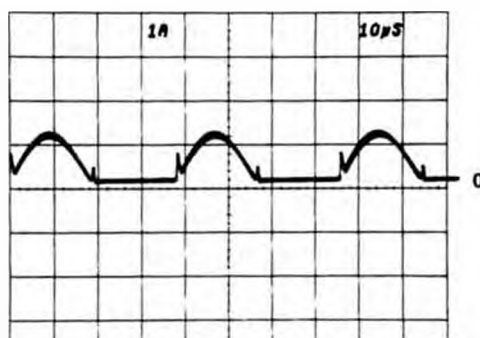
5.14 Compare the test oscilloscope waveforms to the waveforms shown in Fig. 4-6C, 4-6D, and 4-6E. Distorted waveshapes indicate Inverter trouble. High



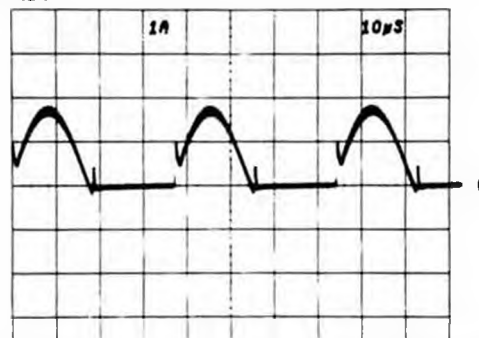
A. At TP836. Inverter stage operating under light load with pre-regulator disabled. Input line voltage about 50% low.



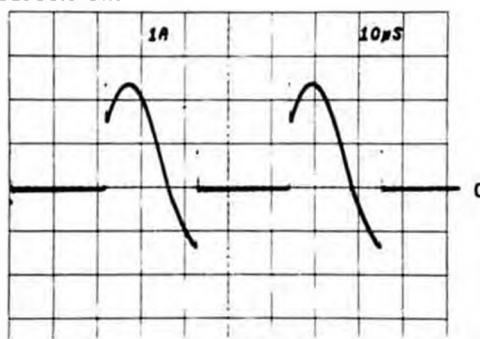
B. At TP836. Inverter stage operating under heavy load with pre-regulator functioning normally. Input line voltage normal.



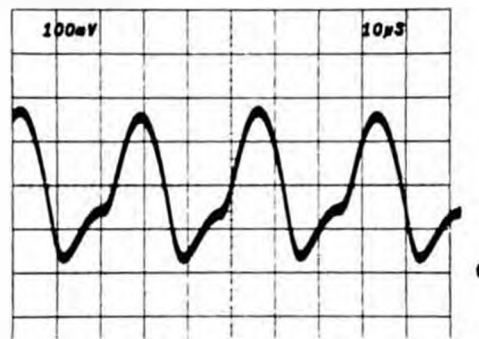
C. Inverter supply current. Inverter stage operating under light load with pre-regulator disabled. Input line voltage about 50% low.



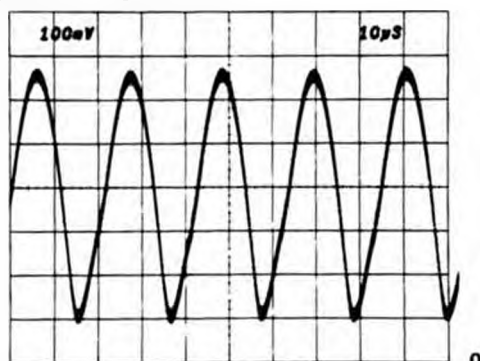
D. Inverter supply current. Inverter stage operating under heavy load with pre-regulator disabled. Input line voltage about 50% low.



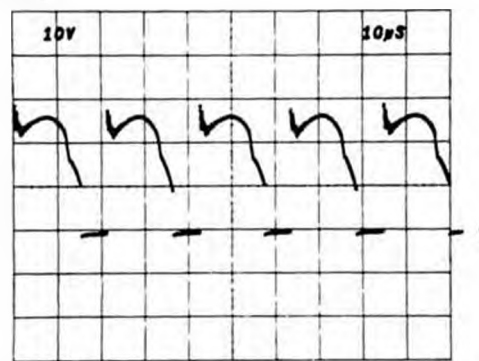
E. Inverter supply current. Inverter stage operating under moderate load with pre-regulator functioning normally. Input line voltage normal.



F. At TP859. Inverter stage operating under light load with pre-regulator functioning normally. Input line voltage normal.



G. At TP859. Inverter stage operating under moderate load with pre-regulator functioning normally. Input line voltage normal.



H. At TP860. Inverter stage operating under moderate load with pre-regulator functioning normally. Input line voltage normal.

Fig. 4-6. Operating waveforms from power supply

current indicates an overload on the transformer secondary.

5.14.1 If the waveforms obtained in steps 5.12 and 5.14 appear normal or near normal, proceed to step 5.15.

5.14.2 If the waveforms in step 5.12 or 5.14 are incorrect, turn off the POWER switch and check the components in the Inverter circuit with an ohmmeter (allow sufficient time for the primary storage capacitors in the Line Input stage to discharge before proceeding).

#### NOTE

*The next two steps check the Rectifier circuits for correct operation.*

5.15 With the Inverter stage operating as given in step 5.11 check the voltmeter reading (voltmeter connected between TP+75V and TPGND). The measured value should be low since the pre-regulator circuitry is disabled, but it should not be zero. If the voltage is zero, reduce the autotransformer setting to zero. Set the POWER switch to off and remove the Rectifier board. Check all components associated with the +75-volt rectifier circuit. If all components appear to be good, replace the Rectifier board and set the POWER switch to ON. Repeat step 5.11. Then, check the AC voltage between terminals 5 and 7 of the power transformer with the voltmeter (set voltmeter to measure at least 150 volts RMS or 210 volts peak).

#### CAUTION

*The Inverter stage will not function properly if the instrument is operated without the load provided by the Rectifier board.*

5.15.1 If AC voltage is not present at the transformer terminals, the transformer may be defective.

5.15.2 If AC voltage is present at the transformer terminals but voltage is not present at TP+75V, further checks of the +75-volt rectifier circuit are necessary to locate the defective component.

5.16 Repeat step 5.15 for each output voltage. Measure the output voltage at the applicable board terminals as shown on the diagram. This completes the Rectifier checks.

#### NOTE

*The next nine steps check the pre-regulator circuitry for correct operation.*

5.17 Set the 7704 POWER switch to the off position.

5.18 Replace Q860 in its socket.

5.19 Connect the voltmeter between TP+75V and TPGND on the Rectifier board.

5.20 Reconnect the 10X probe to the test oscilloscope. Then, connect the probe tip to TP836 on the Inverter board. Be sure that the test oscilloscope is properly grounded by the three-wire power cord before proceeding. Set the test oscilloscope for a vertical deflection of 10 volts/division at a sweep rate of 10 microseconds/division with AC, internal triggering in the automatic mode.

5.21 Connect the probe ground clip to TP820 (see CAUTION in step 5.8).

5.22 Set the autotransformer output voltage to zero. Then, set the 7704 POWER switch to ON.

5.23 Slowly increase the autotransformer output voltage until the Inverter stage runs continuously as shown by the waveform on the test oscilloscope. Do not allow the voltage on the voltmeter to exceed 75 volts.

5.24 While observing the test oscilloscope waveform, observe the change in the waveform produced by slightly raising and lowering the output voltage of the autotransformer. As the line voltage is increased, the Inverter frequency should decrease; i.e., the period should become longer. When the line voltage is at the nominal level (117V) and the instrument has a two plug-in load, the voltage at TP+75V should be +75 volts  $\pm 0.375$  volt. Refer to the Calibration Procedure if adjustment is necessary.

5.25 If a malfunction in the pre-regulator circuitry is suspected, monitor the waveforms at TP859 and TP860 with respect to TPGND. Compare with the waveforms shown in Fig. 4-6F, 4-6G and 4-6H. Use the ohmmeter to locate defective components (with POWER switch off). Check the transistors with the transistor tester. This completes the pre-regulator circuitry check.

**Troubleshooting the Readout System.** The following procedure provides a guide to troubleshooting the Readout System of the 7704.



**NOTE**

*In the following procedure, the integrated circuits can be checked by interchanging with similar types on the Readout System board or with other instruments of the same type. Also, the voltages and waveforms as described in the Circuit Description and given on the diagrams can be used to check the operation of the integrated circuits where replacement devices are not available.*

**1. Isolating the Trouble**

- 1.1 Remove the Readout System board from the instrument and check for damaged components, damaged circuit board, or improperly installed transistors or integrated circuits. Check that the index of all integrated circuits on the Readout System board matches the index of the socket. If no defects are found, re-install the board on the instrument.
- 1.2 Set the 7704 POWER switch to ON and note which of the following problems exist. Then refer to the step listed.
  - 1.2.1 No readout in any word location. Go to step 2.1.
  - 1.2.2 All readout words incorrect. Go to step 3.1.
  - 1.2.3 Some readout words correct, some incorrect. Go to step 4.1.

**2. No Readout**

- 2.1 Remove all plug-in units from the instrument.
- 2.2 Remove dual transistor Q1143 from the Readout System board.
- 2.3 Set the 7704 POWER switch to ON and allow a warm-up period.

**NOTE**

*Observe the readout display and refer to one of the following steps.*

- 2.4 80 zeros in display (40 within top division of graticule, 40 within bottom division).
  - 2.4.1 If correct display of 80 zeros is obtained, interchange U1130 and U1170. Then return to step 1.2. If the present readout display is in any way different than the original problem, the trouble is located in the U1130 or U1170 circuits.

- 2.4.2 If step 2.4.1 does not correct the readout display, interchange U1166 and U1186 and return to step 1.2. If the present readout display is in any way different from the original problem, the trouble is located in the U1166 or U1186 circuits.

- 2.4.3 If less than 80 zeros are displayed, check output of U1226 (see Fig. 3-44). If incorrect, the trouble is located in the U1226 or U1210 circuits. If correct, check U1130, U1170, U1166, and U1186 circuits as given in steps 2.4.1 and 2.4.2.

**2.5 80 dots in display**

- 2.5.1 Exchange character generator U1251 with one of the other character generators U1252 – U1255. If display is still only dots, check U1166 by interchanging it with U1186.
- 2.5.2 If 80 characters are displayed (exact character will depend on which character generator was substituted), re-install the character generators in the correct sockets and replace U1251 with a new integrated circuit.

**2.6 Pattern other than 80 zeros or dots**

- 2.6.1 Check Channel Address Code (see Table 3-4). If incorrect, check U1230-U1231-U1232.
- 2.6.2 Check Q1274, Q1278, Q1284, and Q1288 with the transistor tester (see recommended troubleshooting equipment). If correct, check U1260 and U1270 circuits.

**2.7 No display**

- 2.7.1 Turn front-panel READOUT control fully clockwise and check voltage at interconnecting pin XM.
  - 2.7.1.1 If less than about -13 volts, check R1040 and S1040. Also check interconnecting leads.
  - 2.7.1.2 If greater than -13 volts, check voltage at TP1255: If zero volts or more negative, check the U1210 circuit; if +1 volt or greater, check Q1150-Q1152-Q1155-Q1163. Finally, check U1190.

- 2.7.2 Check waveforms at TP1215, TP1217, and pin 5 of U1210. If correct, check the level at pin 16 of U1226.

- 2.8 Re-install Q1143 in its socket. Check readout display.



### 3. All Readout Words Incorrect

3.1 If only one character is wrong in all displayed readouts, check the character generator which produces this character.

3.2 Install a time-base unit in any compartment and turn the time/division switch throughout its range. Note which portions of the readout display are missing or incorrect in each decade of the time/division switch.

3.3 Install the time-base unit in another compartment and repeat step 3.2. If the results are the same, continue with this step. If the readout is now correct, go to step 4.1.

3.4 Remove the time-base unit and substitute a different unit and repeat step 3.2. If the results are the same, continue with this step. If the readout is now correct, check the original plug-in units.

3.5 Interchange U1130 and U1170 and repeat step 3.2. If the readout is still incorrect but different portions of the readout display are wrong, the trouble is in either the U1130 or U1170 circuit. If the readout is correct, the error may have been corrected; check readout in all plug-in compartments for original error. If no change is noted, proceed to next step.

3.6 Repeat step 3.5, only this time interchange U1166 and U1186.

3.7 If the zeros adding or prefix shifting portion of the readout display is incorrect, check following steps:

3.7.1 Check waveform at TP1130 to see if information is being encoded during time-slot 1. If not, check U1130 by substitution with U1170. Also check the encoding network in the plug-in unit.

3.7.2 Check for a Word Trigger pulse at pin 9 of U1190 (one pulse for each 10 time-slot pulses). If not present, check U1227 and U1226 circuits.

3.7.3 Check for presence of row 3 information at pin 16 and column 1, 2, 3, 4 information at pins 12, 13, 10 and 11 respectively of U1190 (current signals). If no signal is present, check U1166 and U1186.

3.7.4 Check waveform at TP1190 (see Fig. 3-48). If not present, check U1190 circuit.

### 4. Some Readout Words Correct, Some Incorrect.

4.1 Install different plug-in units in the compartment(s) producing the incorrect readout. Check resulting display.

4.1.1 Readout correct. Check original plug-in unit.

4.1.2 Readout still incorrect.

4.1.2.1 Interchange U1130 and U1170 and check the resulting display. If the readout is still incorrect but different portions of the readout display are wrong, the trouble is in either U1130 or U1170. If the readout is correct, the error may have been corrected; check readout in all plug-in compartments. If no change is noted, proceed to the next step.

4.1.2.2 Repeat step 4.1.2.1, only this time interchange U1166 and U1186.

4.1.2.3 Check all time-slot pulses connected to the plug-in unit at the plug-in interface connector. Pulses must be exactly -15 volts in amplitude. If not, check U1210 and U1226 circuits, and the interconnecting wires.

4.2 This completes the troubleshooting procedure for the Readout System.

## CORRECTIVE MAINTENANCE

### General

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

### Obtaining Replacement Parts

**Standard Parts.** All electrical and mechanical part replacements for the 7704 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts lists for value, tolerance, rating and description.

### NOTE

*When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance in the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.*

**Special Parts.** In addition to the standard electronic components, some special components are used in the 7704. These components are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special components are indicated in the Electrical Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

**Ordering Parts.** When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type.
2. Instrument serial number.
3. A description of the part (if electrical, include circuit number).
4. Tektronix Part Number.

## Soldering Techniques

### WARNING

*Disconnect the instrument from the power source before soldering.*

**Circuit Boards.** Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material.

The following technique should be used to replace a component on a circuit board. Use the procedures given under Component Replacement to remove the boards from the instrument before soldering.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board as it may damage the board.

2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick into the hole to clean it out. A vacuum-type desoldering tool can also be used for this purpose.

3. Bend the leads of the new component to fit the holes in the boards. Insert the leads into the holes in the board so the component is firmly seated against the board, or as positioned originally. If it does not seat properly, heat the solder and gently press the component into place.

4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint; do not apply too much solder. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip the excess lead that protrudes through the board.

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

**Metal Terminals.** When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. Use a soldering iron with a 40- to 75-watt rating and a 1/8-inch wide wedge-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely. Use a heat sink to protect heat-sensitive components.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder joint, clip off the excess.

4. Clean the flux from the solder joint with a flux-remover solvent.

## Component Replacement

### WARNING

*Disconnect the instrument from the power source before replacing components.*

**General.** The exploded-view drawings associated with the Mechanical Parts List (located on back of diagram pull-out pages) may be helpful in the removal or disassembly of individual components or sub-assemblies.

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

**WARNING**

*Line AC and stored DC potentials are present inside the power-unit. This instrument should be operated with an isolation transformer whenever troubleshooting the circuitry in the power-unit. Follow the recommended troubleshooting procedure given under Special Troubleshooting Information.*

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

2. Set the power-unit on the rear feet so that the cable which interconnects the power-unit and the rest of the instrument will not obstruct removal of the power-unit cover.

**WARNING**

*Disconnect the instrument from the power source before removing the power-unit cover. A warning light is provided on the Line Input circuit board (on left side of power-unit). Do not remove the power-unit cover until this light has extinguished.*

3. Remove the four screws on the front of the power-unit and pull the protective cover off of the power unit. EMI shielding strips are mounted around the edges of this cover to reduce EMI radiation out of the power-unit. Because of these shielding strips, the cover fits firmly onto the power-unit.

4. The power-unit is now open for maintenance or repair. See the instructions under Troubleshooting the Power Supply for information on locating a trouble in the power supply. For information on replacing the transformer, see Power Transformer Replacement.

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

**Circuit Board Replacement.** If a circuit board is damaged beyond repair, either the entire assembly including all soldered on components, or the board only, can be replaced. Part numbers are given in the Mechanical Parts List for either the completely wired (670- \_\_\_\_\_) or the

unwired board (388- \_\_\_\_\_). Most of the main circuit boards in this instrument plug onto the chassis or onto other circuit boards (exceptions; Main Interface, Calibrator, Line Input, Inverter and Rectifier boards). Use the following procedure to remove the plug-on circuit boards (removal instructions for the exceptions will be given later).

**A. PLUG-ON BOARDS.**

1. Disconnect any pin connectors located on the front of the board.

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

3. Pull out on the edges of the board until the board clears the chassis terminals. Attempt to lift the board away from the chassis in such a way that it remains parallel to the chassis at all times so as not to bend the interconnecting terminals.

4. To replace a plug-on circuit board, position it so the securing-screw holders mate with the guide posts on the chassis.

5. Gently press the circuit board against the chassis. Be sure that all of the interconnecting pins and sockets mate properly.

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

**B. MAIN INTERFACE CIRCUIT BOARD REPLACEMENT.**

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 (remove plug-in units to gain access to plug-on boards on front of Main Interface board).

3. Disconnect the six multi-pin connectors located at the top of the Main Interface board. Note the order of these connectors so they can be correctly replaced.

4. Remove the three screws from inside each plug-in compartment which hold the plug-in interface connectors

to the chassis of this instrument (total of 12 screws). Also remove the two screws which hold the ground straps to the chassis.

5. Slide the Main Interface board assembly to the rear and disconnect all of the pin connectors. Now, the Main Interface board assembly can be removed from the instrument.

6. To replace the Main Interface 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 in Figs. 4-9 and 4-10.

#### **C. CALIBRATOR BOARD REPLACEMENT.**

To replace the Calibrator circuit board, use the following procedure:

1. Lower the swing-down chassis.
2. Rotate the CALIBRATOR and RATE switches fully counterclockwise.
3. Remove the knobs from the CALIBRATOR and RATE switches with a 1/16-inch hex-key wrench (CALIBRATOR knob has two set screws).
4. Remove the securing nut which holds the switch/board assembly to the front panel with a #14 nut driver.
5. Remove the screw holding the rear of the Calibrator board to the support bracket.
6. Slide the Calibrator switch/board assembly out of the front panel and then disconnect the three multi-pin connectors from the board.
7. To replace the Calibrator switch/board assembly, reverse the above procedure. Match the arrows on the multi-pin connectors to the arrows on the board. Be sure the front-panel knobs are installed so they indicate the correct switch positions.

#### **D. RECTIFIER BOARD REMOVAL.**

The Rectifier circuit board is mounted inside the power-unit. To remove this board, proceed as follows:

1. Remove the cover from the power-unit as described previously.

2. The Rectifier board can be removed from the power chassis in the manner described for the plug-on circuit boards.

3. To replace the board, reverse the procedure.

#### **E. LINE INPUT BOARD REMOVAL.**

The Line Input circuit board is also mounted inside the power unit. To remove this board, proceed as follows:

1. Remove the power-unit cover as described previously.
2. Loosen the two securing screws on the board.
3. Pull out on the edges of the board until the board clears the chassis terminals.
4. Unsolder the seven leads connected to this board.
5. To replace the board, reverse the above procedure. Correct location of the soldered wires is shown in Fig. 4-23.

#### **F. INVERTER BOARD REMOVAL.**

To replace the Inverter circuit board, use the following procedure:

1. Remove the power-unit cover as described previously.
2. Remove the plastic snap-in feet from the rear panel and then remove the two screws holding each of the cord holders to the rear panel.
3. Remove the four remaining screws which hold the rear panel to the rear subpanel. These screws also provide the bottom support for the power transformer.
4. Remove the four screws which hold the ceramic heat sink (on Inverter Board) to the rear subpanel. Also remove the two screws located next to the Line Selector assembly which hold the power chassis to the rear subpanel.
5. Loosen the securing screws which mount the Line Input board to the chassis. Then, swing this board aside for the next step (the Line Input board can be plugged back into place for troubleshooting with the supply separated).
6. Now, slide the power chassis/transformer assembly away from the rear subpanel.

7. Disconnect the four leads between the pin connectors on the power chassis and the inverter board. Then unsolder the three leads at points PA, PB, and PC, and the shielded coax.

8. Remove the two screws which mount the Inverter board to the power chassis.

9. To replace the Inverter board, reverse the order of removal. Correct connection of the wires is shown in Fig. 4-24.

**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.

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.

**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 as 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 swing-down chassis, first remove the Low-Voltage Regulator board. Then, take out the mounting screws and remove the defective transistor. When replacing the transistor, tighten the mounting screws just tight enough to hold the transistor in place. Then, temporarily re-install the Low-Voltage Regulator board to align the transistor with the sockets in the board. Remove the board and firmly tighten the mounting screws.

**Interconnecting Pin Replacement.** Two types of interconnecting pins are used in this instrument to interconnect the circuit boards and/or the components of this instrument. When the connection is made at the chassis of the instrument, a chassis feed-thru pin is used which is mounted in an insulated bushing. When the interconnection is made at a circuit board, the pin is soldered into the board. In addition, 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. CHASSIS FEED-THRU PINS.

To replace a chassis feed-thru pin, first disconnect any end-lead pin connectors from the pin. Then pull the dam-

aged pin out of the chassis from the rear. If the plastic bushing does not come out with the pin, remove it from the chassis hole. Press the new plastic bushing into the chassis hole. Now, insert the long end of the new feed-thru pin into the plastic bushing from the rear of the chassis. Gently press the feed-thru pin until it is seated firmly into the plastic bushing. Be careful not to bend the pin as it is inserted into the bushing. Check to see that the new feed-thru pin is perpendicular to the chassis and in line with other associated pins.

#### NOTE

*The feed-thru pins which must conduct large amounts of current are of a special heavy-duty design. These pins can be replaced by pressing the complete feed-thru pin/bushing out of the chassis to the rear and pressing the replacement part back into the chassis.*

#### 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 circuit 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 or chassis 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. Slide out the power-unit as described previously.
2. Remove the seven screws holding the upper portion of the rear panel to the rear frame. Pull outward on the rear feet to remove the panel.
3. Remove the plastic CRT mask, light filter and metal light shield.
4. 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.
5. Press inward on the white tabs of the graticule-light assembly and pull the assembly out of the CRT bezel (leave wires connected).
6. Disconnect the CRT anode plug from the jack located on the right side of the main bulkhead. Ground this lead to the chassis to dissipate any stored charge.

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

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

9. Loosen the two 3/32-inch hex-socket 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.

10. 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. Seat the CRT firmly against the cushions mounted on each corner of the faceplate.

2. Place the black-plastic CRT mask over the CRT faceplate.

3. 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 re-install the CRT bezel. Firmly tighten the four screws.

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

5. Replace the CRT base socket.

6. Reconnect the CRT anode plug.

7. Carefully reconnect the deflection-plate connectors. Correct location is shown on the CRT shield. After each connector is installed, lightly pull on its lead to be sure that it will remain in its socket.

8. Replace the graticule-light assembly.

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

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

11. Re-install the power-unit.

12. Check the calibration of the complete instrument. Calibration procedure is given in Section 5.

## WARNING

*Incorrect adjustment of the high-voltage, -50-volt, and +75-volt supplies may result in excessive X-Ray emission from the CRT faceplate. See the Calibration Procedure for correct adjustment.*

**Switch Replacement.** Several different types of switches are used in this instrument. The toggle, micro, 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 switches and the 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 knobs, 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 Calibrator board/switch assembly as described previously.

2. Remove the two screws which hold the metal covers on the switches. The front switch section on the Calibrator

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, loosen the two hex-socket screws in the shaft at the front of the rear switch section with a 0.050-inch hex-key wrench. Pull the long shaft out of the switch assembly.

4. Remove the four screws which hold the cam switch to the circuit board (from rear side of board).

5. 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.

6. To replace defective switch contacts, unsolder the damaged contact and clean the solder from the hole in the circuit board. Then, position the new contact in the hole so it is properly aligned in relation to the other switch contacts and the mating area on the circuit board (alignment tool provided in switch repair kit). Solder the new contact into place; be sure that the spring end of the contact has adequate clearance from the circuit board.

7. To re-install 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 switches can be replaced using the normal replacement procedures. See the information under Light-Bulb Replacement for instructions on replacing the light bulbs. 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 switch.

2. 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).

3. 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.

4. 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 switch assembly.

To replace the A TRIGGER SOURCE or B TRIGGER SOURCE pushbutton switches, proceed as follows:

1. Disconnect the multi-pin connector from the switch.

2. Press the center of the release bar of the switch holder, then press on the front-panel pushbuttons to remove the switch from the holder. Figure 4-7 shows a detailed view of the switch holder.

3. To replace the switch, reverse the above procedure. The switch locks into the holder as it is pressed into place. Match the arrow on the multi-pin connector to the arrow on the switch assembly.

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

#### A. MODE SWITCHES.

To replace light bulbs in the VERTICAL MODE or HORIZONTAL MODE switches, proceed as follows:

1. Remove the applicable mode switch as given previously.

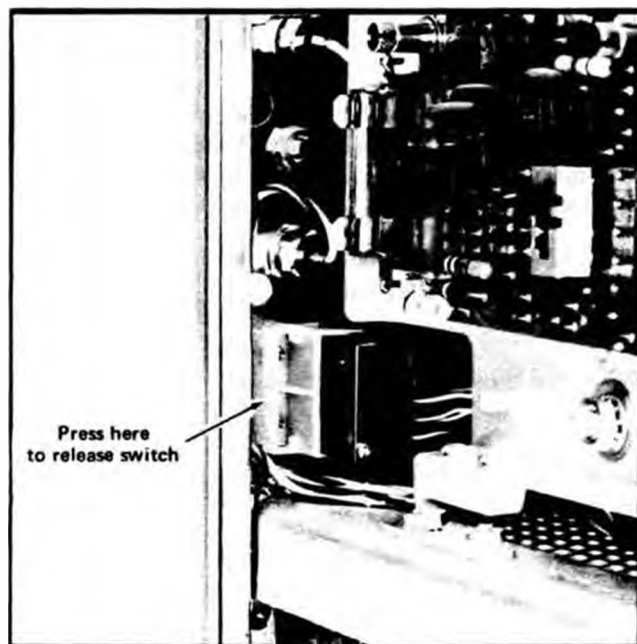


Fig. 4-7. Detailed view of trigger source switch holder (B TRIGGER SOURCE switch shown).



2. Pull outward to remove the button associated with the bulb that is not working.

3. Unsolder the bulb leads on the top of the circuit board and remove the defective bulb.

4. Install the new bulb and solder it to the circuit board.

5. Replace the button. Press it firmly into place. Notice that there are two actuating plungers for each switch section. These plungers must enter the button evenly and completely. After the buttons are replaced, check that all of the buttons of the switch operate properly. If any of the buttons do not remain in the actuated position, again firmly press on the button which was removed.

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 screw which holds the metal cover on the back of the switch to expose the light bulb.

3. Note the position of the bulb on the switch. Then 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 metal cover on the switch.

7. Re-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 this instru-

ment. To replace either of these bulbs, pull the bulb/cap assembly off of 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.** The power transformer in this instrument is warranted for the life of the instrument. If the power transformer becomes defective, contact your local Tektronix Field Office or representative for a warranty replacement (see the Warranty note in the front of this manual). Be sure to replace only with a direct replacement Tektronix transformer.

To replace the power transformer, proceed as follows:

1. Follow the eight steps given under Inverter Board Removal.

2. Remove the Rectifier board from the power chassis.

3. Unsolder the four leads which come out of the side of the power transformer. Note the color and location of these wires for replacement.

4. Reverse the order of removal to replace the power transformer.

**High-Voltage Compartment.** The components located in the high-voltage compartment can be reached for maintenance or replacement by using the following procedure.

### NOTE

*All solder joints in the high-voltage compartment should have smooth surfaces. Any protrusions may cause high-voltage arcing at high altitudes.*

1. Remove the seven screws holding the upper portion of the rear panel to the rear frame. Pull outward on the rear feet to remove the panel.

2. Disconnect the CRT base socket.

3. Disconnect the CRT anode plug and discharge it to the chassis. Using an insulated probe or wire, discharge the jack portion of the CRT anode connector to chassis ground.

4. Remove the two screws located at the front by the CRT anode connector which hold the high-voltage compartment to the chassis.

5. Guide the high-voltage compartment away from the instrument chassis. Be careful not to damage any of the components or the pin connectors on the High Voltage/Z-Axis Amplifier circuit board. Lay the high-voltage compartment down on the swing-down chassis (place a protective mat between the swing-down chassis and the High Voltage/Z-Axis Amplifier board).

6. Remove the three screws which hold the plastic cover onto the high-voltage box.

7. Using an insulated shorting strap, discharge the exposed connections to chassis ground.

8. Unsolder the lead between the encapsulated voltage-multiplier assembly and the high-voltage transformer. Now, all of the circuitry in the high-voltage box can be reached for maintenance or replacement except those in the encapsulated assembly.

9. To replace the encapsulated assembly or the plastic high-voltage box, unsolder the remaining lead between the high-voltage transformer and the encapsulated assembly. Then, remove the four screws located beneath the High Voltage/Z-Axis Amplifier circuit board (remove board to reach screws). Also, remove the nut on the ground lug.

10. To replace the high-voltage compartment, reverse the above procedure. Be careful not to pinch any of the interconnecting wires when replacing the cover to the high-voltage box or when re-attaching the high-voltage compartment to the chassis.

**Fuse Replacement.** Table 4-4 gives the rating, location and function of the fuses used in this instrument.

TABLE 4-4

Fuse Ratings

Circuit Number	Rating	Function	Location
F801	4A Fast	Line Input	Line Selector Assembly
F810	2A Fast	Inverter	
F901	0.25A Fast	+75 volts	Low Voltage Regulator Board
F902	0.25A Fast	+150 volts	
F921	2A Fast	High Voltage	
F957	1A Fast	Graticule Lights	
F1040	6A Fast	Control Illumination	Front of swing-down chassis

### 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 supply affects all circuits, calibration of the entire instrument should be checked if work has been done in the low-voltage supply or if the power transformer has been replaced. The Performance Check procedure provides a quick and convenient means of checking instrument operation.

### 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. Fig. 8 in the Mechanical Parts List illustrates how to repackage the 7704 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.

### NOTE

*The packaging material is not designed to protect the plug-ins if shipped installed in the plug-in compartments. The plug-ins should be shipped in their own shipping cartons.*

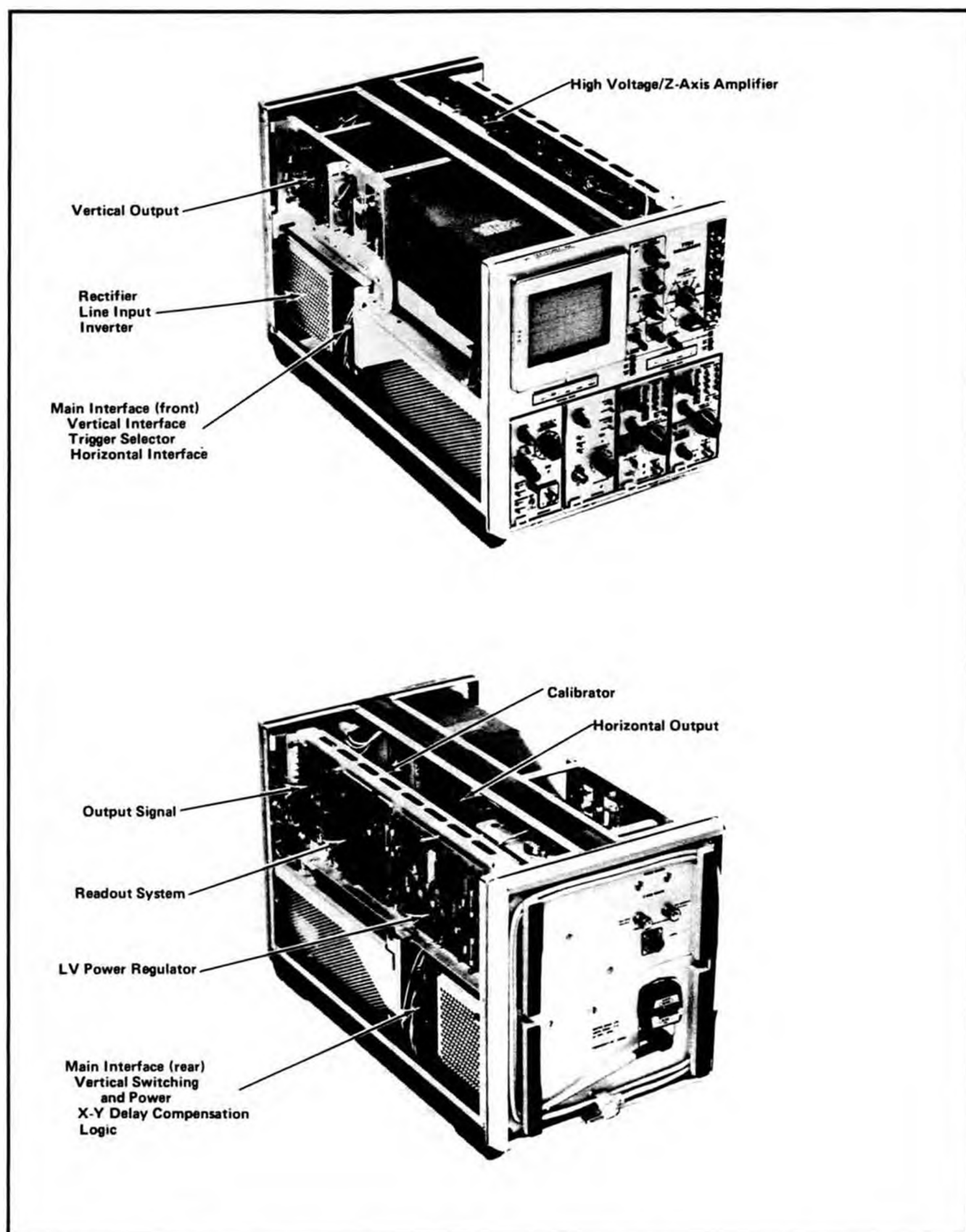


Fig. 4-8. Location of circuit boards in the 7704.

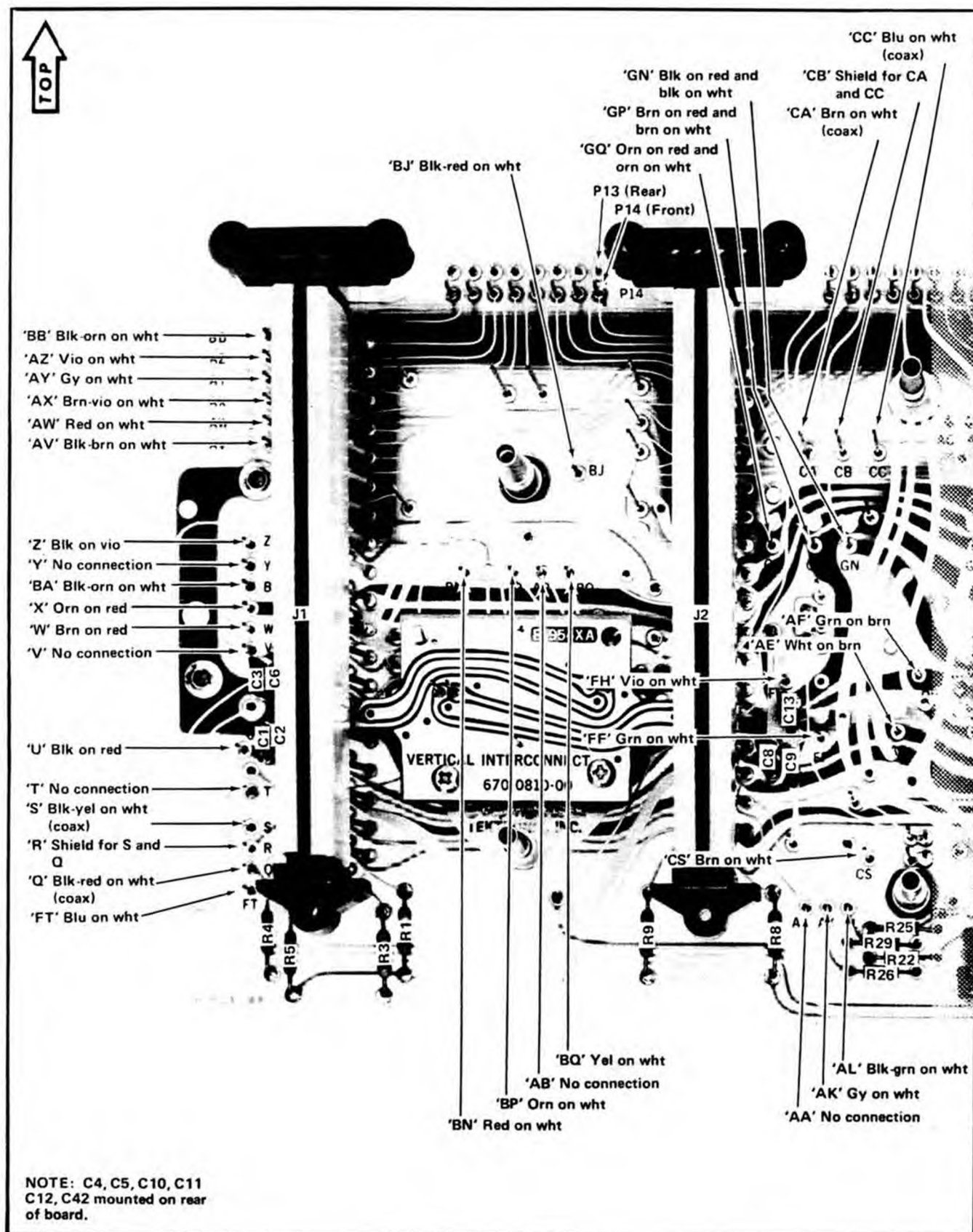


Fig. 4-9. Partial Main Interface circuit board.

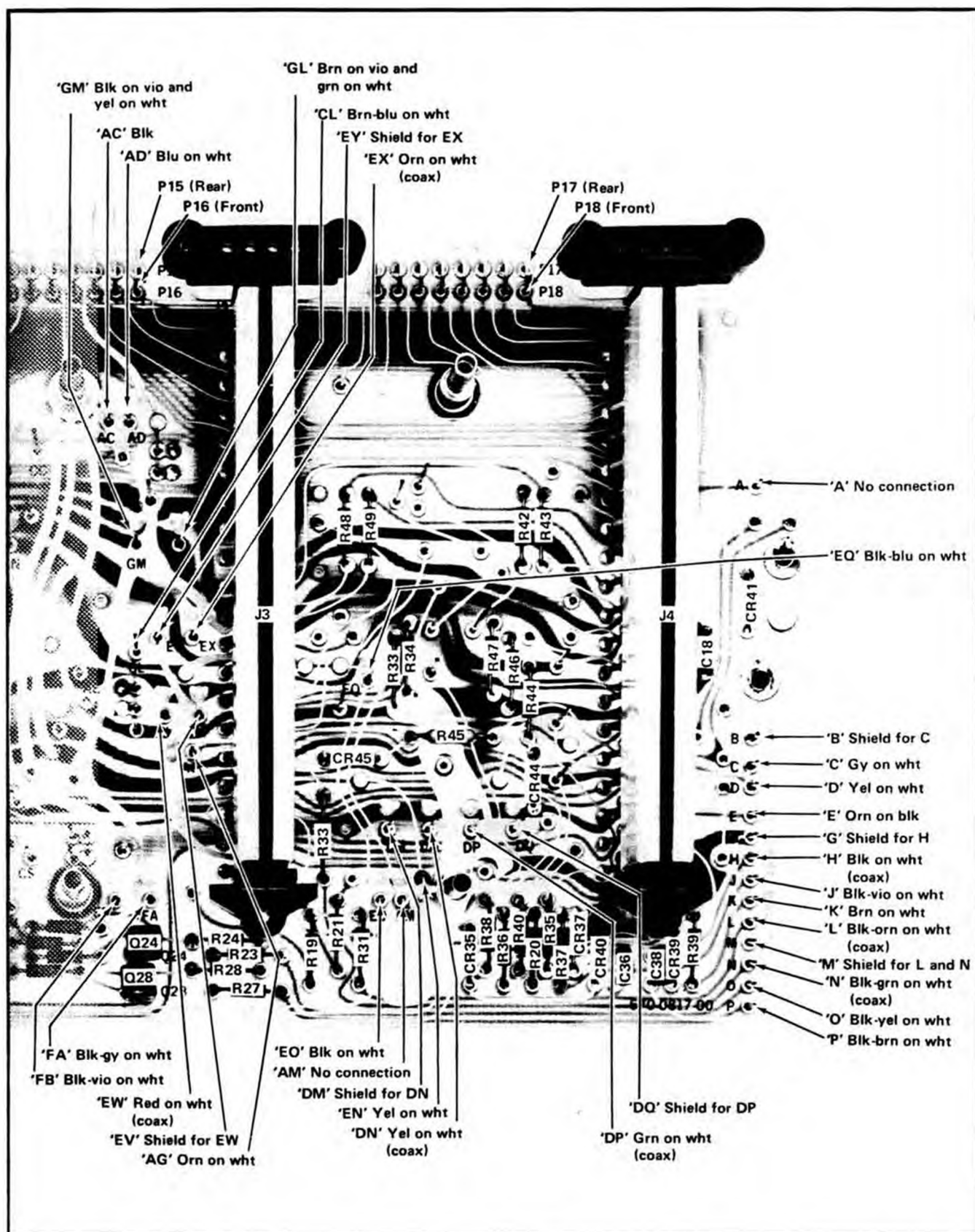


Fig. 4-10. Partial Main Interface circuit board.



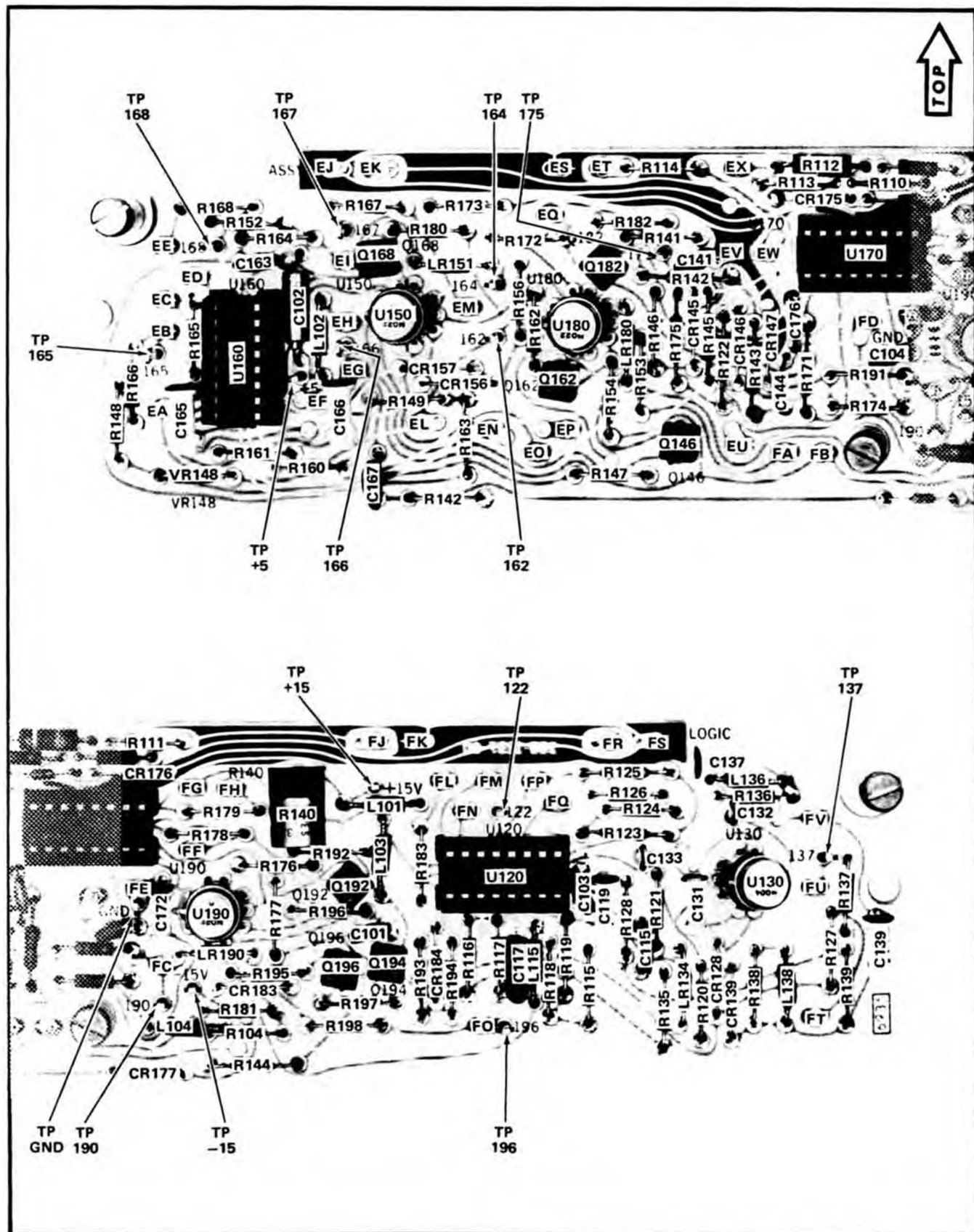


Fig. 4-11. Logic circuit board.

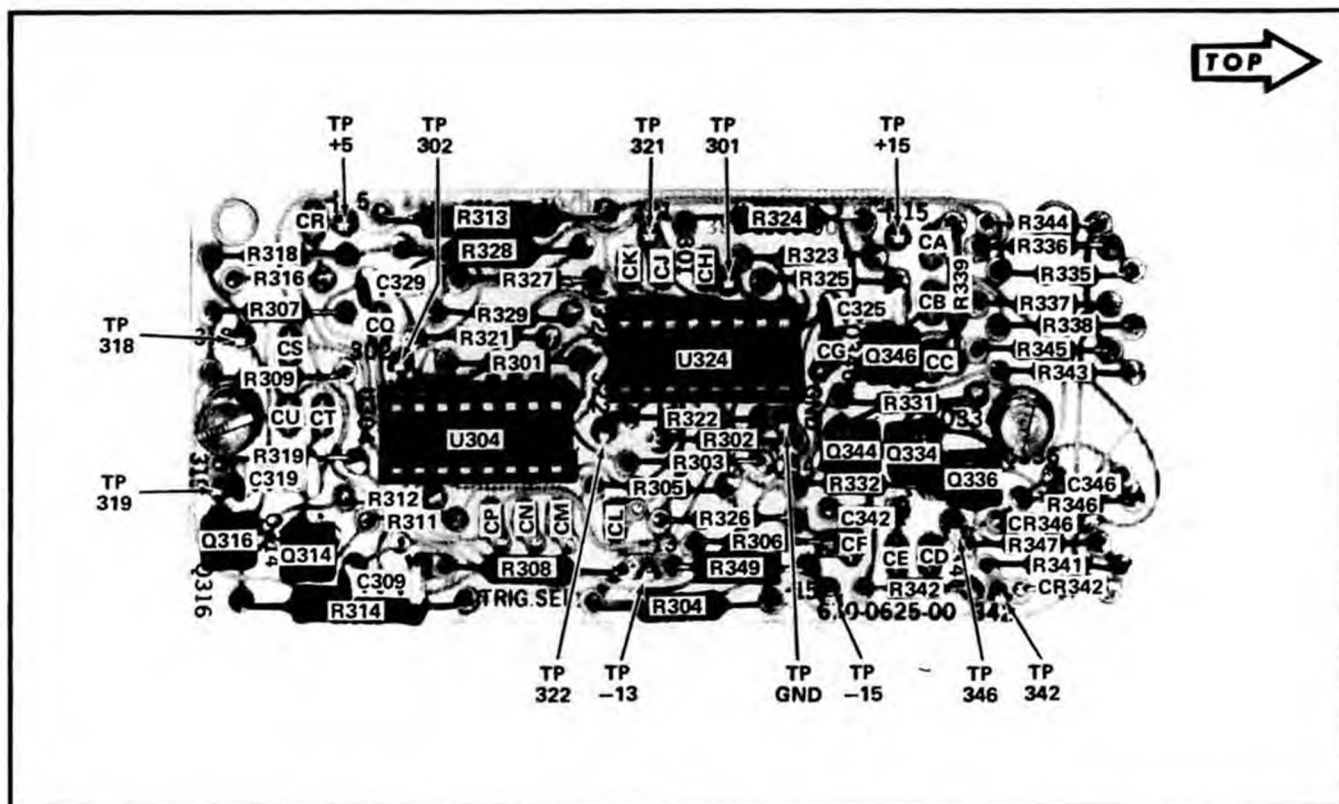


Fig. 4-12. Trigger Selector circuit board.

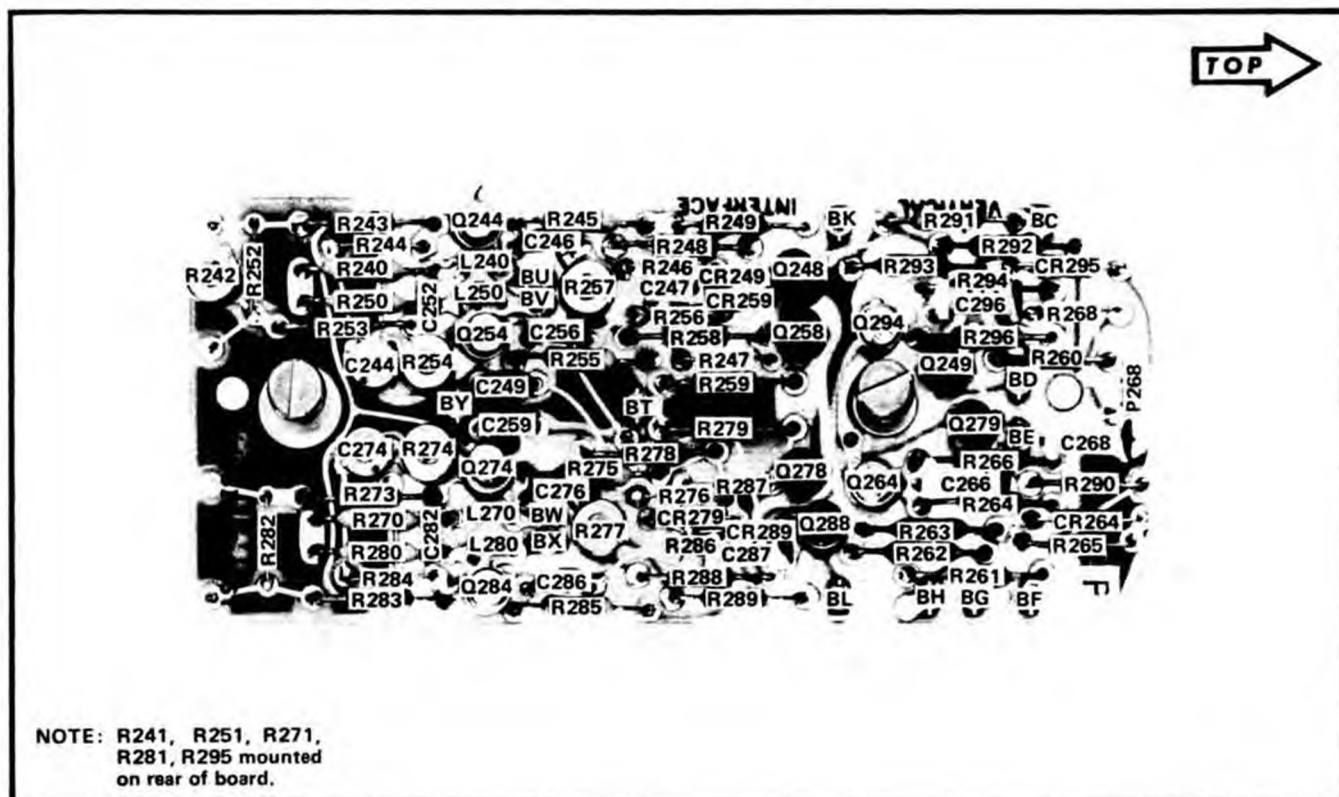


Fig. 4-13. Vertical Interface circuit board.

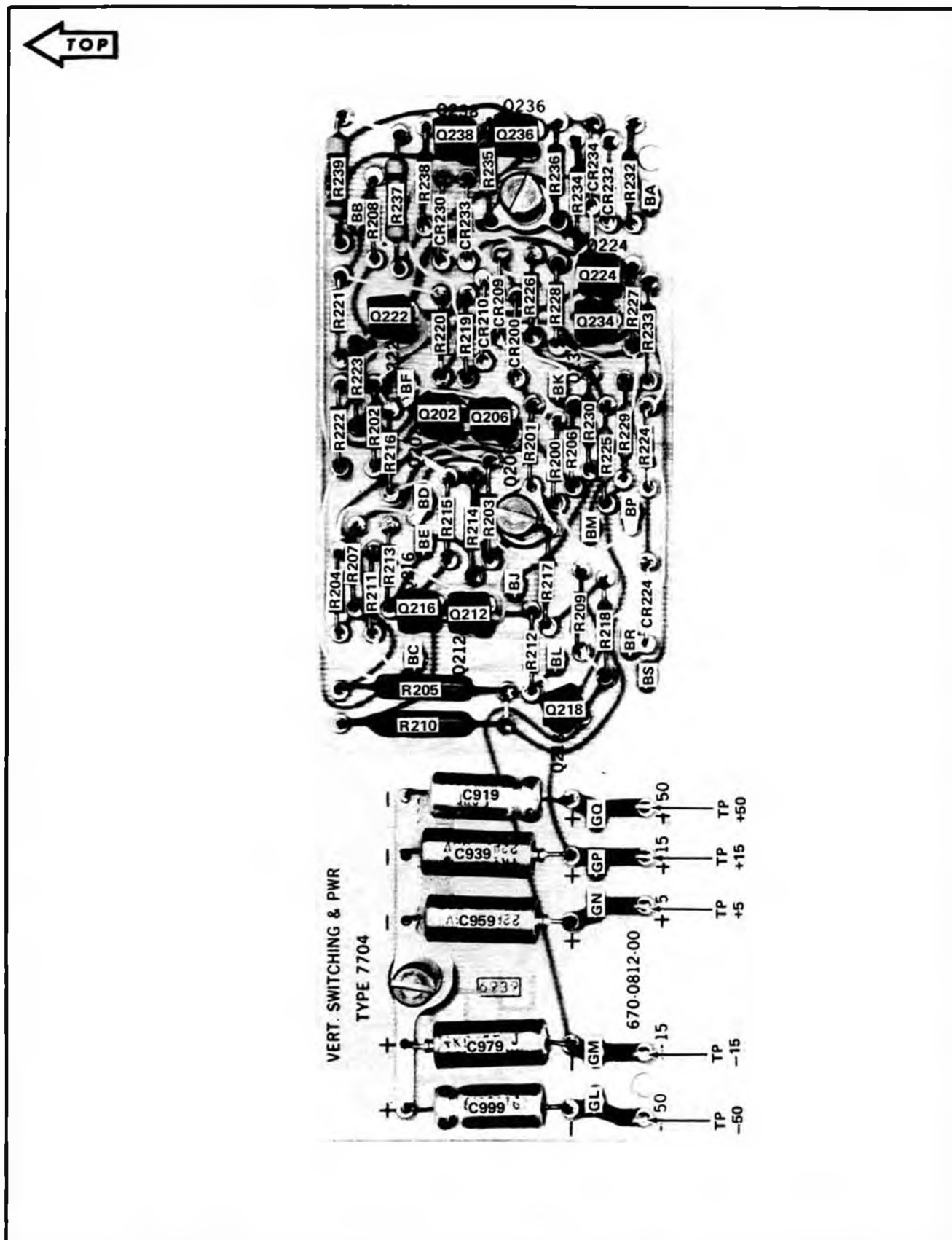
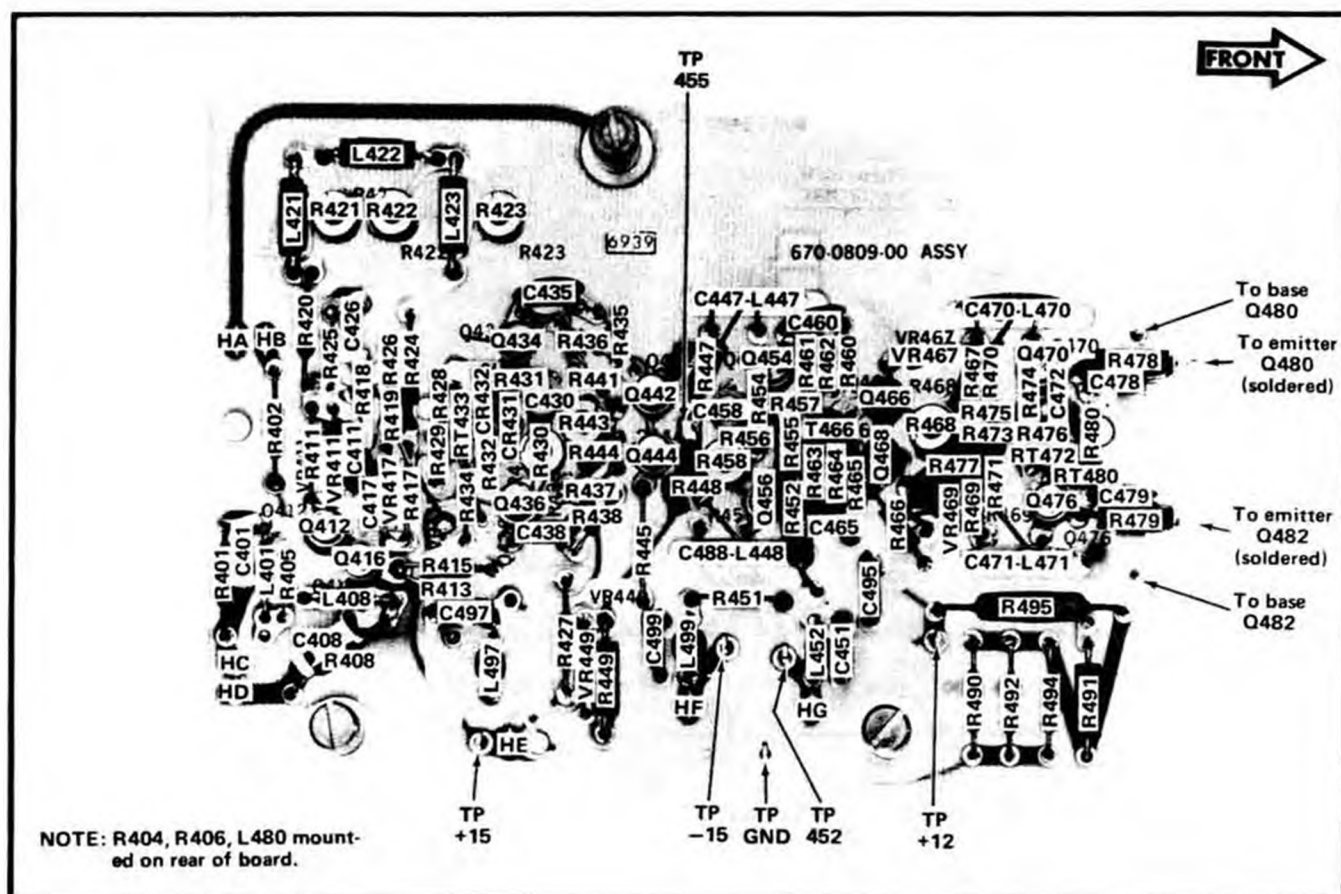
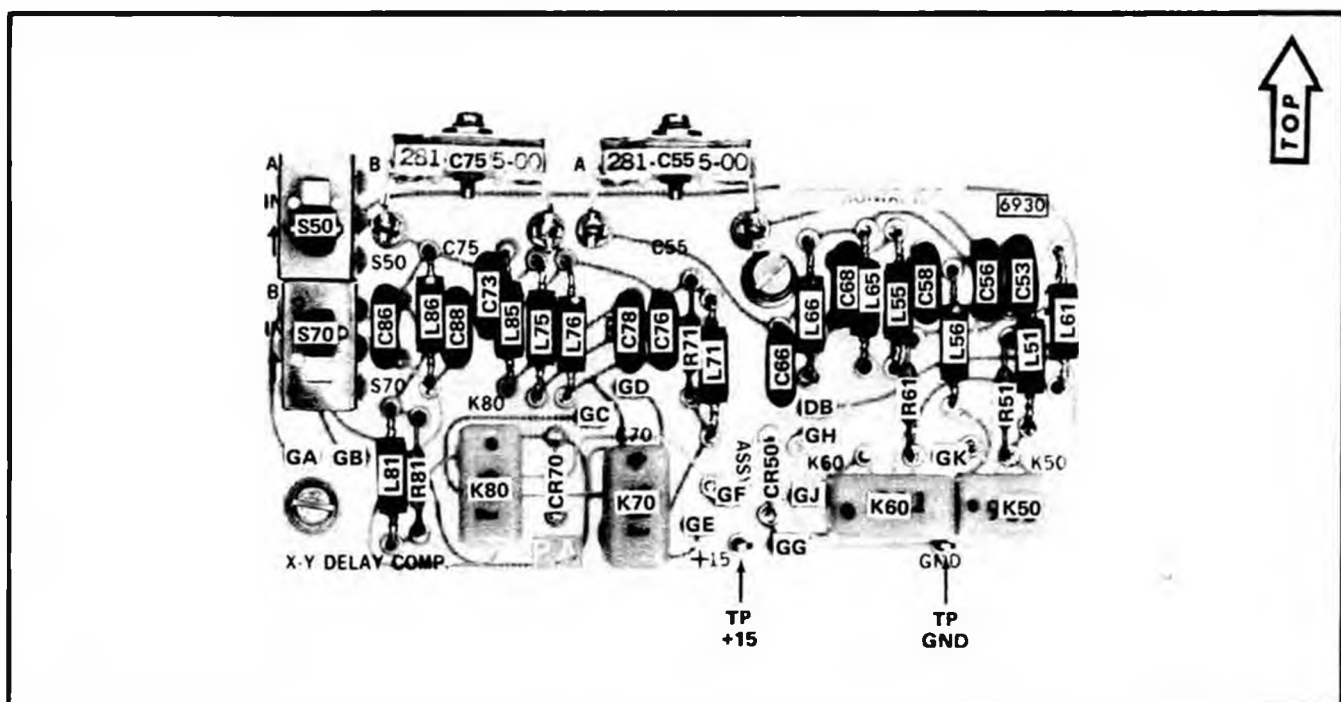


Fig. 4-14. Vertical Switching and Power circuit board.





