INSTRUCTION MANUAL

Serial Number 700-110

7504 OSCILLOSCOPE

Tektronix, Inc.

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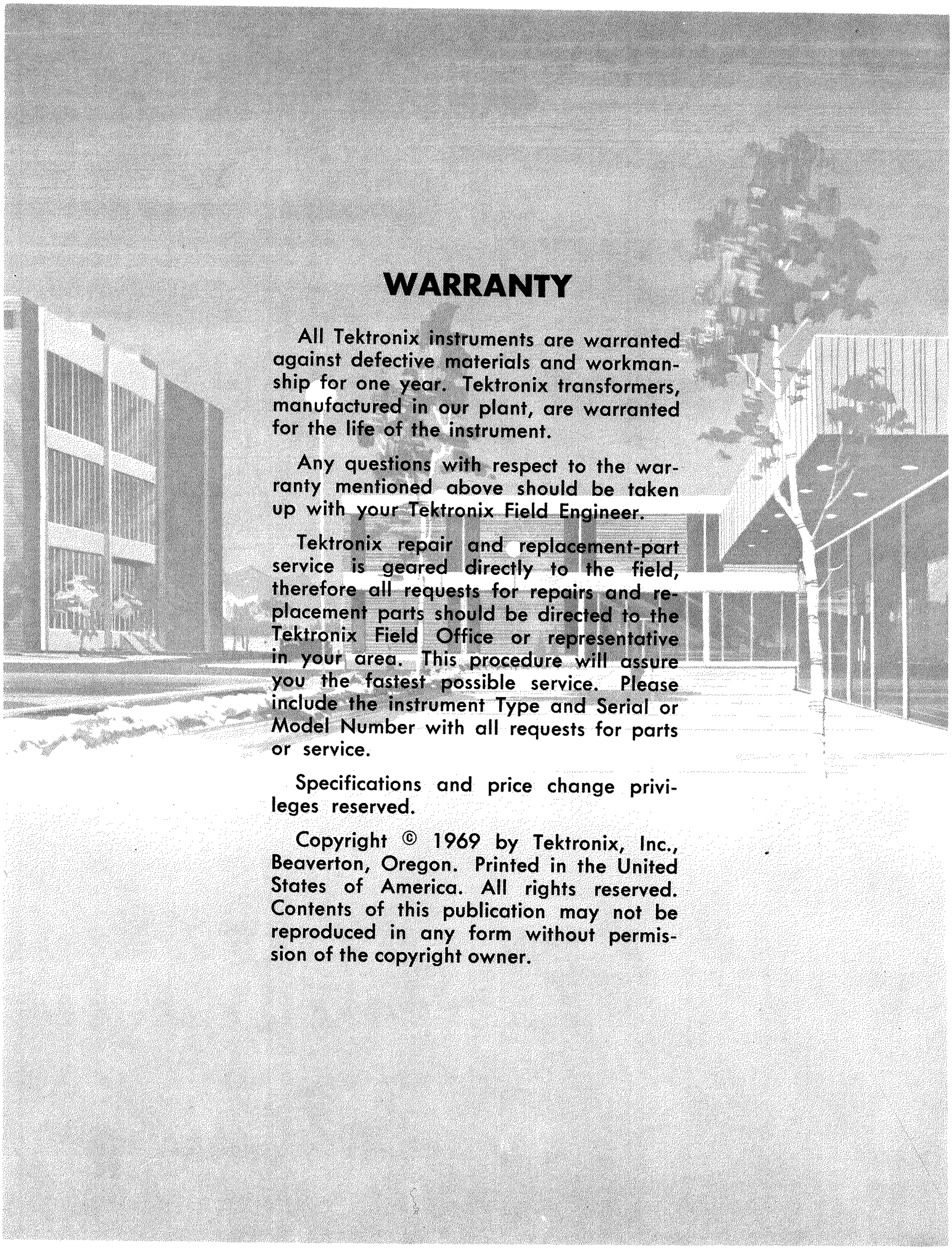

WARRANTY

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.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

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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.

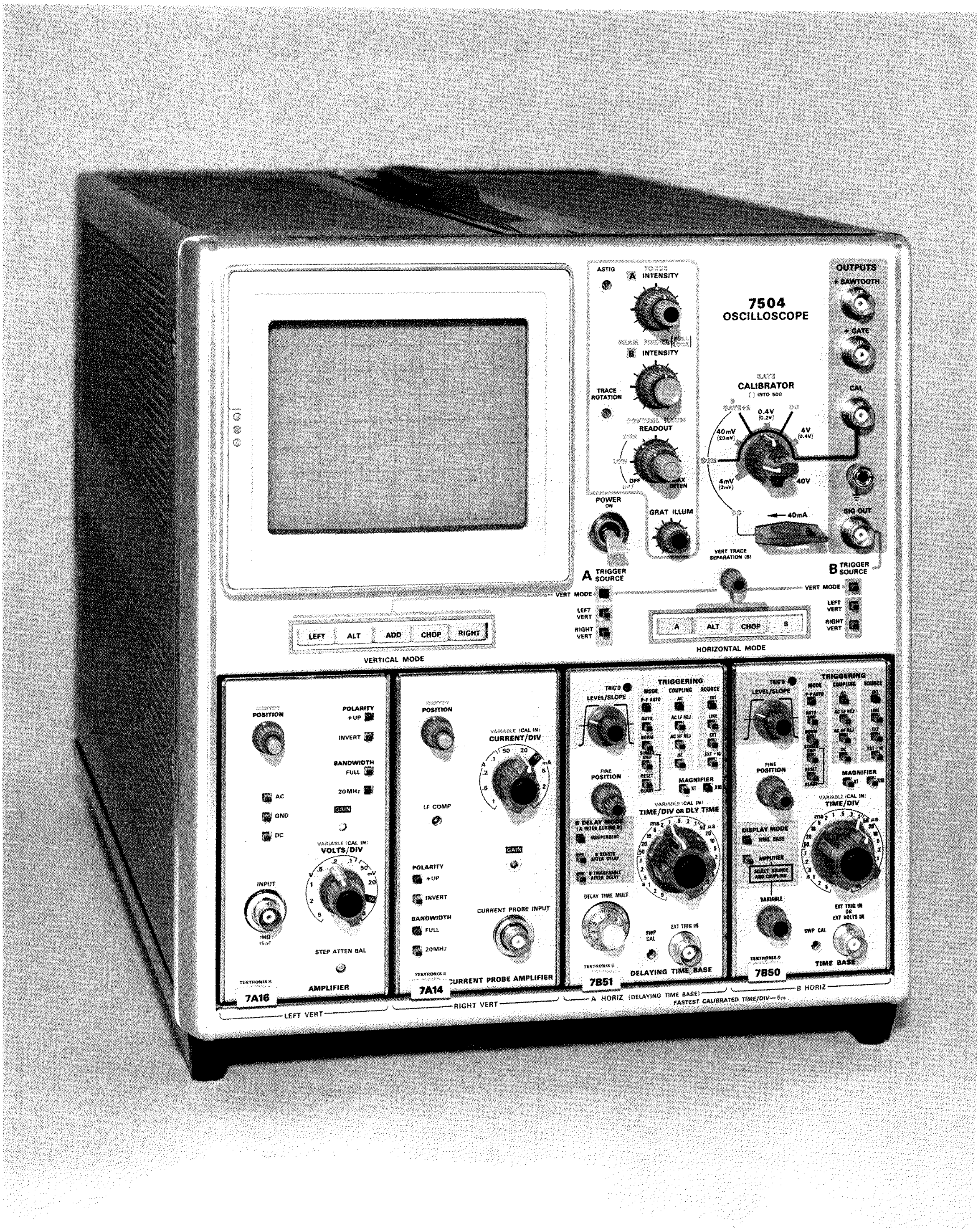

Fig. 1-1. Type 7504 Oscilloscope.

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

	7500-Series			7700-Series		Vertical System Deflection Factor Accuracy*			SIG OUT		Horizontal System
Plug-In Unit	Probe	BW	T_r	BW	T_r	EXT CAL 0-50°C	INT CAL 15°-35°C	INT CAL 0-50°C	BW	T_r	
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 Any	1.0 MHz ±10%	350 ns ±9%	1 MHz ±10%	350 ns ±9%	2%	3%	4%	1.0 MHz ±10%	350 ns ±9%	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.

***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.

PLUG-IN OPTIONS
MAJOR CHARACTERISTICS
AMPLIFIERS

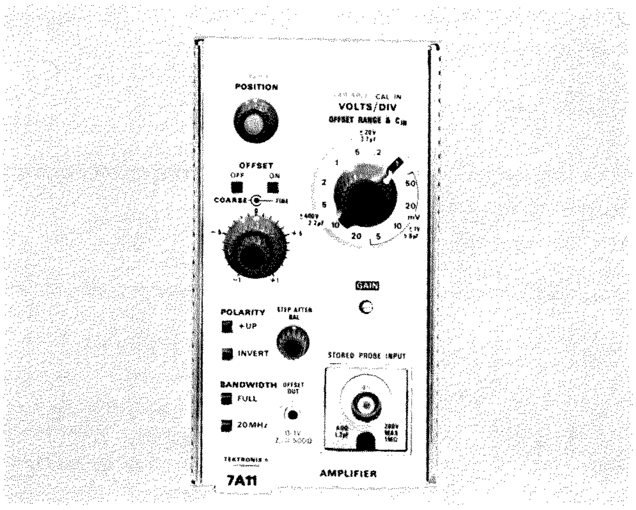

Fig. 1. 7A11 FET Probe Wide Band Amplifier (All specifications at Probe tip).

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

Deflection Factor	5 mV/div to 20 V/div
Input Resistance	1 MΩ 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 overscaning screen.

7A12 Dual Trace Wide Band Amplifier

Deflection Factor	5 mV/div to 5 V/div, pushbutton selected
Input Resistance	1 MΩ 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.

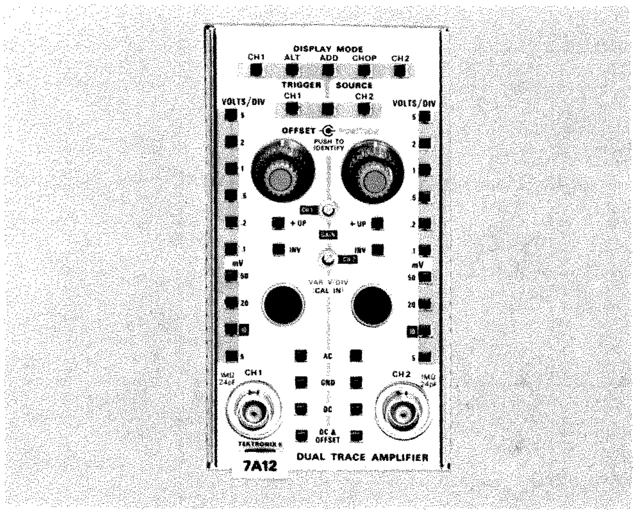

Fig. 2. 7A12 Dual Trace Wide Band Amplifier.

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 MΩ within 0.15%
Input Capacitance	20 pF within 0.4 pF

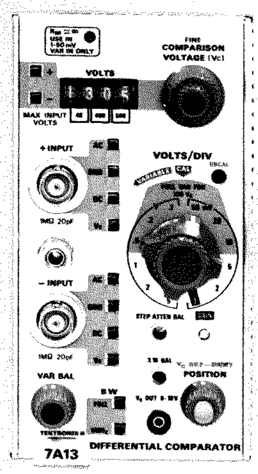

Fig. 3. 7A13 Differential Comparator and Differential Amplifier.

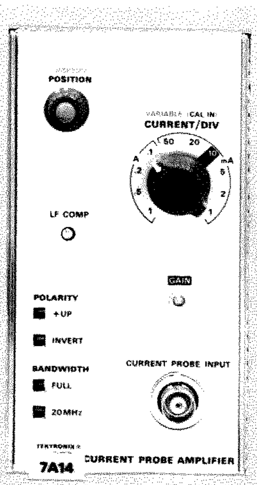

Fig. 4. 7A14 Current Probe Amplifier.

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.

7A16 Wide Band Amplifier

Deflection Factor	5 mV/div to 5 V/div
Input Resistance	1 MΩ 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

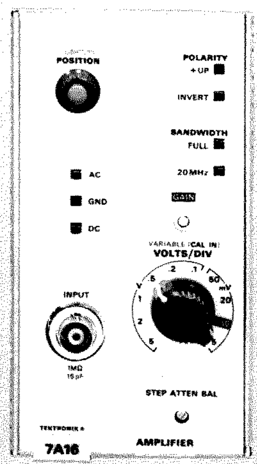

Fig. 5. 7A16 Wide Band Amplifier.

AMPLIFIERS (Cont)

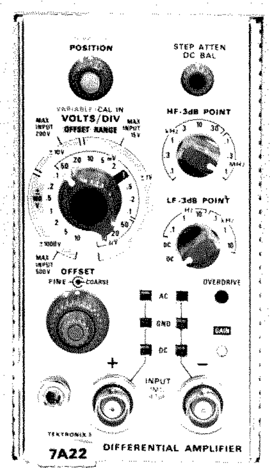

Fig. 6. 7A22 High-Gain Differential Amplifier.

7A22 High-Gain Differential Amplifier

Deflection Factor	10 µV/div to 10 V/div
Input Resistance	1 MΩ within 1%
Input Capacitance	47 pF within 2.5 pF
Displayed Noise	16 µV at 10 µV/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

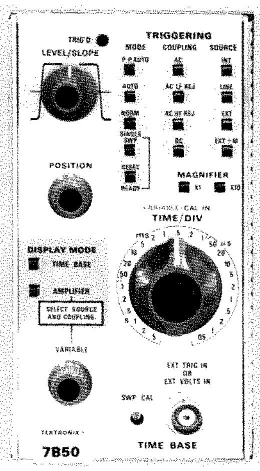

Fig. 7. 7B50 Time Base.

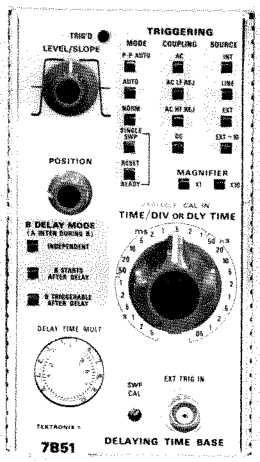

Fig. 8. 7B51 Delaying Time Base.

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 µs/div within 1%.
Multiplier Incremental Linearity	Within 0.2%
Jitter	1 part or less in 50,000 of 10X the TIME/DIV setting

REAL TIME TIME BASES (Cont)

7B70 Time Base

Sweep Rate	0.02 µs/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.

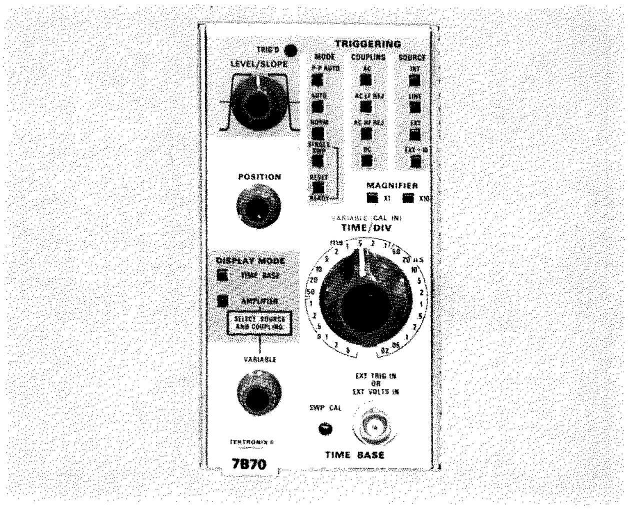

Fig. 9. 7B70 Time Base.

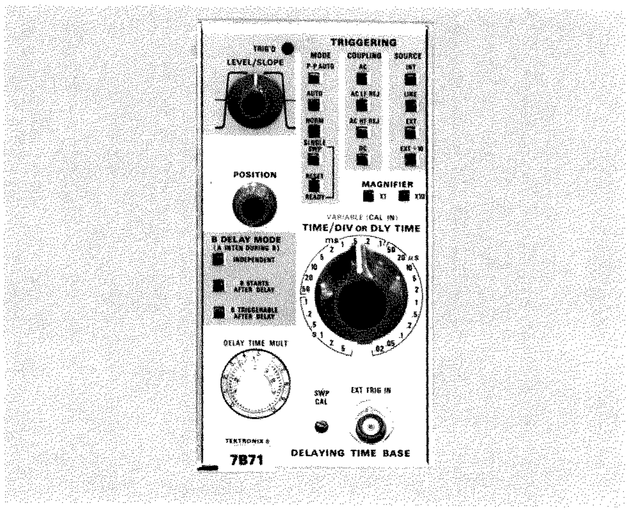

Fig. 10. 7B71 Delaying Time Base.

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.

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 µs/div within 1%
Multiplier Incremental Linearity	within 0.2%
Jitter	1 part or less in 50,000 of 10X TIME/DIV setting.

SAMPLING UNIT

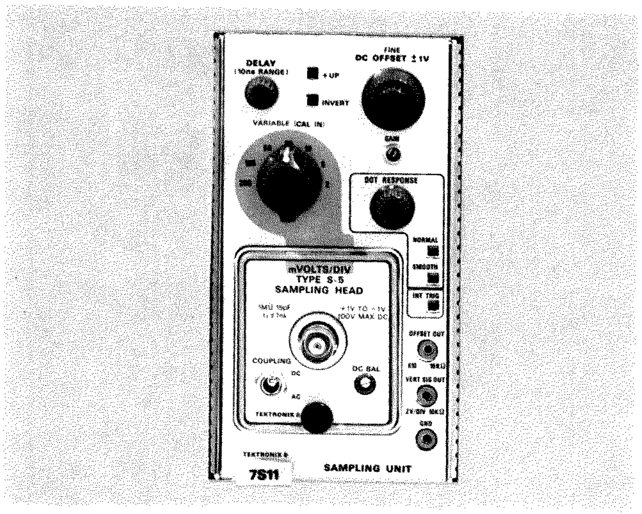

Fig. 11. 7S11 Sampling Unit.

7S11 Sampling Unit

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

DC Offset	±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 μs/Div to 10 ps/Div Real time, 5 ms/Div to 0.1 μs/Div
Time Position Ranges	Equivalent time, 50 ns to 50 μs 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 Ω Input	DC to 500 MHz
External, 1 MΩ Input	DC to 100 MHz
External, 50 Ω 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

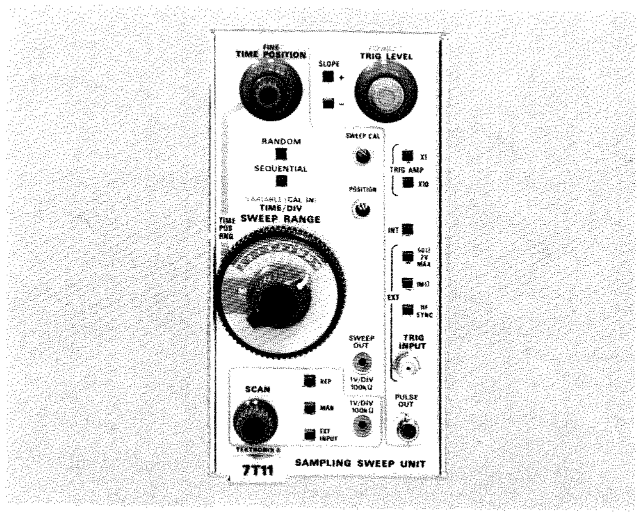

Fig. 12. 7T11 Sampling Sweep Unit.

DELAY LINE

7M11 50 Ω 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.

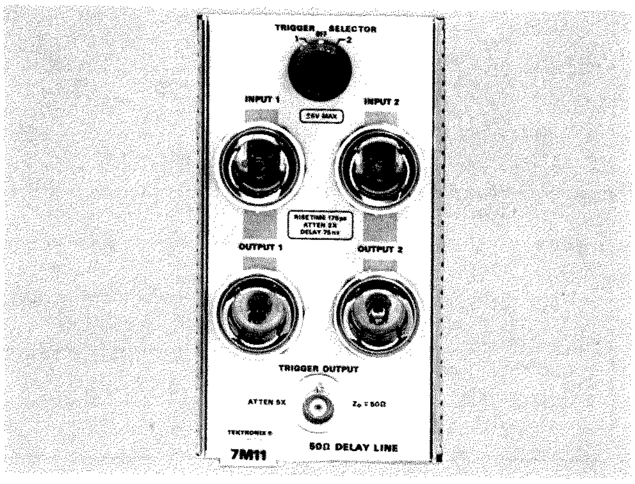

Fig. 13. 7M11 50 Ω Delay Line, Dual channel.

SAMPLING HEADS

Signal Input Heads

S-1 Sampling Head

Input Resistance	50 Ω
Risetime	350 ps
Random noise	less than 2 mV

S-2 Sampling Head

Input Resistance	50 Ω
Risetime	50 ps
Random noise	Less than 6 mV

S-3 Sampling Head (with attached probe)

Input Resistance	100 kΩ
Input Capacitance	2.3 pF
Risetime	350 ps
Random noise	Less than 3 mV

S-4 Sampling (3 mm input connector)

Input Resistance	50 Ω
Risetime	25 ps
Random noise	Less than 5 mV

S-5 Sampling Head

Input Resistance	1 MΩ
Risetime (with 10X probe)	1 ns
Noise	Less than 500 μV

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 pretrigger 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

NOTES

SECTION 1
TYPE 7504 SPECIFICATION

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

Introduction

The Tektronix Type 7504 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 Type 7504 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 280 watts (60 hertz, 115-volt line).

The Type 7504 features a CRT with an 8 X 10 centimeter graticule area with small spot size and high writing rate. 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 Type 7504 only. See the system specification later in this section for characteristics of the complete system.

TABLE 1-1

ELECTRICAL

Characteristic	Performance
VERTICAL DEFLECTION SYSTEM	
Deflection Factor	Compatible with all 7-series plug-in units.
Deflection Accuracy	Less than 1% difference between compartments.
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.
Isolation Between Compartments	At least 100:1 from DC to 75 megahertz.
Chopped Mode Repetition Rate	One megahertz ±20%.
Time segment from each compartment	0.4 to 0.6 microsecond.
Delay Line	Permits viewing of leading edge of triggering signal.

Characteristic	Performance
Vertical Display Modes (selected by front-panel VERTICAL MODE switch)	Left: Left vertical only. ALT: Dual-trace, alternate between vertical units. ADD: Added algebraically. CHOP: Dual-trace, chopped between vertical units. RIGHT: Right vertical only.
Trace Separation Range for Dual Sweep Modes	B trace can be positioned at least + and − four 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	Five nanoseconds/division.
Phase Shift Between Vertical and Horizontal Deflection Systems	
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.
Chopped Mode	
Repetition rate	200 kilohertz ±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 only. ALT: Dual-sweep, alternate between horizontal units. CHOP: Dual-sweep, chopped between horizontal units. B: B horizontal only.

Characteristic	Performance	
CALIBRATOR		
Wave Shape	Square wave.	
Polarity	Positive going with baseline at zero volts.	
Output Voltage (selected by front-panel CALIBRATOR switch)		
Open circuit	Four millivolts to 40 volts in five decade steps.	
Into 50 ohms	Two millivolts to 0.4 volts in four steps.	
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	+15°C to +35°C	0°C to +50°C
	Within 0.25%.	Within 0.5%
Duty Cycle	50% ±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 voltage vs repetition frequency	Two volts peak-to-peak, DC to two megahertz; reducing to 0.4 volts peak-to-peak at 10 megahertz.	
Polarity of operation	Positive-going signal decreases trace intensity; negative-going signal increases trace intensity.	
Minimum pulse width that provides intensity modulation	40 nanoseconds at two volts.	

Characteristic	Performance
Input resistance	500 ohms ±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 from DC to 75 megahertz.
Polarity of operation	Positive-going signal decreases trace intensity; negative-going signal increases trace intensity.
Minimum pulse width that provides intensity modulation	Five nanoseconds at 60 volts.
Input resistance at DC	7.5 kilohms ±10%.
Maximum input voltage	60 volts (DC + peak AC). 60 volts peak-to-peak AC.

SIGNAL OUTPUTS

Characteristic	Performance
+ 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 ±one volt (into one megohm).
Output voltage	
Rate of rise	
Into 50 ohms	50 millivolts/unit of time ±15%.[1]
Into one megohm	One volt/unit of time ±10%.[1]
Peak voltage	
Into 50 ohms	Greater than 500 millivolts.
Into one megohm	Greater than 10 volts.
Output resistance	950 ohms ±2%.
+ Gate	
Source (selected by internal Gate switch)	From A HORIZ time-base unit, B HORIZ time-base unit, or the delaying time-base unit (in A HORIZ compartment).
Output voltage	
Into 50 ohms	0.5 volt ±10%.
Into one megohm	10 volts ±10%.
Risetime into 50 ohms	20 nanoseconds or less.
Output resistance	950 ohms ±2%.
Vertical Signal Output	
Source	Determined by B TRIGGER SOURCE switch.
Output voltage	
Into 50 ohms	25 millivolts/division of vertical deflection ±25%.
Into one megohm	0.5 volt/division of vertical deflection ±25%.
Output resistance	950 ohms ±2%

POWER SUPPLY

Characteristic	Performance
Line Voltage Range (AC, RMS)	*Line voltage and range selected by Line Voltage Selector assembly on rear panel.*
115-volts nominal	90 to 110 volts. 104 to 126 volts. 112 to 136 volts.
230-volts nominal	180 to 220 volts. 208 to 252 volts. 224 to 272 volts.
Line Frequency	48 to 440 hertz.
Maximum Power Consumption	280 watts, 3.2 amperes at 60 hertz, 115-volt line.

CATHODE-RAY TUBE (CRT)

Characteristic	Performance
Graticule	
Type	Internal with variable edge lighting.
Area	Eight divisions vertical by ten divisions horizontal. Each division equals one centimeter.
Resolution	
Horizontal	At least 15 lines/division.
Vertical	At least 15 lines/division.
Geometry	0.1 division or less total bowing of a displayed horizontal or vertical line.
Beam Finder	Limits display within graticule area.

[1] Unit of time selected by time-base time/division switch.

Characteristic	Performance
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 2250 centimeters/microsecond with Polaroid[2] 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 1500 centimeters/microsecond with Polaroid Type 410 film (10,000 ASA) and P31 CRT phosphor.

TABLE 1-2

ENVIRONMENTAL

NOTE

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.

Characteristic	Performance
Temperature Range	
Operating	0°C to +50°C.
Non-operating	−55°C to +75°C.
Altitude	
Operating	15,000 feet.
Non-operating	Test limit 50,000 feet.
Electro-magnetic Interference (EMI) as tested in MIL-I 6181 D (when equipped with EMI modification 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 instruments, without plug-ins)	Qualifies under National Safe Transit Committee test procedure 1A.

[2]Registered trademark of the Polaroid Corporation.

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 inches (30.5 centimeters).
Length	24.6 inches (62.2 centimeters).
Net Weight (instrument only)	54 pounds (24.6 kilograms).

STANDARD ACCESSORIES

Standard accessories supplied with the Type 7504 are listed on the last pull-out page of 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 Type 7504 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 alpha-numeric 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 equilize 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.

NOTES

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 Type 7504, 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

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.

The Type 7504 can be operated from either a 115-volt or a 230-volt nominal line voltage source. The Line Voltage Selector assembly on the rear panel converts this instrument from one operating voltage to the other. In addition, this assembly changes the primary connections of the power transformer to allow selection of one of three regulating ranges. The assembly also includes the two line fuses to provide the correct protection for the instrument as the line voltage is changed. Use the following procedure to obtain correct instrument operation from the line voltage available.

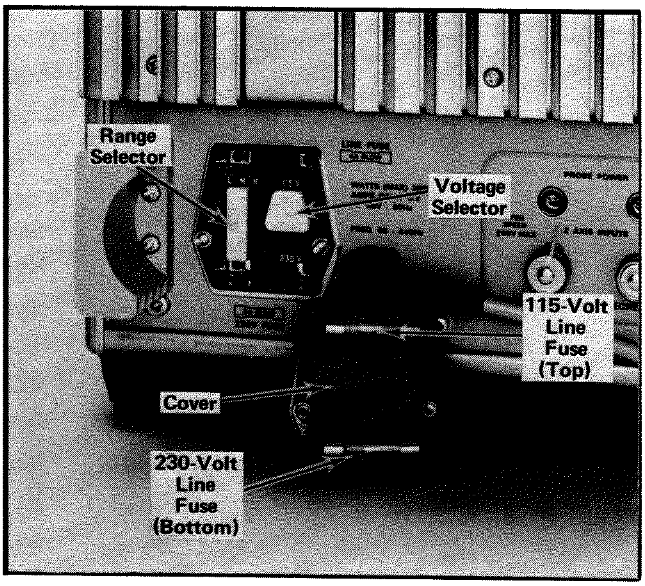

Fig. 2-1. Line Voltage Selector assembly on rear panel (shown with cover removed).

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 Voltage Selector switch bar (see Fig. 2-1); turn it around 180° and plug it back into the remaining holes. Change the line-cord power plug to match the power-source receptable 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. To change regulating ranges, pull out the Range Selector switch bar (see Fig. 2-1); slide it to the desired position and plug it back in. Select a range which is centered about the average line voltage to which the instrument is to be connected (see Table 2-1).

TABLE 2-1
Regulating Ranges

Range Selector Switch Position	Regulating Range 115-volts nominal	230-volts nominal
LO (switch bar in left holes)	90 to 110 volts	180 to 220 volts
M (switch bar in middle holes)	104 to 126 volts	208 to 252 volts
HI (switch bar in right holes)	112 to 136 volts	224 to 272 volts

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

6. Before applying power to the instrument, check that the indicating tabs on the switch bars are protruding through the correct holes for the desired nominal line voltage and regulating range.

CAUTION

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

The Type 7504 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 plastic holders on the lower corners of the rear panel provide a convenient cord wrap to store the power cord when not in use (see Fig. 2-2).

Operating Temperature

The Type 7504 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 Type 7504 is cooled by convection air flow through the instrument. Components which require the most cooling are mounted externally on a heat radiator at the rear of this 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 or the heat radiator on the rear. Maintain the clearance provided by the feet on the bottom 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 Type 7504 to be tilted up about 10° for more convenient viewing (see Fig. 2-3).

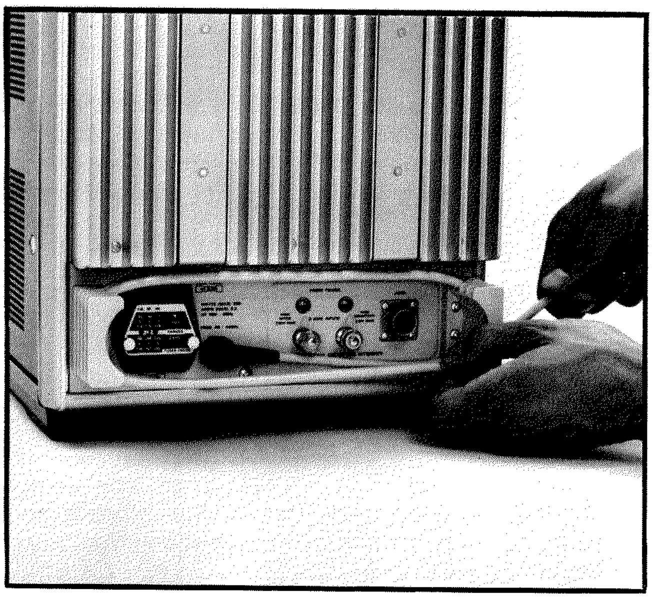

Fig. 2-2. Cord wrap provided on rear panel to store power cord.

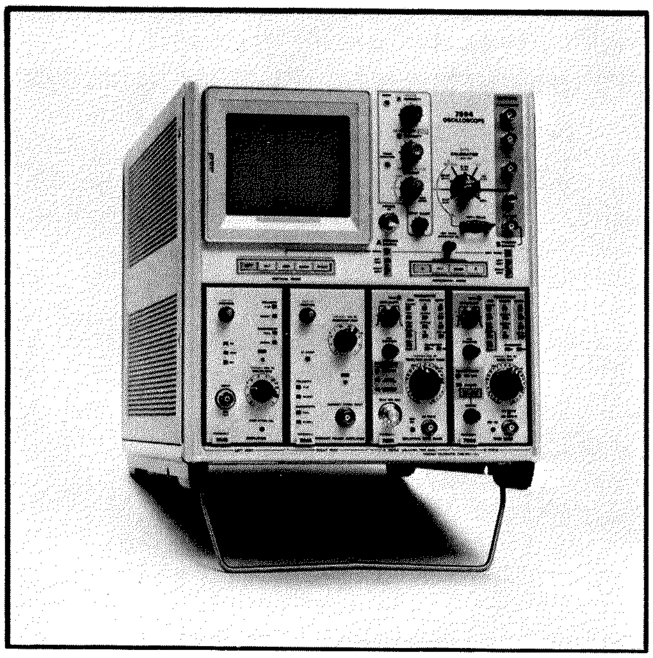

Fig. 2-3. Instrument positioned on bail-type stand.

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PLUG-IN UNITS

General

The Type 7504 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 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. However, installation of the plug-ins with the power on may on occasion cause the power-supply protection circuits of the Type 7504 to interrupt the power to the instrument. This is due to the sudden surge of current that is demanded as a plug-in is connected to the power-supply circuits. If the Type 7504 is not operating after the plug-ins are inserted (neither the A nor the B INTENSITY indicators is lighted), turn off the POWER switch momentarily and return it to ON.

It is not necessary that all of the plug-in compartments be filled to operate the instrument; only the plug-ins needed for the measurement which is to be made are necessary. 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 Type 7504 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 Type 7504 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 both vertical compartments. 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 7B-series plug-in can be used as a delayed time-base in the B HORIZ compartment.

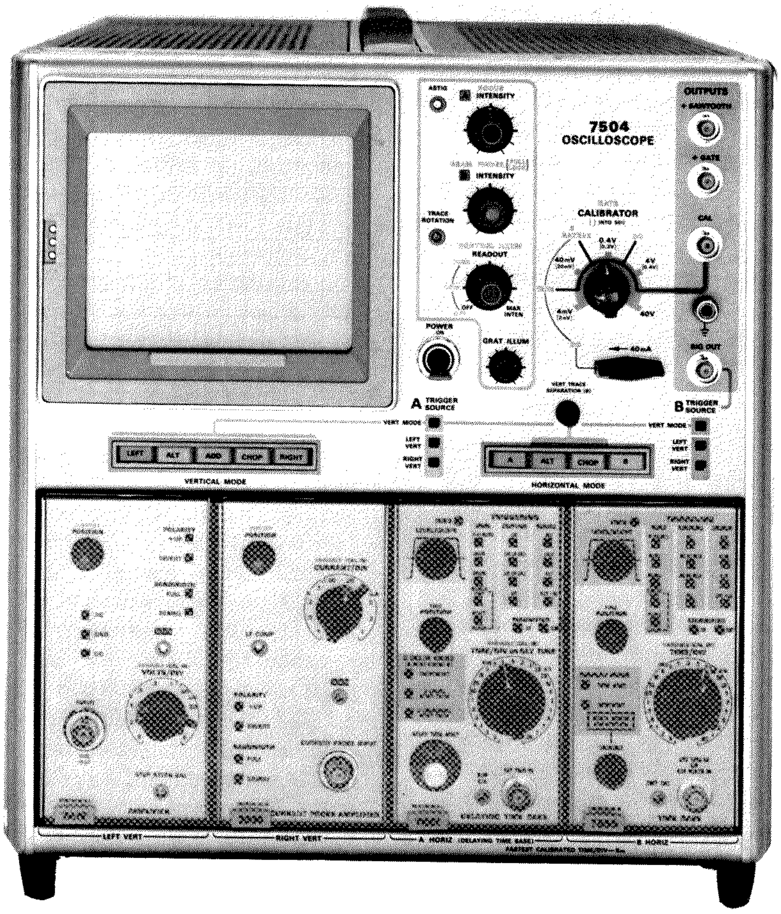
X-Y displays can be obtained in two ways with the Type 7504 system. If a 7B-series time-base plug-in is available which has an amplifier feature, the X signal can be routed through one of the vertical units via the internal-trigger pickoff circuitry to the horizontal system. Then, the vertical (Y) signal 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.

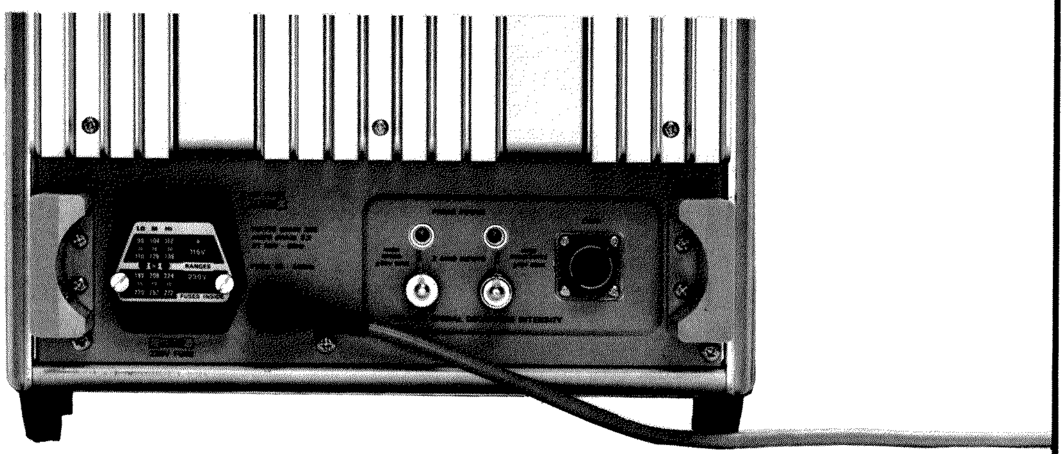
CONTROLS AND CONNECTORS

General

The major controls and connectors for operation of the Type 7504 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 Type 7504. 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. Front panel



B. Partial rear panel

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

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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.
B INTENSITY	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.
BEAM FINDER (PULL LOCK)	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.
READOUT	Controls brightness of the readout portion of the CRT display. In the fully counterclockwise position, the Readout System is inoperative.
CONTROL ILLUM	Controls illumination level of pushbutton switches on Type 7504 and the associated plug-ins. OFF: All pushbutton lights off. A and B INTENSITY lights remain at low intensity to provide a power-on indication. LOW: All pushbuttons illuminated at low intensity. HIGH: Pushbuttons illuminated at maximum intensity.
TRACE ROTATION	Screwdriver adjustment to align trace with horizontal graticule lines.
GRAT ILLUM	Controls graticule illumination.

Mode Selectors

VERTICAL MODE	Selects vertical mode of operation. LEFT: Signal from plug-in unit in LEFT VERT compartment is displayed. CHOP: 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. ADD: Signals from plug-in units in both LEFT VERT and RIGHT VERT compartments are algebraically added and the algebraic sum displayed on the CRT. ALT: 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. RIGHT: Signal from plug-in unit in RIGHT VERT compartment is displayed.
A TRIGGER SOURCE	Selects source of internal trigger signal for the time-base in the A HORIZ compartment.

	VERT MODE: Trigger signal automatically follows the vertical display except in CHOP (vertical); then the trigger signal is the same as for ADD.
	LEFT VERT: Trigger signal is obtained from plug-in unit in LEFT VERT compartment.
	RIGHT VERT: Trigger signal is obtained from plug-in unit in RIGHT VERT compartment.
HORIZONTAL MODE	Selects horizontal mode of operation.
	A: Signal from plug-in unit in the A HORIZ compartment is displayed.
	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.
	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.
	B: Signal from plug-in unit in the B HORIZ compartment is displayed.
B TRIGGER SOURCE	Selects source of internal trigger signal for the time-base in the B HORIZ compartment.
	VERT MODE: Trigger signal automatically follows the vertical display except in CHOP (vertical); then trigger signal is the same as for ADD.
	LEFT VERT: Trigger signal is obtained from plug-in unit in LEFT VERT compartment.
	RIGHT VERT: Trigger signal is obtained from plug-in unit in the RIGHT VERT compartment.
VERT TRACE SEPARATION (B)	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.

Calibrator

CALIBRATOR	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).
RATE	Selects the mode and repetition rate of the output from the Calibrator.
	DC (current only): 40 milliampere DC current through current loop. No voltage at CAL connector.
	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.
	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.
	DC (volts only): DC voltage available at CAL connector (amplitude determined by CALIBRATOR switch). No current through 40 mA current loop.

Outputs

+ SAWTOOTH	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.
+ GATE	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.
CAL	Provides positive-going calibrator output when voltage operation is selected (see calibrator RATE).
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 Type 7504 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).

Rear Panel

Line Voltage Selector (not labeled)	Switching assembly to select the nominal operating voltage and the line voltage range. The assembly also includes the line fuses. Voltage Selector: Selects nominal operating voltage range (115 or 230 volts). Range Selector: Selects line voltage range (low, medium, high).
PROBE POWER	Power source for active probe systems.
Z-AXIS INPUTS	Input connector for intensity modulation of the CRT display. HIGH SPEED: Input connector for high-amplitude Z-axis signals; usable over full frequency range of instrument. HIGH SENSITIVITY: Input connector for low-amplitude Z-axis signals; usable for signals with repetition rates of DC to 10 megahertz; input voltage derating necessary between two 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)	Plastic holders on lower corners of 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 Type 7504. 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 SEPARATION (B)	Midrange
B TRIGGER SOURCE	VERT MODE

2. Connect the Type 7504 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 Voltage 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 (rear midrange).

8. Connect the CAL connector to the input connector 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

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 VERTICAL 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 the HORIZONTAL MODE switches and notice the A or B INTENSITY lights; these 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 buttons of the Type 7504 and the plug-in units are illuminated.

31. Change the CONTROL ILLUM switch to the HIGH position. Notice that the selected buttons of the Type 7504 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 this 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 either of the vertical 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 vertical unit and time-base unit which are displayed 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 ÷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 Type 7504 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 ÷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 highter 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 Type 7504. 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 Type 7504. 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.

GENERAL OPERATING INFORMATION

Simplified Operating Instructions

General. The following information is provided to aid in quickly obtaining the correct setting for the Type 7504 to present a display. The operator should be familiar with the complete function and operation of the 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.

TYPE 7504 TEST SETUP CHART

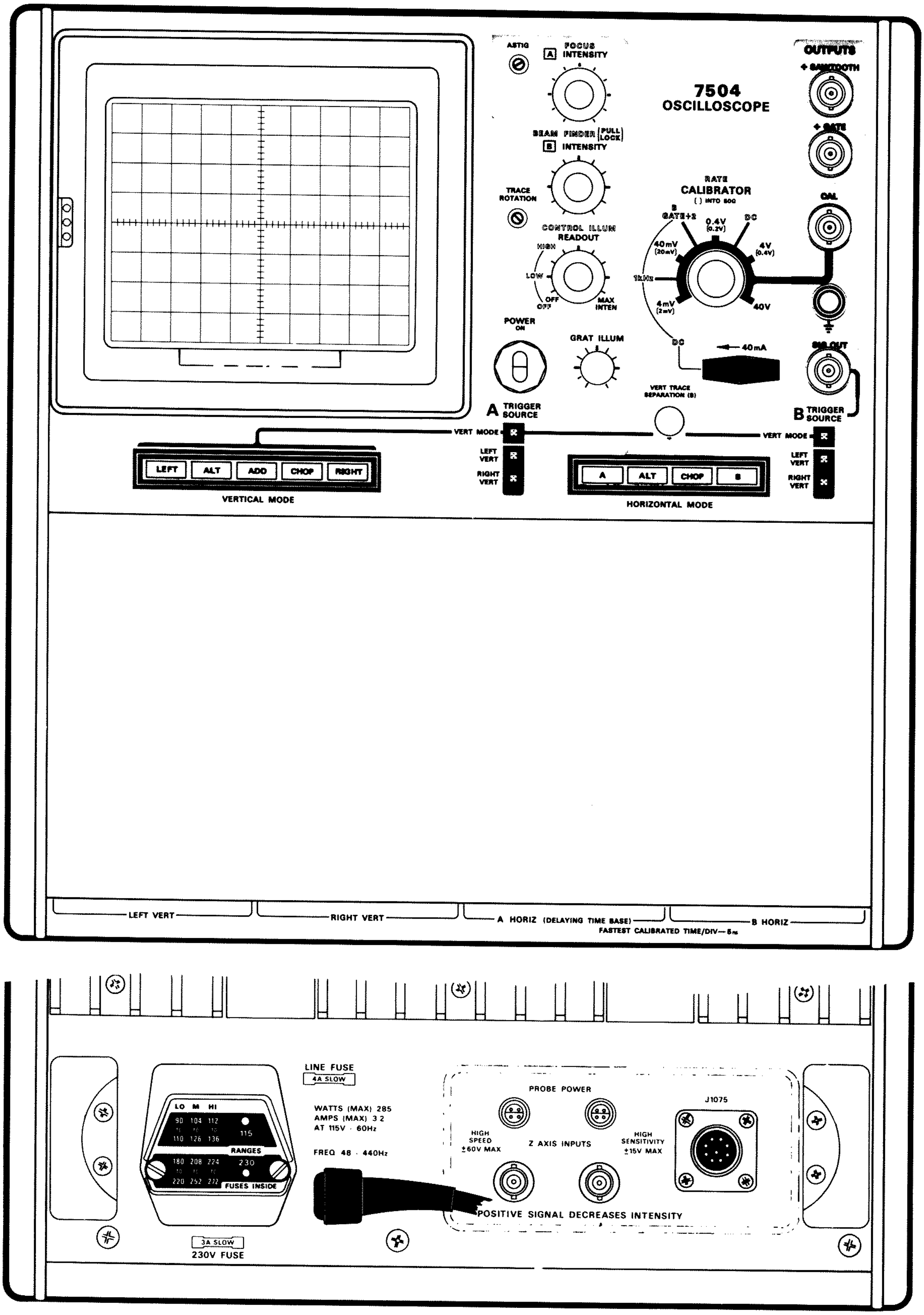


Fig. 2-5.

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 ot 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 Type 7504 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 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 Type 7504 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 Type 7504 and defines the various measurement lines. The terminology defined here will be used in all discussions involving graticule measurements.

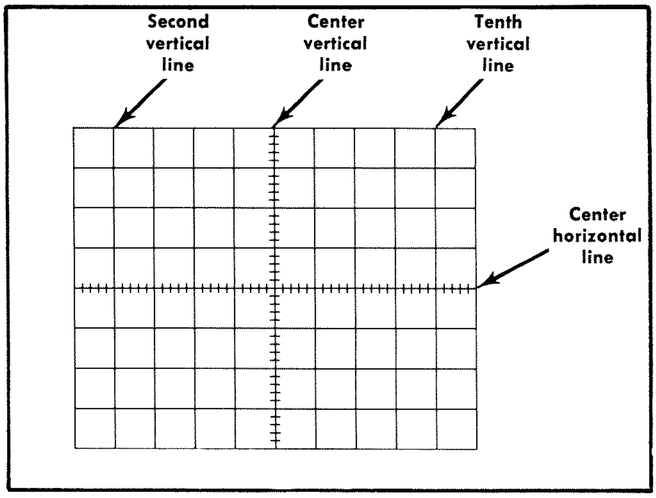


Fig. 2-6. Definition of measurement lines on Type 7504 graticule.

Light Filter

The tinted filter provided with the Type 7504 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 Type 7504. 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. 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 Type 7504. 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 Type 7504 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 Type 7504 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.

Readout

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.

The Readout System of the Type 7504 allows alpha-numeric 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 Type 7504 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 unit and channel (amplifier units only). When the "Identify" button of an amplifier unit is pressed, the word INDENTIFY 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.

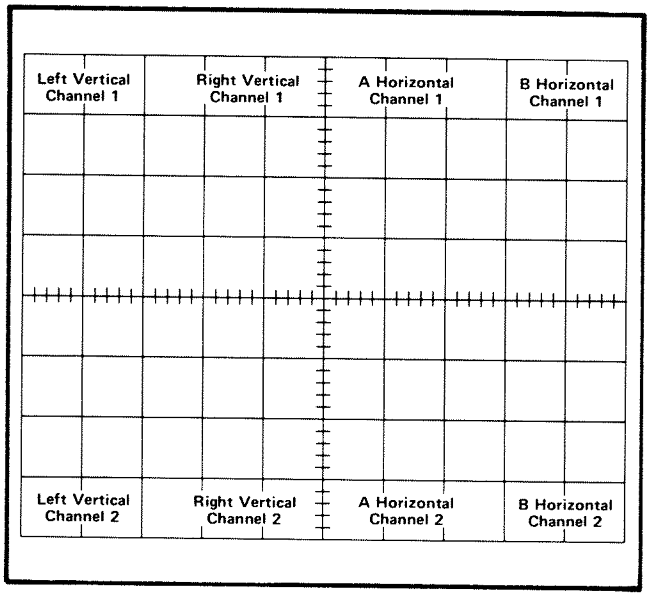


Fig. 2-7. Location of readout on the CRT identifying the originating plug-in and channel.

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 Type 7504 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 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.

TABLE 2-2

Display Combinations[1]

VERTICAL MODE Switch Position	HORIZONTAL MODE Switch Position	Comments
LEFT	A B	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	ALT CHOP	Two traces. Vertical deflection from single unit; horizontal deflection from both units.
ALT	A B	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	ALT 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 B	One trace. Vertical deflection is algebraic summation of both units; horizontal deflection from single unit.
	ALT CHOP	Two traces. Vertical deflection is algebraic summation of both units; horizontal deflection from both units.
CHOP	A B	Two traces. Vertical deflection from both units; horizontal deflection from single unit.
	ALT CHOP	Four traces. Vertical deflection from both units; horizontal deflection from both units.
RIGHT	A B	One trace. Vertical deflection from single unit; horizontal deflection from single unit.
	ALT CHOP	Two traces. Vertical deflection from single unit; horizontal deflection from both units.

[1]Combinations given for single-channel vertical and horizontal units only.

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 Type 7504 is greater than 20:1 at 75 megahertz. The rejection ratio increases to 100:1 at DC.

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 electronixally 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 tor further information. 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 no 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 Type 7504 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 Type 7504. 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 Type 7504 at any time. Order Tektronix Part No. 040-0528-00 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.

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 Type 7504. The following discussions list the use and limitations of each mode.

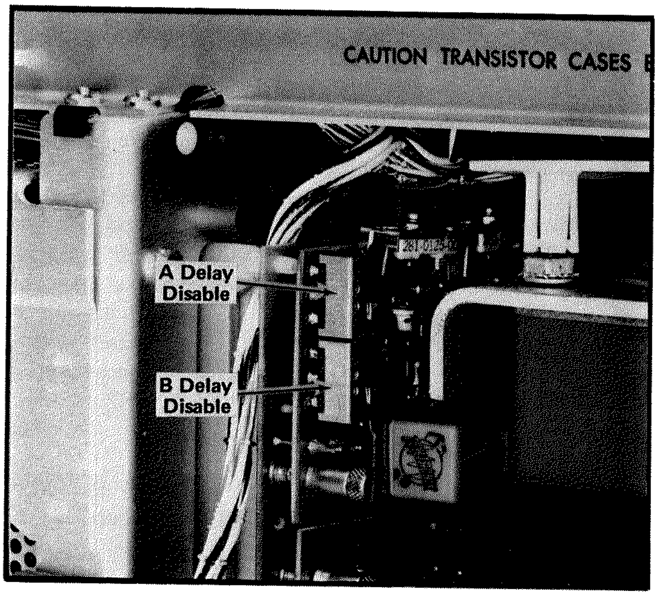


Fig. 2-8. Location of A and B Delay Disable switches (behind right side panel).

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 aplications 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 75 megahertz. Maximum input voltage for signals connected to the HIGH SPEED input is 60 volts (DC plus peak AC). Replace the grounding 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 sawtooth signals. This is accomplished in the Type 7504 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 of the display Complete information on operation using the Z-axis feature is given under Intensity Modulation. This type of raster display could be used to provide a television-type display.

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 Type 7504.

Calibrator

General. The internal calibrator of the Type 7504 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 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 obtained 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 squarewave 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 ÷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. 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 milliampere 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. An 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

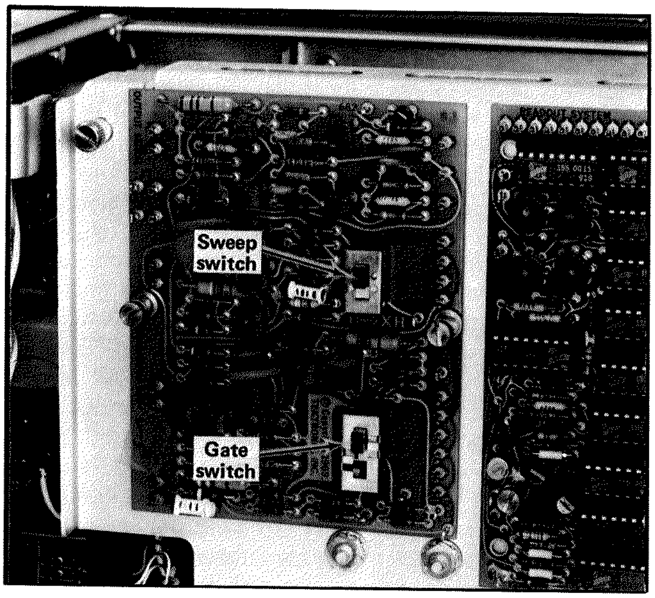


Fig. 2-9. Location of Sweep and Gate switches (behind right side panel).

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 signal 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 of this manual).

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 Type 7504 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

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

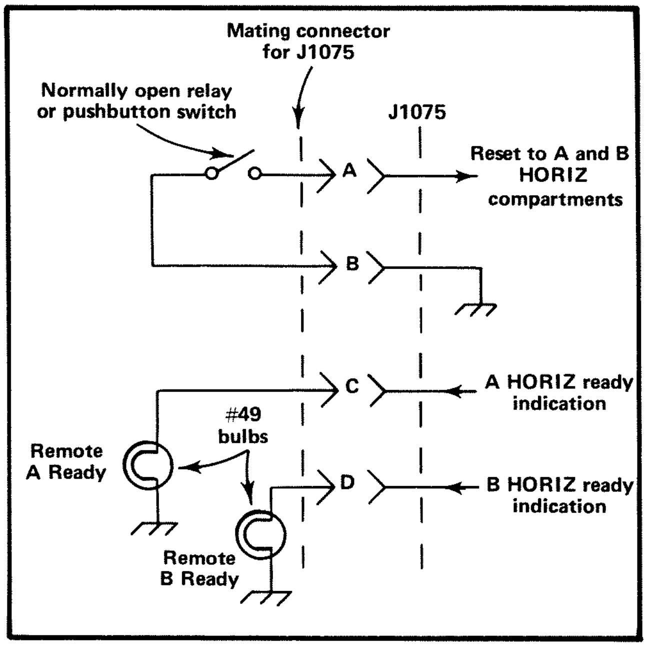


Fig. 2-10. Typical circuit for remote single-sweep reset operation.

(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 Type 7504 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.

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 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.

NOTES

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 Type 7504 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 Type 7504 before the individual circuits are discussed in detail. A basic block diagram of the Type 7504 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 vertical signal selected 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 a readout display.

Horizontal signals for display on the CRT are connected to the X-Y Delay Compensation and Horizontal Interface circuit from both horizontal plug-in compartments. The X-Y Delay Compensation network (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 Interface circuit determines whether the signal from the A and/or B horizontal unit is displayed. The horizontal signal selected by the Horizontal Interface circuit 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 a readout display. The Readout System 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.

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 Type 7504 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 input network for the Z-AXIS INPUTS and the output connectors to supply probe power to active probe systems.

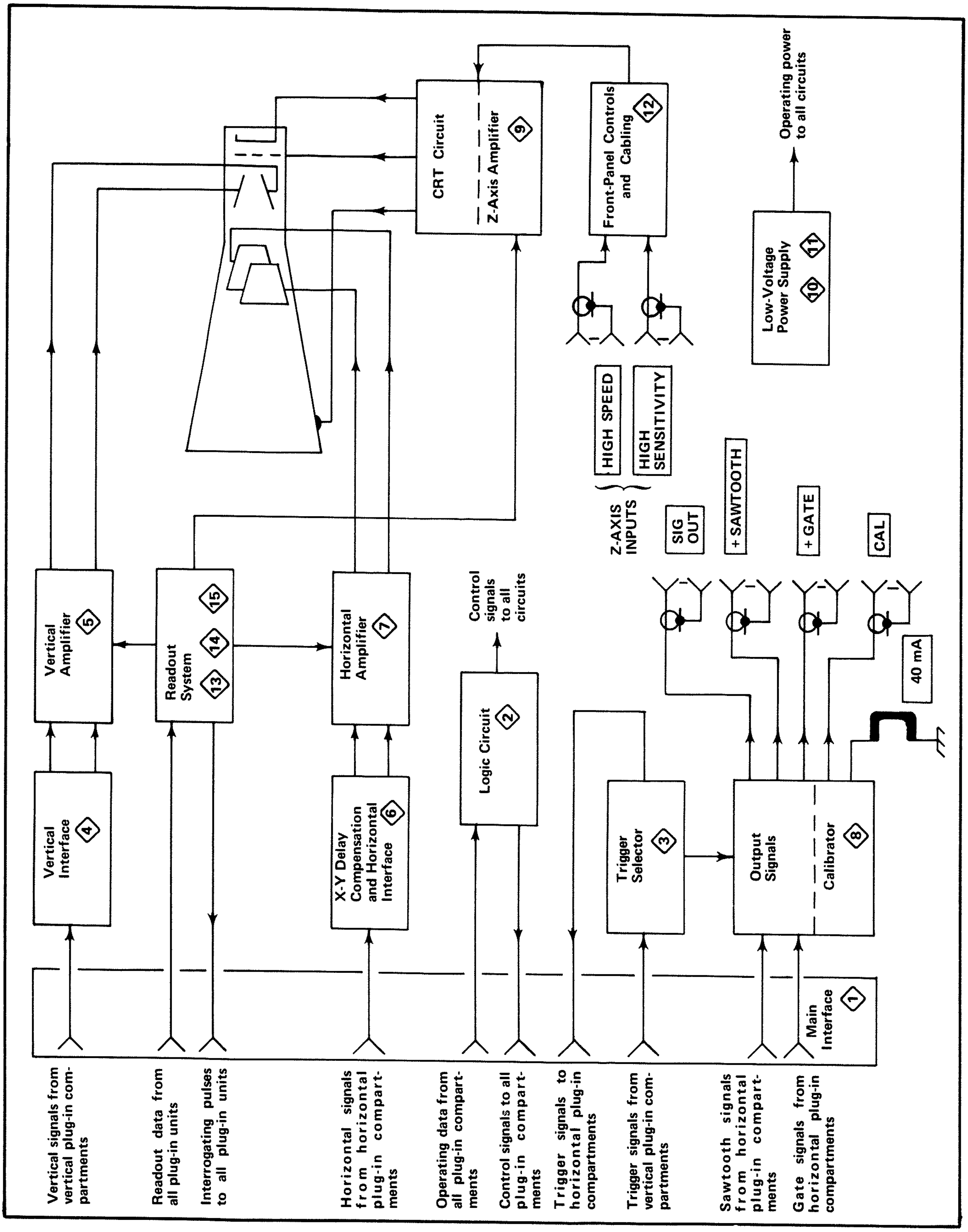


Fig. 3-1. Basic block diagram of the Type 7504 Oscilloscope.

CIRCUIT OPERATION

General

This section provides a detailed description of the electrical operation and relationship of the circuits in the Type 7504. 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 Type 7504 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.

TABLE 3-1

Basic Logic Reference

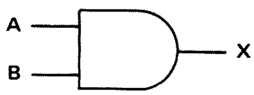
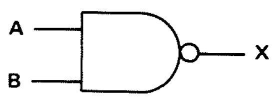
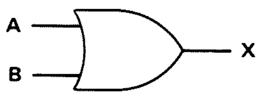
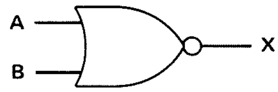
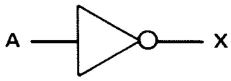
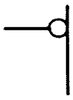
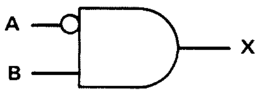
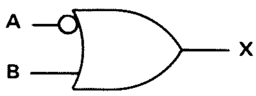
Device	Symbol	Description	Input/Output Table
AND gate		A device with two or more inputs and one output. The output of the AND gate is HI if and only if all of the inputs are at the HI state.	Input: A, B / Output: X LO LO → LO LO HI → LO HI LO → LO HI HI → HI
NAND gate		A device with two or more inputs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

TABLE 3-1 (cont.)

Basic Logic Reference

<table>
<tr><th>Device</th><th>Symbol</th><th>Description</th><th>Input/Output Table</th></tr>
<tr><td>NOR gate</td><td></td><td>A device with two or more inputs and one output. The output of the NOR gate is LO if one or more of the inputs are at the HI state.</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>A</td><td>B</td><td>X</td></tr><tr><td>LO</td><td>LO</td><td>HI</td></tr><tr><td>LO</td><td>HI</td><td>LO</td></tr><tr><td>HI</td><td>LO</td><td>LO</td></tr><tr><td>HI</td><td>HI</td><td>LO</td></tr></table></td></tr>
<tr><td>Inverter</td><td></td><td>A device with one input and one output. The output state is always opposite to the input state.</td><td><table><tr><th>Input</th><th>Output</th></tr><tr><td>A</td><td>X</td></tr><tr><td>LO</td><td>HI</td></tr><tr><td>HI</td><td>LO</td></tr></table></td></tr>
<tr><td rowspan="2">LO-state indicator</td><td>
</td><td>A small circle at the input or output of a symbol indicates that the LO state is the significant state. Absence of the circle indicates that the HI state is the significant state. Two examples follow:

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

The output of this gate is HI if and only if the A input is LO and the B input is HI.</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>A</td><td>B</td><td>X</td></tr><tr><td>LO</td><td>LO</td><td>LO</td></tr><tr><td>LO</td><td>HI</td><td>HI</td></tr><tr><td>HI</td><td>LO</td><td>LO</td></tr><tr><td>HI</td><td>HI</td><td>LO</td></tr></table></td></tr>
<tr><td></td><td>OR gate with LO-state indicator at the A input:

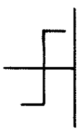
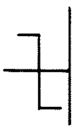
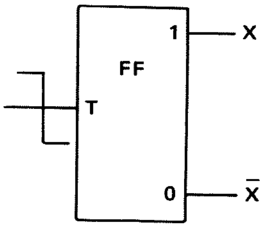
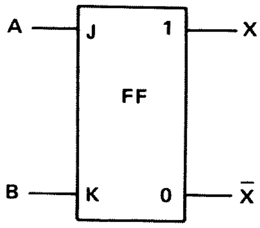
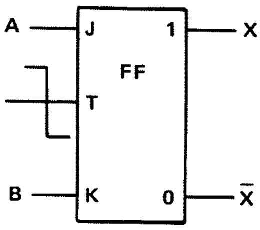
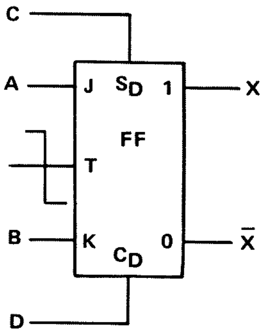
The output of this gate is HI if either the A input is LO or the B input is HI.</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>A</td><td>B</td><td>X</td></tr><tr><td>LO</td><td>LO</td><td>HI</td></tr><tr><td>LO</td><td>HI</td><td>HI</td></tr><tr><td>HI</td><td>LO</td><td>LO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

TABLE 3-1 (cont.)

Basic Logic Reference

<table>
<tr><th>Device</th><th>Symbol</th><th>Description</th><th>Input/Output Table</th></tr>
<tr>
<td>Triggered (toggle) Flip-Flop</td>
<td>
</td>
<td>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.</td>
<td><table>
<tr><th colspan="2">Input</th><th colspan="2">Output</th></tr>
<tr><th colspan="2">Condition before trigger pulse</th><th colspan="2">Condition after trigger pulse</th></tr>
<tr><td>X</td><td>$\overline{X}$</td><td>X</td><td>$\overline{X}$</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></td>
</tr>
<tr>
<td>Set-Clear (J-K) Flip-Flop</td>
<td>
</td>
<td>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).</td>
<td><table>
<tr><th colspan="2">Input</th><th colspan="2">Output</th></tr>
<tr><td>A</td><td>B</td><td>X</td><td>$\overline{X}$</td></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></td>
</tr>
<tr>
<td>Triggered Set-Clear (J-K) Flip-Flop</td>
<td>Without direct inputs


With direct inputs

</td>
<td>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.

For devices with direct-set (S_D) or direct-clear (C_D) inputs, the indicated state at either of these inputs over-rides all other inputs (including trigger) to set the outputs to the states shown in the input/output table.</td>
<td><table>
<tr><th colspan="4">Input</th><th colspan="2">Output</th></tr>
<tr><td>A</td><td>B</td><td>C[1]</td><td>D[1]</td><td>X</td><td>$\overline{X}$</td></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">Changes state</td></tr>
<tr><td colspan="6">Conditions for direct-set, direct-clear operation</td></tr>
<tr><td>Φ</td><td>Φ</td><td>LO</td><td>LO</td><td colspan="2">No change</td></tr>
<tr><td>Φ</td><td>Φ</td><td>LO</td><td>HI</td><td>LO</td><td>HI</td></tr>
<tr><td>Φ</td><td>Φ</td><td>HI</td><td>LO</td><td>HI</td><td>LO</td></tr>
<tr><td>Φ</td><td>Φ</td><td>HI</td><td>HI</td><td colspan="2">Undefined</td></tr>
</table>
Φ = Has no effect in this case

[1] Applies only with direct inputs.</td>
</tr>
</table>

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 Type 7504 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 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.

   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.

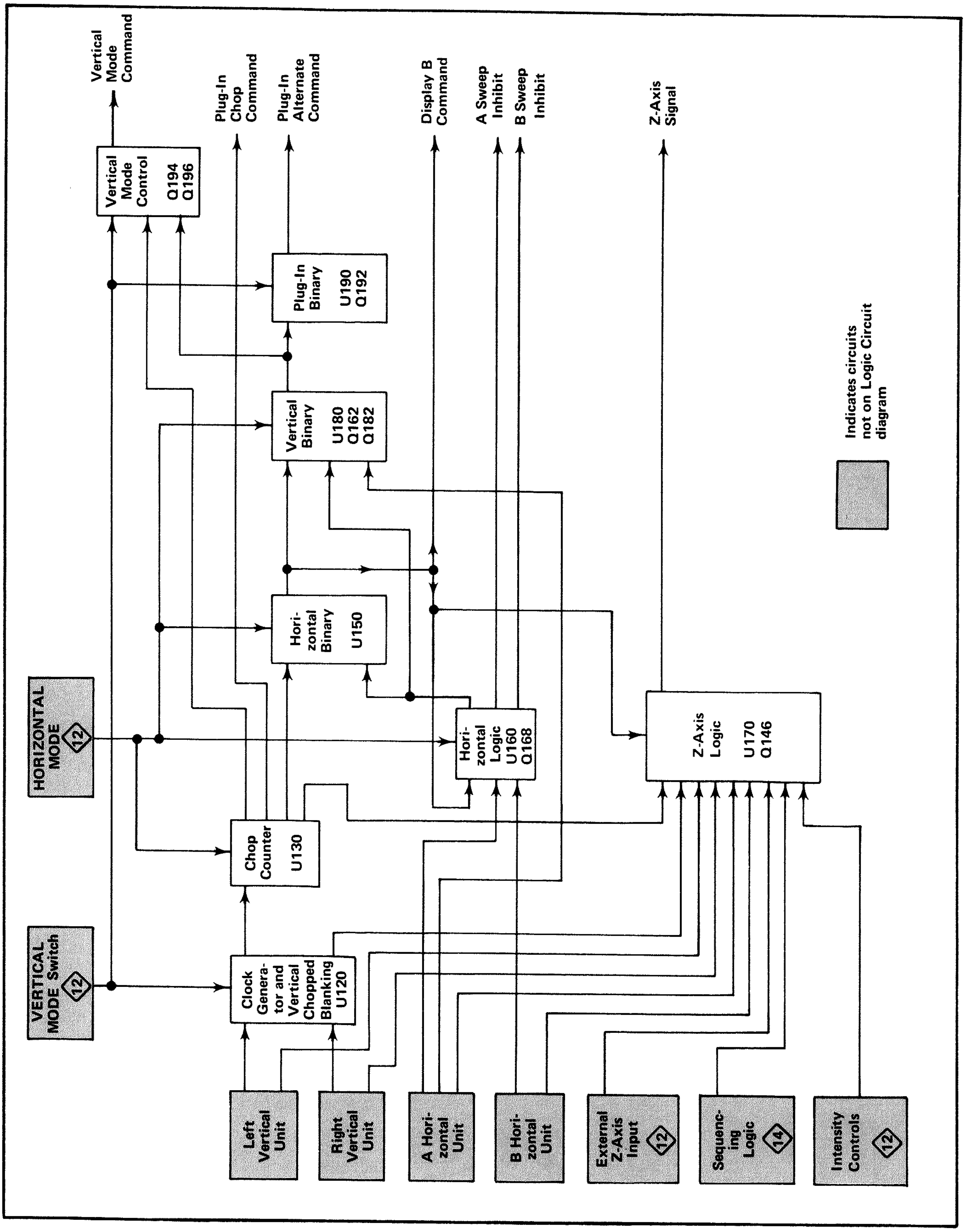


Fig. 3-2. Block diagram of Logic Circuit.

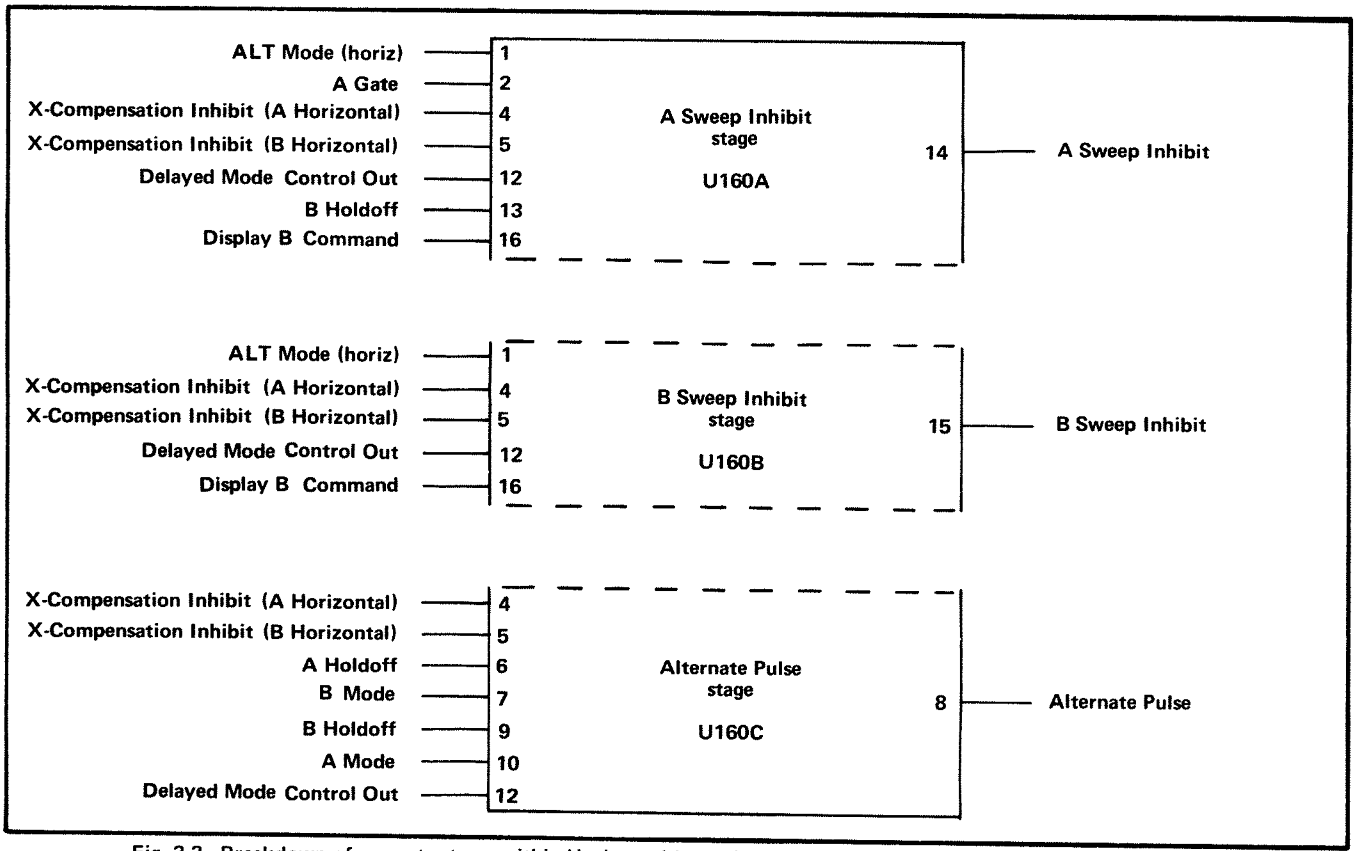
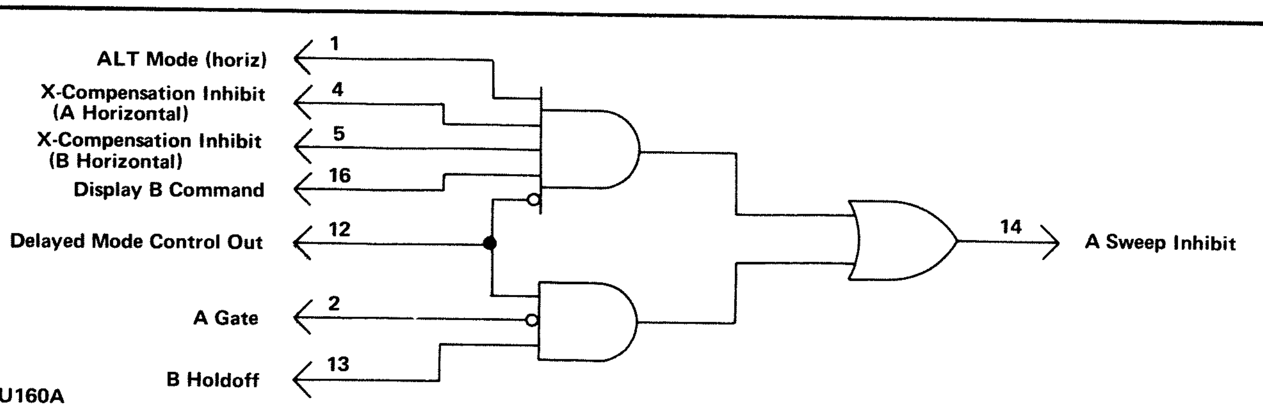


Fig. 3-3. Breakdown of separate stages within Horizontal Logic (U160) showing inputs and outputs for each stage.