**Fig. 4-15. Vertical Output circuit board.**



**Fig. 4-16. X-Y Delay Compensation circuit board (optional).**



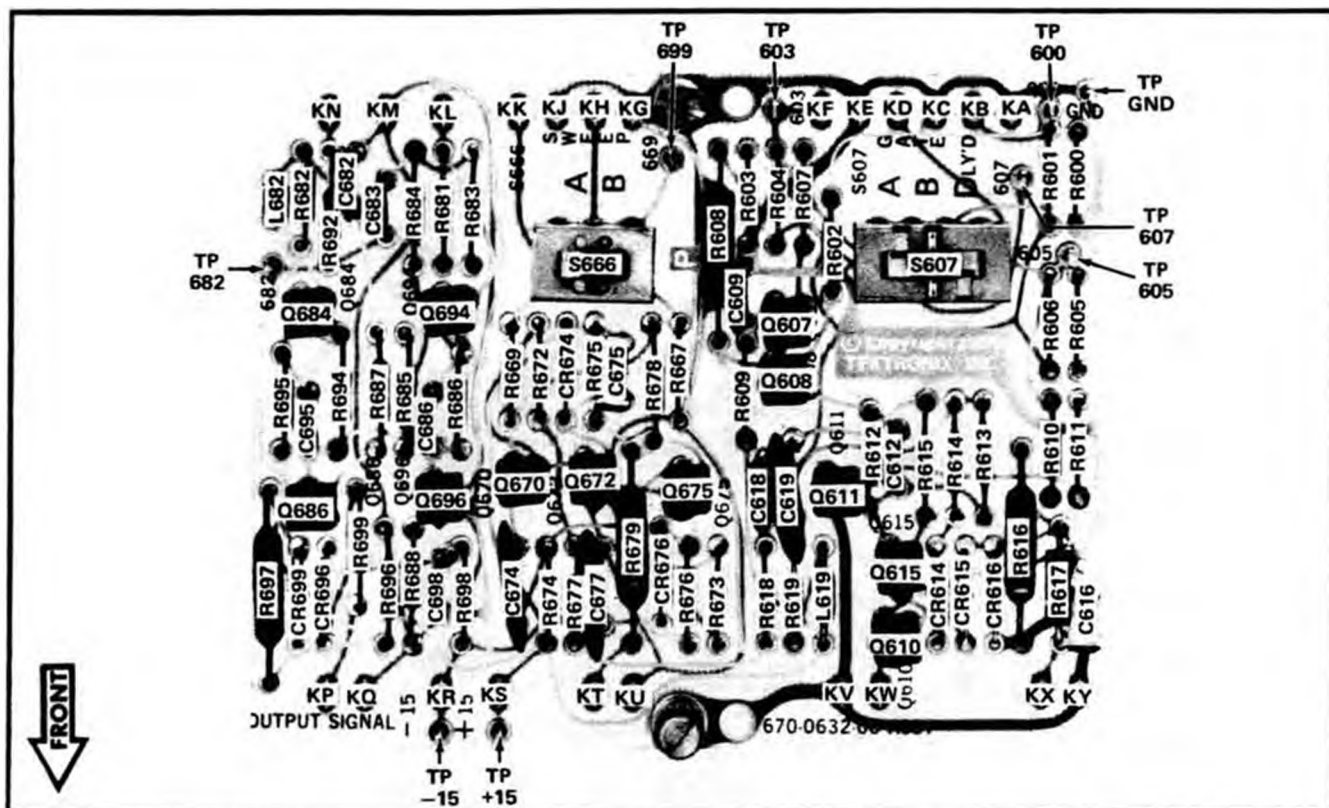


Fig. 4-19. Output Signal circuit board.

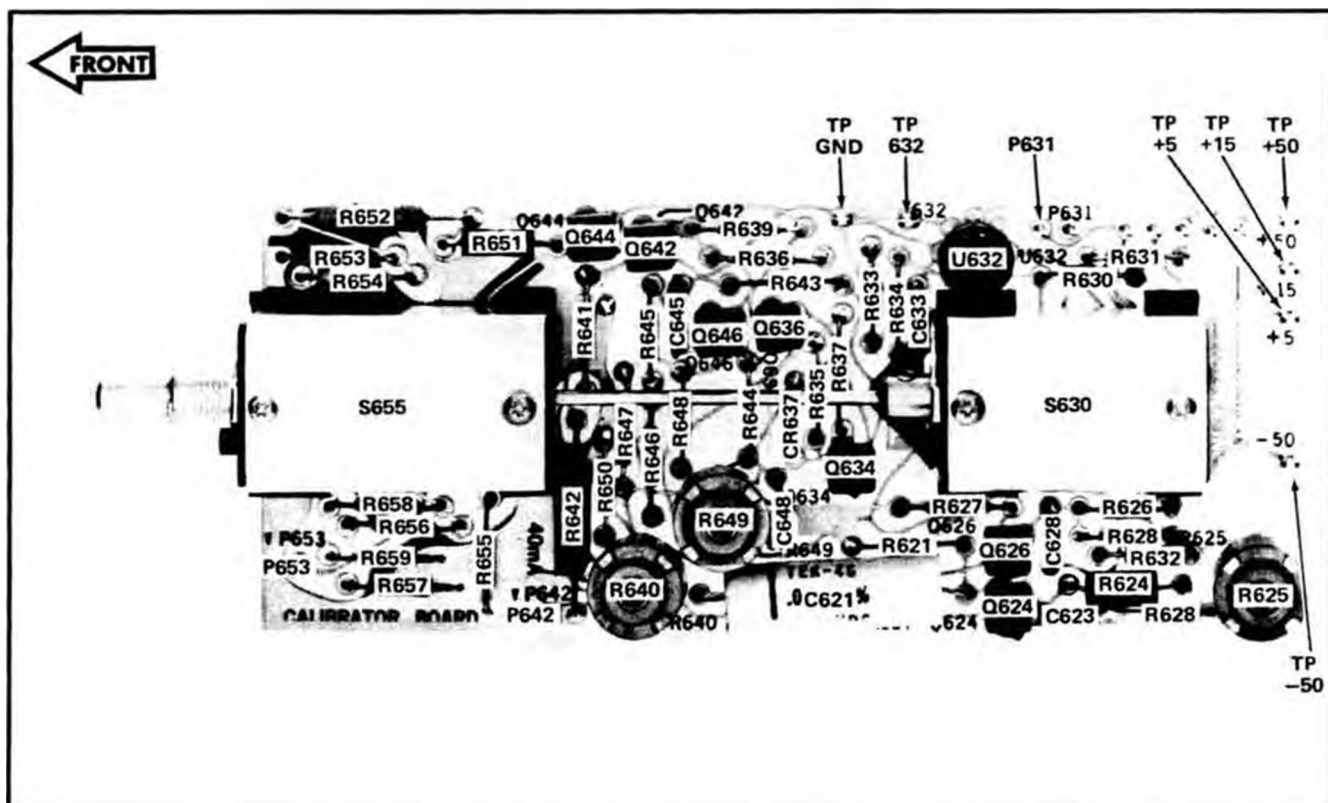
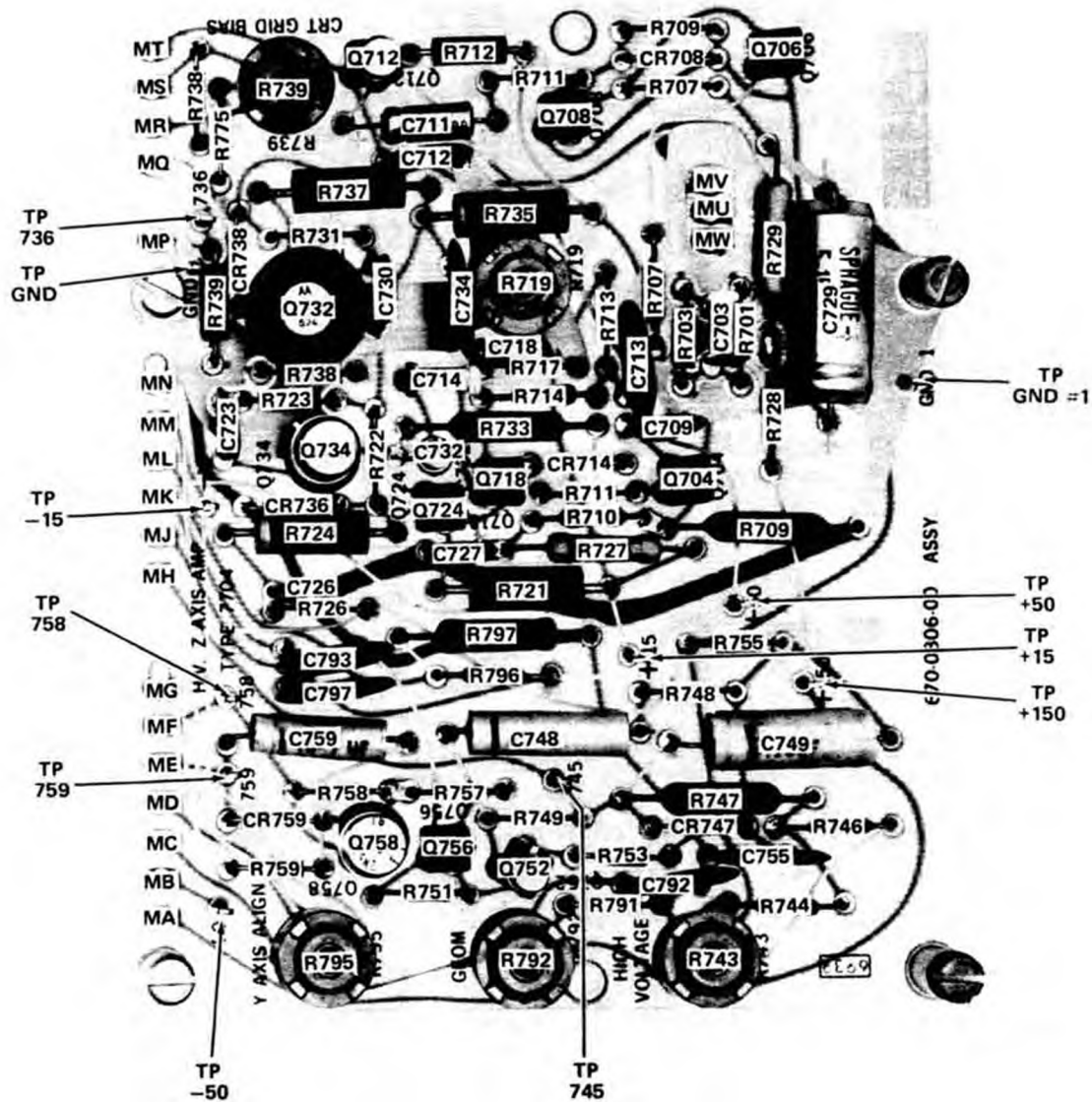


Fig. 4-20. Calibration circuit board/switch assembly.



**Fig. 4-21. High Voltage/Z-Axis Amplifier circuit board.**



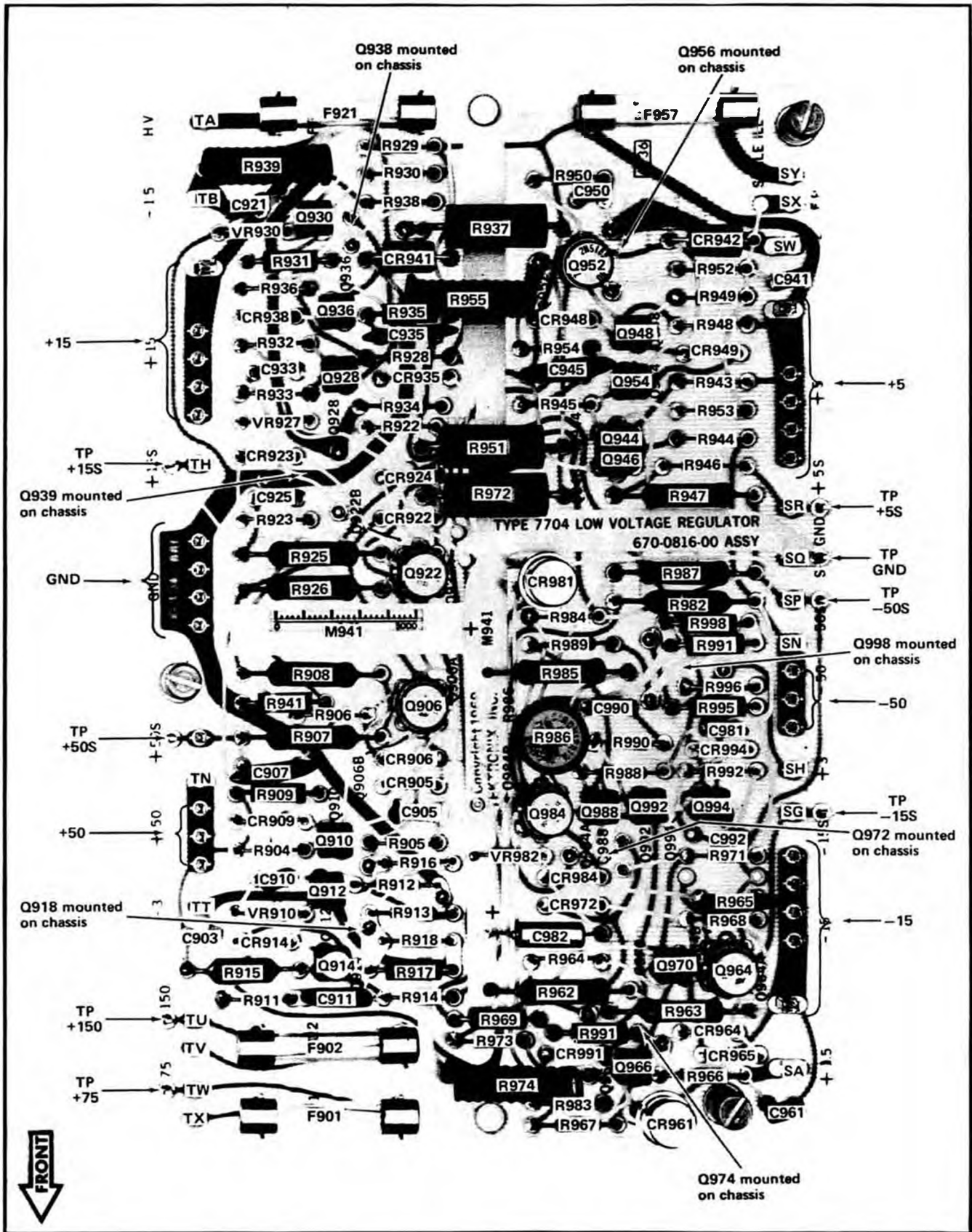


Fig. 4-22. Low Voltage Regulator circuit board.

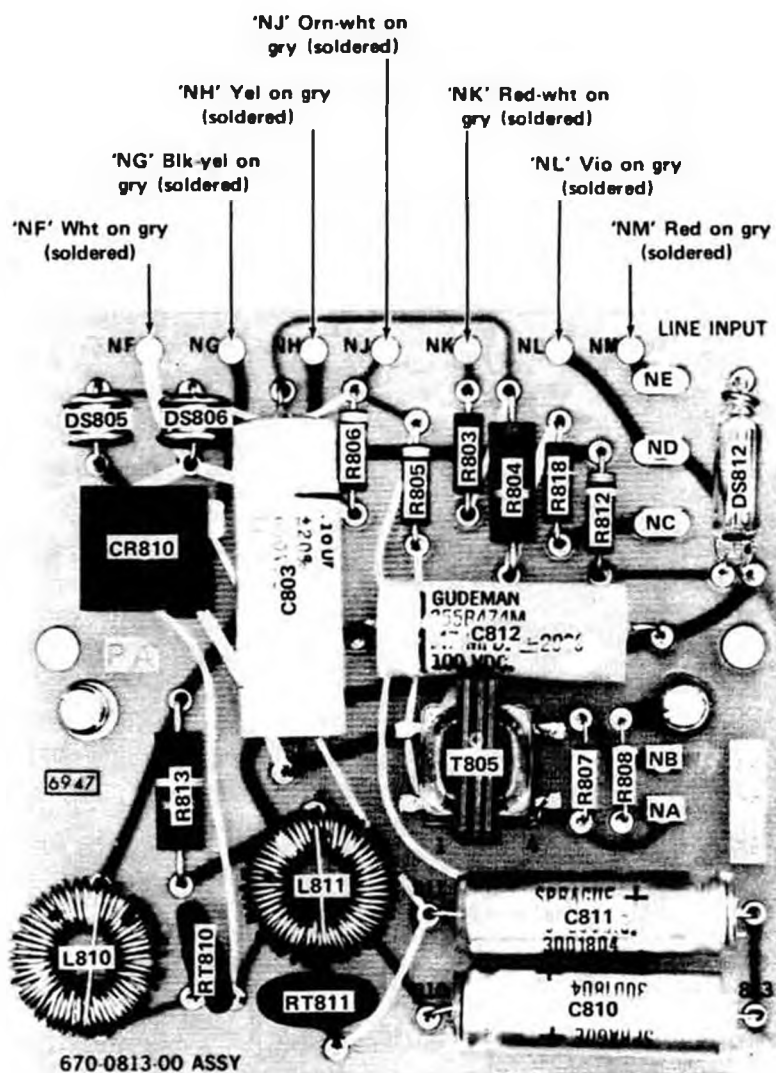
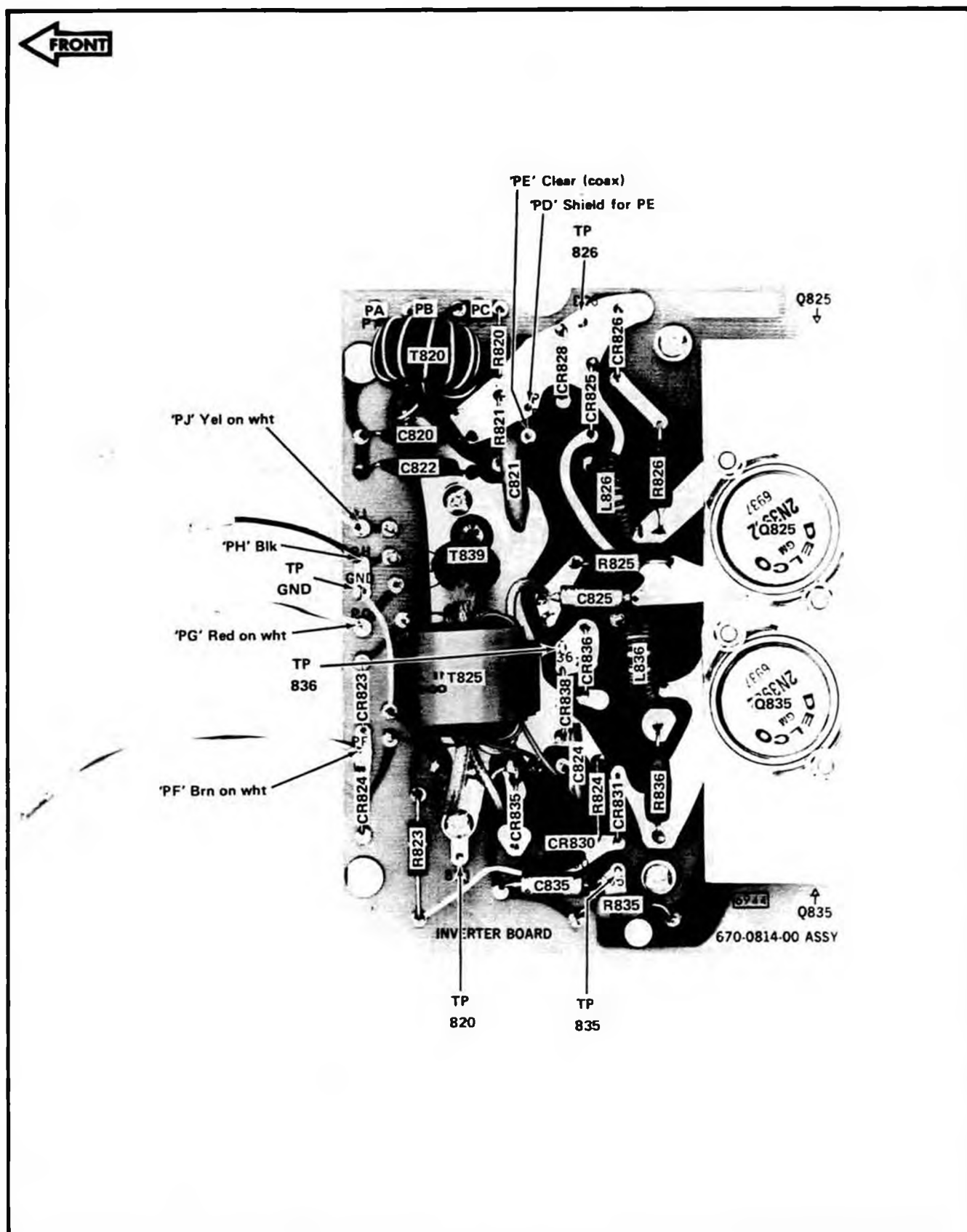


Fig. 4-23. Line Input circuit board.



**Fig. 4-24. Inverter circuit board.**

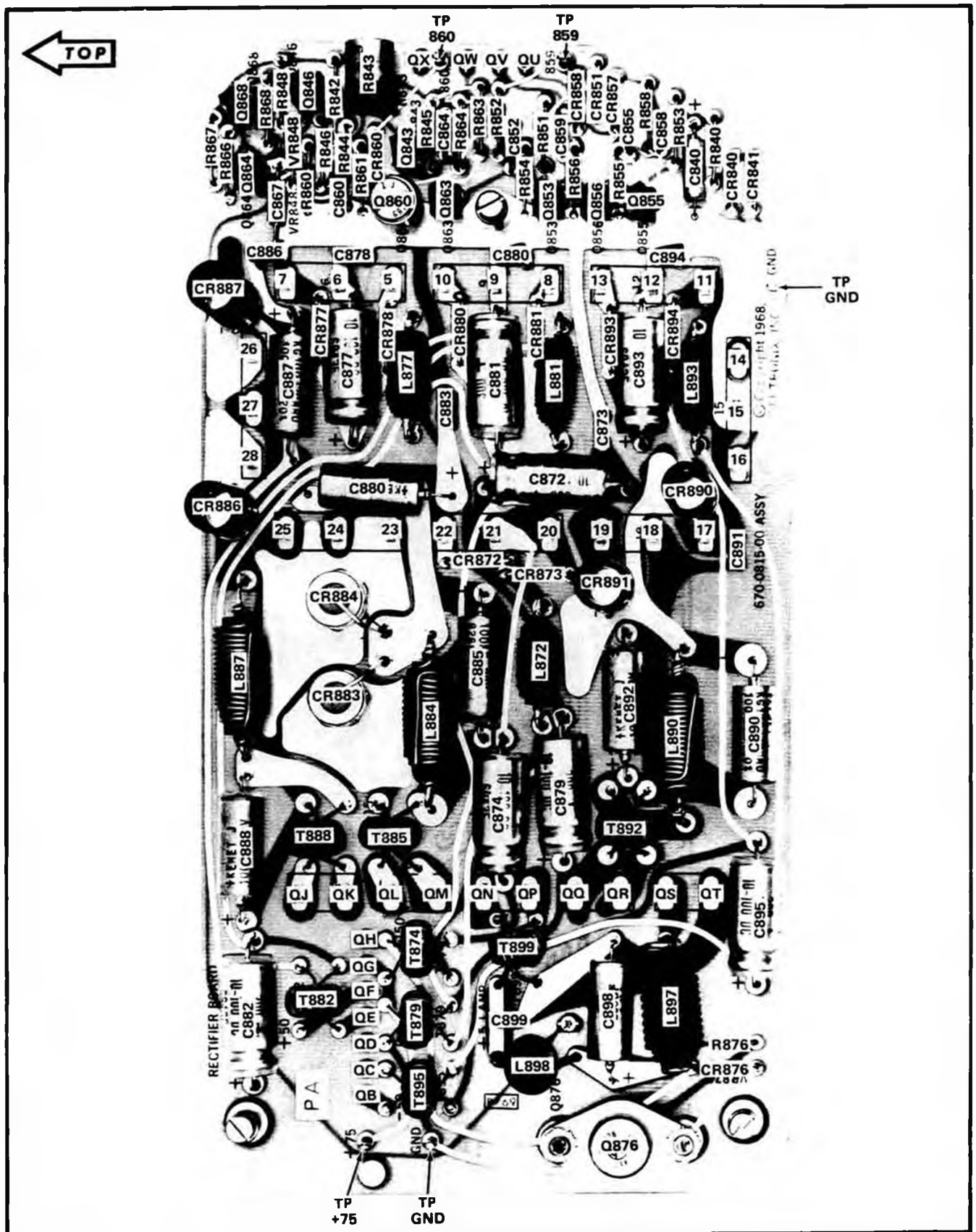


Fig. 4-25. Rectifier circuit board.



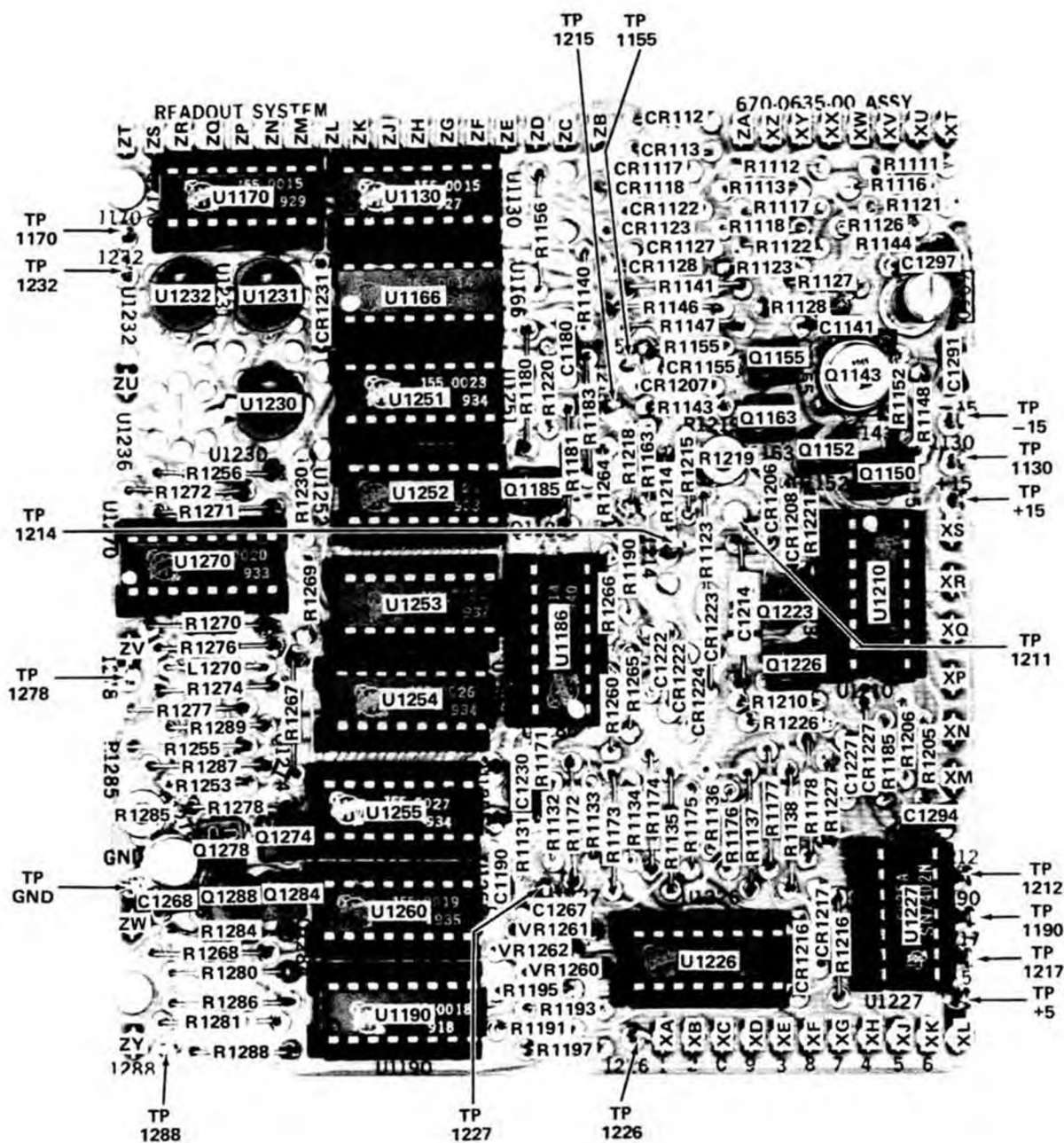


Fig. 4-26. Readout System circuit board.

# SECTION 5

## PERFORMANCE CHECK/CALIBRATION

*Change information, if any, affecting this section will be found at the rear of the manual.*

### Introduction

To assure instrument accuracy, check the calibration of the 7704 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.

As an aid to the calibration of the instrument, a Short-Form Procedure is given prior to the complete procedure. To facilitate instrument calibration for the experienced calibrator, the Short-Form Procedure lists the calibration adjustments necessary for each step and the applicable tolerances. This procedure also includes the step number and title as listed in the complete Performance Check/Calibration Procedure and the page number on which each step begins. Therefore, the Short-Form Procedure can be used as an index to locate a step in the complete procedure. Another feature of the Short-Form Procedure is the spaces provided to record performance data or to check off steps as they are completed. This procedure can be reproduced and used as a permanent record of instrument calibration.

The complete Performance Check/Calibration Procedure can be used to check instrument performance without removing the covers or making internal adjustments by performing all portions except the ADJUST— part of a step. Screwdriver adjustments which are accessible without removing the covers are adjusted as part of the performance check procedure. A note titled PERFORMANCE CHECK ONLY gives instructions which are applicable only to the performance check procedure and lists the next applicable step for the performance check procedure.

Completion of each step in the complete Performance Check/Calibration Procedure insures that this instrument meets the electrical specifications given in Section 1. Where possible, instrument performance is checked before an adjustment is made. For best overall instrument performance when performing a complete calibration procedure, make each adjustment to the exact setting even if the CHECK— is within the allowable tolerance.

### NOTE

*All waveforms shown in this procedure were taken with a Tektronix Oscilloscope Camera System. Limits, tolerances and waveforms in this procedure are given as calibration guides and should not be interpreted as instrument specifications except as specified in Section 1.*

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 check or adjust only part of the instrument, set the controls as given under Preliminary Control Settings and start with the nearest test equipment picture preceding the desired portion. If any controls need to be changed from the preliminary settings for this portion of the calibration procedure, they are listed under the heading Partial Procedure following the equipment required picture. 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 readjustment is necessary, also check the calibration of any steps listed in the INTERACTION— part of the step.

### TEST EQUIPMENT REQUIRED

#### General

The following test equipment and accessories, or its equivalent, is required for complete calibration of the 7704. Specifications given are the minimum necessary for accurate calibration. Therefore, some of the recommended equipment may have specifications which exceed those given. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

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

## Test Equipment

1. Variable autotransformer.<sup>1</sup> Must be capable of supplying about 250 volt-amperes over a range of 95 to 136 volts (190 to 272 volts for 230-volt nominal line). (If autotransformer does not have an AC voltmeter to indicate output voltage, monitor the output with an AC voltmeter with a range of at least 136 or 272 volts, RMS.) For example, General Radio W10MT3A Metered Variac Autotransformer. (Use General Radio W20HMT3A for 230-volt nominal operation.)

2. Precision DC voltmeter.<sup>1</sup> Accuracy, within 0.1%; resolution, 50 microvolts; range zero to 500 volts. For example, Fluke Model 825A Differential DC Voltmeter.

3. DC voltmeter (VOM). Range, zero to 6000 volts; accuracy, checked to within 1% at –2960 volts. For example, Triplett Model 630-NA.<sup>2</sup>

4. Time-mark generator. Marker outputs, 5 nano-seconds to 0.5 second; marker accuracy, within 0.1%. Tektronix Type 184 Time-Mark Generator recommended.

5. Constant-amplitude sine-wave generator. Frequency, 350 kilohertz to 100 megahertz; reference frequency, 50 kilohertz; output amplitude, variable from five millivolts to five volts peak to peak into 50 ohms; amplitude accuracy, output amplitude constant within 3% at 50 kilohertz and 350 kilohertz to 100 megahertz. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

6. High-frequency constant amplitude signal generator. Frequency, 65 megahertz to above 190 megahertz; reference frequency, 3 megahertz; output amplitude, variable from 0.5 volt to five volts; amplitude accuracy, within 1% at three megahertz and from 65 megahertz to 300 megahertz. Tektronix calibration fixture 067-0532-00 recommended.

7. Vertical plug-in unit, Tektronix 7A16. Two required.

8. Time Base plug-in unit, Tektronix 7B70.

9. Delaying Time Base plug-in unit, Tektronix 7B71.

<sup>1</sup> Not required for performance check only.

<sup>2</sup> If a precision voltage divider is available for use with the precision DC voltmeter (such as Fluke 80E-2) it can be used in place of this meter.

10. Tektronix Calibration Fixture, 067-0587-00.

11. Probe, 10X attenuation, 290 megahertz bandwidth. Tektronix P6053.

12. Probe, 1X attenuation, 30 MHz bandwidth. Tektronix P6052.

13. Dual Input Coupler. Matched signal transfer to each input. Tektronix Calibration Fixture 067-0525-00.

## Accessories

14. BNC T connector. Tektronix Part No. 103-0030-00.

15. In-line termination. Impedance, 50 ohms; accuracy,  $\pm 2\%$ ; connectors, BNC. Tektronix Part No. 011-0049-01.

16. In-line termination. Impedance, 50 ohms; wattage rating, two watts; accuracy,  $\pm 2\%$ , connectors, GR874 input with BNC male output. Tektronix Part No. 017-0083-00.

17. Cable. Impedance, 50 ohms; type RG-58/U; length, 18 inches; connectors, BNC. Tektronix Part No. 012-0076-00.

18. Cable. Impedance, 50 ohms; type RG-58/U; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-01.

19. Adapter. Adapts GR874 connector to BNC female connector. Tektronix Part No. 017-0064-00.

## Adjustment Tools

20. Screwdriver. Three-inch shaft. Tektronix Part No. 003-0192-00.

21. Low-capacitance screwdriver.<sup>1</sup> 1 1/2-inch shaft. Tektronix Part No. 003-0000-00.

22. Tuning tool.<sup>1</sup> Handle and insert for 5/64-inch (ID) hex cores. Tektronix Part No. 003-0307-00 and 003-0310-00.

## SHORT-FORM PROCEDURE AND INDEX

7704, Serial No. \_\_\_\_\_

Calibration Date \_\_\_\_\_

Elapsed Time Reading \_\_\_\_\_

Calibrated By \_\_\_\_\_

## 1. Adjust +75 Volt Power Supply (R843) Page 5-7

REQUIREMENT: +75 Volts,  $\pm 0.375$  volt.

PERFORMANCE: +\_\_\_\_\_ volts.

## 2. Adjust -50 Volt Power Supply (R986) Page 5-8

REQUIREMENT: -50 volts,  $\pm 0.1$  volt.

PERFORMANCE: -\_\_\_\_\_ volts.

## 3. Check Power Supply Voltages and Regulation Page 5-8

REQUIREMENT			PERFORMANCE
Supply	Voltage Tolerance	Total Ripple	
+5 volt	$\pm 0.15$ volt	2 mV or less	_____
+15 volt	$\pm 0.3$ volt	2 mV or less	_____
+50 volt	$\pm 0.6$ volt	5 mV or less	_____
+75 volt	Set in step 1	200 mV or less	_____
+150 volt	$\pm 6$ volts	300 mV or less	_____
-15 volt	$\pm 0.3$ volt	2 mV or less	_____
-50 volt	Set in step 2	5 mV or less	_____
5 volt (Control Illum)	+0.2 to -0.5 volt	10 mV or less	_____

## 4. Adjust High Voltage Power Supply (R743) Page 5-9

REQUIREMENT: -2960 volts,  $\pm 59.2$  volts

PERFORMANCE: -\_\_\_\_\_ volts.

## 5. Check/Adjust CRT Grid Bias and Maximum Intensity Levels (R739, R140) Page 5-9

REQUIREMENT: See step 5 for complete procedure.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

## 6. Check/Adjust ASTIG control Page 5-10

REQUIREMENT: Optimum focus of CRT display.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

## 7. Check/Adjust TRACE ROTATION and Y Axis Alignment (R795) Page 5-10

REQUIREMENT: Trace alignment vertically and horizontally  $\pm 0.1$  division.PERFORMANCE: Trace alignment vertically and horizontally  $\pm$  \_\_\_\_\_ division.

## 8. Check/Adjust Vertical Amplifier, Left Vertical and Right Vertical Centering (R443, R257, R277) Page 5-12

REQUIREMENT: Traces centered,  $\pm 0.6$  division with no readout.Traces centered,  $\pm 0.8$  division with readout.PERFORMANCE: Traces centered,  $\pm$  \_\_\_\_\_ division.

## 9. Check/Adjust Vertical Output Amplifier Gain (R468) Page 5-12

REQUIREMENT: Six divisions,  $\pm 0.06$  division.

PERFORMANCE: \_\_\_\_\_ divisions.

## 10. Check/Adjust Right Vertical Amplifier Gain (R242) Page 5-13

REQUIREMENT: Matches Left Vertical Amplifier within 1%.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

## Performance Check/Calibration—7704

11. Check Vertical Amplifier Low Frequency Linearity Page 5-13  
C483, C485, L483, L484, R274, R254, R421, R422, R423, R430, R458)  
REQUIREMENT: Compression or expansion of 0.1 division or less.  
PERFORMANCE: Compression or expansion of \_\_\_\_\_ division.
12. Check/Adjust Horizontal Amplifier Thermal Balance (R571) Page 5-14  
REQUIREMENT: See step 12 for complete procedure.  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
13. Check/Adjust Horizontal Amplifier Centering (R529) Page 5-15  
REQUIREMENT: Trace centered,  $\pm 0.6$  division with no readout.  
Trace centered,  $\pm 0.8$  division with readout.  
PERFORMANCE: Trace centered  $\pm$  \_\_\_\_\_ division.
14. Check/Adjust Horizontal Amplifier Gain and DC Linearity (R522) Page 5-15  
REQUIREMENT: Eight divisions deflection,  $\pm 0.08$  division; linearity,  $\pm 0.05$  division.  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
15. Check/Adjust Readout Character Separation and Operation (R1285) Page 5-16  
REQUIREMENT: See step 15 for complete procedure.  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
16. Check/Adjust CRT Geometry (R792) Page 5-17  
REQUIREMENT: Bowing of markers within 0.1 division. Trace parallel to the top and bottom of the graticule within 0.1 division.  
PERFORMANCE: Within \_\_\_\_\_ division.
17. Check/Adjust Vertical Amplifier Transient Response (C244, C274, C430, C458, C483, C485, L483, L484, R274, R254, R421, R422, R423, R430, R458) Page 5-19  
REQUIREMENT: Optimum square leading corner.  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
18. Check Vertical Amplifier Bandwidth Page 5-19  
REQUIREMENT: At least 190 megahertz bandwidth.  
PERFORMANCE: Bandwidth, \_\_\_\_\_ megahertz.
19. Check Vertical SIG OUT Bandwidth Page 5-20  
REQUIREMENT: 65 megahertz or higher.  
PERFORMANCE: \_\_\_\_\_ megahertz.
20. Check Channel Isolation Page 5-20  
REQUIREMENT: 0.1 division or less (100:1 DC to 150 MHz).  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
21. Check/Adjust High Frequency Timing (C569, C579, C568, R568) Page 5-20  
REQUIREMENT: See step 21 for complete procedure.  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.
22. Check/Adjust CALIBRATOR (R649, R640, R625) Page 5-21  
REQUIREMENT: 0.4 volt  $\pm 0.004$  volt.  
PERFORMANCE: 0.4 volt  $\pm$  \_\_\_\_\_ volt.  
REQUIREMENT: 1 kHz  $\pm 0.25\%$ .  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.  
REQUIREMENT: 50% duty factor  $\pm 0.1\%$ .  
PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_.

REQUIREMENT: 4 mV through 4 V waveform rise-time and falltime, 0.25  $\mu$ s or less.

40 V waveform risetime and falltime, 2  $\mu$ s or less.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

23. Check/Adjust X-Y Delay Compensation Page 5-23  
(C55, C70)

REQUIREMENT: Waveform eye-opening of 0.28 division or less.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

24. Check Horizontal Bandwidth with Phase Correction Page 5-24

REQUIREMENT: -3 dB Bandwidth at least 3 MHz.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

25. Check VERT TRACE SEPARATION Page 5-24  
(B) Control Range

REQUIREMENT: B trace can be positioned from +4 to +6 divisions to -4 to -6 divisions from the position of the A trace.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

26. Check/Adjust Z-Axis Amplifier Compensation (C732, R719) Page 5-25

REQUIREMENT: Waveform risetime of 30 nanoseconds or less.

PERFORMANCE: Waveform risetime \_\_\_\_\_ nanoseconds.

27. Check + SAWTOOTH OUT Signal Page 5-25

REQUIREMENT: Output amplitude 10 volts or greater.

PERFORMANCE: Output amplitude \_\_\_\_\_ volts.

28. Check + GATE OUT Signal Page 5-26

REQUIREMENT: Output voltage 10 volts  $\pm$  1 volt.

PERFORMANCE: Output voltage \_\_\_\_\_ volts.

29. Check Chopped Mode Operation Page 5-26

REQUIREMENT: See step 29 for complete procedure.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

30. Check External Z-Axis Inputs Page 5-26

REQUIREMENT: See step 30 for complete procedure.

PERFORMANCE: Correct \_\_\_\_\_; Incorrect \_\_\_\_\_

## PERFORMANCE CHECK/CALIBRATION PROCEDURE

### General

The following procedure is arranged so the 7704 Oscilloscope can be calibrated with the least interaction of adjustments and reconnection of equipment. A picture of the test equipment required for each group of steps is given to aid in identification of the necessary equipment. The control settings and test equipment setup throughout this procedure continue from the preceding step(s) unless noted otherwise. The control settings can be checked at any "test equipment required" picture by setting the controls as given at the start of the procedure under the heading Preliminary Control Settings. Then make any changes listed following the test equipment required picture.

### NOTE

*Control titles which are printed on the front panel of the 7704 are capitalized in this procedure (e.g., INTENSITY). Internal adjustments are initially capitalized only (e.g., CH 1 Gain).*

The following procedure uses the equipment listed under Test Equipment Required. If other equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used. 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.

**Performance Check/Calibration—7704**

**NOTE**

*For best overall accuracy, this instrument should be calibrated and checked at an ambient temperature of +25°C ±5°C. However, the performance of this instrument can be checked at any temperature within the 0°C to +50°C range; any specification changes related to temperature are noted in the calibration procedure.*

**Preliminary Procedure for Performance Check Only**

- 1. Connect the 7704 to a power source which meets the voltage and frequency requirements of this instrument.
- 2. Set the controls as given under Preliminary Control Settings. Allow at least 20 minutes warmup before proceeding.
- 3. Begin performance check with step 5.

**Preliminary Procedure for Complete Calibration**

- 1. Connect the autotransformer and test equipment to a suitable power source.

- 2. Turn on the autotransformer.

- 3. Set the autotransformer output for the nominal line voltage to be used (115 volts or 230 volts).

- 4. Remove the side and bottom panels from the 7704.

- 5. Check that the voltage selector on the 7704 rear panel is set to correspond to the autotransformer output voltage.

**Preliminary Control Settings**

Set the 7704 controls as follows: (no plug-ins need be installed at this time).

VERTICAL MODE	LEFT
HORIZONTAL MODE	A
A TRIGGER SOURCE	VERT MODE
B TRIGGER SOURCE	VERT MODE
FOCUS	CCW
A INTENSITY	CCW
B INTENSITY	CCW
CONTROL ILLUM	OFF
READOUT	CCW (in detent)
CALIBRATOR	4 V
RATE	1 kHz

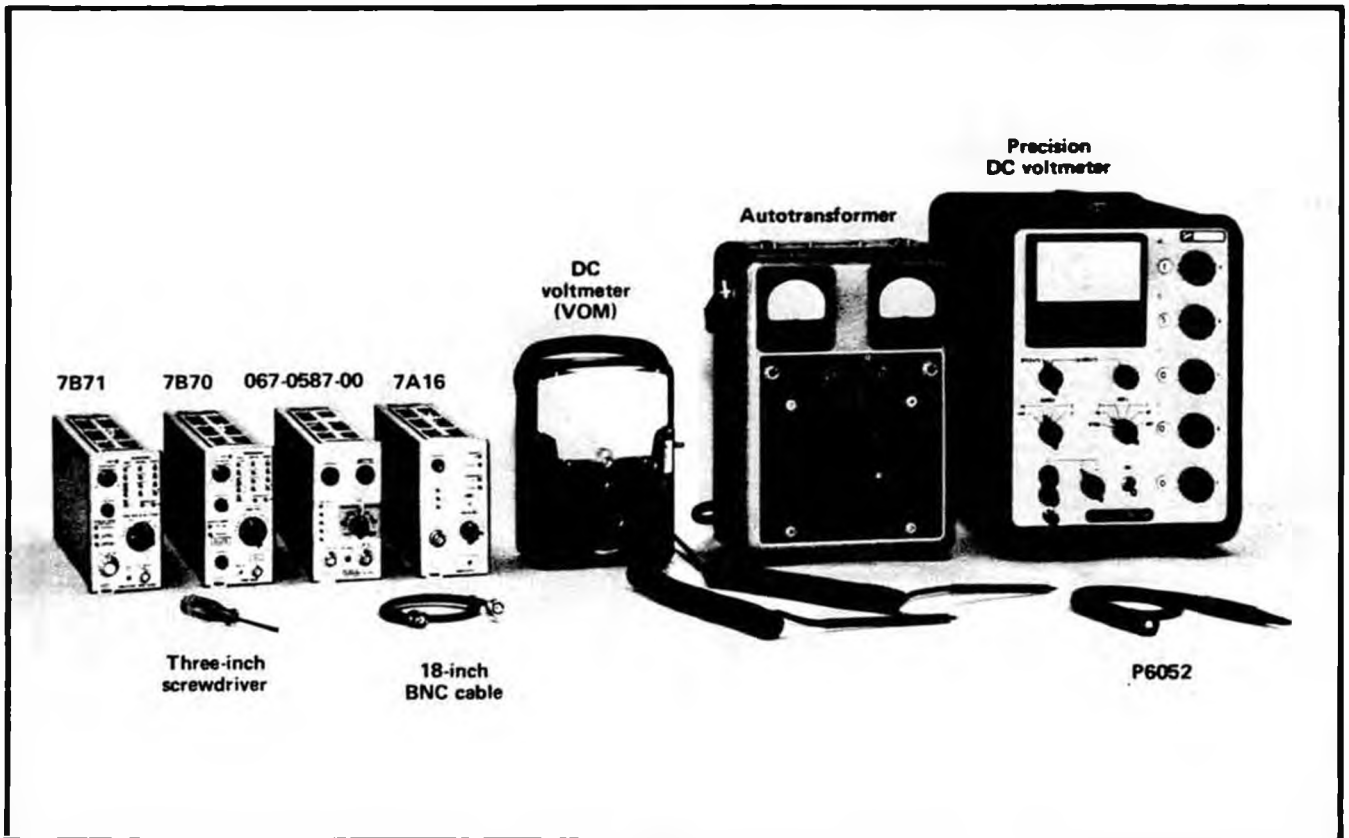


Fig. 5-1. Test equipment required for steps 1 through 11.

### 1. Adjust +75 Volt Power Supply

①

e. Remove the meter lead from the +75 volt test point.

#### PERFORMANCE CHECK ONLY

Steps 1 through 4 are not applicable to a performance check. Set controls as given under Preliminary Control Settings and begin with step 5.

f. Check step 4.

a. Test equipment required for steps 1 through 11 is shown in Fig. 5-1.

b. Connect the precision DC voltmeter between the +75 volt test point (see Fig. 5-2) on the power supply Regulator circuit board and ground.

c. CHECK—Meter reading; +75 volts,  $\pm 0.375$  volt.

d. ADJUST— +75 Volt adjust R483 (see Fig. 5-3) for a meter reading of exactly +75 volts.

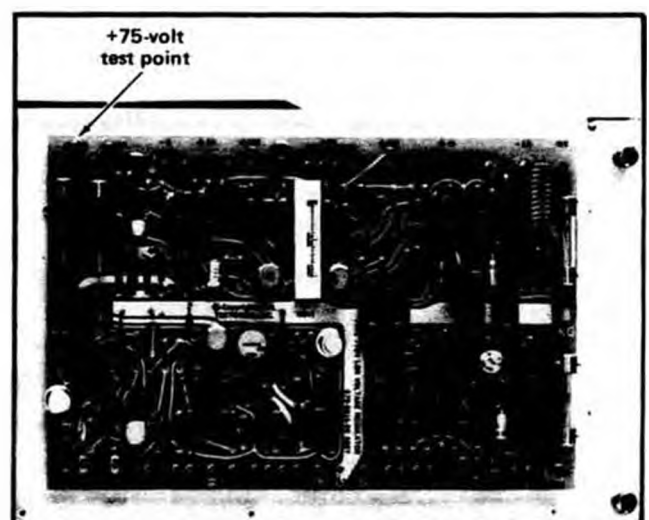


Fig. 5-2. Location of +75 volt test point on power supply regulator circuit board.



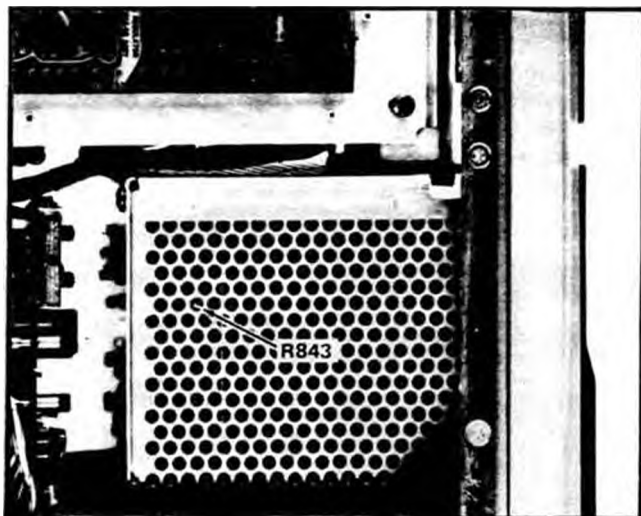


Fig. 5-3. Location of +75 Volt adjust R843.

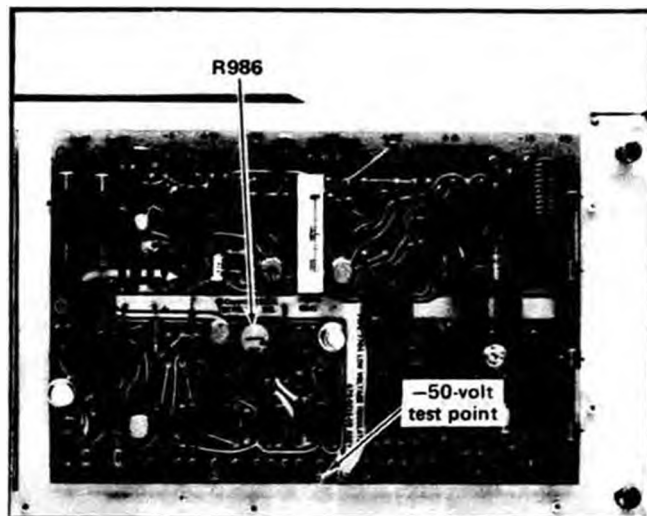


Fig. 5-4. Location of -50 Volt adjust R986 and test point.

## 2. Adjust -50 Volt Power Supply

①

a. Connect the precision DC voltmeter between the -50 volt test point on the power supply Regulator circuit board and ground (see Fig. 5-4).

b. CHECK—Meter reading; -50 volts,  $\pm 0.1$  volt.

c. ADJUST— -50 Volt adjust R986 (see Fig. 5-4) for a meter reading of exactly -50 volts.

d. INTERACTION—May affect the operation of all other circuits in the 7704. Check step 4.

e. Remove the meter lead from the -50 volt test point.

## 3. Check Power Supply Voltages And Regulation

a. Table 5-1 lists the power supplies in the instrument. Check each supply with the precision DC voltmeter for output voltage within the given tolerance. Power supply test points are shown in Fig. 5-5.

b. Remove the precision DC voltmeter from the 7704.

c. Install a 7A16 in the LEFT VERT compartment and a 7B71 in the A HORIZ compartment.

d. Connect an 18-inch BNC cable between the CALIBRATOR connector and the Input connector on the 7A16.

TABLE 5-1

Power Supply	Output Voltage Tolerance	Ripple limits
+ 5 Volt	$\pm 0.15$ volt	2 mV or less
+ 15 Volt	$\pm 0.3$ volt	2 mV or less
+ 50 Volt	$\pm 0.6$ volt	5 mV or less
+ 75 Volt	$\pm 0.375$ volt	200 mV or less
+150 Volt	$\pm 6$ volts	300 mV or less
-15 Volt	$\pm 0.3$ volt	2 mV or less
-50 Volt	$\pm 0.1$ volt	5 mV or less
5 Volt (Control Illum)	+0.2 volt to -0.5 volt	10 mV or less

e. Set the CALIBRATOR switch to 40 mV and the Volts/Div switch on the 7A16 to 10 mV.

f. Set the triggering controls on the 7B71 for a free running trace.

g. Adjust the Gain control on the 7A16 for four divisions of vertical deflection (preliminary adjustment).

h. Remove the 50-ohm BNC cable from the 7A16.

i. Connect a P6052 probe (set for X1 attenuation) to the Input connector of the 7A16.

j. CHECK—Refer to Fig. 5-5 for the appropriate test points and check each supply for proper regulation at 90 VAC, 115 VAC, and 136 VAC line voltages. Ripple limits are given in Table 5-1.

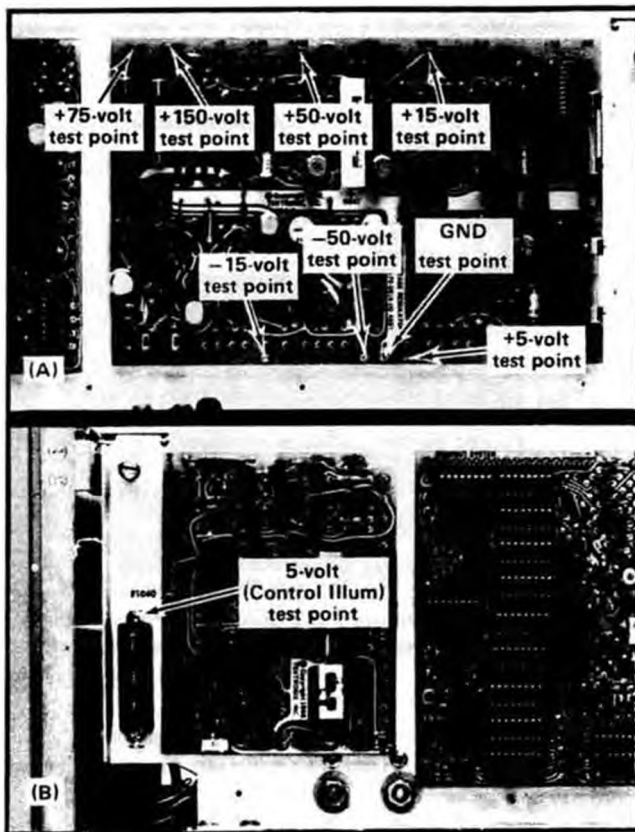


Fig. 5-5. (A) Location of power supply test points on Regulator circuit board. (B) Location of 5 Volt (Control Illum) power supply test point.

k. Remove the P6052 probe from the 7704.

l. Return the autotransformer output voltage to 115 VAC.

#### 4. Adjust High Voltage Power Supply

##### **WARNING**

*Care should be taken to accurately adjust the High Voltage supply, the -50 Volt supply, and the +75 Volt supply to minimize x-ray emission from the CRT faceplate.*

a. Turn off the power to the 7704.

b. Connect the DC voltmeter (VOM) between the high voltage test point (see Fig. 5-6) and ground.<sup>3</sup>

<sup>3</sup> If a precision high voltage divider is available, this measurement should be made using the precision divider in conjunction with the precision DC voltmeter.

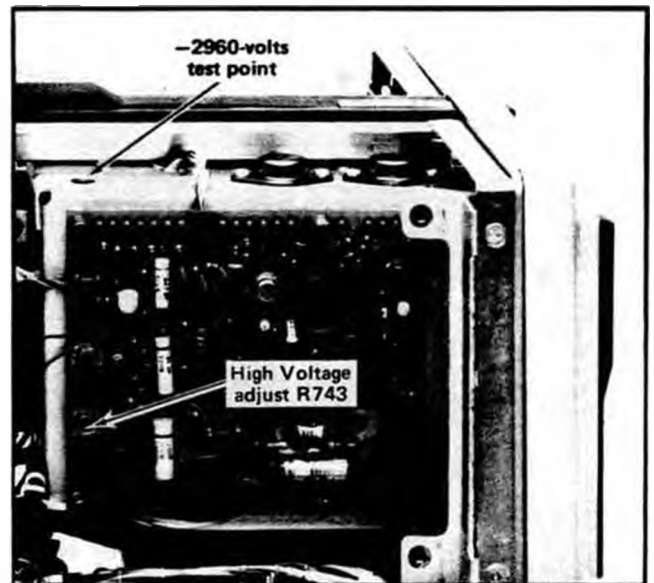


Fig. 5-6. Location of -2960 Volts test point and High Voltage adjust R743.

c. Turn on the power to the 7704.

d. CHECK—Meter reading of -2960 volts,  $\pm 59.2$  volts.

e. ADJUST—High Voltage. R743 (see Fig. 5-6) for a meter reading of -2960 volts.

f. Turn off the power to the 7704.

g. Remove the meter leads from the 7704.

h. Turn on the power to the 7704.

i. INTERACTION—Check step 5.

#### 5. Check/Adjust CRT Grid Bias and Maximum Intensity Levels

a. Install the 067-0587-00 calibration fixture in the LEFT VERT compartment.

b. Install the 7B71 Delaying Time Base plug-in in the A HORIZ compartment.

c. Set the 7B71 Time/Div switch to 5 s.

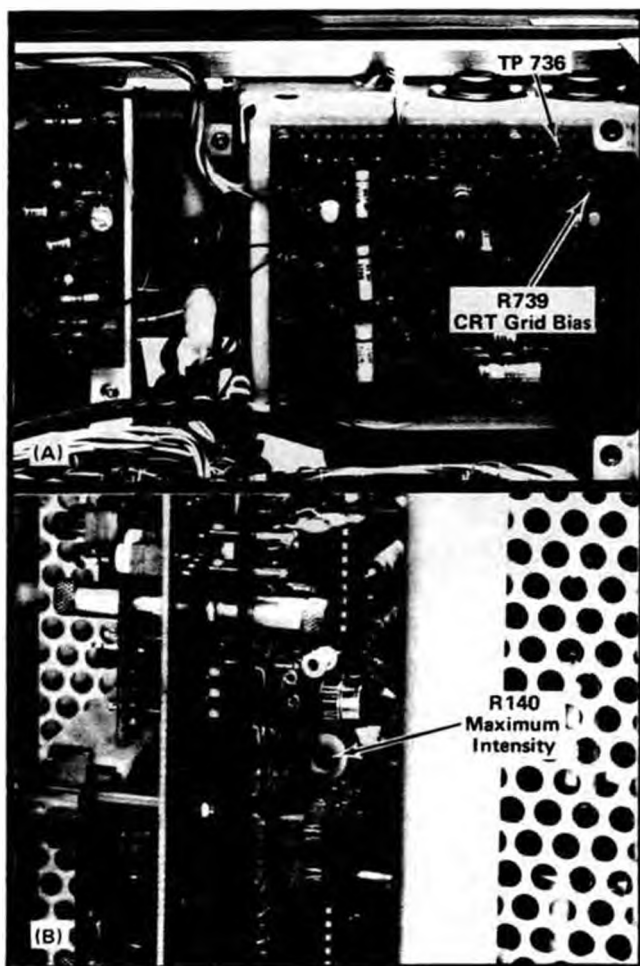


Fig. 5-7. (A) Location of TP736 and CRT Grid Bias Adjustment R739. (B) Location of Maximum Intensity adjustment R140.

d. Connect the DC voltmeter (VOM) between test point 736 on the Z Axis circuit board and ground (see Fig. 5-7A).

e. With the 7B71 Delaying Time Base free-running at 5 s/div, note the voltage measured at test point 736 with the A INTENSITY control fully counterclockwise.

f. Adjust the A INTENSITY control for a meter reading four volts more positive than the reading noted in step e.

g. CHECK—Dot on CRT screen should be just extinguished.

h. ADJUST—R739 (see Fig. 5-7A) so the dot on the CRT screen is just extinguished.

i. Change the 7B71 Time/Div control to 50 ms.

j. With the trace fully de-focused and positioned off screen, set the A INTENSITY control to the full clockwise position.

k. CHECK—Meter reading should be 64 volts more positive than the reading noted in step e.

l. ADJUST—R140 (see Fig. 5-7B) for a meter reading 64 volts more positive than the reading noted in step e.

m. Set the 7B71 Time/Div control to .1 S.

n. CHECK—Meter reading should be +35 to +50 volts.