(A) U160A

Input: ALT Mode (horiz) 1	A Gate 2	X-Compensation Inhibit (A Horizontal) 4	X-Compensation Inhibit (B Horizontal) 5	Delayed Mode Control Out 12	B Holdoff 13	Display B Command 16	Output: A Sweep Inhibit 14
HI	Φ	HI	HI	LO	Φ	HI	HI
Φ	LO	Φ	Φ	HI	HI	Φ	HI
All other combinations							LO

(B)

Φ = Has no effect in this case

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

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.

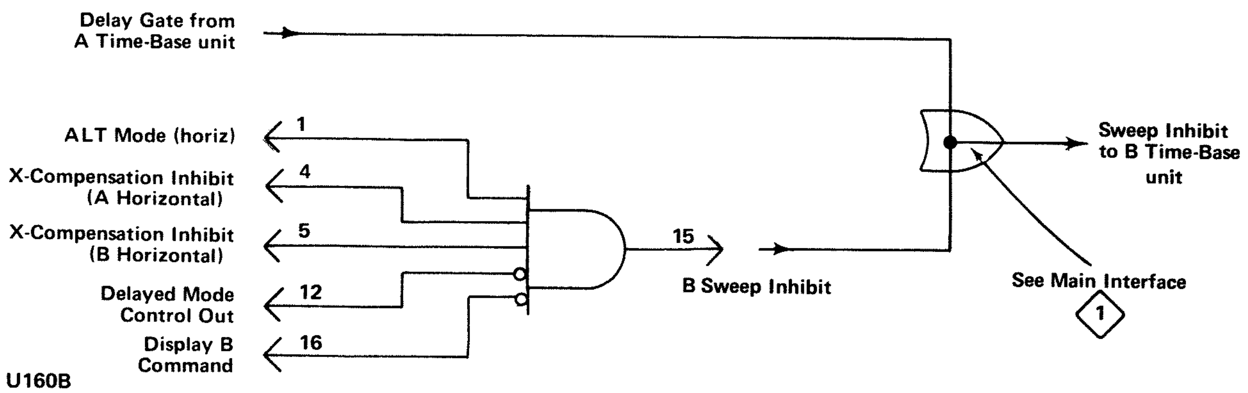
Pin 12 LO—A Time-Base unit in independent (non-delayed) mode.

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

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



(A) U160B

Input					Output
ALT Mode (horiz)	X-Compensation Inhibit (A Horizontal)	X-Compensation Inhibit (B Horizontal)	Delayed Mode Control Out	Display B Command	B Sweep Inhibit
1	4	5	12	16	15
HI	HI	HI	LO	LO	HI
All other combinations					LO

(B)

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

Ⓐ

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.

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[1].

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

Pin 9 HI—Holdoff pulse produced at end of B Sweep[1].

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.

[1]**Simultaneous HI at pins 6 and 9 are not required; a HI at either input produces an Alternate Pulse if other conditions are met.**

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 horizontal 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.

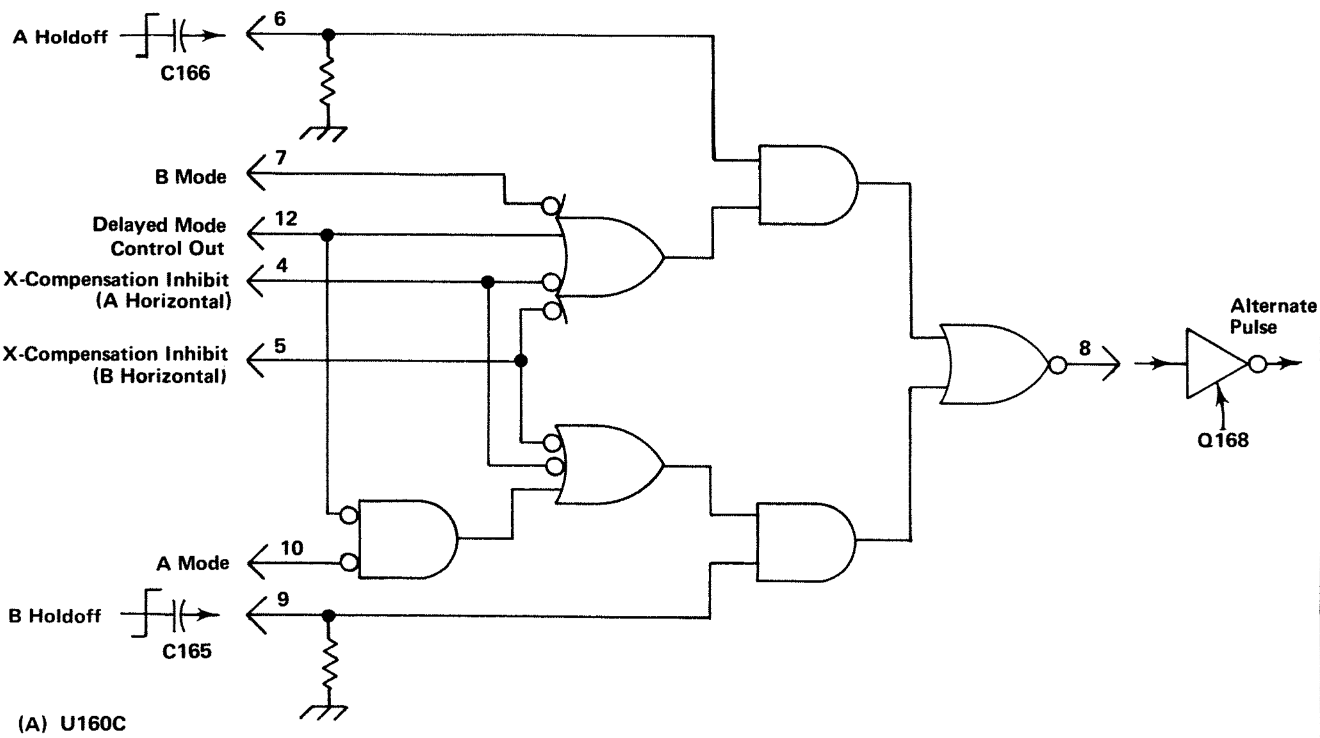
Fig. 3-7 identifies the inputs to the Z-Axis Logic circuit. This circuit is current-driven at all inputs except pins 5 and 15. The current at pins 1, 2, 9 and 16 is variable from 0 to 4 milliamperes and is determined by the applicable current source to control the output current at pin 8.

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 or 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. 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. For conditions that do not require limiting, about 2.5 milliamperes is connected to pins 7 and 9. This current is established by resistors R141-R142-R143-R144-R145-R140-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 display which will be displayed in the delayed mode. The A Intensified current is supplied to pin



(A) U160C

Input							Output	
X-Compensation Inhibit (A Horizontal)	X-Compensation Inhibit (B Horizontal)	A Holdoff	B Mode	B Holdoff	A Mode	Delayed Mode Control Out	Time-Base which is source of Alternate Pulse	
4	5	6	7	9	10	12	8[2]	Horizontal Conditions
HI	Φ	HI[1]	LO	Φ	HI	Φ	A	A only
Φ	HI	Φ	HI	HI[1]	LO	LO	B	B only
HI	HI	HI[1]	LO	HI[1]	LO	LO	A and B	ALT or CHOP
HI	HI	HI[1]	Φ	Φ	Φ	HI	A	A delays B
HI	LO	HI[1]	LO	LO	Φ	Φ	A	A with vertical unit in B compartment.
LO	HI	LO	Φ	HI[1]	LO	LO	B	B with vertical unit in A compartment.
All other combinations							No output pulse (LO at output)	

Φ = Has no effect in this case

[1]Positive-going pulse. Where both A and B Holdoff are required to be HI, a HI at either input produces an Alternate Pulse.

[2]Negative-going pulse.

(B)

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

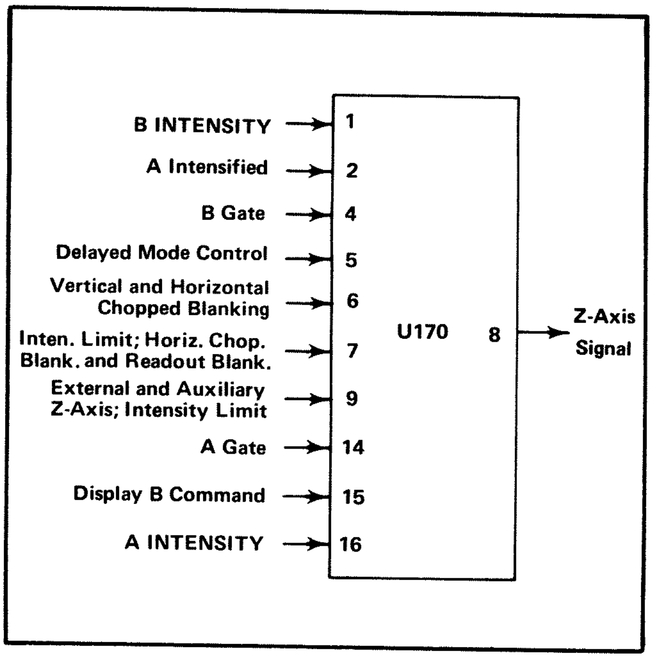


Fig. 3-7. Input and output pins for Z-Axis Logic stage.

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 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 volts 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 3, 4, 7 and 10 are determined by the HORIZONTAL MODE switch (see Front-Panel Controls and Cabling diagram). 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.

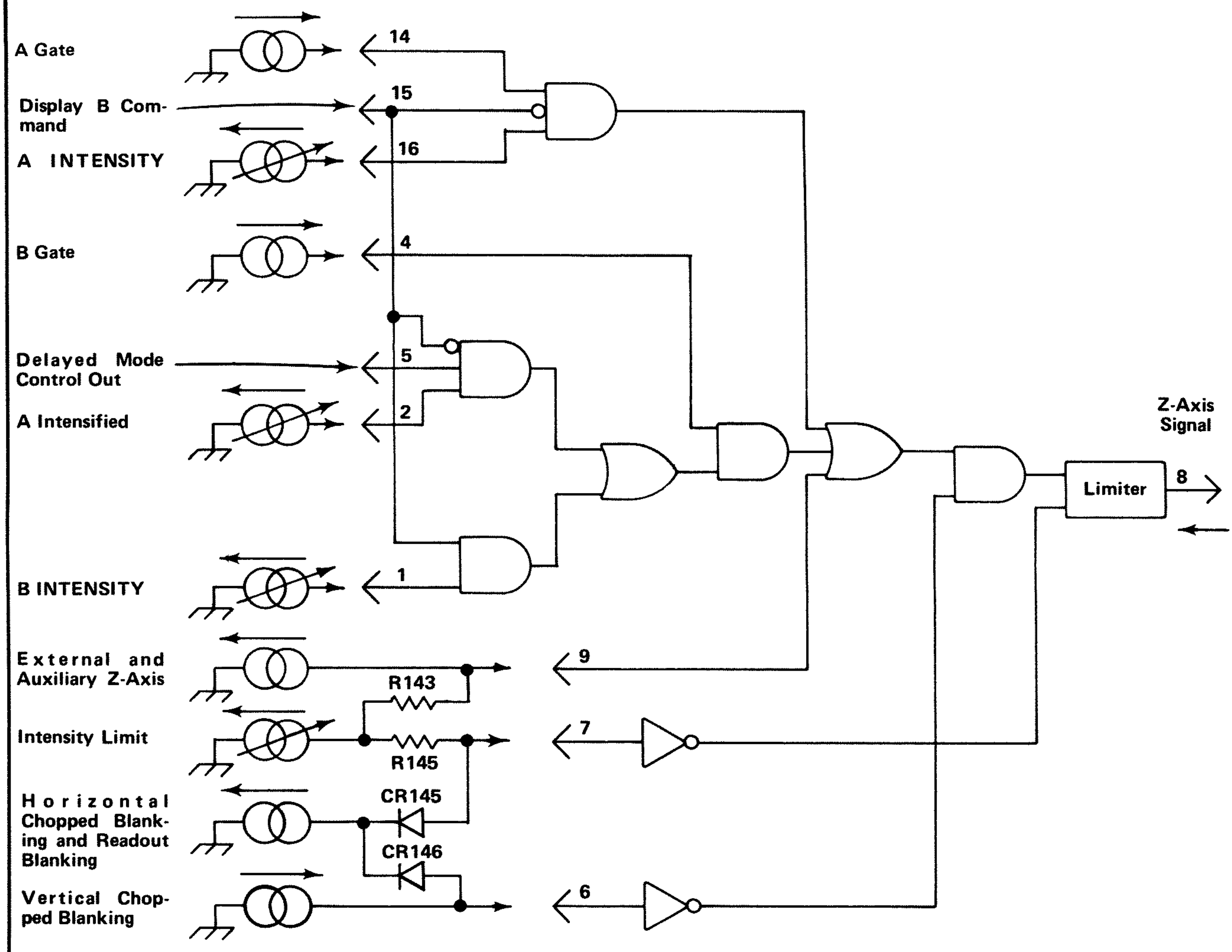
Pin 10 LO—HORIZONTAL MODE switch set to any position except CHOP.

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.



(A)

Input: B INTENSITY 1[1]	A Intensified 2[1]	B Gate 4	Delayed Mode Control Out 5	Vertical and Horizontal Chopped Blanking 6	External and Auxiliary Z Axis 9[1]	A Gate 14	Display B Command 15	A INTENSITY 16[1]	Output: Z-Axis Signal 8[1]	Current source controlling Z-Axis Signal
Φ	Φ	Φ	LO	HI	Φ[2]	HI	LO	HI	HI	A INTENSITY
HI	Φ	HI	Φ	HI	Φ[2]	Φ	HI	Φ	HI	B INTENSITY
Φ	HI	HI	HI	HI	Φ[2]	HI	LO	HI	HI	A INTENSITY and A Intensified
Φ	Φ	Φ	Φ	HI	HI	Φ	Φ	Φ	HI	External signal
All other combinations									LO	No output signal

LO = Minimum voltage or 0 mA current.

HI = Maximum voltage or maximum current.

Φ = Has no effect in this case

[1] Current level. LO = 0 mA
HI = Variable from 0 to 4 mA

[2] Current can be added or subtracted for intensity modulation.

(B)

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

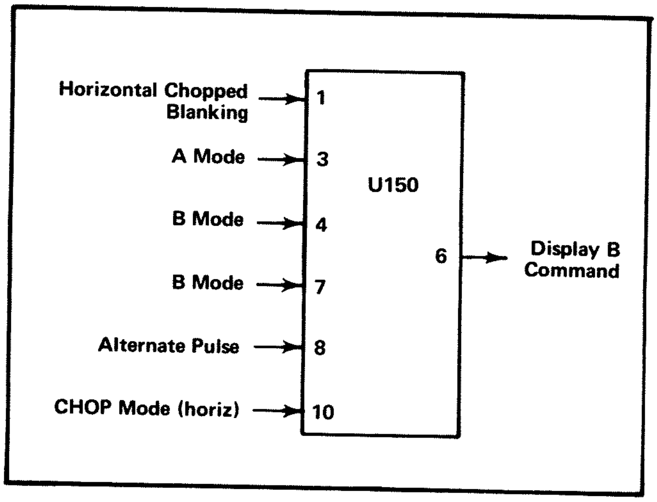


Fig. 3-9. Input and output pins for Horizontal Binary stage.

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). 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-going portion of the Alternate Pulse is received from the Horizontal Logic stage. Repetition rate of the Display B Command in this mode is one-half the repetition rate of the Alternate Pulse. 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.

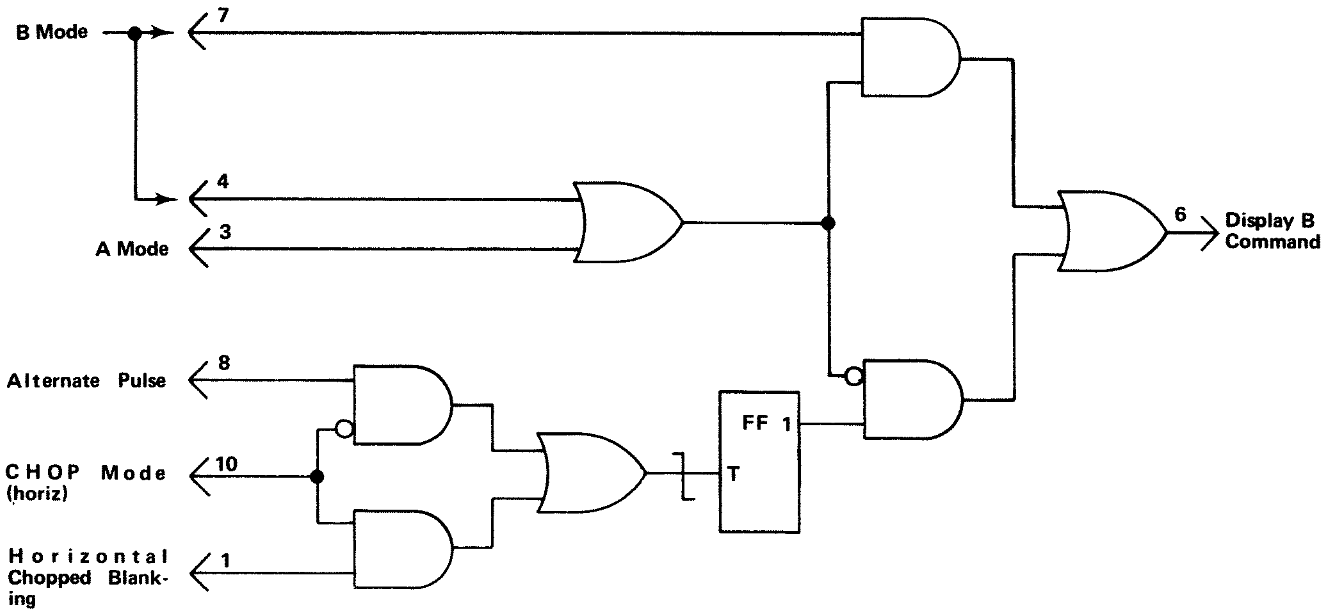
Vertical Binary

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 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 of the Vertical Mode Logic stage in this section for further information.



(A) U150

Input						Output	
Horizontal Chopped Blanking	A Mode	B Mode	B Mode	Alternate Pulse	CHOP Mode (horiz)	Display B Command	
1	3	4	7	8	10	6	Horizontal Display
Φ	HI	LO	LO	Φ	LO	LO	A Horizontal unit
Φ	LO	HI	HI	Φ	LO	HI	B Horizontal unit
LO[1]	LO	LO	LO	Φ	HI	n+1[2]	Chop between A and B
Φ	LO	LO	LO	LO[1]	LO	n+1[3]	Alternate between A and B

Φ = Has no effect in this case

n+1 = If output is LO prior to LO[1], it goes HI, and vice versa

[1]Actuated by negative-going edge.

[2]Repetition rate one-half Horizontal Chopped Blanking rate.

(B) [3]Repetition rate one-half Alternate Pulse rate.

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

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.

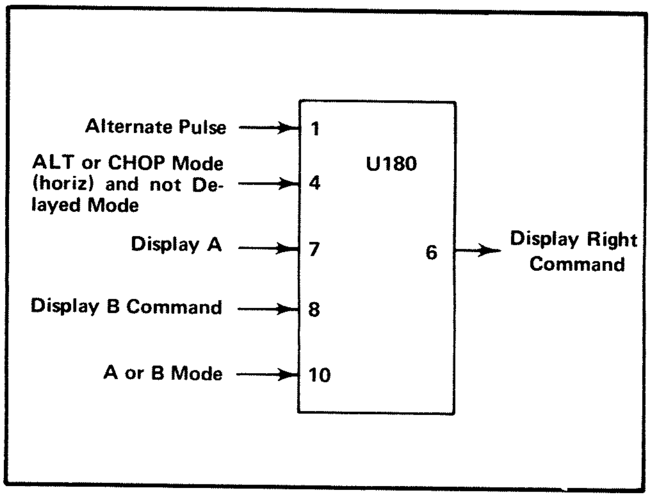


Fig. 3-11. Input and output pins for Vertical Binary stage.

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.

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.

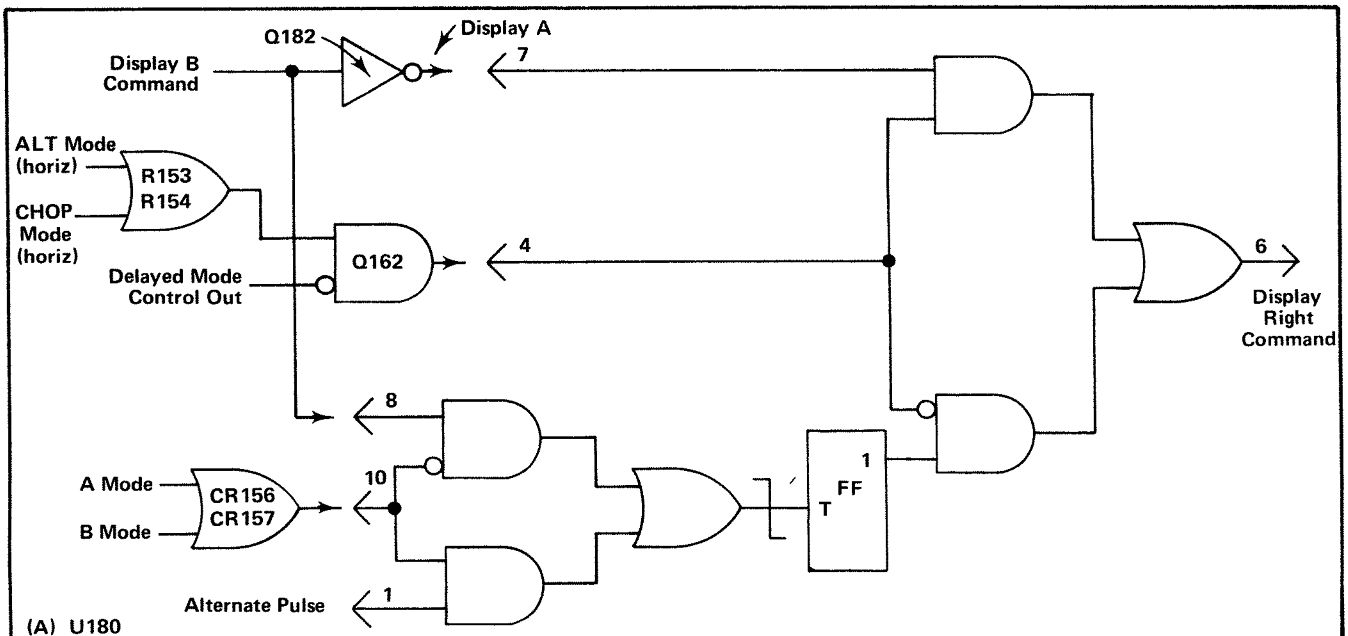
Pin 10 LO—HORIZONTAL MODE switch set to any position except A or B.

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 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



(A) U180

Input: Alternate Pulse 1	Input: ALT or CHOP Mode (horiz) and not Delayed Mode 4	Input: Display A 7	Input: Display B Command 8	Input: A or B Mode 10	Output: Display Right Command 6	Horizontal Mode
LO[1]	LO	Φ	Φ	HI	n+1[2]	A or B
Φ	HI	HI	LO	LO	HI	Display Right } ALT or CHOP, Non-delayed Mode (Sweep-slaving)
Φ	HI	LO	HI	LO	LO	Display Left } ALT or CHOP, Non-delayed Mode (Sweep-slaving)
Φ	LO	Φ	LO[1]	LO	n+1[3]	ALT or CHOP, Delayed Mode

Φ = Has no effect in this case.

n+1 = If output is LO prior to LO[1] it goes HI, and vice versa.

[1] Actuated by negative-going edge.

[2] Repetition rate one-half Alternate Pulse rate.

[3] Repetition rate one-half Display B rate.

(B)

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

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.

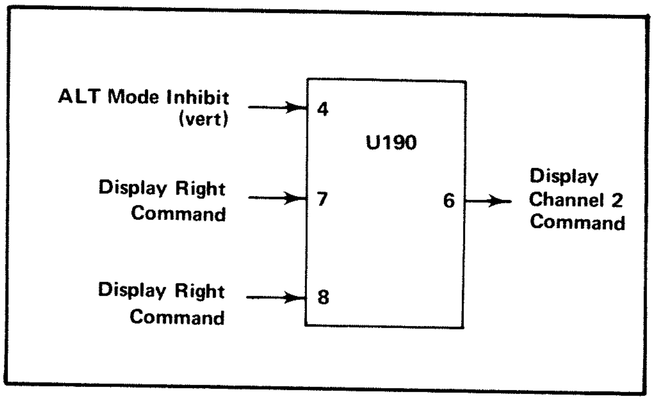
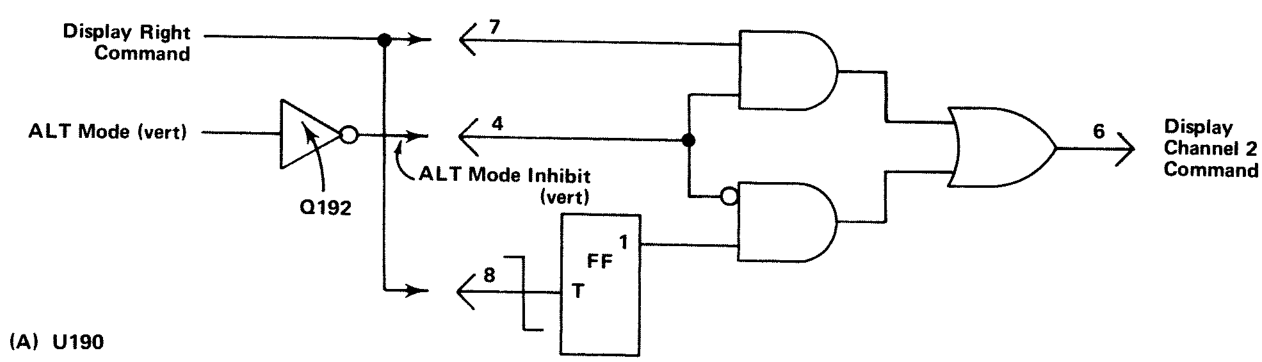


Fig. 3-13. Input and output pins for Plug-In Binary stage.

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



(A) U190

Input			Output	
ALT Mode Inhibit (vert) 4	Display Right Command 7	Display Right Command 8	Display Channel 2 Command 6	Comments
LO	Φ	LO[1]	n+1[2]	ALT Vertical Mode
HI	LO	Φ	LO	Channel 1 displayed } All vertical modes except ALT, provides sweep-slaving for non-delayed dual-sweep operation.
HI	HI	Φ	HI	Channel 2 displayed }

Φ = Has no effect in this case.

n+1 = If output is LO prior to LO[1] it goes HI, and vice versa.

[1]Actuated by negative-going edge.

(B) [2]Repetition rate one-half Display Right Command rate.

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

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 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 volts 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

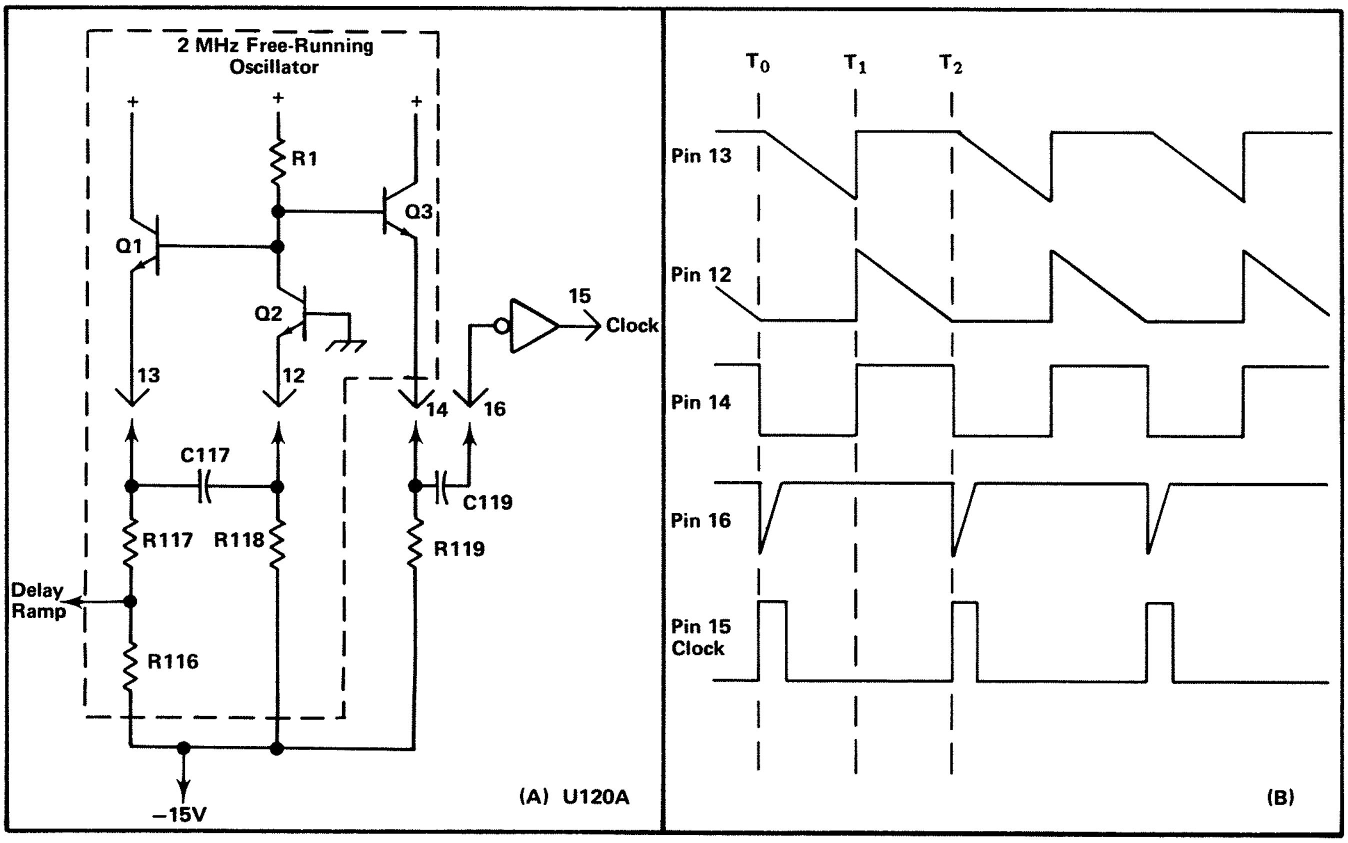


Fig. 3-15. (A) Diagram of Clock Generator stage, (B) Idealized waveforms for Clock Generator stage.

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 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

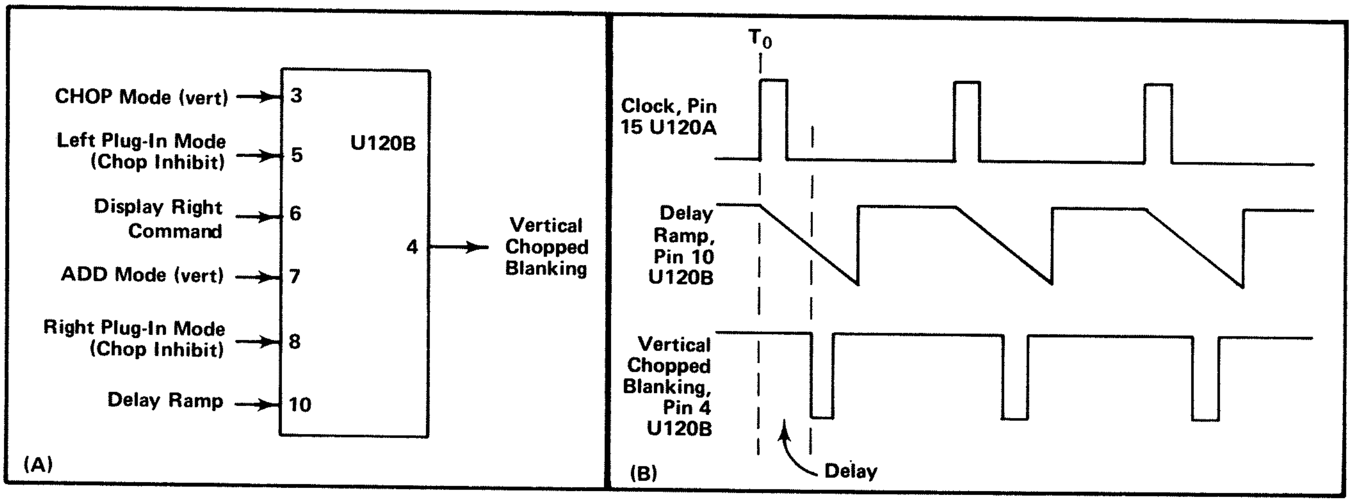


Fig. 3-16. (A) Input and output pins for Vertical Chopped Blanking stage, (B) Idealized waveforms for Vertical Chopped Blanking stage.

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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 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.

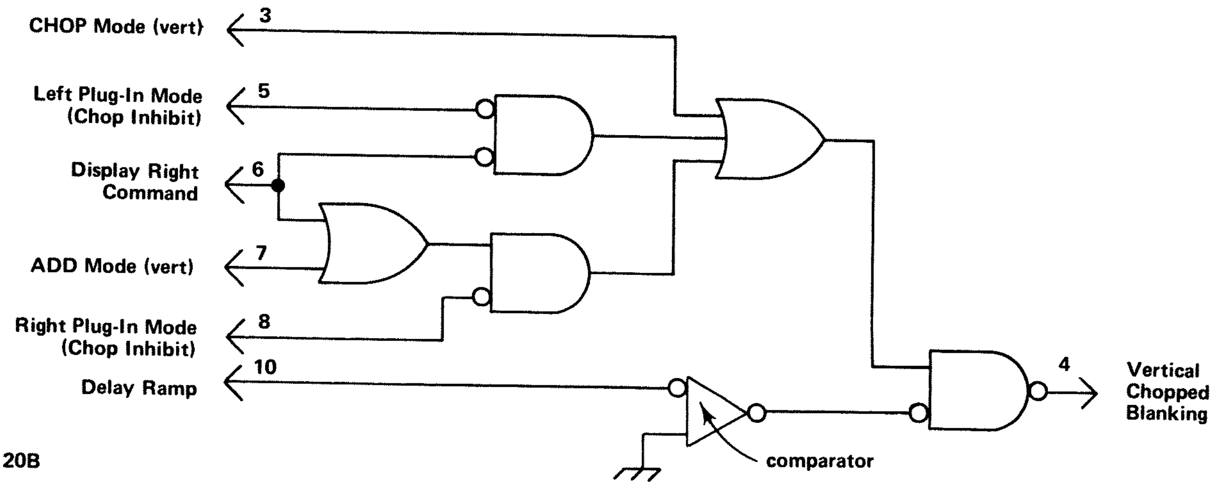
Pin 8 LO—Right Vertical unit set to chopped mode (can be HI if pin 5 is LO).

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 function 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.



(A) U120B

Input						Output	
CHOP Mode (vert)	Left Plug-In Mode (Chop Inhibit)	Display Right Command	Add Mode (vert)	Right Plug-In Mode (Chop Inhibit)	Delay Ramp	Vertical Chopped Blanking	
3	5	6	7	8	10[1]	4[2]	Conditions
HI	Φ	Φ	LO	Φ	LO	LO	CHOP Mode (vert)
LO	LO	LO	LO	Φ	LO	LO	Left Plug-in Chopped
LO	Φ	HI	LO	LO	LO	LO	Right Plug-in Chopped
LO	LO[3]	Φ	HI	LO[3]	LO	LO	ADD Mode, Left or Right Plug-in Chopped
All other combinations						HI	No Vertical Chopped Blanking pulses at output.

Φ = Has no effect in this case.

[1] Ramp signal; considered LO when more negative than about zero volts.

[2] Negative-going pulse at two megahertz rate.

[3] Pin 5 can be HI and not affect operation if pin 8 is LO, and vice versa.