#### NOTE

*This tolerance is intended as a guide to correct instrument operation and is not an instrument specification.*

o. Reduce the A INTENSITY Level to a normal viewing level.

p. Remove the DC voltmeter (VOM) leads from the 7704.

### 6. Check/Adjust ASTIG Control



a. Apply sufficient calibrator signal to the Aux In connector of the 067-0587-00 calibration fixture to obtain about two divisions of vertical deflection.

b. CHECK—Optimum focused CRT display can be obtained by adjusting the FOCUS control.

c. ADJUST—FOCUS and ASTIG adjustments to obtain optimum focused display.

### 7. Check/Adjust TRACE ROTATION and Y Axis Alignment



a. Remove the 7B71 Delaying Time Base from the A HORIZ compartment and install it in the B HORIZ compartment.

b. Remove the 067-0587-00 calibration fixture from the LEFT VERT compartment and install it in the A HORIZ compartment.

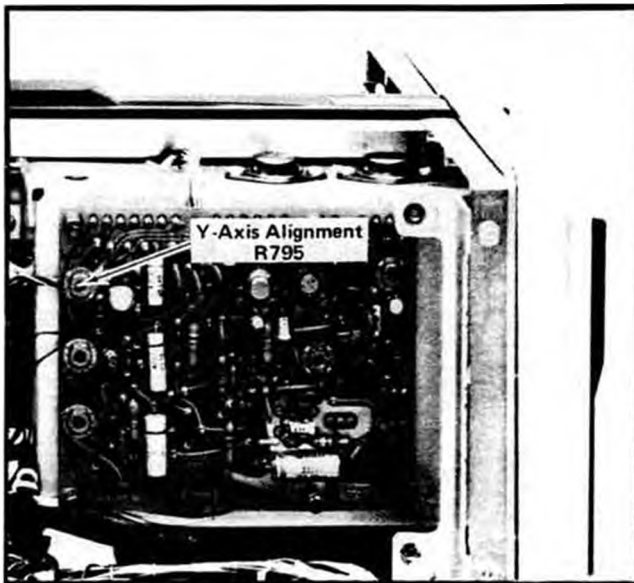


Fig. 5-8. Location of Y Axis Alignment control R795.

c. Install a 7B70 Time Base in the RIGHT VERT compartment.

d. Change the following control settings:

VERTICAL MODE	ALT
HORIZONTAL MODE	ALT

e. Position the two traces to the vertical and horizontal centerlines of the CRT graticule. Use the VERT TRACE SEPARATION (B) control to position the horizontal trace and the calibration fixture Position control to position the vertical trace.

f. CHECK—The vertical trace aligns with the graticule center vertical line within 0.1 division and the horizontal trace aligns with the graticule center horizontal line within 0.1 division.

g. ADJUST—TRACE ROTATION and Y Axis Alignment R795 (see Fig. 5-8) so the vertical and horizontal traces align with the vertical and horizontal graticule center lines exactly.

h. INTERACTION—Check step 13.

#### NOTE

*If the 7704 under calibration contains Option 1, (readout deleted) omit step 8 and proceed with step 8A.*

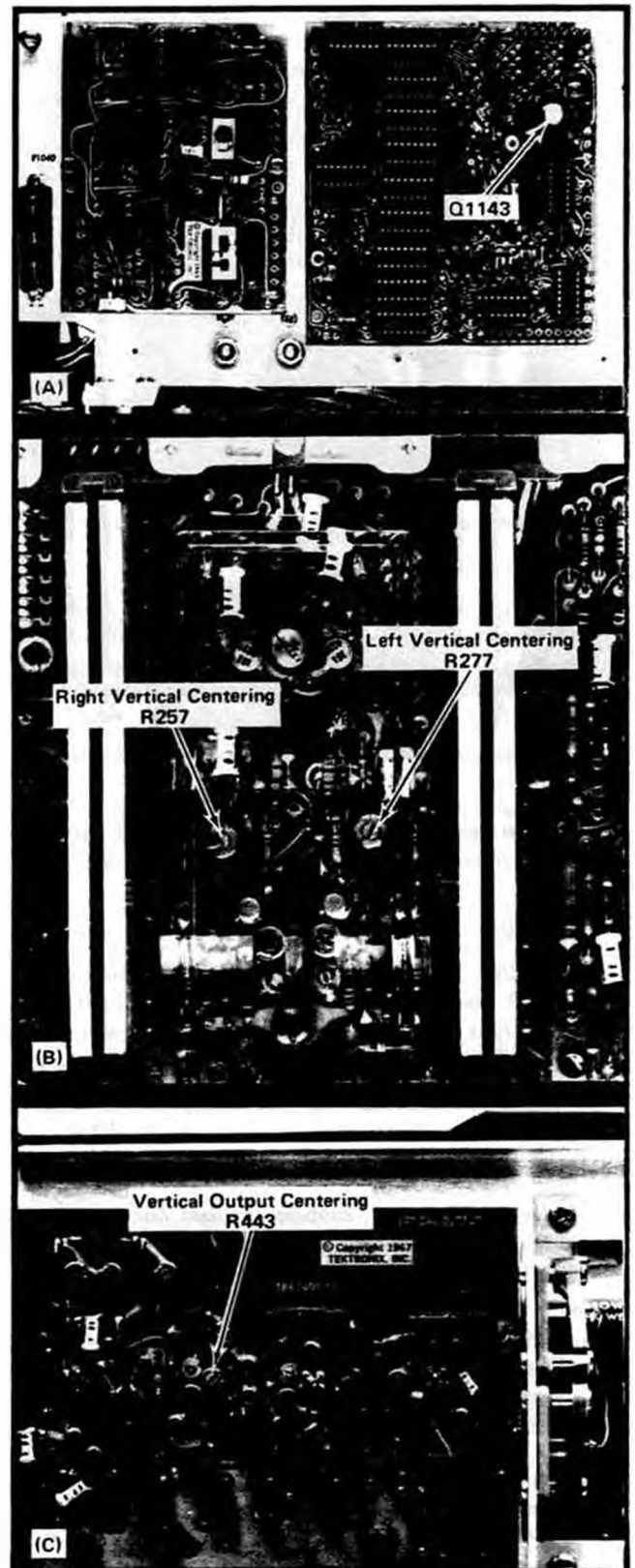


Fig. 5-9. (A) Location of Q1143. (B) Location of Left Vertical Centering adjustment R277 and Right Vertical Centering adjustment R257. (C) Location of Vertical Output Amplifier Centering adjustment R443.

## 8. Check/Adjust Vertical Output Amplifier Centering and Left Vertical and Right Vertical Centering (For Instruments With Readout)



- a. Turn off the 7704 power.
- b. Remove Q1143 (see Fig. 5-9A) from its socket.
- c. Turn on the 7704 power.
- d. Remove the 7B70 Time Base from the RIGHT VERT compartment.
- e. Change the HORIZONTAL MODE switch to B.

f. CHECK—Displayed readout characters should be equally spaced vertically from the graticule center line. The alternating traces should be within 0.8 division of the graticule center line.

### NOTE

*This tolerance is intended as a guide to correct instrument operation and is not an instrument specification.*

g. ADJUST—Vertical Output Amplifier Centering adjustment R443 (see Fig. 5-9C) for equal spacing of the displayed readout characters from the graticule center line. Adjust R257 and R277 (see Fig. 5-9B) to position the alternating traces to the graticule center line.

### NOTE

*If the 7704 under calibration does not contain Option 1 (Readout deleted) omit step 8A and proceed with step 9.*

## 8A. Check/Adjust Vertical Output Amplifier Centering and Left Vertical and Right Vertical Centering (For Instruments Without Readout)



- a. Remove the 7B70 Time Base from the RIGHT VERT compartment.
- b. Change the HORIZONTAL MODE switch to B.
- c. CHECK—Displayed traces should align with the graticule center horizontal line  $\pm 0.6$  division.

### NOTE

*This tolerance is intended as a guide to correct instrument operation and is not an instrument specification.*

d. ADJUST—Left Vertical Centering R277 (see Fig. 5-9B) and Right Vertical Centering R257 (see Fig. 5-9B) to position the alternating traces to the graticule horizontal center line.

e. Change the VERTICAL MODE switch to ADD.

f. CHECK—Trace should align with the graticule horizontal center line  $\pm 0.6$  division.

### NOTE

*This tolerance is intended as a guide to correct instrument operation and is not an instrument specification.*

g. ADJUST—Note the distance the trace is displaced from the graticule horizontal center line. Adjust the Vertical Centering adjustment R443 (see Fig. 5-9C) to position the trace away from the graticule horizontal center line by twice the distance noted prior to adjustment. (e.g., if the trace was down 0.1 division, adjust R443 to position the trace down 0.2 division.)

h. Repeat steps d through g until vertical centering is achieved in all vertical modes.

## 9. Check/Adjust Vertical Output Amplifier Gain



a. Remove the 067-0587-00 calibration fixture from the A HORIZ compartment and install it in the LEFT VERT compartment.

b. Set the VERTICAL MODE switch to LEFT.

c. Set the Test switch on the calibration fixture to Vert or Horiz Gain.

d. CHECK—Deflection between the second and sixth traces should be 6 divisions  $\pm 0.06$  division.

### NOTE

*This tolerance is provided as a guide to correct instrument operation and is not an instrument specification.*

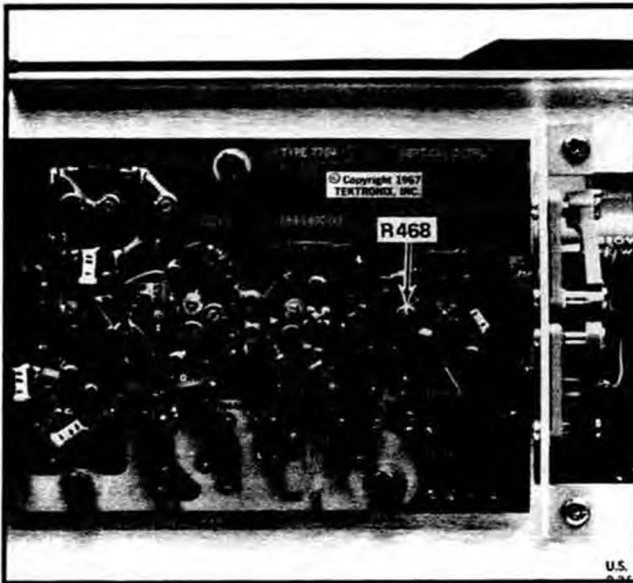


Fig. 5-10. Location of Vertical Output Amplifier Gain control R468.

e. ADJUST—Vertical Output Amplifier Gain control R468 (see Fig. 5-10) for exactly 6 divisions of deflection between the second and the sixth traces.

## 10. Check/Adjust Right Vertical Amplifier Gain



a. Remove the 067-0587-00 calibration fixture from the LEFT VERT compartment and install it in the RIGHT VERT compartment.

b. Change the VERTICAL MODE switch to RIGHT.

c. CHECK—Deflection between the second and sixth traces should match the deflection of the Left Vertical Amplifier within 1% (0.06 division).

d. ADJUST—Right Vertical Amplifier Gain adjustment R242 (see Fig. 5-11) to match the gain of the Right Vertical to the gain of the Left Vertical within 1% (0.06 division).

## 11. Check Vertical Amplifier Low Frequency Linearity

a. Set the Test switch on the 067-0587-00 calibration fixture to Aux In.

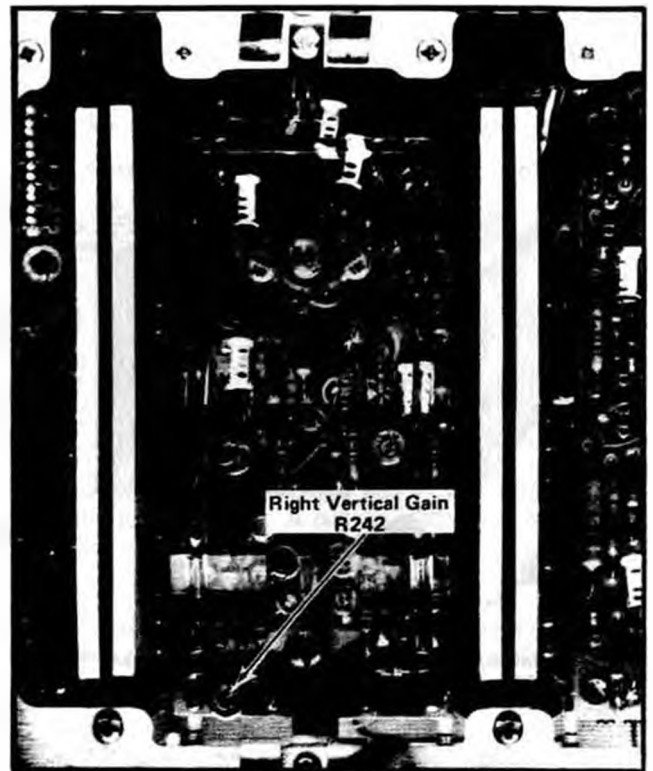


Fig. 5-11. Location of Right Vertical Amplifier Gain control R242.

b. Connect the CALIBRATOR connector to the Aux In connector on the calibration fixture via a 50-ohm BNC cable.

c. Adjust the CALIBRATOR output amplitude and the calibration fixture Amplitude Step or Aux control for exactly two divisions of vertical deflection at the center of the CRT graticule.

d. Set the top of the display to the upper graticule line.

e. CHECK—Compression or expansion of less than 0.1 division.

f. Set the bottom of the display to the bottom graticule line.

g. CHECK—Compression or expansion of less than 0.1 division.

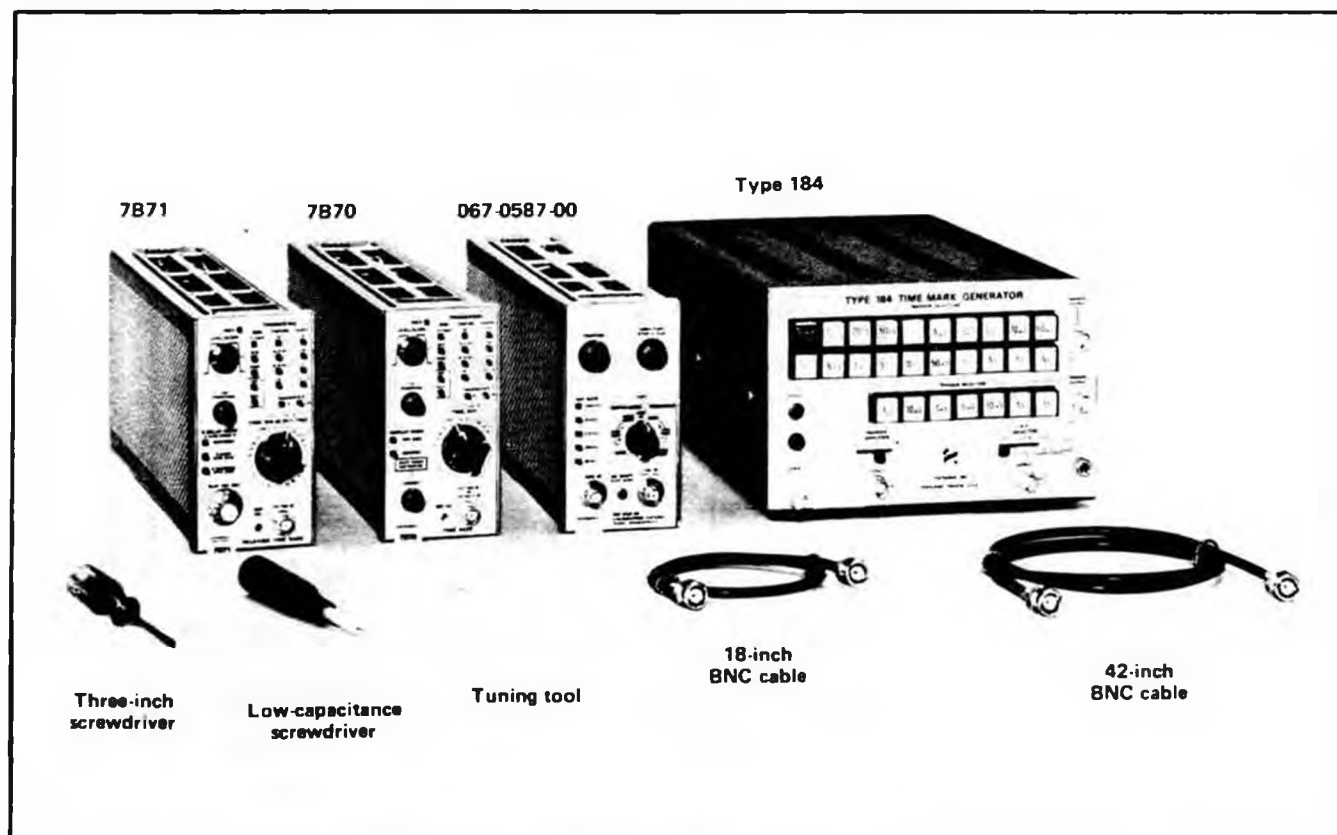


Fig. 5-12. Test equipment required for steps 12 through 17.

### Partial Procedure

If beginning a partial procedure with this step, set the controls as given under Preliminary Control Settings except as follows:

VERTICAL MODE	RIGHT
HORIZONTAL MODE	CHOP
FOCUS	Focused CRT display
A INTENSITY	Normal viewing level
B INTENSITY	For visible characters if available
READOUT	

### 12. Check/Adjust Horizontal Amplifier Thermal Balance

①

a. Test equipment required for steps 12 through 17 is shown in Fig. 5-12.

b. Install a 7B70 Time Base in the B HORIZ compartment.

c. Install a 7B71 Delaying Time Base in the A HORIZ compartment.

d. Install the 067-0587-00 calibration fixture in the RIGHT VERT compartment.

e. Set the 7B71 Time/Div switch to 50 ms with the Mag at X10.

f. Set the 7B70 Time/Div switch to 50  $\mu$ s with the Mag at X1.

g. Connect the Type 184 Time Mark Generator to the input connector of the calibration fixture via a 50-ohm BNC cable.

h. Set the Type 184 Marker Selector switch to 50  $\mu$ s.

i. Set the VERTICAL MODE switch to RIGHT and the HORIZONTAL MODE switch to CHOP.

j. Adjust the Level/Slope control on the 7B70 for a stable display of the time markers.



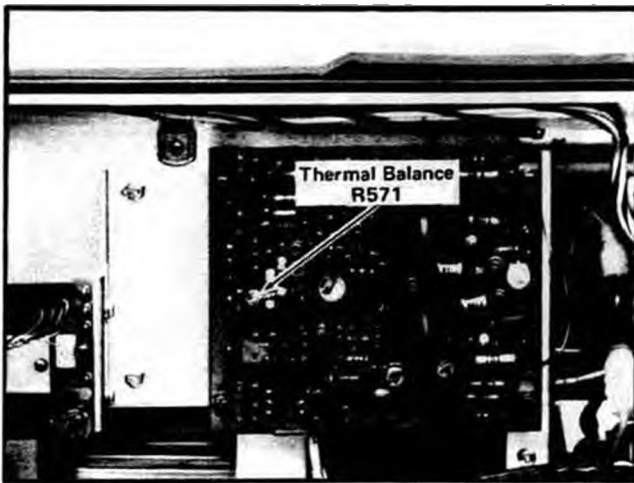


Fig. 5-13. Location of Horizontal Amplifier Thermal Balance adjustment R571.

k. CHECK—Minimum horizontal movement of the readout characters (if available) and the displayed time markers.

l. ADJUST—Thermal Balance adjustment R571 (see Fig. 5-13) for minimum movement of the readout characters (if available) and the displayed time markers.

m. Change the 7B71 Time/Div switch to 50  $\mu$ s with the Mag switch to X1.

n. Change the 7B70 Time/Div switch to 50 ms with the Mag switch to X10.

o. Change the Level/Slope control of the 7B70 to provide a free-running sweep and the Level/Slope control of the 7B71 for a stable display of the time markers.

p. CHECK—Minimum horizontal movement of the readout characters (if available) and the displayed time markers.

q. ADJUST—Compromise the setting of the Thermal Balance adjustment R571 (see Fig. 5-13) as set in step l to provide minimum horizontal movement of the readout characters and the displayed time markers.

r. INTERACTION—Check steps 13 and 14.

### 13. Check/Adjust Horizontal Amplifier Centering

a. Install the 067-0587-00 calibration fixture in the B HORIZ compartment and the 7B71 Delaying Time Base in the LEFT VERT compartment.

b. Set the VERTICAL MODE switch to LEFT and the HORIZONTAL MODE switch to B HORIZ.

c. Set the calibration fixture Test switch to Triggering Gain.

d. CHECK—Vertical trace should align with the graticule vertical center line  $\pm 0.8$  division ( $\pm 0.6$  division if the 7704 under calibration does not contain a readout circuit board). Check in all positions of the HORIZONTAL MODE switch.

#### NOTE

*This tolerance is provided as a guide to correct instrument operation and is not an instrument specification.*

e. ADJUST—Horizontal Centering adjustment R529 (see Fig. 5-14) to position the trace to the graticule vertical center line.

f. INTERACTION—Check steps 12 and 14.

### 14. Check/Adjust Horizontal Amplifier Gain and DC Linearity

a. Change the 067-0587-00 calibration fixture Test switch to Vert or Horiz Gain.

b. CHECK—Deflection between the second and eighth traces is 8 divisions  $\pm 0.08$  division.

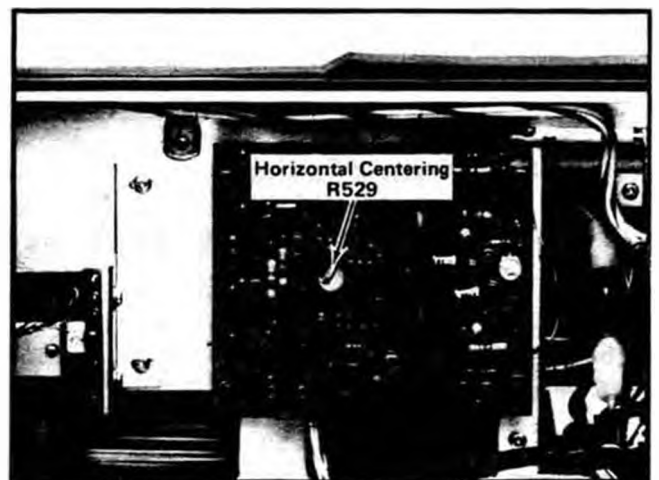


Fig. 5-14. Location of Horizontal Centering adjustment R529.



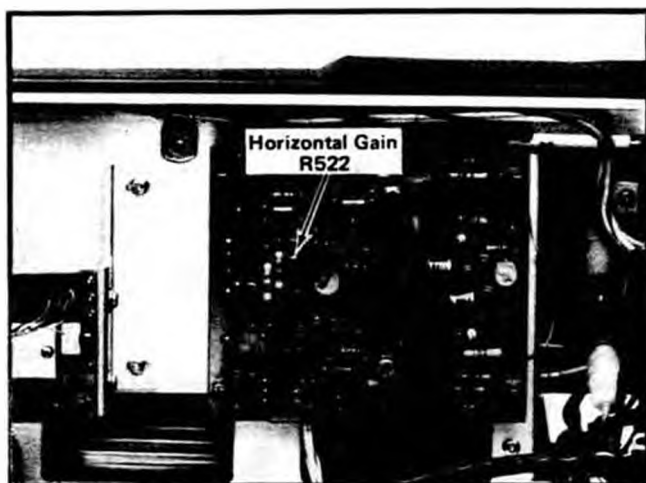


Fig. 5-15. Location of Horizontal Amplifier Gain adjust R522.

**NOTE**

*This tolerance is provided as a guide to correct instrument operation and is not an instrument specification.*

c. ADJUST—Horizontal Amplifier Gain adjustment R522 (see Fig. 5-15) for 8 divisions of deflection between the second and eighth traces.

d. CHECK—With gain set exactly, all nine vertical traces should align with their respective graticule lines within 0.05 division.

e. INTERACTION—Check steps 12 and 13.

**NOTE**

*If the 7704 being calibrated contains Option 1 (readout deleted), omit step 15 and continue with step 16.*

## 15. Check/Adjust Readout Character Vertical Separation and Operation

a. Remove all of the plug-ins from the plug-in compartments.

b. Remove Q1143 (see Fig. 5-16A) if not previously removed.

c. Adjust the READOUT intensity control for visible readout characters.

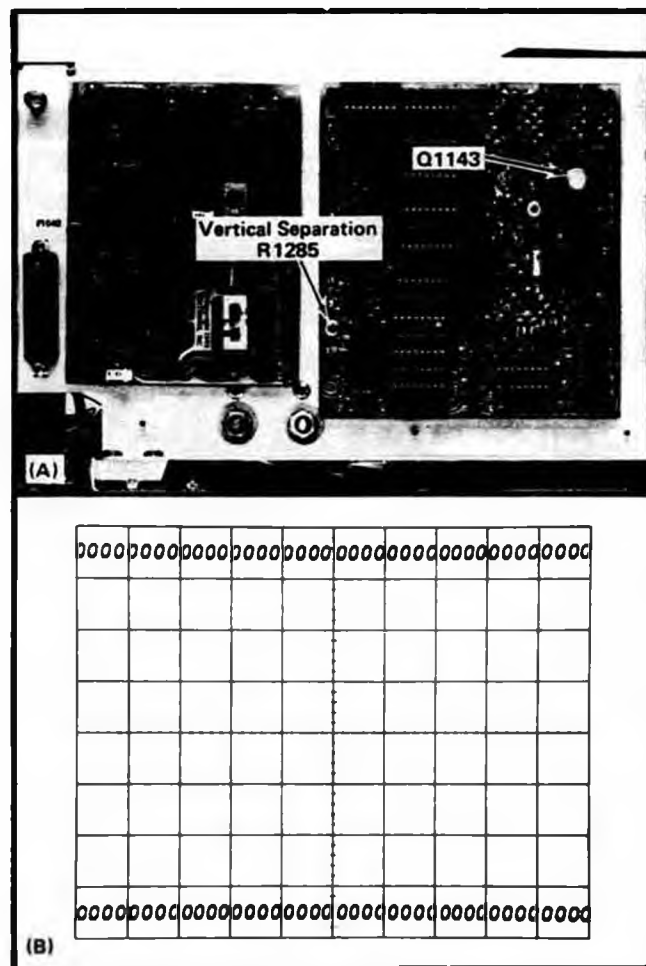


Fig. 5-16. (A) Location of Q1143 and R1285. (B) Readout display with Q1143 removed.

d. CHECK—CRT display for two rows of zeros, 40 zeros to a row with no character overlap. Total length of each row of characters should be 9.5 divisions to 10.5 divisions. Character height should be 0.25 division to 0.4 division. There should be one zero or less to the right of the right edge of the graticule and one zero or less to the left of the left edge of the graticule in each row. The two rows of zeros should be located vertically approximately in the middle of the extreme upper and lower graticule divisions. See Fig. 5-16B.

**NOTE**

*Some of these tolerances are provided as a guide to correct instrument operation and are not instrument specifications.*

e. ADJUST—Readout Vertical Separation adjust R1285 (see Fig. 5-16A) to position the rows of readout characters approximately in the middle of the extreme upper and lower graticule divisions.

f. Turn off the 7704 power.

g. Install Q1143 (removed in step 8) in its socket on the Readout circuit board.

h. Turn on the 7704 power.

## 16. Check/Adjust CRT Geometry



a. Install the 067-0587-00 calibration fixture in the LEFT VERT compartment and the 7B70 Time Base in the B HORIZ compartment.

b. Apply 1 ms and .1 ms time markers to the Aux In connector of the calibration fixture.

c. Adjust the Level/Slope control on the 7B70 for a stable display.

d. Adjust the Amplitude Step or Aux control on the calibration fixture so the time markers extend above and below the upper and lower graticule limits.

e. Adjust the 7B70 Time/Div and Variable control if necessary to obtain one 1 ms marker per horizontal division.

f. CHECK—CRT display for no more than 0.1 division of tilt or bowing of time markers anywhere in the graticule area.

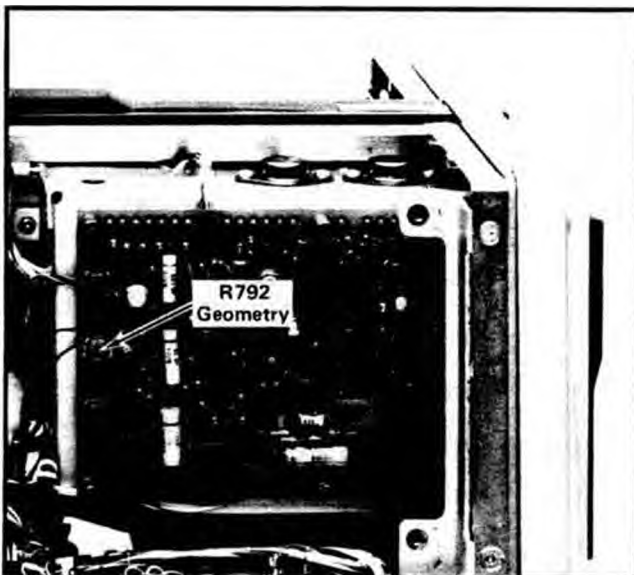


Fig. 5-17. Location of Geometry adjustment R792.

g. ADJUST—Geometry adjustment R792 (see Fig. 5-17) for no more than 0.1 division of tilt or bowing of time markers anywhere in the graticule area.

h. Remove the time markers from the calibration fixture input.

## 17. Check/Adjust Vertical Amplifier Transient Response



a. Set the 067-0587-00 calibration fixture Test switch to Step Resp + with the Rep Rate switch set to 250 kHz.

b. Adjust the calibration fixture Amplitude Step or Aux control for six divisions of vertical deflection.

c. Adjust the 7B70 Level/Slope control for a stable display.

d. CHECK—CRT display for optimum pulse square leading corner and flat top.

e. ADJUST—Refer to Table 5-2 and adjust for optimum pulse square leading corner and flat top. Adjustment locations are shown in Fig. 5-18A and 5-18B.

TABLE 5-2

Adjustment	Area affected
R423	First .5 $\mu$ s
R421	First .3 $\mu$ s
R422	First .1 $\mu$ s
C430, R430	First 20 ns
C483, C484, L483, L484	First 10 ns
C458, R458	First 5 ns
C274, R274	Front corner

f. Remove the calibration fixture from the LEFT VERT compartment and install it in the RIGHT VERT compartment.

g. Set VERTICAL MODE switch to RIGHT.

h. CHECK—CRT display for optimum pulse square leading corner and flat top.

i. ADJUST—C244 and R254 (see Fig. 5-18B) for best front corner.

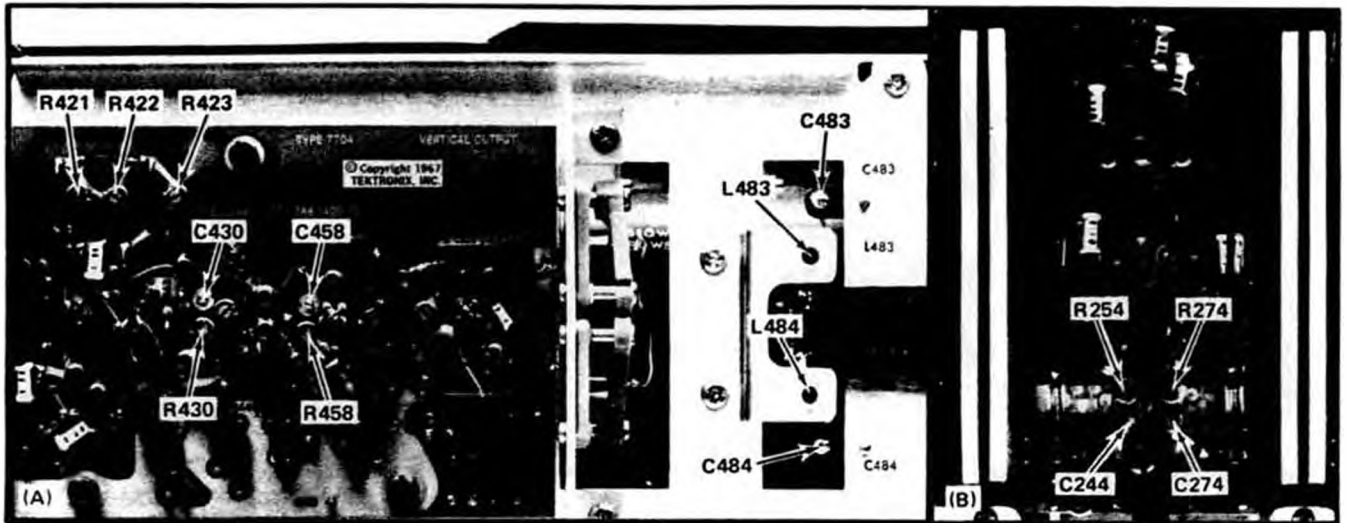


Fig. 5-18. (A) Location of Vertical Amplifier transient response adjustments. (B) Right Vertical Amplifier Transient Response Adjustments.

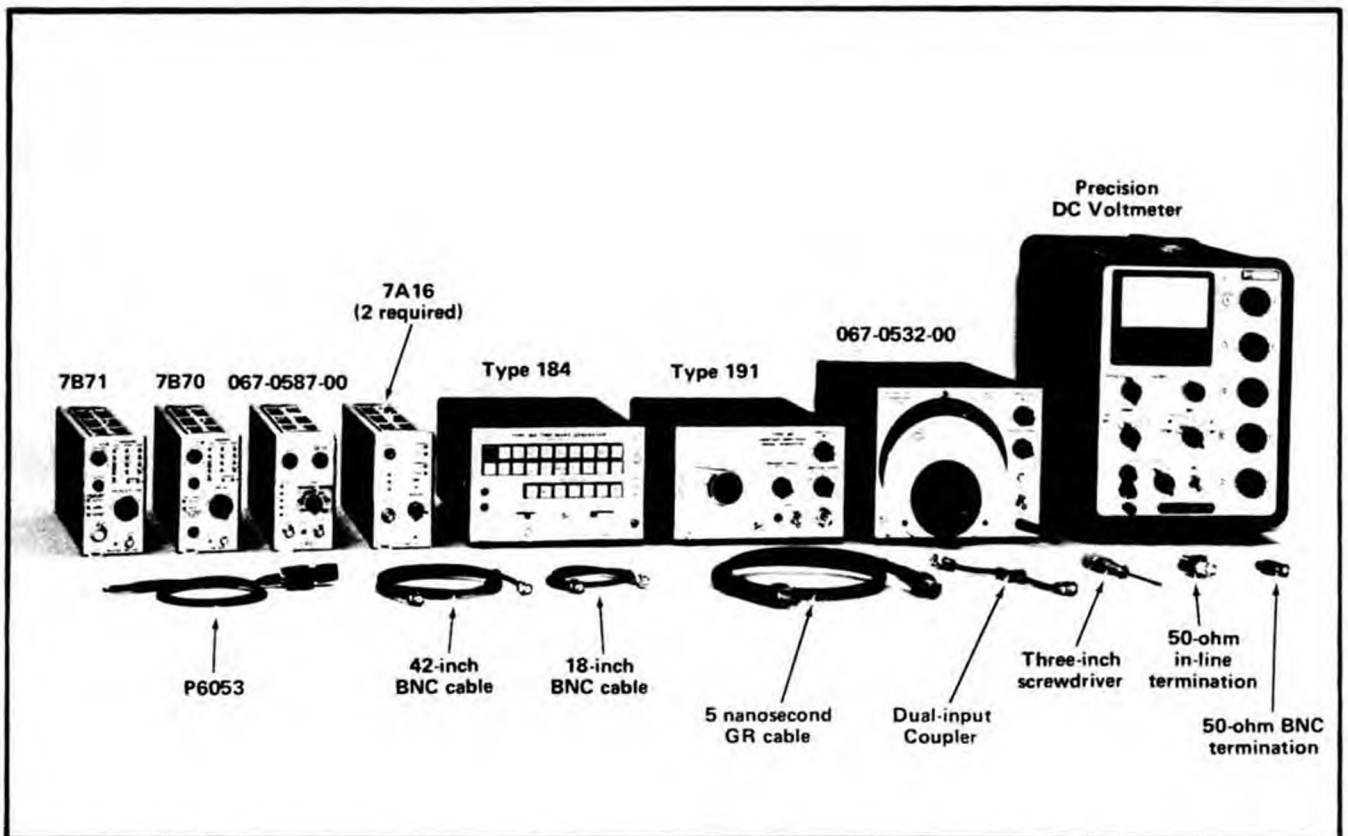


Fig. 5-19. Test equipment required for steps 18 through 30.

### Partial Procedure

If beginning a partial procedure with this step, set the controls as given under Preliminary Control Settings except as follows:

VERTICAL MODE	RIGHT
HORIZONTAL MODE	B

### 18. Check Vertical Amplifier Bandwidth

a. Test equipment required for steps 18 through 30 is shown in Fig. 5-19.

b. Change the 067-0587-00 calibration fixture Test switch to Vert or Horiz Freq Resp.

c. Connect the 067-0532-00 High Frequency Constant Amplitude Signal Generator to the 067-0587-00 calibration fixture CW In connector via a GR to BNC adapter and a 50-ohm BNC cable.

d. Adjust the Constant Amplitude Signal Generator to display six divisions of deflection of 3 megahertz reference frequency.

e. Change the Constant Amplitude Signal Generator frequency range switch to 65-500.

f. Without changing the output amplitude, increase the output frequency of the constant amplitude signal generator until the display is reduced to 4.2 divisions (−3 dB point).

g. CHECK—Output frequency of 190 megahertz or higher (180 megahertz or higher if being checked at temperatures of 0°C to +50°C).

h. Remove the 067-0587-00 calibration fixture from the RIGHT VERT compartment and install it in the LEFT VERT compartment.

i. Change the VERTICAL MODE switch to LEFT.

j. Repeat steps b through f.

k. Remove all test equipment from the 7704.

## 19. Check Vertical SIG OUT Bandwidth

a. Remove the 067-0587-00 calibration fixture from the LEFT VERT compartment and install it in the RIGHT VERT compartment.

b. Install a 7A16 in the LEFT VERT compartment.

c. Connect the vertical SIG OUT connector to the Input connector of the 7A16 via an 18-inch 50-ohm BNC cable with a 50-ohm in-line BNC termination at the 7A16 Input connector.

d. Set the B TRIGGER SOURCE switch to RIGHT VERTICAL.

e. Connect the output of the Type 191 Constant Amplitude Signal Generator to the CW In connector on the calibration fixture via a five-nanosecond GR cable and a 50-ohm in-line termination.

f. Set the output frequency of the Type 191 to 2 megahertz.

g. Set the VERTICAL MODE switch to LEFT.

h. Set the output amplitude of the Type 191 to obtain 6 divisions of vertical deflection.

i. Without changing the output amplitude of the Type 191, increase the output frequency until the display is reduced to 4.2 divisions (–3 dB point).

j. CHECK—Output frequency should be 65 megahertz (computed from risetime) or higher.

k. Remove all test equipment from the 7704.

## 20. Check Channel Isolation

a. Remove the 067-0587-00 calibration fixture from the RIGHT VERT compartment.

b. Set the 7A16 Volts/Div switch to .5 V.

c. Connect the output of the 067-0532-00 High Frequency Signal Generator to the Input connector of the 7A16.

d. Set the signal generator for an output frequency of 150 megahertz.

e. Adjust the output amplitude of the signal generator to obtain eight divisions of deflection.

f. Set the VERTICAL MODE switch to RIGHT.

g. CHECK—CRT trace for no more than 0.1 division of 150 megahertz signal.

h. Repeat steps d through g with the 7A16 installed in the RIGHT VERT compartment. Check the LEFT VERTICAL to see how much 150 megahertz signal is present.

i. Remove all test equipment from the 7704.

## 21. Check/Adjust High Frequency Timing

a. Connect one millisecond time-markers to the 7A16 Input connector.

b. Set the 7B70 Time/Div switch to 1 ms.

c. Set the B TRIGGER SOURCE switch to VERT MODE.

d. Set the 7B70 Level/Slope control for a stable display.

e. CHECK—CRT display for one time marker per division.

f. ADJUST—7B70 Swp Cal control for one time marker per division.

g. Change the 7B70 Time/Div switch to .05  $\mu$ s.

h. Observe the setting of adjustable capacitors C569 and C579 (see Fig. 5-20). Nominal setting for them is equal adjustment at or near minimum capacity (turned out).

i. Apply 50 ns time markers to the 7A16.

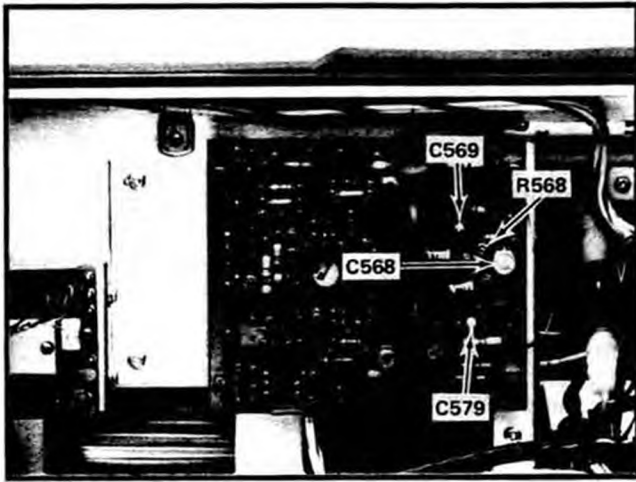


Fig. 5-20. Location of C569, C579, C568, and R568.

#### NOTE

*For the faster time markers, it may become necessary to externally trigger the time base from the trigger output connector on the Type 184.*

j. Observe the amount of timing error present at  $0.5\ \mu\text{s}$  per division with the magnifier set to X1 (timing set exactly at  $.1\ \mu\text{s}/\text{division}$ ).

k. Set the 7B70 Time/Div switch to  $.05\ \mu\text{s}$  with the magnifier set to X10.

l. Apply 5 ns time markers to the 7A16.

m. CHECK—Timing error present is equal to the timing error observed at  $.05\ \mu\text{s}/\text{div}$  with X1 magnifier.

n. ADJUST—C568 (see Fig. 5-20) to adjust timing to the same timing error observed at  $.05\ \mu\text{s}/\text{div}$  with X1 magnifier.

o. Set the 7B70 Time/Div switch to  $.02\ \mu\text{s}/\text{div}$  with X10 magnification.

p. CHECK—Timing error present is equal to the timing error observed at  $.02\ \mu\text{s}/\text{div}$  with X1 magnifier.

q. ADJUST—R568 (see Fig. 5-20) to adjust timing to the same timing error observed at  $.02\ \mu\text{s}/\text{div}$  with X1 magnifier.

r. Repeat steps j through q until proper timing is obtained.

s. Remove all test equipment from the 7704.

## 22. Check/Adjust CALIBRATOR

①

a. Connect the Precision DC voltmeter to the CAL connector.

b. Set the RATE switch to DC.

c. Set the CALIBRATOR switch to .4 V.

d. CHECK—Output voltage measurement of .4 volt  $\pm 0.004$  volt ( $\pm 0.008$  volt if measurement is made in the  $0^\circ\text{C}$  to  $+50^\circ\text{C}$  temperature range).

e. ADJUST—R649 (see Fig. 5-21) for an output voltage of .4 volt.

f. Connect the Precision DC voltmeter to monitor the voltage across R642 (see Fig. 5-21).

g. CHECK—Voltage measurement of 30.6 volts  $\pm 0.306$  volt ( $\pm 0.612$  volt if the measurement is being made in the  $0^\circ\text{C}$  to  $+50^\circ\text{C}$  temperature range).

h. ADJUST—40 mA R640 (see Fig. 5-21) for a voltage measurement of 30.6 volts.

i. Remove the Precision DC voltmeter from the 7704.

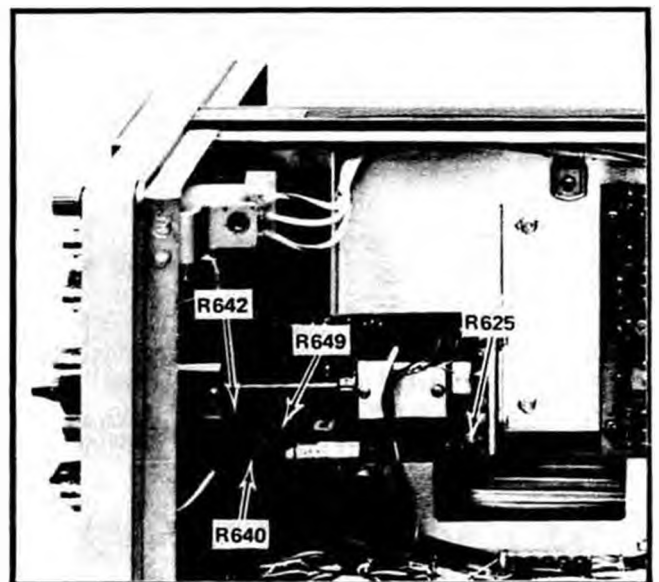


Fig. 5-21. Location of R625, R640, R642, and R649.

## Performance Check/Calibration—7704

- j. Install the 7A16 in the LEFT VERT compartment.
- k. Install the 067-0587-00 calibration fixture in the RIGHT VERT compartment.
- l. Apply one millisecond time markers from the Type 184 to the Input connector of the 7A16.
- m. Set the CALIBRATOR RATE switch to 1 kHz.
- n. Apply four volts of 1 kHz calibrator signal to the Aux In connector of the calibration fixture.
- o. Set the VERTICAL MODE switch to ALT.
- p. Set the B TRIGGER SOURCE switch to VERT MODE.
- q. Set the 7B70 Triggering to Norm, AC, Int with the Time/Div switch set to 1 ms.
- r. Adjust the deflection factors of the two vertical plug-in units to obtain about 2 divisions of deflection of time markers and 2 divisions of calibrator square wave.
- s. CHECK—Leading edges of calibrator square wave align with the 1 millisecond time markers.
- t. ADJUST—R625 (see Fig. 5-21) to align the leading edges of the calibrator square wave with the 1 millisecond time markers.
- u. Set the B TRIGGER SOURCE switch to RIGHT.
- v. Set the VERTICAL MODE switch to ADD.
- w. Set the 7B70 Time/Div switch to .2 ms.
- x. CHECK—Minimum drift of time markers across calibrator square wave.
- y. ADJUST—R625 (see Fig. 5-21) for slowest drift of time markers across calibrator square wave.
- z. Set the B TRIGGER SOURCE switch to VERT MODE.
  - aa. Set the 7B70 Level/Slope control so a triggered trace is present only when the time markers occur during the positive portion of the calibrator square wave.
  - ab. Set the 7B70 Triggering Coupling switch to AC LF REJ.
  - ac. Set the 7B70 Time/Div switch to .2 s.
  - ad. CHECK—The amount of time required for the time markers to drift across the positive level of the calibrator square wave to the negative level and back to the positive level must be more than 0.4 second (more than 0.2 second if check is being made in the 0°C to +50°C temperature range).
  - ae. ADJUST—repeat steps u through y to adjust R625 (see Fig. 5-21) for slowest drift of time markers.
  - af. Remove the cable from the input connector of the 7A16.
  - ag. Remove the cable from the input connector of the calibration fixture and connect it to the input connector of the 7A16.
  - ah. Set the VERTICAL MODE switch to LEFT.
  - ai. Adjust the 7A16 Volts/Div switch to obtain approximately five divisions of vertical deflection.
  - aj. Set the 7B70 Triggering Coupling switch to AC.
  - ak. Adjust the 7B70 Level/Slope control for a stable display triggered on the rising portion of the square wave.
  - al. CHECK—Displayed waveform has a risetime from the 10% to the 90% point of .25  $\mu$ s or less.
  - am. Adjust the 7B70 Level/Slope control for stable display triggered on the falling portion of the square wave.

an. CHECK—Displayed waveform has a falltime from the 90% to the 10% point of .25  $\mu$ s or less.

ao. Change the CALIBRATOR switch to 40 V.

ap. Adjust the 7A16 Volts/Div switch to obtain five divisions of vertical deflection.

aq. CHECK—With the 7B70 Level/Slope control set to trigger on the falling portion of the square wave, falltime from 90% to 10% must be 2  $\mu$ s or less.

ar. Set the 7B70 Level/Slope control to trigger on the rising portion of the square wave.

as. CHECK—Displayed waveform for a risetime from the 10% point to the 90% point of 2  $\mu$ s or less.

at. Change the 7A16 Volts/Div switch to 2 V and the CALIBRATOR switch to 4 V.

au. Set the 7B70 Time/Div switch to 50  $\mu$ s with the Mag switch set to X10.

av. Adjust the 7B70 Level/Slope control for a stable display with the sweep starting at the 50% point of the rising edge of the waveform.

aw. Horizontally position the falling edge of the waveform to align with the vertical graticule center line.

ax. Set the Polarity switch on the 7A16 to Invert.

ay. CHECK—Duty cycle of the calibrator waveform is 50%  $\pm$  0.1% indicated by horizontal shift of the falling edge of the waveform of 0.4 division or less.

az. Install a 7B71 Delaying Time Base in the A HORIZ compartment.

ba. Set the HORIZONTAL MODE switch to A.

bb. Set the 7704 CALIBRATOR RATE switch to B GATE  $\div$  2.

bc. Set the 7B71 Time/Div switch to .2  $\mu$ s.

bd. With the 7B70 sweep untriggered and free running, set the 7B71 Level/Slope control to obtain a stable display.

be. CHECK—CRT display for a square wave with a time duration of approximately 5.5 division (1.1 ms) per cycle.

bf. Remove all cable connections from the 7704.

## 23. Check/Adjust X-Y Delay Compensation ①

### NOTE

*If the 7704 under calibration does not contain Option 2, omit step 23 and proceed with step 24.*

a. Remove the 067-0587-00 from the RIGHT VERT compartment.

b. Remove the 7B70 Time Base from the B HORIZ compartment.

c. Remove the 7A16 Amplifier from the LEFT VERT compartment and install it in the RIGHT VERT compartment.

d. Install a second 7A16 in the A HORIZ compartment.

e. Change the following front panel control settings:

VERTICAL MODE	RIGHT
HORIZONTAL MODE	A

f. Set the Volts/Div switches on the 7A16's to 10 mV.

g. Connect the output of the Type 191 Constant Amplitude Signal Generator to the input connectors of the 7A16's via a five-nanosecond GR cable, a 50-ohm in-line termination, and a dual-input coupler.

h. Adjust the output amplitude of the Type 191 to obtain 8 divisions of vertical deflection and 8 divisions of horizontal deflection of 50 kHz reference frequency.



## Performance Check/Calibration—7704

i. Set the Type 191 for an output frequency of 2 megahertz.

j. Set the Delay Disable switches S50 and S70 (see Fig. 5-22) to their In positions.

k. CHECK—Eye opening in the CRT display of 0.28 division or less.

l. ADJUST—C55 (see Fig. 5-22) for an eye opening of 0.28 division or less.

m. Remove the 7A16 from the A HORIZ compartment and install it in the B HORIZ compartment.

n. Change the HORIZONTAL MODE switch to B.

o. CHECK—Eye opening in the CRT display of 0.28 division or less.

p. ADJUST—C70 (see Fig. 5-22) for an eye opening of 0.28 division or less.

q. Remove all test equipment from the 7704.

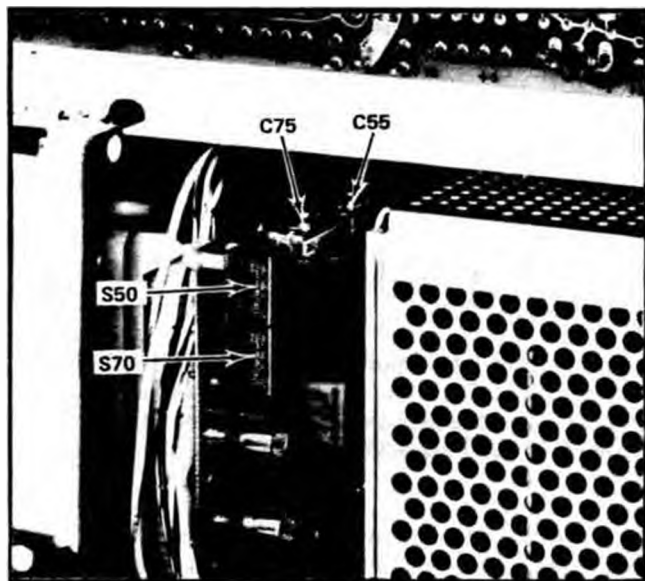


Fig. 5-22. Location of C55, C75, S50 and S70.

## 24. Check Horizontal Bandwidth With Phase Correction

a. Remove the 7A16 from the RIGHT VERT compartment.

b. Install a 7B70 in the RIGHT VERT compartment.

c. Set the Volts/Div switch of the 7A16 to .1 V.

d. Connect the output of the Type 191 to the Input connector of the 7A16 via the 5 ns GR cable and a 50-ohm in-line termination.

e. Set the Time/Div switch of the 7B70 to .1 ms.

f. Set the Frequency Range switch of the Type 191 to 50 kHz.

g. Adjust the Type 191 output amplitude for 10 divisions of horizontal deflection.

h. Change the output frequency of the Type 191 to 3 MHz.

i. CHECK—CRT display for 7.1 divisions of horizontal deflection (−3 dB point).

j. Remove all test equipment and plug-ins from the 7704.

## 25. Check VERT TRACE SEPARATION (B) Control Range

a. Install a 7A16 in the RIGHT VERT compartment.

b. Install a 7B71 Delaying Time Base in the A HORIZ compartment.

c. Install a 7B70 Time Base in the B HORIZ compartment.

d. Set the HORIZONTAL MODE switch to A and the VERTICAL MODE switch to RIGHT.

e. Using the 7A16 Position control, position the A trace to the upper graticule limit.

- f. Set the HORIZONTAL MODE switch to ALT.
- g. Turn the VERT TRACE SEPARATION (B) control fully CCW.
- h. CHECK—B trace must be positioned at least 4 but no more than 6 divisions below A trace.
- i. Using the 7A16 Position control, position A trace to the lower graticule limit.
- j. Turn the VERT TRACE SEPARATION (B) control fully CW.
- k. CHECK—B trace must be positioned at least 4 but no more than 6 divisions above A trace.

## 26. Check/Adjust Z-Axis Amplifier Compensation



- a. Connect a P6053 Probe to the Input connector of the 7A16.
- b. Set the HORIZONTAL MODE switch to B.
- c. Set the 7B70 Time/Div switch to .02  $\mu$ s.
- d. Connect the P6053 probe to test point 736 (see Fig. 5-23) on the Z-Axis circuit board.

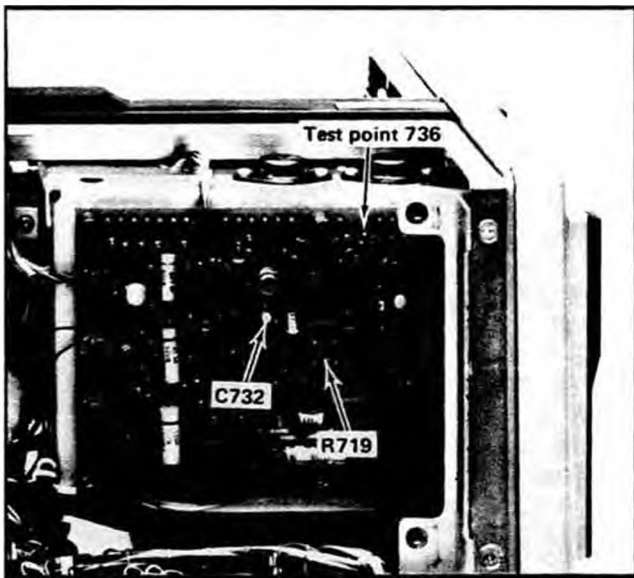


Fig. 5-23. Location of test point 736, C732, and R719.

- e. Adjust the B INTENSITY control for 30 volts of unblanking waveform displayed on the CRT.
- f. ADJUST—R719 and C732 (see Fig. 5-23) for optimum square leading corner and a waveform risetime of 30 nanoseconds or less.
- g. ADJUST—R719 and C732 (see Fig. 5-23) for optimum square leading corner and a waveform risetime of 30 nanoseconds or less.
- h. Remove the P6053 probe from the 7704.
- i. Return the B INTENSITY control to a normal viewing level.

## 27. Check + SAWTOOTH OUT Signal

- a. Connect the + SAWTOOTH OUT connector to the input of the 7A16 via a 50-ohm BNC cable.
- b. Set the HORIZONTAL MODE switch to A.
- c. Set the Swp A or B switch S666 (see Fig. 5-24) to the B position.
- d. Set the 7A16 Volts/Div switch to 2 V.
- e. Set the 7B71 Time/Div switch to 1 ms and the 7B70 Time/Div switch to .5 ms.

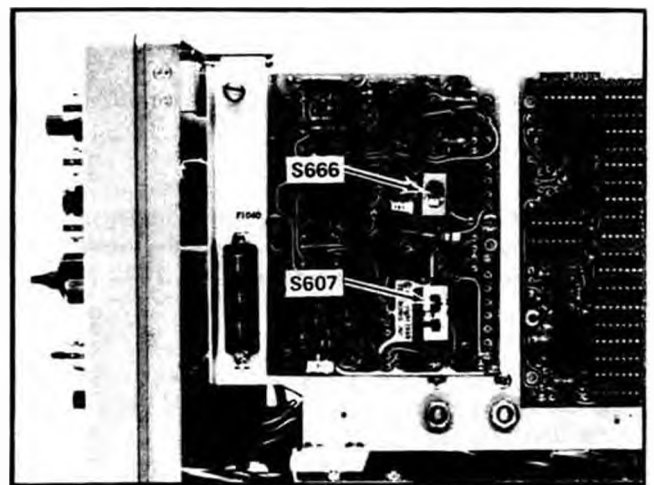


Fig. 5-24. Location of S666 and S607.

## Performance Check/Calibration—7704

f. CHECK—CRT for sawtooth waveform display approximately 5 divisions in amplitude with the sawtooth waveform duration equal to the setting of the 7B70 Time/Div switch.

g. Change the HORIZONTAL MODE switch to B.

h. Change the Swp A or B switch S666 (see Fig. 5-24) to the A position.

i. Change the 7B71 Time/Div switch to .5 ms and the 7B70 Time/Div switch to 1 ms.

j. CHECK—CRT for sawtooth waveform display approximately 5 divisions in amplitude with the sawtooth waveform duration equal to the setting of the 7B71 Time/Div switch.

### 28. Check + GATE Out Signal

a. Remove the 50-ohm BNC cable from the + SAWTOOTH connector and connect it to the + GATE connector.

b. Set the Gate A, B, or Dlyd switch S607 (see Fig. 5-24) to the A position.

c. CHECK—CRT for gate waveform display approximately 5 divisions in amplitude with the time duration of the gate pulses equal to the setting of the 7B71 Time/Div switch.

d. Change the HORIZONTAL MODE switch to A.

e. Change the Gate A, B, or Dlyd switch S607 (see Fig. 5-24) to the B position.

f. CHECK—CRT for gate waveform display approximately 5 divisions in amplitude with the time duration of the gate pulses equal to the setting of the 7B70 Time/Div switch.

g. Set the Gate A, B, or Dlyd switch S607 (see Fig. 5-24) to the Dlyd position.

h. Change the 7B71 B Delay Mode switch to B Starts After Delay.

i. CHECK—CRT display for Delay Gate waveform approximately 5 divisions in amplitude with the time duration of the gate pulse equal to the setting of the 7B70 Time/Div switch.

j. Remove the 50-ohm BNC cable from the 7704.

### 29. Checked Chopped Mode Operation

a. Set the VERTICAL MODE switch to CHOP.

b. Connect the P6053 Probe to the Ext Trig In connector of the 7B71 Delaying Time Base.

c. Connect the tip of the P6053 Probe to test point 137 (see Fig. 5-25) located on the Logic circuit board.

d. Adjust the 7B71 Level/Slope control to obtain a stable display.

e. CHECK—CRT display for chopped waveform display with each channel time segment including blanked portion equal to 0.4  $\mu$ s to 0.6  $\mu$ s. Also check that the unblanked portion of each channel time segment consists of at least 75% of total channel time segment.

f. Remove the P6053 probe from the 7704.

### 30. Check External Z Axis Inputs

a. Connect the output of the Type 191 Constant Amplitude Signal Generator to the Input connector of the 7A16

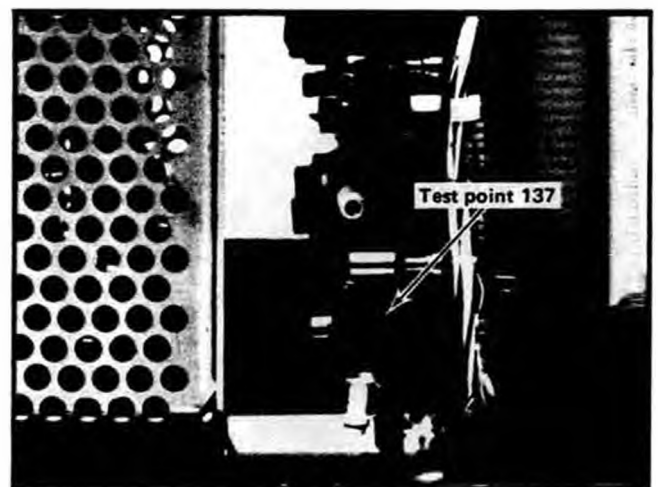


Fig. 5-25. Location of test point 137.

via a 5 ns GR cable, a 50-ohm in-line termination and a T-connector.

b. Set the 7A16 Volts/Div switch to 1 V.

c. Set the Type 191 frequency range switch to 50 kHz.

d. Adjust the output amplitude of the Type 191 for two volts.

e. Connect the open end of the T-connector to the HIGH SENSITIVITY connector on the 7704 rear panel via a 50-ohm BNC cable.

f. CHECK—CRT display for blanking of the top portion of the displayed waveform.

g. Remove the 50-ohm BNC cable from the HIGH SENSITIVITY connector and connect it to the HIGH SPEED input.

h. Change the output amplitude of the Type 191 to maximum.

i. CHECK—CRT display for blanking of the top portion of the displayed waveform.

j. Remove all test equipment from the 7704.

This completes the calibration/checkout procedure for the 7704. Disconnect the instrument from the autotransformer output. Replace the cabinet and any shields removed during the procedure. If the instrument has been completely checked and adjusted to the tolerances given in this procedure, it will meet or exceed the specifications given in Section 1.

## PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound



## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

## SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

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# SECTION 6

## ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
<b>CHASSIS</b>				
<b>Bulbs</b>				
DS780	150-0030-00			Neon, NE 2 V
DS781	150-0030-00			Neon, NE 2 V
DS785	150-0030-00			Neon, NE 2 V
DS786	150-0030-00			Neon, NE 2 V
DS787	150-0030-00			Neon, NE 2 V
DS788	150-0030-00			Neon, NE 2 V
DS1035	*150-0048-01			Incandescent #683, selected
DS1037	*150-0048-01			Incandescent #683, selected
<b>Capacitors</b>				
Tolerance $\pm 20\%$ unless otherwise indicated.				
C400	281-0670-00		1.8 pF	Cer 500 V $\pm 0.1$ pF
C493	281-0064-00		0.25-1.5 pF, Var	Tub.
C494	281-0064-00		0.25-1.5 pF, Var	Tub.
C489	283-0003-00		0.01 $\mu$ F	Cer 150 V
C742	283-0021-00		0.001 $\mu$ F	Cer 5000 V
C762	290-0312-00		47 $\mu$ F	Elect. 35 V 10%
C763	290-0135-00		15 $\mu$ F	Elect. 20 V
C764	285-0629-00		0.047 $\mu$ F	PTM 100 V
C771	290-0305-00		3 $\mu$ F	Elect. 150 V
C772	283-0082-00		0.01 $\mu$ F	Cer 4000 V + 80% - 20%
C779	283-0082-00		0.01 $\mu$ F	Cer 4000 V + 80% - 20%
C780	290-0305-00		3 $\mu$ F	Elect. 150 V
C781 <sup>1</sup>				
C782 <sup>1</sup>				
C783 <sup>1</sup>				
C784 <sup>1</sup>				
C785 <sup>1</sup>				
C786 <sup>1</sup>				
C787 <sup>1</sup>				
C788	283-0082-00		0.01 $\mu$ F	Cer 4000 V + 80% - 20%
C789	283-0082-00		0.01 $\mu$ F	Cer 4000 V
C790	283-0082-00		0.01 $\mu$ F	Cer 4000 V
C791	283-0077-00		330 pF	Cer 500 V 5%
C800	281-0708-00		5600 pF	Cer 250 V
C801	281-0708-00		5600 pF	Cer 250 V

<sup>1</sup>Furnished as a unit with Power Supply subassembly (\*119-0227-00).



## CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Capacitors (cont)						
C813	290-0413-00	980 $\mu$ F	Elect.	200 V	+ 50% — 10%	
C814	290-0413-00	980 $\mu$ F	Elect.	200 V	+ 50% — 10%	
C870	285-0878-00	0.3 $\mu$ F	PTM	900 V	5%	
C896	290-0426-00	330 $\mu$ F	Elect.	6 V		
C897	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% — 20%	
C1056	281-0501-00	4.7 pF	Cer	500 V	$\pm$ 1 pF	
C1057	281-0625-00	35 pF	Cer	500 V	5%	
C1081	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% — 20%	
C1082	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% — 20%	
C1083	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% — 20%	

## Semiconductor Device, Diodes

CR771	*152-0242-00	Silicon	Selected from 1N486A
CR772	152-0408-00	Silicon	High voltage, 10,000 V
CR780	*152-0107-00	Silicon	Replaceable by 1N647
CR781	152-0408-00	Silicon	High voltage, 10,000 V
CR782 <sup>2</sup>			
CR783 <sup>2</sup>			
CR784 <sup>2</sup>			
CR785 <sup>2</sup>			
CR786 <sup>2</sup>			
VR786	152-0247-00	Zener	1N989B 400 mW, 150 V, 5%
CR896	152-0397-00	Silicon	Fast recovery, 50 V maximum
CR897	152-0397-00	Silicon	Fast recovery, reverse voltage
CR1040	*152-0274-00	Silicon	Replaceable by 1N1200
CR1041	*152-0274-00	Silicon	Replaceable by 1N1200

## Fuses

F800	159-0017-00	4 A 3 AG	Fast-Blo
F810	159-0021-00	2 A 3 AG	Fast-Blo
F1040	159-0014-00	5 A 3 AG	Fast-Blo

## Line Filter

FL801<sup>3</sup>

## Delay Line

DL400	*119-0214-00	Delay line
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<sup>2</sup>Furnished as a unit with Power Supply subassembly (\*119-0227-001.<sup>3</sup>See Mechanical Parts List for replacement parts.

## CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Connectors</b>				
J650	131-0818-00			BNC, receptacle, electrical
J1055	131-0106-01			Receptacle, electrical
J1060	131-0106-01			Receptacle, electrical
J1075	136-0089-00			9 pin
J1080	131-0771-00			Receptacle, electrical, 4 contact
J1085	131-0771-00			Receptacle, electrical, 4 contact
P1041	*131-0765-00			Terminal, feedthru
<b>Inductors</b>				
L481	*108-0241-00			0.05 $\mu$ H
L482	*108-0241-00			0.05 $\mu$ H
L483	*114-0232-00			0.13-0.22 $\mu$ H, Var
L484	*114-0232-00			0.13-0.22 $\mu$ H, Var
L642	*119-0199-00			Current loop
L762	*108-0422-01			80 $\mu$ H
L764	*108-0231-00			4.5 $\mu$ H
L781	*108-0553-00			47 $\mu$ H
L788	*108-0553-00			47 $\mu$ H
L790	*108-0544-00			Trace rotation
L795	*108-0546-00			Y-AXIS alignment
L800	*108-0586-00			116 $\mu$ H
L801	*108-0586-00			116 $\mu$ H
L870 <sup>1</sup>				
<b>Transistors</b>				
Q480	*151-0211-00		Silicon	Selected from 2N3866
Q482	*151-0211-00		Silicon	Selected from 2N3866
Q764	*151-0140-00		Silicon	Selected from 2N3055
Q766	*151-0140-00		Silicon	Selected from 2N3055
Q918	*151-0140-00		Silicon	Selected from 2N3055
Q938	*151-0148-00		Silicon	Selected from 40250 RCA
Q939	*151-0141-00		Silicon	Selected from 40251 RCA
Q956	*151-0141-00		Silicon	Selected from 40251 RCA
Q972	*151-0148-00		Silicon	Selected from 40250 RCA
Q974	*151-0141-00		Silicon	Selected from 40251 RCA
Q998	*151-0140-00		Silicon	Selected from 2N3055

<sup>1</sup>Furnished as a unit with Power Supply subassembly (\*119-0229-00).

## CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description	
<b>Resistors</b>					
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.					
R231	311-0091-00		1 k $\Omega$ , Var		
R483	315-0122-00		1.2 k $\Omega$	$\frac{1}{4}$ W	5%
R484	315-0122-00		1.2 k $\Omega$	$\frac{1}{4}$ W	5%
R485	308-0425-00		350 $\Omega$	5 W	WW
R487	308-0425-00		350 $\Omega$	5 W	WW
R489	305-0510-00		51 $\Omega$	2 W	5%
R740			180 k $\Omega$		
R741			470 k $\Omega$		
R742	*307-0205-00		29.45 M $\Omega$		
R743			80 M $\Omega$		
R744			19 M $\Omega$		
R779	315-0205-00		2 M $\Omega$	$\frac{1}{4}$ W	5%
R780	315-0273-00		27 k $\Omega$	$\frac{1}{4}$ W	5%
R782	301-0205-00		2 M $\Omega$	$\frac{1}{2}$ W	5%
R783	301-0225-00		2.2 M $\Omega$	$\frac{1}{2}$ W	5%
R785 <sup>a</sup>	311-0945-00		5 M $\Omega$ , Var		
R786A <sup>a</sup>					
R786B <sup>a</sup>					
R786C <sup>a</sup>					
R786D <sup>a</sup>					
R786E <sup>a</sup>					
R787 <sup>a</sup>					
R788	316-0470-00		47 $\Omega$	$\frac{1}{4}$ W	
R789	301-0471-00		470 $\Omega$	$\frac{1}{2}$ W	5%
R790	311-0964-00		2.5 k $\Omega$ , Var		
R793	311-0467-00		100 k $\Omega$ , Var		
R801	303-0102-00		1 k $\Omega$	1 W	5%
R957	311-0939-00		25 $\Omega$ , Var		
R1035 <sup>b</sup>	311-0973-00		5 k $\Omega$ , Var		
R1037 <sup>c</sup>	311-0945-00		5 k $\Omega$ , Var		
R1040 <sup>d</sup>			5 k $\Omega$ , Var		
R1056	315-0562-00		5.6 k $\Omega$	$\frac{1}{4}$ W	5%
R1058	315-0133-00		13 k $\Omega$	$\frac{1}{4}$ W	5%
R1060	315-0241-00		240 $\Omega$	$\frac{1}{4}$ W	5%

<sup>a</sup>Furnished as a unit with R1037.<sup>b</sup>Furnished as a unit with Power Supply subassembly (\*119-0227-00).<sup>c</sup>Furnished as a unit with S455A,B.<sup>d</sup>Furnished as a unit with R785.<sup>e</sup>Furnished as a unit with S1040A,B.

**CHASSIS (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
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**Switches****Wired or Unwired**

S455A, B <sup>10</sup>				
S800	260-1102-00		Toggle	POWER
S801	260-0879-00		Thermostatic	Open 191° F, Close 161° F
S810 <sup>11</sup>				
S1040A, B <sup>12</sup>			Rotary	READOUT

**Transformers**

T762	276-0591-00		Core, toroid ferrite	
T764	*120-0634-00		H. V. Power	
T800	*120-0635-00		Line filter	
T870	*120-0633-00		L. V. Power	

**Electron Tube**

V799	*154-0609-00		T7700-31-1	CRT Standard Phosphor
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**MAIN INTERFACE Circuit Board Assembly****\*670-0817-00****Complete Board****Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C1	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C2	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C3	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80% - 20%
C4	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80% - 20%
C5	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C6	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C8	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C9	283-0177-00	1 $\mu$ F	Cer	25 V	+80% - 20%
C10	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80% - 20%
C11	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80% - 20%

<sup>10</sup>Furnished as a unit with R1035.<sup>11</sup>See Mechanical Parts List. Line Voltage Selector Body.<sup>12</sup>Furnished as a unit with R1040.

## MAIN INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
<b>Capacitors (cont)</b>				
C12	283-0177-00		1 $\mu$ F	Cer 25 V +80%–20%
C13	283-0177-00		1 $\mu$ F	Cer 25 V +80%–20%
C18	283-0192-00		0.47 $\mu$ F	Cer 3 V +80%–20%
C36	283-0178-00		0.1 $\mu$ F	Cer 100 V +80%–20%
C38	283-0178-00		0.1 $\mu$ F	Cer 100 V +80%–20%
C42	281-0529-00		1.5 pF	Cer 500 V $\pm 0.25$ pF

## Semiconductor Device, Diodes

CR35	*152-0185-00	Silicon	Replaceable by 1N4152
CR37	*152-0185-00	Silicon	Replaceable by 1N4152
CR39	*152-0185-00	Silicon	Replaceable by 1N4152
CR40	*152-0185-00	Silicon	Replaceable by 1N4152
CR41	*152-0185-00	Silicon	Replaceable by 1N4152
CR44	*152-0185-00	Silicon	Replaceable by 1N4152
CR45	*152-0185-00	Silicon	Replaceable by 1N4152

## Connectors

J1	131-0767-02	Receptacle, electrical, 76 contact
J2	151-0767-02	Receptacle, electrical, 76 contact
J3	131-0767-00	Receptacle, electrical, 76 contact
J4	131-0767-00	Receptacle, electrical, 76 contact

## Transistors

Q24	151-0190-00	Silicon	2N3906
Q28	151-0190-00	Silicon	2N3906

## Resistors

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R1	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R3	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R4	321-0231-00	2.49 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R5	321-0231-00	2.49 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R8	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R9	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R19	315-0202-00	2 k $\Omega$	$\frac{1}{4}$ W		5%
R20	315-0202-00	2 k $\Omega$	$\frac{1}{4}$ W		5%
R21	315-0302-00	3 k $\Omega$	$\frac{1}{4}$ W		5%
R22	315-0103-00	10 k $\Omega$	$\frac{1}{4}$ W		5%

**MAIN INTERFACE Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description		
Resistors (cont)					
R23	315-0562-00	5.6 kΩ	¼ W		5%
R24	315-0302-00	3 kΩ	¼ W		5%
R25	315-0513-00	51 kΩ	¼ W		5%
R26	315-0103-00	10 kΩ	¼ W		5%
R27	315-0562-00	5.6 kΩ	¼ W		5%
R28	315-0302-00	3 kΩ	¼ W		5%
R29	315-0513-00	51 Ω	⅛ W		5%
R31	315-0132-00	1.3 kΩ	⅛ W		5%
R32	321-0204-00	1.3 kΩ	⅛ W	Prec	1%
R33	315-0510-00	51 Ω	¼ W		5%
R34	315-0510-00	51 Ω	¼ W		5%
R35	315-0132-00	1.3 kΩ	¼ W		5%
R36	315-0104-00	100 kΩ	¼ W		5%
R37	315-0152-00	1.5 kΩ	¼ W		5%
R38	315-0104-00	100 kΩ	¼ W		5%
R39	315-0152-00	1.5 kΩ	¼ W		5%
R40	315-0243-00	24 kΩ	¼ W		5%
R42	315-0511-00	510 Ω	¼ W		5%
R43	315-0511-00	510 Ω	¼ W		5%
R44	315-0472-00	4.7 kΩ	¼ W		5%
R45	321-0222-00	2 kΩ	⅛ W	Prec	1%
R46	315-0510-00	51 Ω	¼ W		5%
R47	315-0510-00	51 Ω	¼ W		5%
R48	315-0511-00	510 Ω	¼ W		5%
R49	315-0511-00	510 Ω	¼ W		5%

**INSTRUMENT OPTIONS****Option 1—without READOUT Circuit Board Assembly (\*670-0635-00)****Option 2—with X-Y DELAY COMP Circuit Board Assembly (\*670-0839-00)****X-Y DELAY COMP. Circuit Board Assembly****\*670-0839-00****Complete Board****Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C53	283-0633-00	77 pF	Mica	100 V	1%
C55	281-0125-00	90-400 pF, Var	Mica		
C56	283-0671-00	164 pF	Mica	500 V	1%
C58	283-0670-00	375 pF	Cer	500 V	1%
C66	283-0671-00	164 pF	Mica	500 V	1%

## X-Y DELAY COMP. Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Capacitors (cont)						
C68	283-0670-00		375 pF	Cer	500 V	1%
C73	283-0533-00		77 pF	Mica	100 V	1%
C75	281-0125-00		90-400 pF, Var	Mica		
C76	283-0671-00		164 pF	Mica	500 V	1%
C78	283-0670-00		375 pF	Cer	500 V	1%
C86	283-0671-00		164 pF	Mica	500 V	1%
C88	283-0670-00		375 pF	Cer	500 V	1%

## Semiconductor Device, Diodes

CR50	*152-0185-00	Silicon	Replaceable by 1N4152
CR70	*152-0185-00	Silicon	Replaceable by 1N4152

## Relays

K50	*148-0034-00	Armature, dpdt, 15 V DC
K60	*148-0034-00	Armature, dpdt, 15 V DC
K70	*148-0034-00	Armature, dpdt, 15 V DC
K80	*148-0034-00	Armature, dpdt, 15 V DC

## Inductors

L51	*108-0559-00	1.605 $\mu$ H
L55	*108-0560-00	1.64 $\mu$ H
L56	*108-0561-00	3.75 $\mu$ H
L61	*108-0559-00	1.605 $\mu$ H
L65	*108-0560-00	1.64 $\mu$ H
L66	*108-0561-00	3.75 $\mu$ H
L71	*108-0559-00	1.605 $\mu$ H
L75	*108-0560-00	1.64 $\mu$ H
L76	*108-0561-00	3.75 $\mu$ H
L81	*108-0559-00	1.605 $\mu$ H
L85	*108-0560-00	1.64 $\mu$ H
L86	*108-0561-00	3.75 $\mu$ H

## Resistors

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R51	321-0068-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R61	321-0068-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R71	321-0068-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R81	321-0068-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%

**X-Y DELAY COMP Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Switches</b>				
	<b>Wired or Unwired</b>			
S50	260-0723-00		Slide	DELAY DISABLE B
S70	260-0723-00		Slide	DELAY DISABLE A

**LOGIC Circuit Board Assembly****\*670-0848-00****Complete Board****Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C101	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80%—20%
C102	290-0134-00	22 $\mu$ F	Elect.	15 V	
C103	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80%—20%
C104	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80%—20%
C115	283-0003-00	0.01 $\mu$ F	Cer	150 V	
C117	283-0668-00	184 pF	Mica	500 V	1%
C119	281-0554-00	24 pF	Cer	500 V	5%
C131	281-0525-00	470 pF	Cer	500 V	
C132	281-0543-00	270 pF	Cer	500 V	10%
C133	281-0525-00	470 pF	Cer	500 V	
C137	281-0629-00	33 pF	Cer	600 V	5%
C139	281-0629-00	33 pF	Cer	600 V	5%
C141	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80%—20%
C144	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C163	283-0116-00	820 pF	Cer	500 V	5%
C165	281-0603-00	39 pF	Cer	500 V	5%
C166	281-0603-00	39 pF	Cer	500 V	5%
C167	283-0084-00	270 pF	Cer	1000 V	5%
C172	281-0523-00	100 pF	Cer	350 V	
C176	283-0000-00	0.001 $\mu$ F	Cer	500 V	

**Semiconductor Device, Diodes**

CR128	*152-0185-00	Silicon	Replaceable by 1N4152
CR139	*152-0185-00	Silicon	Replaceable by 1N4152
CR145	*152-0153-00	Silicon	Tek Spec
CR146	*152-0153-00	Silicon	Tek Spec
CR147	*152-0185-00	Silicon	Replaceable by 1N4152



## LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
<b>Semiconductor Device. Diodes (cont)</b>			
VR148	152-0166-00	Zener	1N753A 400 mW, 6.2 V, 5%
CR156	*152-0185-00	Silicon	Replaceable by 1N4152
CR157	*152-0185-00	Silicon	Replaceable by 1N4152
CR175	*152-0185-00	Silicon	Replaceable by 1N4152
CR183	*152-0185-00	Silicon	Replaceable by 1N4152
CR184	*152-0185-00	Silicon	Replaceable by 1N4152

**Inductors**

L101	*108-0245-00	3.9 $\mu$ H	
L102	*108-0245-00	3.9 $\mu$ H	
L103	*108-0245-00	3.9 $\mu$ H	
L104	*108-0245-00	3.9 $\mu$ H	
L115	*108-0245-00	3.9 $\mu$ H	
L136	*108-0245-00	3.9 $\mu$ H	
L138	*108-0245-00	3.9 $\mu$ H	
LR134	*108-0543-00	1.1 $\mu$ H (wound on a 47 $\Omega$ , $\frac{1}{4}$ W, 5% resistor)	
LR151	*108-0543-00	1.1 $\mu$ H (wound on a 47 $\Omega$ , $\frac{1}{4}$ W, 5% resistor)	
LR180	*108-0543-00	1.1 $\mu$ H (wound on a 47 $\Omega$ , $\frac{1}{4}$ W, 5% resistor)	
LR190	*108-0543-00	1.1 $\mu$ H (wound on a 47 $\Omega$ , $\frac{1}{4}$ W, 5% resistor)	

**Transistors**

Q146	*151-0198-00	Silicon	Replaceable by MPS 918
Q162	*151-0198-00	Silicon	Replaceable by MPS 918
Q168	151-0223-00	Silicon	2N4275
Q182	*151-0198-00	Silicon	Replaceable by MPS 918
Q192	151-0188-00	Silicon	2N3906
Q194	*151-0192-00	Silicon	Replaceable by MPS 6521
Q196	*151-0192-00	Silicon	Replaceable by MPS 6521

**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R104	315-0100-00	10 $\Omega$	$\frac{1}{4}$ W	5%
R110	315-0510-00	51 $\Omega$	$\frac{1}{4}$ W	5%
R111	315-0510-00	51 $\Omega$	$\frac{1}{4}$ W	5%
R112	301-0241-00	240 $\Omega$	$\frac{1}{2}$ W	5%
R113	315-0510-00	51 $\Omega$	$\frac{1}{4}$ W	5%

## LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R114	315-0510-00		51 $\Omega$	$\frac{1}{4}$ W		5%
R115	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R116	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R117	315-0471-00		470 $\Omega$	$\frac{1}{4}$ W		5%
R118	315-0822-00		8.2 k $\Omega$	$\frac{1}{4}$ W		5%
R119	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R120	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R121	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R122	321-0289-00		10 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R123	321-0193-00		1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R124	315-0223-00		22 k $\Omega$	$\frac{1}{4}$ W		5%
R125	321-0193-00		1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R126	315-0223-00		22 k $\Omega$	$\frac{1}{4}$ W		5%
R127	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R128	315-0202-00		2 k $\Omega$	$\frac{1}{4}$ W		5%
R135	315-0752-00		7.5 k $\Omega$	$\frac{1}{4}$ W		5%
R136	315-0271-00		270 $\Omega$	$\frac{1}{4}$ W		5%
R137	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R138	315-0271-00		270 $\Omega$	$\frac{1}{4}$ W		5%
R139	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R140	311-0807-00		1 k $\Omega$ , Var			
R141	315-0151-00		150 $\Omega$	$\frac{1}{4}$ W		5%
R142	321-0225-00		2.15 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R143	321-0226-00		2.21 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R144	321-0210-00		1.5 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R145	321-0224-00		2.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R146	315-0242-00		2.4 k $\Omega$	$\frac{1}{4}$ W		5%
R147	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R148	315-0303-00		30 k $\Omega$	$\frac{1}{4}$ W		5%
R149	315-0682-00		6.8 k $\Omega$	$\frac{1}{4}$ W		5%
R152	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R153	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R154	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R156	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R160	315-0201-00		200 $\Omega$	$\frac{1}{4}$ W		5%
R161	315-0103-00		10 k $\Omega$	$\frac{1}{4}$ W		5%
R162	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W		5%
R163	315-0183-00		18 k $\Omega$	$\frac{1}{4}$ W		5%
R164	315-0102-00		1 k $\Omega$	$\frac{1}{4}$ W		5%
R165	315-0201-00		200 $\Omega$	$\frac{1}{4}$ W		5%

## LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R166	315-0153-00		15 kΩ	1/4 W		5%
R167	315-0222-00		2.2 kΩ	1/4 W		5%
R168	315-0332-00		3.3 kΩ	1/4 W		5%
R169	315-0472-00		4.7 kΩ	1/4 W		5%
R171	321-0205-00		1.33 kΩ	1/8 W	Prec	1%
R172	315-0201-00		200 Ω	1/4 W		5%
R173	315-0622-00		6.2 kΩ	1/4 W		5%
R174	315-0622-00		6.2 kΩ	1/4 W		5%
R175	321-0328-00		25.5 kΩ	1/8 W	Prec	1%
R176	315-0302-00		3 kΩ	1/4 W		5%
R177	315-0363-00		36 kΩ	1/4 W		5%
R178	315-0392-00		3.9 kΩ	1/4 W		5%
R179	315-0302-00		3 kΩ	1/4 W		5%
R180	315-0222-00		2.2 kΩ	1/4 W		5%
R181	315-0332-00		3.3 kΩ	1/4 W		5%
R182	315-0102-00		1 kΩ	1/4 W		5%
R183	315-0202-00		2 kΩ	1/4 W		5%
R191	315-0332-00		3.3 kΩ	1/4 W		5%
R192	315-0103-00		10 kΩ	1/4 W		5%
R193	315-0302-00		3 kΩ	1/4 W		5%
R194	315-0303-00		30 kΩ	1/4 W		5%
R195	315-0222-00		2.2 kΩ	1/4 W		5%
R196	315-0102-00		1 kΩ	1/4 W		5%
R197	315-0301-00		300 Ω	1/4 W		5%
R198	315-0332-00		3.3 kΩ	1/4 W		5%

## Integrated Circuits

U120	*155-0011-00	Monolithic
U130	*155-0010-00	Monolithic
U150	*155-0013-00	Monolithic
U160	*155-0009-00	Monolithic
U170	*155-0012-00	Monolithic
U180	*155-0013-00	Monolithic
U190	*155-0013-00	Monolithic

## VERT. SW. AND POWER INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
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\*670-0812-00

Complete Board

## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C919	290-0271-00	9 $\mu$ F	Elect.	125 V	+20%—15%
C939	290-0162-00	22 $\mu$ F	Elect.	35 V	
C959	290-0162-00	22 $\mu$ F	Elect.	35 V	
C979	290-0162-00	22 $\mu$ F	Elect.	35 V	
C999	290-0271-00	9 $\mu$ F	Elect.	125 V	+20%—15%

## Semiconductor Device, Diodes

CR200	152-0141-02	Silicon	1N4152
CR209	152-0141-02	Silicon	1N4152
CR210	152-0141-02	Silicon	1N4152
CR224	152-0141-02	Silicon	1N4152
CR230	152-0141-02	Silicon	1N4152
CR232	152-0141-02	Silicon	1N4152
CR233	152-0141-02	Silicon	1N4152
CR234	152-0141-02	Silicon	1N4152

## Transistors

Q202	151-0188-00	Silicon	2N3906
Q206	151-0188-00	Silicon	2N3906
Q212	151-0188-00	Silicon	2N3906
Q216	151-0188-00	Silicon	2N3906
Q218	151-0188-00	Silicon	2N3906
Q222	151-0188-00	Silicon	2N3906
Q224	151-0190-00	Silicon	2N3904
Q234	151-0190-00	Silicon	2N3904
Q236	151-0188-00	Silicon	2N3906
Q238	151-0188-00	Silicon	2N3906

## Resistors

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R200	315-0392-00	3.9 k $\Omega$	$\frac{1}{4}$ W	5%
R201	315-0242-00	2.4 k $\Omega$	$\frac{1}{4}$ W	5%
R202	315-0153-00	15 k $\Omega$	$\frac{1}{4}$ W	5%
R203	315-0122-00	1.2 k $\Omega$	$\frac{1}{4}$ W	5%
R204	315-0111-00	110 $\Omega$	$\frac{1}{4}$ W	5%

## VERT. SW. AND POWER INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
Resistors (cont)			
R205	323-0226-00	2.21 k $\Omega$	$\frac{1}{2}$ W Prec 1%
R206	315-0101-00	100 $\Omega$	$\frac{1}{4}$ W 5%
R207	315-0101-00	100 $\Omega$	$\frac{1}{4}$ W 5%
R208	315-0471-00	470 $\Omega$	$\frac{1}{4}$ W 5%
R209	315-0183-00	18 k $\Omega$	$\frac{1}{4}$ W 5%
R210	323-0228-00	2.32 k $\Omega$	$\frac{1}{2}$ W Prec 1%
R211	315-0101-00	100 $\Omega$	$\frac{1}{4}$ W 5%
R212	315-0101-00	100 $\Omega$	$\frac{1}{4}$ W 5%
R213	315-0111-00	110 $\Omega$	$\frac{1}{4}$ W 5%
R214	315-0122-00	1.2 k $\Omega$	$\frac{1}{4}$ W 5%
R215	315-0301-00	300 $\Omega$	$\frac{1}{4}$ W 5%
R216	315-0153-00	15 k $\Omega$	$\frac{1}{4}$ W 5%
R217	321-0190-00	931 $\Omega$	$\frac{1}{8}$ W Prec 1%
R218	321-0168-00	549 $\Omega$	$\frac{1}{8}$ W Prec 1%
R219	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W 5%
R220	315-0303-00	30 k $\Omega$	$\frac{1}{4}$ W 5%
R221	315-0471-00	470 $\Omega$	$\frac{1}{4}$ W 5%
R222	315-0103-00	10 k $\Omega$	$\frac{1}{4}$ W 5%
R223	315-0911-00	910 $\Omega$	$\frac{1}{4}$ W 5%
R224	315-0132-00	1.3 k $\Omega$	$\frac{1}{4}$ W 5%
R225	321-0251-00	4.02 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R226	315-0921-00	820 $\Omega$	$\frac{1}{4}$ W 5%
R227	315-0682-00	6.8 k $\Omega$	$\frac{1}{4}$ W 5%
R228	315-0821-00	820 $\Omega$	$\frac{1}{4}$ W 5%
R229	321-0251-00	4.02 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R230	321-0221-00	1.96 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R232	321-0221-00	1.96 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R233	321-0222-00	2 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R234	321-0202-00	1.24 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R235	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R236	321-0260-00	4.99 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R237	322-0187-00	866 $\Omega$	$\frac{1}{4}$ W Prec 1%
R238	321-0129-00	215 $\Omega$	$\frac{1}{8}$ W Prec 1%
R239	322-0187-00	866 $\Omega$	$\frac{1}{4}$ W Prec 1%

## VERTICAL INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
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\*670-0811-00

## Complete Board

## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C244	281-0122-00	2.5-9 pF, Var	Cer		
C246	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C247	281-0557-00	1.8 pF	Cer	500 V	10%
C249	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C256	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C259	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C266	281-0504-00	10 pF	Cer	500 V	10%
C268	281-0504-00	10 pF	Cer	500 V	10%
C274	281-0122-00	2.5-9 pF, Var	Cer		
C276	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C286	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C287	281-0557-00	1.8 pF	Cer	500 V	10%
C296	281-0504-00	10 pF	Cer	500 V	10%

## Semiconductor Device, Diodes

CR249	152-0141-02	Silicon	1N4152
CR259	152-0141-02	Silicon	1N4152
CR264	*152-0153-00	Silicon	Tek Spec
CR279	152-0141-02	Silicon	1N4152
CR289	152-0141-02	Silicon	1N4152
CR295	*152-0153-00	Silicon	Tek Spec

## Inductors

L240	*108-0557-00	35 nH
L250	*108-0557-00	35 nH
L270	*108-0557-00	35 nH
L280	*108-0557-00	35 nH

## Transistors

Q244	151-0202-00	Silicon	2N4261
Q248	*151-0259-00	Silicon	Selected from 2N3563
Q249	151-0190-00	Silicon	2N3904
Q254	151-0202-00	Silicon	2N4261
Q258	*151-0259-00	Silicon	Selected from 2N3563

## VERTICAL INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
<b>Transistors (cont)</b>			
Q264	151-0222-00	Silicon	2N4251
Q274	151-0202-00	Silicon	2N4261
Q278	*151-0259-00	Silicon	Selected from 2N3563
Q279	151-0190-00	Silicon	2N3904
Q284	151-0202-00	Silicon	2N4261
Q288	*151-0259-00	Silicon	Selected from 2N3563
Q294	151-0222-00	Silicon	2N4251

**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R240	321-0825-03	50.8 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{4}\%$
R241	322-0206-00	1.37 k $\Omega$	$\frac{1}{4}$ W	Prec	1%
R242	311-0543-00	50 $\Omega$ , Var			
R243	321-0058-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R244	317-0270-00	27 $\Omega$	$\frac{1}{8}$ W		5%
R245	321-0160-00	453 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R246	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R247	317-0181-00	180 $\Omega$	$\frac{1}{8}$ W		5%
R248	321-0166-00	523 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R249	321-0191-00	953 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R250	321-0825-03	50.8 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{4}\%$
R251	322-0206-00	1.37 k $\Omega$	$\frac{1}{4}$ W	Prec	1%
R252	317-0550-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R253	321-0058-00	49.9 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R254	311-0505-00	200 $\Omega$ , Var			
R255	321-0160-00	453 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R256	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R257	311-0543-00	50 $\Omega$ , Var			
R258	321-0166-00	523 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R259	321-0191-00	953 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R260	315-0103-00	10 k $\Omega$	$\frac{1}{4}$ W		5%
R261	321-0143-00	301 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R262	321-0123-00	187 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R263	321-0083-00	71.5 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R264	321-0091-00	86.6 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R265	315-0513-00	51 k $\Omega$	$\frac{1}{4}$ W		5%
R266	321-0062-00	43.2 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R268	317-0181-00	180 $\Omega$	$\frac{1}{8}$ W		5%
R270	321-0825-03	50.8 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{4}\%$
R271	322-0206-00	1.37 k $\Omega$	$\frac{1}{4}$ W	Prec	1%

## VERTICAL INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R273	321-0068-00		49.9 Ω	1/8 W	Prec	1%
R274	311-0605-00		200 Ω, Var			
R275	321-0160-00		453 Ω	1/8 W	Prec	1%
R276	317-0560-00		56 Ω	1/8 W		5%
R277	311-0643-00		50 Ω, Var			
R278	321-0166-00		523 Ω	1/8 W	Prec	1%
R279	321-0191-00		853 Ω	1/8 W	Prec	1%
R280	321-0825-03		50.8 Ω	1/8 W	Prec	1/4 %
R281	322-0206-00		1.37 kΩ	1/4 W	Prec	1%
R282	317-0130-00		13 Ω	1/8 W		5%
R283	321-0068-00		49.9 Ω	1/8 W	Prec	1%
R284	317-0270-00		27 Ω	1/8 W		5%
R285	321-0160-00		453 Ω	1/8 W	Prec	1%
R286	317-0560-00		56 Ω	1/8 W		5%
R287	317-0181-00		180 Ω	1/8 W		5%
R288	321-0166-00		523 Ω	1/8 W	Prec	1%
R289	321-0191-00		953 Ω	1/8 W	Prec	1%
R290	315-0103-00		10 kΩ	1/4 W		5%
R291	321-0143-00		301 Ω	1/8 W	Prec	1%
R292	321-0123-00		187 Ω	1/8 W	Prec	1%
R293	321-0083-00		71.5 Ω	1/8 W	Prec	1%
R294	321-0091-00		86.6 Ω	1/8 W	Prec	1%
R295	323-0128-00		210 Ω	1/2 W	Prec	1%
R296	321-0062-00		43.2 Ω	1/8 W	Prec	1%

## TRIG. SEL. Circuit Board Assembly

\*670-0625-00

Complete Board

## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C309	281-0541-00	6.8 pF	Cer	500 V	10%
C319	281-0626-00	3.3 pF	Cer	500 V	5%
C325	281-0541-00	6.8 pF	Cer	500 V	10%
C329	281-0541-00	6.8 pF	Cer	500 V	10%
C342	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C346	283-0000-00	0.001 $\mu$ F	Cer	500 V	



## TRIG. SEL. Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Semiconductor Device, Diodes						
CR342	152-0141-02		Silicon	1N4152		
CR346	152-0141-02		Silicon	1N4152		
Transistors						
Q314	151-0221-00		Silicon	2N4258		
Q316	151-0221-00		Silicon	2N4258		
Q334	*151-0259-00		Silicon	Selected from 2N3563		
Q336	*151-0259-00		Silicon	Selected from 2N3563		
Q344	151-0221-00		Silicon	2N4258		
Q346	151-0221-00		Silicon	2N4258		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R301	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R302	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R303	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R304	322-0184-00		806 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R305	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R306	321-0218-00		1.82 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R307	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R308	322-0184-00		806 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R309	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R311	317-0330-00		33 $\Omega$	$\frac{1}{8}$ W		5%
R312	317-0330-00		33 $\Omega$	$\frac{1}{8}$ W		5%
R313	323-0155-00		402 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R314	323-0155-00		402 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R316	317-0331-00		330 $\Omega$	$\frac{1}{8}$ W		5%
R318	321-0214-00		1.65 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R319	321-0214-00		1.65 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R321	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R322	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R323	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R324	322-0184-00		806 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R325	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R326	321-0218-00		1.82 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R327	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R328	322-0184-00		806 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R329	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R331	321-0044-00		28 $\Omega$	$\frac{1}{8}$ W	Prec	1%

**TRIG. SEL. Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R332	321-0044-00		28 Ω	1/8 W	Prec	1%
R335	321-0220-00		1.91 kΩ	1/8 W	Prec	1%
R336	321-0143-00		301 Ω	1/8 W	Prec	1%
R337	321-0129-00		215 Ω	1/8 W	Prec	1%
R338	321-0129-00		215 Ω	1/8 W	Prec	1%
R339	321-0097-00		100 Ω	1/8 W	Prec	1%
R341	321-0214-00		1.65 kΩ	1/8 W	Prec	1%
R342	315-0331-00		330 Ω	1/4 W		5%
R343	321-0040-00		25.5 Ω	1/8 W	Prec	1%
R344	315-0561-00		560 Ω	1/4 W		5%
R345	321-0040-00		25.5 Ω	1/8 W	Prec	1%
R346	315-0331-00		330 Ω	1/4 W		5%
R347	321-0214-00		1.65 kΩ	1/8 W	Prec	1%
R349	301-0220-00		22 Ω	1/2 W		5%

**Integrated Circuits**

U304	*155-0022-00	Monolithic
U324	*155-0022-00	Monolithic

**HORIZONTAL INTERFACE Circuit Board Assembly**

\*670-0808-00

Complete Board

**Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C361	283-0000-00	0.001 $\mu$ F	Cer	500 V
C371	283-0000-00	0.001 $\mu$ F	Cer	500 V

**Transistors**

Q384	151-0220-00	Silicon	2N4122
Q394	151-0220-00	Silicon	2N4122

**HORIZONTAL INTERFACE Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
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**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R352	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R354	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R356	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R358	321-1068-02		50.5 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R361	315-0303-00		30 k $\Omega$	$\frac{1}{4}$ W		5%
R363	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R365	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R367	323-0187-00		866 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R369	321-0218-00		1.82 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R371	315-0303-00		30 k $\Omega$	$\frac{1}{4}$ W		5%
R373	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R375	321-0741-02		40.9 $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R377	323-0187-00		866 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R381	317-0200-00		20 $\Omega$	$\frac{1}{8}$ W		5%
R383	323-0155-00		402 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R385	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R387	317-0241-00		240 $\Omega$	$\frac{1}{8}$ W		5%
R389	322-0219-00		1.87 k $\Omega$	$\frac{1}{4}$ W	Prec	1%
R391	317-0200-00		20 $\Omega$	$\frac{1}{8}$ W		5%
R393	323-0155-00		402 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R395	321-0199-00		1.15 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R397	317-0241-00		240 $\Omega$	$\frac{1}{8}$ W		5%
R399	322-0219-00		1.87 k $\Omega$	$\frac{1}{4}$ W	Prec	1%

**Integrated Circuits**

U364	*155-0022-00	Monolithic
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**VERTICAL OUTPUT Circuit Board Assembly**

\*670-0809-00

Complete Board

**Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C401	281-0572-00	6.8 pF	Cer	500 V	$\pm 0.5$ pF
C408	281-0572-00	6.8 pF	Cer	500 V	$\pm 0.5$ pF
C411	283-0001-00	0.005 $\mu$ F	Cer	500 V	
C417	283-0001-00	0.005 $\mu$ F	Cer	500 V	
C426	281-0547-00	2.7 pF	Cer	500 V	10%

## VERTICAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors (cont)						
C430	281-0122-00		2.5-9 pF, Var	Glass		
C435	283-0078-00		0.001 $\mu$ F	Cer	500 V	
C438	283-0078-00		0.001 $\mu$ F	Cer	500 V	
C447 <sup>13</sup>						
C448 <sup>14</sup>						
C451	283-0003-00		0.01 $\mu$ F	Cer	150 V	
C458	281-0123-00		5-25 pF, Var	Cer		
C460	283-0078-00		0.001 $\mu$ F	Cer	500 V	
C465	283-0078-00		0.001 $\mu$ F	Cer	500 V	
C470 <sup>15</sup>						
C471 <sup>16</sup>						
C472	281-0645-00		8.2 pF	Cer	500 V	$\pm 0.25$ pF
C478	283-0003-00		0.01 $\mu$ F	Cer	150 V	
C479	283-0003-00		0.01 $\mu$ F	Cer	150 V	
C495	283-0003-00		0.01 $\mu$ F	Cer	150 V	
C497	283-0003-00		0.01 $\mu$ F	Cer	150 V	
C499	283-0003-00		0.01 $\mu$ F	Cer	150 V	

## Semiconductor Device, Diodes

VR411	152-0166-00	Zener	1N753A	400 mW, 6.2 V, 5%
VR417	152-0166-00	Zener	1N753A	400 mW, 6.2 V, 5%
CR431	152-0271-00	Silicon	Voltage variable capacitance	
CR432	152-0271-00	Silicon	Voltage variable capacitance	
CR449	152-0166-00	Zener	1N753A	400 mW, 6.2 V, 5%
VR467	152-0195-00	Zener	1N751A	400 mW, 5.1 V, 5%
VR469	152-0195-00	Zener	1N751A	400 mW, 5.1 V, 5%

## Inductors

L401	*108-0260-00	0.1 $\mu$ H
L408	*108-0260-00	0.1 $\mu$ H
L421	*108-0103-00	2.5 $\mu$ H
L422	*108-0095-01	1.4 $\mu$ H
L423	*108-0146-00	5 $\mu$ H

<sup>13</sup>Furnished as a unit with L447.<sup>14</sup>Furnished as a unit with L448.<sup>15</sup>Furnished as a unit with L470.<sup>16</sup>Furnished as a unit with L471.

## VERTICAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Inductors (cont)</b>				
L447 <sup>17</sup>	*388-0867-00			T coil, 4 turns
L448 <sup>18</sup>	*388-0867-00			T coil, 4 turns
L452	*108-0440-00			8 $\mu$ H
L470 <sup>19</sup>	*388-0868-00			T coil, 3 turns
L471 <sup>20</sup>	*388-0868-00			T coil, 3 turns
L480	*108-0440-00			8 $\mu$ H
L497	*108-0440-00			8 $\mu$ H
L499	*108-0440-00			8 $\mu$ H

**Transistors**

Q412	*151-0213-00	Silicon	Selected from 2N4251
Q416	*151-0213-00	Silicon	Selected from 2N4251
Q434	151-0202-00	Silicon	2N4261
Q436	151-0202-00	Silicon	2N4261
Q442	151-0202-00	Silicon	2N4261
Q444	151-0202-00	Silicon	2N4261
Q454	151-0222-00	Silicon	2N4251
Q456	151-0222-00	Silicon	2N4251
Q466	*151-0259-00	Silicon	Selected from 2N3563
Q468	*151-0259-00	Silicon	Selected from 2N3563
Q470	*151-0213-00	Silicon	Selected from 2N4251
Q476	*151-0213-00	Silicon	Selected from 2N4251

**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R401	321-0067-00	48.7 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R402	321-0184-00	806 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R404	323-0229-00	2.37 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R405	317-0101-00	100 $\Omega$	$\frac{1}{8}$ W		5%
R406	323-0229-00	2.37 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R408	321-0067-00	48.7 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R411	315-0201-00	200 $\Omega$	$\frac{1}{4}$ W		5%
R413	315-0222-00	2.2 k $\Omega$	$\frac{1}{4}$ W		5%
R415	315-0161-00	160 $\Omega$	$\frac{1}{4}$ W		5%
R417	315-0201-00	200 $\Omega$	$\frac{1}{4}$ W		5%

<sup>17</sup>Furnished as a unit with C447.<sup>18</sup>Furnished as a unit with C448.<sup>19</sup>Furnished as a unit with C470.<sup>20</sup>Furnished as a unit with C471.

## VERTICAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description			
Resistors (cont)							
R418	321-0105-00		121 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R419	321-0105-00		121 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R420	321-0116-00		158 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R421	311-0622-00		100 $\Omega$ , Var				
R422	311-0605-00		200 $\Omega$ , Var				
R423	311-0643-00		50 $\Omega$ , Var				
R424	321-0116-00		158 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R425	317-0101-00		100 $\Omega$	$\frac{1}{8}$ W			5%
R426	317-0101-00		100 $\Omega$	$\frac{1}{8}$ W			5%
R427	321-0130-00		221 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R428	321-0105-00		121 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R429	321-0105-00		121 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R430	311-0635-00		1 k $\Omega$ , Var				
R431	317-0820-00		82 $\Omega$	$\frac{1}{8}$ W			5%
R432	317-0820-00		82 $\Omega$	$\frac{1}{8}$ W			5%
RT433	307-0181-00		100 k $\Omega$	Thermal			
R434	315-0512-00		5.1 k $\Omega$	$\frac{1}{4}$ W			5%
R435	317-0390-00		39 $\Omega$	$\frac{1}{8}$ W			5%
R436	317-0431-00		430 $\Omega$	$\frac{1}{8}$ W			5%
R437	317-0431-00		430 $\Omega$	$\frac{1}{8}$ W			5%
R438	317-0390-00		39 $\Omega$	$\frac{1}{8}$ W			5%
R441	317-0512-00		5.1 k $\Omega$	$\frac{1}{8}$ W			5%
R443	311-0507-00		10 k $\Omega$ , Var				
R444	317-0512-00		5.1 k $\Omega$	$\frac{1}{8}$ W			5%
R445	315-0221-00		220 $\Omega$	$\frac{1}{4}$ W			5%
R447	321-0094-00		93.1 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R448	321-0094-00		93.1 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R449	301-0331-00		330 $\Omega$	$\frac{1}{2}$ W			5%
R451	315-0112-00		1.1 k $\Omega$	$\frac{1}{4}$ W			5%
R452	323-0125-00		196 $\Omega$	$\frac{1}{2}$ W	Prec		1%
R454	321-0055-00		36.5 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R455	321-0055-00		36.5 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R456	321-0055-00		36.5 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R457	321-0055-00		36.5 $\Omega$	$\frac{1}{8}$ W	Prec		1%
R458	311-0505-00		200 $\Omega$ , Var				
R460	317-0470-00		47 $\Omega$	$\frac{1}{8}$ W			5%
R461	317-0221-00		220 $\Omega$	$\frac{1}{8}$ W			5%
R462	317-0221-00		220 $\Omega$	$\frac{1}{8}$ W			5%
R463	317-0221-00		220 $\Omega$	$\frac{1}{8}$ W			5%
R464	317-0221-00		220 $\Omega$	$\frac{1}{8}$ W			5%

## VERTICAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R465	317-0470-00		47 Ω	1/8 W		5%
R466	315-0181-00		180 Ω	1/4 W		5%
R467	317-0101-00		100 Ω	1/8 W		5%
R468	311-0633-00		5 kΩ, Var			
R469	317-0181-00		180 Ω	1/8 W		5%
R470	321-0076-00		60.4 Ω	1/8 W	Prec	1%
R471	321-0076-00		60.4 Ω	1/8 W	Prec	1%
RT472	307-0127-00		1 kΩ	Thermal		
R473	321-0036-00		23.2 Ω	1/8 W	Prec	1%
R474	321-0036-00		23.2 Ω	1/8 W	Prec	1%
R475	321-0036-00		23.2 Ω	1/8 W	Prec	1%
R476	321-0036-00		23.2 Ω	1/8 W	Prec	1%
R477	308-0450-00		70 Ω	3 W	WW	1%
R478	301-0150-00		15 Ω	1/2 W		5%
R479	301-0150-00		15 Ω	1/2 W		5%
R480	315-0201-00		200 Ω	1/4 W		5%
RT480	307-0124-00		5 kΩ	Thermal		
R490	321-0016-00		14.3 Ω	1/8 W	Prec	1%
R491	301-0180-00		18 Ω	1/2 W		5%
R492	321-0016-00		14.3 Ω	1/8 W	Prec	1%
R494	321-0017-00		14.7 Ω	1/8 W	Prec	1%
R495	323-0034-00		22.1 Ω	1/2 W	Prec	1%

## Transformer

T466	*120-0469-00	Toroid, 3 turns, bifilar
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## HORIZONTAL OUTPUT Circuit Board Assembly

\*670-0807-00

Complete Board

## Capacitors

Tolerance = 20% unless otherwise indicated.

C501	283-0010-00	0.05 $\mu$ F	Cer	50 V
C503	290-0135-00	15 $\mu$ F	Elect.	20 V
C505	290-0135-00	15 $\mu$ F	Elect.	20 V
C527	283-0000-00	0.001 $\mu$ F	Cer	500 V
C537	283-0000-00	0.001 $\mu$ F	Cer	500 V

## HORIZONTAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors (cont)						
C544	283-0093-00		0.0047 $\mu$ F	Cer	500 V	5%
C554	283-0041-00		0.0033 $\mu$ F	Cer	500 V	5%
C560	283-0092-00		0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C563	281-0513-00		27 pF	Cer	500 V	
C564	283-0080-00		0.022 $\mu$ F	Cer	25 V	+ 80% — 20%
C568	281-0091-00		2-8 pF, Var	Cer		
C569	281-0064-00		0.25-1.5 pF, Var	Tub.		
C573	281-0513-00		27 pF	Cer	500 V	
C579	281-0064-00		0.25-1.5 pF, Var	Tub.		
C580	283-0057-00		0.1 $\mu$ F	Cer	200 V	+ 80% — 20%
C583	283-0092-00		0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C586	283-0031-00		0.1 $\mu$ F	Cer	25 V	+ 80% — 20%
C590	283-0057-00		0.1 $\mu$ F	Cer	200 V	+ 80% — 20%
C593	283-0092-00		0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C596	283-0081-00		0.1 $\mu$ F	Cer	25 V	+ 80% — 20%

## Semiconductor Device, Diodes

CR528	*152-0153-00	Silicon	Tek Spec
CR538	*152-0153-00	Silicon	Tek Spec
CR544	*152-0153-00	Silicon	Tek Spec
CR554	*152-0153-00	Silicon	Tek Spec
CR558	*152-0185-00	Silicon	Replaceable by 1N4152
CR560	152-0333-00	Silicon	High speed and conductance
CR562	*152-0185-00	Silicon	Replaceable by 1N4152
CR570	152-0333-00	Silicon	High speed and conductance

## Inductors

L503	*108-0245-00	3.9 $\mu$ H
L505	*108-0245-00	3.9 $\mu$ H
L589	276-0543-00	Core, ferrite
L599	276-0543-00	Core, ferrite

## Transistors

Q514	151-0190-00	Silicon	2N3904
Q526	*151-0127-00	Silicon	Selected from 2N2369
Q536	*151-0127-00	Silicon	Selected from 2N2369
Q544	*151-0127-00	Silicon	Selected from 2N2369
Q548	151-0220-00	Silicon	2N4122



## HORIZONTAL OUTPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Transistors (cont)				
Q554	151-0301-00		Silicon	2N2907
Q558	151-0220-00		Silicon	2N4122
Q562	151-0190-00		Silicon	2N3904
Q564	*151-0127-00		Silicon	Selected from 2N2369
Q574	*151-0127-00		Silicon	Selected from 2N2369
Q592	*151-0270-00		Silicon	High voltage, Tek Spec
Q584	*151-0274-00		Silicon	Selected from 2N3501
Q592	*151-0270-00		Silicon	High voltage, Tek Spec
Q594	*151-0274-00		Silicon	Selected from 2N3501
Resistors				
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R501	315-0201-00		200 $\Omega$	$\frac{1}{4}$ W 5%
R511	315-0302-00		3 k $\Omega$	$\frac{1}{4}$ W 5%
R513	315-0102-00		1 k $\Omega$	$\frac{1}{4}$ W 5%
R515	315-0221-00		220 $\Omega$	$\frac{1}{4}$ W 5%
R521	323-0168-00		549 $\Omega$	$\frac{1}{2}$ W Prec 1%
R522	311-0622-01		100 $\Omega$ , Var	
R524	315-0511-00		510 $\Omega$	$\frac{1}{4}$ W 5%
R525	321-0184-00		806 $\Omega$	$\frac{1}{8}$ W Prec 1%
R526	321-0073-00		56.2 $\Omega$	$\frac{1}{8}$ W Prec 1%
R527	321-0096-00		97.6 $\Omega$	$\frac{1}{8}$ W Prec 1%
R528	321-0178-00		698 $\Omega$	$\frac{1}{8}$ W Prec 1%
R529	311-0658-00		500 $\Omega$ , Var	
R531	323-0168-00		549 $\Omega$	$\frac{1}{2}$ W Prec 1%
R532	321-0066-00		47.5 $\Omega$	$\frac{1}{8}$ W Prec 1%
R533	321-0071-00		53.6 $\Omega$	$\frac{1}{8}$ W Prec 1%
RT534	307-0127-00		1 k $\Omega$	Thermal
R536	321-0070-00		52.3 $\Omega$	$\frac{1}{8}$ W Prec 1%
R537	321-0096-00		97.6 $\Omega$	$\frac{1}{8}$ W Prec 1%
R538	321-0178-00		698 $\Omega$	$\frac{1}{8}$ W Prec 1%
R543	323-0101-00		110 $\Omega$	$\frac{1}{2}$ W Prec 1%
R544	321-0108-00		130 $\Omega$	$\frac{1}{8}$ W Prec 1%
R546	323-0086-00		76.8 $\Omega$	$\frac{1}{2}$ W Prec 1%
R547	321-0186-00		845 $\Omega$	$\frac{1}{8}$ W Prec 1%
R548	321-0244-00		3.4 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R549	315-0152-00		1.5 k $\Omega$	$\frac{1}{4}$ W 5%
R553	323-0133-00		237 $\Omega$	$\frac{1}{2}$ W Prec 1%
R554	321-0120-00		174 $\Omega$	$\frac{1}{8}$ W Prec 1%
R556	323-0178-00		698 $\Omega$	$\frac{1}{2}$ W Prec 1%
R557	321-0251-00		4.02 k $\Omega$	$\frac{1}{8}$ W Prec 1%
R558	321-0193-00		1 k $\Omega$	$\frac{1}{8}$ W Prec 1%

**HORIZONTAL OUTPUT Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R559	315-0681-00		680 $\Omega$	$\frac{1}{4}$ W		5%
R562	321-0190-00		931 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R563	322-0126-00		200 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R564	315-0220-00		22 $\Omega$	$\frac{1}{4}$ W		5%
R565	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R566	321-0230-00		2.43 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R567	321-0224-00		2.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R568	311-0533-00		5 k $\Omega$ , Var			
R569	323-0316-00		19.1 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R571	311-0643-00		50 $\Omega$ , Var			
R572	321-0177-00		681 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R573	322-0126-00		200 $\Omega$	$\frac{1}{4}$ W	Prec	1%
R575	315-0332-00		3.3 k $\Omega$	$\frac{1}{4}$ W		5%
R576	321-0230-00		2.43 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R577	321-0224-00		2.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R579	323-0316-00		19.1 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R581	303-0273-00		27 k $\Omega$	1 W		5%
R582	323-0233-00		2.61 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R583	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W		5%
R585	303-0202-00		2 k $\Omega$	1 W		5%
R586	315-0820-00		82 $\Omega$	$\frac{1}{4}$ W		5%
R588	323-0253-00		4.22 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R589	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R591	303-0273-00		27 k $\Omega$	1 W		5%
R592	323-0233-00		2.61 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R593	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W		5%
R595	303-0202-00		2 k $\Omega$	1 W		5%
R596	315-0820-00		82 $\Omega$	$\frac{1}{4}$ W		5%
R597	323-0349-00		42.2 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R598	323-0349-00		42.2 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R599	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%

**OUTPUT SIGNAL Circuit Board Assembly****\*670-0632-00****Complete Board****Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C609	283-0080-00	0.022 $\mu$ F	Cer	25 V	+ 80%—20%
C612	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C616	281-0603-00	39 pF	Cer	500 V	5%
C618	283-0080-00	0.022 $\mu$ F	Cer	25 V	+ 80%—20%
C619	283-0031-00	0.1 $\mu$ F	Cer	25 V	+ 80%—20%

## OUTPUT SIGNAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors (cont)						
C674	283-0081-00		0.1 $\mu$ F	Cer	500 V	
C675	281-0510-00		22 pF	Cer	25 V	+ 80% — 20%
C677	283-0081-00		0.1 $\mu$ F	Cer	500 V	10%
C682	283-0003-00		0.1 $\mu$ F	Cer	25 V	+ 80% — 20%
C683	283-0000-00		0.01 $\mu$ F	Cer	150 V	

C686	283-0000-00		0.001 $\mu$ F	Cer	500 V	
C695	283-0000-00		0.001 $\mu$ F	Cer	500 V	
C698	283-0000-00		0.001 $\mu$ F	Cer	500 V	

## Semiconductor Device, Diodes

CR614	*152-0185-00		Silicon	Replaceable by 1N4152		
CR615	*152-0185-00		Silicon	Replaceable by 1N4152		
CR616	*152-0185-00		Silicon	Replaceable by 1N4152		
CR674	*152-0185-00		Silicon	Replaceable by 1N4152		
CR676	*152-0185-00		Silicon	Replaceable by 1N4152		
CR696	*152-0185-00		Silicon	Replaceable by 1N4152		
CR699	*152-0185-00		Silicon	Replaceable by 1N4152		

## Inductors

L619	*108-0245-00		3.9 $\mu$ H			
L682	*108-0440-00		8 $\mu$ H			

## Transistors

Q607	151-0190-00		Silicon	2N3904		
Q608	151-0190-00		Silicon	2N3904		
Q610	151-0190-00		Silicon	2N3904		
Q611	151-0190-00		Silicon	2N3904		
Q615	151-0188-00		Silicon	2N3906		

Q670	151-0190-00		Silicon	2N3904		
Q672	151-0190-00		Silicon	2N3904		
Q675	151-0220-00		Silicon	2N4122		
Q684	151-0221-00		Silicon	2N4258		
Q686	151-0188-00		Silicon	2N3906		

Q694	151-0221-00		Silicon	2N4258		
Q696	151-0188-00		Silicon	2N3906		

## OUTPUT SIGNAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R600	315-0201-00		200 $\Omega$	$\frac{1}{4}$ W		5%
R601	315-0752-00		7.5 k $\Omega$	$\frac{1}{4}$ W		5%
R602	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R603	315-0181-00		180 $\Omega$	$\frac{1}{4}$ W		5%
R604	315-0123-00		12 k $\Omega$	$\frac{1}{4}$ W		5%
R605	315-0181-00		180 $\Omega$	$\frac{1}{4}$ W		5%
R606	315-0123-00		12 k $\Omega$	$\frac{1}{4}$ W		5%
R607	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R608	323-0193-00		1 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R609	315-0821-00		820 $\Omega$	$\frac{1}{4}$ W		5%
R610	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R611	315-0822-00		8.2 k $\Omega$	$\frac{1}{4}$ W		5%
R612	315-0551-00		560 $\Omega$	$\frac{1}{4}$ W		5%
R613	321-0143-00		301 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R614	321-0180-00		732 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R615	321-0226-00		2.21 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R616	323-0189-00		909 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R617	301-0390-00		39 $\Omega$	$\frac{1}{2}$ W		5%
R618	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W		5%
R619	315-0220-00		22 $\Omega$	$\frac{1}{4}$ W		5%
R667	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W		5%
R669	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R672	315-0222-00		2.2 k $\Omega$	$\frac{1}{4}$ W		5%
R673	315-0241-00		240 $\Omega$	$\frac{1}{4}$ W		5%
R674	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R675	315-0152-00		1.5 k $\Omega$	$\frac{1}{4}$ W		5%
R676	315-0272-00		2.7 k $\Omega$	$\frac{1}{4}$ W		5%
R677	315-0220-00		22 $\Omega$	$\frac{1}{4}$ W		5%
R678	321-0260-00		4.99 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R679	323-0190-00		931 $\Omega$	$\frac{1}{2}$ W	Prec	1%
R681	321-0069-00		51.1 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R682	307-0106-00		4.7 $\Omega$	$\frac{1}{4}$ W		5%
R683	321-0032-00		69.8 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R684	321-0091-00		86.6 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R685	321-0020-00		15.8 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R686	315-0151-00		150 $\Omega$	$\frac{1}{4}$ W		5%
R687	321-0229-00		2.37 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R688	321-0244-00		3.4 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R692	321-0069-00		51.1 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R694	321-0020-00		15.8 $\Omega$	$\frac{1}{8}$ W	Prec	1%

## OUTPUT SIGNAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R695	315-0151-00		150 Ω	1/4 W		5%
R696	321-0224-00		2.1 kΩ	1/8 W	Prec	1%
R697	323-0208-00		1.43 kΩ	1/2 W	Prec	1%
R698	307-0106-00		4.7 Ω	1/4 W		5%
R699	321-0097-00		100 Ω	1/8 W	Prec	1%

## Switches

Wired or Unwired

S607	260-0984-00	Slide	GATE
S665	260-0723-00	Slide	SWP

## CALIBRATOR Circuit Board Assembly

\*670-0633-00

Complete Board

## Capacitors

Tolerance —20% unless otherwise indicated.

C621	285-0824-00	0.047 $\mu$ F	PTM	100 V	1%
C623	283-0095-00	56 pF	Cer	200 V	10%
C628	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C633	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80% —20%
C645	283-0003-00	0.01 $\mu$ F	Cer	150 V	
C648	283-0000-00	0.001 $\mu$ F	Cer	500 V	

## Semiconductor Device, Diode

CR637	*152-0185-00	Silicon	Replaceable by 1N4152
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## Transistors

Q624	151-0273-00	Silicon	2N5249
Q626	151-0273-00	Silicon	2N5249
Q634	151-0190-00	Silicon	2N3904
Q636	151-0190-00	Silicon	2N3904
Q642	151-0276-00	Silicon	2N5087
Q644	151-0276-00	Silicon	2N5087
Q646	151-0190-00	Silicon	2N3904

## CALIBRATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
<b>Resistors</b>						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R621	321-0364-00	60.4 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R623	315-0272-00	2.7 k $\Omega$	$\frac{1}{4}$ W			5%
R624	308-0569-00	2.7 k $\Omega$	3 W	WW		1%
R625	311-0480-00	500 $\Omega$ , Var				
R626	315-0153-00	15 k $\Omega$	$\frac{1}{4}$ W			5%
R627	321-0374-00	76.8 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R628	315-0472-00	4.7 k $\Omega$	$\frac{1}{4}$ W			5%
R630	315-0302-00	3 k $\Omega$	$\frac{1}{4}$ W			5%
R631	315-0302-00	3 k $\Omega$	$\frac{1}{4}$ W			5%
R632	315-0123-00	12 k $\Omega$	$\frac{1}{4}$ W			5%
R633	315-0560-00	56 $\Omega$	$\frac{1}{4}$ W			5%
R634	315-0511-00	510 $\Omega$	$\frac{1}{4}$ W			5%
R635	315-0513-00	51 k $\Omega$	$\frac{1}{4}$ W			5%
R636	321-0315-00	18.7 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R637	321-0356-00	49.9 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R639	321-0195-00	1.05 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R640	311-0510-00	10 k $\Omega$ , Var				
R641	321-0297-00	12.1 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R642	323-0249-00	3.83 k $\Omega$	$\frac{1}{2}$ W	Prec		1%
R643	321-1188-06	898 $\Omega$	$\frac{1}{8}$ W	Prec		$\frac{1}{4}\%$
R644	315-0103-00	10 k $\Omega$	$\frac{1}{4}$ W			5%
R645	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W			5%
R646	321-0281-06	8.25 k $\Omega$	$\frac{1}{8}$ W	Prec		$\frac{1}{4}\%$
R647	321-0820-06	42 k $\Omega$	$\frac{1}{8}$ W	Prec		$\frac{1}{4}\%$
R648	315-0913-00	91 k $\Omega$	$\frac{1}{4}$ W			5%
R649	311-0624-00	200 k $\Omega$ , Var				
R650	316-0101-00	100 $\Omega$	$\frac{1}{4}$ W			
R651	301-0103-00	10 k $\Omega$	$\frac{1}{2}$ W			5%
R652	323-0761-07	4.05 k $\Omega$	$\frac{1}{2}$ W	Prec		1/10%
R653	321-0815-07	4.1 k $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R654	321-0812-07	455 $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R655	321-0811-07	56.3 $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R656	321-0813-07	495 $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R657	321-0810-07	55 $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R658	321-0816-07	5 k $\Omega$	$\frac{1}{8}$ W	Prec		1/10%
R659	321-1068-07	50.5 $\Omega$	$\frac{1}{8}$ W	Prec		1/10%

## CALIBRATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
<b>Switches</b>				
	<b>Wired or Unwired</b>			
S630 <sup>21</sup>	*670-0633-00		Cam	CALIBRATOR RATE
S655 <sup>21</sup>	*670-0633-00		Cam	

**Integrated Circuit**

U632	156-0012-00	Clocked J-K Flipflop Replaceable by Fairchild $\mu$ L923		
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**Z AXIS Circuit Board Assembly**

\*670-0806-00

Complete Board

**Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C703	281-0504-00	10 pF	Cer	500 V	10%
C711	290-0305-00	3 $\mu$ F	Elect.	150 V	
C712	283-0004-00	0.02 $\mu$ F	Cer	150 V	
C713	283-0090-00	0.022 $\mu$ F	Cer	25 V	+ 80% — 20%
C716	283-0081-00	0.1 $\mu$ F	Cer	25 V	+ 80% — 20%
C718	281-0572-00	6.8 pF	Cer	500 V	$\pm 0.5$ pF
C719	283-0078-00	0.001 $\mu$ F	Cer	500 V	
C723	283-0078-00	0.001 $\mu$ F	Cer	500 V	
C726	283-0080-00	0.022 $\mu$ F	Cer	25 V	+ 80% — 20%
C727	283-0030-00	0.022 $\mu$ F	Cer	25 V	+ 80% — 20%
C729	290-0149-00	5 $\mu$ F	Elect.	150 V	
C730	283-0110-00	0.005 $\mu$ F	Cer	150 V	
C732	281-0064-00	0.25-1.5 pF, Var	Tub.		
C734	283-0092-00	0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C747	285-0622-00	0.1 $\mu$ F	PTM	100 V	
C748	285-0604-00	0.01 $\mu$ F	PTM	400 V	
C755	283-0010-00	0.05 $\mu$ F	Cer	150 V	
C759	285-0629-00	0.047 $\mu$ F	PTM	100 V	
C792	283-0092-00	0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C793	283-0092-00	0.03 $\mu$ F	Cer	200 V	+ 80% — 20%
C797	283-0092-00	0.03 $\mu$ F	Cer	200 V	+ 80% — 20%

<sup>21</sup>See Mechanical Parts List for replacement parts.

**Z AXIS Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description		
Semiconductor Device, Diodes					
CR708	*152-0185-00	Silicon	Replaceable by 1N4152		
CR718	*152-0185-00	Silicon	Replaceable by 1N4152		
CR734	*152-0185-00	Silicon	Replaceable by 1N4152		
CR735	*152-0107-00	Silicon	Replaceable by 1N647		
CR747	152-0246-00	Silicon	Low leakage 250 mW, 40 V		
CR759	*152-0185-00	Silicon	Replaceable by 1N4152		
Transistors					
Q704	151-0190-00	Silicon	2N3904		
Q706	151-0190-00	Silicon	2N3904		
Q709	151-0190-00	Silicon	2N3904		
Q712	151-0250-00	Silicon	2N5184		
Q718	151-0220-00	Silicon	2N4122		
Q724	151-0220-00	Silicon	2N4122		
Q732	151-0214-00	Silicon	2N3495		
Q734	*151-0124-00	Silicon	Selected from 2N3119		
Q752	*151-0126-00	Silicon	Replaceable by 2N2484		
Q756	151-0188-00	Silicon	2N3906		
Q758	151-0260-00	Silicon	2N5189		
Resistors					
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated					
R701	315-0471-00	470 $\Omega$	$\frac{1}{4}$ W	Prec	5%
R703	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W		5%
R705	321-0261-00	5.11 k $\Omega$	$\frac{1}{8}$ W		1%
R707	315-0823-00	82 k $\Omega$	$\frac{1}{4}$ W		5%
R709	315-0104-00	100 k $\Omega$	$\frac{1}{4}$ W		5%
R711	315-0104-00	100 k $\Omega$	$\frac{1}{4}$ W	Prec	5%
R712	301-0335-00	3.3 M $\Omega$	$\frac{1}{2}$ W		5%
R713	323-0139-00	274 $\Omega$	$\frac{1}{2}$ W		1%
R714	315-0121-00	120 $\Omega$	$\frac{1}{4}$ W		5%
R715	321-0060-00	41.2 $\Omega$	$\frac{1}{8}$ W		1%
R716	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W	Prec	5%
R717	321-0219-00	1.87 k $\Omega$	$\frac{1}{8}$ W		1%
R718	315-0161-00	160 $\Omega$	$\frac{1}{4}$ W		5%
R719	311-0442-00	250 $\Omega$ , Var			
R721	303-0121-00	120 $\Omega$	1 W		5%



## Z AXIS Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R722	315-0131-00	130 $\Omega$	$\frac{1}{4}$ W			5%
R723	315-0750-00	75 $\Omega$	$\frac{1}{4}$ W			5%
R724	303-0471-00	470 $\Omega$	1 W			5%
R726	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W			5%
R727	323-0145-00	316 $\Omega$	$\frac{1}{2}$ W	Prec		1%
R728	321-0320-00	21 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R729	323-0360-00	54.9 k $\Omega$	$\frac{1}{2}$ W	Prec		1%
R731	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W			5%
R732	323-0307-00	15.4 k $\Omega$	$\frac{1}{2}$ W	Prec		1%
R733	303-0432-00	4.3 k $\Omega$	1 W			5%
R734	303-0203-00	20 k $\Omega$	1 W			5%
R735	315-0200-00	20 $\Omega$	$\frac{1}{4}$ W			5%
R736	301-0101-00	100 $\Omega$	$\frac{1}{2}$ W			5%
R737	315-0223-00	22 k $\Omega$	$\frac{1}{4}$ W			5%
R738	315-0154-00	150 k $\Omega$	$\frac{1}{4}$ W			5%
R739	311-0942-00	50 k $\Omega$ , Var				
R743	311-0510-00	10 k $\Omega$ , Var				
R744	321-0383-00	95.3 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R745	323-0505-00	1.78 M $\Omega$	$\frac{1}{2}$ W	Prec		1%
R746	321-0437-00	348 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R747	315-0473-00	47 k $\Omega$	$\frac{1}{4}$ W			5%
R748	315-0153-00	15 k $\Omega$	$\frac{1}{4}$ W			5%
R751	315-0474-00	470 k $\Omega$	$\frac{1}{4}$ W			5%
R753	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W			5%
R755	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W			5%
R757	315-0101-00	100 $\Omega$	$\frac{1}{4}$ W			5%
R758	315-0104-00	100 k $\Omega$	$\frac{1}{4}$ W			5%
R759	315-0302-00	3 k $\Omega$	$\frac{1}{4}$ W			5%
R791	315-0333-00	33 k $\Omega$	$\frac{1}{4}$ W			5%
R792	311-0465-00	100 k $\Omega$ , Var				
R795	311-0463-00	5 k $\Omega$ , Var				
R796	321-0194-00	1.02 k $\Omega$	$\frac{1}{8}$ W	Prec		1%
R797	323-0285-00	9.09 k $\Omega$	$\frac{1}{2}$ W	Prec		1%

## LINE INPUT Circuit Board Assembly

\*670-0813-00

Complete Board

## Bulbs

DS805	119-0181-00	Surge voltage protector
DS806	119-0181-00	Surge voltage protector
DS812	150-0053-00	Neon NE, 86T

## LINE INPUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
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## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C803	285-0587-00		0.1 $\mu$ F	PTM 600 V	
C810	290-0414-00		8 $\mu$ F	Elect. 200 V	+ 50%—10%
C811	290-0414-00		8 $\mu$ F	Elect. 200 V	+ 50%—10%
C812	285-0623-00		0.47 $\mu$ F	PTM 100 V	

## Semiconductor Device, Diode

CR810	152-0396-00		Silicon	Full wave, 400 V
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## Inductors

L810	*108-0585-00		116 $\mu$ H	
L811	*108-0585-00		116 $\mu$ H	

## Resistors

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R803	301-0510-00		51 $\Omega$	$\frac{1}{2}$ W	5%
R804	304-0105-00		1 M $\Omega$	1 W	
R805	301-0433-00		43 k $\Omega$	$\frac{1}{2}$ W	5%
R806	301-0433-00		43 k $\Omega$	$\frac{1}{2}$ W	5%
R807	315-0201-00		200 $\Omega$	$\frac{1}{4}$ W	5%

R808	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W	5%
RT810	307-0157-00		5 $\Omega$	Thermal	
RT811	307-0157-00		5 $\Omega$	Thermal	
R812	302-0395-00		3.9 M $\Omega$	$\frac{1}{2}$ W	
R813	304-0154-00		150 k $\Omega$	1 W	

R818	302-0154-00		150 k $\Omega$	$\frac{1}{2}$ W
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## Transformer

T805	*120-0636-00		Line trigger
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## INVERTER Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
	*670-0814-00			Complete Board

## Capacitors

Tolerance - 20% unless otherwise indicated.

C820	283-0044-00		0.001 $\mu$ F	Cer	3000 V	
C821	283-0006-00		0.02 $\mu$ F	Cer	500 V	
C822	283-0044-00		0.001 $\mu$ F	Cer	3000 V	
C824	283-0002-00		0.01 $\mu$ F	Cer	500 V	
C825	290-0284-00		4.7 $\mu$ F	Elect.	35 V	10%
C835	290-0284-00		4.7 $\mu$ F	Elect.	35 V	10%

## Semiconductor Device, Diodes

CR823	*152-0061-00		Silicon	Tek Spec	
CR824	*152-0061-00		Silicon	Tek Spec	
CR825	152-0413-00		Silicon	Fast recovery, 400 V maximum	
CR826	152-0413-00		Silicon	Fast recovery, 400 V maximum	
CR828	152-0400-00		Silicon	Fast recovery, 400 V maximum	
CR830	152-0401-00		Silicon	Voltage trigger (32 $\pm$ 3 V)	
CR831	*152-0107-00		Silicon	Replaceable by 1N647	
CR835	152-0413-00		Silicon	Fast recovery, 400 V maximum	
CR836	152-0413-00		Silicon	Fast recovery, 400 V maximum	
CR838	152-0400-00		Silicon	Fast recovery, 400 V maximum	

## Inductors

L826	*108-0574-00		30 $\mu$ H	
L836	*108-0574-00		30 $\mu$ H	

## Transistors

Q825	151-0266-00		Silicon	2N3902
Q835	151-0266-00		Silicon	2N3902

**INVERTER Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R820	315-0331-00		330 $\Omega$	$\frac{1}{4}$ W		5%
R821	315-0100-00		10 $\Omega$	$\frac{1}{4}$ W		5%
R823	302-0154-00		150 k $\Omega$	$\frac{1}{2}$ W		
R824	321-0365-00		61.9 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R825	308-0574-00		10 $\Omega$	2 W	WW	5%
R826	303-0555-00		5 $\Omega$	3 W	WW	5%
R835	308-0574-00		10 $\Omega$	2 W	WW	5%
R836	308-0555-00		5 $\Omega$	3 W	WW	5%

**Transformers**

T820	*120-0640-00	Toroid, 18 turns, bifilar
T825 )	*120-0641-00	Toroid, assembly
T839 )		

**RECTIFIER Circuit Board Assembly**

\*670-0815-00

Complete Board

**Capacitors**Tolerance  $\pm 20\%$  unless otherwise indicated.

C840	290-0284-00	4.7 $\mu$ F	Elect.	35 V	10%
C852	283-0067-00	0.001 $\mu$ F	Cer	200 V	10%
C855	283-0028-00	0.0022 $\mu$ F	Cer	50 V	
C856	283-0028-00	0.0022 $\mu$ F	Cer	50 V	
C858	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%
C860	283-0067-00	0.001 $\mu$ F	Cer	200 V	10%
C864	283-0067-00	0.001 $\mu$ F	Cer	200 V	10%
C867	290-0246-00	3.3 $\mu$ F	Elect.	15 V	10%
C872	290-0194-00	10 $\mu$ F	Elect.	100 V	
C873	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%
C874	290-0194-00	10 $\mu$ F	Elect.	100 V	
C877	290-0194-00	10 $\mu$ F	Elect.	100 V	
C878	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%
C879	290-0194-00	10 $\mu$ F	Elect.	100 V	
C880	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%

## RECTIFIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors (cont)						
C881	290-0194-00		10 $\mu$ F	Elect.	100 V	+ 80% — 20%
C882	290-0194-00		10 $\mu$ F	Elect.	100 V	
C883	283-0177-00		1 $\mu$ F	Cer	25 V	
C884	290-0425-00		100 $\mu$ F	Elect.	20 V	
C885	290-0296-00		100 $\mu$ F	Elect.	20 V	
C886	283-0177-00		1 $\mu$ F	Cer	25 V	+ 80% — 20%
C887	290-0425-00		100 $\mu$ F	Elect.	20 V	
C888	290-0296-00		100 $\mu$ F	Elect.	20 V	
C890	290-0425-00		100 $\mu$ F	Elect.	20 V	
C891	283-0177-00		1 $\mu$ F	Cer	25 V	
C892	290-0296-00		100 $\mu$ F	Elect.	20 V	+ 80% — 20%
C893	290-0194-00		10 $\mu$ F	Elect.	100 V	
C894	283-0178-00		0.1 $\mu$ F	Elect.	100 V	
C895	290-0194-00		10 $\mu$ F	Elect.	100 V	
C898	290-0138-00		330 $\mu$ F	Elect.	6 V	
C899	283-0177-00		1 $\mu$ F	Cer	25 V	+ 80% — 20%

## Semiconductor Device, Diodes

CR840	152-0333-00	Silicon	High speed and conductance
CR841	152-0333-00	Silicon	High speed and conductance
VR848	152-0212-00	Zener	1N936 500 mW, 9 V, 5%
CR857	*152-0185-00	Silicon	Replaceable by 1N4152
CR858	*152-0185-00	Silicon	Replaceable by 1N4152
CR859	*152-0185-00	Silicon	Replaceable by 1N4152
CR860	152-0333-00	Silicon	High speed and conductance
CR872	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR873	152-0414-00	Silicon	Fast recovery, 200 V maximum
VR876	152-0289-00	Zener	1N991B, 400 mW, 180 V, 5%
CR877	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR878	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR880	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR881	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR883	152-0397-00	Silicon	Fast recovery, 50 V maximum
CR884	152-0397-00	Silicon	Fast recovery, 50 V maximum
CR886	152-0412-00	Silicon	Fast recovery, 50 V maximum
CR887	152-0412-00	Silicon	Fast recovery, 50 V maximum
CR890	152-0412-00	Silicon	Fast recovery, 50 V maximum
CR891	152-0412-00	Silicon	Fast recovery, 50 V maximum
CR893	152-0414-00	Silicon	Fast recovery, 200 V maximum
CR894	152-0414-00	Silicon	Fast recovery, 200 V maximum

## RECTIFIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Inductors</b>				
L872	*108-0422-01		80 $\mu$ H	
L877	*103-0422-01		80 $\mu$ H	
L881	*108-0422-01		80 $\mu$ H	
L884	*108-0337-00		25 $\mu$ H	
L887	*108-0337-00		25 $\mu$ H	
L890	*108-0337-00		25 $\mu$ H	
L893	*108-0422-01		80 $\mu$ H	
L897	*108-0556-00		12 $\mu$ H	
L898	*108-0554-00		5 $\mu$ H	
<b>Transistors</b>				
Q843	151-0188-00	Silicon	2N3906	
Q846	151-0188-00	Silicon	2N3906	
Q853	151-0190-00	Silicon	2N3904	
Q855	151-0190-00	Silicon	2N3904	
Q856	151-0190-00	Silicon	2N3904	
Q860	151-0260-00	Silicon	2N5189	
Q863	*151-0192-00	Silicon	Replaceable by MPS 6521	
Q864	151-0190-00	Silicon	2N3904	
Q868	151-0190-00	Silicon	2N3904	
Q876	151-0505-00	Silicon	Controlled rectifier	
<b>Resistors</b>				
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R840	315-0100-00	10 $\Omega$	$\frac{1}{4}$ W	5%
R842	321-0213-00	1.62 k $\Omega$	$\frac{1}{8}$ W	Prec 1%
R843	311-0363-00	500 $\Omega$ , Var		
R844	321-0222-00	2 k $\Omega$	$\frac{1}{8}$ W	Prec 1%
R845	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W	5%
R846	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W	5%
R848	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W	5%
R851	315-0202-00	2 k $\Omega$	$\frac{1}{4}$ W	5%
R852	315-0104-00	100 k $\Omega$	$\frac{1}{4}$ W	5%
R853	315-0472-00	4.7 k $\Omega$	$\frac{1}{4}$ W	5%
R854	315-0242-00	2.4 k $\Omega$	$\frac{1}{4}$ W	5%
R855	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W	5%
R856	315-0102-00	1 k $\Omega$	$\frac{1}{4}$ W	5%
R858	315-0150-00	15 $\Omega$	$\frac{1}{4}$ W	5%
R860	315-0473-00	47 k $\Omega$	$\frac{1}{4}$ W	5%

## RECTIFIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Resistors (cont)</b>				
R861	315-0104-00		100 k $\Omega$	1/4 W 5%
R863	315-0272-00		2.7 k $\Omega$	1/4 W 5%
R864	315-0471-00		470 $\Omega$	1/4 W 5%
R866	315-0102-00		1 k $\Omega$	1/4 W 5%
R867	315-0104-00		100 k $\Omega$	1/4 W 5%
R868	315-0472-00		4.7 k $\Omega$	1/4 W 5%
R876	315-0102-00		1 k $\Omega$	1/4 W 5%

## Transformers

T874	*120-0638-00		Toroid, 15 turns, bifilar
T879	*120-0638-00		Toroid, 15 turns, bifilar
T882	*120-0638-00		Toroid, 15 turns, bifilar
T885	*120-0639-00		Toroid, 8 turns, bifilar
T888	*120-0639-00		Toroid, 8 turns, bifilar
T892	*120-0639-00		Toroid, 8 turns, bifilar
T895	*120-0638-00		Toroid, 15 turns, bifilar
T899	*120-0637-00		Toroid, 5 turns, bifilar

## L. V. REGULATOR Circuit Board Assembly

\*670-0816-00

Complete Board

## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C903	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%
C905	281-0546-00	330 pF	Cer	500 V	10%
C907	283-0083-00	0.0047 $\mu$ F	Cer	500 V	5%
C910	283-0177-00	1 $\mu$ F	Cer	25 V	+80%—20%
C911	283-0190-00	0.47 $\mu$ F	Cer	50 V	5%
C921	283-0177-00	1 $\mu$ F	Cer	25 V	+80%—20%
C925	283-0003-00	0.01 $\mu$ F	Cer	150 V	
C933	283-0114-00	0.0015 $\mu$ F	Cer	200 V	5%
C935	283-0081-00	0.1 $\mu$ F	Cer	25 V	+80%—20%
C941	283-0177-00	1 $\mu$ F	Cer	25 V	+80%—20%
C945	283-0081-00	0.1 $\mu$ F	Cer	25 V	+80%—20%
C950	283-0177-00	1 $\mu$ F	Cer	25 V	+80%—20%
C961	283-0177-00	1 $\mu$ F	Cer	25 V	+80%—20%
C968	283-0041-00	0.0033 $\mu$ F	Cer	500 V	5%
C981	283-0178-00	0.1 $\mu$ F	Cer	100 V	+80%—20%

## L. V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
<b>Capacitors (cont)</b>			
C982	290-0187-00	4.7 $\mu$ F	Elect. 35 V
C990	283-0065-00	0.001 $\mu$ F	Cer 100 V 5%
C992	283-0177-00	1 $\mu$ F	Cer 25 V +80%—20%

## Semiconductor Device, Diodes

CR905	*152-0185-00	Silicon	Replaceable by 1N4152
CR906	*152-0185-00	Silicon	Replaceable by 1N4152
CR909	*152-0061-00	Silicon	Tek Spec
VR910	152-0168-00	Zener	1N963A 400 mW, 12 V, 5%
CR914	*152-0185-00	Silicon	Replaceable by 1N4152
CR922	*152-0185-00	Silicon	Replaceable by 1N4152
CR923	*152-0185-00	Silicon	Replaceable by 1N4152
CR924	*152-0185-00	Silicon	Replaceable by 1N4152
VR927	152-0280-00	Zener	1N753A 400 mW, 6.2 V, 5%
VR930	152-0195-00	Zener	1N751A 400 mW, 5.1 V, 5%
CR935	*152-0061-00	Silicon	Tek Spec
CR938	*152-0185-00	Silicon	Replaceable by 1N4152
CR941	152-0066-00	Silicon	1N3194
CR942	152-0066-00	Silicon	1N3194
CR948	*152-0185-00	Silicon	Replaceable by 1N4152
CR949	*152-0185-00	Silicon	Replaceable by 1N4152
CR961	152-0418-00	Silicon	300 V, 3 A
CR964	*152-0185-00	Silicon	Replaceable by 1N4152
CR965	*152-0185-00	Silicon	Replaceable by 1N4152
CR972	*152-0185-00	Silicon	Replaceable by 1N4152
CR981	152-0418-00	Silicon	300 V, 3 A
VR982	152-0411-00	Zener	1N937, 250 mW, 9 V, 5%
CR984	*152-0185-00	Silicon	Replaceable by 1N4152
CR991	*152-0185-00	Silicon	Replaceable by 1N4152
CR994	*152-0185-00	Silicon	Replaceable by 1N4152

## Fuses

F901	159-0028-00	1/4 A 3AG	Fast-Blo
F902	159-0028-00	1/4 A 3AG	Fast-Blo
F921	159-0021-00	2 A 3AG	Fast-Blo
F957	159-0022-00	1 A 3AG	Fast-Blo

## Meter

M941	149-0030-00	Elapsed time
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## L. V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Transistors</b>				
Q906	151-0232-00		Silicon	Dual
Q910	*151-0192-00		Silicon	Replaceable by MPS 6521
Q912	151-0190-00		Silicon	2N3904
Q914	151-0250-00		Silicon	2N5184
Q922	151-0232-00		Silicon	Dual
Q928	151-0190-00		Silicon	2N3904
Q930	151-0188-00		Silicon	2N3906
Q936	*151-0192-00		Silicon	Replaceable by MPS 6521
Q944	*151-0216-00		Silicon	Replaceable by MPS 6523
Q946	*151-0216-00		Silicon	Replaceable by MPS 6523
Q948	151-0188-00		Silicon	2N3906
Q952	151-0260-00		Silicon	2N5189
Q954	151-0188-00		Silicon	2N3906
Q964	151-0232-00		Silicon	Dual
Q966	151-0190-00		Silicon	2N3904
Q970	*151-0192-00		Silicon	Replaceable by MPS 6521
Q984	151-0232-00		Silicon	Dual
Q988	151-0190-00		Silicon	2N3904
Q992	*151-0192-00		Silicon	Replaceable by MPS 6521
Q994	151-0188-00		Silicon	2N3906

**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R904	315-0434-00	430 k $\Omega$	1/4 W		5%
R905	315-0323-00	82 k $\Omega$	1/4 W		5%
R906	315-0274-00	270 k $\Omega$	1/4 W		5%
R907	323-0289-07	10 k $\Omega$	1/2 W	Prec	1/10%
R908	323-0289-07	10 k $\Omega$	1/2 W	Prec	1/10%
R909	301-0103-00	10 k $\Omega$	1/2 W		5%
R911	307-0108-00	6.8 $\Omega$	1/4 W		5%
R912	321-0356-00	49.9 k $\Omega$	1/8 W	Prec	1%
R913	321-0155-00	402 $\Omega$	1/8 W	Prec	1%
R914	315-0513-00	51 k $\Omega$	1/4 W		5%
R915	308-0292-00	2.2 k $\Omega$	3 W	WW	5%
R916	315-0121-00	120 $\Omega$	1/4 W		5%
R917	307-0093-00	1.2 $\Omega$	1/2 W		5%
R918	307-0103-00	2.7 $\Omega$	1/4 W		5%
R922	315-0274-00	270 k $\Omega$	1/4 W		5%
R923	315-0704-00	200 k $\Omega$	1/4 W		5%
R925	323-0758-07	3 k $\Omega$	1/2 W	Prec	1/10%
R926	323-0787-07	10 k $\Omega$	1/2 W	Prec	1/10%
R928	321-0306-00	15 k $\Omega$	1/8 W	Prec	1%
R929	315-0201-00	200 $\Omega$	1/4 W		5%

## L. V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R930	315-0621-00		620 $\Omega$	$\frac{1}{4}$ W		5%
R931	301-0102-00		1 k $\Omega$	$\frac{1}{2}$ W		5%
R932	315-0474-00		470 k $\Omega$	$\frac{1}{4}$ W		5%
R933	315-0222-00		2.2 k $\Omega$	$\frac{1}{4}$ W		5%
R934	321-0150-00		357 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R935	301-0621-00		620 $\Omega$	$\frac{1}{2}$ W		5%
R936	315-0153-00		15 k $\Omega$	$\frac{1}{4}$ W		5%
R937	306-0180-00		18 $\Omega$	2 W		
R938	315-0151-00		150 $\Omega$	$\frac{1}{4}$ W		5%
R939	*308-0560-00		0.12 $\Omega$	5 W	WW	5%
R941	301-0395-00		3.9 M $\Omega$	$\frac{1}{2}$ W		5%
R943	315-0222-00		2.2 k $\Omega$	$\frac{1}{4}$ W		5%
R944	315-0473-00		47 k $\Omega$	$\frac{1}{4}$ W		5%
R945	315-0390-00		39 $\Omega$	$\frac{1}{4}$ W		5%
R946	321-0193-07		1 k $\Omega$	$\frac{1}{8}$ W	Prec	1/10%
R947	323-0289-07		10 k $\Omega$	$\frac{1}{2}$ W	Prec	1/10%
R948	315-0471-00		470 $\Omega$	$\frac{1}{4}$ W		5%
R949	315-0471-00		470 $\Omega$	$\frac{1}{4}$ W		5%
R950	315-0101-00		100 $\Omega$	$\frac{1}{4}$ W		5%
R951	306-0180-00		18 $\Omega$	2 W		
R952	315-0151-00		150 $\Omega$	$\frac{1}{4}$ W		5%
R953	315-0472-00		4.7 k $\Omega$	$\frac{1}{4}$ W		5%
R954	315-0331-00		330 $\Omega$	$\frac{1}{4}$ W		5%
R955	*303-0560-00		0.12 $\Omega$	5 W	WW	5%
R962	323-0758-07		3 k $\Omega$	$\frac{1}{2}$ W	Prec	1/10%
R963	323-0763-07		7 k $\Omega$	$\frac{1}{2}$ W	Prec	1/10%
R964	315-0434-00		430 k $\Omega$	$\frac{1}{4}$ W		5%
R965	315-0164-00		160 k $\Omega$	$\frac{1}{4}$ W		5%
R966	321-0306-00		15 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R967	321-0150-00		357 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R968	315-0162-00		1.6 k $\Omega$	$\frac{1}{4}$ W		5%
R969	301-0621-00		620 $\Omega$	$\frac{1}{2}$ W		5%
R971	315-0153-00		15 k $\Omega$	$\frac{1}{4}$ W		5%
R972	306-0180-00		18 $\Omega$	2 W		
R973	315-0151-00		150 $\Omega$	$\frac{1}{4}$ W		5%
R974	*308-0560-00		0.12 $\Omega$	5 W	WW	5%
R982	323-0264-00		5.49 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R983	315-0474-00		470 k $\Omega$	$\frac{1}{4}$ W		5%
R984	315-0204-00		200 k $\Omega$	$\frac{1}{4}$ W		5%
R985	323-0771-09		1.375 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R986	311-0515-00		250 $\Omega$ , Var			
R987	323-0772-09		6.71 k $\Omega$	$\frac{1}{2}$ W	Prec	1%
R988	321-0356-00		49.9 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R989	321-0150-00		357 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R990	315-0622-00		6.2 k $\Omega$	$\frac{1}{4}$ W		5%

## L. V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description	
<b>Resistors (cont)</b>					
R991	301-0103-00		10 k $\Omega$	$\frac{1}{2}$ W	5%
R992	315-0470-00		47 $\Omega$	$\frac{1}{4}$ W	5%
R995	301-0621-00		620 $\Omega$	$\frac{1}{2}$ W	5%
R996	315-0121-00		120 $\Omega$	$\frac{1}{4}$ W	5%
R997	307-0093-00		1.2 $\Omega$	$\frac{1}{2}$ W	5%
R998	307-0093-00		1.2 $\Omega$	$\frac{1}{2}$ W	

## READOUT Circuit Board Assembly

\*670-0635-00

Complete Board

## Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C1141	283-0032-00	470 pF	Cer	500 V	5%
C1180	283-0032-00	470 pF	Cer	500 V	5%
C1190	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C1214	285-0598-00	0.0082 $\mu$ F	PTM	100 V	5%
C1222	283-0103-00	180 pF	Cer	500 V	5%
C1227	283-0103-00	180 pF	Cer	500 V	5%
C1230	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C1267	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C1268	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% - 20%
C1291	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% - 20%
C1294	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% - 20%
C1297	283-0177-00	1 $\mu$ F	Cer	25 V	+ 80% - 20%

## Semiconductor Device, Diodes

CR1112	*152-0185-00	Silicon	Replaceable by 1N4152
CR1113	*152-0185-00	Silicon	Replaceable by 1N4152
CR1117	*152-0185-00	Silicon	Replaceable by 1N4152
CR1118	*152-0185-00	Silicon	Replaceable by 1N4152
CR1122	*152-0185-00	Silicon	Replaceable by 1N4152
CR1123	*152-0185-00	Silicon	Replaceable by 1N4152
CR1127	*152-0185-00	Silicon	Replaceable by 1N4152
CR1128	*152-0185-00	Silicon	Replaceable by 1N4152
CR1155	*152-0185-00	Silicon	Replaceable by 1N4152
CR1206	*152-0185-00	Silicon	Replaceable by 1N4152

## READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
<b>Semiconductor Device, Diodes (cont)</b>				
CR1207	*152-0185-00		Silicon	Replaceable by 1N4152
CR1208	*152-0185-00		Silicon	Replaceable by 1N4152
CR1216	*152-0185-00		Silicon	Replaceable by 1N4152
CR1217	*152-0185-00		Silicon	Replaceable by 1N4152
CR1222	*152-0185-00		Silicon	Replaceable by 1N4152
CR1223	*152-0185-00		Silicon	Replaceable by 1N4152
CR1224	*152-0185-00		Silicon	Replaceable by 1N4152
CR1227	*152-0185-00		Silicon	Replaceable by 1N4152
CR1231	*152-0185-00		Silicon	Replaceable by 1N4152
VR1260	*152-0405-00		Zener	Tek Spec, 1 W, 15 V, 5%
VR1261	*152-0405-00		Zener	Tek Spec, 1 W, 15 V, 5%
VR1262	*152-0405-00		Zener	Tek Spec, 1 W, 15 V, 5%

**Inductor**

L1270	*108-0331-01	0.75 $\mu$ F
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**Transistors**

Q1143	151-0232-00	Silicon	Dual
Q1150	151-0190-00	Silicon	2N3904
Q1152	151-0190-00	Silicon	2N3904
Q1155	151-0188-00	Silicon	2N3906
Q1163	151-0190-00	Silicon	2N3904
Q1185	*151-0192-00	Silicon	Replaceable by MPS 6521
Q1223	151-0188-00	Silicon	2N3906
Q1226	151-0190-00	Silicon	2N3904
Q1274	151-0188-00	Silicon	2N3906
Q1278	151-0188-00	Silicon	2N3906
Q1284	151-0188-00	Silicon	2N3906
Q1288	151-0188-00	Silicon	2N3906

**Resistors**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R1111	317-0102-00	1 k $\Omega$	$\frac{1}{8}$ W	5%
R1112	317-0751-00	750 $\Omega$	$\frac{1}{8}$ W	5%
R1113	317-0751-00	750 $\Omega$	$\frac{1}{8}$ W	5%
R1116	317-0102-00	1 k $\Omega$	$\frac{1}{8}$ W	5%
R1117	317-0751-00	750 $\Omega$	$\frac{1}{8}$ W	5%

## READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R1118	317-0751-00		750 $\Omega$	$\frac{1}{8}$ W		5%
R1121	317-0102-00		1 k $\Omega$	$\frac{1}{8}$ W		5%
R1122	317-0751-00		750 $\Omega$	$\frac{1}{8}$ W		5%
R1123	317-0751-00		750 $\Omega$	$\frac{1}{8}$ W		5%
R1126	317-0102-00		1 k $\Omega$	$\frac{1}{8}$ W		5%
R1127	317-0751-00		750 $\Omega$	$\frac{1}{8}$ W		5%
R1128	317-0751-00		750 $\Omega$	$\frac{1}{8}$ W		5%
R1131	317-0513-00		51 k $\Omega$	$\frac{1}{8}$ W		5%
R1132	317-0133-00		13 k $\Omega$	$\frac{1}{8}$ W		5%
R1133	317-0133-00		13 k $\Omega$	$\frac{1}{8}$ W		5%
R1134	317-0753-00		75 k $\Omega$	$\frac{1}{8}$ W		5%
R1135	321-0310-00		16.5 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1136	317-0513-00		51 k $\Omega$	$\frac{1}{8}$ W		5%
R1137	321-0321-00		21.5 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1138	321-0335-00		30.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1140	317-0752-00		7.5 k $\Omega$	$\frac{1}{8}$ W		5%
R1141	321-0261-00		5.11 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1143	317-0133-00		13 k $\Omega$	$\frac{1}{8}$ W		5%
R1144	317-0154-00		150 k $\Omega$	$\frac{1}{8}$ W		5%
R1146	321-0181-00		750 $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1147	321-0301-00		13.3 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1148	317-0102-00		1 k $\Omega$	$\frac{1}{8}$ W		5%
R1152	317-0152-00		1.5 k $\Omega$	$\frac{1}{8}$ W		5%
R1155	317-0552-00		5.6 k $\Omega$	$\frac{1}{8}$ W		5%
R1156	321-0297-00		12.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1163	317-0243-00		24 k $\Omega$	$\frac{1}{8}$ W		5%
R1171	317-0154-00		150 k $\Omega$	$\frac{1}{8}$ W		5%
R1172	321-0335-00		30.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1173	321-0344-00		37.5 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1174	321-0335-00		30.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1175	317-0513-00		51 k $\Omega$	$\frac{1}{8}$ W		5%
R1176	317-0154-00		150 k $\Omega$	$\frac{1}{8}$ W		5%
R1177	321-0335-00		30.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1178	321-0335-00		30.1 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1180	321-0262-00		5.23 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1181	321-0371-00		71.5 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1183	321-0401-00		147 k $\Omega$	$\frac{1}{8}$ W	Prec	1%
R1185	317-0103-00		10 k $\Omega$	$\frac{1}{8}$ W		5%
R1190	317-0303-00		30 k $\Omega$	$\frac{1}{8}$ W		5%
R1191	317-0203-00		20 k $\Omega$	$\frac{1}{8}$ W		5%

## READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R1193	317-0203-00	20 kΩ	1/8 W			5%
R1195	317-0203-00	20 kΩ	1/8 W			5%
R1197	317-0203-00	20 kΩ	1/8 W			5%
R1205	317-0432-00	4.3 kΩ	1/8 W			5%
R1206	317-0683-00	68 kΩ	1/8 W			5%
R1210	317-0104-00	100 kΩ	1/8 W			5%
R1214	317-0393-00	39 kΩ	1/8 W			5%
R1215	317-0562-00	5.6 kΩ	1/8 W			5%
R1216	315-0152-00	1.5 kΩ	1/4 W			5%
R1220	317-0103-00	10 kΩ	1/8 W			5%
R1221	317-0752-00	7.5 kΩ	1/8 W			5%
R1223	315-0242-00	2.4 kΩ	1/4 W			5%
R1226	317-0152-00	1.5 kΩ	1/8 W			5%
R1227	317-0512-00	5.1 kΩ	1/8 W			5%
R1230	317-0512-00	5.1 kΩ	1/8 W			5%
R1255	321-0222-00	2 kΩ	1/8 W	Prec		1%
R1256	321-0176-00	665 Ω	1/8 W	Prec		1%
R1257	321-0250-00	3.92 kΩ	1/8 W	Prec		1%
R1258	317-0223-00	22 kΩ	1/8 W			5%
R1260	317-0102-00	1 kΩ	1/8 W			5%
R1264	317-0272-00	2.7 kΩ	1/8 W			5%
R1265	317-0512-00	5.1 kΩ	1/8 W			
R1266	317-0822-00	8.2 kΩ	1/8 W			5%
R1268	321-0296-00	11.8 kΩ	1/8 W	Prec		1%
R1269	317-0823-00	82 kΩ	1/8 W			5%
R1270	321-0222-00	2 kΩ	1/8 W	Prec		1%
R1271	321-0216-00	1.74 kΩ	1/8 W	Prec		1%
R1272	321-0245-00	3.48 kΩ	1/8 W	Prec		1%
R1274	321-0209-00	1.47 kΩ	1/8 W	Prec		1%
R1276	321-0241-00	3.16 kΩ	1/8 W	Prec		1%
R1277	321-0255-00	4.42 kΩ	1/8 W	Prec		1%
R1278	315-0152-00	1.5 kΩ	1/4 W			5%
R1280	321-0273-00	6.81 kΩ	1/8 W	Prec		1%
R1281	321-0193-00	1 kΩ	1/8 W	Prec		1%
R1284	321-0199-00	1.15 kΩ	1/8 W	Prec		1%
R1285	311-0635-00	1 kΩ, Var				
R1286	321-0204-00	1.3 kΩ	1/8 W	Prec		1%
R1287	321-0245-00	3.48 kΩ	1/8 W	Prec		1%
R1288	315-0152-00	1.5 kΩ	1/4 W			5%
R1289	315-0511-00	510 Ω	1/4 W			5%

**READOUT Circuit Board Assembly (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
<b>Integrated Circuits</b>			
U1130	*155-0015-00		Monolithic
U1166	*155-0014-00		Monolithic
U1170	*155-0015-00		Monolithic
U1186	*155-0014-00		Monolithic
U1190	*155-0018-00		Monolithic
U1210	*155-0021-00		Monolithic
U1226	*155-0017-00		Monolithic
U1227	156-0043-00		Quad 2-Input NOR Gate Replaceable by TISN7402N
U1230	156-0012-00		Clocked J-K Flipflop Replaceable by Fairchild $\mu$ L923
U1231	156-0012-00		Clocked J-K Flipflop Replaceable by Fairchild $\mu$ L923
U1232	156-0012-00		Clocked J-K Flipflop Replaceable by Fairchild $\mu$ L923
U1251	*155-0023-00		Monolithic
U1252	*155-0024-00		Monolithic
U1253	*155-0025-00		Monolithic
U1254	*155-0026-00		Monolithic
U1255	*155-0027-00		Monolithic
U1260	*155-0019-00		Monolithic
U1270	*155-0020-00		Monolithic

**GRATICULE LIGHT Circuit Board Assembly**

\*670-0702-00

Complete Board

**Bulbs**

DS957	150-0029-00	Incandescent	GE 349
DS958	150-0029-00	Incandescent	GE 349
DS959	150-0029-00	Incandescent	GE 349

**B TRIG. SOURCE Circuit Board Assembly**

\*670-0821-00

Complete Board

**Bulb**

DS1001	*150-0057-01	Incandescent	7153AS15, selected
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**Switch**

Wired or Unwired

S1001 <sup>22</sup>	*670-0821-00	Pushbutton	B TRIG SOURCE
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<sup>22</sup>See Mechanical Parts List for replacement parts.

**A TRIG. SOURCE Circuit Board Assembly**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
*670-0792-00		Complete Board		
Bulb				
DS1011	*150-0057-01		Incandescent	7153AS15, selected
Switch				
Wired or Unwired				
S1011	*670-0792-00		Pushbutton	A TRIG SOURCE

**VERT. MODE Circuit Board Assembly**

*670-0791-00		Complete Board	
Bulbs			
DS1021	*150-0057-01	Incandescent, 7153AS15, selected	
DS1023	*150-0057-01	Incandescent, 7153AS15, selected	
DS1025	*150-0057-01	Incandescent, 7153AS15, selected	
DS1027	*150-0057-01	Incandescent, 7153AS15, selected	
DS1029	*150-0057-01	Incandescent, 7153AS15, selected	
Semiconductor Device, Diodes			
CR1021	*152-0185-00	Silicon	Replaceable by 1N4152
CR1022	*152-0185-00	Silicon	Replaceable by 1N4152
CR1023	*152-0185-00	Silicon	Replaceable by 1N4152
CR1027	*152-0185-00	Silicon	Replaceable by 1N4152

**Resistor**Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R1023	315-0153-00	15 k $\Omega$	1/4 W	5%
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**Switch**

<b>Wired or Unwired</b>				
S1021 <sup>23</sup>	*670-0791-00		Pushbutton	VERT MODE

<sup>23</sup>See Mechanical Parts List for replacement parts.



**HORIZ. MODE Circuit Board Assembly**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
*670-0790-00		Complete Board	
Bulbs			
DS1031	*150-0057-01	Incandescent, 7153AS15, selected	
DS1032	*150-0057-01	Incandescent, 7153AS15, selected	
DS1033	*150-0057-01	Incandescent, 7153AS15, selected	
DS1034	*150-0057-01	Incandescent, 7153AS15, selected	
Resistor			
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.			
R1025	316-0270-00	27 $\Omega$	$\frac{1}{4}$ W
Switch			
Wired or Unwired			
S1031 <sup>24</sup>	*670-0790-00	Pushbutton	HORIZ MODE

<sup>24</sup>See Mechanical Parts List for replacement parts.

## VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise on the individual diagrams:

### Test Oscilloscope (with 10X Probe)

Frequency response	DC to 30 MHz
Deflection factor (with probe)	50 millivolts to 50 volts/division
Input impedance	10 megohm, 13 picofarads
Probe ground	7704 chassis ground
Trigger source	External from +GATE connector to indicate true time relationship between signals
Recommended type (as used for wave- forms on diagrams)	Tektronix 7504 with 7A16 and 7B50 plug-in units

### Voltmeter

Type	Non-loading digital multimeter
Input impedance	0 to 1.5 volts; $\geq 1 \text{ k}\Omega$ 15 to 1000 volts; $10 \text{ M}\Omega$
Range	0 to 1000 volts
Reference voltage	7704 chassis ground
Recommended type (as used for voltages on diagrams)	Fairchild Model 7050

### 7704 Conditions

Line voltage	115 volts
Signal applied	No signal applied for voltage measurements. Apply 4 volts of 1 kHz calibrator signal from test scope to + INPUT of 7A22 for waveforms only.
Connectors	No connections for voltage measurements. For waveforms CAL out signal is applied to external trigger input of test scope. Also see Signal applied above.
Trace position	Centered
Control settings	As follows except as noted otherwise on individual diagrams.

### 7704

A INTENSITY	Counterclockwise
FOCUS	Midrange
B INTENSITY	Counterclockwise
BEAM FINDER	Released
READOUT	OFF
CONTROL ILLUM	OFF
GRAT ILLUM	Counterclockwise
CALIBRATOR	4 V
RATE	1 kHz
VERTICAL MODE	LEFT
A TRIGGER SOURCE	VERT MODE
HORIZONTAL MODE	A
VERT TRACE	Midrange
SEPARATION (B)	
B TRIGGER SOURCE	VERT MODE
Internal Sweep switch	A
Internal Gate switch	A

### Left Vertical Plug-In (7A22)

Position	Centered
Volts/Div	1 V
Variable	Cal
Offset	Centered
HF -3 dB Point	1 MHz
LF -3 dB Point	DC
+ Input	Gnd
- Input	Gnd

### Right Vertical Plug-In (7A16)

Position	Centered
Polarity	+ UP
Input Coupling	Gnd
BW	Full
Volts/Div	.1
Variable	Cal

### A Horiz Plug-In (7B51)

Level/Slope	Midrange, positive slope
Position	Centered
B Delay Mode	Independent
Delay Time Mult	0.0
Triggering	
Mode	NORM
Coupling	AC
Source	Int
Magnifier	X1
Time/Div	1 ms
Variable	Cal

### B Horiz Plug-In (7B50)

Level/Slope	Midrange, positive slope
Position	Centered
Display Mode	Time Base
Variable	Centered
Triggering	
Mode	NORM
Coupling	AC
Source	Int
Magnifier	X1
Time/Div	1 ms
Variable	Cal

The following control settings and connections were changed to obtain waveform photographs.

### Left Vert (7A22)

+ Input	DC
Position	Vertically center display
Apply 4 volts of 1 kHz calibrator to the + Input	

### A Horiz (7B51)

Triggering Mode	P-P Auto
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### B Horiz (7B50)

Triggering Mode	P-P Auto
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All voltages given on the diagrams are in volts. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule. Readouts are simulated in larger-than-normal type. Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration or front-panel control settings.

### NOTE

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

# SECTION 7

## DIAGRAMS

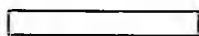
### and

## MECHANICAL PARTS ILLUSTRATIONS

The following special symbols are used on the diagrams:



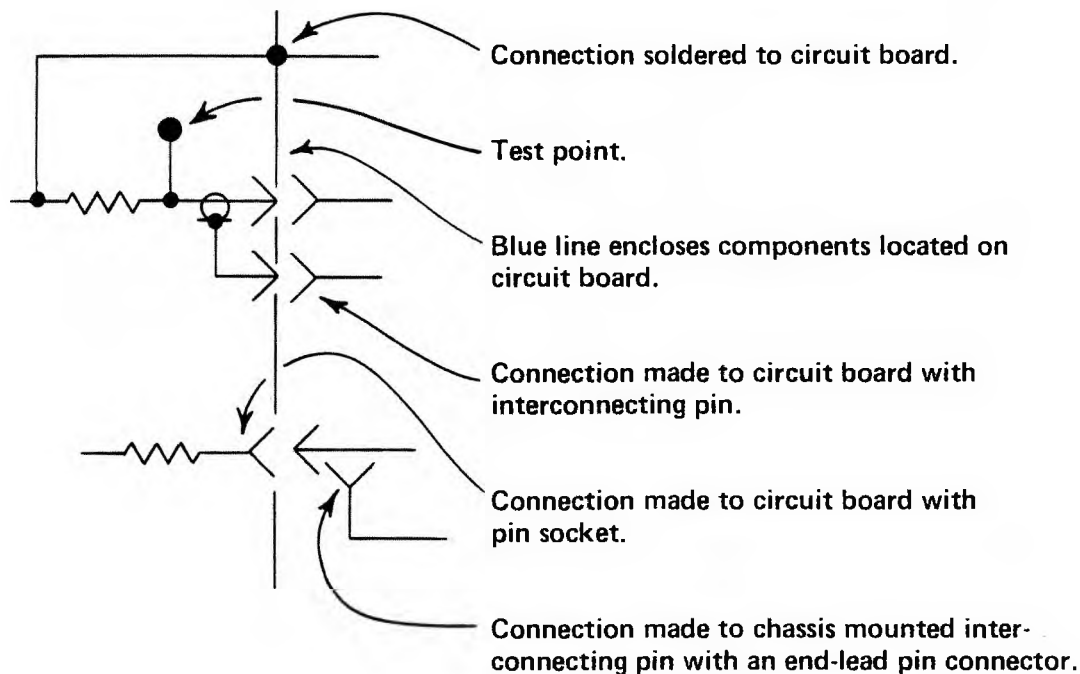
Screwdriver adjustment.

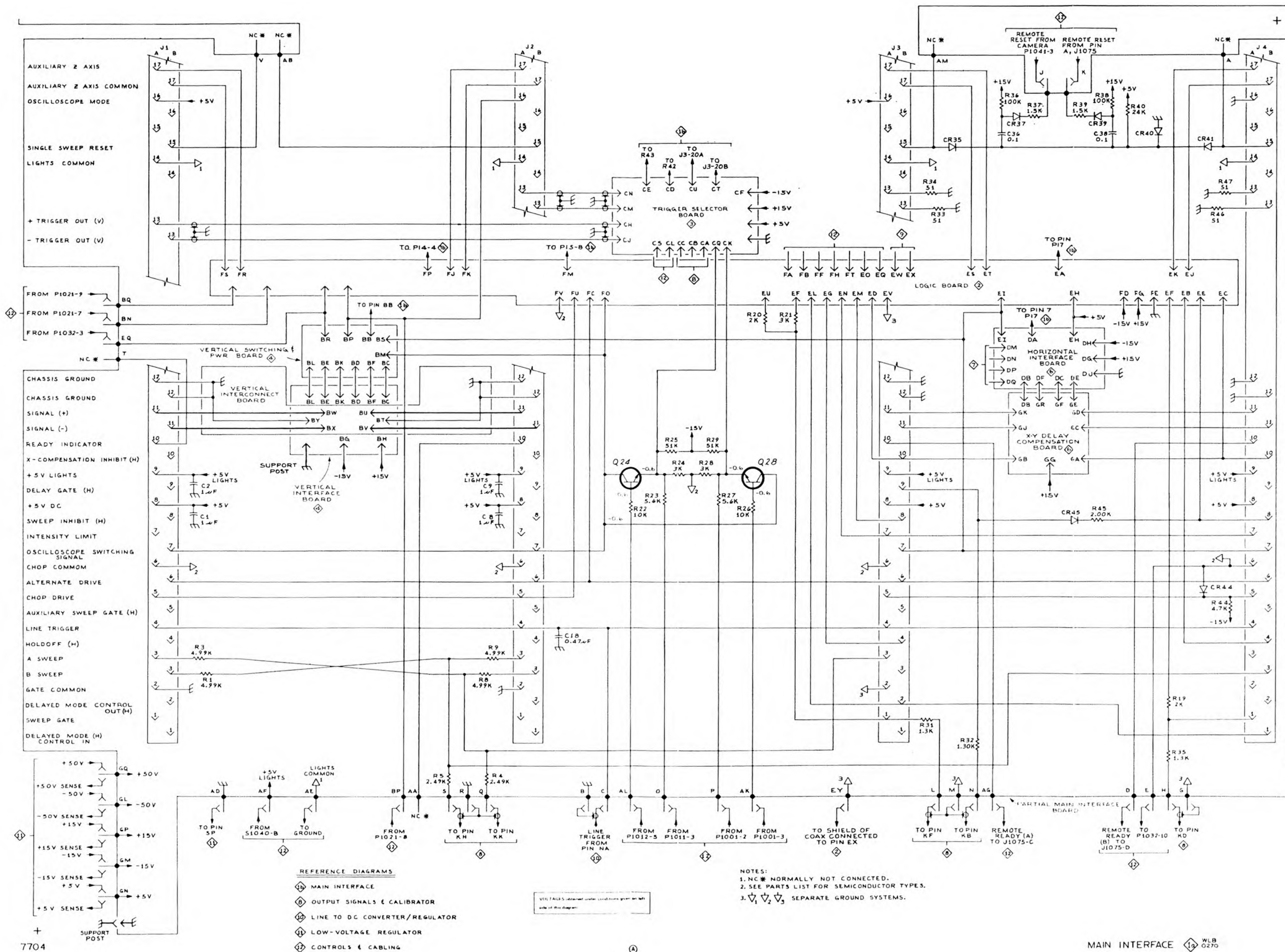


Front- or rear-panel control or connector.



Refers to the indicated diagram.

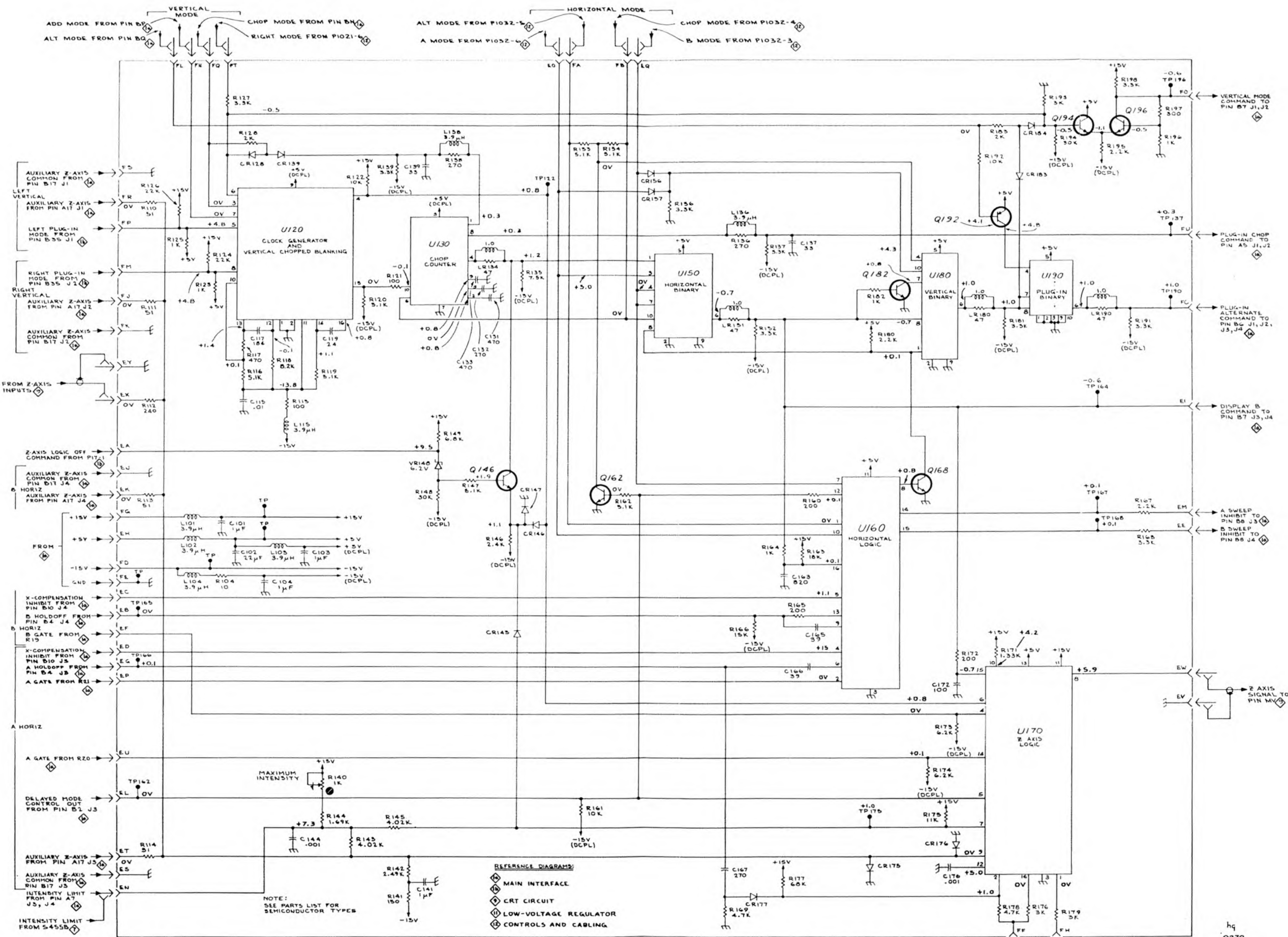


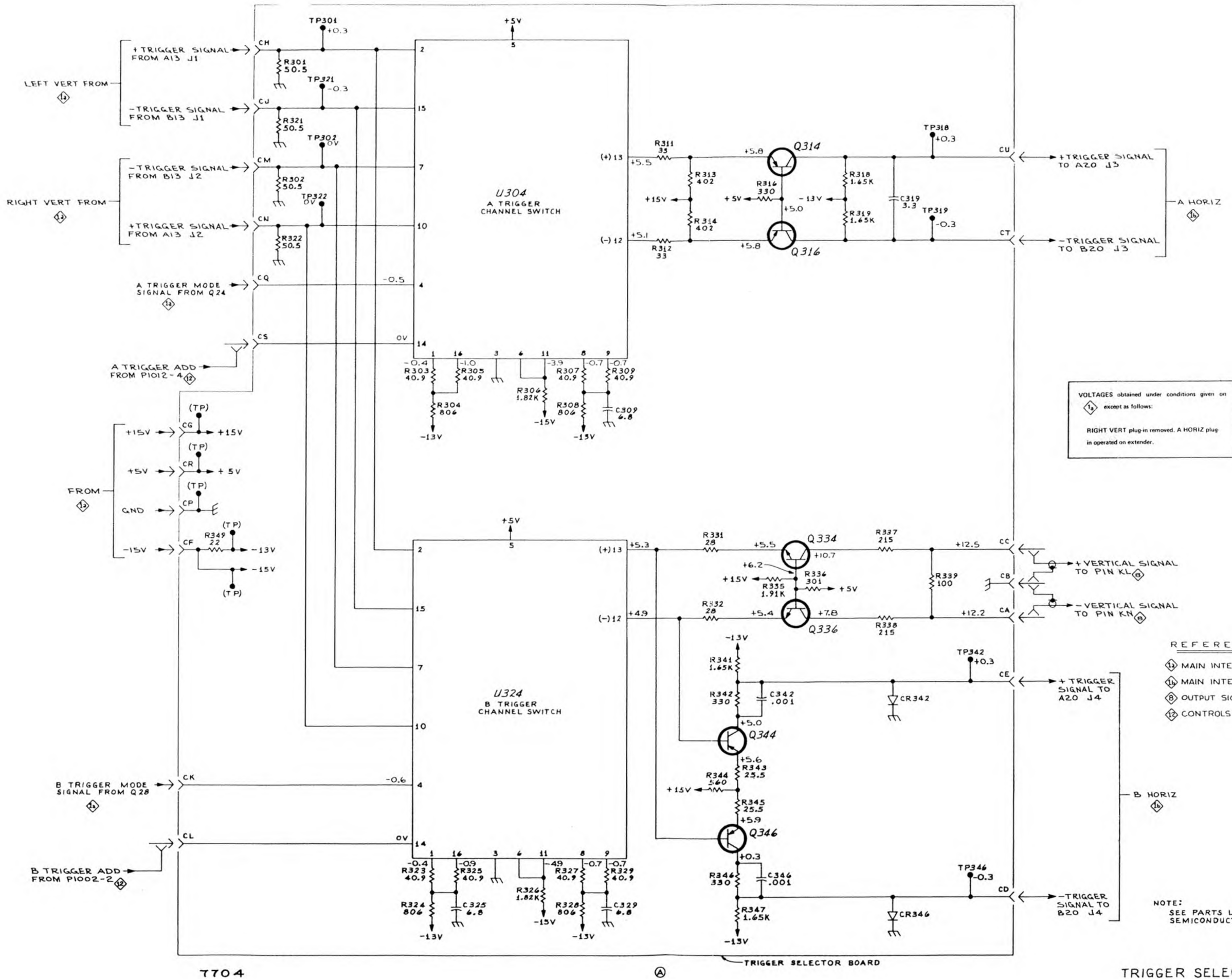










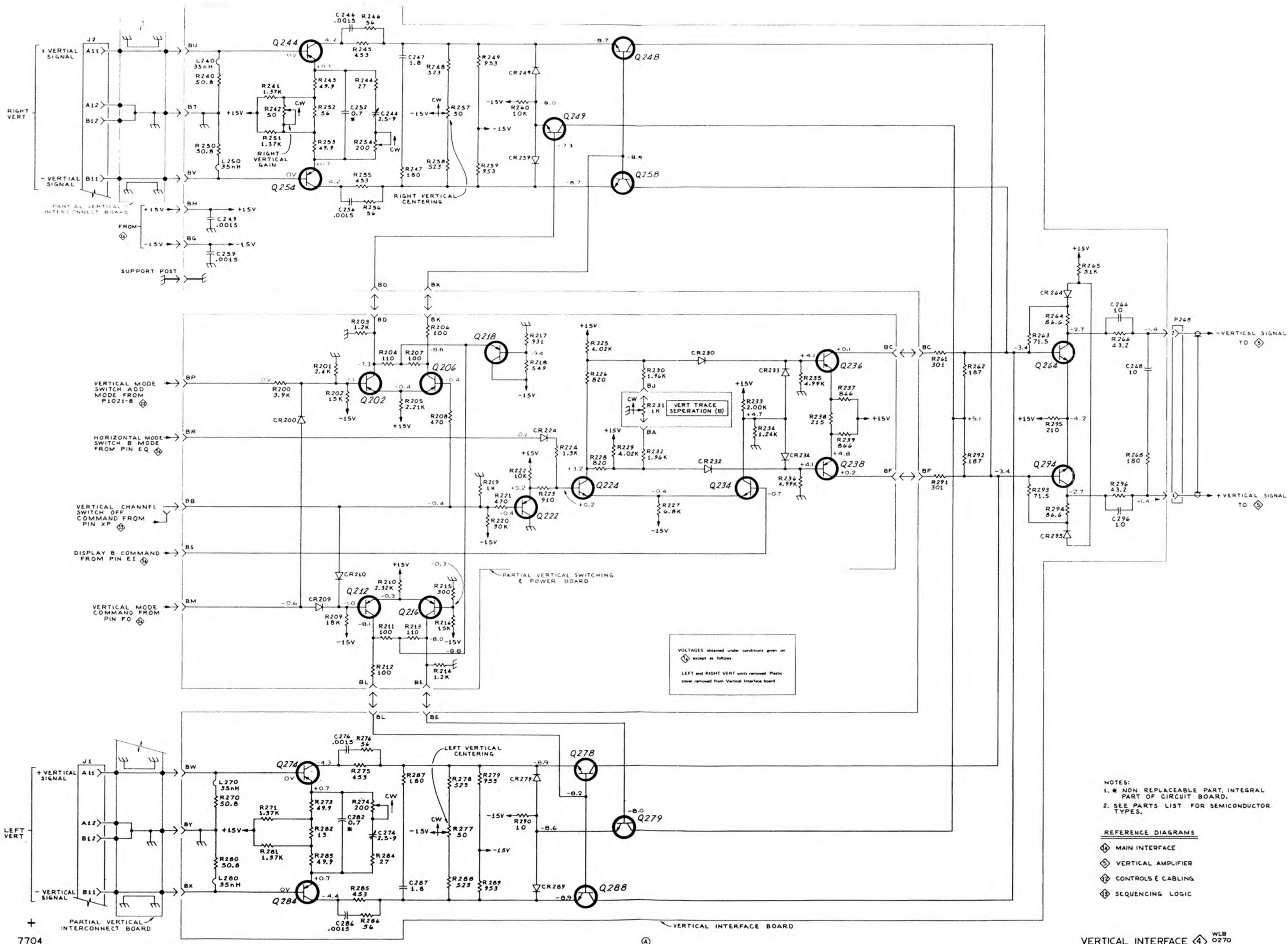


T704

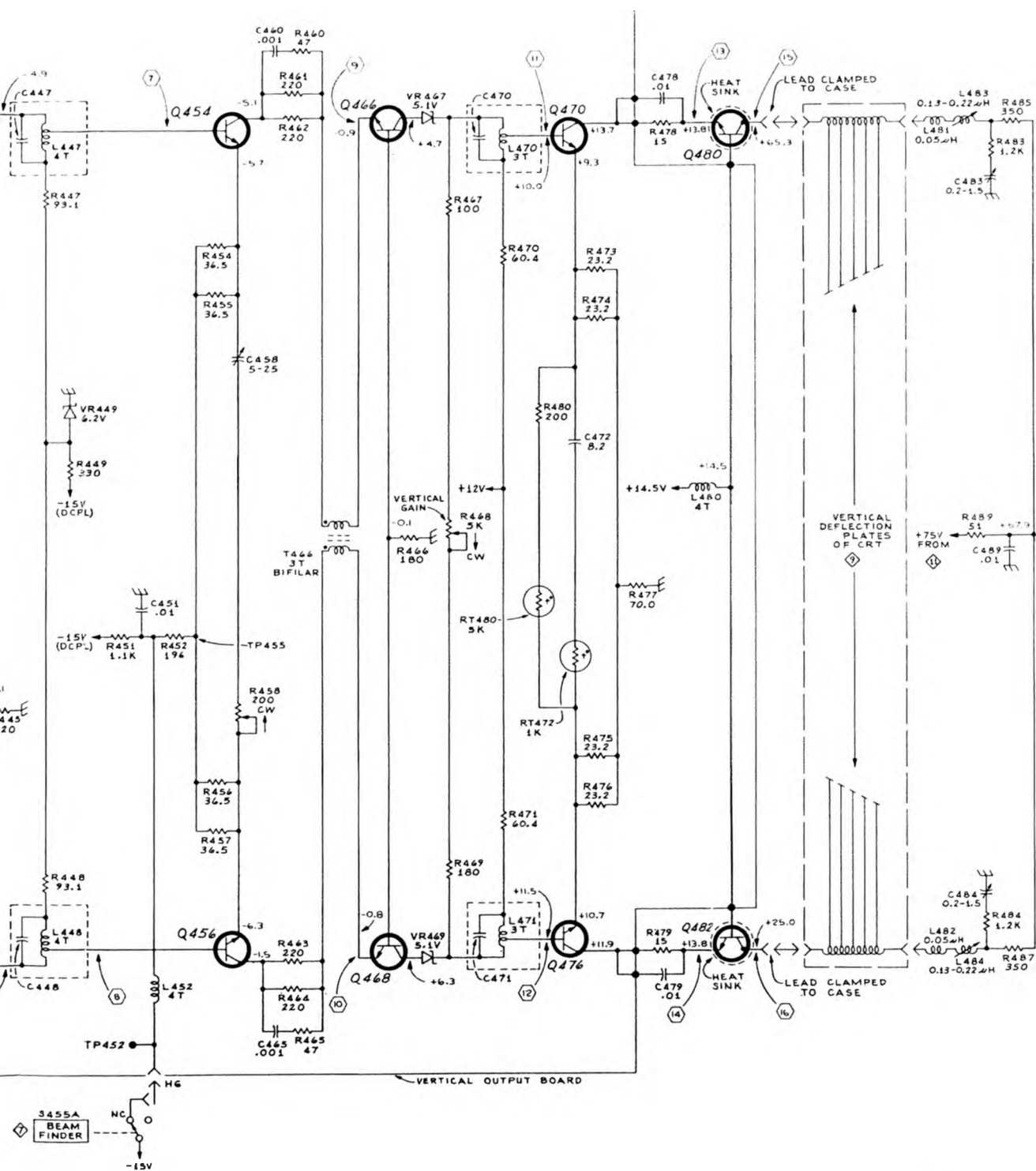
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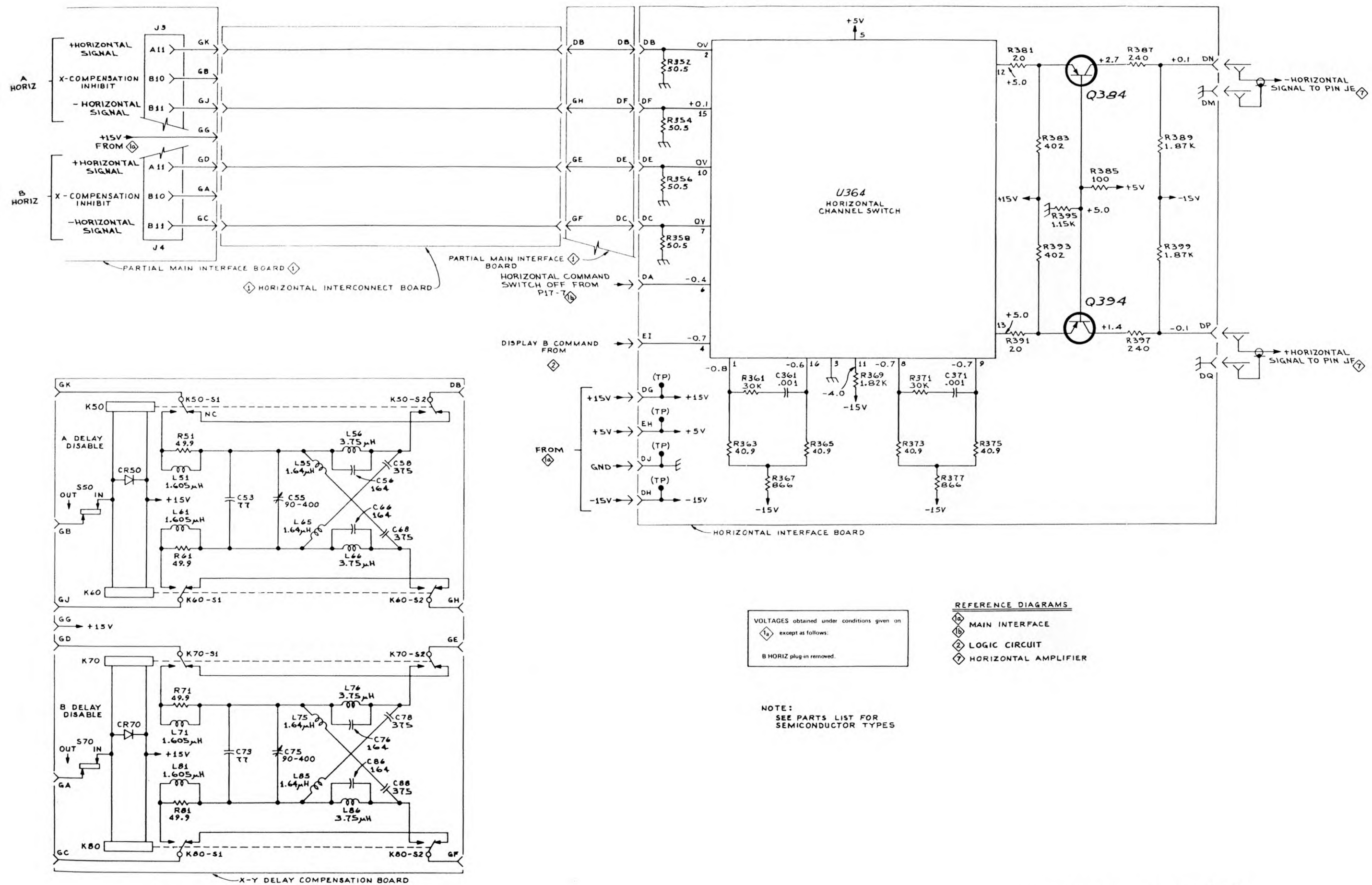
TRIGGER SELECTOR 3 WLB 0270











VOLTAGES obtained under conditions given on except as follows:  
B HORIZ plug-in removed.