(B)

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

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 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

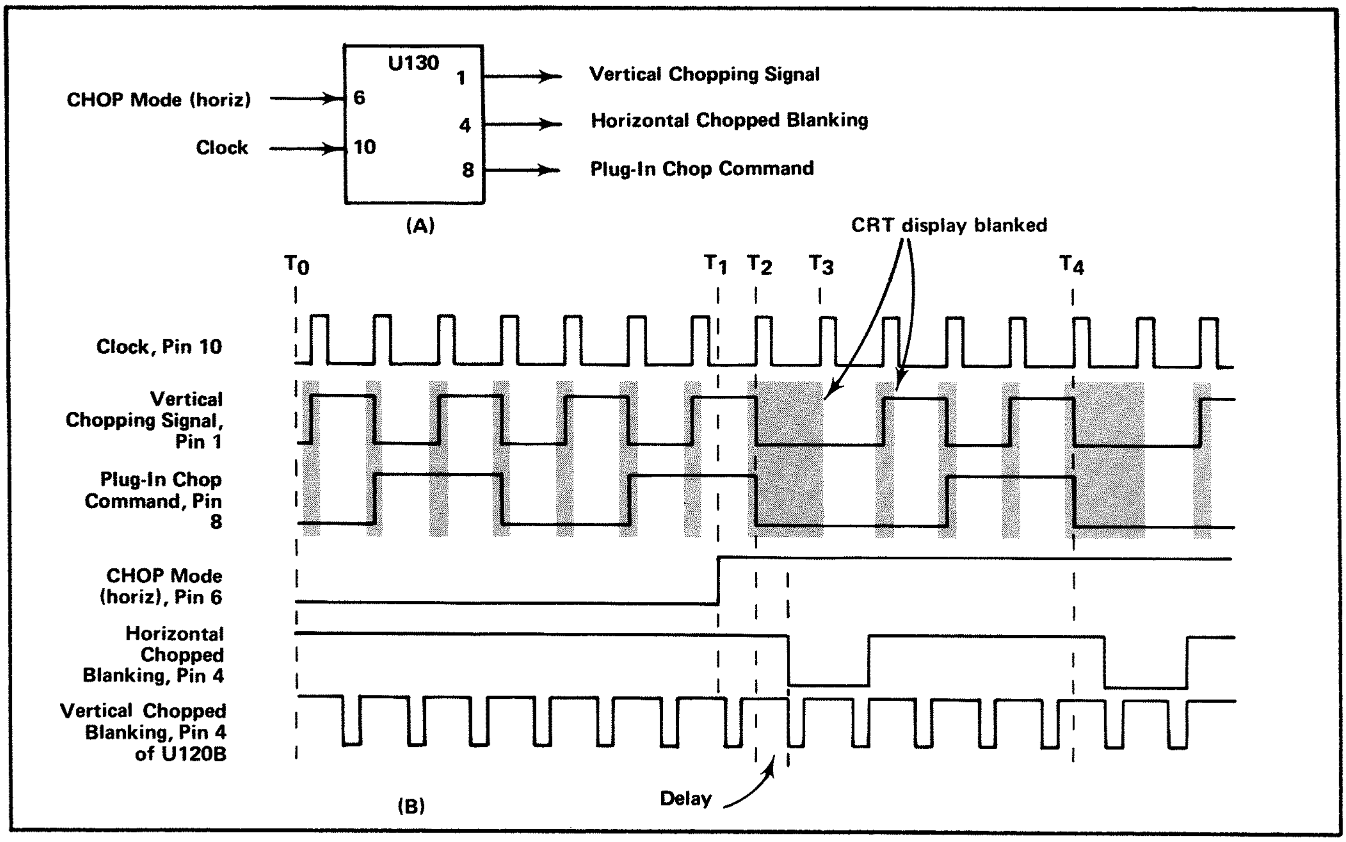


Fig. 3-18. (A) Input and output pins for Chop Counter stage, (B) Idealized waveforms for Chop Counter stage.

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 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_3 changes only the Horizontal Chopped Blanking output at pin 4. The level on this pin goes HI after the delay time to unblank the CRT.

For the next three 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_4) both outputs are again at their HI level. The fourth Clock pulse at T_4 switches the output at pin 1, pin 8, and pin 4 (after delay) to the LO level to start the next cycle. Notice that a Horizontal Chopped Blanking pulse is produced at pin 4 with every fifth Clock pulse. Also notice that with the HORIZONTAL MODE switch set to CHOP, two complete cycles of the Vertical Chopping Signal are produced with each five Clock pulses (repetition rate two-fifths Clock rate) and one complete cycle of the Plug-In Chop Command for every five Clock pulses (one-fifth Clock rate). Notice that the large shaded area produced by the Horizontal Chopped Blanking pulse (see Fig. 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. 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.

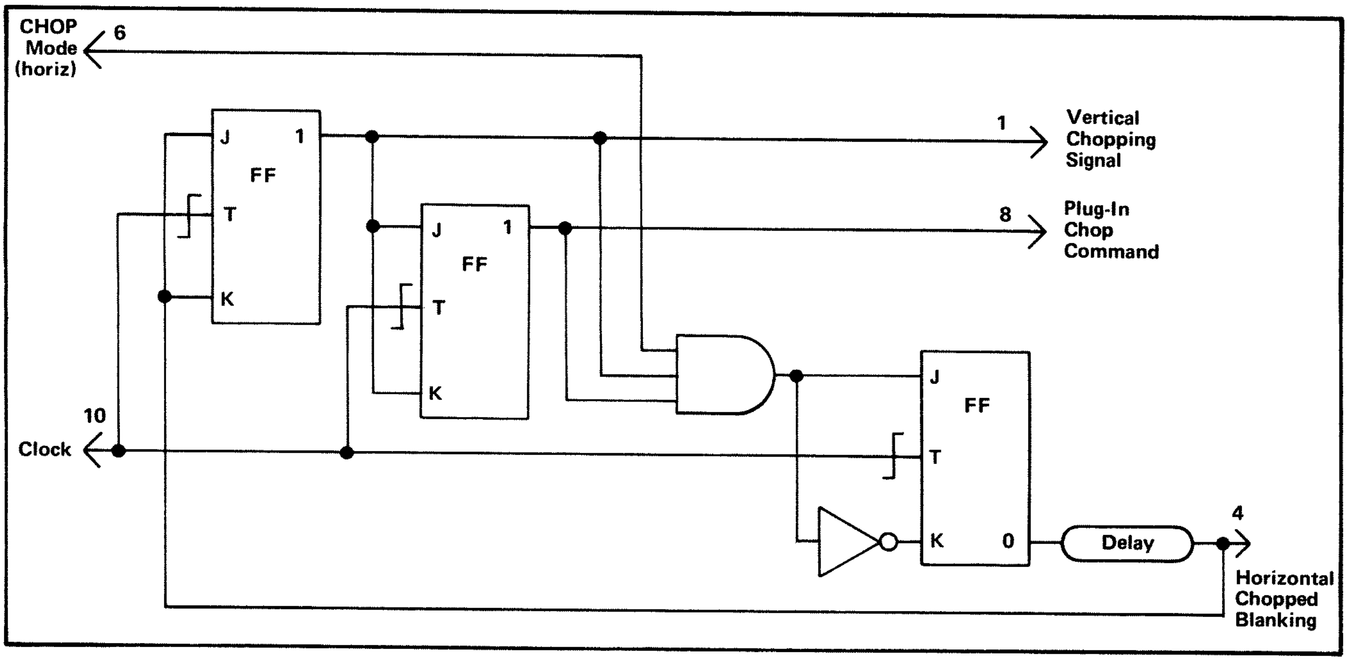


Fig. 3-19. Logic diagram of Chop Counter stage.

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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 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).

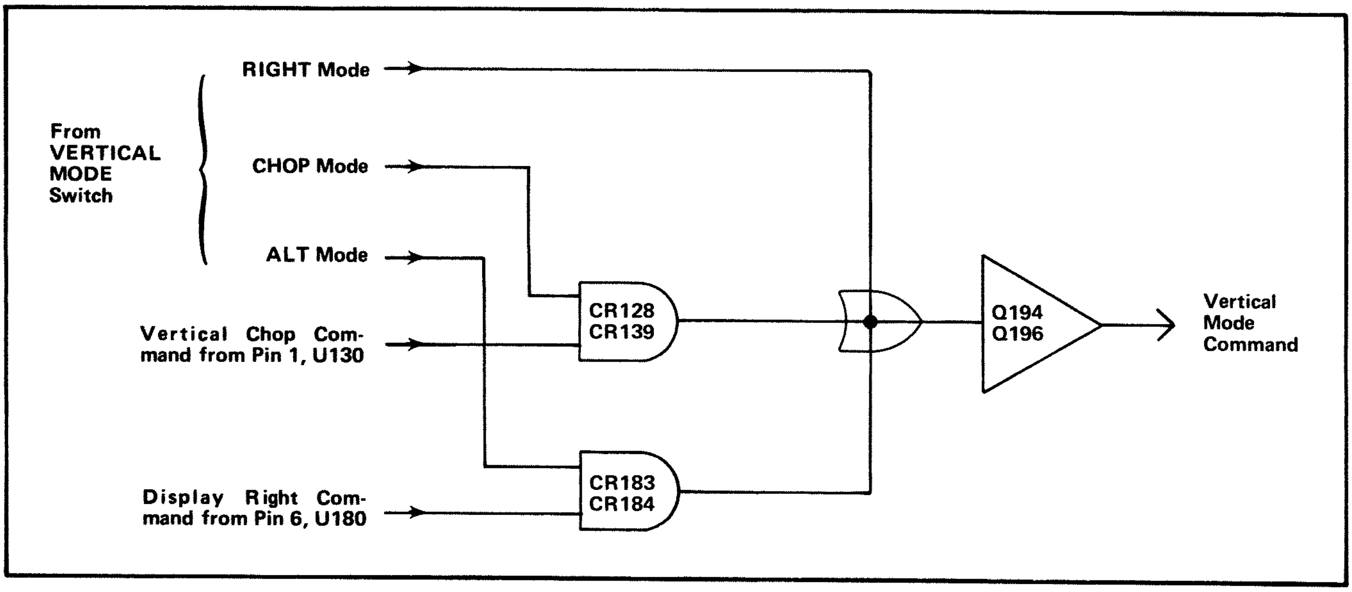

Fig. 3-20. Logic diagram of Vertical Mode Logic stage.

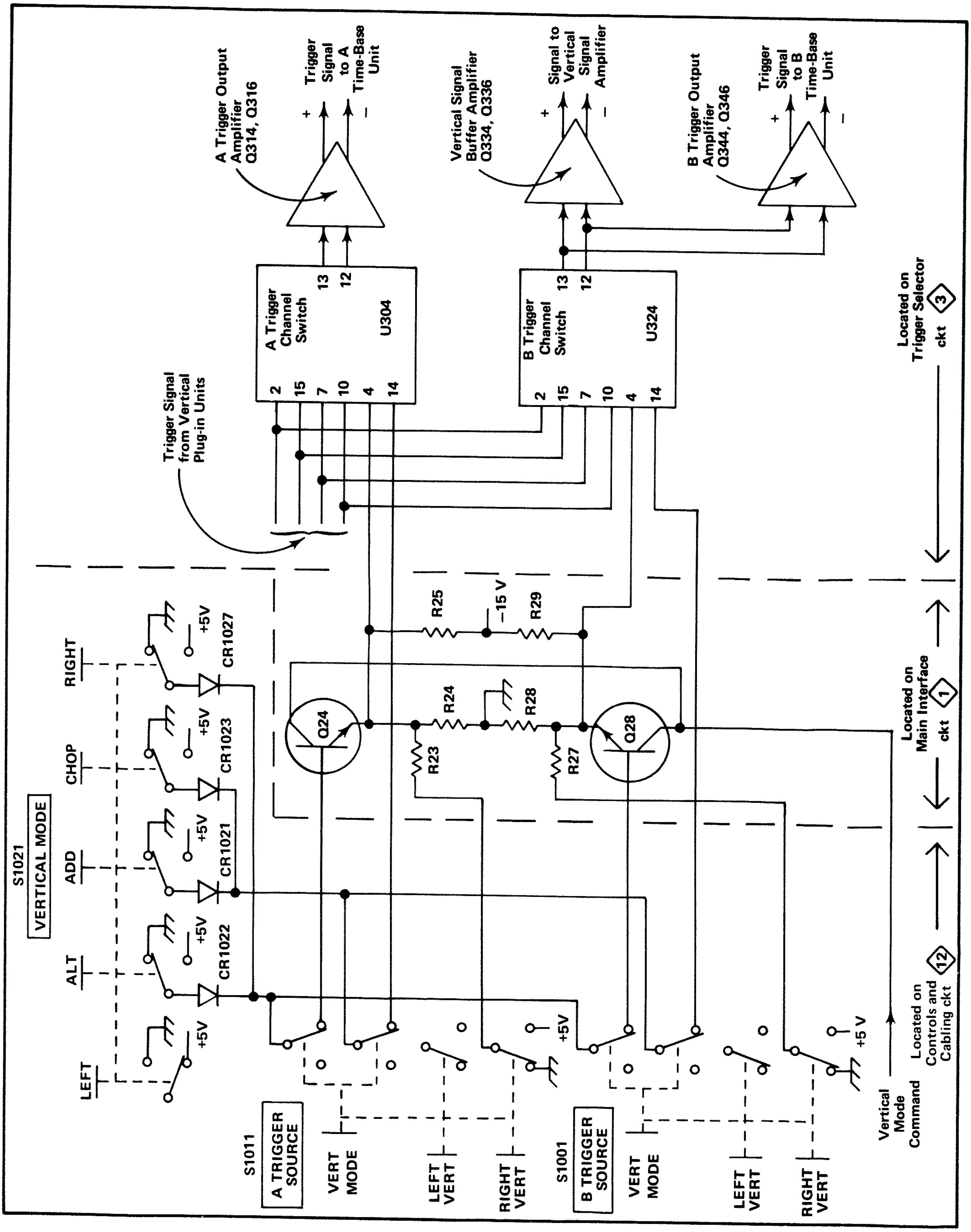

Fig. 3-21. Simplified schematic of trigger selector circuitry.

A and B TRIGGER SOURCE switch positions →

VERTICAL MODE switch positions	VERT MODE	LEFT VERT	RIGHT VERT
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[1] (both; added algebraically)	LO (Left Vertical)	HI (Right Vertical)
CHOP			
RIGHT	HI (Right Vertical)		

[1]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).

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 command from the Logic Circuit applied in 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 command 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 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 command 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 VERTICAL MODE switch, the level at pin 4 switches between the LO and HI level at a rate

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

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

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.

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 unit 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 following circuits. 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 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 includes an input from the Readout System to block the vertical signal while readout information is displayed on the CRT. 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 Channel Switch

The Vertical Channel Switch determines which input signal provides the vertical signal to the Delay-Line Driver stage as controlled by the Vertical Mode Command from the Logic Circuit. Resistors R201-R202 and R203-R204 establish the input resistance of this stage and provide a load for the Left and Right Vertical units. Resistors R209-R210-R211 and R217-R218-R219 establish the operating levels for this stage. R209-R211 and R217-R219 set the current gain for each channel. C207-R207 and C214-R214 provide frequency compensation.

This stage is made up primarily of integrated circuit U214, which is the same type as used for the Trigger Channel Switches. An input/output table for U214 is

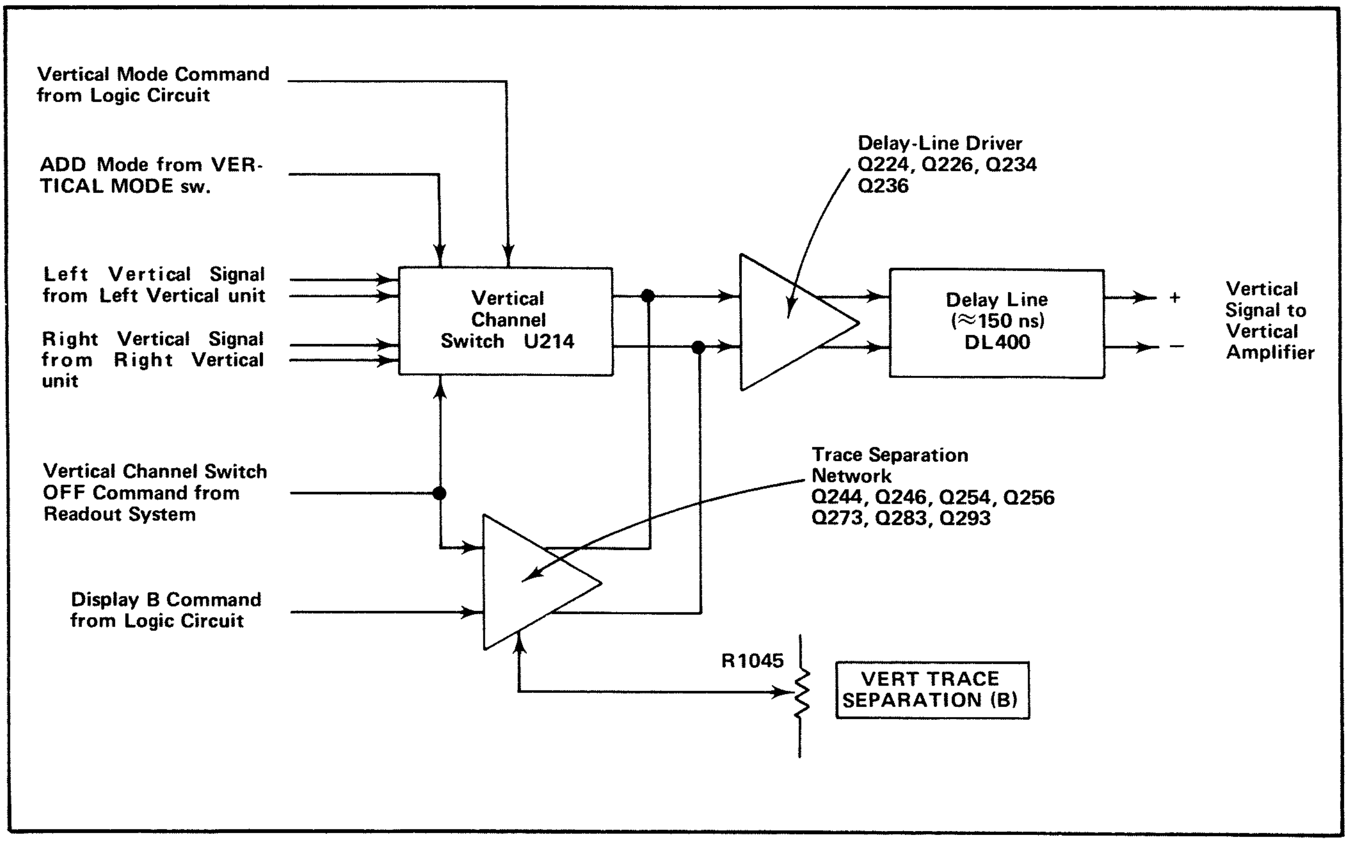

Fig. 3-24. Vertical Interface detailed block diagram.

shown in Fig. 3-25. U214 provides a high-impedance differential input for the signal from the Left Vertical unit at pins 2 and 15 and the signal from the Right Vertical unit at pins 7 and 10. The output signal at pins 12 and 13 is a differential signal which is connected to the Delay-Line Driver stage through R221-R222. 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 following stage as the VERTICAL MODE switch is changed.

When the VERTICAL MODE switch is set to LEFT, the level at pin 4 is LO. This level allows the signal from the Left Vertical unit to pass to the output while the signal from the Right Vertical unit is blocked. In the RIGHT position of the VERTICAL MODE switch, the level at pin 4 is HI. Now, the signal from the Right Vertical unit is connected to the output while the signal from the Left Vertical unit is blocked.

When the VERTICAL MODE switch is set to either ALT or CHOP, the Vertical Mode Command at pin 4 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 Signal 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 level is applied to pin 14 and the level at pin 4 is LO as determined by the

Input: Vertical Mode Command	Input: ADD Mode (Vert)	Input: Vertical Channel Switch OFF	Output: Output signal
4	14	6	12, 13
LO	LO	LO	Left vertical signal
HI	LO	LO	Right vertical signal
LO	HI	LO	Both (added algebraically)
Φ	Φ	HI	Neither (blocked by Readout System)

Φ = Has no effect in this case

Fig. 3-25. Input/output table for Vertical Channel Switch.

Vertical Mode Control stage in the Logic Circuit. This allows both the Right and Left Vertical signals to pass to the output pins. Now, the signal from both vertical units is algebraically added and the resultant signal determines the vertical deflection.

The Vertical Channel Switch OFF signal 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 vertical 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 vertical units so there is no signal output from this stage under this condition.

Trace Separation Network

The Trace Separation Network 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 conduction of Q244-Q246-Q254-Q256 through Q273 and Q283. When the B Sweep is being displayed (for ALT or CHOP horizontal operation), the Display B Command is HI to forward bias Q273. This provides a constant current, determined by R281, to Q254 and Q256. The amount of current through each of these transistors is determined by the VERT TRACE SEPARATION (B) control, R1045. This control varies the voltage at the base of Q254 through R14 and R257. The level set at the base of Q254 changes the current flow through Q244-Q254, and since Q273 is supplying a constant current, it changes the current through Q246-Q256 also. The output current at the collectors of Q244-Q246 is connected to the emitters of Q224-Q226 in the Delay-Line Driver stage to offset the B Sweep display up to about four divisions from 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), Q273 is reverse biased and there is no current through Q254 and Q256. Instead, the current from R281 flows through Q283 to the base circuits of Q244 and Q246 to establish the vertical position of the A Sweep display. Q254 and Q256 are now by-passed so the VERT TRACE SEPARATION (B) control is effectively 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 Q283 through R291. This raises the emitter of Q273 positive enough so that it remains reverse biased even though the Display B Command at its base is HI for this mode. The current through R281 bypasses Q254 and Q256 so the VERT TRACE SEPARATION (B) control again has no effect. The Vertical Channel Switch OFF signal from the Readout System is applied to the base of Q293. Q293 is quiescently conducting through R293 and CR293 to hold CR292 reverse biased. When the Readout System is ready to display readout information, the Vertical Channel Switch OFF signal goes HI resulting in a HI level at the anode of CR293. This forward biases CR292 and allows current from R293 to forward bias Q283 and reverse bias Q273. The Trace Separation Network is disabled (as well as the Vertical Channel Switch) so the Readout System has full control of the trace position (see Readout System description for more information).

Delay-Line Driver

Output of the Vertical Channel Switch stage, along with any positioning current from the Trace Separation Network, is connected to the emitters of Q224-Q226. These transistors are connected as common-base amplifiers to provide a low-impedance current-summing point. The signal at the collectors of Q224-Q226 is connected to the bases of Q234-Q236 through R224 and R225. When the trace is at center screen, diodes CR233-CR234 in the emitter circuits of Q234-Q236 are slightly forward biased by the positive voltage applied to their anodes through R228. As the emitter of either Q234 or Q236 goes positive due to the applied signal at their bases, the corresponding diode is reverse biased and its internal resistance increases. This change in resistance produces a decrease in the gain of this stage for large signals, which compensates for the inherent expansion characteristic of the CRT. Output signal from the Delay-Line Driver stage is connected to the Delay Line through T236. This transformer prevents high-frequency common-mode oscillation of Q234-Q236. R236 provides the reverse termination for the Delay Line.

Delay Line

The Delay Line DL400 provides approximately 150 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.

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 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.

Buffer Amplifier

The Buffer Amplifier stage, Q404-Q406, provides a low input impedance for the Vertical Amplifier circuit to permit accurate Delay Line termination. C401-R401, C407-R407 and C400, along with the input resistance of this stage, provide the forward termination for the Delay Line. Collector current for the Delay-Line Driver stage in the Vertical Interface circuit is provided from this stage. The Centering adjustment R405 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 stage are at the same potential. R406 adjusts the thermal balance of the Vertical Amplifier circuit by varying the emitter current of Q404-Q406. The output signal from the Buffer Amplifier stage is connected to the First Push-Pull Amplifier stage through C411-R411 and C412-R412.

First Push-Pull Amplifier

Q424-Q444 and Q426-Q446 are connected as a push-pull cascode amplifier stage. The Vertical Gain adjustment R415 sets the resistance between the bases of Q424 and Q426 to control the current gain of Q424-Q426. This adjustment sets the overall gain of the vertical deflection system. Thermistors RT423-RT424 and varactors CR431-CR432 provide high-frequency temperature compensation for the Vertical Amplifier circuit. As the internal temperature of the instrument rises, the resistance of RT423-RT424 decreases to reduce the reverse bias on CR431-CR432. This increases the capacitance of varactors CR431-CR432 to change the emitter compensation of Q424-Q426 to maintain high-frequency response at high temperatures. The network C434-C435-C436-C437-C439-R434-R435-R436-R437-R439 provide high-frequency compensation. C435-R435 in this network are adjustable to provide high-frequency delay-line compensation. C434-R434 provide high-frequency response adjustment for this stage. The output signals at the collectors of Q424-Q426 are connected to the common-base transistors Q444-Q446 through C428-R428-R441 and C429-R429-R442. The low input re-

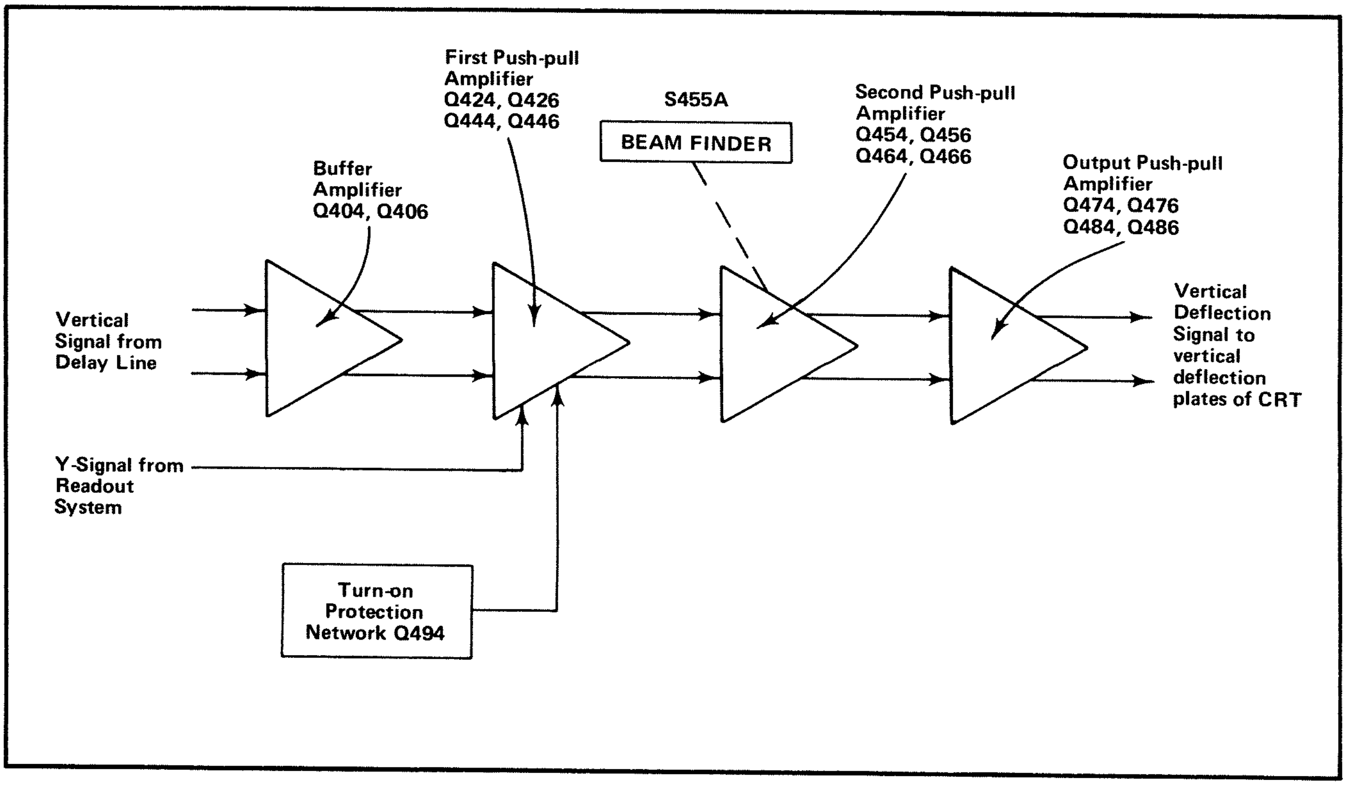

Fig. 3-26. Vertical Amplifier detailed block diagram.

sistance of the Q444-Q446 common-base transistors allows this stage to provide maximum high-frequency performance.

Q494 and its associated components provide a positioning voltage to deflect the CRT beam upward, off the display area when the instrument is turned on to protect the CRT phosphor from damage due to a high-intensity spot on the display area. When this instrument is turned off, C491 quickly discharges through CR491. Then, when the instrument is turned back on, C491 begins to charge toward −15 volts through R491 since CR491 is reverse biased. While C491 is charging, Q494 is forward biased, and it conducts current away from Q446 through CR493. This current-shunting deflects the display off the viewing area vertically until the high-voltage circuits reach their full operating capabilities. As C491 continues to charge, the collector level of Q494 rises positive until CR493 is reverse biased, which disconnects the Turn-on Protection Network from the Emitter circuit of Q446.

For readout displays, the Y-signal from the Readout System is connected to the emitter of Q446 through R494. Since the signal from the vertical units is blocked in the Vertical Channel Switch under this condition (see Vertical Interface discussion), the readout signal provides the only vertical deflection. Although this signal is connected to the emitter of Q446 as a single-ended signal, it is converted to a push-pull signal by the cross-coupling networks in the following stages.

Second Push-Pull Amplifier

The Second Push-Pull Amplifier, Q454-Q464 and Q456-Q466, 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. L447-R446 in the base circuit and C450 in the emitter circuit of Q454-Q456 provide high-frequency compensation for the Vertical Amplifier circuit.

Normally, the emitter current for Q454-Q456 is supplied through parallel paths; S455A-L454-C454 and R454. When S455A is pressed in, the current source through L454 is interrupted and the only emitter-current source for Q454-Q456 is through R454. This limits the dynamic range of this stage by limiting its current, so the display is compressed vertically within the graticule area. At the same time, −15 volts is connected to the emitters of Q464-Q466 through R461-R462 to maintain the same DC currents in the following stages as when the BEAM FINDER switch is in the normal position. 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.

Output Push-pull Amplifier

The collector signals from Q464-Q466 are connected to the bases of Q474-Q476 in the Output Push-pull Amplifier through L474-L476. These inductors provide series peaking for the very high-frequency components of the vertical signal. Q474-Q484 and Q476-Q486 operate in the same manner as the previous stages. The output signals at the collectors of Q484-Q486 provide the vertical deflection signal for the CRT. RC networks C484-R484 and C486-R486 in the base circuits of Q484-Q486 and LR networks LR486-LR487 prevent oscillation of the output transistors. Diode CR485 provides protection for the output transistors by disconnecting the base circuit of Q484-Q486 from the +15-volt supply if it is shorted to ground or to a negative supply. R475-R477 also provide protection for these transistors by providing a small current source to the emitters of Q484-Q486 to prevent them from turning off completely if no current is supplied from the previous transistors. Additional high-frequency compensation for this stage is provided by variable inductor L485.

X-Y DELAY COMPENSATION and HORIZONTAL INTERFACE

General

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 Interface 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 Interface circuit without delay.

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. Diodes CR50 and CR70 shunt the voltage produced across the relays when the actuating level is removed. 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. LR networks L51-R51 and L61-R61 along with capacitors C53 and C55 provide a constant input impedance. The LC network comprised 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 Interface circuit 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 Interface circuit.

Horizontal Channel Switch

The Horizontal Channel Switch determines which input signal provides horizontal signal to the Horizontal Amplifier circuit as controlled by the Display B Command from the Logic Circuit. Resistors R371-R372 and R373-R374 establish the input resistance of this stage and provide a load for the A and B Horizontal units. Resistors R384-R385-R386 and R391-R392-R393 establish the operating levels for this stage. R384-R385 and R391-R392 set the current gain for each channel. C381-R381 and C388-R388 provide frequency compensation. Thermistors RT383 and RT390 provide a constant gain for this stage as the ambient temperature changes.

This stage is made up primarily of integrated circuit U384 which is the same type as used for the Trigger

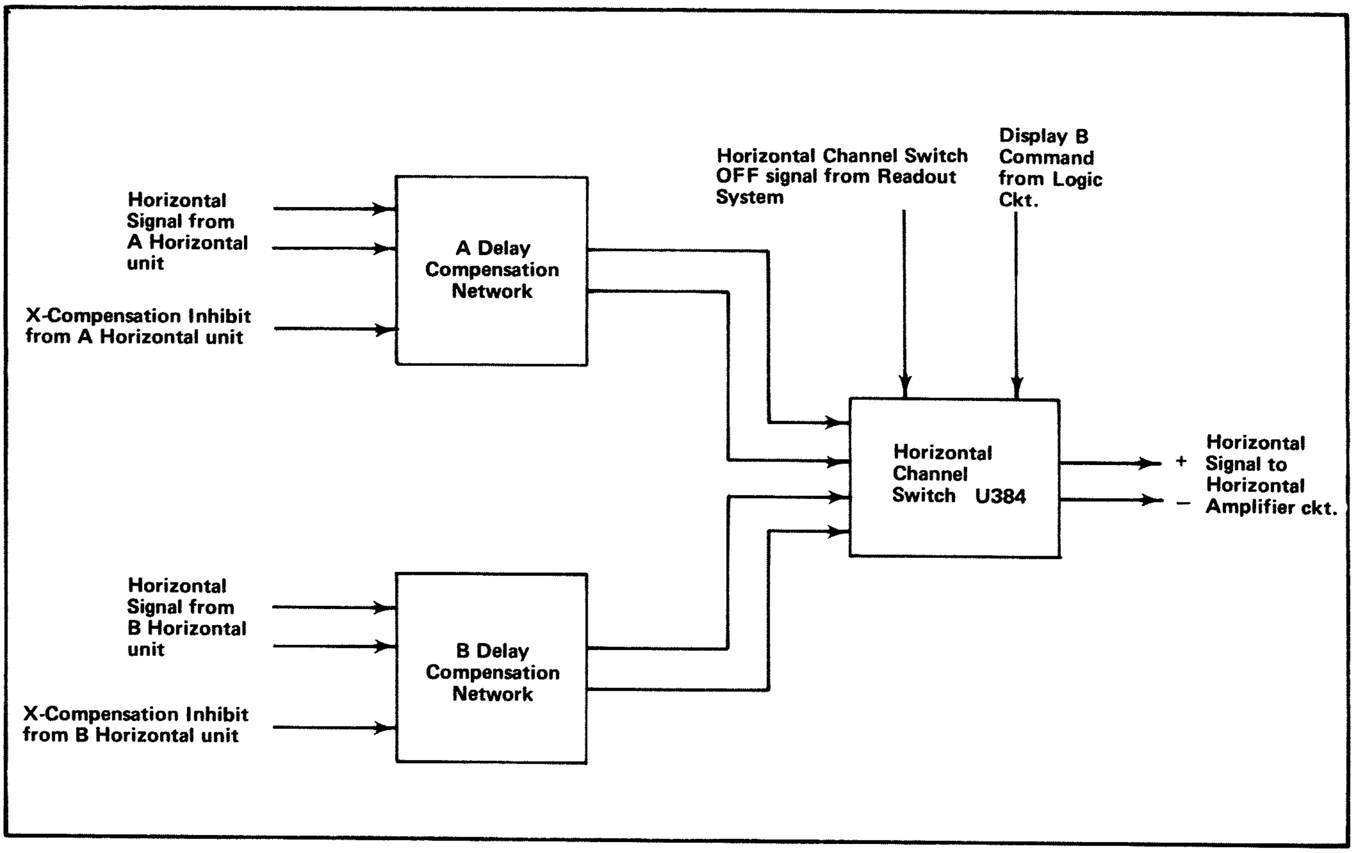

Fig. 3-27. Horizontal Interface Detailed block diagram.

Channel Switch and Vertical Channel Switch stages. An input/output table for U384 is shown in Fig. 3-28. U384 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.

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

Φ = Has no effect in this case

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

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 Display B Command 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 Display B Command is LO and the signal from the B Horizontal Unit is displayed when the Display B Command is HI.

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

The output signal at pins 12 and 13 is connected to the Horizontal Amplifier circuit via the Main Interface circuit. Resistors R395-R396 and R398-R399 establish the correct operating DC levels for U384 as well as to establish a load resistance of about 50 ohms for this stage.

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 Q504 and Q514. The Input Amplifier is driven from an equivalent 50-ohm source. This stage provides adjustments to set the overall gain of the Horizontal Amplifier circuit and to balance the collector current of Q504 and Q514. Resistors R502-R503-R504-R514-R515 provide degeneration between the emitters of Q504 and Q514. Horizontal Gain adjustment R515 determines the amount of emitter degeneration to control the signal gain of this stage. DC Center adjustment R505 balances the quiescent current through Q504 and Q514 to produce a centered spot on the CRT with no horizontal deflection signal applied.

For readout displays, the X-signal from the Readout System is connected to the base of Q514 through R511. The signal from the horizontal units is blocked by the Horizontal Channel Switch (see Horizontal Interface description). Q514 and Q504 operate as a paraphase amplifier to display the readout information. The signal connected to the base of Q514 produces an inverted output signal at the collector of Q514. At the same time, the emitter of Q514 moves in the same direction as the applied signal, and this change is connected to the emitter of Q504 through R502 and R515. As far as readout-signal change is concerned, Q504 operates as an emitter-driven common-base stage.

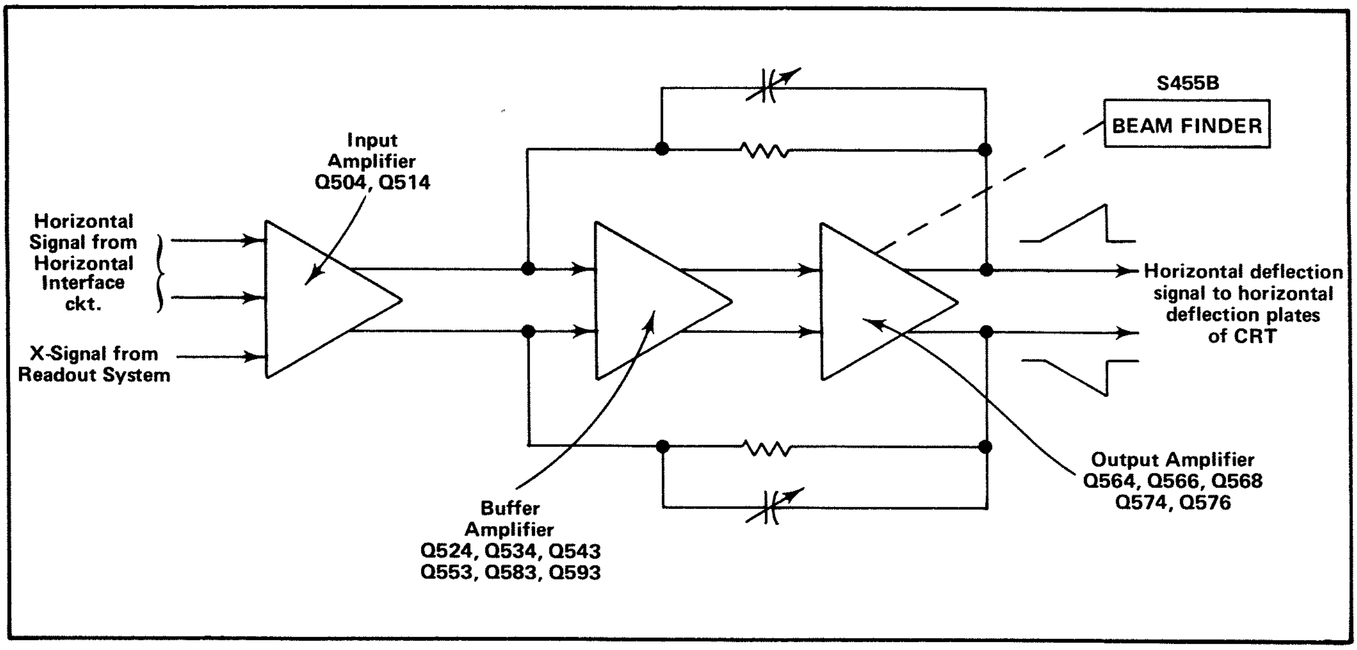

Fig. 3-29. Horizontal Amplifier detailed block diagram.

Therefore, the change at its emitter produces a similar change at its collector. Thus the single-ended input signal at the base of Q514 is available as a push-pull signal at the collectors of Q504 and Q514. For instruments which are not equipped with a Readout System, R511 is connected to ground at the chassis where the Readout System board is mounted.

Buffer Amplifier and Output Amplifier

The signal from the Input Amplifier stage is connected to the Buffer Amplifier through the limiting network CR508-CR518-CR523-CR533. These diodes protect the Buffer Amplifier stage from being overdriven by excessive current drive from the Input Amplifier stage. The output signal from the Input Amplifier stage is a current signal. With normal horizontal deflection signals which produce an on-screen display, CR523 and CR533 remain forward biased and CR508-CR518 are reverse biased. However, when high-amplitude horizontal deflection signals are applied to this circuit as a result of sweep magnification or high-amplitude external horizontal signals, either CR523 or CR533 is reverse biased, depending on the polarity of the overdrive signal. This results in a sufficient voltage change at the anode of either CR508 or CR518 to forward bias it. The shunt diodes provide a current path for the signal current to limit the voltage change during the overdrive condition. Limit Center adjustment R525 balances the quiescent current at the emitters of Q524 and Q534 so limiting does not occur during the displayed portion of the horizontal deflection signal.

The Buffer Amplifier Q524-Q534 provides a low-impedance input for the signal current from the Input Amplifier. The signal at the collectors of Q524-Q534 is connected to the Output Amplifier through emitter followers Q543-Q553. Q543 and Q553 provide a current gain for the horizontal deflection signal. Each half of the Output Amplifier is a current driven stage with a voltage output to drive the horizontal deflection plates of the CRT and feedback to the input of the Buffer Amplifier stage for linearity. The Output Amplifier has a low input impedance and requires very little voltage change at the input to produce the desired output change. Q568 provides a stable voltage source for the bases of Q566-Q576. Diodes CR564-CR574 limit the negative level at the bases of Q564 and Q574 to about 0.6 volts to protect these transistors in case of failure or removal of Q543 or Q553. Negative feedback is provided from the collectors of Q566 and Q576 to the input of the Buffer Amplifier through feedback networks C581-R580-R581-Q583-C588-R588-R589 and C591-R590-R591-Q593-C598-R598-R599. Emitter followers Q583-Q593 in the feedback networks provide isolation between the input of the Buffer Amplifier and the output of the Output Amplifier stage. With this configuration, the input impedance of the Buffer Amplifier appears low since the feedback network beyond the emitter followers is effectively disconnected as far as the input signal is concerned. However, the total feedback network is active for the feedback signal. Variable capacitors C581, C588, C591 and C598 adjust the transient response of the feedback networks to provide good linearity at fast sweep rates.

The BEAM FINDER switch S455B reduces horizontal scan by limiting the voltage swing of Q566 and Q576 when actuated. Normally the collectors of these transistors are returned to +150 volts and CR565 is reverse biased to disconnect the +75-volt level. However, when the BEAM FINDER switch is actuated, the power from the +150-volt supply is interrupted and the collector voltage for Q566-Q576 is supplied from the +75-volt supply through CR565. This reduced collector voltage limits the output voltage swing at the collectors of Q566-Q576 to limit the trace within the graticule area.

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.

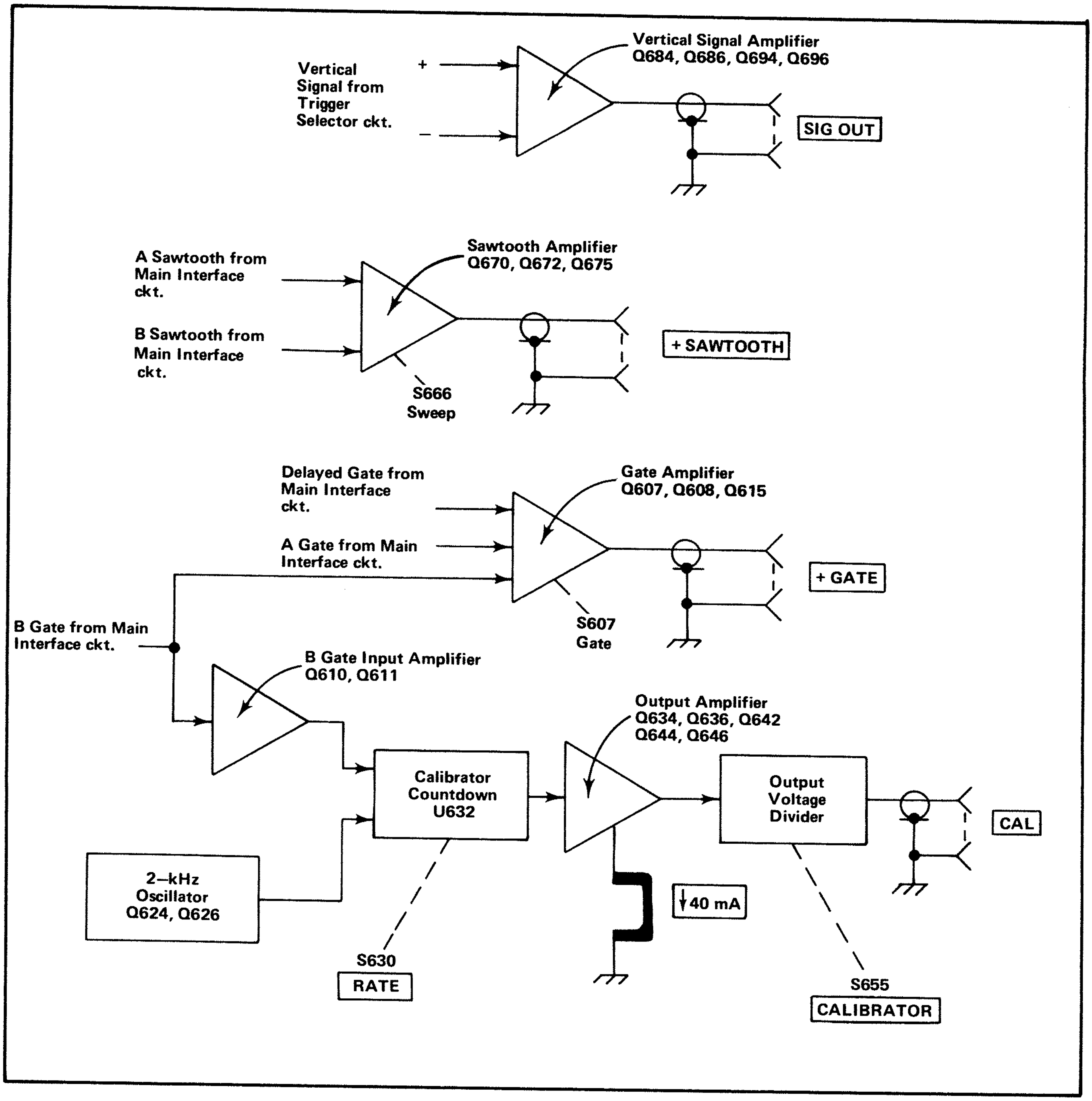

Fig. 3-30. Output Signals and Calibrator detailed block diagram.

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 resistance 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 chassis 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 R4 and R5 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, Q762 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 R4 or R5, 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 +25-volt supply through the collector-base junction of Q675. Then, CR674 is forward biased to clamp 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 for 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 connector and CR616 clamps the output at about −0.6 volts 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 of the Calibrator. Q611 provides temperature compensation for this stage.

Calibrator

General. The Calibrator circuit provides a 40 milliampere 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.

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.

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 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 R646-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 current divider to determine the current through the front-panel 40 mA current loop 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 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 milliampere 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 ÷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.

High-Voltage Oscillator

Unregulated voltage for operation of the high-voltage supply is provided from the +15-Volts Rectifier (see Low-Voltage Power Supply). Diode CR759 disconnects the negative side of this unregulated voltage from the collector of Q756 at the time of turn-on. This allows the starting current for the High-Voltage Oscillator to be supplied from the +15-Volt Supply through R759 and Q756. As the output of the high-voltage supply increases to its required output level, the collector of Q756 goes negative until CR759 is forward biased. Now the collector supply level for Q756 is provided by the negative side of the unregulated voltage. 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

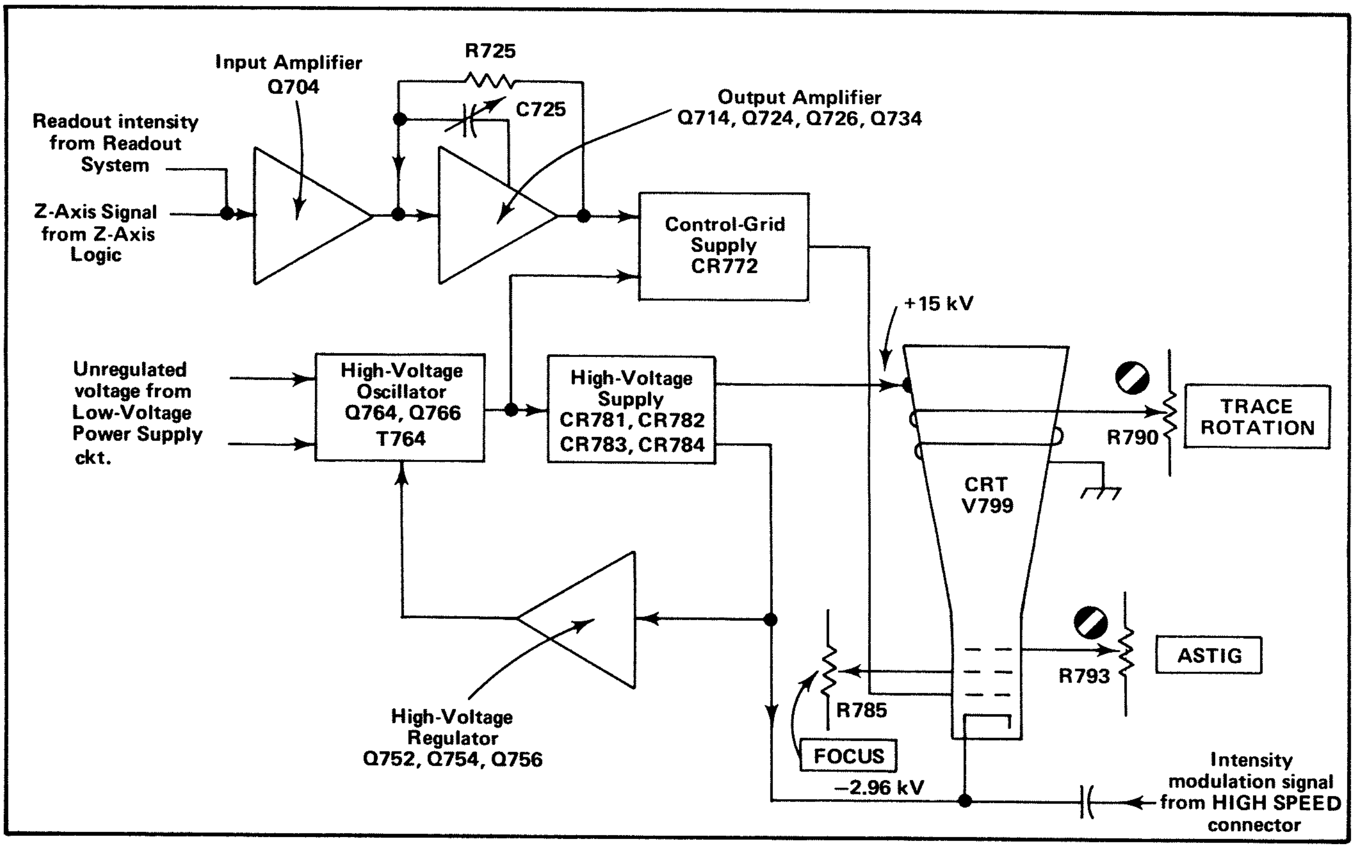

Fig. 3-32. CRT Circuit detailed block diagram.

control the current for the High-Voltage Oscillator after the stage reaches operating potentials to regulate the output level.

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 winding 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 Q756, 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 shapes the signal in the primary of T764 so it maintains essentially a sine-wave characteristic. The amplitude of the oscillations in the primary of T764 is controlled by the High-Voltage Regulator stage to set the total accelerating potential 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 Q754 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, provides the reference level for this stage. High-Voltage adjustment R745 sets the quiescent level at the base of Q752 to a level which establishes a −2.96 kV operating potential at the CRT cathode. CR741 protects Q752 from excessive reverse emitter-base voltage.

Regulation occurs as follows: If the output voltage at the −2.96 kV test point starts to go positive (less negative), a sample of this positive-going change is connected to the base of Q752. Both Q752 and Q754 are forward biased by this positive change, which in turn increases the conduction of Q756. This results in a more positive level at the emitter of Q756 and a more positive bias level at the bases of Q764 and Q766. 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 −2.96 kV 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 supply and the Control-Grid Supply, the total high-voltage output is regulated by sampling the output of the negative 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 potentials 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 tripler C782-C783-C784-CR782-CR783-CR784. This rectified voltage is filtered by C785-R780-R781 to provide a constant output of about +15 kilovolts. All of these components are included in an encapsulated assembly. The negative accelerating potential for the CRT cathode is also obtained from this same secondary winding. Half-wave rectifier CR781 provides an output voltage of about −2.96 kilovolts which is connected to the CRT filament and 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. 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 CRT Grid Bias adjustment R775. 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 if either the Control-Grid Supply or negative High-Voltage Supply should fail. 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 C789-R786-C786. This signal changes the CRT bias, and thereby the intensity of the display, by changing the level on the cathode. RC divider C1056-C1057-R1056-R1058 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-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 shields 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.

Z-Axis Amplifier

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

Input Amplifier. Transistor Q704 is a common-base amplifier to establish a low input impedance for the Z-Axis Amplifier stage. Zener diode VR709 provides an operating level of about +5.1 volts at the base of Q704. The quiescent current to the emitter of Q704 is set by the DC level adjustment R705 so the Z-Axis Amplifier circuit operates within its linear range. 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 C725-R725. The output voltage is determined by the input current multiplied by the feedback resistor and is expressed by the formula: $E_{out} \cong I_{in} \times R_{FB}$ where R725 is R_{FB}. The signal current change at the base of Q714 for maximum intensity is about 4 milliamperes. Therefore, the output voltage change is about 63 volts (4 mA X 15.8 kΩ). AC feedback is provided from the base circuit of Q734 to the base of Q714 by C725 which is adjusted for optimum step response. This provides a fast-rise unblanking gate output signal with minimum overshoot or ringing. Otherwise, the CRT display would vary in intensity level following sudden changes in blanking level.

The signal from the Input Amplifier stage is connected to the bases of Q724 (through C723) and Q726 through emitter follower Q714. These transistors are connected as a collector-coupled complementary amplifier to provide a linear, fast output signal while consuming minimum quiescent power. Q726 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 signal at the emitter of Q714 are coupled to the base of Q724 through C723. Since Q724 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 Q726, an NPN-type transistor). Emitter follower Q734 and diode CR734 provide a low-impedance output with fast response for both positive- and negative-going changes in output level. CR734, connected across the base-emitter junction of Q734, improves the output response for the negative-going portion of the unblanking gate. When the base of Q734 is driven negative to cutoff, CR734 is forward biased to quickly pull the emitter of Q734 negative also to provide a fast falling edge on the output signal. The signal at the emitter of Q734 is connected to the Control-Grid Supply stage through R736.

Diodes CR714, CR726 and CR736 provide protection for the Z-Axis Amplifier circuit. CR714 and CR736 protect this stage from damage due to high-voltage surges connected back into this circuit from the high-voltage supplies. CR726 protects Q726 by clamping its base at –0.6 volts if Q714 fails or is removed from its socket while the instrument is on.

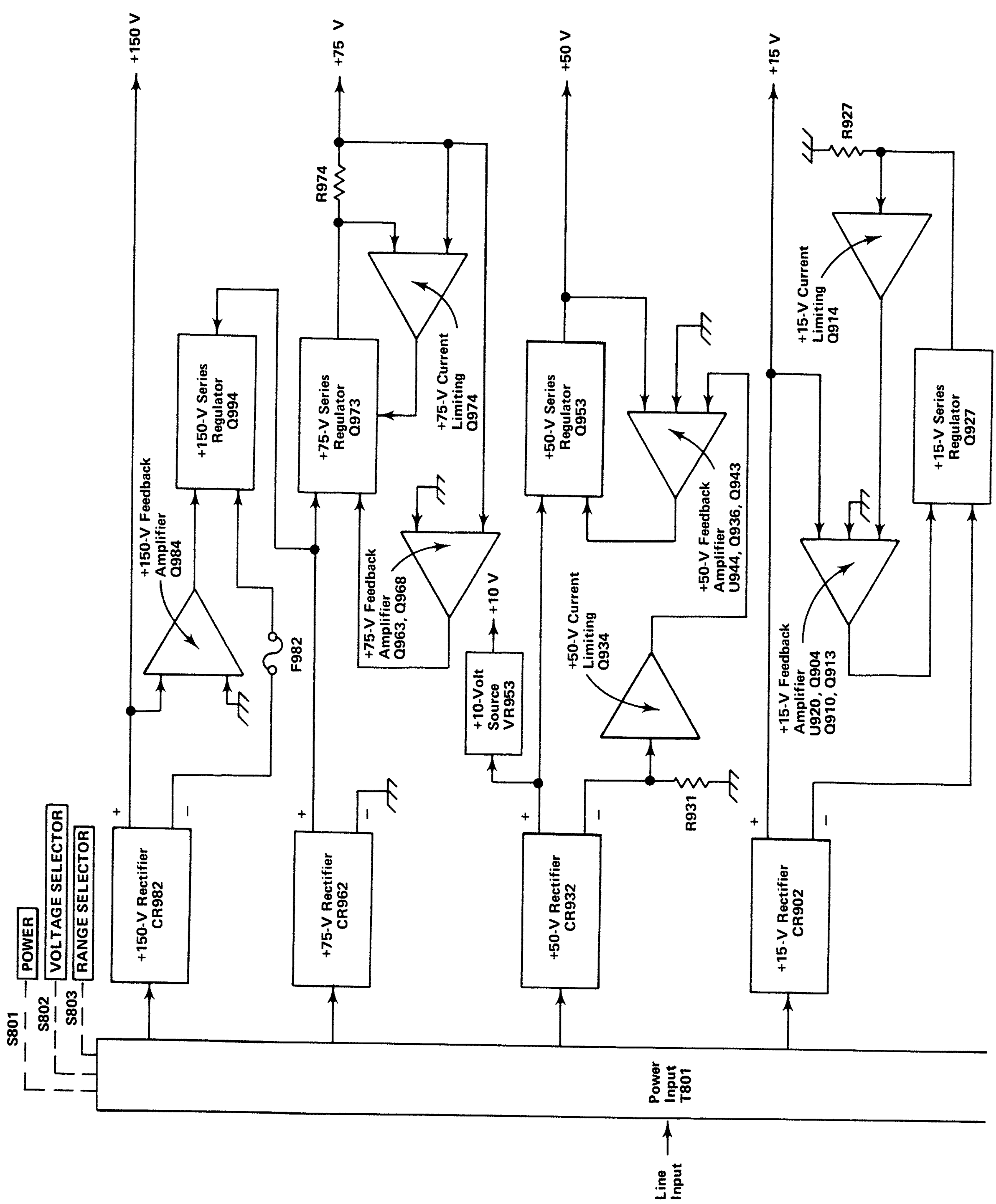

Fig. 3-33. Low-Voltage Power Supply detailed block diagram.

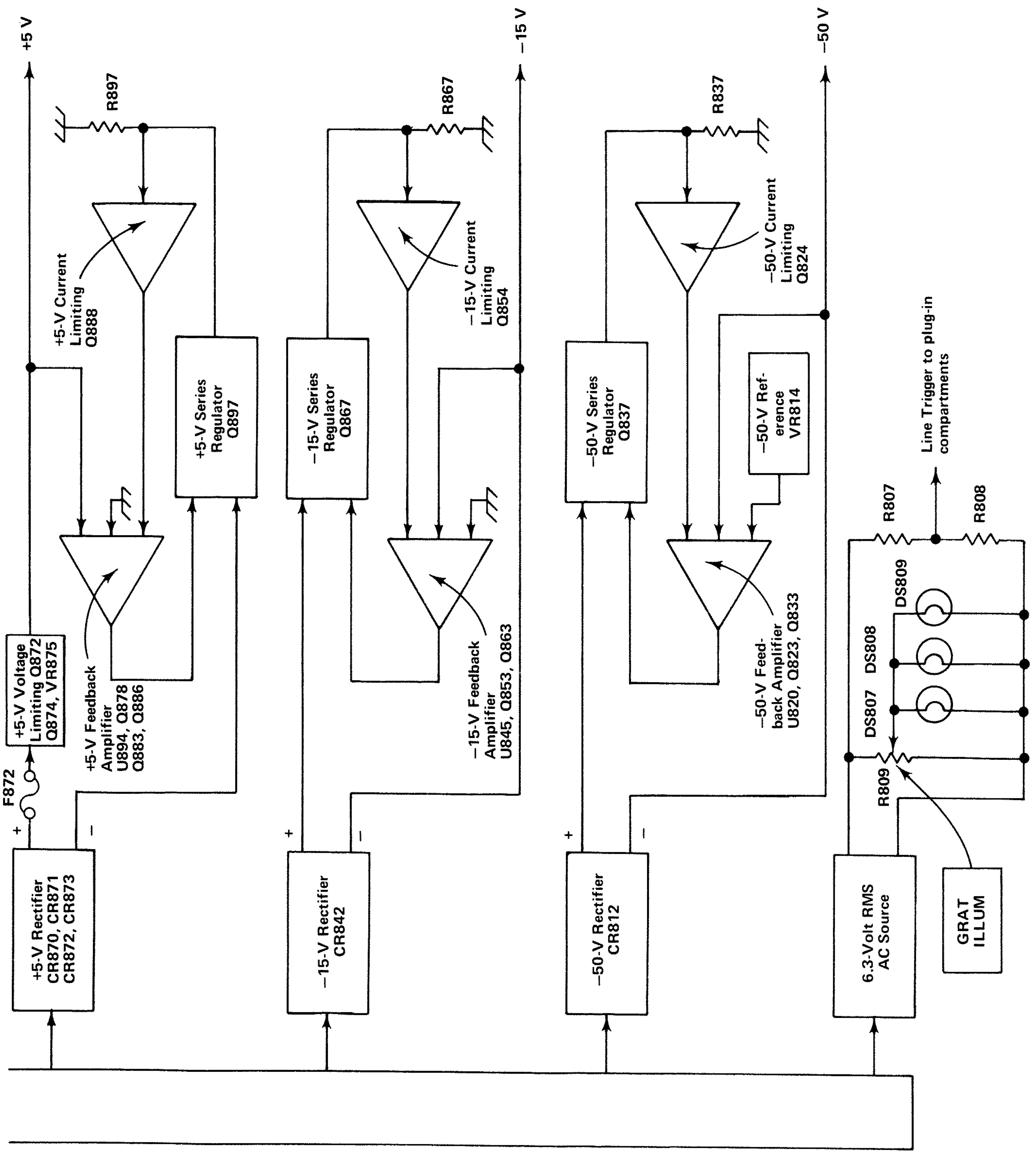

Fig. 3-33. Low-Voltage Power Supply detailed block diagram.

LOW-VOLTAGE POWER SUPPLY

General

The Low-Voltage Power Supply circuit provides the operating power for this instrument from seven regulated supplies. Electronic regulation is used to provide stable, low-ripple output voltages. Each regulated supply (except the +150-Volt Supply) contains a short-protection circuit to prevent instrument damage if a supply is inadvertently shorted to ground. The Power Input stage includes the Voltage Selector Assembly. This assembly allows selection of the nominal operating voltage and regulating range for the instrument. Fig. 3-33 shows a detailed block diagram of the Low-Voltage Power Supply circuit. A schematic of this circuit is shown on diagrams 10 and 11 at the rear of this manual.

Power Input

Power is applied to the primary of transformer T801 through the EMI (electro-magnetic interference) filter FL801, 115-volt line fuse F801, POWER switch S801, thermal cutout TK801, Voltage Selector switch S802 and Range Selector switch S803. The Voltage Selector switch S802 connects the two halves of the primary of T801 in parallel for 115-volt nominal operation, or in series for 230-volt nominal operation. A second line fuse, F802, is connected into the circuit when the Voltage Selector switch is set to 230 V position to provide the correct protection for 230-volt operation (F802 current rating less than rating of F801).

The Range Selector switch S803 allows the instrument to regulate correctly on higher or lower than normal line voltages. Each half of the primary of T801 has taps above and below the 115-volt (230) nominal point. As the Range Selector switch S803 is switched from LO to M to HI, more turns are effectively added to the primary winding and the turns ratio is decreased. This configuration compensates for higher or lower than normal line voltage to extend the regulating range of the Low-Voltage Power Supply.

Thermal cutout TK801 provides thermal protection for this instrument. If the internal temperature of the instrument exceeds a safe operating level, TK801 opens to interrupt the applied power. When the temperature returns to a safe level, TK801 automatically closes to re-apply the power.

−50-Volt Supply

The following discussion includes the description of the −50-V Rectifier, −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 −50-V Rectifier assembly CR812 rectifies the output at the secondary of T801 to provide the unregulated voltage source for this supply. CR812 is connected as a bridge rectifier and its output voltage is filtered by C812 before it is applied to the −50-V Series Regulator Q837. Integrated circuit U820 and transistors Q823, Q833 and Q837 operate as a feedback-stabilized regulator circuit to maintain a constant −50-volt output level. U820 is connected as a differential amplifier (see Fig. 3-34A) to compare the feedback signal at pin 1 against the reference signal at pin 5. The error output signal at pin 6 reflects the difference, if any, between the two inputs. The change in level at the error output is always in the same direction as the change at the feedback input (in phase). Q3 provides a constant current to Q1-Q2 as established by R1-R2 and the operating potentials connected to pins 3, 4 and 7. Pin 8 is connected to a V_{CC} supply voltage to provide the correct operating potential for Q1.

Zener diode VR814 sets a reference level of about −6.2 volts at pin 5 of U820. A sample of the output voltage from this supply is connected to the feedback input (pin 1) through divider R813-R815-R811. R815 in this divider is adjustable to set the output voltage level of this supply. Notice that the feedback voltage to this divider is obtained from a line labeled −50 V Sense. Fig. 3-35 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 quite small, 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 ripple, changes in load, or changes in line voltage, the voltage across divider R813-R815-R811 decreases also. This results in a more positive level at the feedback input of U820 than at the reference input and the output current decreases. This decrease in output current from U820 allows more base current to flow through Q823 and Q833 to result in increased conduction of the −50-V Series Regulator Q837. This action increases the load current and the output voltage of this supply increases (more negative). The feedback voltage from the −50 V Sense line increases and the feedback input of U820 returns to the same level as the reference input. Similarly, if the output level of this supply increases (more negative), the output current of U820 increases. The feedback through Q823 and Q833 reduces the conduction of the −50-V Series Regulator to decrease the output voltage of this supply.

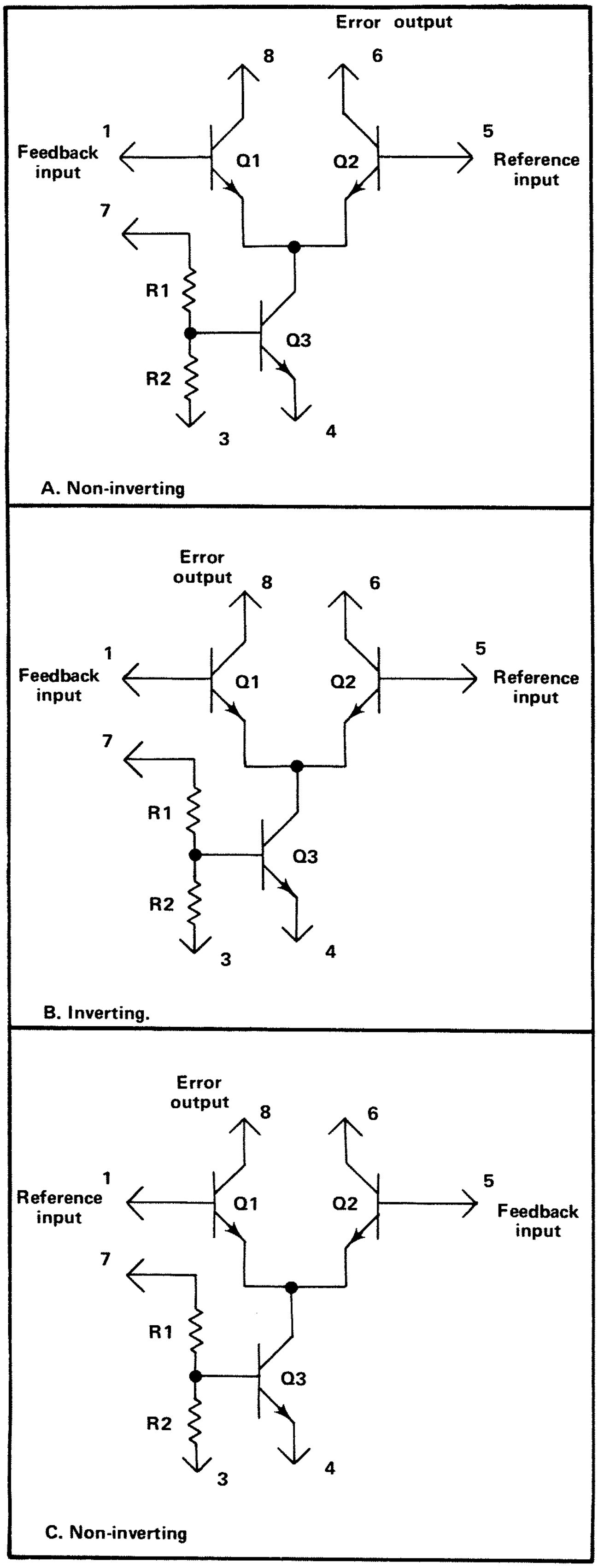

Fig. 3-34. Simplified schematics of RCA CA3028A in configurations used in the Type 7504.

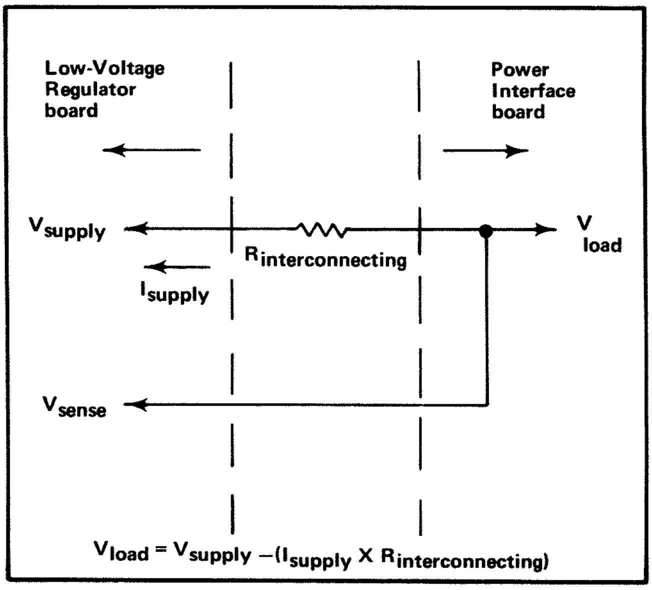

Fig. 3-35. Schematic illustrating voltage drop between power-supply output and load due to resistance of interconnecting wire.

The −50 Volts adjustment R815 determines the divider ratio to the error input of U820 and thereby determines the feedback voltage. This adjustment sets the output level of the supply in the following manner: if R815 is adjusted so the voltage at its variable arm goes less negative (closer to ground), this appears as an error signal at pin 1 of U820. In the same manner as described previously, this positive-going change at the feedback input of U820 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 R813-R815-R811 and the divider action returns the feedback input of U820 to about −6.2 volts. Notice that the feedback action of this supply forces a change in the output level which always returns the feedback input of U820 to the same level as the reference input. In this manner, the output level of the −50-Volt Supply can be set to exactly −50 volts by correct adjustment of R815.

The −50-V Current Limiting stage Q824 protects the −50-Volt Supply if excess current is demanded from this supply. Since the ground return for the −50-Volt Supply is through R837, all current from the −50-Volt Supply must flow through R837. Transistor Q824 senses the voltage drop across R837. Under normal operation, there is about 0.25-volt drop across R837 which is not sufficient to forward bias Q824. 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 R847 increases until it is sufficient to forward bias Q824. The collector current of Q824 results in a reduction of current through Q823 and Q833 to limit the conduction of Q837. As the output voltage decreases due to the malfunction at the output, the bias established at the base of Q824 by divider R827-R829 increases. This increases the conduction of Q824 to further limit the current through Q837. The current limiting protects Q837 from damage due to excess power dissipation. Several protection diodes are also included in this circuit. CR818 protects U820 by preventing pin 1 from going more than about 0.6 volt more positive than pin 5. CR832 prevents the base of Q833 from going more positive than about +0.85 volt. CR838 protects the −50-Volt Supply from damage if its output is shorted to one of the positive supplies. C824-R824 prevent oscillation in the feedback network.

−15-Volt Supply

Rectified voltage for operation of the −15-Volt Supply is provided by rectifier assembly CR842. This voltage is filtered by C842 to provide the unregulated voltage source for this supply. Basic operation of all stages in the −15-Volt Supply except the −15-V Feedback Amplifier is the same as for the −50-Volt Supply. Reference level for this supply is established by the ground connection at the reference input (pin 1) of U845. This is the same integrated circuit type as used in the −15-V Feedback Amplifier and the operation and function are the same. Feedback voltage to pin 5 of U845 is provided by divider R843-R844 between the −15-V Sense line and the +15-V Sense line. The divider ratio of R843-R844 is 1 to 1 and precision resistors are used so that the output level of this supply is −15 volts when the error input of U845 is near zero volts as controlled by the feedback. The level on the +15-V Sense line is held stable by the +15-Volt Supply. Any change at the output of the −15-Volt Supply appears at pin 1 of U845 as an error signal. The output voltage is regulated in the same manner as described for the −50-Volt Supply. Diode CR844 protects U845 by preventing pin 1 from going more than about 0.6 volt more positive than pin 5 (ground). CR848 prevents the base of Q854 from going more positive than about +5.6 volts.

+5-Volt Supply

Bridge rectifier CR870-CR871-CR872-CR873 provides the rectified voltage for the +5-Volt Supply. This unregulated voltage is also connected to the Control Illumination Network on the Front-Panel Controls and Cabling diagram to provide power to the front-panel indicator bulbs of this instrument as well as the associated plug-in units. The +5-V Series Regulator Q897 operates the same as the series regulators in the negative supplies except that it is connected in the negative side of the supply. The +5-V Feedback Amplifier U894 is connected in the inverting configuration (see Fig. 3-34B). In this configuration, the change at the error output (pin 8) is out of phase with the feedback signal at pin 1. A ground reference level is provided at pin 5 and the feedback voltage is connected to pin 1. Regulation occurs as follows: If the output of this supply goes more positive, the positve change at the feedback input of U894 results in an increase in output current at pin 8. This reduces the base current to Q883 and a resultant reduction of base current for Q886 and the +5-V Series Regulator Q897. The decreased base current for Q897 reduces the output current of this supply to decrease the voltage across the load. Zener diode VR882 provides voltage shifting between Q883 and Q886 without appreciable current loss, while CR886 provides reverse-bias protection for Q886.