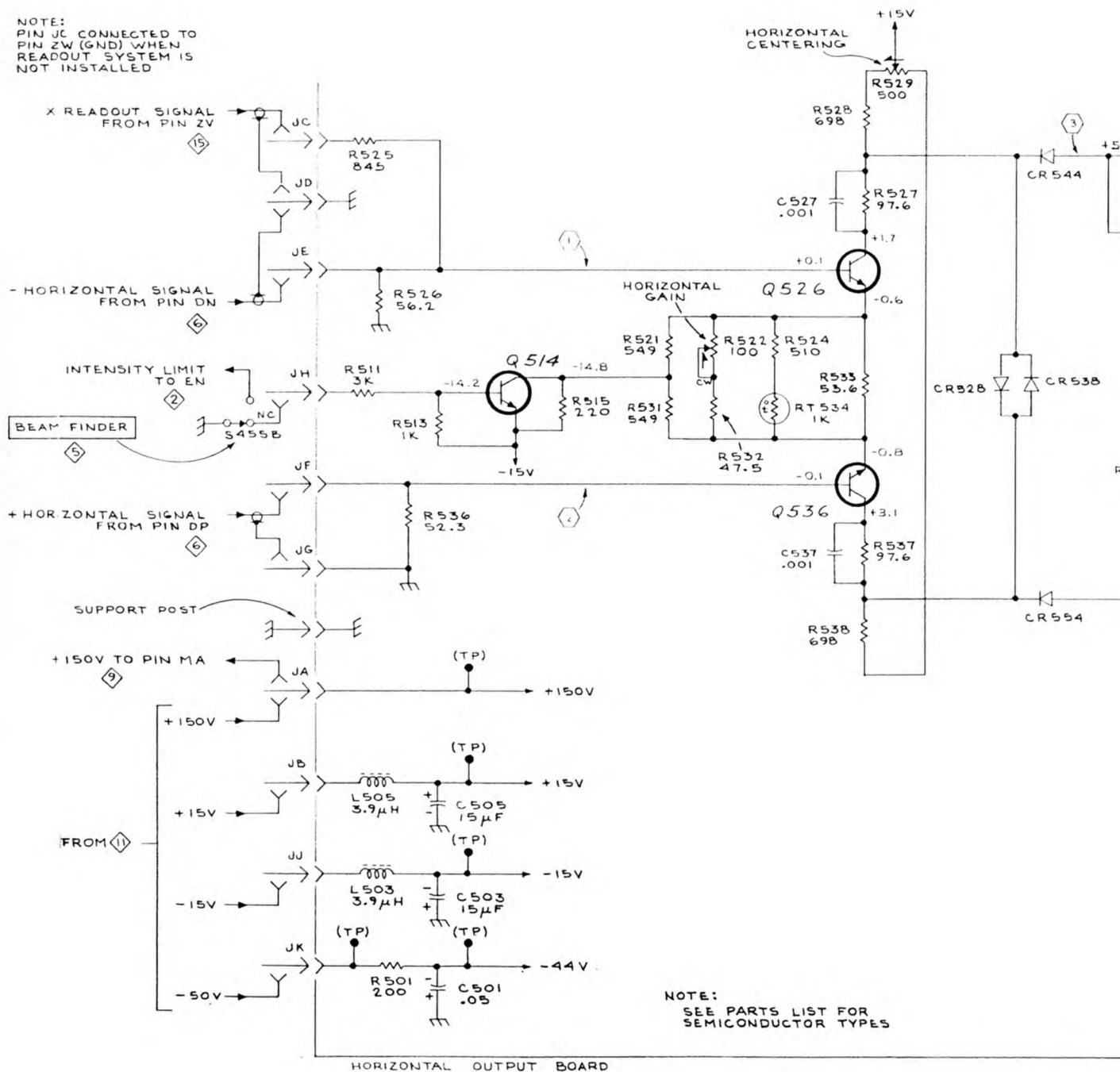
**REFERENCE DIAGRAMS**  
 1 MAIN INTERFACE  
 2 LOGIC CIRCUIT  
 7 HORIZONTAL AMPLIFIER

**NOTE:**  
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

# REFERENCE DIAGRAMS:

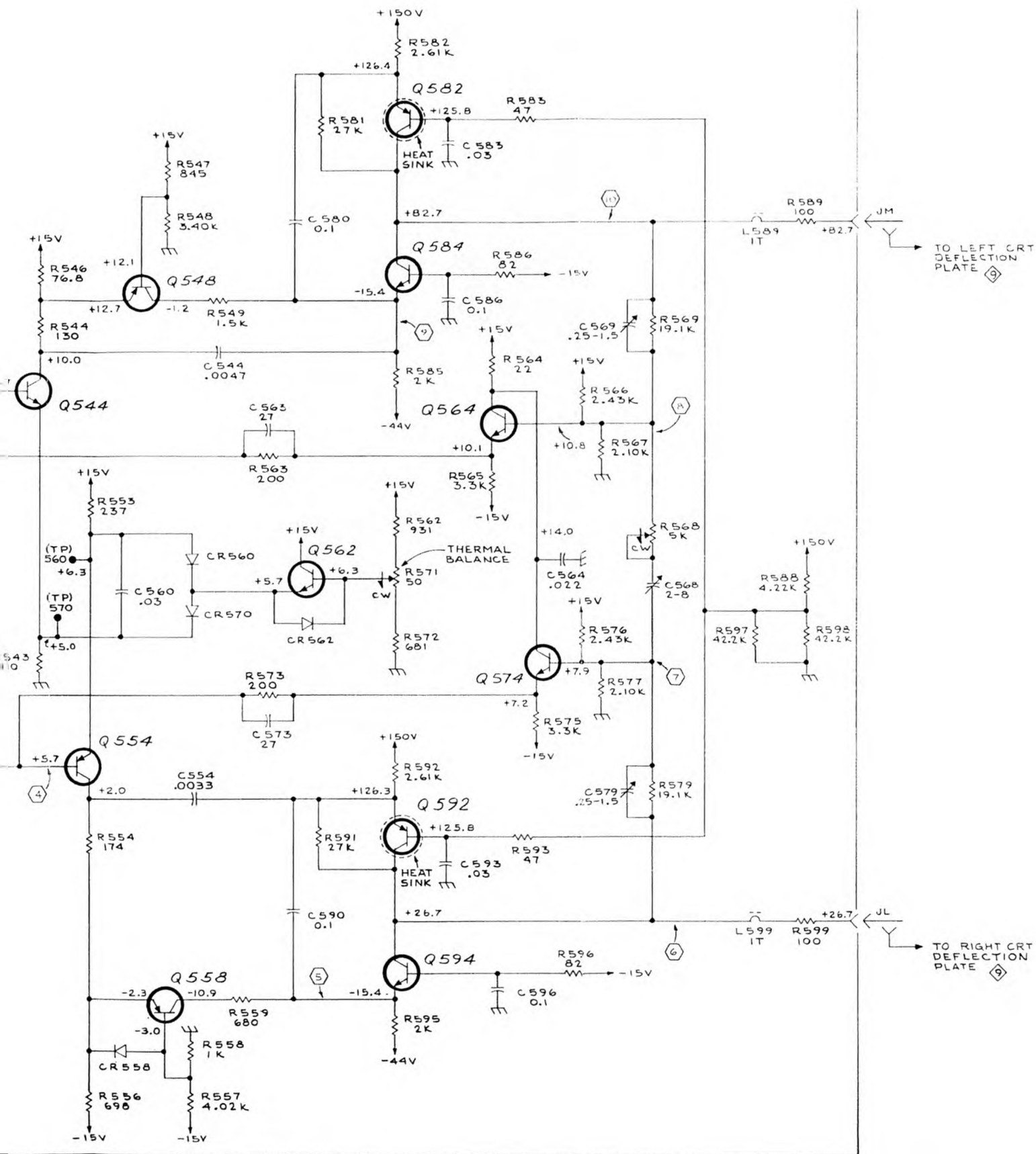
- ② LOGIC CIRCUIT
- ⑤ VERTICAL AMPLIFIER
- ⑥ HORIZONTAL INTERFACE
- ⑨ CRT CIRCUIT
- ⑪ LOW-VOLTAGE REGULATOR
- ⑮ CHARACTER GENERATORS & OUTPUT

NOTE:  
PIN JC CONNECTED TO  
PIN ZW (GND) WHEN  
READOUT SYSTEM IS  
NOT INSTALLED



NOTE:  
SEE PARTS LIST FOR  
SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under  
conditions on ④

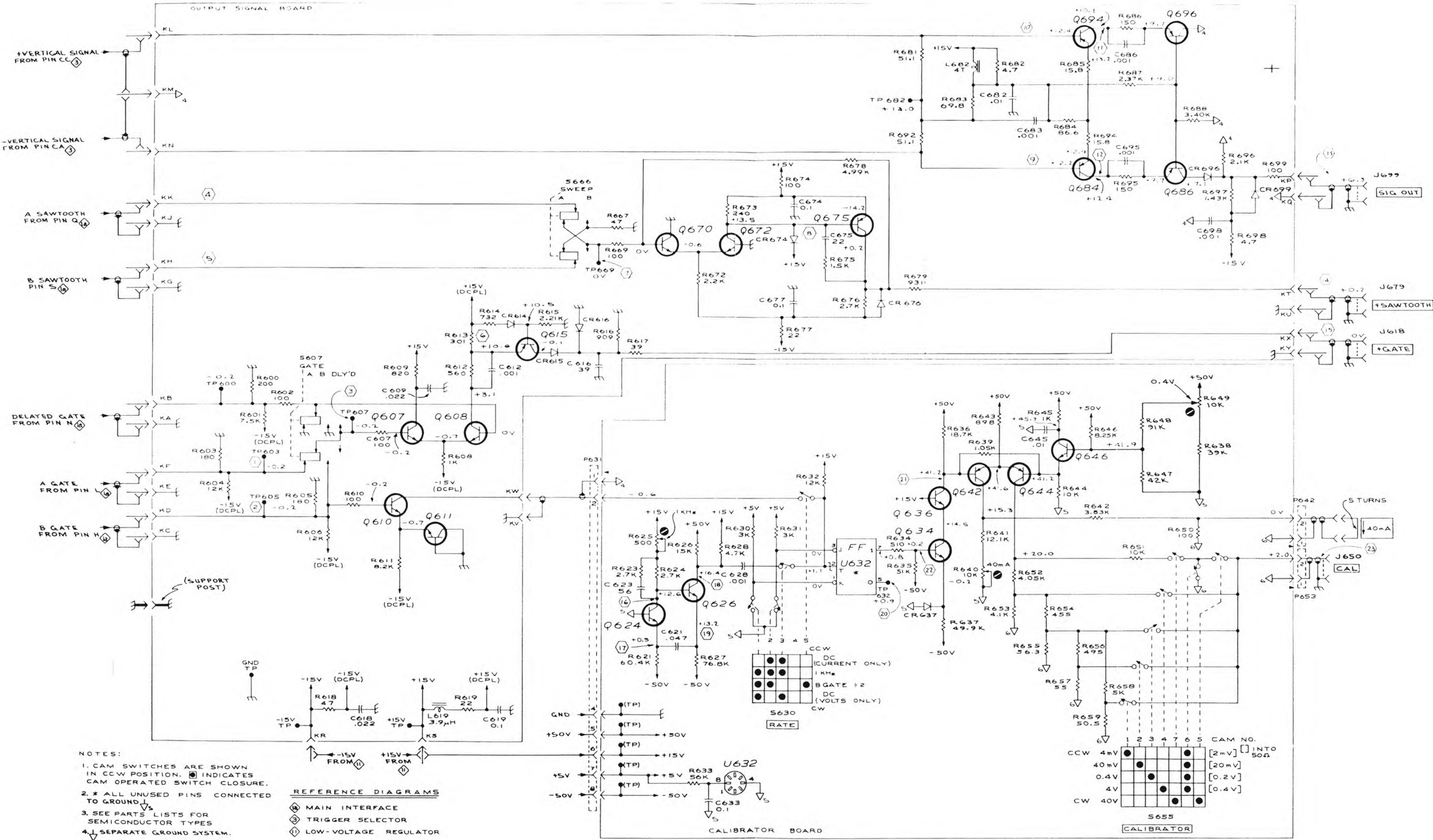


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0270

HORIZONTAL AMPLIFIER

7





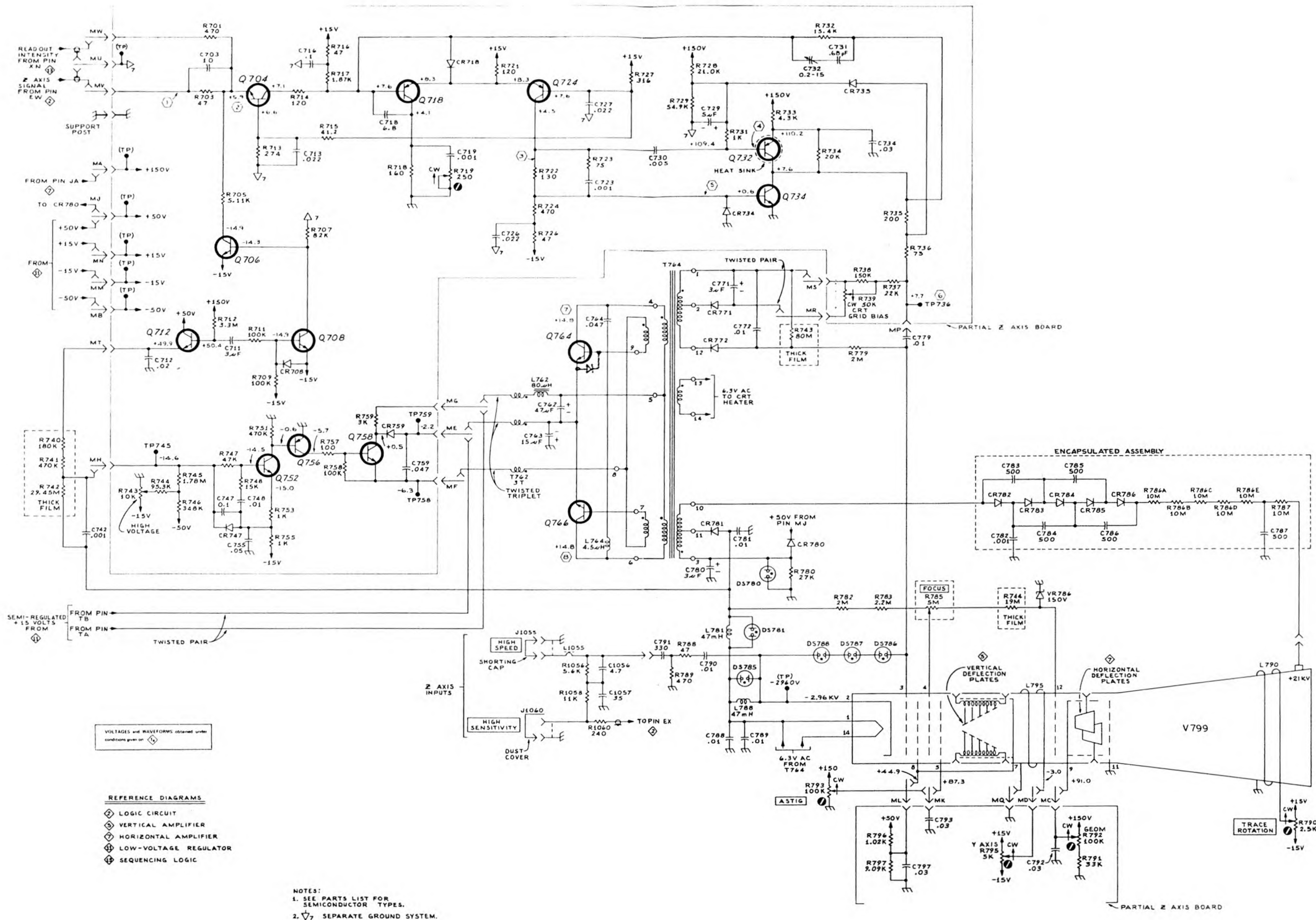
- NOTES:
1. CAM SWITCHES ARE SHOWN IN CCW POSITION. INDICATES CAM OPERATED SWITCH CLOSURE.
  2. \* ALL UNUSED PINS CONNECTED TO GROUND.
  3. SEE PARTS LISTS FOR SEMICONDUCTOR TYPES.
  4. SEPARATE GROUND SYSTEM.

- REFERENCE DIAGRAMS
- MAIN INTERFACE
  - TRIGGER SELECTOR
  - LOW-VOLTAGE REGULATOR

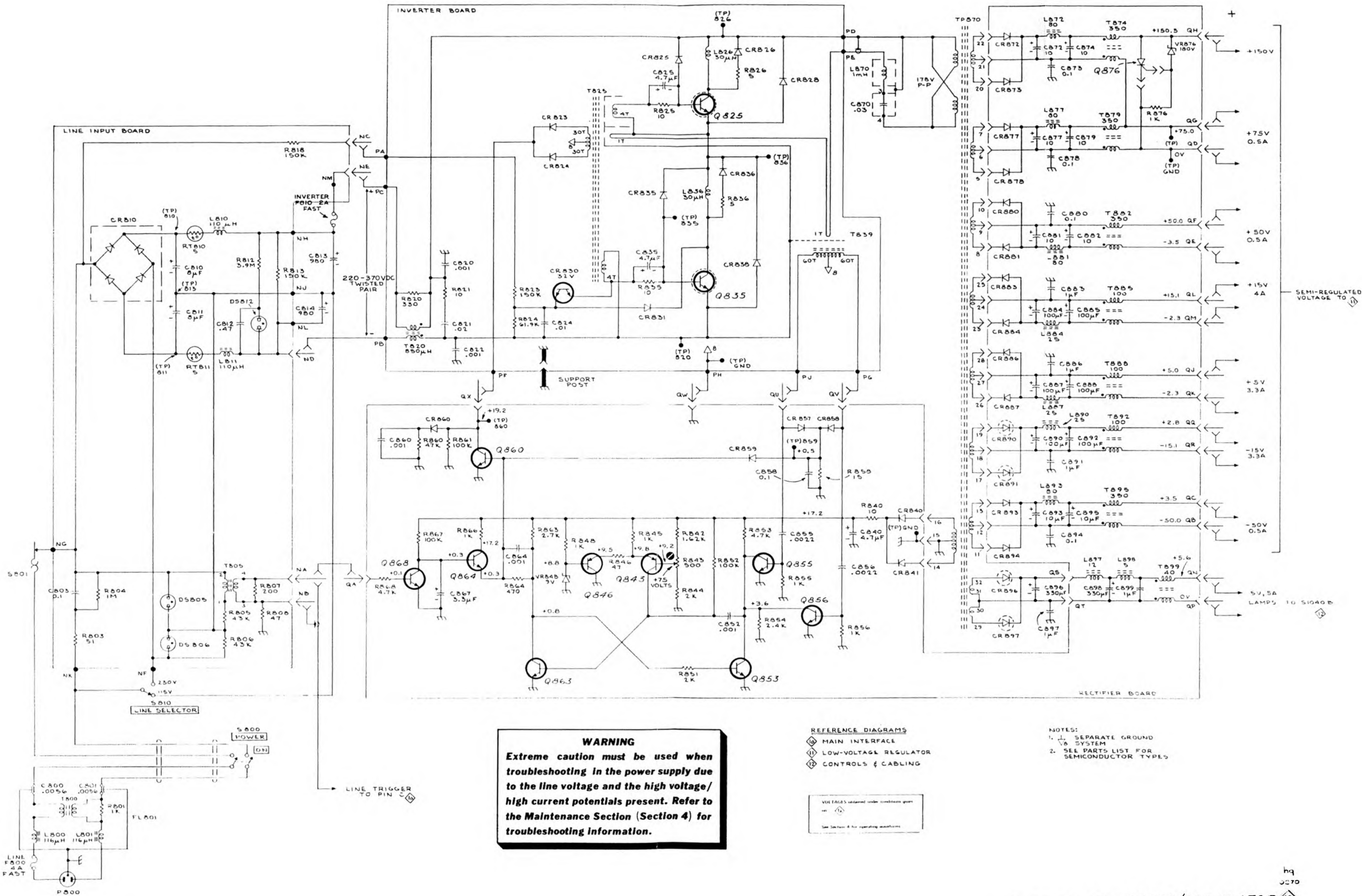
VOLTAGES and WAVEFORMS obtained under conditions given on

OUTPUT SIGNALS & CALIBRATOR

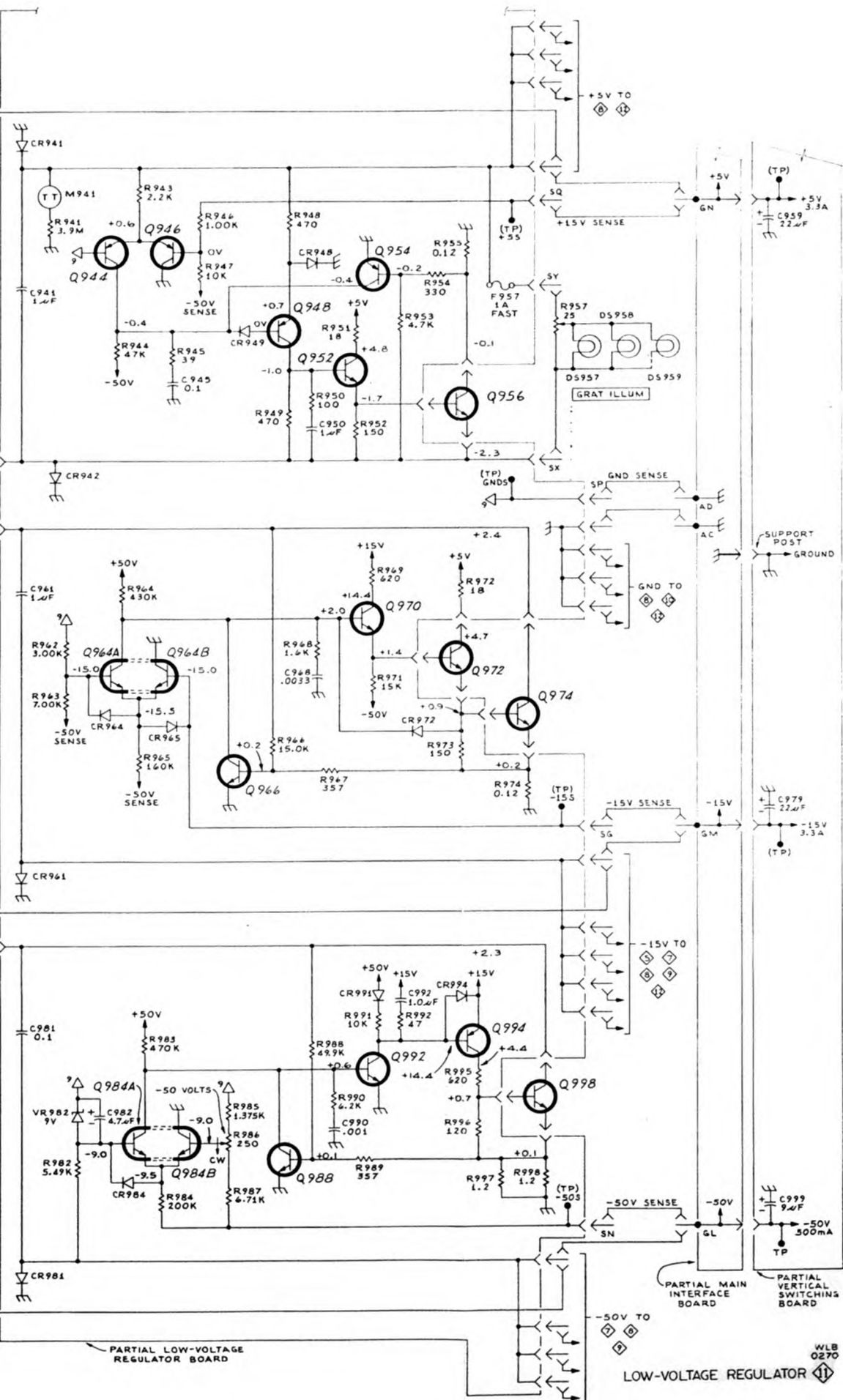
VRS 0270

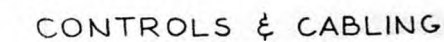
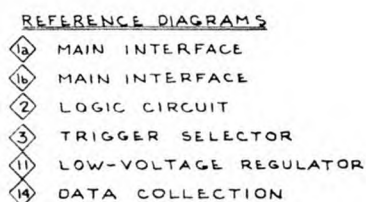
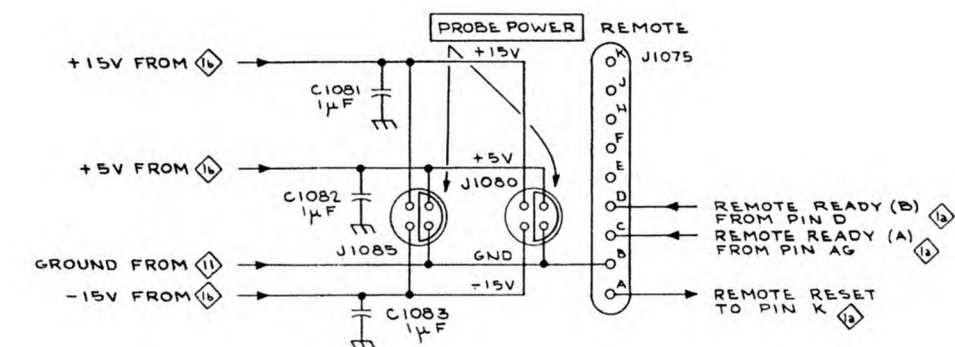
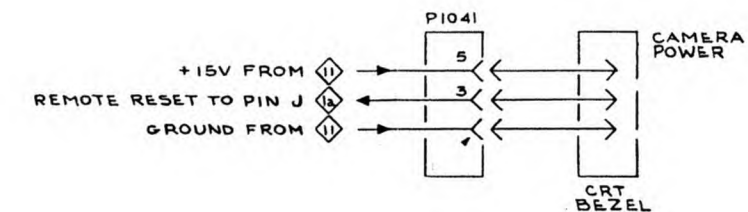








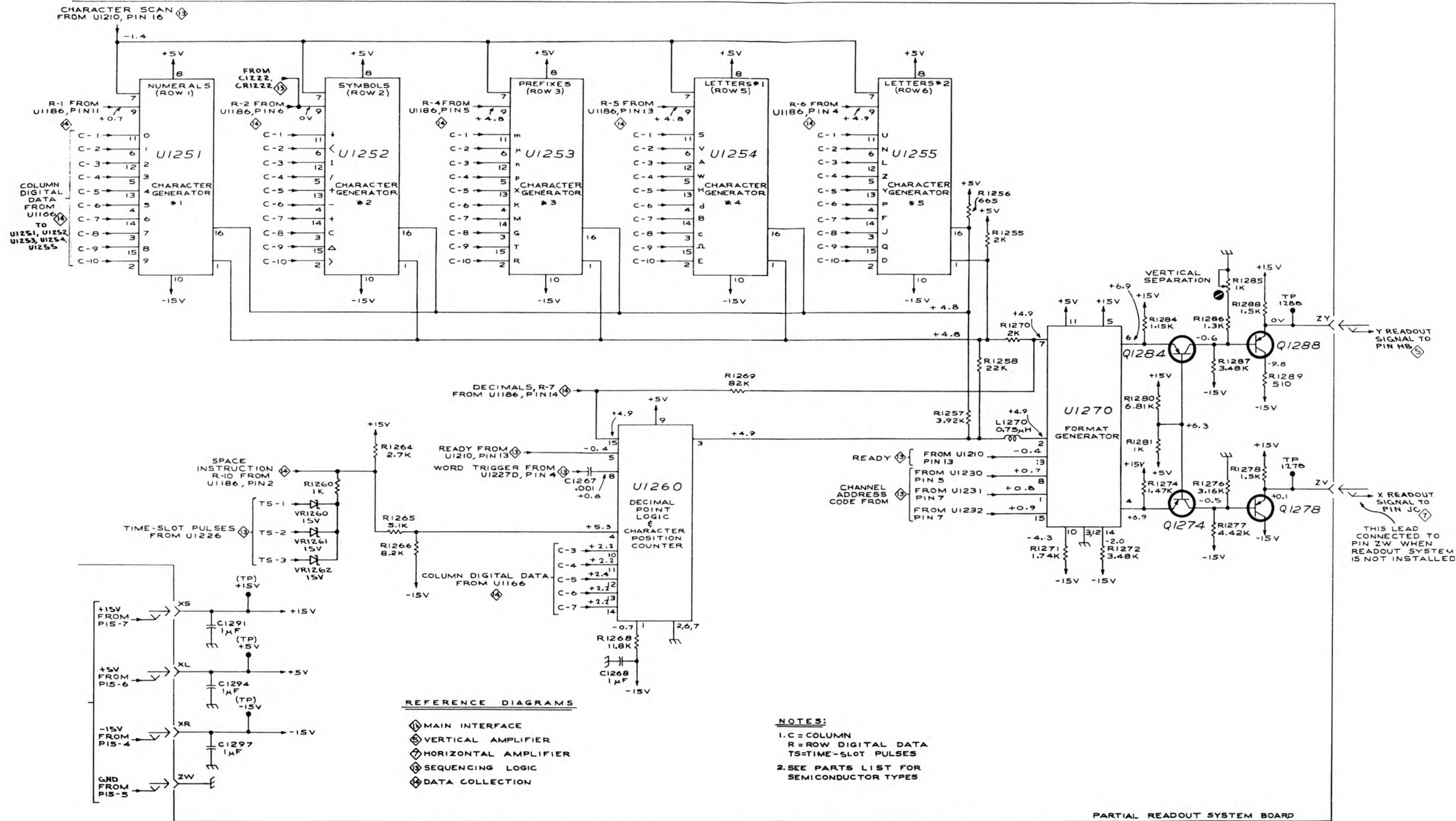




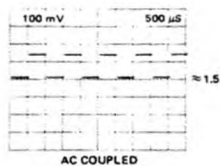




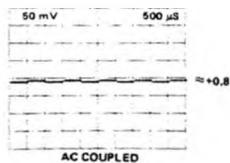




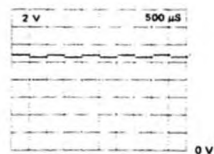
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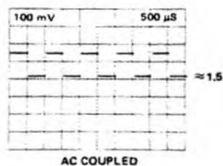
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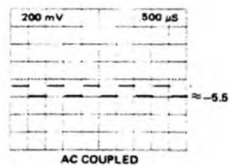
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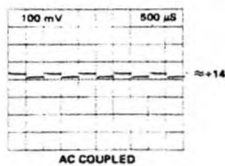
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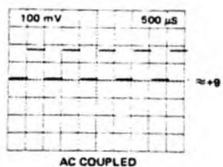
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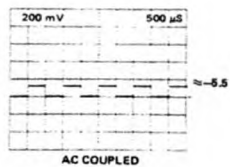
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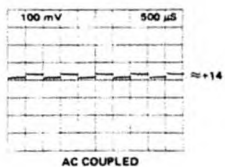
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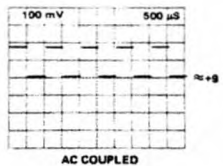
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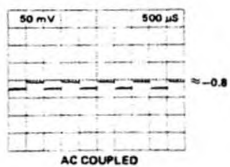
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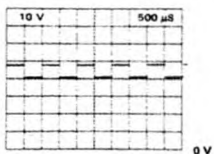
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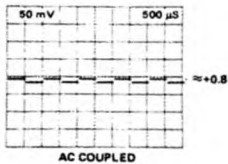
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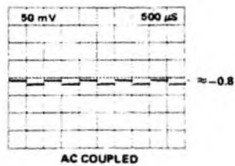
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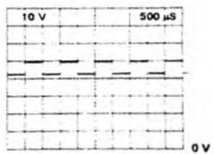
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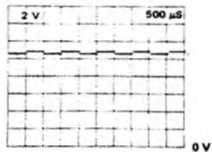
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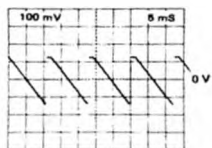


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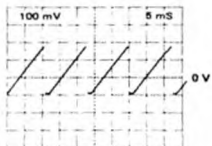




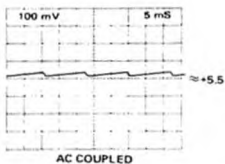
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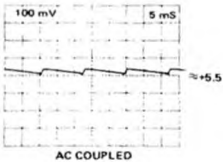
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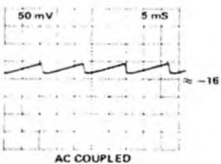
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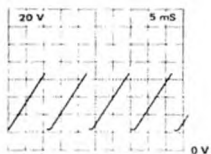
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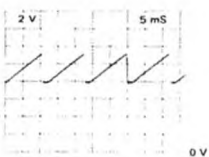
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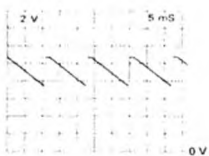
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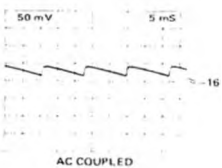
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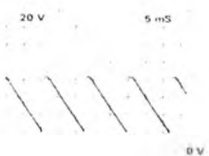
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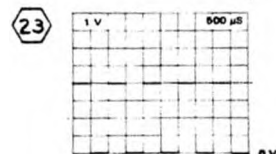
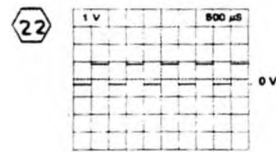
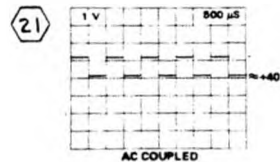
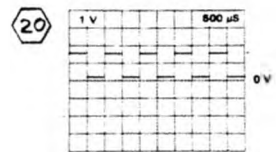
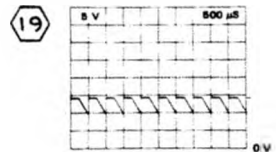
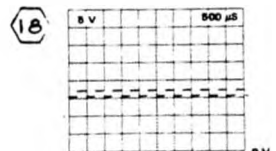
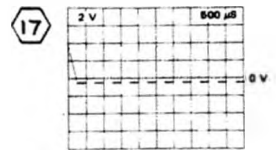
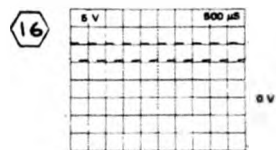
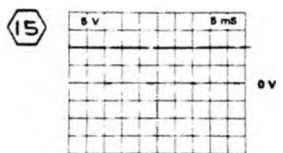
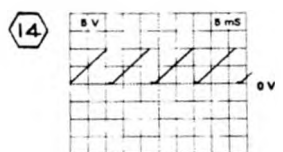
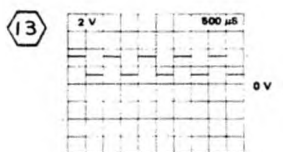
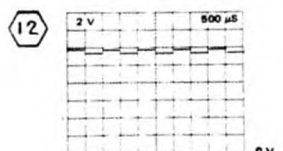
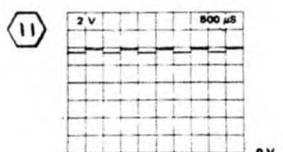
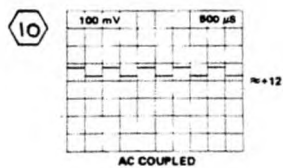
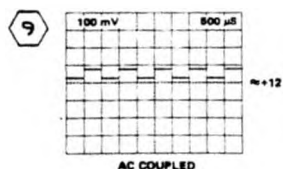
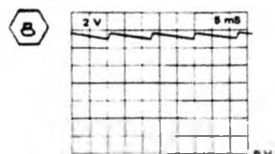
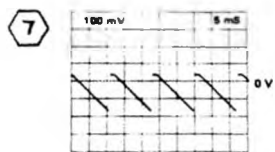
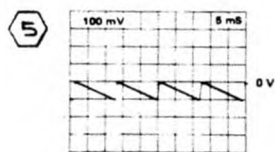
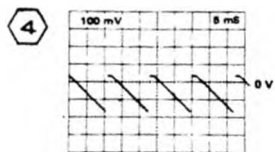
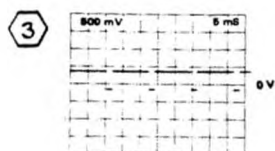
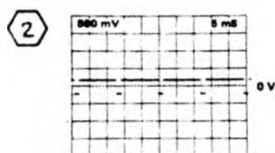
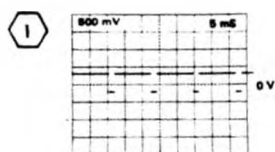


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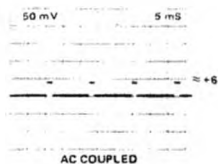


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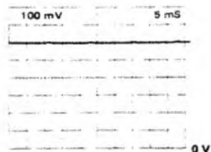




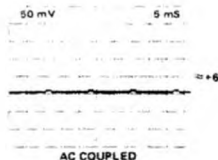
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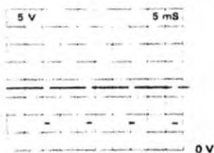
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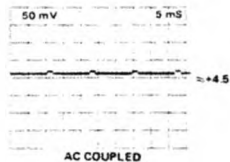
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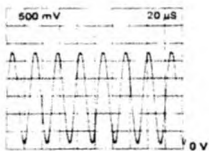
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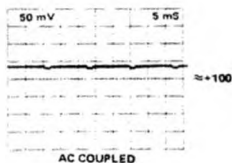
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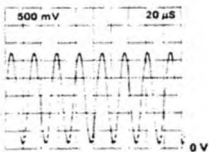
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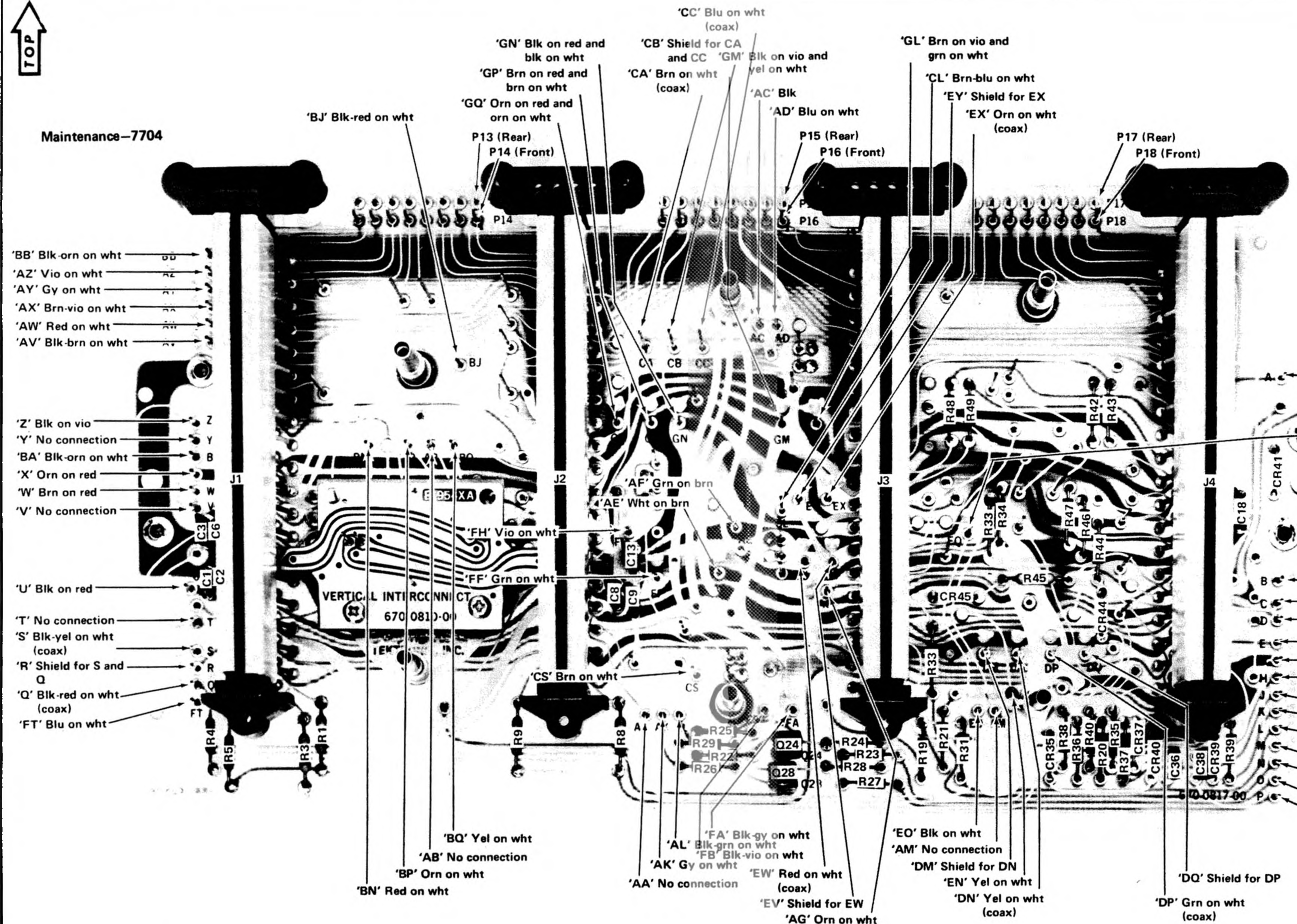
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TOP

Maintenance-7704

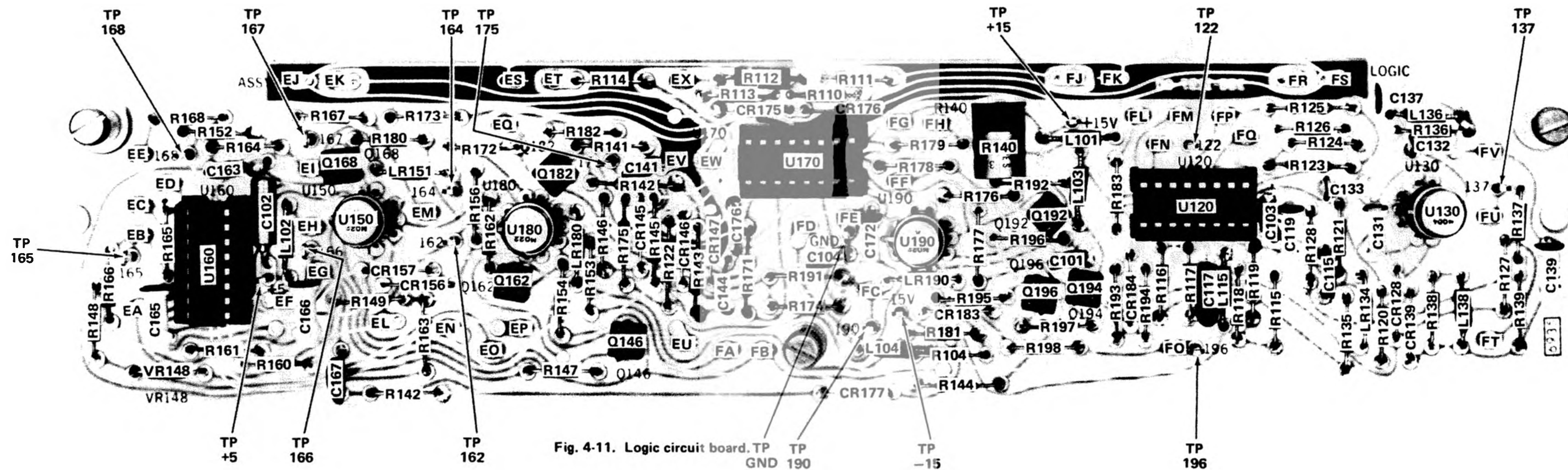


NOTE: C4, C5, C10, C11  
C12, C42 mounted on rear  
of board.

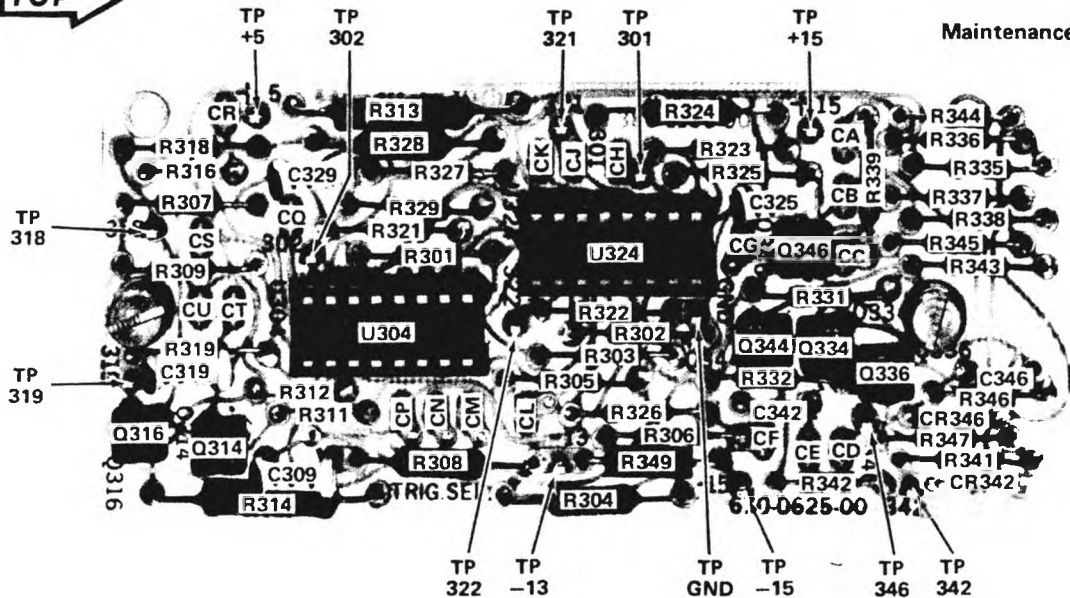
Fig. 4-9. Partial Main Interface circuit board.

Fig. 4-10. Partial Main Interface circuit board.



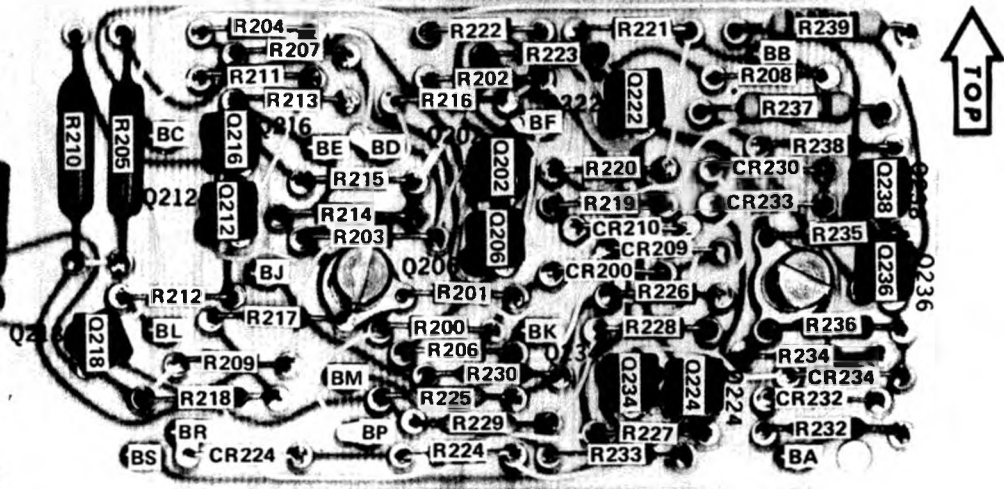




**Maintenance—7704**

**Fig. 4-12. Trigger Selector circuit board.**





**↑**  
**TOP**



FRONT

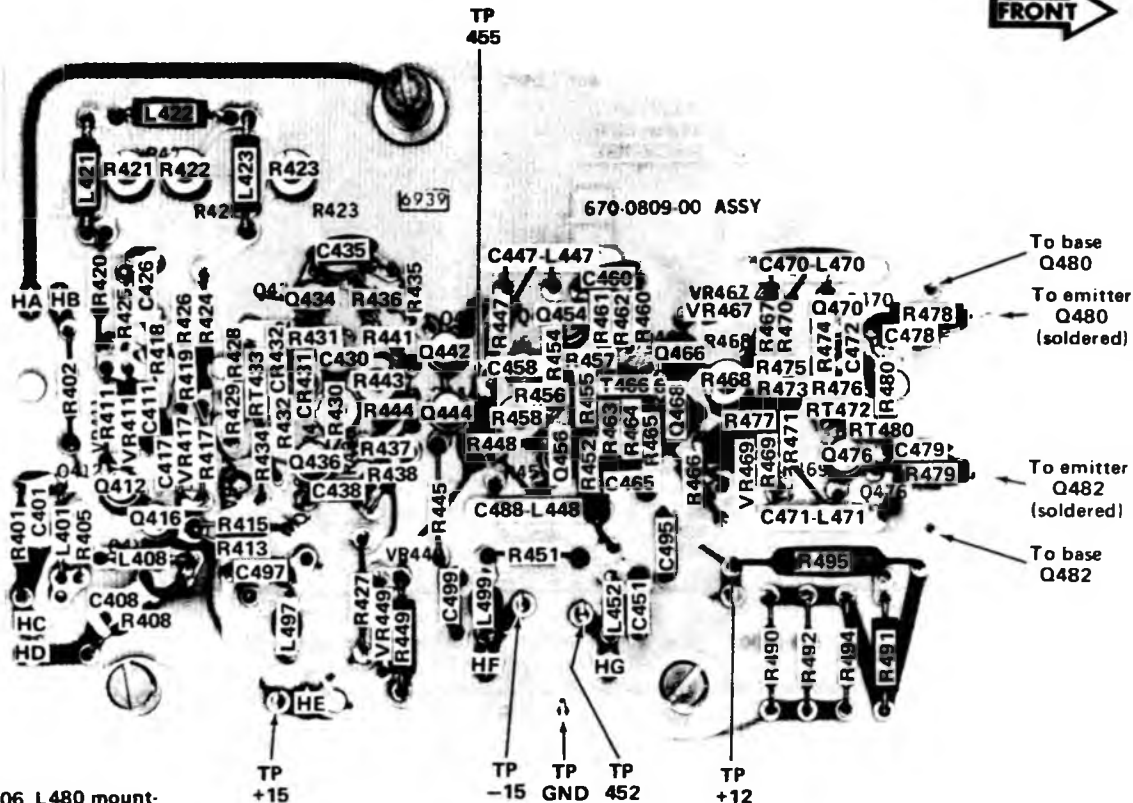


Fig. 4-15. Vertical Output circuit board.

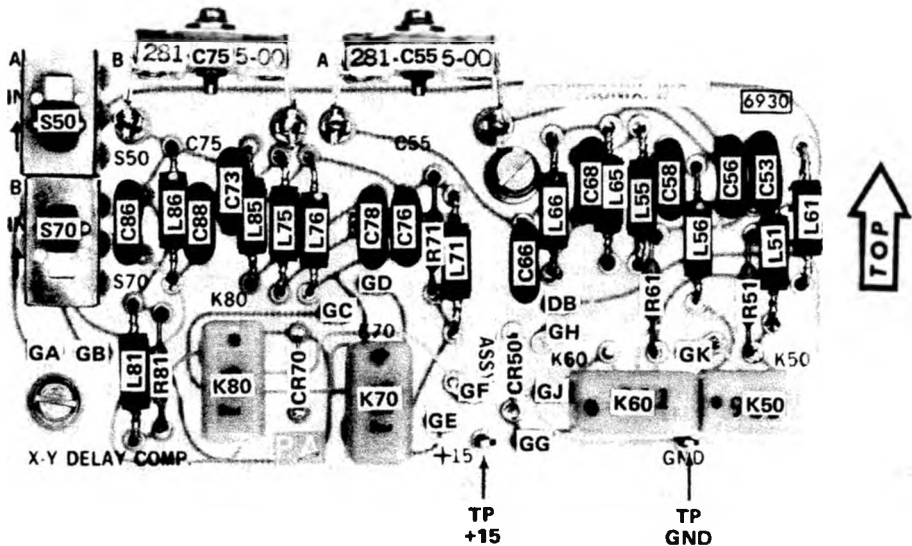


Fig. 4-16. X-Y Delay Compensation circuit board (optional).