The ground return for the +5-V Series Regulator is through current-sensing resistor R897. In the same manner as described for the previous supplies, the normal current through R897 is not sufficient to forward bias the +5-V Current Limiting stage Q888. However, when excess current is demanded from this supply, the voltage drop across R897 increases and Q888 is forward biased. The collector current of Q888 flows through R878 to decrease the voltage level at the anode of CR878. When this voltage drops to about +11 volts, CR878 and Q878 are reverse biased to reduce the conduction of Q883, Q886 and the +5-V Series Regulator Q897 which provides current limiting.

The +5-V Voltage Limiting stage provides protection for the light bulbs and integrated circuits which are powered from this supply if the output voltage rises above the normal five-volt level. The +5-volt output of this supply is connected across zener diode VR875 through R875. Under normal conditions, there is not enough voltage across VR875 to place it in the zener region. However, if the output of this supply rises positive due to a short to a more positive supply, or similar malfunction, the gate of Q874 (programmable unijunction transistor) is clamped at about +5.6 volts through R874 by zener diode VR875. As the output voltage increases to about +6 volts, Q874 is forward biased and its cathode current triggers silicon-controlled rectifier Q872 through R872. When Q872 conducts, it effectively shorts the output of the +5-V Supply to ground, demanding high output current. This high current is sensed by the +5-V Current Limiting stage and the output current is reduced as described previously. The output remains limited until the instrument is turned off and the problem is corrected. A momentary voltage surge may also trigger the +5-V Voltage Limiting stage and cause the +5-Volt Supply to shut down. Power can be restored in this case by momentarily turning off the POWER switch and returning it to ON.

Fuse F872 provides further current protection for this supply. If the +5-V Current Limiting stage malfunctions (for example, collector of +5-V Series Regulator shorted to ground) and a condition occurs which demands current limiting, F872 opens to interrupt the output of this supply before damage can occur. Diode CR893 provides protection for U894 by providing an alternate current path from the −15-Volt Supply if the −50-Volt Supply fails. CR898 protects this circuit if the output is shorted to one of the negative supplies. Due to the high current output of this supply, a separate ground return is used for this supply to prevent its heavy return current from affecting other supplies in this instrument.

The elapsed-time meter M898 is connected to the +5-volt output through R898. This meter records the amount of time that this instrument has been operating; full-scale reading is 5000 hours.

+15-Volt Supply

Rectifier assembly CR902 provides the rectified voltage for the +15-Volt Supply. This unregulated voltage is also connected to the High-Voltage Oscillator stage in the CRT Circuit through F901. This fuse protects the +15-V Rectifier from damage due to failures in the High-Voltage Oscillator stage. Basic operation of the stages in this circuit are the same as described for the previous supplies. Diode CR904 prevents the junction of R904-R905 from going more positive than about −14.4 volts to protect Q910. CR906 normally clamps the emitter of Q904 at about +5.5 volts. However, when the +15-V Current Limiting stage comes into operation it disconnects the +5-Volt Supply at its cathode so the base of Q904 can be pulled negative to limit the output current of this supply. CR910 protects Q910-Q913 by limiting the reverse bias across them to about 0.6 volt. CR915 limits the positive level at the base of Q904 to about +5.6 volts if the output of this supply is shorted to one of the more positive supplies.

+50-Volt Supply

Bridge rectifier assembly CR932 provides the rectified voltage for the +50-Volt Supply. This unregulated voltage is applied across zener diode VR953 through R953 to provide a +10-volt source for operation of several circuits within the Low-Voltage Power Supply circuit. The unregulated voltage from CR932 is also the collector source for the +50-V Series Regulator. Regulation occurs much the same as described for the previous supplies. Notice that the reference level is connected to pin 1 and the feedback signal to pin 5 of U944. However, since the output is obtained from pin 8 (see Fig. 3-34C), the circuit is a non-inverting differential amplifier as described for the −50-Volt Supply. Feedback from U944 controls the conduction of the +50-V Series Regulator Q953 through Q936 and Q943. The +75-volt unregulated voltage provides the collector current for Q943 through R944. Diode CR944 forces the collector of Q943 to always be about 0.6 volts more positive than the collector of Q953. The +50-V Current Limiting stage Q934 senses the voltage drop across R931 to provide protection for this supply if excess current is demanded.

+75-Volt Supply

Unregulated +75-volts is provided by bridge rectifier assembly CR962 and filtered by C962-R962. Q973 is connected as a series regulator with R973 connected across Q973 to reduce its dissipation. Regulation is achieved as follows: Q963 and Q968 provide feedback from the +75-volt output to the +75-V Series Regulator. The ground connection at the emitter of Q968 provides a reference for this stage. The base level of Q963 is determined by divider R963-R965 between the −50-V Sense line and the output of this supply. Since the −50-V Sense line is held constant, any change that appears at the base of Q963 is due to changes in the +75-volt output level. To follow the regulation, assume that the output goes more positive. This appears as an error signal at the base of Q963 and in turn at the base of Q968. Q968 is forward biased, which results in a reduction of bias on the +75-V Series Regulator Q973. The current through Q973 is reduced, to supply less current through the load to correct the original error. Only a portion of the output current flows through Q973 and the degree of regulation this configuration can achieve is limited to the amount of current that Q973 controls. However, this stage provides adequate regulation for the circuits where the +75-volt level is used and allows a lower wattage-rating transistor to be used in the regulator circuit. The +75-V Current Limiting stage Q974 senses the voltage drop across R974 to protect Q973 from damage due to excess current. Normally, the current through R974 is insufficient to forward bias Q974. However, when excess current is demanded from this supply, Q974 is forward biased and the addition of the Q974 current in the base circuit of the +75-V Shunt Regulator limits the conduction of Q973 to a level which protects it from damage. Diode CR963 limits the base excursion of Q963 to about −0.6 volt if the output of this supply is interrupted. CR969 protects Q973 if Q968 fails.

+150-Volt Supply

Bridge rectifier assembly CR982 provides the rectified voltage for the +150-Volt Supply. However, this secondary winding of T801 does not supply the full potential necessary to obtain the +150-volt output level. To provide the required output level, the negative side of this supply is connected to the output of the +75-Volt Supply so that the two supplies are effectively connected in series between ground and the +150-volt output. +150-V Feedback Amplifier Q984 and +150-V Series Regulator Q994 provide basic regulation for the output level in a manner similar to that described for the +75-Volt Supply. Changes in the output level appear as an error signal at the base of Q984 (reference established by ground connection at emitter). These changes are reflected to the base of Q994 to provide regulation of the output level. Fuse F982 protects this supply if the output is shorted. However, since the response time of F982 is slow to a shorted condition, CR992 is provided to protect Q994 from breakdown until F982 opens. Diodes CR984 and CR994 limit the reverse bias on Q984 and Q994 respectively to about 0.6 volts if the output of this supply is shorted.

6.3-Volt RMS AC Source

The 6.3-volt RMS secondary winding of T801 provides power for the graticule illumination lights DS807, DS808 and DS809. The current through these lights is determined by the GRAT ILLUM control R809 to change the illumination of the graticule lines. Voltage divider R807-R808 provides a sample of the line voltage to the plug-in connectors in the Main Interface circuit for internal triggering at line frequency or for other applications.

CONTROLS AND CABLING

General

Diagram 12 shows the front-panel controls of the Type 7504 and the interconnections between these controls and the circuit boards, as well as interconnections between the circuit boards 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 Type 7504 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. This diagram also shows the wiring for the Camera Power Connector on the CRT bezel, the rear panel PROBE POWER connectors J1080-J1085, and the Remote connector J1075.

READOUT SYSTEM

Introduction to Readout System

General. The Readout System in the Type 7504 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. 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 Type 7504 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. 3-36 shows one complete frame 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. 3-37). Columns C-0 (column zero) to C-10 (column 10) can be addressed in the Type 7504 system.

Row—One of the horizontal lines in the Character Selection Matrix (Fig. 3-37). Rows R-1 (row 1) to R-10 (row 10) can be addressed in the Type 7504 system.

Time-slot—A location in a pulse train. In the Type 7504 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 Type 7504 CRT. The position of each word is fixed and is directly related to the plug-in unit from which it originated. Fig. 3-36 shows the area of the graticule where the readout from each plug-in unit is displayed. Notice that channel 1 of each plug-in unit is displayed within the top division of the CRT and channel 2 is displayed directly below within the bottom division. Fig. 3-38 shows a typical display where only channel 1 of the Right Vertical unit and the B Horizontal unit are selected for display.

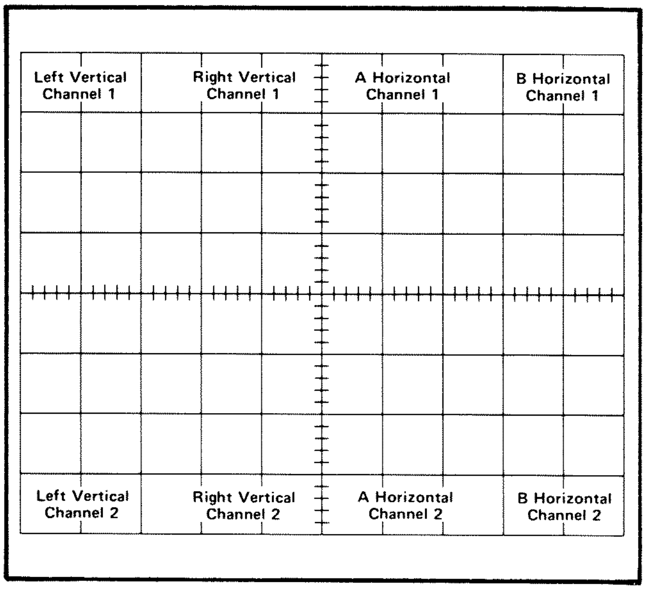

Fig. 3-36. Location of readout words on the CRT identifying the originating plug-in and channel (one complete frame shown).

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. 3-37. 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. 3-39. This description is intended to basically relate the 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 milliampere (100 microamperes/step) on the row and column output lines. This row and column correspond to the row and column of the Character Selection Matrix in Fig. 3-37. 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);

Row Number ↓ / Column Number →		C-0	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
	Current (Milli-amperes)	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		m	μ	n	p	X	K	M	G	T	R
R-5	0.4		S	V	A	W	H	d	B	c	Ω	E
R-6	0.5		U	N	L	Z	Y	P	F	J	Q	D
R-7	0.6				Decimal* 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*										

(shaded) Unused locations. Available for future expansion of Readout System

* Operational address.

Fig. 3-37. Character Selection Matrix for Type 7504 Readout System.

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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 TS-6 TS-7	Not encoded by plug-in unit. Left blank to allow addition of zeros by Readout System.
TS-8	Defines the prefix which modifies the units of measurement.
TS-9 TS-10	Define the units of measurement of the plug-in unit. May be standard units of measurement (V, A, S, etc.) or special units selected from the Character Selection Matrix.

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 a binary 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 to be produced from the Character Selection Matrix 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 in 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.

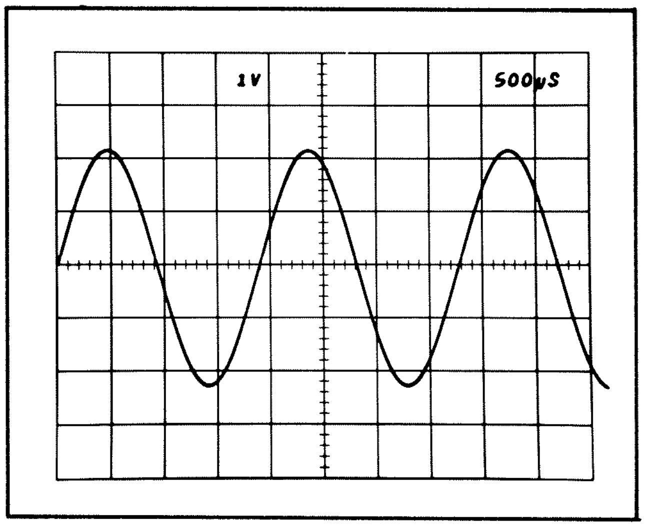

Fig. 3-38. Typical readout display where only channel 1 of the Right Vertical and B Horizontal units are displayed.

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

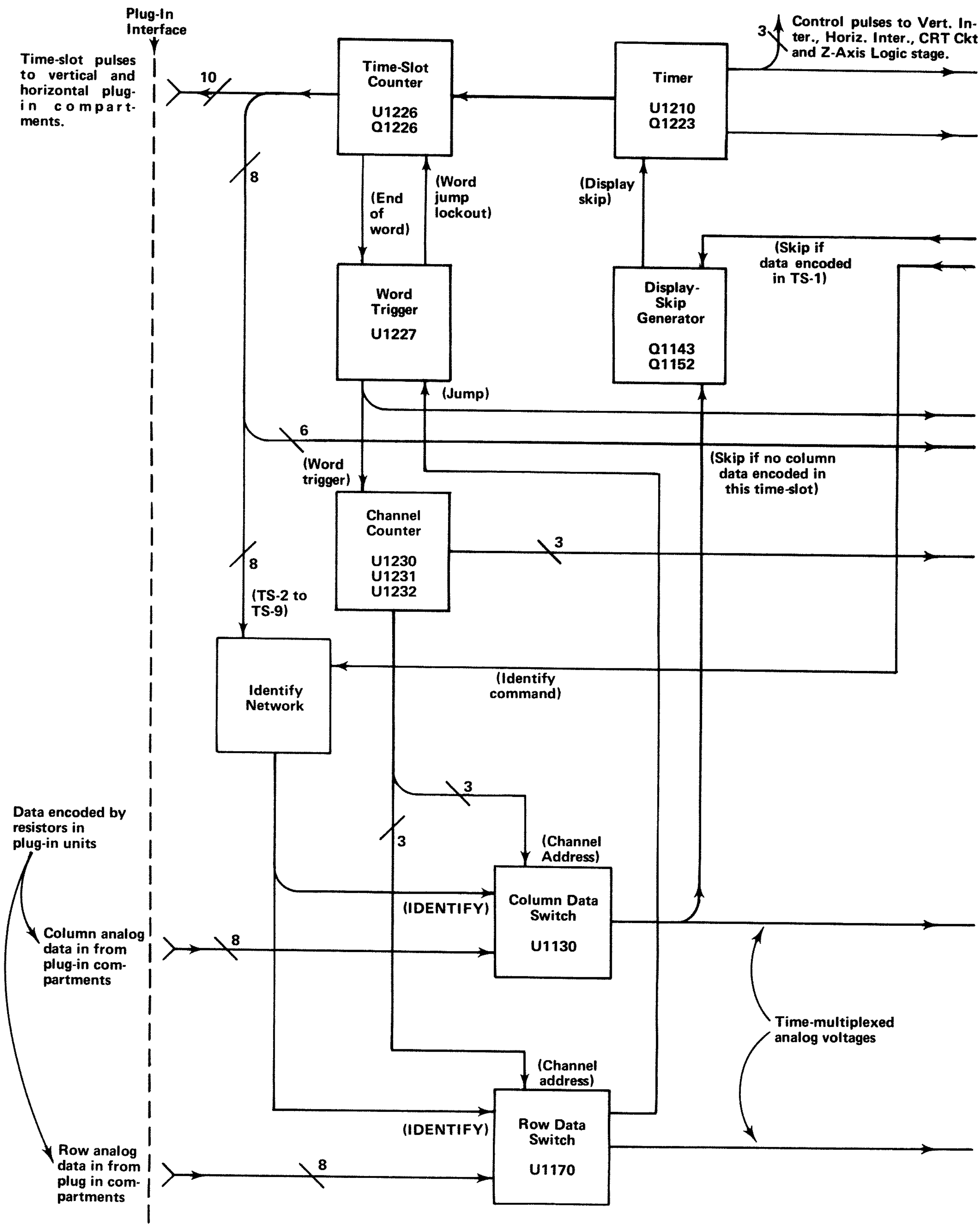

Fig. 3-39. Detailed block diagram of Readout System.

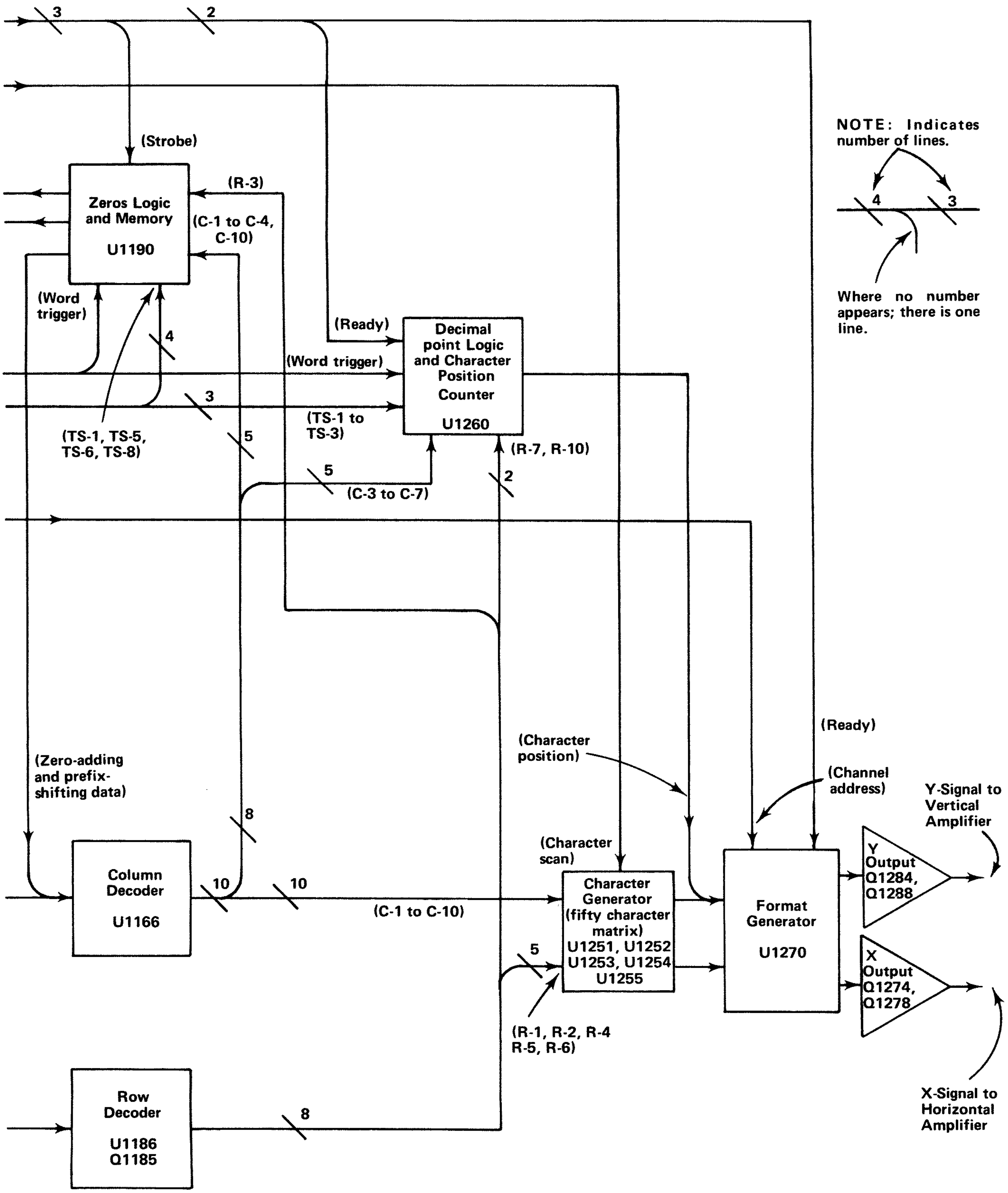

Fig. 3-39. Detailed block diagram of Readout System.

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.

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. 3-40). 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. 3-41). 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 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 CRT to the level determined by the READOUT intensity control R1040 (see diagram 12). 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 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

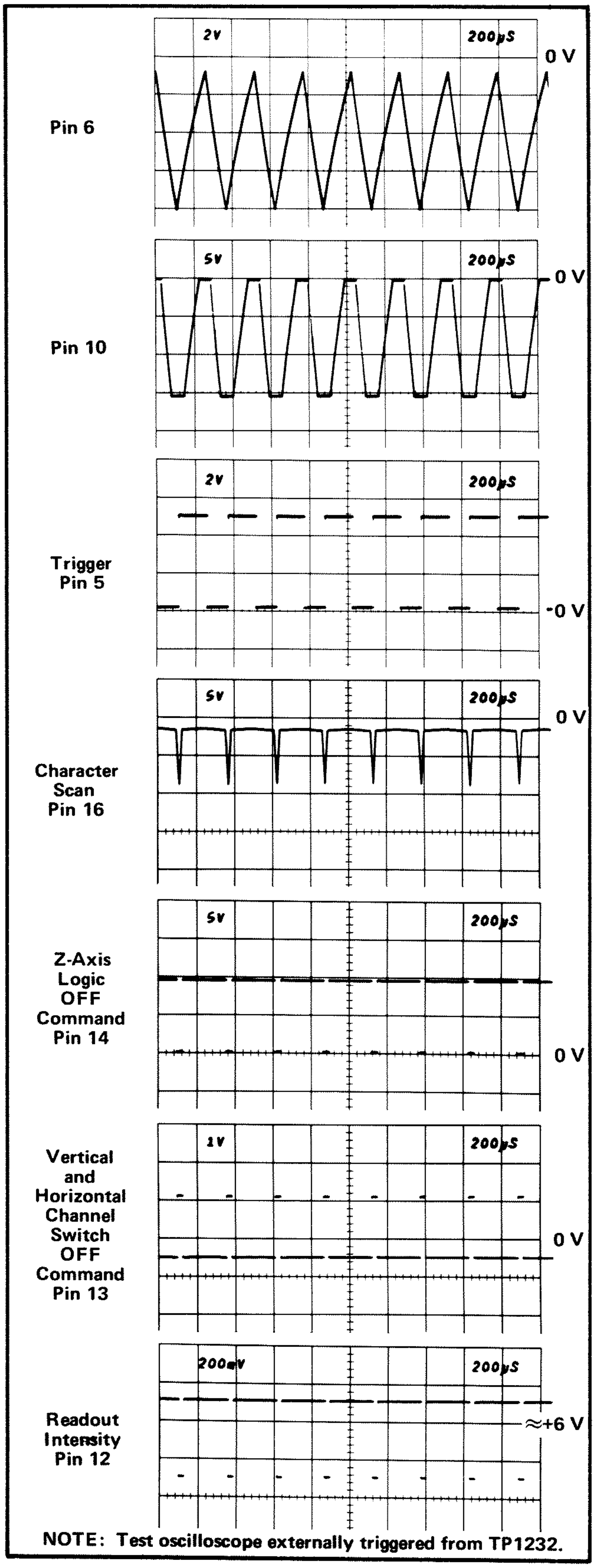

Fig. 3-40. Output waveforms of Timer stage.

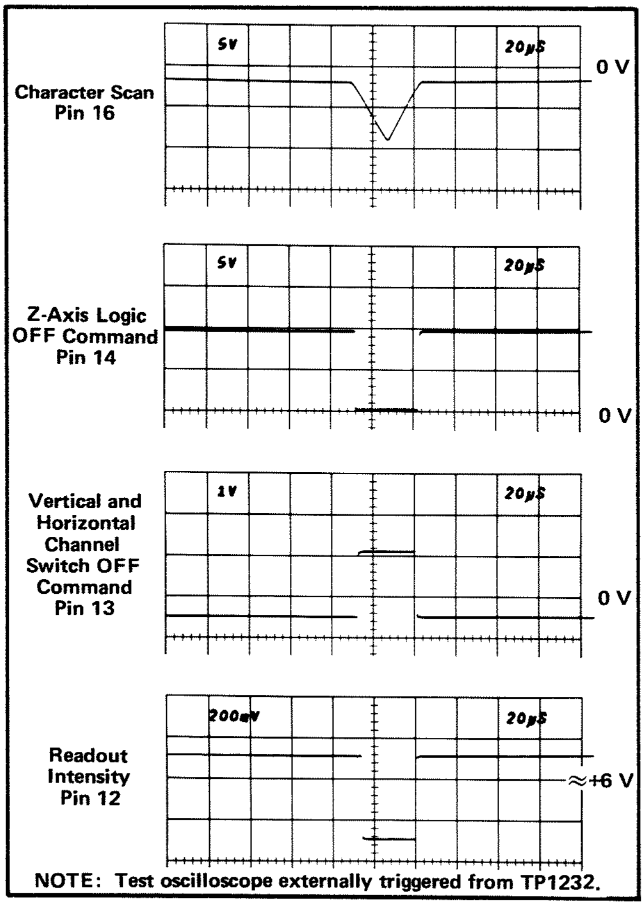

Fig. 3-41. Detail of outputs at pins 12, 13, 14 and 16 of U1210.

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. 3-42 show the operation of the Timer stage when the Display-Skip condition occurs for all positions in a word. Notice that there is no output at 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

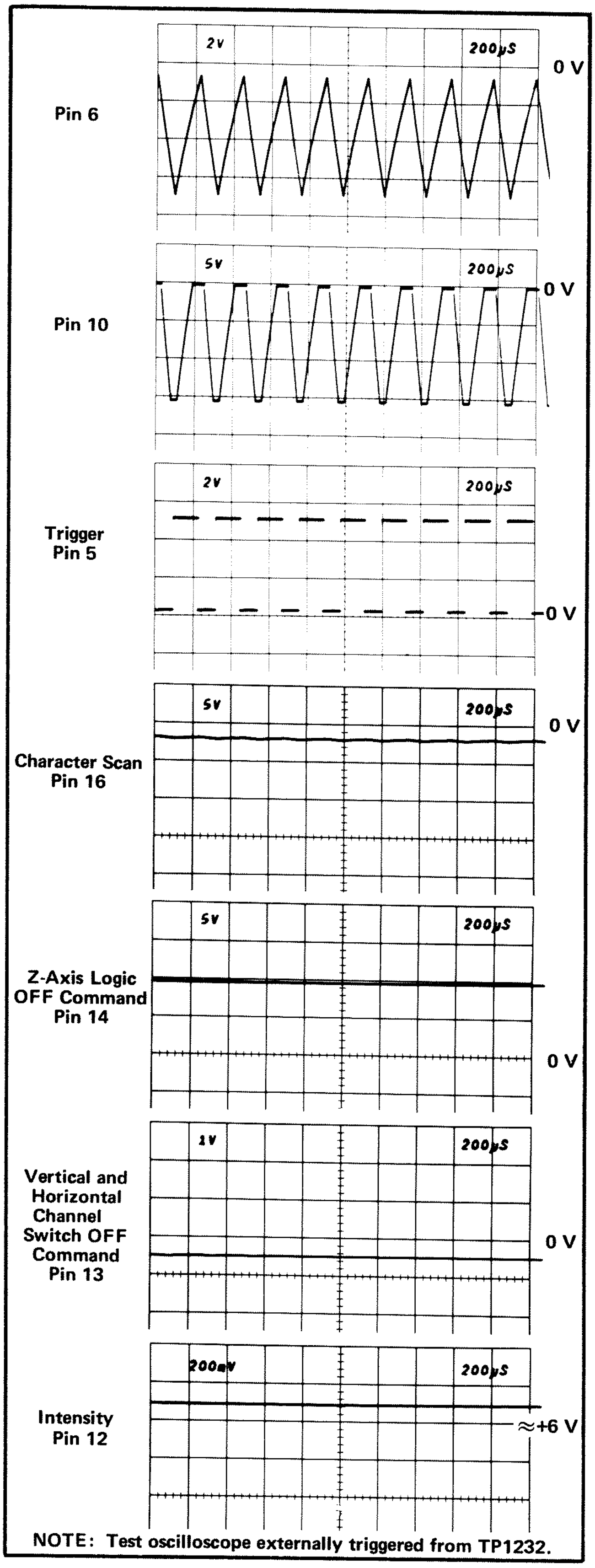

Fig. 3-42. Timer stage operation when Display-Skip condition occurs.

when a readout display is not desired. When R1040 is turned fully counterclockwise, switch S1040A opens. This interrupts the current to pin 11 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. 3-43 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 the 4 two-input NOR gates in U1227. Quiescently, pin 2 of U1227C is LO as established by the operating conditions of U1227A-U1227B. Therefore, the LO End-of-Word pulse produced by the Time-Slot Counter stage results in 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 advance pulse is also produced by U1227D when a Jump signal is received at pin 8 of U1227A. This condition can occur during any time-slot (see Row Decoder for further information on origin of the Jump signal). 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. 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. At the same time, a HI level is 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.

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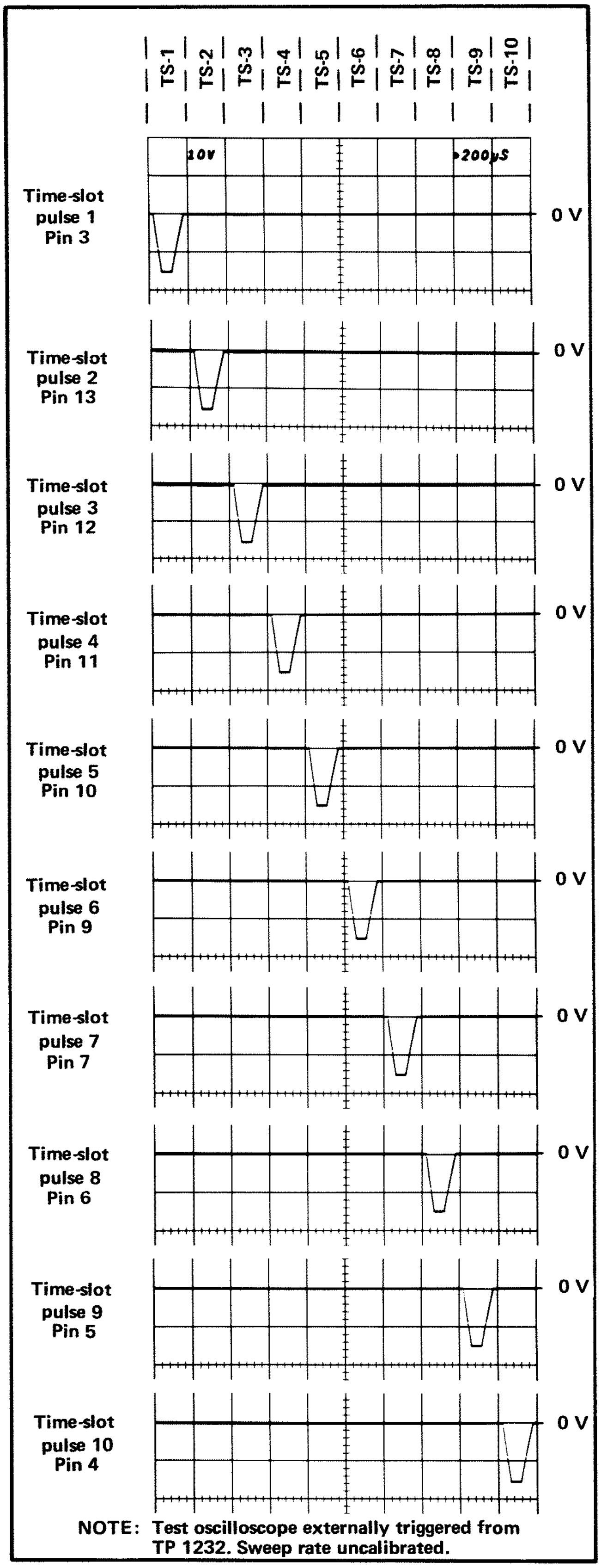


Fig. 3-43. Time-relationship of the time-slot (TS) pulses produced by U1226.

The next Trigger pulse is not recognized by the Time-Slot Counter stage since it is held in time-slot 1 by U1227. However, this Trigger pulse resets the Word Trigger stage through C1227. Pin 13 of U1227B goes LO to enable 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 stages 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 stage to the next word. When the next Trigger pulse is received at pin 15, the Time-Slot Counter stage returns to the normal sequence of operation and produces an output on the time-slot 1 line.

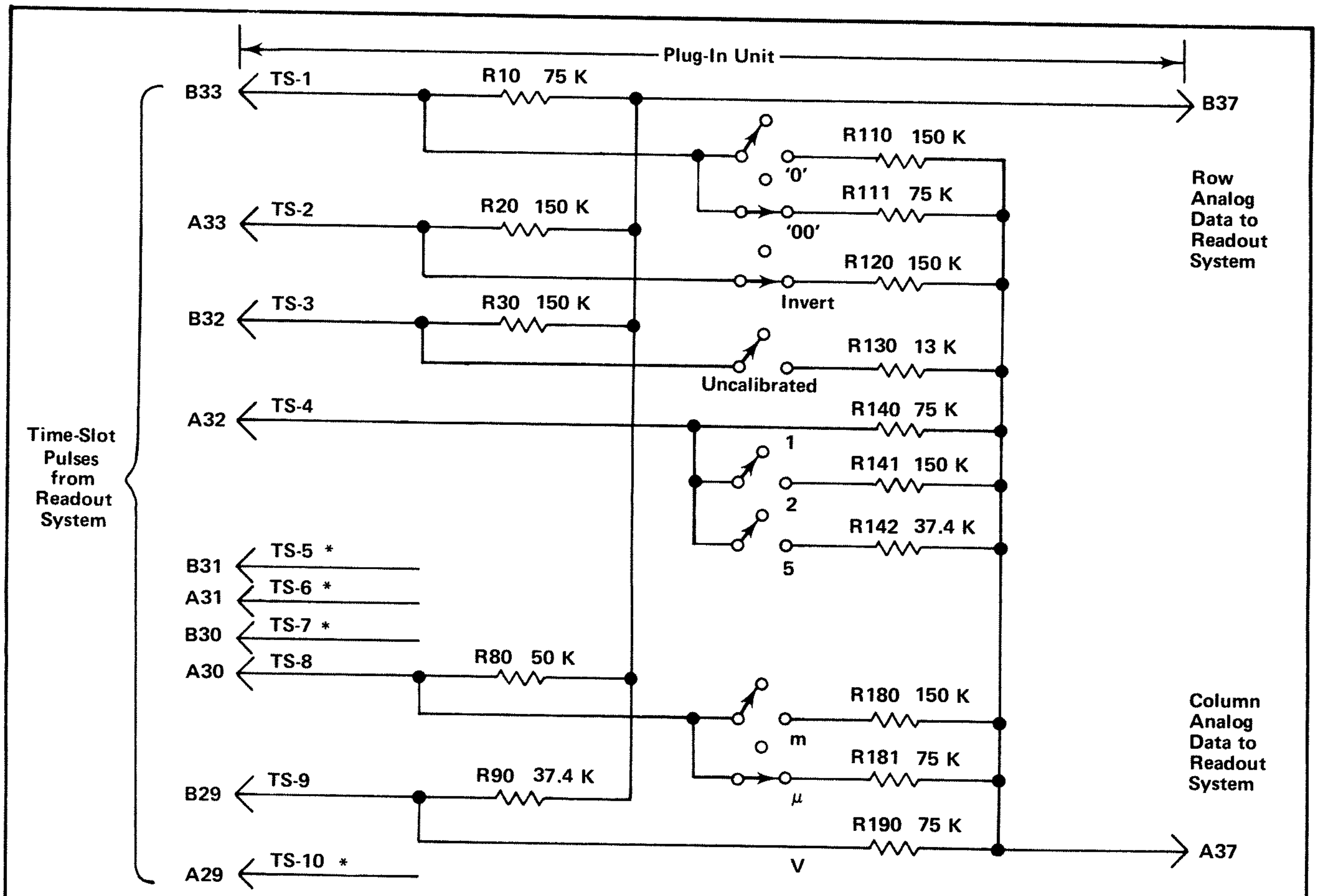
Channel Counter

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 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. 3-37). 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 3-44 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. 3-44 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. 3-45A 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



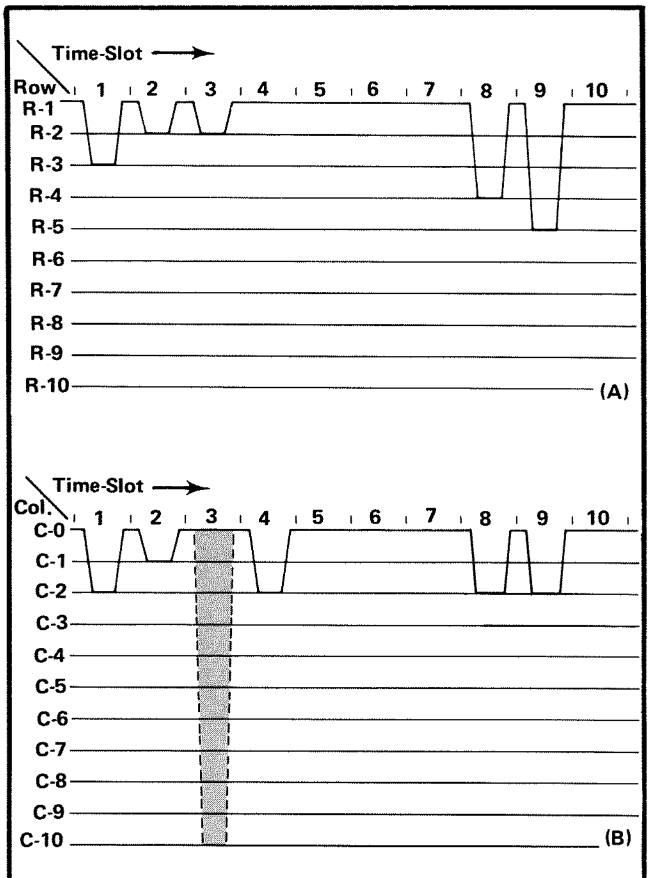
*Not used in standard format.

Fig. 3-44. Typical encoding scheme for voltage-sensing amplifier plug-in unit. Coding shown for deflection factor of 100 microvolts.

left-hand side of the waveform correspond to the rows in the Character Selection Matrix shown in Figure 3-37. 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. 3-44 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. 3-45B 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 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 μ prefix in the Character Selection Matrix. The final data output is provided from time-slot 9 by R190 connected to the column output and R90 to the row 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 ↓ 100 μV.

In the above example, the row analog data was programmed to define which row of the Character Selection Matrix was addressed to obtain information in each time-slot. The



Program for 100 μV, inverted, calibrated (uncalibrated operation shown by shaded area)

Fig. 3-45. Idealized current waveforms of: (A) Row analog data, (B) Column analog data.

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. 3-45B). 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 μV. 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. 3-44, 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. 3-44), 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 the 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).

In addition to the data inputs from the plug-ins, channel-inhibit inputs are provided from each of the plug-in units. 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 by-pass 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.

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	Φ	Φ	Φ	IDENTIFY

Φ = Has no effect in this case.

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 Q1143 so its base is about at +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 output. The size of the character which will be displayed on the CRT is determined 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 13) 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. 3-46. Typical output waveforms for the five possible input conditions that can occur are shown in Fig. 3-47. 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, or 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

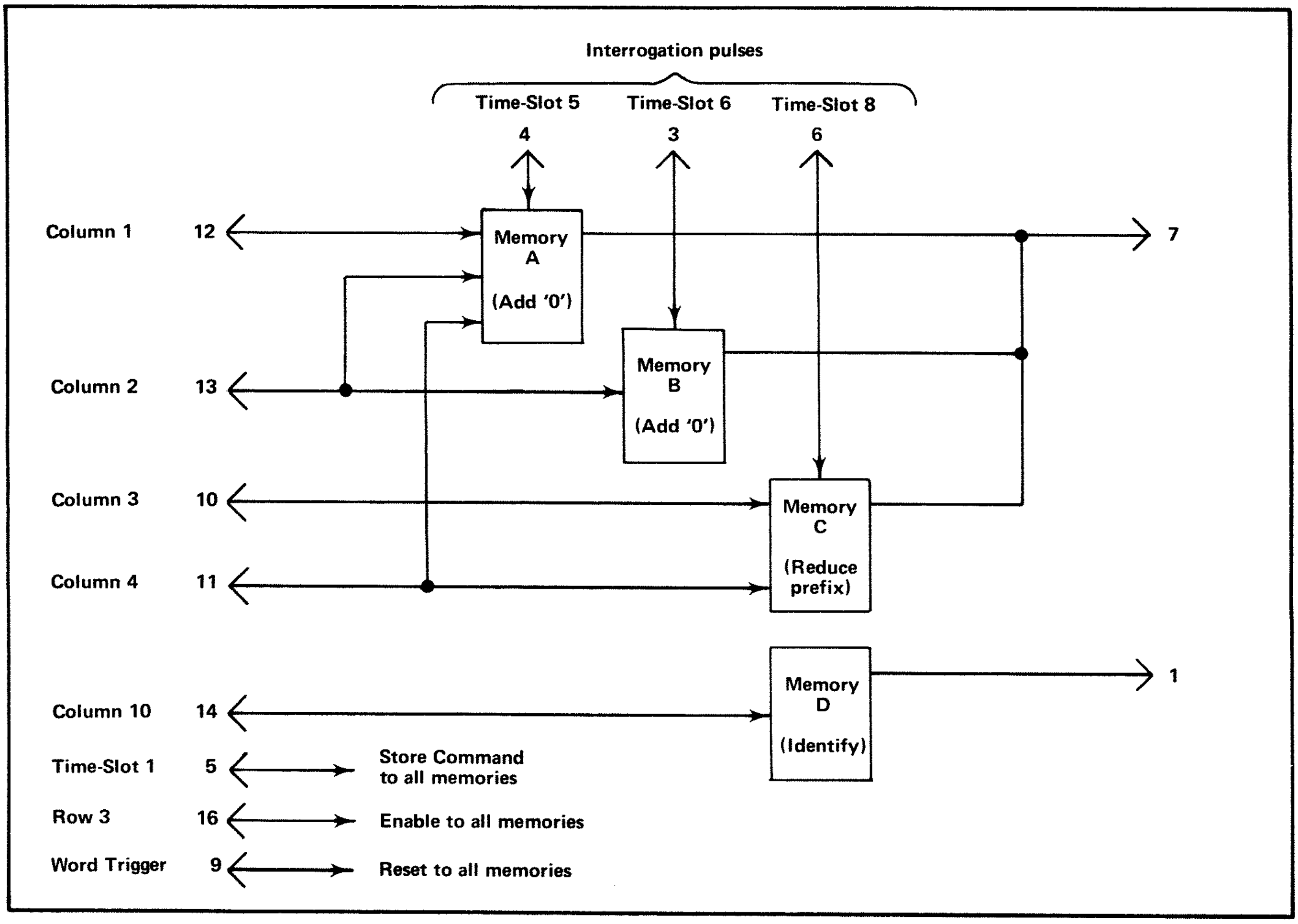


Fig. 3-46. Block representation of memory sequence in U1190.

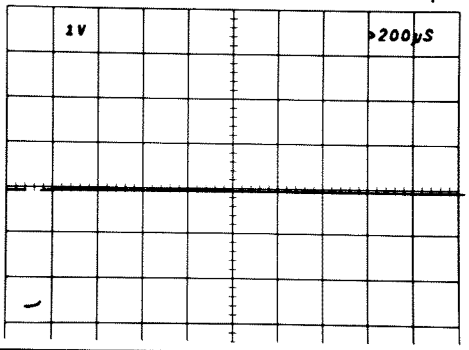
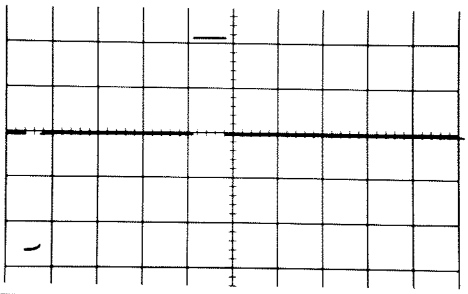
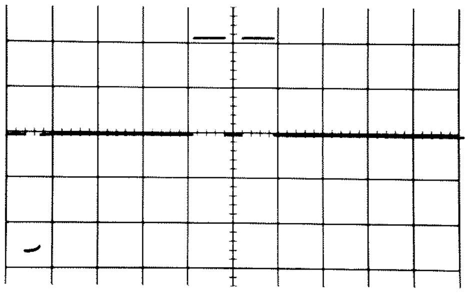
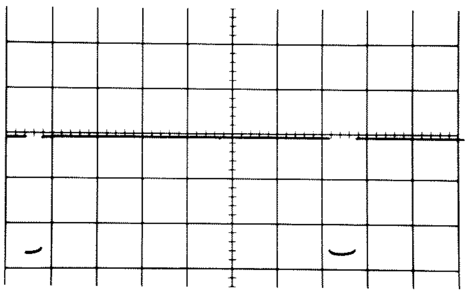
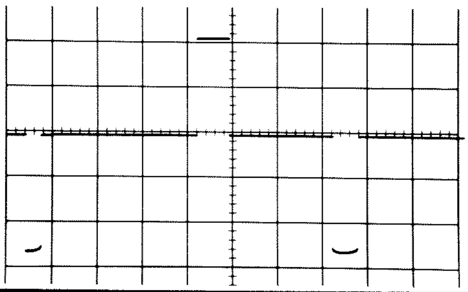
Input Pin of U1190 Activated	Command	Time-Slots
14	IDENTIFY	TS-1 TS-2 TS-3 TS-4 TS-5 TS-6 TS-7 TS-8 TS-9 TS-10  0 V
12	Add one zero	 0 V
13	Add two zeros	 0 V
10	Decrease prefix	 0 V
11	Decrease prefix and add one zero	 0 V

Fig. 3-47. Typical output waveforms for Zeros Logic and Memory Stage operation (at pin 7 of U1190).

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. 3-37 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 μV program shown in Fig. 3-44, 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 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. 3-37). 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, <, μ, 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 μ 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. 3-37). 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. 3-48). For example, if column 3 and row 7 are encoded during time-slot 1, the system is instructed to place a decimal point in location #3. As shown in Fig. 3-48, this displays a decimal point before the third character that can be displayed on CRT (first three time-slots produce a space whether data is encoded or not; see previous paragraph). The simultaneous Format Generator stage through R1269 raises the decimal point so it appears between the displayed characters.

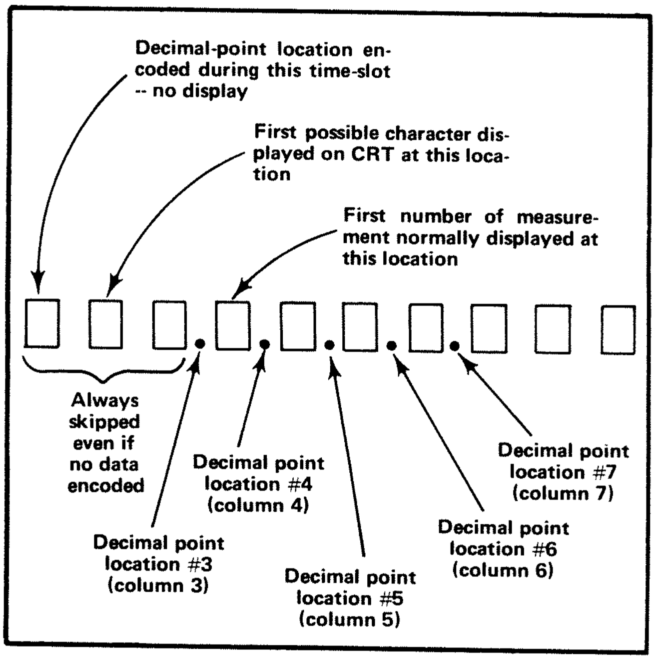


Fig. 3-48. Readout word relating 10 possible character locations to the decimal-point instructions that can be encoded, and the resultant CRT display.

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. 3-36). 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 (coincident with the Vertical/Horizontal Channel Switch OFF command) activates this stage so it can produce the output for the Readout System.

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

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 providing 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 similar 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. 3-49 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.

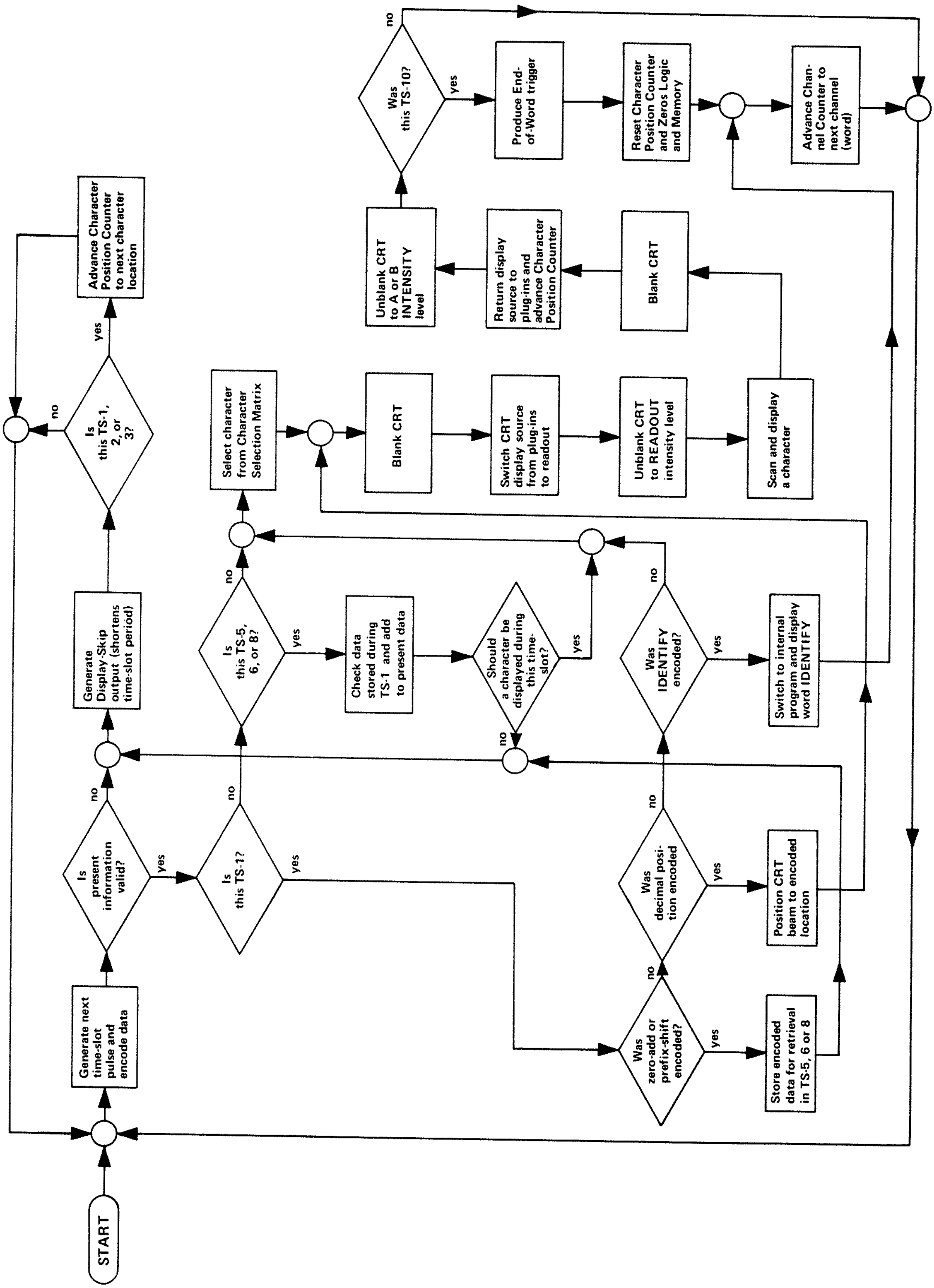


Fig. 3-49. Flow chart for character generation by the Readout System.

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 Type 7504.

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 Type 7504 are held in place by four slotted fasteners. To remove the panels, turn each fastener couterclockwise 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 and High Voltage/Z-Axis Amp 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 Type 7504 to gain better access to the Logic, Power Interface 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 five 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.

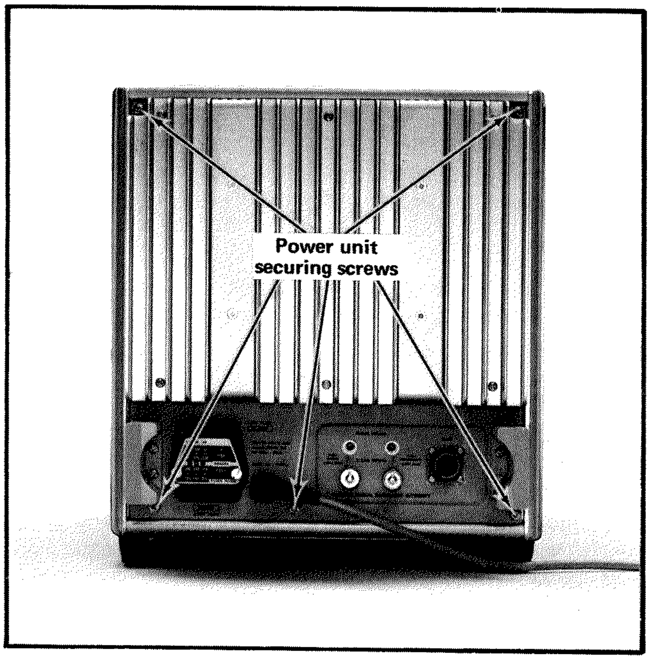


Fig. 4-1. Securing screws for power unit (rear of instrument).

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 Type 7504 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

General. The Type 7504 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. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Exterior. Loose dust accumulated on the outside of the Type 7504 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 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 Type 7504 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 Type 7504 are not recommended. The best check of semiconductor performance is actual operation in the instrument. More details on checking semiconductor operation are given under troubleshooting.

Recalibration

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

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 200 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 Type 7504. 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.

TABLE 4-1

Component Numbers

Component numbers on diagrams	Diagram numbers	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, 350-399	6	X-Y Delay Compensation and Horizontal Interface
500-599	7	Horizontal Amplifier
600-699	8	Output Signals and Calibrator
700-799	9	Z-Axis Amplifier and CRT Circuit
800-999	10	Low-Voltage Rectifiers
	11	Low-Voltage Regulators
1000-1099	12	Front-Panel Controls and Cabling
1200-1249	13	Sequencing Logic
1100-1199	14	Data Collection
1250-1299	15	Character Generators and Output

Troubleshooting Aids

Diagrams. Complete circuit diagrams are given on foldout 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 Type 7504 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. The contacts of the cam-type 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. 4-7 through 4-22 show the circuit boards used in the Type 7504. Fig. 4-6 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 Type 7504 is color-coded to facilitate circuit tracing. Table 4-2 gives the wiring color-code used in the Type 7504.

TABLE 4-2

Wiring Color-Code

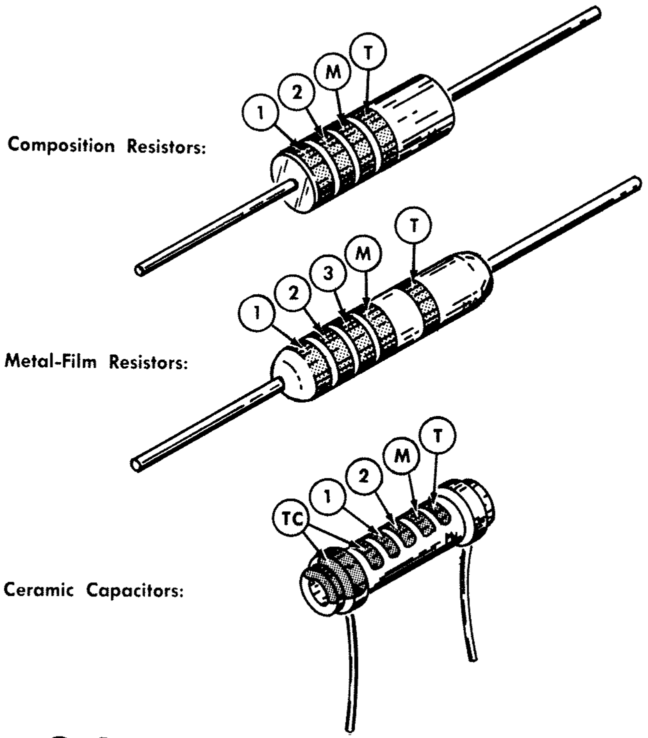
Supply or Function	Background Color	Stripe[1]
−50 volt	Violet	Brown
−15 volt	Violet	Black
+5 volt	Red	Black
+15 volt	Red	Brown
+50 volt	Red	Orange
+75 volt	Red	Yellow
+150 volt	Red	Green
Chassis ground	Black[2]	Footnote[3]
Safety ground	Green	Yellow
AC (internal)	Gray[2]	Footnote[4]
Bulb filaments	Brown	Footnote[4]
Signal leads	White[2]	Footnote[4]

[1] If more than one stripe appears on lead, extra stripes are for lead identification only (for circuit tracing).

[2] See WARNING note concerning power-cord color-code.

[3] White stripe indicates floating (signal)ground.

[4] All stripes for lead identification only (for circuit tracing).



1 2 and 3 —1st, 2nd and 3rd significant figures;

M —multiplier; T —tolerance;

TC —temperature coefficient.

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier		Tolerance	
		Resistors	Capacitors	Resistors	Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^{2}	10^{2}	±2%	±2%
Orange	3	10^{3}	10^{3}	±3%	±3%
Yellow	4	10^{4}	10^{4}	±4%	+100% −0%
Green	5	10^{5}	10^{5}	±0.5%	±5% or 0.5 pF*
Blue	6	10^{6}	10^{6}	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

NOTE: T and/or TC color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-2. Color-code for resistors and ceramic capacitors.

WARNING

This color code applies to leads within the Type 7504 only. Color code of the AC power cord is:

Black	*Line*
White	*Neutral*
Green	*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 Type 7504. 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 Type 7504 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.

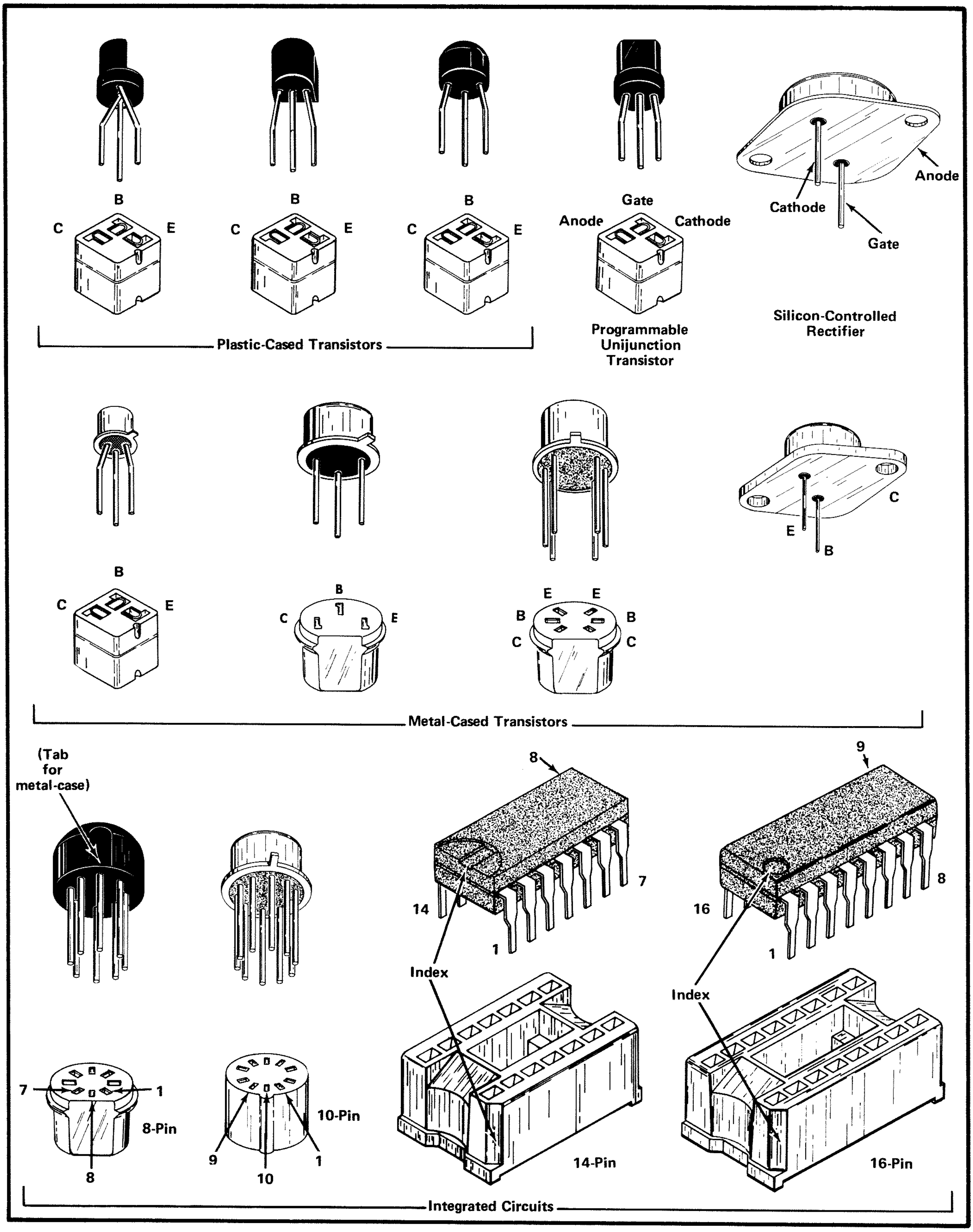


Fig. 4-3. Electrode configuration for semiconductors in this instrument.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 7504.

1. Transistor Tester

Description: Tektronix Type 576 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

2. Multimeter

Description: VTVM, 10 megohm input impedance and 0 to 500 volts range; 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: DC to 50 megahertz frequency response, 50 millivolts to 50 volts/division deflection factor. A 10X probe should be used to reduce circuit loading.

Purpose: To check waveforms in this instrument.

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 Type 7504, 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 Type 7504 is defective.

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 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 LV Regulator board; see Section 5 for test point location) to the ground test point on this board. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedure given in the Calibration section to adjust the power supplies.

TABLE 4-3

Power Supply Tolerance and Ripple (Referenced to TP GND)

Power Supply	Test point	Tolerance	Maximum ripple (peak-to-peak)
−50 volt	TP −50	±0.10 volts	Five millivolts
−15 volt	TP −15	±0.75 volts	Two millivolts
+5 volt	TP +5	±0.15 volts	Two millivolts
+15 volt	TP +15	±0.30 volts	Two millivolts
+50 volt	TP +50	±0.60 volts	Five millivolts
+75 volt	TP +75	±2.25 volts	200 millivolts
+150 volt	TP +150	±6.0 volts	300 millivolts

Fig. 4-4 provides a guide for locating a defective circuit. This chart does not include checks for all possible defects; use steps 6 and 7 in such cases. Start from the top of the chart and perform the given 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.

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.

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 Type 7504. 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 its 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.

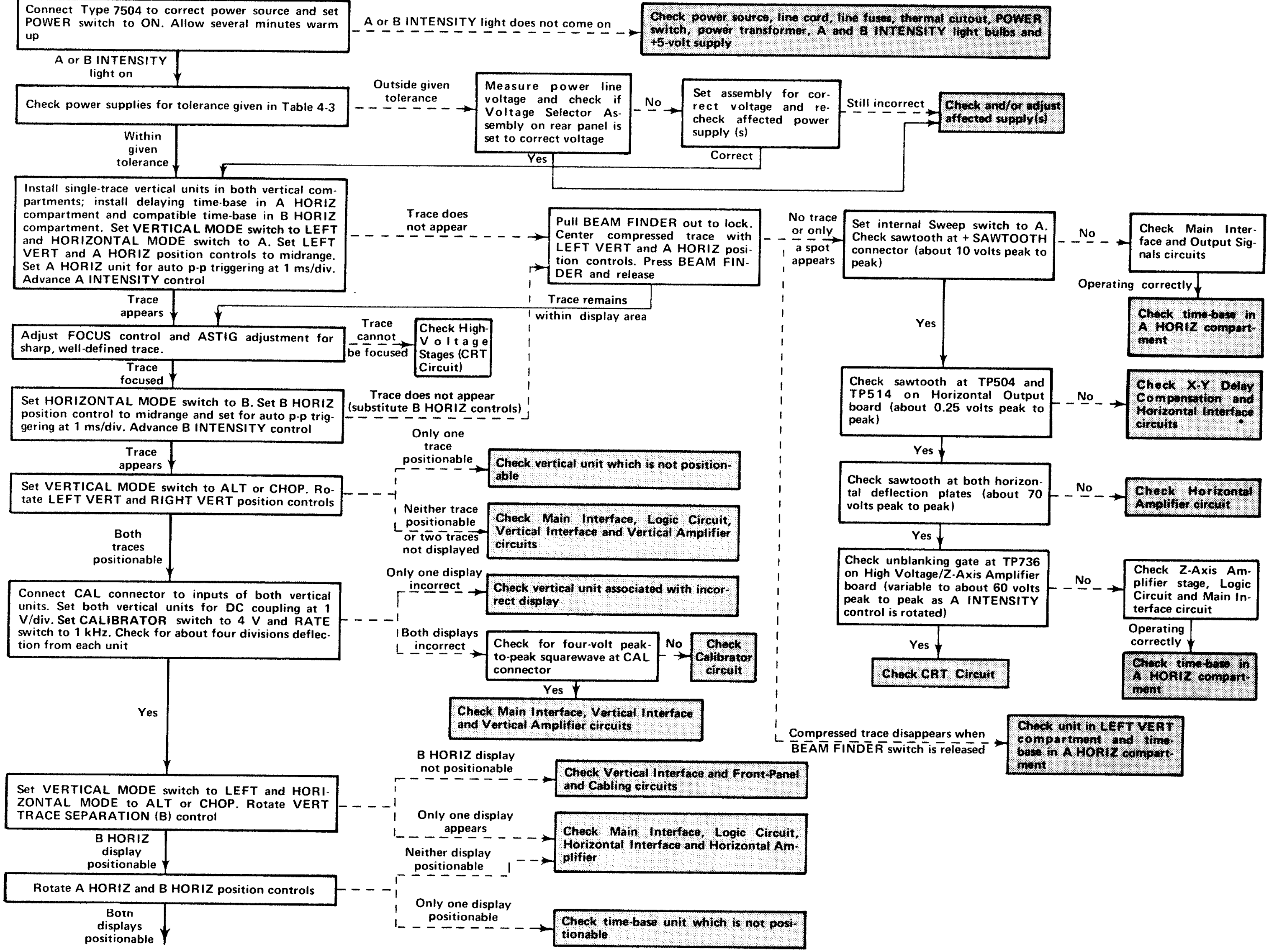
C. RESISTORS.

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).

CIRCUIT ISOLATION TROUBLESHOOTING CHART



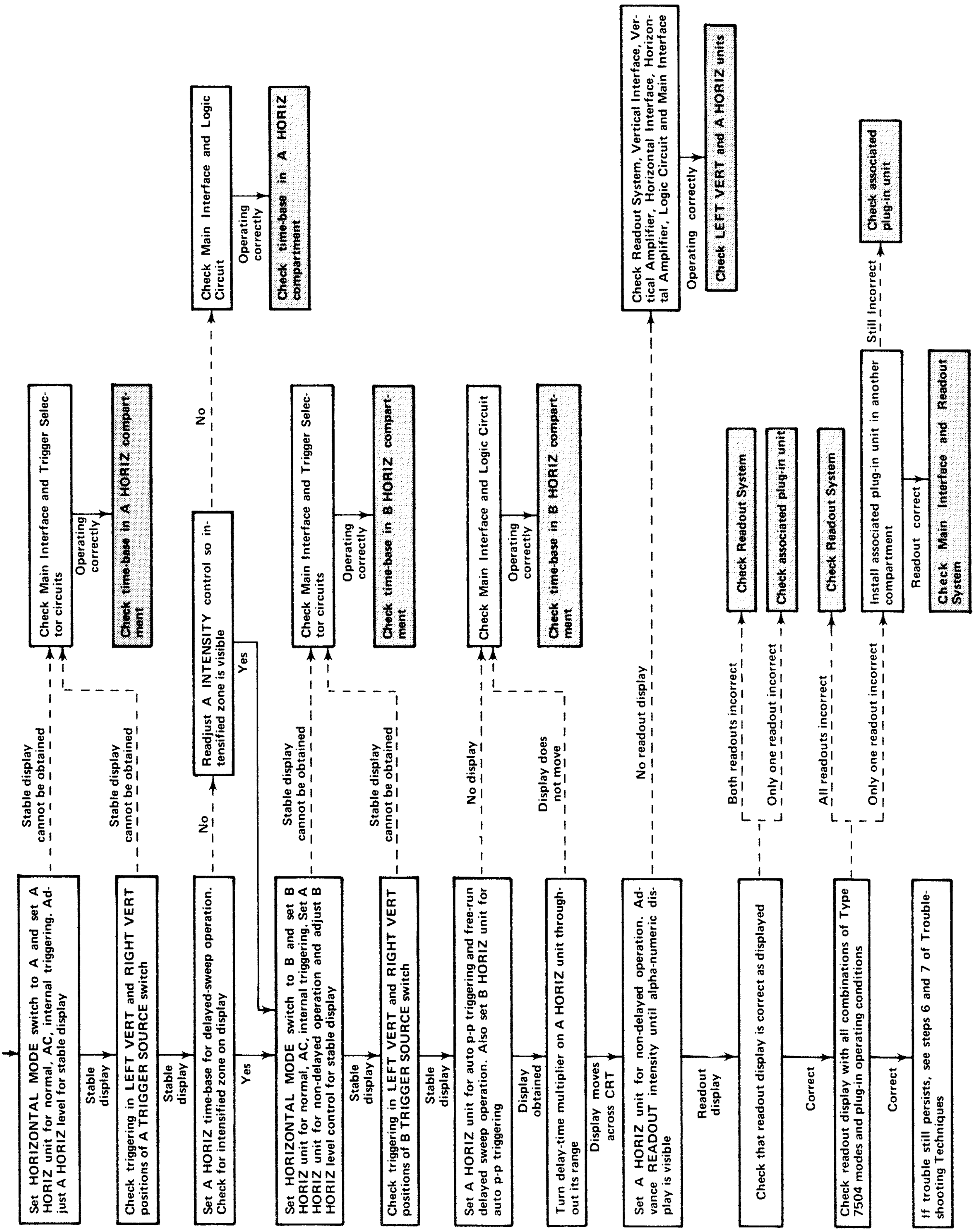


Fig. 4-4. Troubleshooting chart for Type 7504.

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 7504. 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 Readout System. The following procedure provides a guide to troubleshooting the Readout System of the 7504.

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 7504 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 7504 POWER switch to ON and allow a warmup 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 then 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 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 U1266 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 Type 7504 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 Type 7504. 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 board. Insert the leads into the holes in the boards 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 (Figs. 1 through 5, located on back of diagram pullout pages) may be helpful in the removal or disassembly of individual components or subassemblies.

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-on the chassis or other circuit boards (exceptions; Main Interface, Calibrator, 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 have properly mated.

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. 4-7 and 4-8.

C. RECTIFIER BOARD REMOVAL.

To remove the Rectifier board, proceed as follows:

1. Remove the two screws which hold the Rectifier board to the chassis.

2. Remove the screws which mount the two rectifier assemblies to the chassis.

3. Disconnect all of the pin connectors and the two multi-pin connectors from the Rectifier board.

4. To replace the Rectifier 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 Fig. 4-20.

D. 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.

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.

Access to Power Transistors. Some of the power transistors associated with the Low-Voltage Power Supply are mounted on the heat radiator at the rear of this instrument. To gain access to these transistors, remove the two Phillips-head screws which secure the protective aluminum strips to the heat radiator. The transistors are mounted in sockets so they can be removed from the rear by taking out the two screws in the mounting tabs (cases elevated above chassis). To replace the sockets or wiring, take out the six screws which hold the heat radiator to the rear of the power-unit.

NOTE

After replacing a power transistor, check that the collector is not shorted to ground before applying power.

To replace a power transistor mounted on the swing-down chassis, first remove the LV Power 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 LV Regulator Board to align the transistor with the sockets in the board. Remove the board and tighten the mounting screws.

Interconnecting Pin Replacement. Two types of interconnecting pins are used in the Type 7504 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 the end-lead pin connector(s) from the pin. Then pull the damaged 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 pin replacement kit including necessary tools, instructions and replacement pins is available from Tektronix, Inc. 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. Then 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 re-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 if 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 plastic CRT mask, light filter and metal light shield.

3. 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.

4. Press inward on the white tabs on the graticule-light assembly and pull the assembly out of the CRT bezel (leave wires connected).

5. 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.

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

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

8. 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.

9. 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 if firmly. Guide the anode lead through the cutout in the bulkhead and 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 shield and the bulkhead. 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-sockets 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.

Switch Replacement. Several different types of switches are used in the Type 7504. 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 avail-

able 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, follow the instructions given in the switch repair kit.

7. To re-install the switch assembly, reverse the above procedure.

B. PUSHBUTTON SWITCHES.

The pushbutton switches are not repairable and should be replaced if defective. Components which are mounted on the circuit board associated with the pushbutton switch can be replaced using the normal replacement procedures. See the information under Light-Bulb Replacement for instructions on replacing the light bulbs. 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 and press on the front-panel pushbuttons to remove the switch from the holder. Fig. 4-5 shows a detailed view of the switch holder.

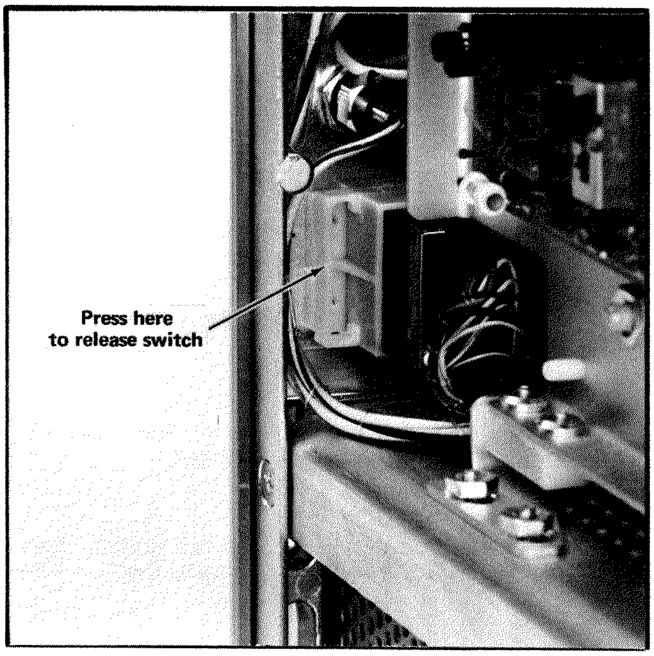


Fig. 4-5. Detailed view of trigger source switch holder (B TRIGGER SOURCE switch shown).

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.

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 instrument. 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.