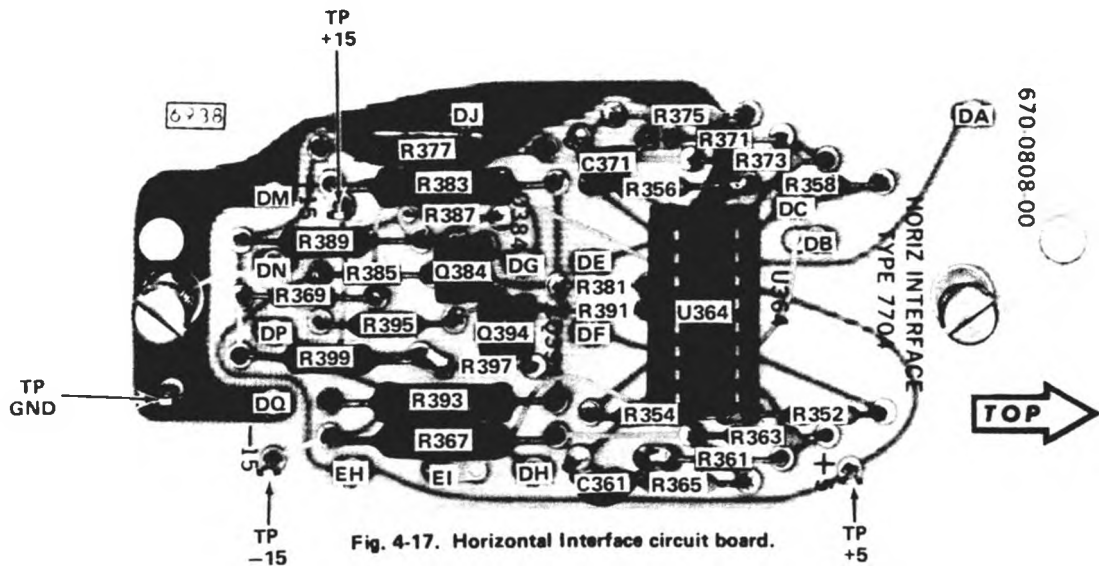
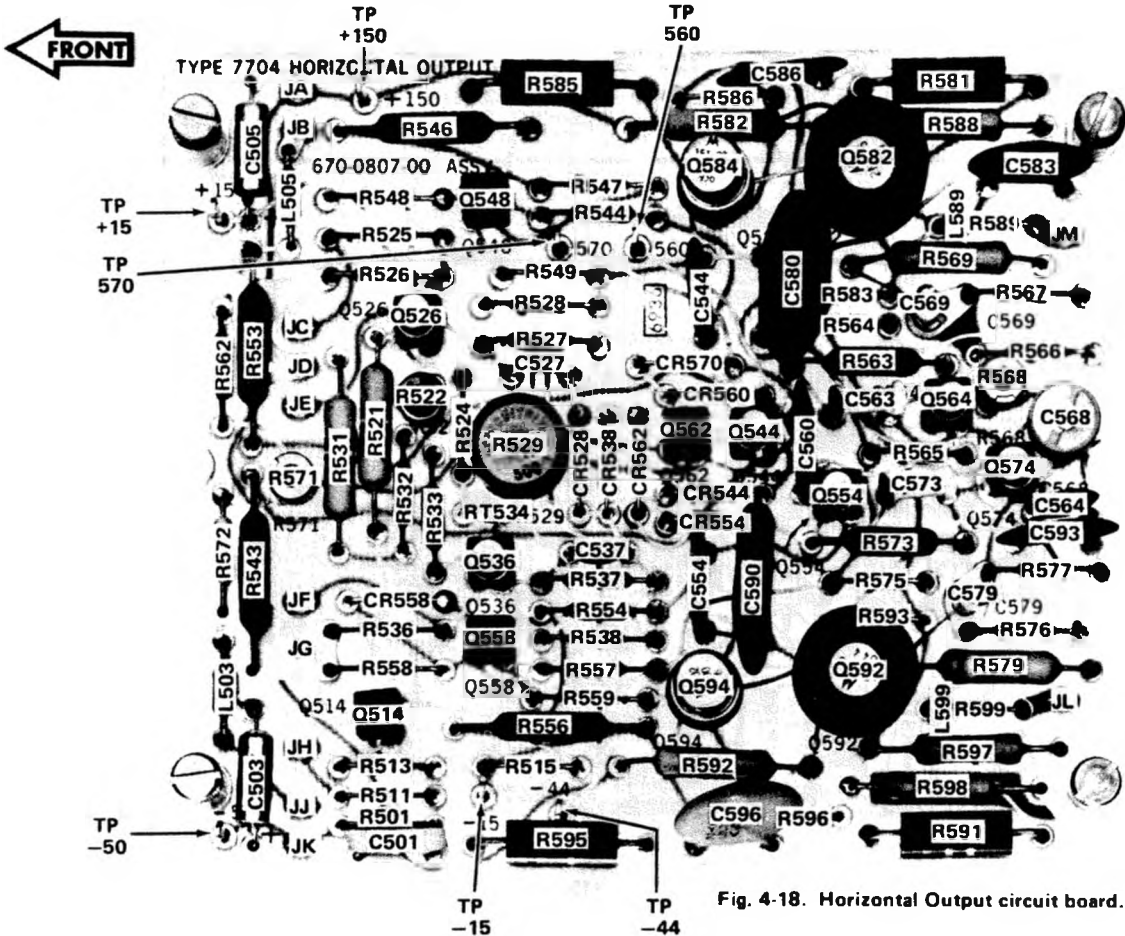
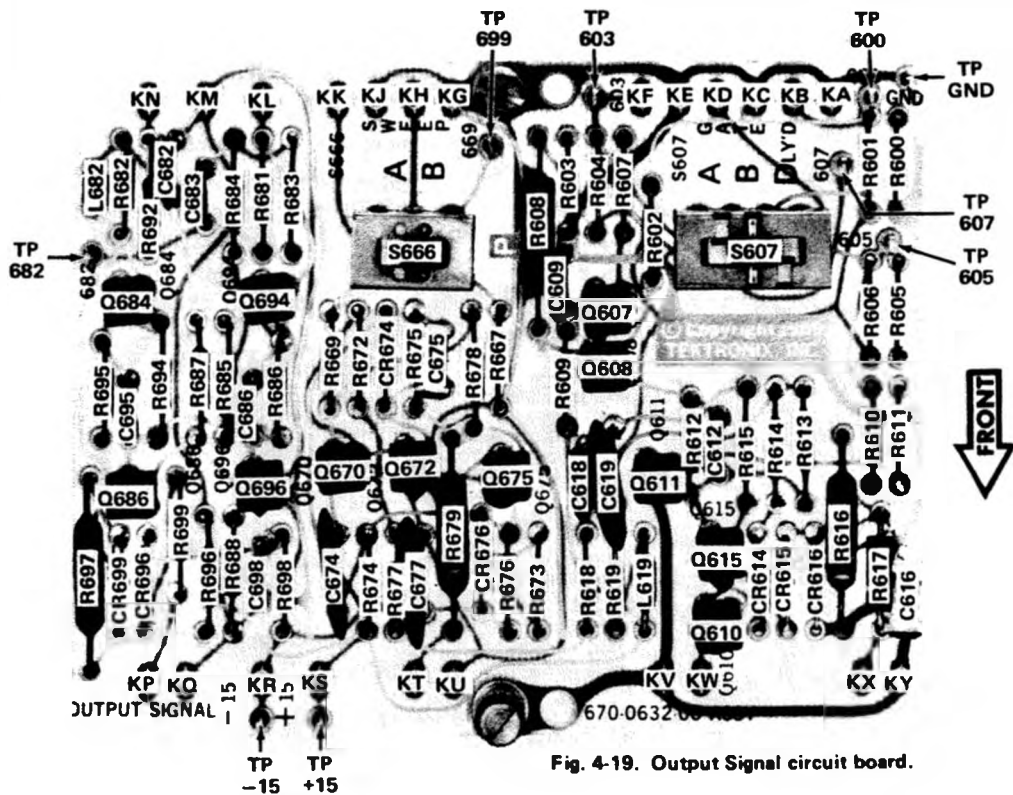


Fig. 4-17. Horizontal Interface circuit board.



**Fig. 4-18. Horizontal Output circuit board.**



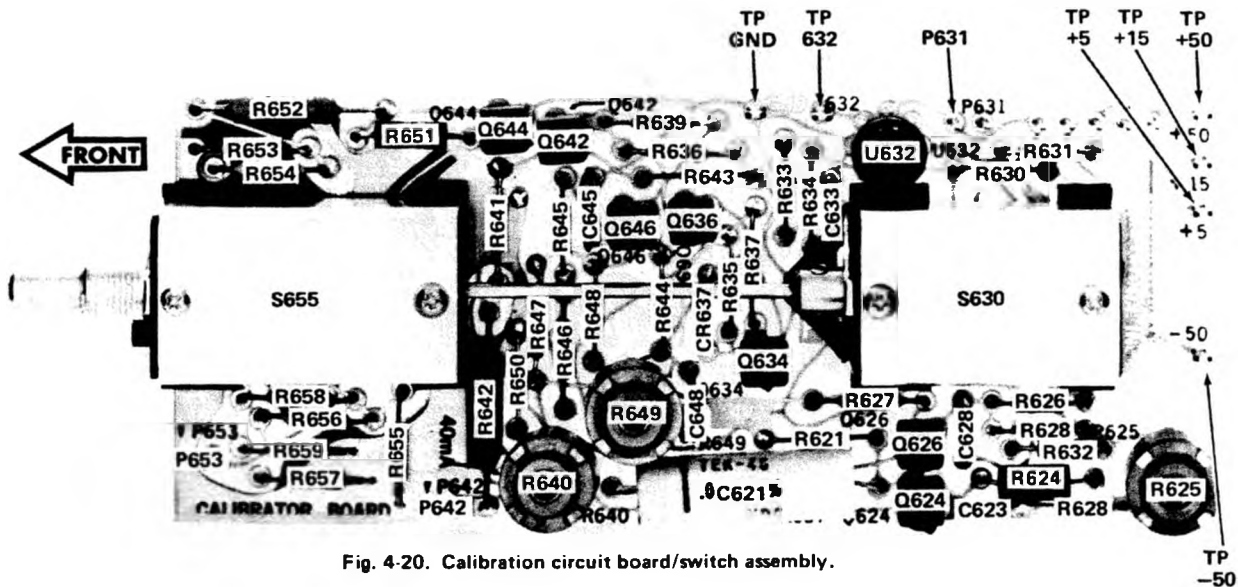
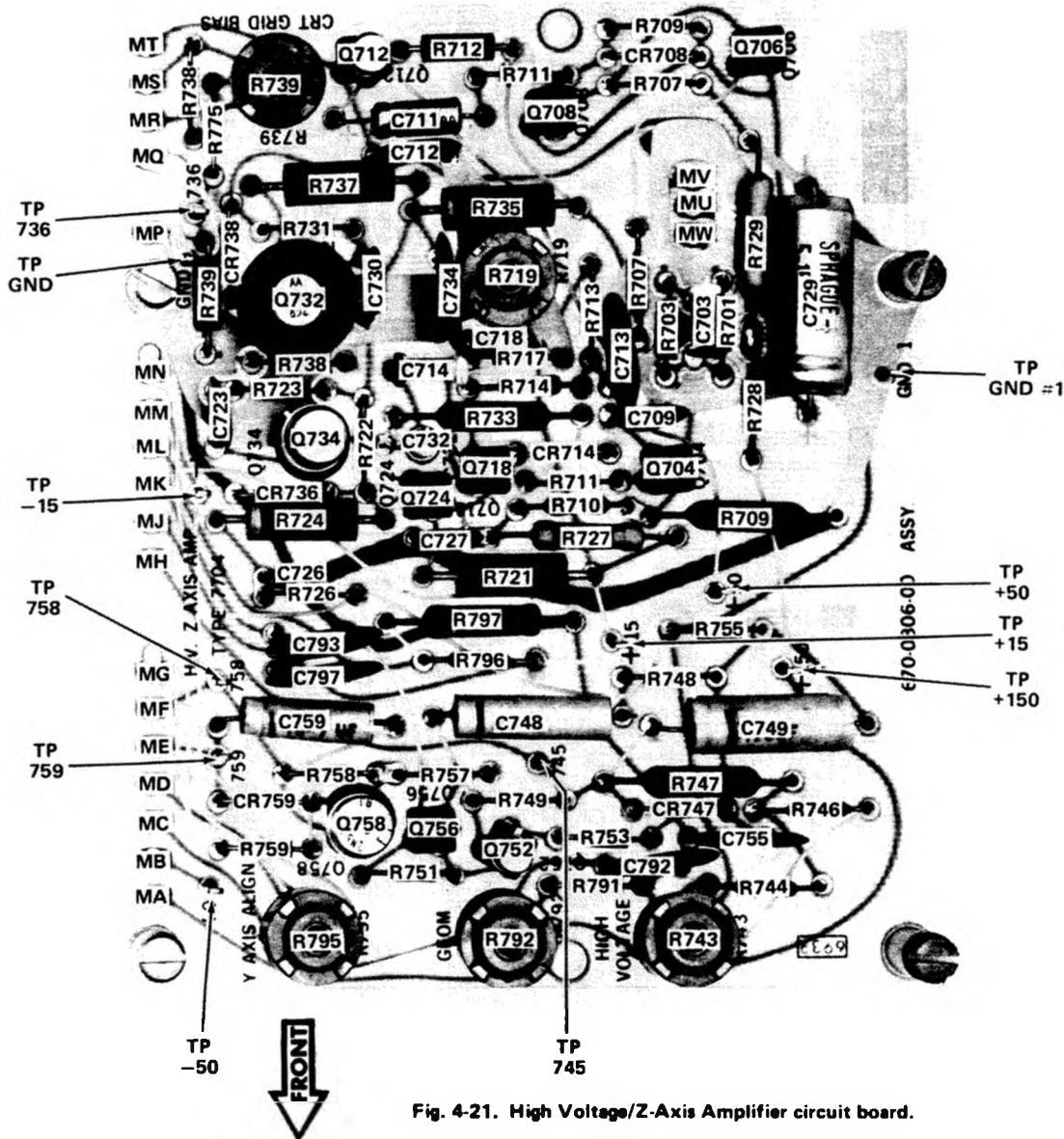


Fig. 4-20. Calibration circuit board/switch assembly.





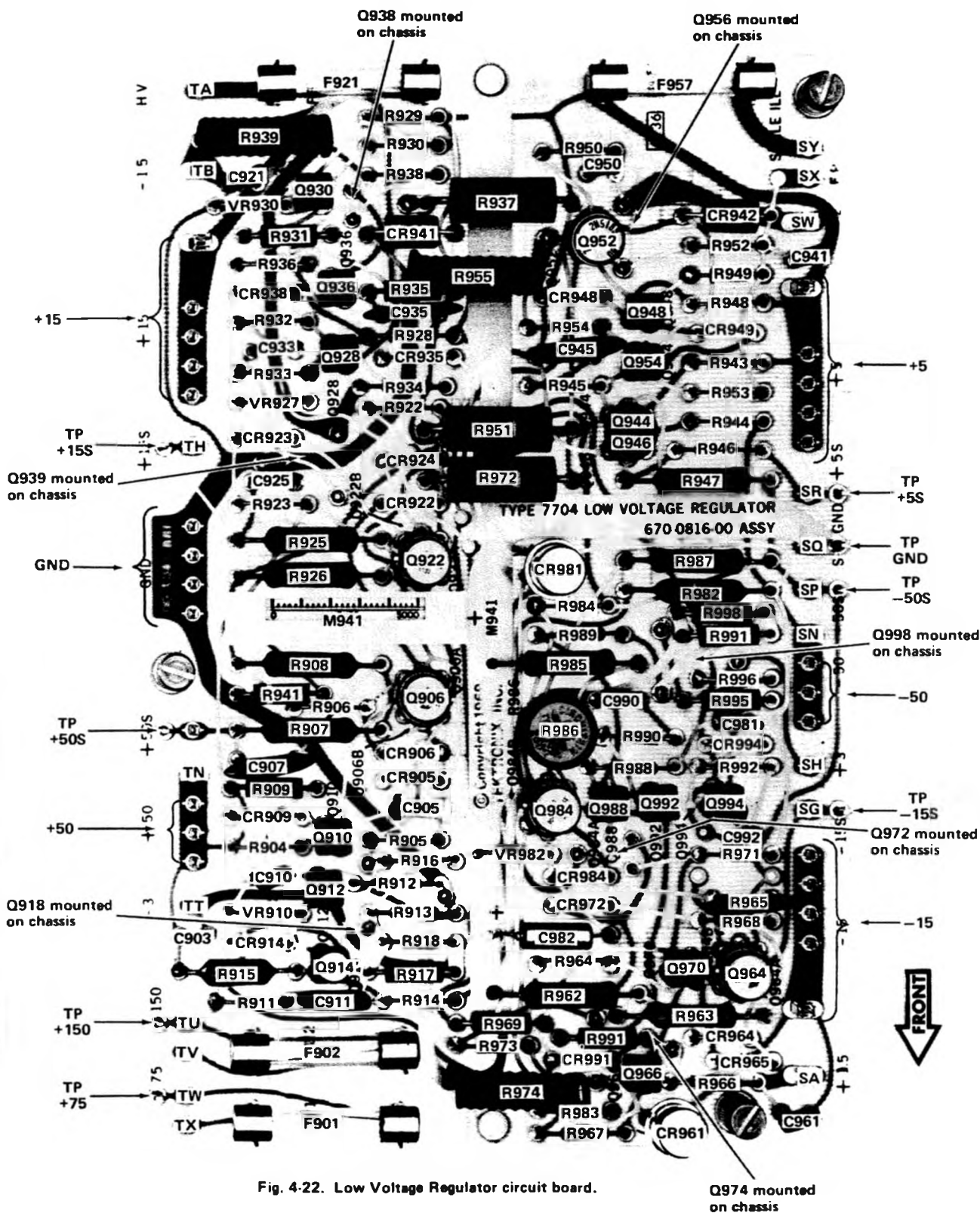


Fig. 4-22. Low Voltage Regulator circuit board.

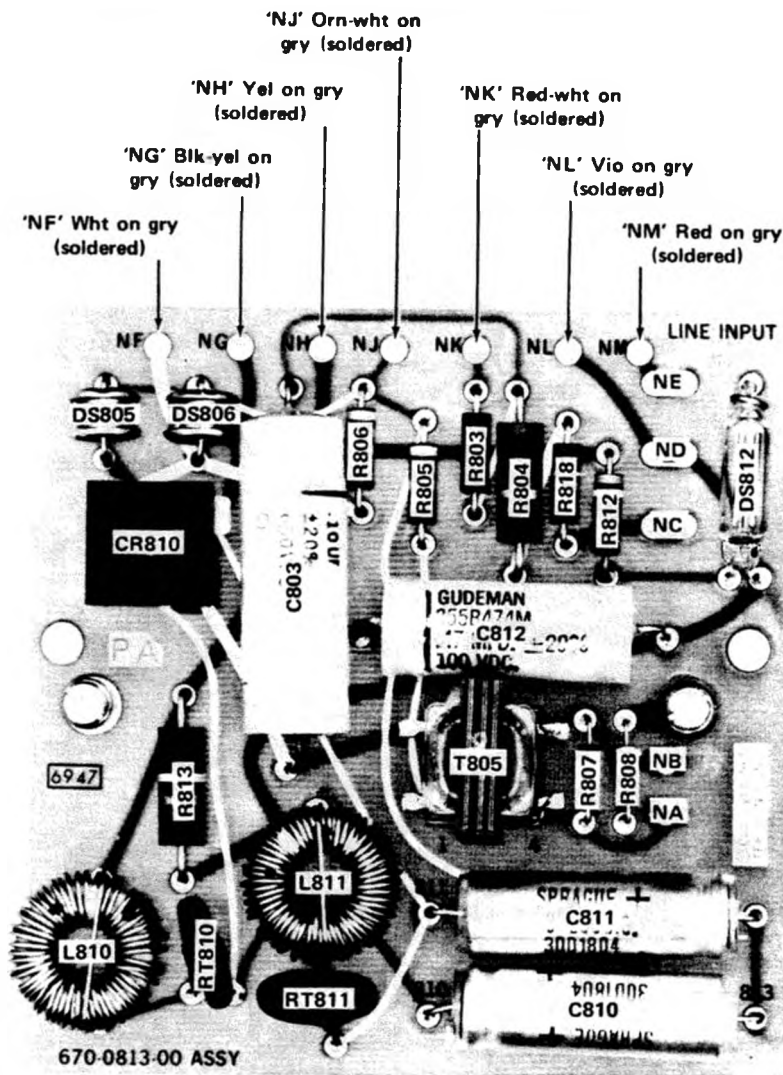


Fig. 4-23. Line Input circuit board.

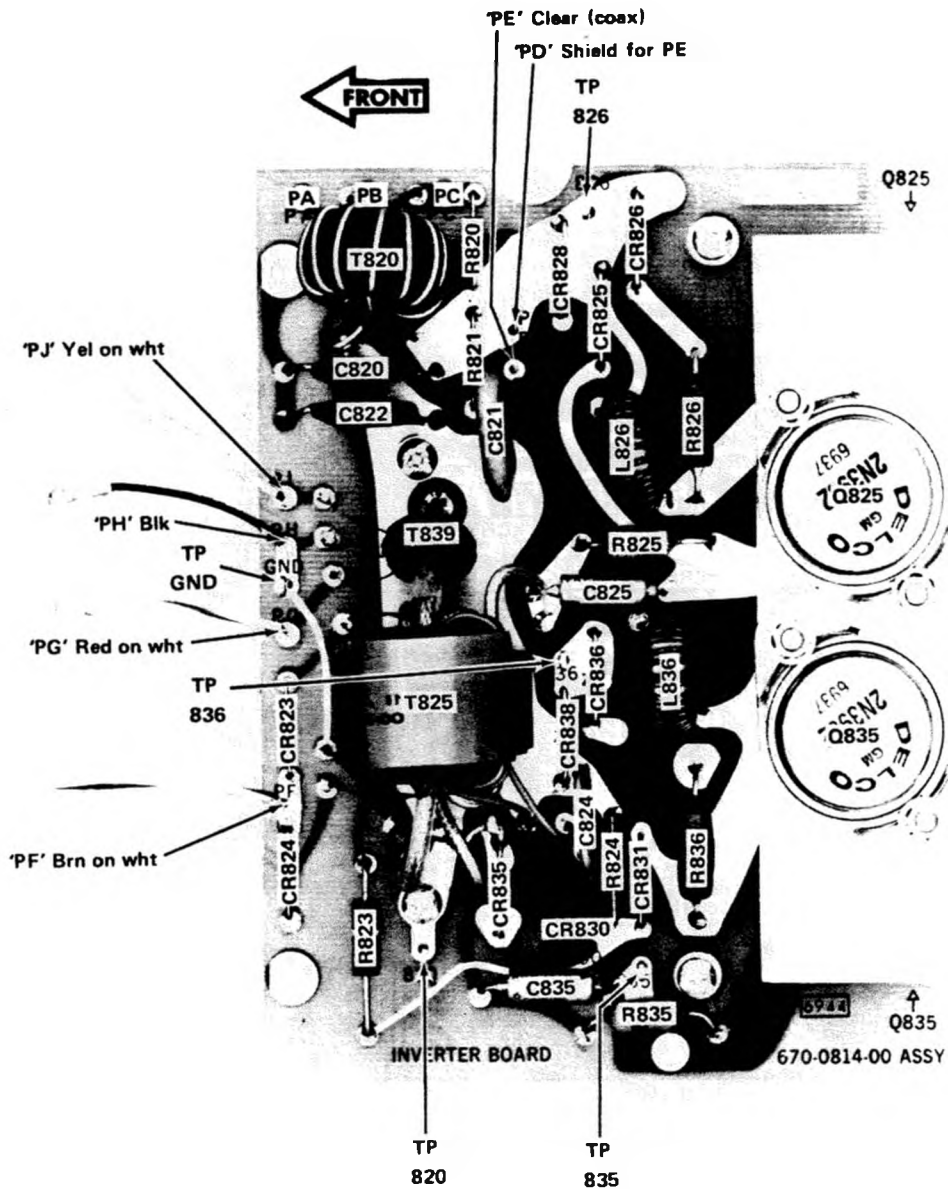
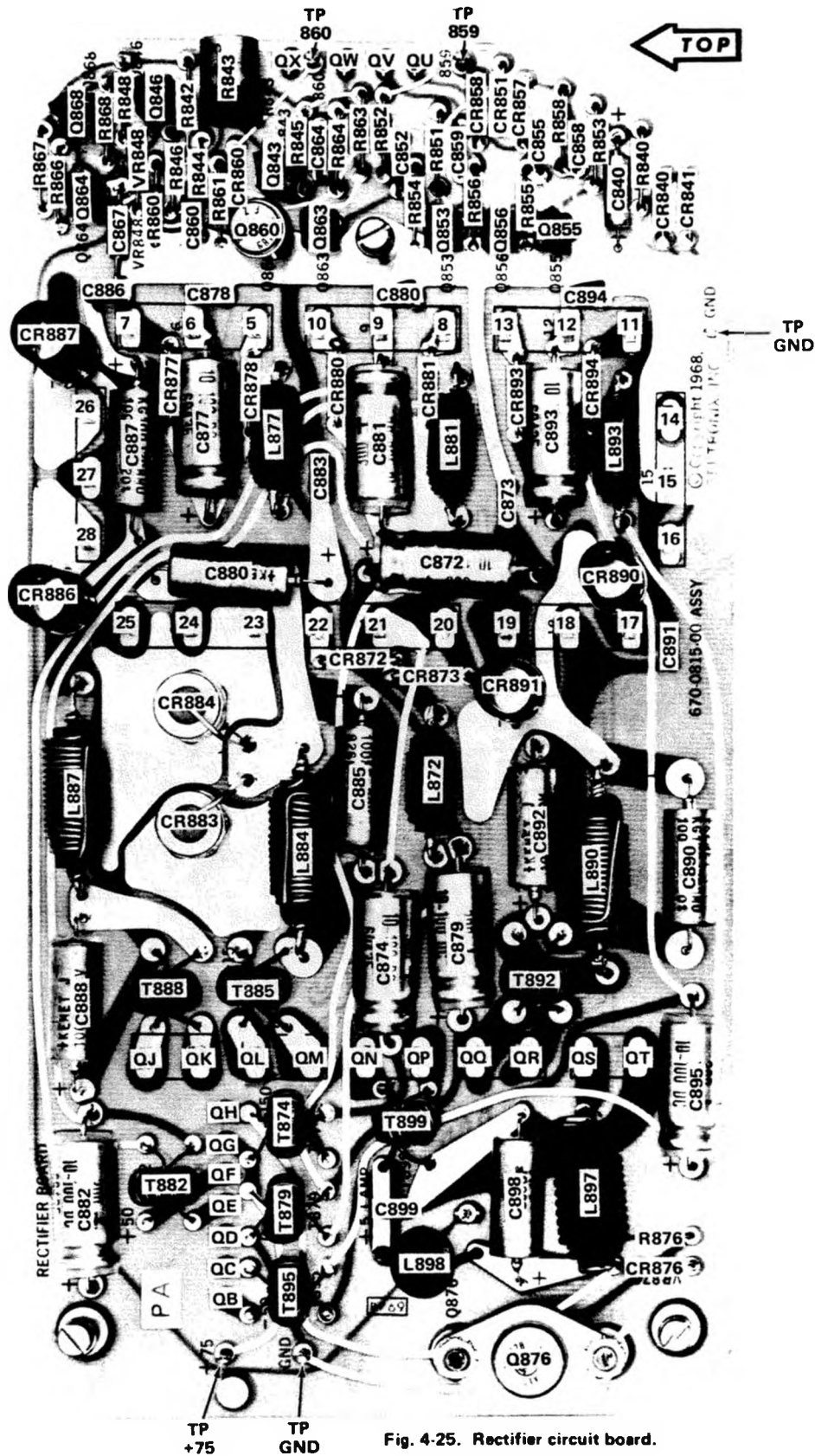
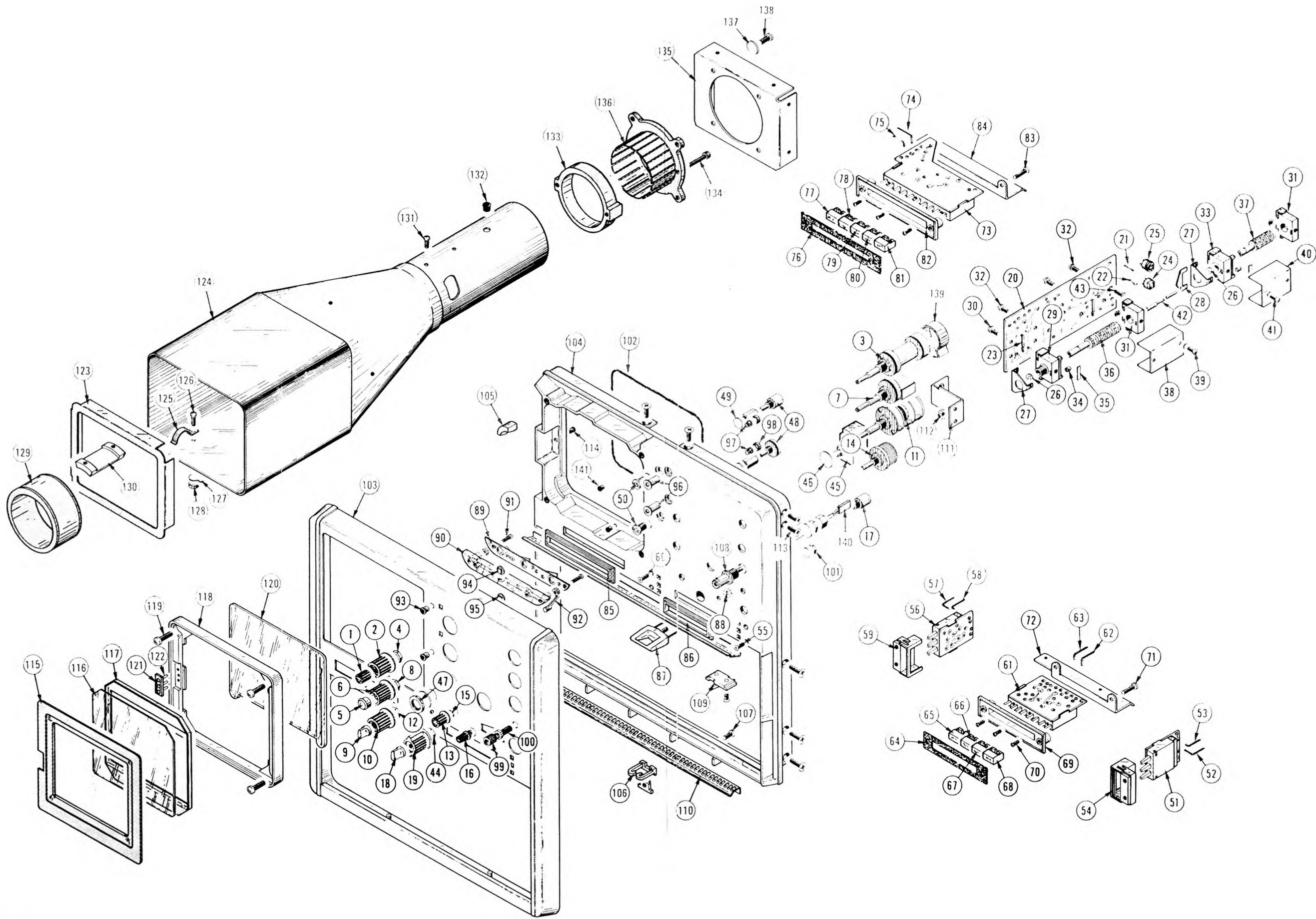


Fig. 4-24. Inverter circuit board.

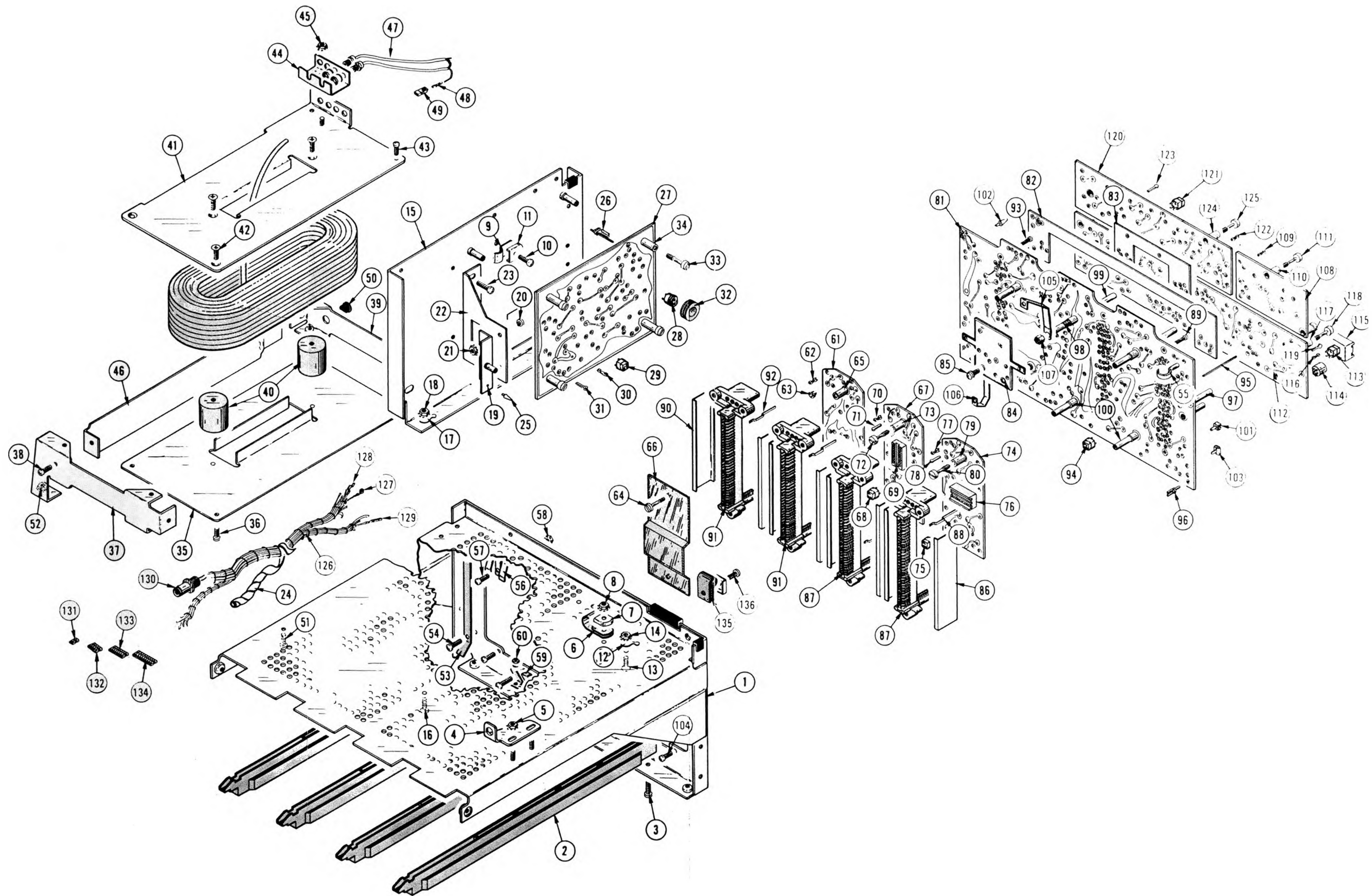


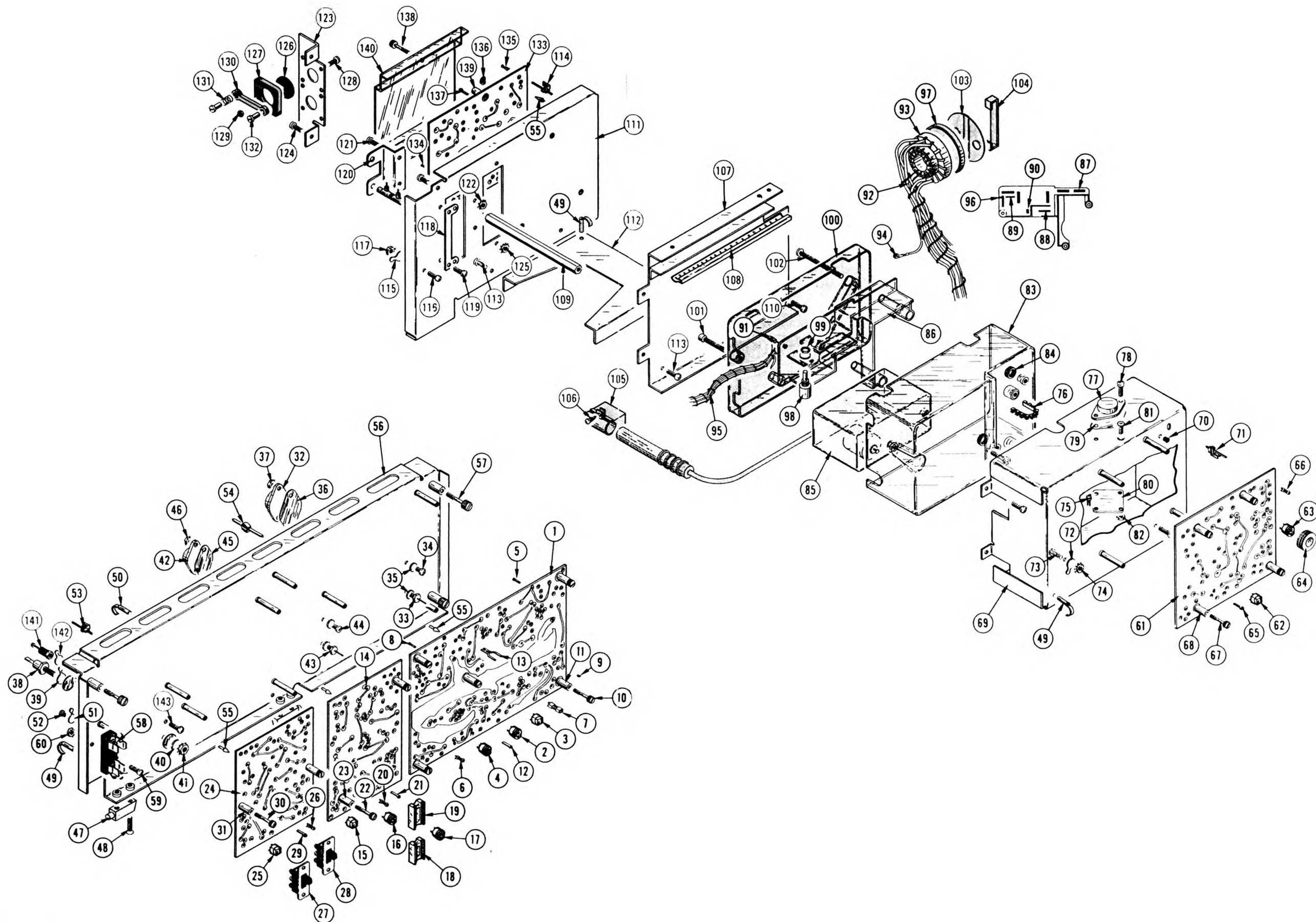




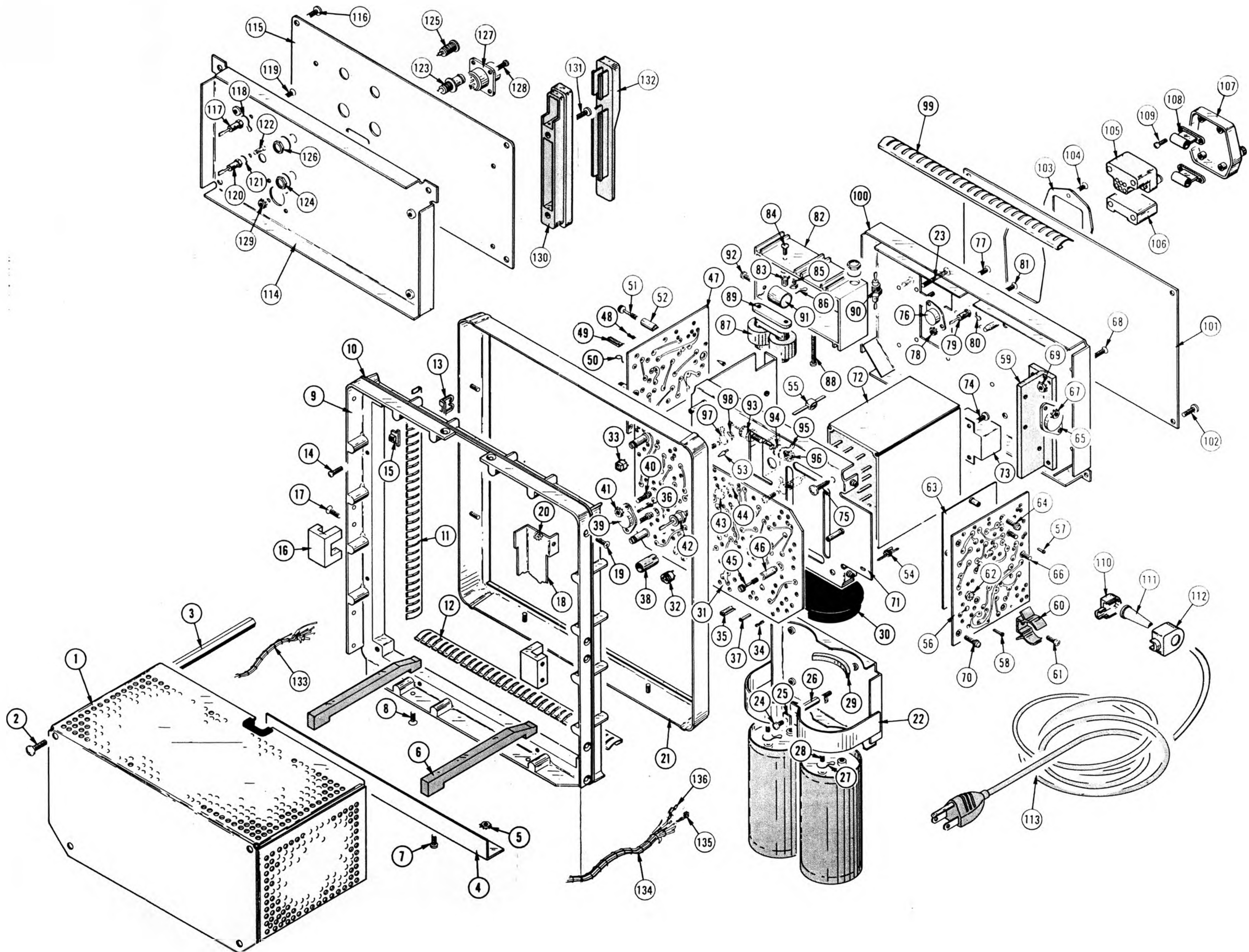


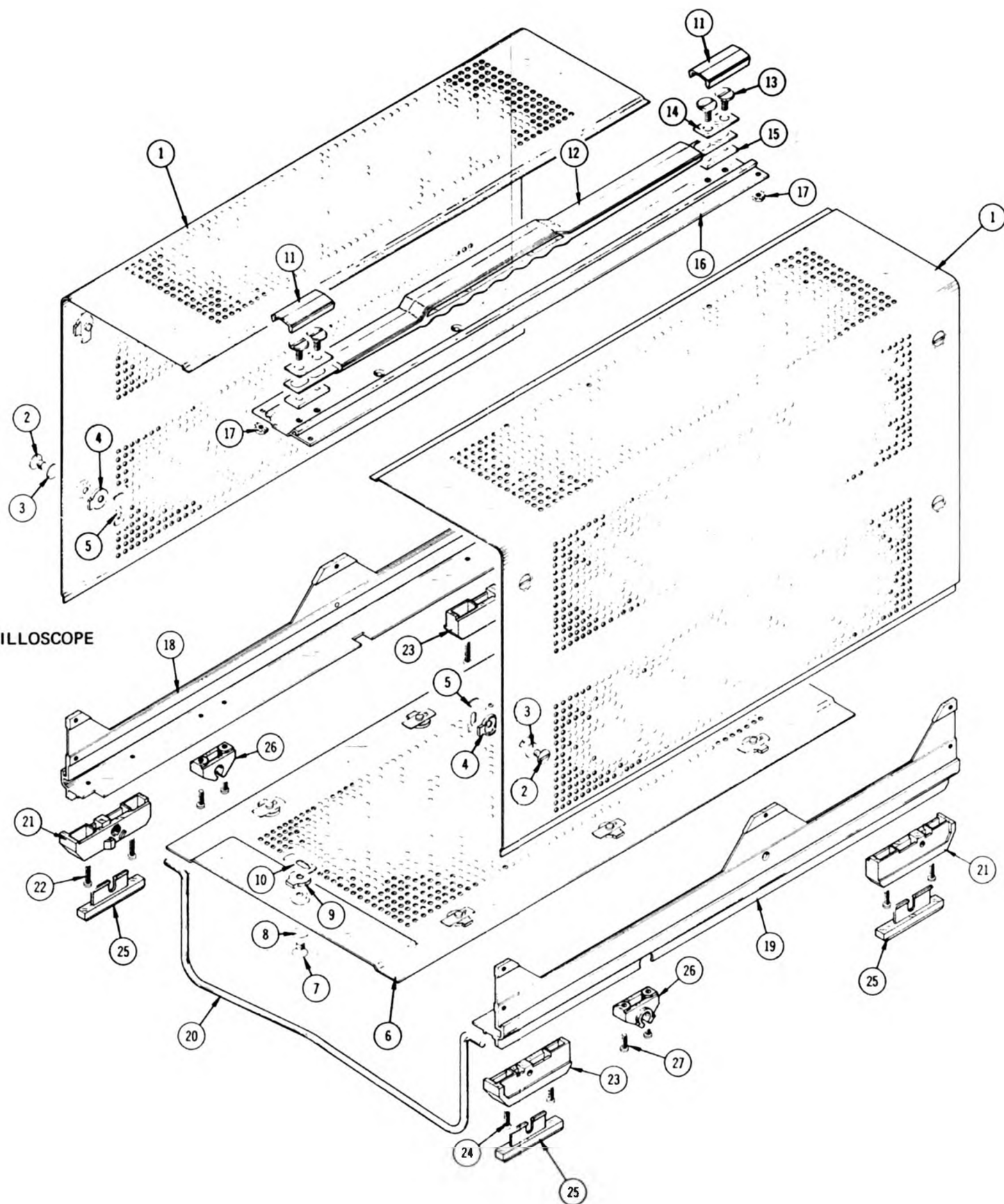
7704 OSCILLOSCOPE











7704 OSCILLOSCOPE

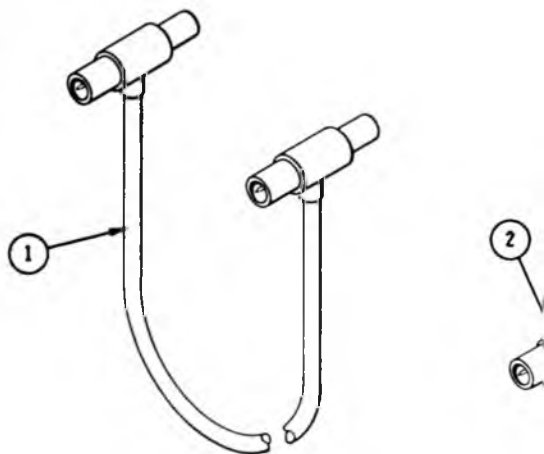
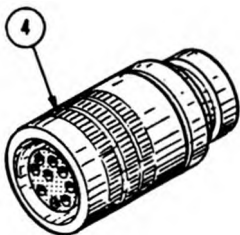
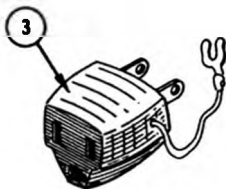


Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc
6-1	012-0087-00		
-2	012-0092-00		
-3	103-0013-00		
-4	134-0049-00		
	070-0981-00		



Q  
t  
y

1 2 3 4 5

# Description

- |   |                                       |
|---|---------------------------------------|
| 2 | PATCH CORD, BNC-BNC, 18 inches long   |
| 1 | JACK, BNC-post                        |
| 1 | ADAPTER, power cord, 3 wire to 2 wire |
| 1 | PLUG, 9 pin, w/male insert            |
| 2 | MANUAL, instruction (not shown)       |

# **OPTION 1** without READOUT Circuit Board Assembly

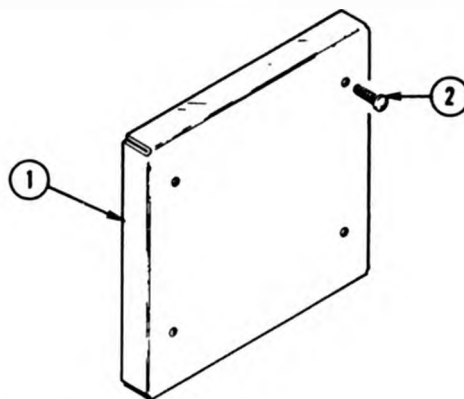


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q ↑ Y	1	2	3	4	5	Description
1	200-1066-00			1						COVER, readout board pins
2	211-0012-00			2						SCREW, 4-40 x 0.375 inch, PHS

**STANDARD ACCESSORIES** same as 7704

## **OPTION 2** X-Y Delay Compensation Network

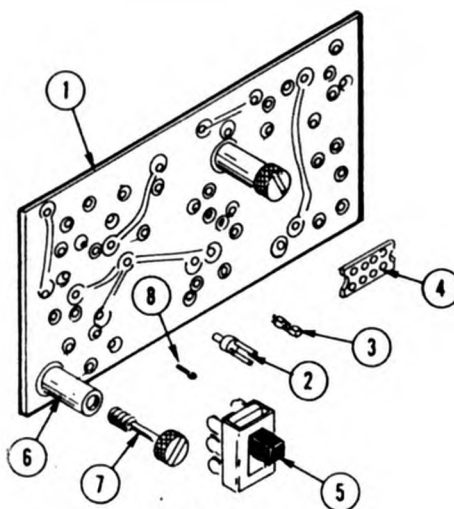


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q ↑ Y	1	2	3	4	5	Description
1	670-0627-00			1						ASSEMBLY, circuit board—X-Y DELAY COMP
	388-1158-00									assembly includes:
				1						BOARD, circuit
2	129-0024-00			4						POST, connecting
3	136-0263-03			11						SOCKET, terminal pin
4	136-0337-00			3						SOCKET, relay, 8 pin
5	260-0723-00			2						SWITCH, slide
6	361-0238-00			2						SPACER, sleeve
7	211-0155-00			2						SCREW, 4-40 x 0.375 inch, PHS
8	214-0579-00			2						PIN, test point

**STANDARD ACCESSORIES** same as 7704

# **OPTION 3** **Electromagnetic Interference (EMI)**

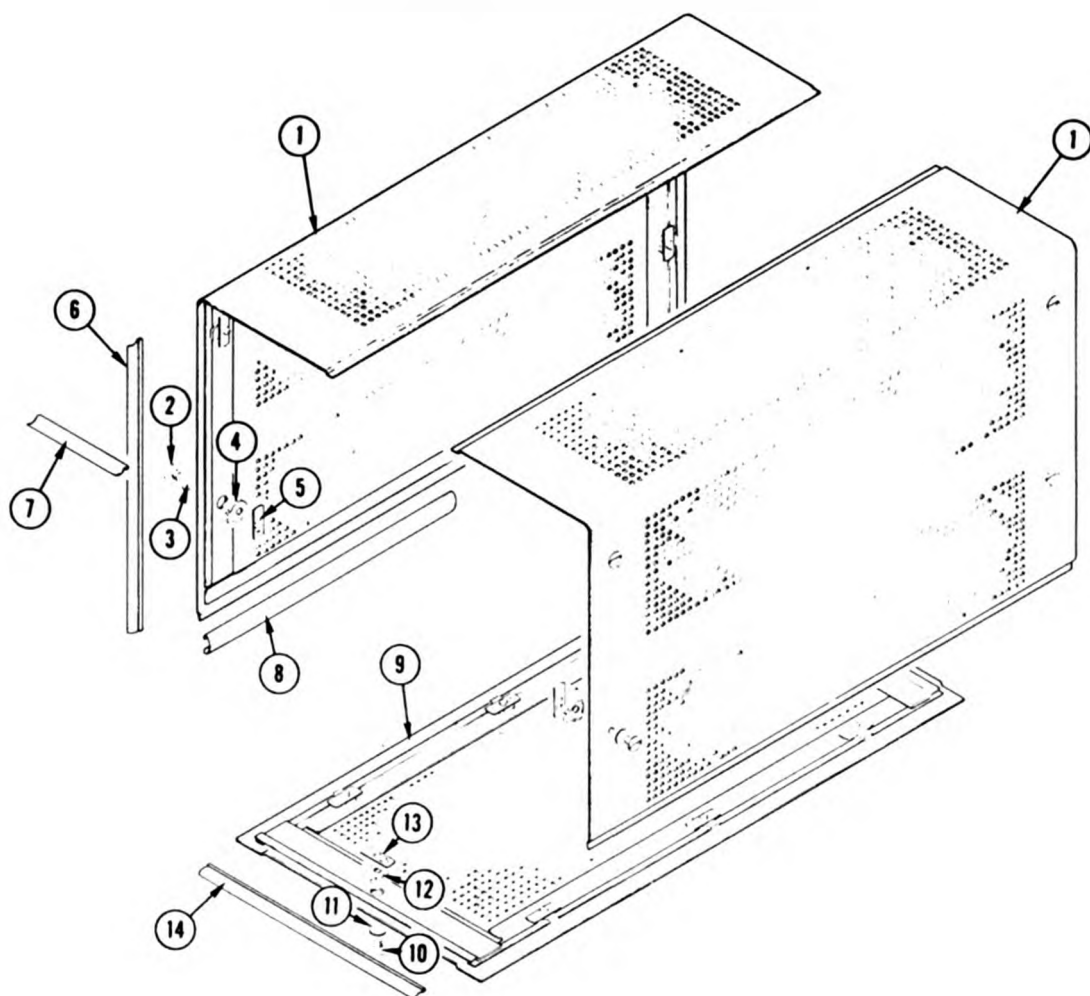


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	Description					
						1	2	3	4	5
1	390-0123-00			2	CABINET SIDE					
	- - - - -			-	each cabinet includes:					
2	214-0603-01			6	PIN, securing					
3	214-0604-00			6	SPRING					
4	386-1634-00			6	PLATE, index, plastic					
5	386-1633-00			6	PLATE, locking					
6	348-0210-00			2	SHIELDING GASKET, 10.887 inches long					
7	348-0209-00			2	SHIELDING GASKET, 4.359 inches long					
8	348-0211-00			4	SHIELDING GASKET, 9.322 inches long					
9	390-0122-00			1	CABINET BOTTOM					
	- - - - -			-	cabinet bottom includes:					
10	214-0603-00			8	PIN, securing					
11	214-0604-00			8	SPRING					
12	386-1634-00			8	PLATE, index, plastic					
13	386-1633-00			8	PLATE, locking					
14	348-0212-00			6	SHIELDING GASKET, 9.100 inches long					
	378-0603-00			1	FILTER, mesh, CRT (not shown)					
	348-0218-00			2	SHIELDING GASKET, 9.900 inches long (not shown)					
	348-0221-00			2	SHIELDING GASKET, 10.400 inches long (not shown)					
<b>STANDARD ACCESSORIES same as 7704 — also includes:</b>										
	378-0625-00			1	FILTER, light, CRT (not shown)					
	426-0514-00			1	FRAME, mask, plastic (not shown)					

**CARTON ASSEMBLY**  
(Part No. 065-0123-00)

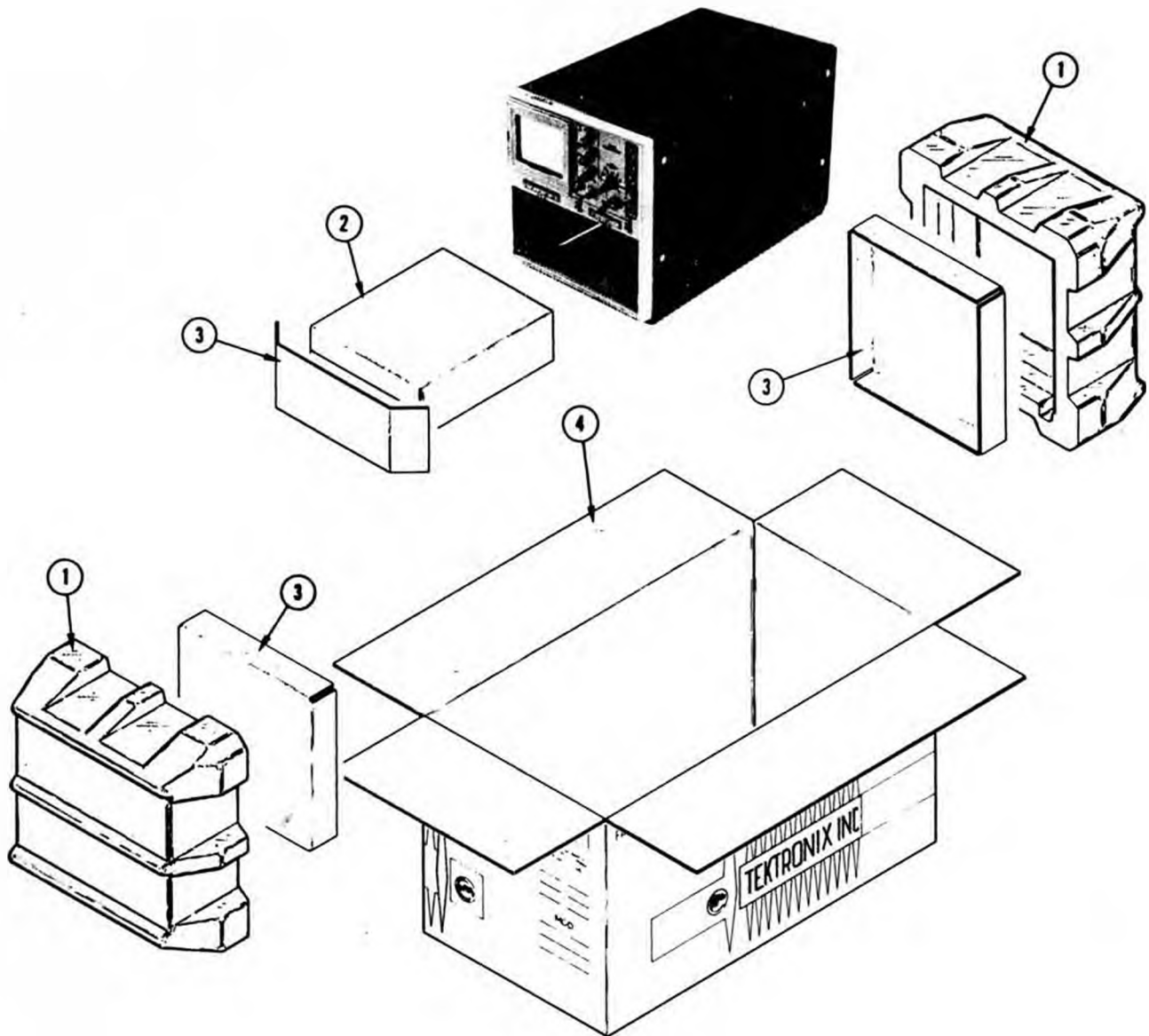


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q t y						Description
					1	2	3	4	5	
8-	065-0123-00			1						ASSEMBLY, carton
-	- - - - -			-						assembly includes:
-1	004-0246-00			2						END CAP, plastic
-2	004-0657-00			1						CARTON, accessory
-3	004-1061-00			1						PAD SET, 3 piece
-4	004-0751-00			1						CARTON



## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

*Assembly and/or Component*  
*Detail Part of Assembly and/or Component*  
*mounting hardware for Detail Part*  
*Parts of Detail Part*  
*mounting hardware for Parts of Detail Part*  
*mounting hardware for Assembly and/or Component*

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

**Mounting hardware must be purchased separately, unless otherwise specified.**

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

# SECTION 8

## MECHANICAL PARTS LIST

FIGURE 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				†	1	2	3	4	
1-1	366-1146-00			1					KNOB, gray—FOCUS
	- - - - -			-					knob includes:
	213-0153-00			1					SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1025-01			1					KNOB, charcoal—INTENSITY A
	- - - - -			-					knob includes:
	213-0153-00			2					SETSCREW, 5-40 x 0.125 inch, HSS
-3	- - - - -			1					RESISTOR, variable
	- - - - -			-					mounting hardware: (not included w/resistor)
	210-0012-00			1					WASHER, lock, internal, 0.375 ID x 0.500 inch OD (not shown)
-4	210-0590-00			1					NUT, hex., 0.375-32 x 0.438 inch
-5	366-1122-00			1					KNOB, gray—BEAM FINDER
	- - - - -			-					knob includes:
	213-0153-00			1					SETSCREW, 5-40 x 0.125 inch, HSS
-6	366-1120-00			1					KNOB, charcoal—INTENSITY B
	- - - - -			-					knob includes:
	213-0153-00			2					SETSCREW, 5-40 x 0.125 inch, HSS
-7	- - - - -			1					RESISTOR, variable
	- - - - -			-					mounting hardware: (not included w/resistor)
-8	210-0590-00			1					NUT, hex., 0.375-32 x 0.438 inch
-9	366-1163-00			1					KNOB, gray—CONTROL ILLUM
	- - - - -			-					knob includes:
	213-0153-00			1					SETSCREW, 5-40 x 0.125 inch, HSS
-10	366-1164-00			1					KNOB, charcoal—READOUT
	- - - - -			-					knob includes:
	213-0153-00			1					SETSCREW, 5-40 x 0.125 inch, HSS
-11	260-1084-00			1					SWITCH, unwired—READOUT
	- - - - -			-					mounting hardware: (not included w/switch)
-12	210-0590-00			1					NUT, hex., 0.375-32 x 0.438 inch
-13	366-1190-00			1					KNOB, charcoal—GRAT ILLUM
	- - - - -			-					knob includes:
	213-0153-00			1					SETSCREW, 5-40 x 0.125 inch, HSS
-14	- - - - -			1					RESISTOR, variable
	- - - - -			-					mounting hardware: (not included w/resistor)
	210-0046-00			1					WASHER, lock, internal, 0.261 ID x 0.400 inch OD
-15	210-0583-00			2					NUT, hex., 0.250-32 x 0.312 inch
-16	366-0392-02			1					KNOB, charcoal—VERT TRACE SEPARATION (B)
-17	- - - - -			1					RESISTOR, variable
	- - - - -			-					mounting hardware: (not included w/resistor)
	213-0020-00			1					SETSCREW, 6-32 x 0.125 inch, HSS (not shown)

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q ↑ Y		1	2	3	4	5	Description
1-18	366-1163-00			1							KNOB, gray—RATE
	- - - - -			-							knob includes:
	213-0153-00			1							SETSCREW, 5-40 x 0.125 inch, HSS
-19	366-1165-00			1							KNOB, charcoal—CALIBRATOR
	- - - - -			-							knob includes:
	213-0153-00			2							SETSCREW, 5-40 x 0.125 inch, HSS
-20	670-0633-00			1							ASSEMBLY, circuit board—CALIBRATOR
	- - - - -			-							assembly includes:
	388-1164-00			1							BOARD, circuit
-21	131-0589-00			11							TERMINAL, pin, 0.500 inch long
-22	214-0579-00			6							PIN, test point
-23	131-0604-00			11							CONTACT-POST ASSEMBLY
-24	136-0220-00			7							SOCKET, transistor, 3 pin, square
-25	136-0237-00			1							SOCKET, integrated circuit, 8 pin
-26	354-0219-00			2							RING, retaining
-27	407-0714-00			2							BRACKET
-28	131-0840-00			1							CONTACT, electrical, grounding
-29	401-0053-00			1							BEARING, front
	- - - - -			-							mounting hardware: (not included w/bearing)
-30	211-0116-00			2							SCREW, sems, 4-40 x 0.312 inch, PHB
-31	401-0061-00			2							BEARING, rear
	- - - - -			-							mounting hardware for each: (not included w/bearing)
-32	211-0116-00			2							SCREW, sems, 4-40 x 0.312 inch, PHB
	210-0591-00			2							NUT, hex., 4-40 x 0.187 inch
-33	401-0058-00			1							BEARING, front
	- - - - -			-							mounting hardware: (not included w/bearing)
	211-0116-00			2							SCREW, sems, 4-40 x 0.312 inch, PHB
-34	214-1127-00			2							ROLLER, detent
-35	214-1126-00 <sup>1</sup>			-							SPRING, flat, gold
	214-1126-01 <sup>1</sup>			-							SPRING, flat, green
	214-1126-02 <sup>1</sup>			-							SPRING, flat, red
-36	105-0120-00			1							DRUM, cam (CALIBRATOR)
-37	105-0118-00			1							DRUM, cam (MODE)
	- - - - -			-							drum includes:
	213-0075-00			2							SETSCREW, 4-40 x 0.093 inch, HSS
-38	200-1033-00			1							COVER, cam switch (CALIBRATOR)
	- - - - -			-							mounting hardware: (not included w/cover)
-39	211-0079-00			2							SCREW, 2-56 x 0.188 inch, PHS
	210-0001-00			2							WASHER, lock, internal, #2
	210-0405-00			1							NUT, hex., 2-56 x 0.187 inch
-40	200-1032-00			1							COVER, cam switch (MODE)
	- - - - -			-							mounting hardware: (not included w/cover)
-41	211-0079-00			2							SCREW, 2-56 x 0.188 inch, PHS
	210-0001-00			2							WASHER, lock, internal, #2
	210-0405-00			1							NUT, hex., 2-56 x 0.187 inch
-42	384-0197-00			1							ROD, extension
	- - - - -			-							mounting hardware: (not included w/assembly)
-43	211-0116-00			1							SCREW, sems, 4-40 x 0.312 inch, PHB
-44	210-0590-00			1							NUT, hex., 0.375-32 x 0.438 inch

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y						Description
				1	2	3	4	5	
1-45	260-1102-00		1						SWITCH, toggle—POWER
	- - - - -		-						mounting hardware: (not included w/switch)
-46	354-0055-00		1						RING, locking
	210-0902-00		1						WASHER, flat, 0.470 ID x 0.656 inch OD
	210-0021-00		2						WASHER, lock, internal, 0.476 ID x 0.600 inch OD
	210-0229-00		1						LUG, solder
	210-0414-00		1						NUT, hex., 0.468-32 x 0.562 inch
-47	210-0473-00		1						NUT, 12 sided, 0.469-32 x 0.634 inch
-48	- - - - -		2						RESISTOR, variable
	- - - - -		-						mounting hardware for each: (not included w/resistor)
	210-0471-00		1						NUT, hex., 0.250-32 x 0.312 inch
-49	210-1026-00		1						WASHER, lock, external, 0.250 inch ID
-50	358-0377-00		1						BUSHING, hex., 0.275 inch long
-51	670-0821-00		1						ASSEMBLY, circuit board—B TRIG SOURCE
	- - - - -		-						assembly includes:
-52	131-0592-00		5						TERMINAL, pin, 0.885 inch long
-53	131-0787-00		5						TERMINAL, pin, 0.640 inch long
	380-0154-00		1						HOUSING, light
	- - - - -		-						mounting hardware: (not included w/housing)
	213-0181-00		1						SCREW, thread forming, #2 x 0.375 inch, PHS
	- - - - -		-						mounting hardware: (not included w/assembly)
-54	352-0195-00		1						HOLDER, plastic
	386-1731-00		1						PLATE, aligning (not shown)
-55	211-0022-00		2						SCREW, 2-56 x 0.188 inch, RHS
-56	670-0792-00		1						ASSEMBLY, circuit board—A TRIG SOURCE
	- - - - -		-						assembly includes:
-57	131-0592-00		5						TERMINAL, pin, 0.885 inch long
-58	131-0787-00		5						TERMINAL, pin, 0.640 inch long
	380-0154-00		1						HOUSING, light
	- - - - -		-						mounting hardware: (not included w/housing)
	213-0181-00		1						SCREW, thread forming, #2 x 0.375 inch, PHS
	- - - - -		-						mounting hardware: (not included w/assembly)
-59	352-0195-00		1						HOLDER, plastic
	386-1731-00		1						PLATE, aligning (not shown)
-60	211-0022-00		2						SCREW, 2-56 x 0.188 inch, RHS
-61	670-0790-00		1						ASSEMBLY, circuit board—HORIZ MODE
	- - - - -		-						assembly includes:
	352-0174-00		4						HOLDER, lamp (not shown)
-62	131-0592-00		8						TERMINAL, pin, 0.885 inch long
-63	131-0787-00		12						TERMINAL, pin, 0.640 inch long
-64	337-1156-00		1						SHIELD, electrical
-65	366-1109-06		1						PUSHBUTTON—A
-66	366-1109-02		1						PUSHBUTTON—ALT
-67	366-1109-04		1						PUSHBUTTON—CHOP
-68	366-1109-07		1						PUSHBUTTON—B
-69	380-0168-00		1						HOUSING, front, plastic
	- - - - -		-						mounting hardware: (not included w/housing)
-70	211-0125-00		3						SCREW, 1-72 x 0.250 inch, PHS
	- - - - -		-						mounting hardware: (not included w/assembly)
-71	211-0511-00		2						SCREW, 6-32 x 0.500 inch, PHS
-72	407-0700-00		1						BRACKET, switch

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y						Description
					1	2	3	4	5	
1-73	670-0791-00			1						ASSEMBLY, circuit board—VERT MODE
	- - - - -			-						assembly includes:
	352-0174-00			5						HOLDER, lamp (not shown)
-74	131-0592-00			7						TERMINAL, pin, 0.885 inch long
-75	131-0787-00			10						TERMINAL, pin, 0.640 inch long
-76	337-1156-00			1						SHIELD, electrical
-77	366-1109-01			1						PUSHBUTTON—LEFT
-78	366-1109-02			1						PUSHBUTTON—ALT
-79	366-1109-03			1						PUSHBUTTON—ADD
-80	366-1109-04			1						PUSHBUTTON—CHOP
-81	366-1109-05			1						PUSHBUTTON—RIGHT
-82	380-0147-00			1						HOUSING, front, plastic
	- - - - -			-						mounting hardware: (not included w/housing)
	211-0125-00			3						SCREW, 1-72 x 0.250 inch, PHS
	- - - - -			-						mounting hardware: (not included w/assembly)
-83	211-0511-00			2						SCREW, 6-32 x 0.500 inch, PHS
-84	407-0701-00			1						BRACKET, switch
-85	200-0984-00			1						BEZEL, plastic (5 button switch)
-86	200-0983-00			1						BEZEL, plastic (4 button switch)
-87	119-0199-00			1						CURRENT LOOP
	- - - - -			-						mounting hardware: (not included w/current loop)
-88	210-0457-00			1						NUT, keps, 6-32 x 0.312 inch
-89	670-0702-00			1						ASSEMBLY, circuit board—GRATICULE LIGHT
	- - - - -			-						assembly includes:
	388-0274-00			1						BOARD, circuit
-90	378-0614-00			1						REFLECTOR, light
	- - - - -			-						mounting hardware: (not included w/reflector)
-91	211-0062-00			2						SCREW, 2-56 x 0.312 inch, RHS
-92	344-0179-00			2						CLIP, reflector
-93	358-0377-00			2						BUSHING
-94	378-0635-01			1						LENS, indicator light (A)
-95	378-0635-02			1						LENS, indicator light (B)
-96	352-0157-00			2						HOLDER, neon
-97	331-0262-00			2						DIFFUSER, light
-98	200-0935-00			2						CAP, neon, plastic
	129-0053-00			1						ASSEMBLY, binding post
	- - - - -			-						assembly includes:
-99	200-0103-00			1						CAP, binding post
-100	355-0507-00			1						STEM, binding post
	210-0046-00			1						WASHER, lock, internal, 0.261 ID x 0.400 inch, OD
-101	210-0455-00			1						NUT, hex., 0.250-28 x 0.375 inch
-102	348-0216-00			1						SHIELDING GASKET, electrical
-103	333-1267-00			1						PANEL, front
-104	426-0442-01			1						FRAME-PANEL, cabinet, front
	- - - - -			-						frame-panel includes:
-105	386-1517-00			4						SUPPORT, CRT, front
	354-0345-00			1						RING, ornamental
-106	105-0151-00			2						CATCH, panel
	- - - - -			-						mounting hardware for each: (not included w/catch)
	343-0248-00			1						RETAINER, panel catch
-107	213-0119-00			1						SCREW, thread forming, 4-40 x 0.375 inch, PHS

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q ↑ y 1 2 3 4 5					Description
1-108	131-0818-00			1					CONNECTOR, receptacle, BNC, w/hardware
-109	351-0202-00			4					GUIDE, plug-in, upper
	- - - - -								mounting hardware for each: (not included w/guide)
	211-0038-00			2					SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-110	348-0204-00			2					SHIELDING GASKET, electrical, 10.632 inches long
-111	386-1518-00			1					SUPPORT, chassis
	- - - - -			-					mounting hardware: (not included w/support)
-112	210-0457-00			2					NUT, keps, 6-32 x 0.312 inch
-113	211-0559-00			2					SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-114	348-0031-00			2					GROMMET, plastic, 0.093 inch diameter
-115	426-0514-00			1					FRAME, mask, plastic
-116	378-0625-00			1					FILTER, light, CRT
-117	331-0258-00			1					MASK, CRT
-118	200-0939-01			1					BEZEL, CRT
	- - - - -			-					mounting hardware: (not included w/bezel)
-119	212-0023-00			4					SCREW, 8-32 x 0.375 inch, PHS
-120	337-1159-00			1					SHIELD, implosion
-121	204-0380-00			1					BODY, terminal, plastic
-122	131-0765-00			3					TERMINAL, feed-thru
-123	331-0245-00			1					MASK, CRT
-124	337-1150-01			1					SHIELD, CRT
-125	131-0807-00			1					CONTACT, CRT grounding
	- - - - -			-					mounting hardware: (not included w/contact)
-126	211-0590-00			1					SCREW, 6-32 x 0.250 inch, PHS
-127	210-0202-00			1					LUG, solder, SE #6
-128	210-0457-00			1					NUT, keps, 6-32 x 0.312 inch
-129	- - - - -			1					COIL
	- - - - -			-					mounting hardware: (not included w/coil)
-130	343-0217-00			1					CLAMP
-131	213-0138-00			2					SCREW, thread forming, 4-40 x 0.187 inch, PHS
-132	348-0055-00			2					GROMMET, plastic, 0.250 inch diameter
-133	354-0347-00			1					RING, clamp, CRT
	- - - - -			-					mounting hardware: (not included w/ring)
	214-1333-00			2					SPRING, helical compression (not shown)
-134	211-0170-00			2					SCREW, 4-40 x 2.750 inches, PHS
-135	407-0610-00			1					BRACKET, CRT shield
-136	343-0205-00			1					RETAINER, CRT
	- - - - -			-					mounting hardware: (not included w/retainer)
-137	210-0949-00			4					WASHER, flat, 0.046 ID x 0.500 inch OD
-138	211-0507-00			4					SCREW, 6-32 x 0.312 inch, PHS
-139	200-0745-00			1					COVER, resistor, plastic
-140	352-0169-00			1					HOLDER, terminal connector, 2 wire
-141	134-0119-00			3					PLUG, hole, plastic

FIGURE 2 PI-HSG, DL, HORIZ OUT. &amp; MAIN INTERFACE

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description
			†	1	2	3	4	
			y					
2-1	380-0146-00		1					HOUSING, plug-in
-2	351-0181-00		4					GUIDE, plug-in
	- - - - -		-					mounting hardware for each: (not included w/guide)
-3	213-0104-00		1					SCREW, thread forming, 6-32 x 0.375 inch, THS
	213-0229-00		1					SCREW, thread forming, #6 x 0.375 inch, FHS (not shown)
-4	214-1179-00		1					BRACKET, hinge pin
	- - - - -		-					mounting hardware: (not included w/bracket)
-5	210-0457-00		2					NUT, keps, 6-32 x 0.312 inch
-6	343-0008-00		1					CLAMP, cable, plastic, 0.750 inch diameter
	- - - - -		-					mounting hardware: (not included w/clamp)
	211-0538-00		1					SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-7	210-0863-00		1					WASHER, D shape, 0.191 ID x 0.515 x 0.515 inch long
-8	210-0457-00		1					NUT, keps, 6-32 x 0.312 inch
-9	343-0042-00		1					CLAMP, cable, half, plastic, 0.312 inch diameter
	- - - - -		-					mounting hardware: (not included w/clamp)
-10	211-0538-00		1					SCREW, thread forming, 5-32 x 0.187 inch, PHS
-11	210-0863-00		1					WASHER, D shape, 0.191 ID x 0.515 x 0.515 inch long
-12	210-0202-00		1					LUG, solder, SE #6
	- - - - -		-					mounting hardware: (not included w/lug)
-13	211-0541-00		1					SCREW, 6-32 x 0.250 inch, 100° csk, FHS
-14	210-0457-00		1					NUT, keps, 6-32 x 0.312 inch
-15	407-0873-00		1					CHASSIS, horizontal
	- - - - -		-					mounting hardware: (not included w/chassis)
-16	211-0538-00		3					SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-17	210-0202-00		1					LUG, solder, SE #6
-18	210-0457-00		3					NUT, keps, 6-32 x 0.312 inch
-19	407-0679-00		1					BRACKET, support
	- - - - -		-					mounting hardware: (not included w/bracket)
-20	211-0507-00		2					SCREW, 6-32 x 0.312 inch, PHS
-21	210-0457-00		2					NUT, keps, 6-32 x 0.312 inch
-22	407-0704-00		1					BRACKET, angle
	- - - - -		-					mounting hardware: (not included w/bracket)
-23	211-0507-00		2					SCREW, 6-32 x 0.312 inch, PHS
-24	162-0579-00		ft					INSULATING SLEEVE, spiral, 24 inches long



FIGURE 2 PI-HSG, DL, HORIZ OUT. &amp; MAIN INTERFACE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				↑ y	1	2	3	4	
2-25	386-1556-00			2					SUPPORT, circuit board
-26	131-0682-03			12					TERMINAL, feed-thru, 0.890 inch long
-27	670-0807-00			1					ASSEMBLY, circuit board—HORIZONTAL OUTPUT
	- - - - -			-					assembly includes:
	388-1398-00			1					BOARD, circuit
-28	136-0183-00			4					SOCKET, transistor, 3 pin
-29	136-0220-00			10					SOCKET, transistor, 3 pin, square
-30	136-0263-03			12					SOCKET, pin terminal
-31	214-0579-00			7					PIN, test point
-32	214-0668-00			2					HEAT SINK, transistor
-33	211-0155-00			4					SCREW, 4-40 x 0.375 inch, knurled
-34	361-0238-00			4					SPACER, sleeve
	119-0214-00			1					ASSEMBLY, delay line
	- - - - -			-					assembly includes:
-35	200-0971-00			1					COVER, bottom
	- - - - -			-					mounting hardware: (not included w/cover)
-36	211-0504-00			4					SCREW, 6-32 x 0.250 inch, PHS
	213-0229-00			4					SCREW, thread forming, #6 x 0.375 inch, FHS (not shown)
-37	386-1553-00			1					SUPPORT, front
	- - - - -			-					mounting hardware: (not included w/support)
-38	211-0504-00			1					SCREW, 6-32 x 0.250 inch, PHS
-39	386-1552-00			1					SUPPORT, rear
-40	129-0215-00			2					POST, plastic
-41	200-0972-00			1					COVER, top
	- - - - -			-					mounting hardware: (not included w/cover)
-42	211-0541-00			2					SCREW, 6-32 x 0.250 inch, 100° csk, FHS
-43	211-0504-00			2					SCREW, 6-32 x 0.250 inch, PHS
	210-0457-00			1					NUT, keps, 6-32 x 0.312 inch (not shown)
-44	407-0613-00			1					BRACKET
	- - - - -			-					mounting hardware: (not included w/bracket)
-45	210-0586-00			1					NUT, keps, 4-40 x 0.250 inch
-46	124-0229-00			1					STRIP, trim
-47	131-0912-00			1					ASSEMBLY, coaxial connector
	- - - - -			-					assembly includes:
-48	131-0707-00			2					CONNECTOR, terminal
-49	352-0169-00			1					HOLDER, terminal connector, 2 wire
-50	348-0067-00			1					GROMMET, plastic, 0.312 inch diameter
	- - - - -			-					mounting hardware: (not included w/assembly)
	211-0507-00			3					SCREW, 6-32 x 0.312 inch, PHS (not shown)
-51	211-0538-00			1					SCREW, 6-32 x 0.375 inch, 100° csk, FHS
-52	210-0457-00			1					NUT, keps, 6-32 x 0.312
-53	131-0800-00			2					CONTACT, electrical, side
	- - - - -			-					mounting hardware for each: (not included w/contact)
-54	211-0005-00			2					SCREW, 4-40 x 0.125 inch, PHS
-55	343-0089-00			1					CLAMP, cable, plastic, large

FIGURE 2 PI-HSG, DL, HORIZ OUT. &amp; MAIN INTERFACE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y						Description
				1	2	3	4	5	
2-56	131-0799-00		2						CONTACT, electrical, upper
	- - - - -		-						mounting hardware for each: (not included w/contact)
-57	211-0008-00		1						SCREW, 4-40 x 0.250 inch, PHS
-58	210-0586-00		1						NUT, keps, 4-40 x 0.250 inch
	131-0799-00		1						CONTACT, electrical, upper (not shown)
	- - - - -		-						mounting hardware: (not included w/contact)
	211-0005-00		1						SCREW, 4-40 x 0.125 inch, PHS
-59	131-0801-00		3						CONTACT, electrical, lower
	- - - - -		-						mounting hardware for each: (not included w/contact)
	211-0022-00		2						SCREW, 2-56 x 0.188 inch, RHS
	210-0001-00		2						WASHER, lock, internal #2
-60	210 0405-00		2						NUT, hex., 2-56 x 0.187 inch
-61	670-0811-00		1						ASSEMBLY, circuit board—VERTICAL INTERFACE
	- - - - -		-						assembly includes:
	388-1402-00		1						BOARD, circuit
	131-0589-00		2						TERMINAL, pin, 0.500 inch long (not shown)
-62	136-0263-03		16						SOCKET, pin terminal
-63	136-0350-00		12						SOCKET, transistor, 3 pin
-64	211-0155-00		2						SCREW, 4-40 x 0.375 inch, knurled
-65	361-0238-00		2						SPACER, sleeve
-66	337-0240-00		1						SHIELD, circuit board, plastic
-67	670-0625-00		1						ASSEMBLY, circuit board—TRIG. SEL
	- - - - -		-						assembly includes:
	388-1156-00		1						BOARD, circuit
-68	136-0220-00		6						SOCKET, transistor, 3 pin, square
-69	136-0260-01		2						SOCKET, integrated circuit, 16 pin
-70	136-0263-03		19						SOCKET, pin terminal
-71	214-0579-00		13						PIN, test point
-72	211-0155-00		2						SCREW, 4-40 x 0.375 inch, knurled
-73	361-0238-00		2						SPACER, sleeve
-74	670-0808-00		1						ASSEMBLY, circuit board—HORIZ INTERFACE
	- - - - -		-						assembly includes:
	388-1399-00		1						BOARD, circuit
-75	136-0220-00		2						SOCKET, transistor, 3 pin, square
-76	136-0260-00		1						SOCKET, integrated circuit, 16 pin
-77	136-0263-03		1						SOCKET, pin terminal
-78	214-0579-00		4						PIN, test point
-79	361-0238-00		2						SPACER, sleeve
-80	211-0155-00		2						SCREW, 4-40 x 0.375 inch, knurled

FIGURE 2 PI-HSG, DL, HORIZ OUT. &amp; MAIN INTERFACE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description
				†	1	2	3	4	
				y					
2-	670-0817-00			1					ASSEMBLY, circuit board—MAIN INTERFACE
	- - - - -			-					assembly includes:
-81	388-1408-00			1					BOARD, circuit
-82	388-1381-00			1					BOARD, circuit—IPC OUTER
-83	388-1380-00			1					BOARD, circuit—IPC INNER
-84	388-1401-01			1					BOARD, circuit—VERTICAL INTERCONNECT
	- - - - -			-					mounting hardware: (not included w/board)
-85	211-0065-00			2					SCREW, 4-40 x 0.188 inch, PHS
	131-0767-00			2					CONNECTOR, receptacle, 76 contact
	- - - - -			-					each connector includes:
-86	200-0950-00			2					COVER, plastic
-87	204-0365-00			1					BODY, plastic
-88	131-0726-00			2					CONTACT SET, electrical, straight
	131-0727-00			2					CONTACT SET, electrical, offset
	- - - - -			-					mounting hardware for each: (not included w/connector)
-89	213-0232-00			2					SCREW, thread forming, 2-56 x 0.312 inch, PHS
	137-0767-02			2					CONNECTOR, receptacle, 76 contact
	- - - - -			-					each connector includes:
-90	200-0950-00			2					COVER, plastic
-91	204-0365-00			1					BODY, plastic
-92	131-0726-00			2					CONTACT SET, electrical, straight
	131-0727-00			2					CONTACT SET, electrical, offset
	131-0899-00			4					CONTACT, short tail
	- - - - -			-					mounting hardware for each: (not included w/connector)
-93	213-0232-00			2					SCREW, thread forming, 2-56 x 0.312 inch, PHS
-94	136-0220-00			2					SOCKET, transistor, 3 pin, square
-95	131-0595-00			9					TERMINAL, pin, 1.370 inches long
	131-0608-00			66					TERMINAL, pin, 0.365 inch long
	131-0590-00			45					TERMINAL, pin, 0.710 inch long
	131-0592-00			56					TERMINAL, pin, 0.832 inch long
	131-0665-00			19					TERMINAL, pin, 0.880 inch long
	131-0787-00			24					TERMINAL, pin, 0.640 inch long
-96	351-0155-00			68					GUIDE, terminal lead, plastic
-97	351-0185-00			4					GUIDE-POST, lock, 0.650 inch long
-98	351-0227-00			3					GUIDE-POST, lock, 0.840 inch long
	351-0213-00			2					GUIDE-POST, lock, 0.285 inch long (not shown)
-99	351-0188-00			4					GUIDE-POST, lock, 0.650 inch long
-100	351-0186-00			3					GUIDE-POST, lock, 0.840 inch long
-101	352-0213-00			4					HOLDER, cable, plastic
-102	386-1557-00			5					SUPPORT, circuit board, plastic
-103	352-0212-00			8					HOLDER, coaxial, grounding
	- - - - -			-					mounting hardware: (not included w/assembly)
-104	213-0034-00			12					SCREW, thread forming, 4-40 x 0.312 inch, RHS
-105	131-0804-00			2					LINK, terminal connector, 1.150 inches long
-106	131-0805-00			1					LINK, terminal connector, 0.900 inch long
-107	220-0561-00			3					NUT, hex., 10-32 x 0.250 inch

FIGURE 2 PI-HSG, DL, HORIZ OUT. &amp; MAIN INTERFACE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y						Description
				1	2	3	4	5	
2-108	670-0878-00		1						ASSEMBLY, circuit board—HORIZONTAL INTERCONNECT
	- - - - -		-						assembly includes:
	388-1531-00		1						BOARD, circuit
-109	136-0263-03		8						SOCKET, pin terminal
-110	361-0238-00		2						SPACER, sleeve
-111	211-0155-00		2						SCREW, 4-40 x 0.375 inch, knurled
-112	670-0848-00		1						ASSEMBLY, circuit board—LOGIC
	- - - - -		-						assembly includes:
	388-1157-00		1						BOARD, circuit
-113	136-0220-00		7						SOCKET, transistor, 3 pin, square
-114	136-0241-00		4						SOCKET, integrated circuit, 10 pin
-115	136-0260-01		3						SOCKET, integrated circuit, 16 pin
-116	136-0263-03		43						SOCKET, pin terminal
-117	361-0238-00		3						SPACER, sleeve
-118	211-0155-00		3						SCREW, 4-40 x 0.375 inch, knurled
-119	214-0579-00		15						PIN, test point
-120	670-0812-00		1						ASSEMBLY, circuit board—VERT SWITCHING & PWR
	- - - - -		-						assembly includes:
	388-1403-00		1						BOARD, circuit
-121	136-0220-00		10						SOCKET, transistor, 3 pin, square
-122	136-0263-03		18						SOCKET, pin connector
-123	214-0579-00		5						PIN, test point
-124	361-0238-00		3						SPACER, sleeve
-125	211-0155-00		3						SCREW, 4-40 x 0.375 inch, knurled
-126	179-1466-00		1						WIRING HARNESS, main
	- - - - -		-						wiring harness includes:
-127	131-0512-00		161						CONNECTOR, terminal
	131-0740-00		2						CONNECTOR, terminal
	131-0755-00		3						CONNECTOR, terminal
-128	131-0738-00		1						CONNECTOR, terminal
	131-0819-00		4						CONNECTOR, terminal
-129	131-0621-00		92						CONNECTOR, terminal
	131-0622-00		1						CONNECTOR, terminal
	131-0707-00		3						CONNECTOR, terminal
-130	131-0818-00		1						CONNECTOR, receptacle, BNC, w/hardware
-131	352-0198-00		1						HOLDER, terminal connector, 2 wire
-132	352-0163-00		1						HOLDER, terminal connector, 5 wire
	352-0201-00		4						HOLDER, terminal connector, 5 wire
-133	352-0204-00		8						HOLDER, terminal connector, 8 wire
-134	352-0206-00		3						HOLDER, terminal connector, 10 wire
-135	343-0007-00		1						CLAMP, cable plastic, 0.625 inch diameter
	- - - - -		-						mounting hardware: (not included w/clamp)
	210-0457-00		1						NUT, keps, 6-32 x 0.312 inch
	210-0863-00		1						WASHER, D shape, 0.191 ID x 0.516 x 0.515 inch long
-136	211-0511-00		1						SCREW, 6-32 x 0.500 inch, PHS

FIGURE 3 REGULATOR CHASSIS &amp; HV POWER

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description
					1 2 3 4 5
3-1	670-0816-00			1	ASSEMBLY, circuit board—LOW VOLTAGE REGULATOR
	- - - - -			-	assembly includes:
	388-1407-00			1	BOARD, circuit
-2	136-0183-00			1	SOCKET, transistor, 3 pin
-3	136-0220-00			13	SOCKET, transistor, 3 pin, square
-4	136-0235-00			5	SOCKET, transistor, 6 contact
-5	136-0254-01			17	SOCKET, connector pin, 0.145 inch long
-6	136-0263-03			39	SOCKET, pin terminal
-7	136-0286-00			6	SOCKET, terminal pin
-8	136-0338-01			4	SOCKET, terminal pin
-9	166-0292-00			2	SLEEVE, support
-10	211-0155-00			3	SCREW, 4-40 x 0.375 inch, knurled
-11	361-0238-00			3	SPACER, sleeve
-12	214-0579-00			8	PIN, test point
-13	344-0154-00			8	CLIP
-14	670-0635-00			1	ASSEMBLY, circuit board—READOUT
	- - - - -			-	assembly includes:
	388-1166-00			1	BOARD, circuit
-15	136-0220-00			11	SOCKET, transistor, 3 pin, square
-16	136-0235-00			1	SOCKET, transistor, 6 pin
-17	136-0237-00			4	SOCKET, transistor, 8 contact
-18	136-0269-00			1	SOCKET, integrated circuit, 14 contact
-19	136-0260-01			14	SOCKET, integrated circuit, 16 contact
-20	136-0263-03			46	SOCKET, pin terminal
-21	214-0579-00			18	PIN, test point
-22	211-0155-00			2	SCREW, 4-40 x 0.375 inch, knurled
-23	361-0238-00			2	SPACER, sleeve
-24	670-0632-00			1	ASSEMBLY, circuit board—OUTPUT SIGNAL
	- - - - -			-	assembly includes:
	388-1163-00			1	BOARD, circuit
-25	136-0220-00			12	SOCKET, transistor, 3 pin, square
-26	136-0263-03			23	SOCKET, pin terminal
-27	260-0723-00			1	SWITCH, slide—SWP
-28	260-0984-00			1	SWITCH, slide—GATE
-29	214-0579-00			9	PIN, test point
-30	211-0155-00			2	SCREW, 4-40 x 0.375 inch, knurled
-31	361-0238-00			2	SPACER, sleeve
-32	- - - - -			5	TRANSISTOR
	- - - - -			-	mounting hardware: (not included w/transistor)
-33	131-0739-00			1	TERMINAL, feed-thru
-34	211-0537-00			1	SCREW, 6-32 x 0.375 inch, THS
-35	210-0975-00			2	WASHER, plastic, shouldered, 0.140 ID x 0.375 inch OD
-36	386-0978-00			1	PLATE, insulator, plastic
-37	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
-38	- - - - -			2	DIODE
	- - - - -			-	mounting hardware for each: (not included w/diode)
-39	210-0224-00			1	LUG, solder, #10
	210-0909-00			2	WASHER, plastic, insulator
-40	210-0910-00			1	WASHER, plastic, 0.190 ID x 0.281 inch OD
	210-0805-00			1	WASHER, flat, 0.204 ID x 0.438 inch OD
-41	220-0410-00			1	NUT, keps, 10-32 x 0.375 inch

FIGURE 3 REGULATOR CHASSIS &amp; HV POWER (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † Y	Description
		Eff	Disc		
3-42	- - - - -			2	TRANSISTOR
-43	131-0739-00			-	mounting hardware for each: (not included w/transistor)
-44	211-0537-00			1	TERMINAL, feed-thru
	210-0975-00			1	SCREW, 6-32 x 0.375 inch, THS
-45	386-0143-00			2	WASHER, plastic, shouldered, 0.140 ID x 0.375 inch OD
-46	210-0457-00			1	PLATE, insulator, plastic
				2	NUT, keps, 6-32 x 0.312 inch
-47	214-1186-00			2	PIN, hinge
	- - - - -			-	mounting hardware for each: (not included w/pin)
-48	211-0114-00			2	SCREW, 4-40 x 0.437 inch, 100° csk, FHS
-49	343-0089-00			4	CLAMP, cable, plastic, large
-50	343-0213-00			2	CLAMP, cable, plastic, medium
-51	210-0202-00			1	LUG, solder, SE #6
	- - - - -			-	mounting hardware: (not included w/lug)
-52	211-0504-00			1	SCREW, 6-32 x 0.250 inch, PHS
-53	131-0682-03			108	TERMINAL, feed-thru, 0.890 inch long
-54	131-0737-00			8	TERMINAL, feed-thru
-55	386-1556-00			9	SUPPORT, circuit board
-56	441-0904-00			1	CHASSIS, low voltage regulator
	- - - - -			-	chassis includes:
-57	213-0172-00			3	THUMBSCREW, 6-32 x 0.812 inch
-58	352-0031-00			1	HOLDER, fuse, single
	- - - - -			-	mounting hardware: (not included w/holder)
-59	211-0510-00			1	SCREW, 6-32 x 0.375 inch, PHS
-60	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-61	670-0806-00			1	ASSEMBLY, circuit board—HV/Z AXIS AMP
	- - - - -			-	assembly includes:
	388-1397-00			1	BOARD, circuit
-62	136-0220-00			7	SOCKET, transistor, 3 pin, square
-63	136-0183-00			4	SOCKET, transistor, 3 pin
-64	214-0668-00			1	HEAT SINK
-65	214-0579-00			11	PIN, test point
-66	136-0263-03			21	SOCKET, terminal pin
-67	211-0155-00			4	SCREW, 4-40 x 0.375 inch, knurled
-68	361-0238-00			4	SPACER, sleeve
	621-0446-00			1	ASSEMBLY, high voltage box
	- - - - -			-	assembly includes:
-69	337-1121-00			1	SHIELD, high voltage
-70	348-0031-00			1	GROMMET, plastic, 0.093 inch diameter
-71	131-0682-00			21	TERMINAL, feed-thru, 0.820 inch long
-72	210-0201-00			1	LUG, solder, SE #4
	- - - - -			-	mounting hardware: (not included w/lug)
-73	211-0038-00			1	SCREW, 4-40 x 0.312 inch, PHS
-74	210-0586-00			1	NUT, keps, 4-40 x 0.250 inch

FIGURE 3 REGULATOR CHASSIS &amp; HV POWER (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y						Description
				1	2	3	4	5	
3-75	131-0309-00		4						CONNECTOR, terminal
	358-0241-00		4						BUSHING, plastic
-76	255-0334-00		fr						CHANNEL, plastic, 1.375 inches long
-77	- - - - -		2						TRANSISTOR
	- - - - -		-						mounting hardware for each: (not included w/transistor)
-78	213-0146-00		2						SCREW, thread forming, #6 x 0.313 inch, PHS
-79	386-0978-00		1						PLATE, insulator, plastic
-80	136-0280-00		2						SOCKET, transistor
	- - - - -		-						mounting hardware for each: (not included w/socket)
-81	211-0038-00		2						SCREW, 4-40 x 0.312, PHS
-82	210-0586-00		2						NUT, keps, 4-40 x 0.250
-83	380-0166-00		1						HOUSING, high voltage
-84	210-1093-00		2						WASHER, plastic, 0.187 ID x 0.312 inch OD
-85	119-0227-00		1						ASSEMBLY, sealed
-86	441-0879-00		1						CHASSIS, high voltage
	- - - - -		-						chassis includes:
-87	124-0164-00		5						STRIP, ceramic, 4 notches
-88	124-0176-00		2						STRIP, ceramic, 4 notches
-89	124-0175-00		1						STRIP, ceramic, 2 notches
-90	124-0163-00		1						STRIP, ceramic, 2 notches
-91	131-0403-00		1						CONNECTOR, feed-thru
-92	136-0375-00		1						ASSEMBLY, CRT socket & cable
	- - - - -		-						assembly includes:
-93	136-0304-02		1						SOCKET, CRT
-94	131-0512-00		7						CONNECTOR, terminal, 0.315 inch long
-95	179-1471-00		1						WIRING HARNESS, high voltage
-96	131-0864-00		1						CONTACT, electrical
-97	200-0917-01		1						COVER, CRT socket
-98	- - - - -		1						RESISTOR, variable
	- - - - -		-						mounting hardware: (not included w/resistor)
	210-0046-00		1						WASHER, lock, internal, 0.261 ID x 0.400 inch OD
-99	210-0583-00		1						NUT, hex., 0.250 x 0.312 inch
-100	200-0988-00		1						COVER, high voltage box
	- - - - -		-						mounting hardware: (not included w/cover)
-101	211-0529-00		1						SCREW, 6-32 x 1.250 inches, Fil HS
-102	211-0530-00		2						SCREW, 6-32 x 1.750 inches, Fil HS
-103	343-0254-00		1						CLAMP, CRT socket
-104	367-0117-00		1						HANDLE, CRT socket
-105	352-0217-00		1						HOLDER, anode connector
	- - - - -		-						mounting hardware: (not included w/holder)
	211-0008-00		2						SCREW, 4-40 x 0.250 inch, PHS
-106	213-0113-00		1						SCREW, thread forming, 2-32 x 0.312 inch, RHS
	- - - - -		-						mounting hardware: (not included w/assembly)
	211-0507-00		5						SCREW, 6-32 x 0.312 inch, PHS

FIGURE 3 REGULATOR CHASSIS &amp; HV POWER (cont)

Fig. & Index No.	Tektronix Tektronix	Serial/Model Eff	No. Disc	Q					Description
				† y	1	2	3	4	
3-107	407-0608-00			1					BRACKET, high voltage
-108	348-0231-00			2					SHIELDING GASKET, electrical, 5.400 inches long
-109	129-0234-00			1					POST, hex., 0.312 x 5.030 inches long
-	- - - - -			-					mounting hardware: (not included w/post)
-110	211-0510-00			2					SCREW, 6-32 x 0.375 inch, PHS
-111	441-0874-00			1					CHASSIS, vertical output
-112	407-0646-00			1					BRACKET, support
-	- - - - -			-					mounting hardware: (not included w/bracket)
-113	211-0537-00			4					SCREW, 6-32 x 0.375 inch, THS
-114	131-0682-02			13					TERMINAL, feed-thru, 0.820 inch long
-115	210-0202-00			2					LUG, solder, SE #6
-	- - - - -			-					mounting hardware for each: (not included w/lug)
-116	211-0504-00			1					SCREW, 6-32 x 0.250 inch, PHS
-117	210-0457-00			1					NUT, keps, 6-32 x 0.312 inch
-118	386-1664-00			1					PLATE, component mounting
-	- - - - -			-					mounting hardware: (not included w/plate)
-119	213-0044-00			2					SCREW, thread forming, 5-40 x 0.187 inch, PHS
-120	407-0607-00			1					BRACKET
-	- - - - -			-					mounting hardware: (not included w/bracket)
-121	211-0507-00			2					SCREW, 6-32 x 0.312 inch, PHS
-122	210-0457-00			2					NUT, keps, 6-32 x 0.312 inch
-123	407-0609-00			1					BRACKET, component
-	- - - - -			-					mounting hardware: (not included w/bracket)
-124	211-0507-00			2					SCREW, 6-32 x 0.312 inch, PHS
-125	210-0457-00			2					NUT, keps, 6-32 x 0.312 inch
-126	214-1138-00			2					HEAT SINK
-127	352-0062-00			2					HOLDER, heat sink
-128	211-0008-00			4					SCREW, 4-40 x 0.250 inch, PHS
-	211-0012-00			4					SCREW, 4-40 x 0.375 inch, PHS (not shown)
-129	210-0406-00			8					NUT, hex., 4-40 x 0.187 inch
-130	343-0097-00			2					CLAMP
-	210-0627-00			2					RIVET (not shown)
-131	214-0368-00			2					SPRING, helical compression
-132	210-0599-00			4					NUT, sleeve



FIGURE 3 REGULATOR CHASSIS &amp; HV POWER (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q ↑ y	1	2	3	4	5	Description
3-133	670-0809-00			1						ASSEMBLY, circuit board—VERTICAL OUTPUT
	- - - - -			-						assembly includes:
	388-1400-00			1						BOARD, circuit
-134	136-0252-01			2						SOCKET, pin connector
-135	136-0263-03			7						SOCKET, terminal pin
-136	136-0350-00			12						SOCKET, transistor, 3 pin
-137	214-0579-00			6						PIN, test point
-138	211-0155-00			3						SCREW, 4-40 x 0.375 inch, knurled
-139	361-0238-00			3						SPACER, sleeve
-140	337-1216-00			1						SHIELD, circuit board, plastic
-141	131-0761-00			1						TERMINAL POST
	- - - - -			-						mounting hardware: (not included w/terminal post)
-142	210-0202-00			1						LUG, solder, SE #6
-143	211-0504-00			1						SCREW, 6-32 x 0.250 inch, PHS

FIGURE 4 LV POWER &amp; REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				1	2	3	4	5	
4-1	437-0102-00			1					CABINET, LV power supply
	- - - - -			-					mounting hardware: (not included w/cabinet)
-2	212-0045-00			4					SCREW, 8-32 x 0.500 inch, THS
-3	129-0229-00			4					POST, hex., 5.250 inches long
-4	407-0652-00			1					BRACKET, support
	- - - - -			-					mounting hardware: (not included w/bracket)
	212-0040-00			2					SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
-5	210-0458-00			2					NUT, keps, 8-32 x 0.343 inch
-6	351-0208-00			2					RAIL, power supply, plastic
	- - - - -			-					mounting hardware for each: (not included w/rail)
-7	213-0054-00			1					SCREW, thread cutting, 6-32 x 0.312 inch, PHS
-8	213-0068-00			1					SCREW, thread cutting, 6-32 x 0.312 inch, 100° csk, FHS
-9	426-0443-04			1					FRAME, cabinet, rear
	- - - - -			-					frame includes:
-10	354-0345-00			1					RING, ornamental
-11	348-0218-00			2					SHIELDING GASKET, electrical, 9.900 inches long
-12	348-0221-00			2					SHIELDING GASKET, electrical, 10.400 inches long
-13	105-0151-00			8					CATCH, panel
	- - - - -			-					mounting hardware for each: (not included w/catch)
-14	213-0088-00			1					SCREW, thread forming, 4-40 x 0.250 inch, PHS
-15	343-0248-00			1					RETAINER, panel catch
-16	407-0647-00			2					BRACKET, panel mounting
	- - - - -			-					mounting hardware for each: (not included w/bracket)
-17	212-0040-00			2					SCREW, 8-32 x 0.375 inch, 100° csk, FHS
-18	386-1548-00			1					SUPPORT, swing-out chassis
	- - - - -			-					mounting hardware: (not included w/support)
-19	212-0040-00			1					SCREW, 8-32 x 0.375 inch, 100° csk, FHS
-20	210-0458-00			1					NUT, keps, 8-32 x 0.344 inch
-21	200-0938-00			1					COVER, frame, rear
-22	407-0651-00			1					BRACKET-STRAP ASSEMBLY
	- - - - -			-					mounting hardware: (not included w/bracket-strap assembly)
-23	211-0619-00			6					SCREW, 6-32 x 1.500 inches, 100° csk, FHS
-24	211-0016-00			1					SCREW, 4-40 x 0.625 inch, RHS
-25	386-1649-00			1					PLATE, backing
-26	129-0230-00			1					POST, hex., 0.188 x 1.500 inches long
-27	210-0206-00			5					LUG, solder, SE #10
-28	212-0518-00			4					SCREW, 10-32 x 0.312 inch, PHS
-29	252-0562-00			ft					PLASTIC CHANNEL, 4 lengths of 2 inches each
-30	200-1007-00			1					COVER, capacitor, plastic

FIGURE 4 LV POWER &amp; REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y	1 2 3 4 5					Description
4-31	670-0815-00		1						ASSEMBLY, circuit board—RECTIFIER
	- - - - -		-						assembly includes:
	388-1406-00		1						BOARD, circuit
-32	136-0183-00		1						SOCKET, transistor, 3 pin
-33	136-0220-00		8						SOCKET, transistor, 3 pin, square
-34	136-0263-00		12						SOCKET, connector pin
-35	136-0286-00		34						SOCKET, terminal pin
-36	136-0338-01		2						SOCKET, terminal pin
-37	214-0579-00		5						PIN, test point
-38	214-0269-00		6						HEAT SINK
-39	- - - - -		1						TRANSISTOR
	- - - - -		-						mounting hardware: (not included w/transistor)
-40	355-0146-00		2						STUD, self locking
-41	210-0586-00		2						NUT, keps, 4-40 x 0.250 inch
-42	- - - - -		2						DIODE
	- - - - -		-						mounting hardware for each: (not included w/diode)
-43	210-0805-00		1						WASHER, flat, 0.204 ID x 0.438 inch OD
	210-0010-00		1						WASHER, lock, internal, #10
-44	210-0410-00		1						NUT, hex., 10-32 x 0.312 inch
-45	211-0155-00		3						SCREW, 4-40 x 0.375 inch, knurled
-46	361-0238-00		3						SPACER, sleeve
-47	670-0813-00		1						ASSEMBLY, circuit board—LINE INPUT
	- - - - -		-						assembly includes:
	388-1404-00		1						BOARD, circuit
-48	136-0263-03		2						SOCKET, pin terminal
-49	136-0286-00		3						SOCKET, terminal pin
-50	343-0043-00		1						CLAMP, neon
-51	211-0155-00		2						SCREW, 4-40 x 0.375 inch, knurled
-52	361-0238-00		2						SPACER, sleeve
-53	386-1556-00		4						SUPPORT, circuit board
-54	131-0682-03		14						TERMINAL, feed-thru, 0.890 inch long
-55	131-0737-00		13						TERMINAL, feed-thru, 0.218 inch long
-56	670-0814-00		1						ASSEMBLY, circuit board—INVERTER
	- - - - -		-						assembly includes:
	388-0405-00		1						BOARD, circuit
-57	136-0254-01		4						SOCKET, connector pin
-58	214-0579-00		5						PIN, test point
-59	214-1194-00		1						HEAT SINK
-60	344-0189-00		1						CLIP, toroid
	- - - - -		-						mounting hardware: (not included w/clip)
-61	211-0008-00		1						SCREW, 4-40 x 0.250 inch, PHS
-62	210-0586-00		1						NUT, keps, 4-40 x 0.250 inch
-63	337-1186-00		1						SHIELD, electrical
-64	211-0116-00		4						SCREW, sems, 4-40 x 0.312 inch, PHB
-65	- - - - -		2						TRANSISTOR
	- - - - -		-						mounting hardware for each: (not included w/transistor)
-66	355-0137-00		2						STUD, self locking
	210-0004-00		2						WASHER, lock, internal, #4
-67	210-0406-00		2						NUT, hex., 4-40 x 0.187 inch
	- - - - -		-						mounting hardware: (not included w/assembly)
-68	211-0114-00		5						SCREW, 4-40 x 0.438 inch, 100° csk, FHS
-69	210-0586-00		5						NUT, keps, 4-40 x 0.250 inch
-70	211-0116-00		2						SCREW, sems, 4-40 x 0.312 inch PHB

FIGURE 4 LV POWER &amp; REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q ↑ y						Description
					1	2	3	4	5	
4-71	441-0893-00			1						CHASSIS, LV power supply
-72	119-0229-00			1						POWER SUPPLY
	- - - - -			-						power supply includes:
-73	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-74	211-0504-00			2						SCREW, 6-32 x 0.250 inch, PHS
	- - - - -			-						mounting hardware: (not included w/power supply)
-75	213-0144-00			8						SCREW, sheet metal, #8 x 0.250 inch, THS
-76	- - - - -			1						THERMO CUTOUT
	- - - - -			-						mounting hardware: (not included w/thermo cutout)
-77	211-0101-00			2						SCREW, 4-40 x 0.250 inch, 100° csk, FHS
-78	210-0586-00			2						NUT, keps, 4-40 x 0.250 inch
-79	131-0775-00			2						TERMINAL, stud
	- - - - -			-						mounting hardware for each: (not included w/terminal)
-80	210-0202-00			1						LUG, solder, SE #6
-81	211-0502-00			1						SCREW, 6-32 x 0.188 inch, 100° csk, FHS
	131-0775-00			1						TERMINAL, stud (not shown)
	- - - - -			-						mounting hardware: (not included w/terminal)
	211-0503-00			1						SCREW, 6-32 x 0.188 inch, PHS
	119-0228-00			1						ASSEMBLY, line filter
	- - - - -			-						assembly includes:
-82	380-0171-00			1						HOUSING, line filter
-83	131-0761-00			2						TERMINAL, post
	- - - - -			-						mounting hardware for each: (not included w/terminal)
	210-0006-00			1						WASHER, lock, internal #6
-84	211-0504-00			1						SCREW, 6-32 x 0.250 inch, PHS
-85	131-0761-00			1						TERMINAL, post
	- - - - -			-						mounting hardware: (not included w/terminal)
	211-0504-00			1						SCREW, 6-32 x 0.250 inch, PHS (not shown)
-86	210-0202-00			1						LUG, solder, SE #6
-87	- - - - -			1						TRANSFORMER
	- - - - -			-						mounting hardware: (not included w/transformer)
-88	211-0166-00			2						SCREW, 4-40 x 1.750 inches, PHS
-89	346-0068-00			1						STRAP, retaining
-90	- - - - -			2						CAPACITOR, w/hardware
-91	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-92	213-0088-00			1						SCREW, thread forming, #4 x 0.250 inch, PHS

FIGURE 4 LV POWER &amp; REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q t y						Description
					1	2	3	4	5	
4-93	- - - - -			2						DIODE
	- - - - -			-						mounting hardware for each: (not included w/diode)
-94	210-0909-00			2						WASHER, plastic, 0.196 ID x 0.625 inch OD
	210-0813-00			1						WASHER, flat, 0.204 ID x 0.438 inch OD
-95	210-0224-00			1						LUG, solder, 0.875 inch long
-96	220-0410-00			1						NUT, keps, 10-32 x 0.375 inch
-97	210-0202-00			1						LUG, solder, SE #6
	- - - - -			-						mounting hardware: (not included w/lug)
	211-0504-00			1						SCREW, 6-32 x 0.250 inch, PHS
-98	210-0407-00			1						NUT, hex., 6-32 x 0.250 inch
-99	348-0240-00			1						SHIELDING GASKET, electrical, 10.140 inches long
-100	386-1612-00			1						SUBPANEL, rear, lower
-101	386-1610-00			1						PANEL, rear, lower
	- - - - -			-						mounting hardware: (not included w/panel)
-102	212-0039-00			4						SCREW, 8-32 x 0.375 inch, THS
-103	386-1561-00			1						PLATE, retaining
	- - - - -			-						mounting hardware: (not included w/plate)
-104	211-0038-00			3						SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-105	204-0373-01			1						BODY ASSEMBLY, line voltage selector
-106	204-0374-01			1						BODY, fuse holder
-107	200-0981-01			1						COVER, line voltage selector
	- - - - -			-						cover includes:
-108	352-0102-00			2						HOLDER, fuse
	- - - - -			-						mounting hardware for each: (not included w/holder)
-109	213-0088-00			2						SCREW, thread forming, #4 x 0.250 inch, PHS
-110	358-0372-00			1						BUSHING, strain relief, bottom
-111	200-1004-00			1						CABLE NIPPLE, plastic
-112	358-0371-00			1						BUSHING, strain relief, top
-113	161-0033-04			1						CABLE ASSEMBLY, power
-114	386-1613-00			1						SUBPANEL, rear, upper
-115	386-1611-00			1						PANEL, rear, upper
	- - - - -			-						mounting hardware: (not included w/panel)
-116	212-0039-00			4						SCREW, 8-32 x 0.375 inch, THS
-117	131-0761-00			2						TERMINAL, post
	- - - - -			-						mounting hardware: (not included w/terminal)
-118	210-0202-00			1						LUG, solder, SE #6
-119	211-0541-00			1						SCREW, 6-32 x 0.250 inch, 100° csk, FHS
-120	131-0761-00			3						TERMINAL, post
	- - - - -			-						mounting hardware: (not included w/terminal)
-121	210-0006-00			1						WASHER, lock, internal, #6
-122	211-0541 00			1						SCREW, 6-32 x 0.250 inch, 100° csk, FHS
-123	131-0106-01			2						CONNECTOR, coaxial, 1 contact, BNC, female
	- - - - -			-						mounting hardware: (not included w/connector)
	210-0012-00			1						WASHER, lock, internal, 0.375 ID x 0.500 inch OD
-124	210-0413-00			1						NUT, hex., 0.375-32 x 0.500 inch

FIGURE 4 LV POWER &amp; REAR (cont)

Fig. & Index	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	1	2	3	4	5	Description
4-125	131-0771-00			2						CONNECTOR, receptacle, 4 contact
	- - - - -			-						mounting hardware for each: (not included w/connector)
	210-0012-00			1						WASHER, lock, internal, 0.375 ID x 0.500 inch OD
-126	220-0551-00			1						NUT, hex.,
-127	136-0089-00			1						SOCKET, 9 pin, w/female insert
	- - - - -			-						mounting hardware: (not included w/socket)
-128	211-0012-00			4						SCREW, 4-40 x 0.375 inch, PHS
-129	210-0586-00			4						NUT, keps, 4-40 x 0.250 inch
-130	358-0224-00			4						FOOT, cabinet, plastic
	- - - - -			-						mounting hardware: (not included w/foot)
-131	212-0020-00			2						SCREW, 8-32 x 1 inch, PHS
-132	348-0225-00			4						PAD, cabinet foot
-133	179-1468-00			1						WIRING HARNESS, line voltage selector
-134	179-1467-00			1						WIRING HARNESS, power
	- - - - -			-						wiring harness includes:
-135	131-0512-00			16						CONNECTOR, terminal
	131-0755-00			2						CONNECTOR, terminal
-136	131-0738-00			14						CONNECTOR, terminal

FIGURE 5 CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y	1	2	3	4	5	Description
5-1	390-0086-00	- - - - -		2						CABINET SIDE
	214-0812-00	- - - - -		-						each cabinet side includes:
		- - - - -		4						ASSEMBLY, latch
		- - - - -		-						each assembly includes:
-2	214-0603-01	- - - - -		1						PIN, securing
-3	214-0604-00	- - - - -		1						SPRING
-4	386-0227-00	- - - - -		1						PLATE, index, plastic
-5	386-0226-00	- - - - -		1						PLATE, locking
-6	390-0085-00	- - - - -		1						CABINET BOTTOM
	214-0812-00	- - - - -		-						cabinet bottom includes:
		- - - - -		8						ASSEMBLY, latch
		- - - - -		-						each assembly includes:
-7	214-0603-01	- - - - -		1						PIN, securing
-8	214-0604-00	- - - - -		1						SPRING
-9	386-0227-00	- - - - -		1						PLATE, index, plastic
-10	386-0226-00	- - - - -		1						PLATE, locking
-11	200-0973-00	- - - - -		2						COVER, 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	426-0484-00	- - - - -		1						FRAME SECTION, cabinet
	212-0040-00	- - - - -		-						mounting hardware: (not included w/frame section)
		- - - - -		4						SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
-17	210-0458-00	- - - - -		4						NUT, keps, 8-32 x 0.343 inch
-18	426-0485-00	- - - - -		1						FRAME SECTION, cabinet, lower left
	212-0040-00	- - - - -		-						mounting hardware: (not included w/frame section)
		- - - - -		4						SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
-19	426-0486-00	- - - - -		1						FRAME SECTION, cabinet, lower right
	212-0040-00	- - - - -		-						mounting hardware: (not included w/frame section)
		- - - - -		4						SCREW, 8-32 x 0.375 inch, 100° csk, FHS (not shown)
-20	348-0193-00	- - - - -		1						FLIP-STAND, cabinet
-21	348-0180-00	- - - - -		2						FOOT, cabinet, left front & right rear
		- - - - -		-						mounting hardware for each: (not included w/foot)
-22	211-0513-00	- - - - -		2						SCREW, 6-32 x 0.625 inch, PHS
-23	348-0181-00	- - - - -		2						FOOT, cabinet, right front & left rear
		- - - - -		-						mounting hardware for each: (not included w/foot)
-24	211-0513-00	- - - - -		2						SCREW, 6-32 x 0.625 inch, PHS
-25	348-0182-00	- - - - -		4						PAD, cabinet foot
-26	343-0256-00	- - - - -		2						RETAINER, block
		- - - - -		-						mounting hardware for each: (not included w/retainer)
-27	212-0091-00	- - - - -		2						SCREW, 8-32 x 0.625 inch, Fil HS
	210-0458-00	- - - - -		2						NUT, keps, 8-32 x 0.343 inch (not shown)

## **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.



## ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

TRIG. SEL.

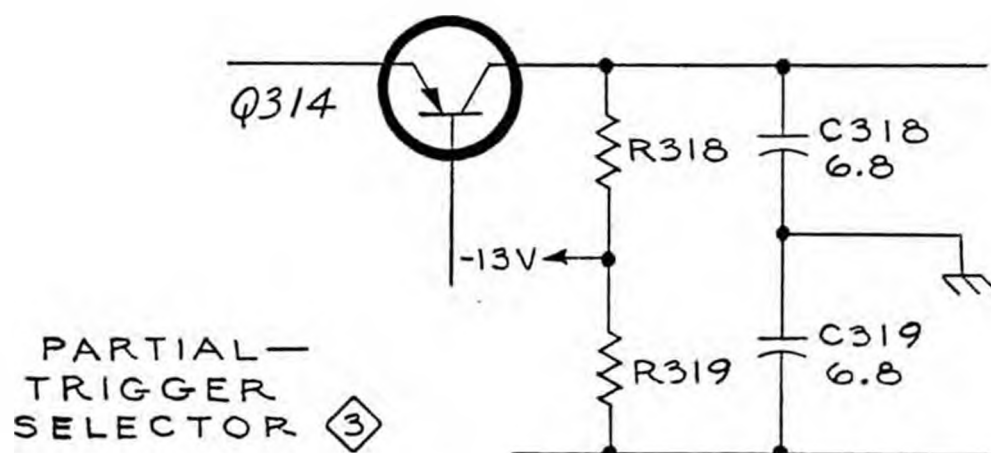
Circuit Board Assembly

CHANGE TO:

C319	281-0616-00	6.8 pF	Cer	200 V
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ADD:

C318	281-0616-00	6.8 pF	Cer	200 V
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## TEXT CORRECTIONS

Section 5 Performance Check/Calibration

Page 5-17 Step 15

ADD: the following parts to Step 15:

- i. Install the 7B70 Time Base in the B HORIZ compartment.
- j. Set the 7B70 Time/Div control to .5 ms.
- k. Set the HORIZONTAL MODE switch to B.
- l. CHECK--Readout display for completeness of characters.
- m. ADJUST--Full Character Scan adjustment R1219 for complete but not overdisplayed characters.

Page 5-17 Step 16

CHANGE: part a of Step 16 to read as follows:

- a. Install the 067-0587-00 calibration fixture in the LEFT VERT compartment.

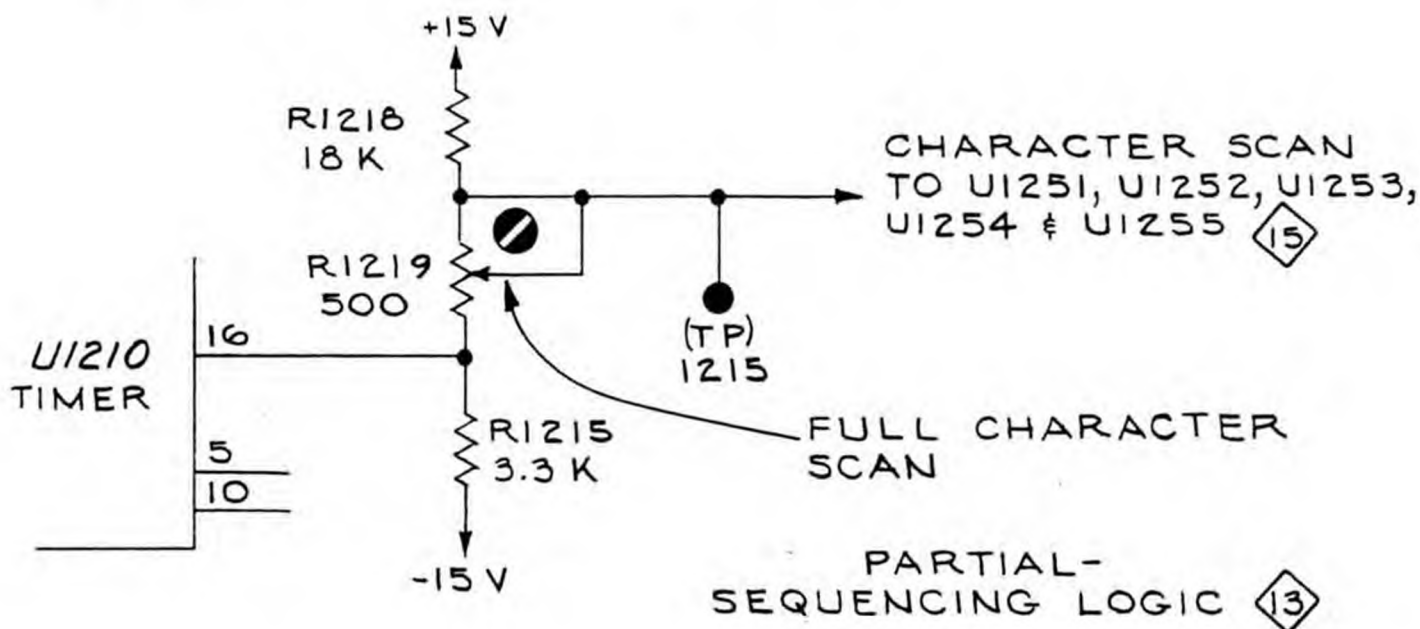
## ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE:

R1215	317-0332-00	3.3 k $\Omega$	1/8 W	5%
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ADD:

R1218	317-0183-00	18 k $\Omega$	1/8 W	5%
R1219	311-0634-00	500 $\Omega$ , Var		



PARTIAL-SEQUENCING LOGIC 13

## ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

## CHASSIS

## CHANGE TO:

L762	108-0422-00	80 $\mu$ H	
T800	119-0228-00		Line Filter
T870	119-0229-00		L. V. Power

## VERTICAL OUTPUT      Circuit Board Assembly

## CHANGE TO:

L422	108-0095-00	1.4 nH
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## HORIZONTAL OUTPUT      Circuit Board Assembly

## CHANGE TO:

C583	290-0305-00	3 $\mu$ F	EMT	150 V
C586	290-0327-00	0.56 $\mu$ F	Fixed	100 V
C593	290-0305-00	3 $\mu$ F	EMT	150 V
C596	290-0327-00	0.56 $\mu$ F	Fixed	100 V
R525	321-0186-00	845 $\Omega$	1/8 W	1%

## Z AXIS      Circuit Board Assembly

## ADD:

C731	281-0537-00	0.68 pF	Cer	500 V
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## CHANGE TO:

R736	301-0750-00	75 $\Omega$	1/2 W	5%
------	-------------	-------------	-------	----

## RECTIFIER

## Circuit Board Assembly

## CHANGE TO:

L872	108-0422-00	80 $\mu$ H
L877	108-0422-00	80 $\mu$ H
L881	108-0422-00	80 $\mu$ H
L893	108-0442-00	80 $\mu$ H