When removing the transformer, tag the leads with the corresponding terminal numbers to aid in connecting the new transformer. After the transformer has been replaced, check the performance of the complete instrument using the procedure given in the Calibration section.

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. Slide out the power-unit as described previously.

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 clamp which holds the jack portion of the CRT anode connector to the chassis.

5. Disconnect the two multi-pin connectors on the High-Voltage/Z-Axis Amplifier board.

6. Remove the three screws on the rear of the high-voltage compartment and the two screws located at the front by the CRT anode connector.

7. 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).

8. Remove the three screws which hold the plastic cover onto the high-voltage box.

9. Using an insulated shorting strap, discharge the exposed connections to chassis ground.

10. Unsolder the three leads 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.

11. To replace the encapsulated assembly or the plastic high-voltage box, remove the four screws located beneath the High Voltage/Z-Axis Amplifier circuit board (remove board to reach screws).

12. 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	Location	Function
F801	4 A Slow	Voltage Selector Assembly	115-volt line
F802	3 A Slow	Voltage Selector Assembly	230-volt line
F872	7 A Fast	LV Regulator	+5 volts
F901	3 A Fast	LV Regulator	High voltage
F982	0.25 A Fast	LV Regulator	+150 volts

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 the Type 7504 is to be shipped for long distances by commercial means of transportation, it is recommended that the instrument be repackaged in the original manner for maximum protection. The original shipping carton can be saved and used for this purpose. Repackaging information and/or 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.

NOTES

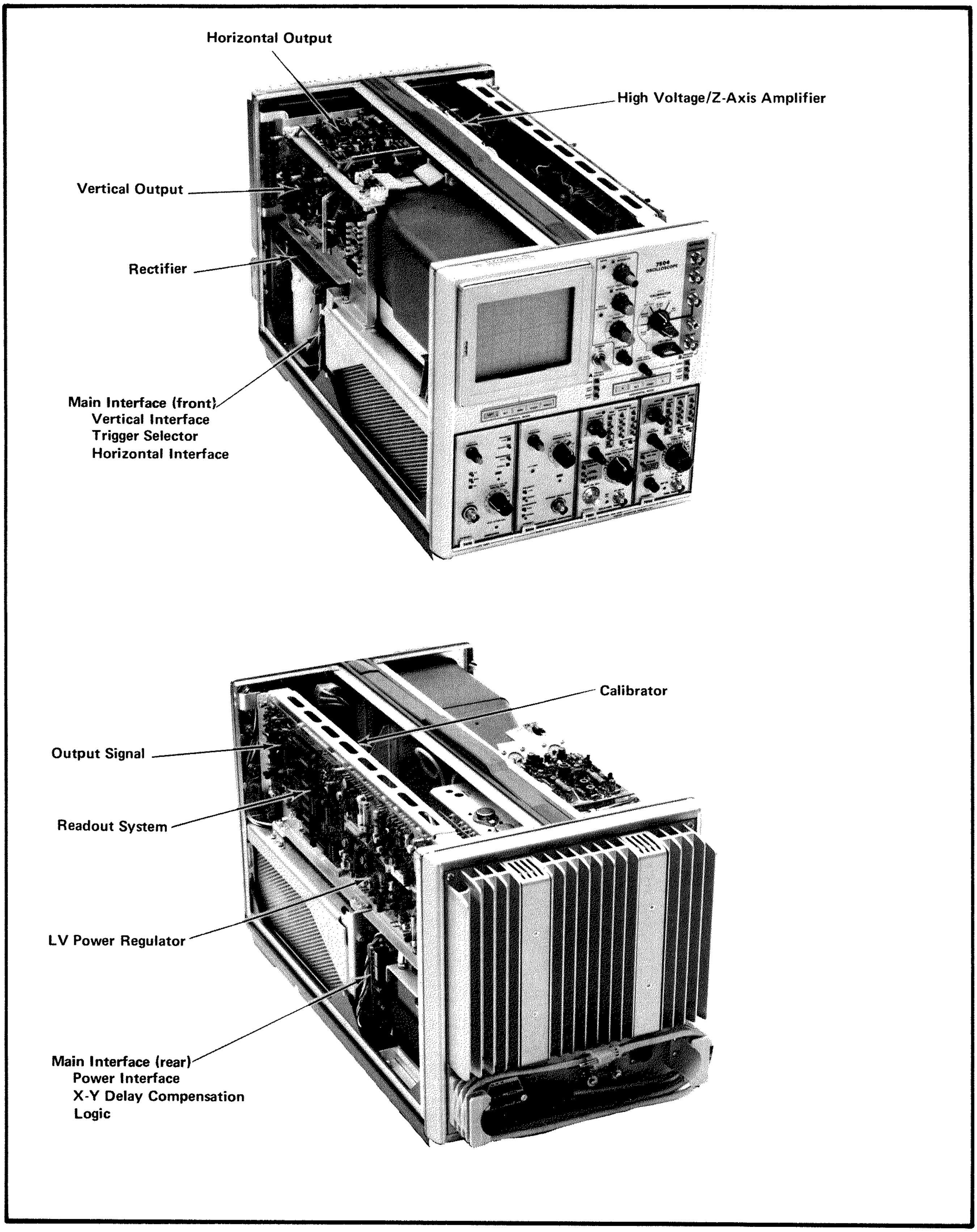


Fig. 4-6. Location of circuit boards in the Type 7504.

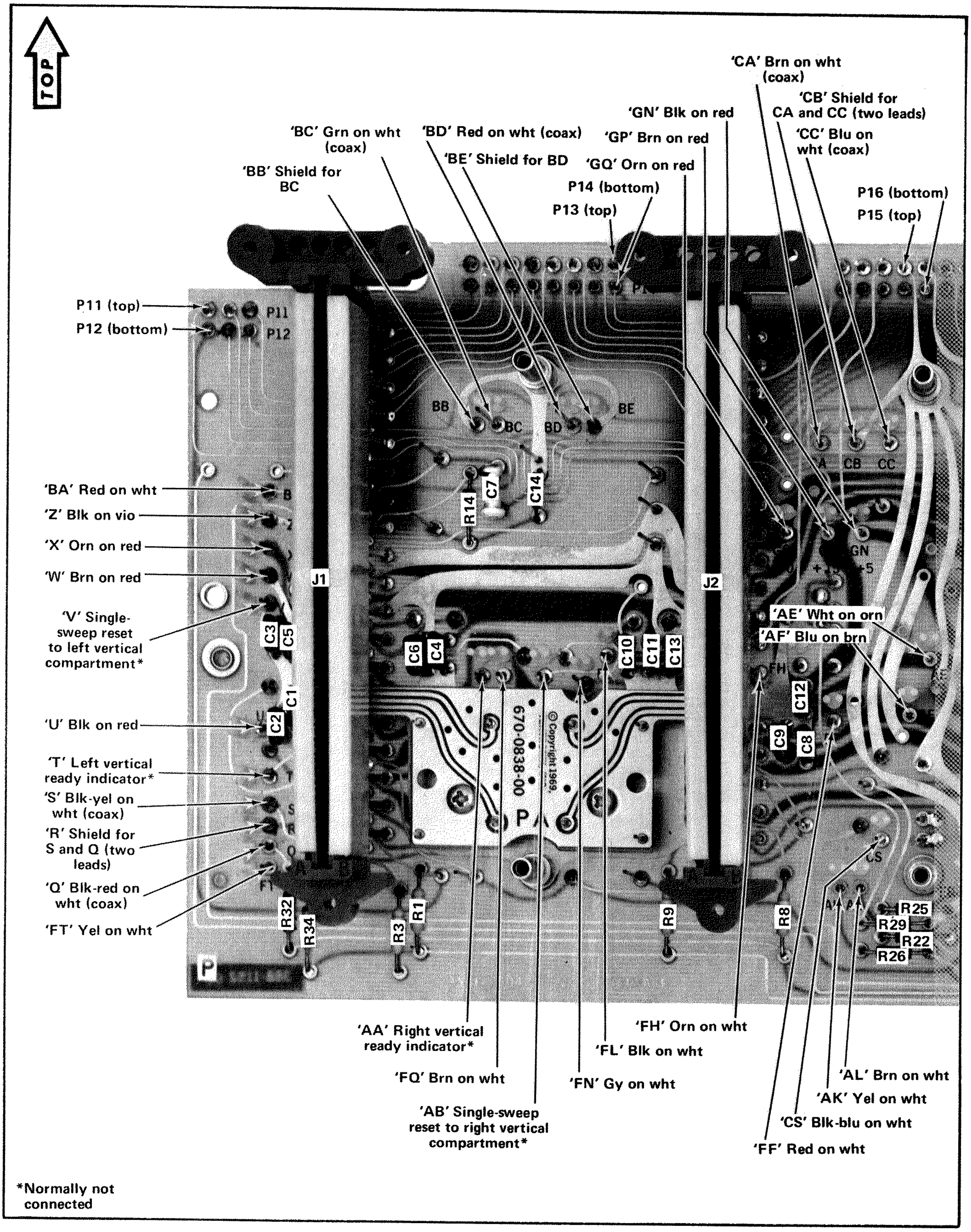


Fig. 4-7. Partial Main Interface circuit board.

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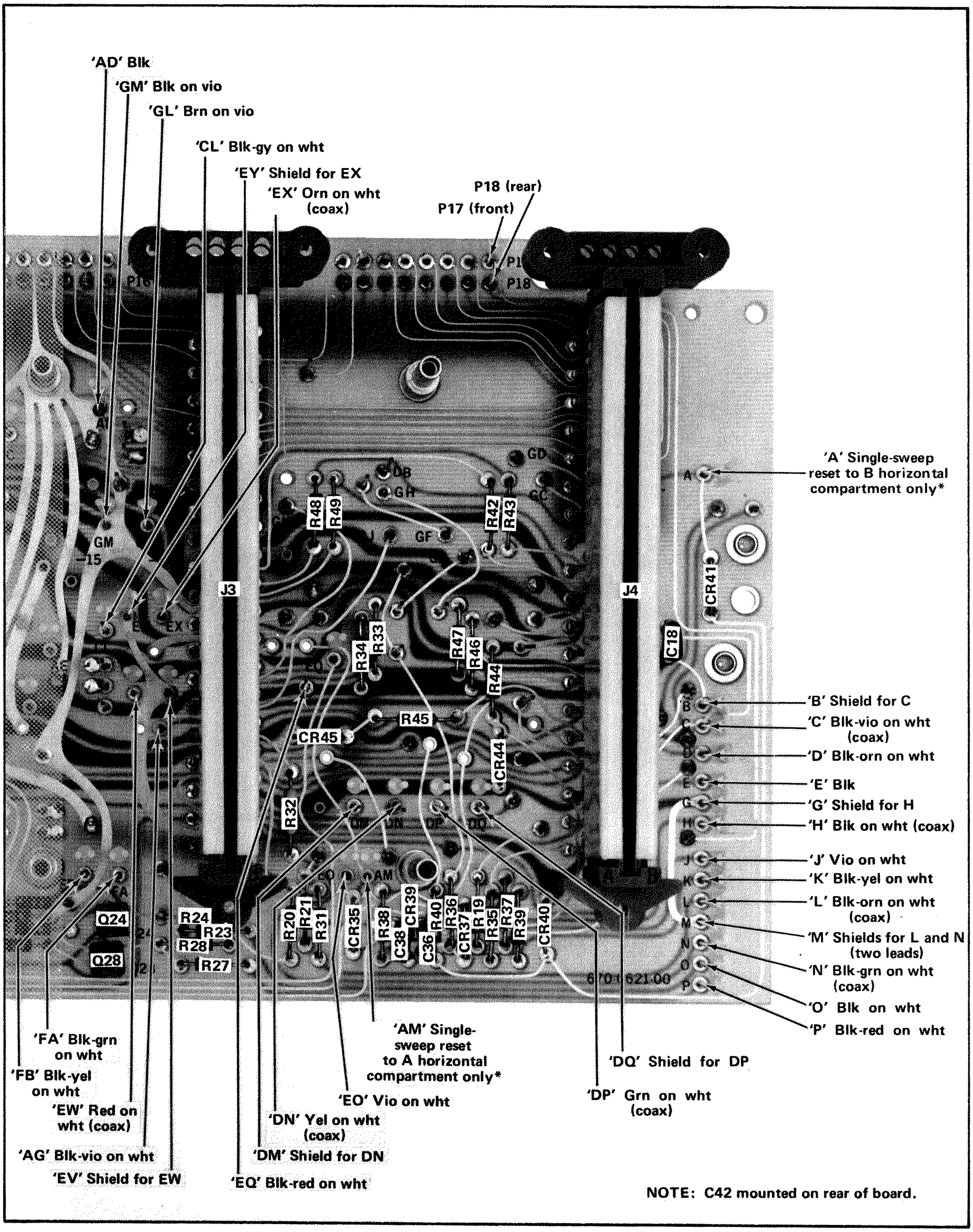

Fig. 4-8. Partial Main Interface circuit board.

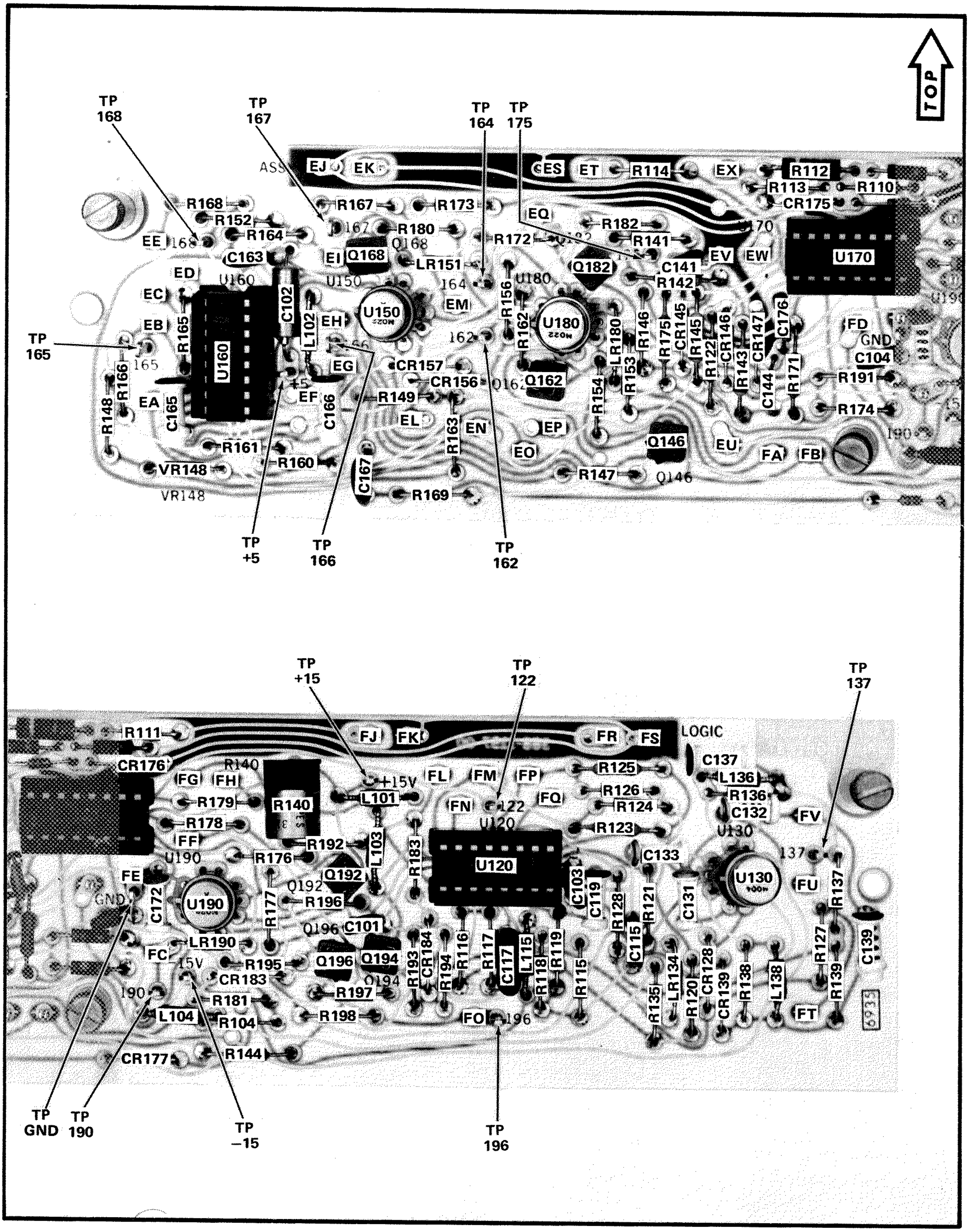

Fig. 4-9. Logic circuit board.

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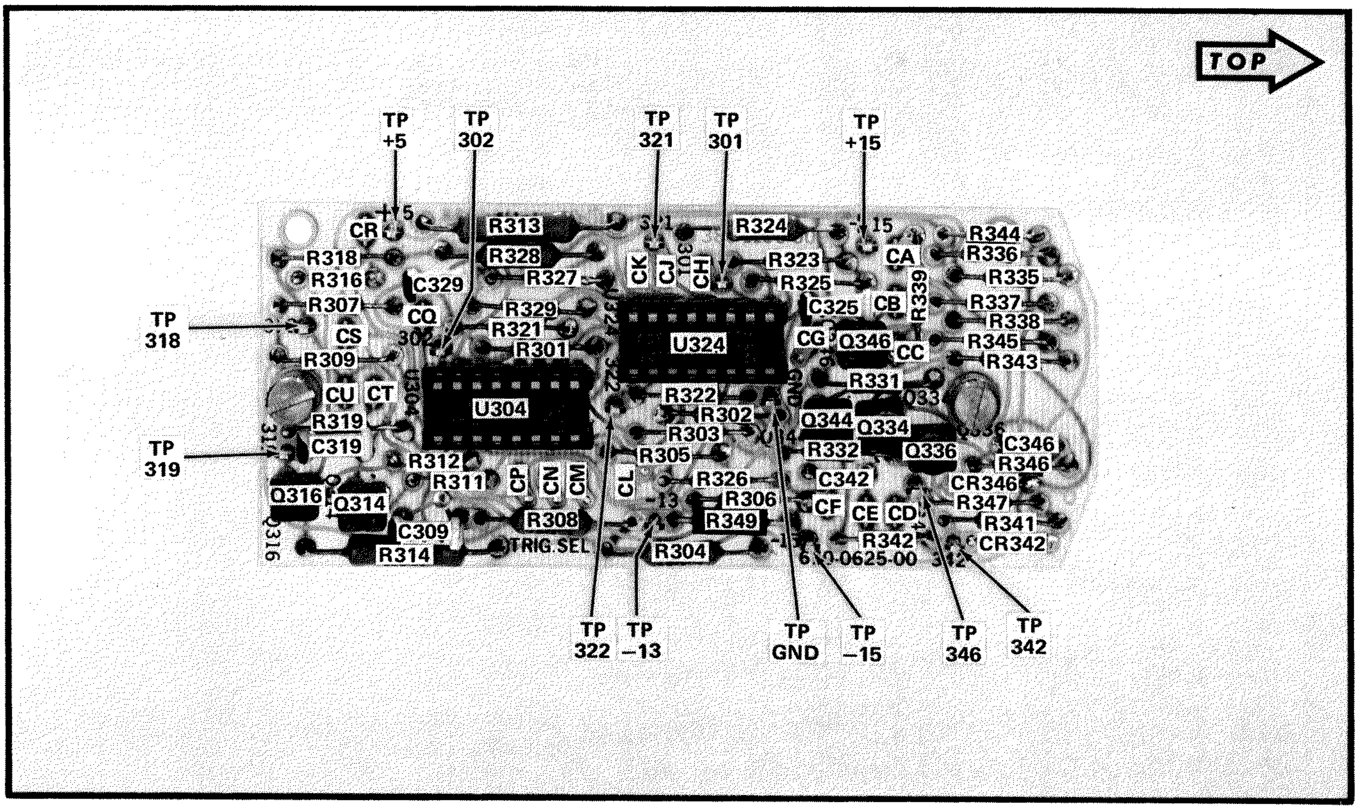


Fig. 4-10. Trigger Selector circuit board.

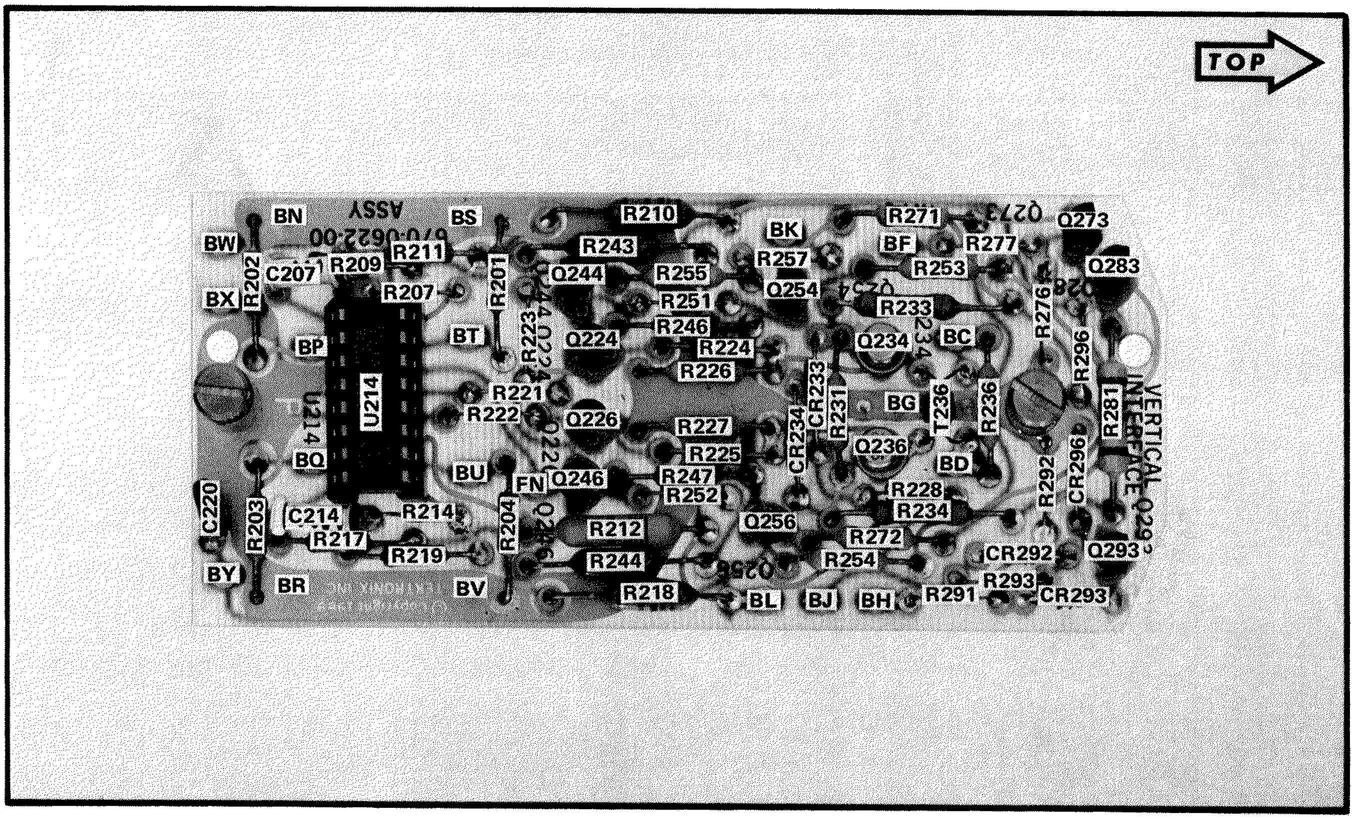


Fig. 4-11. Vertical Interface circuit board.

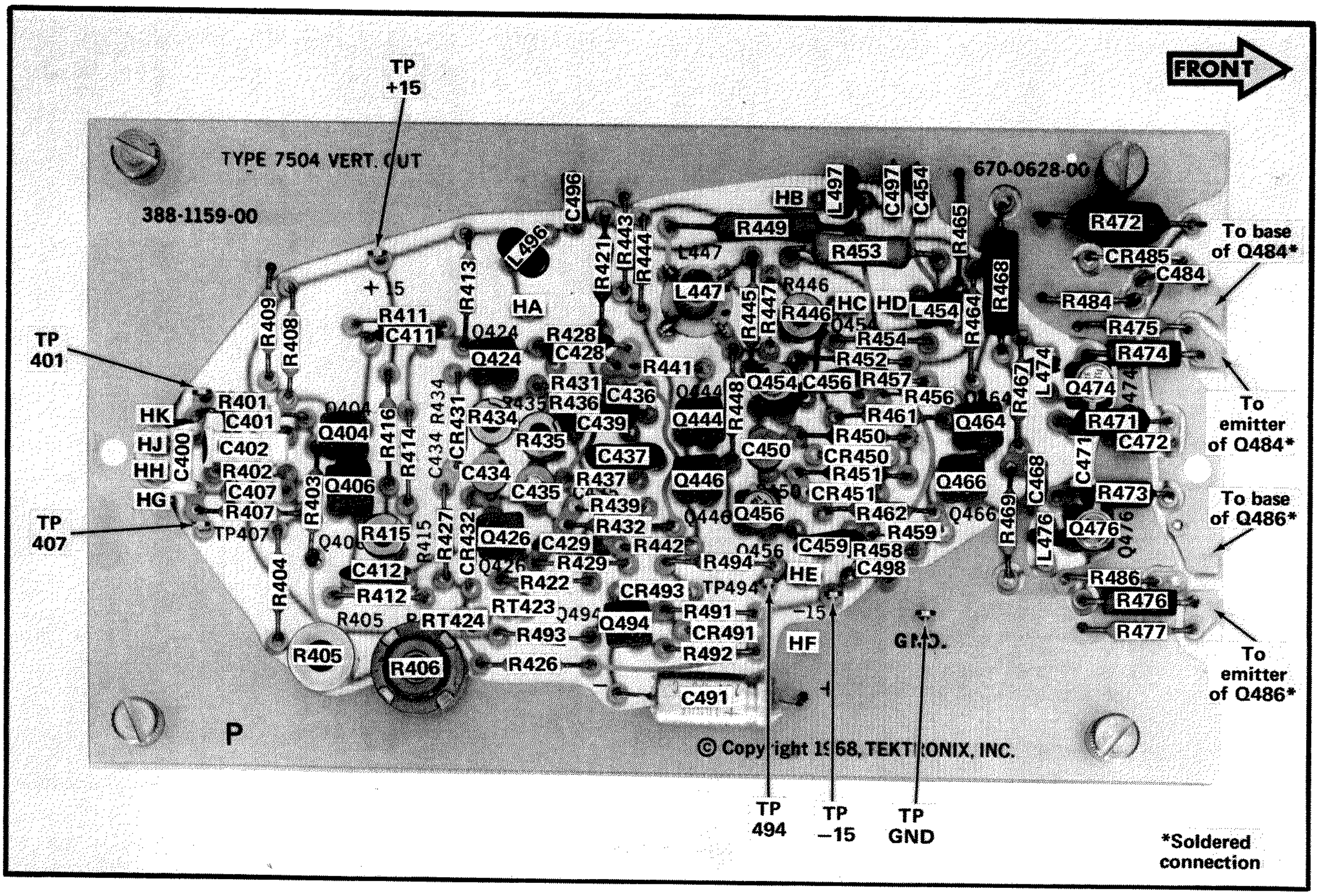


Fig. 4-12. Vertical Output circuit board.

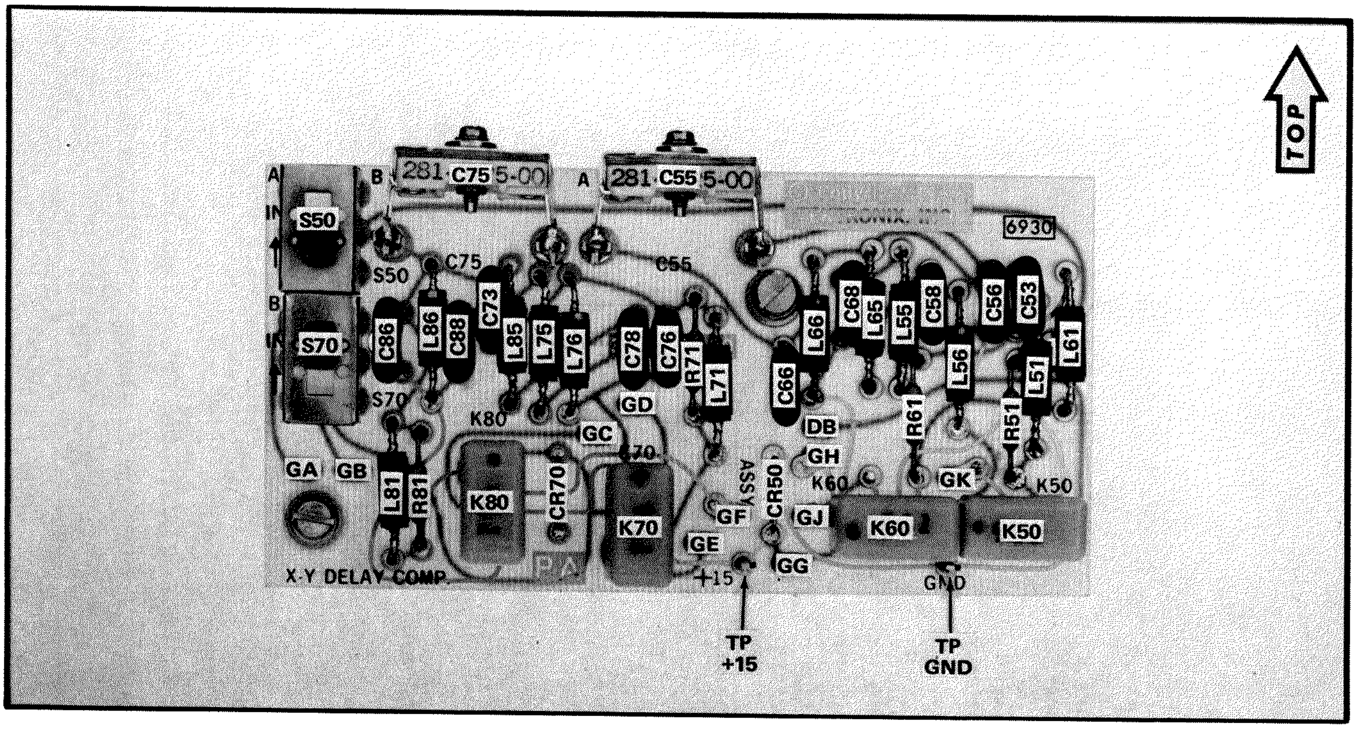


Fig. 4-13. X-Y Delay Compensation circuit board (optional).

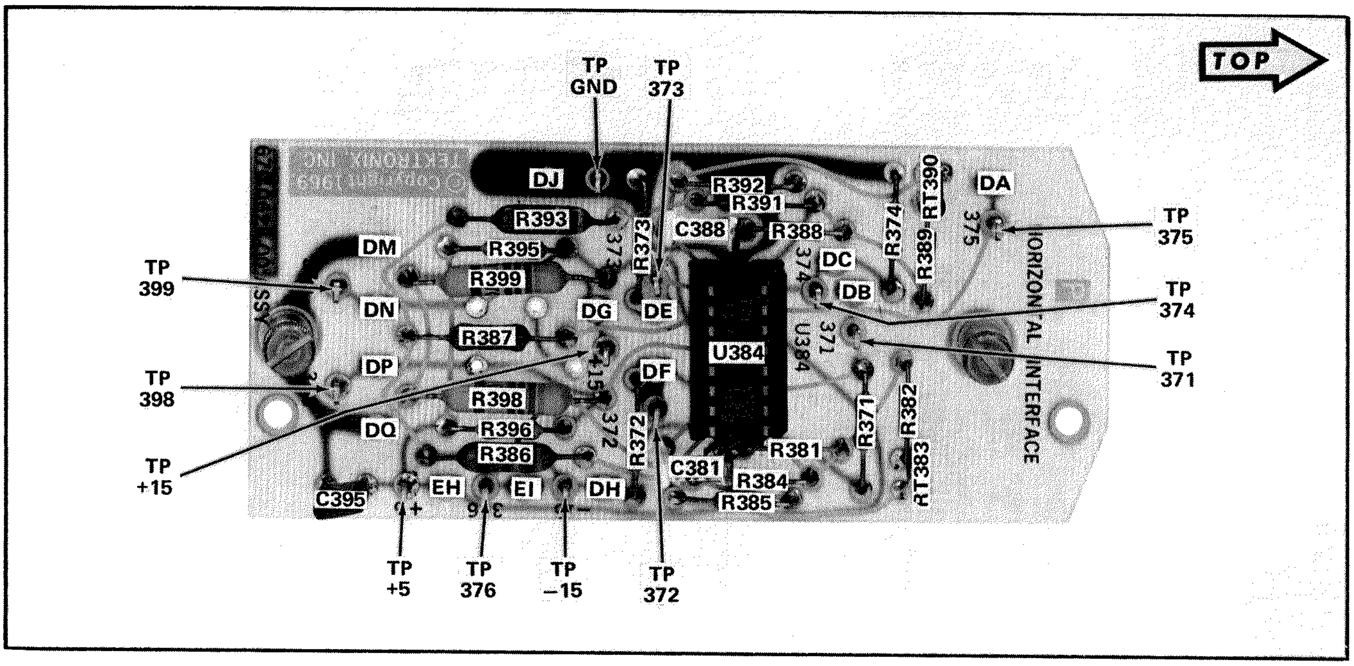
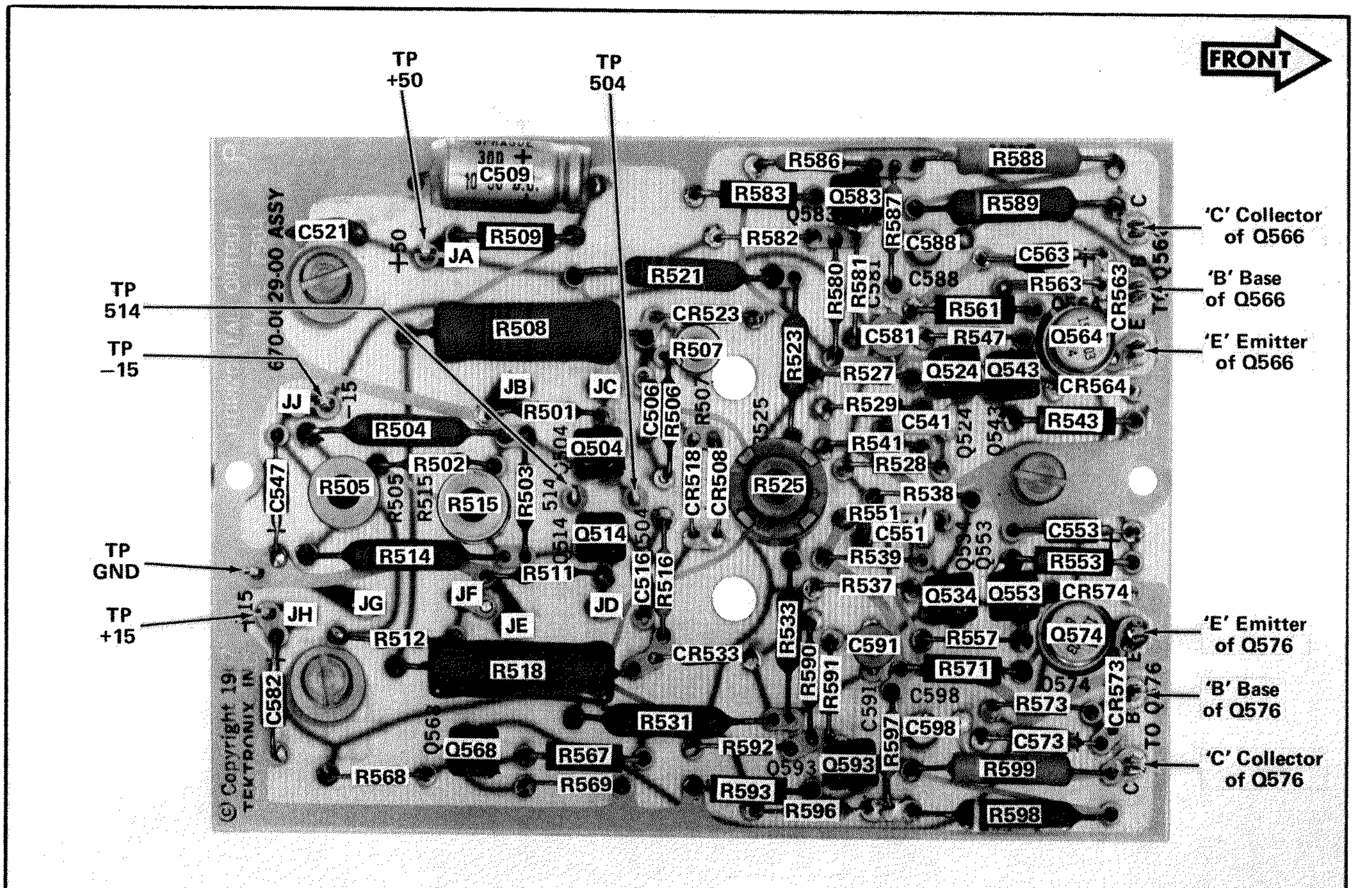


Fig. 4-14. Horizontal Interface circuit board.



NOTE: R578 mounted on rear of board.

Fig. 4-15. Horizontal Output circuit board.

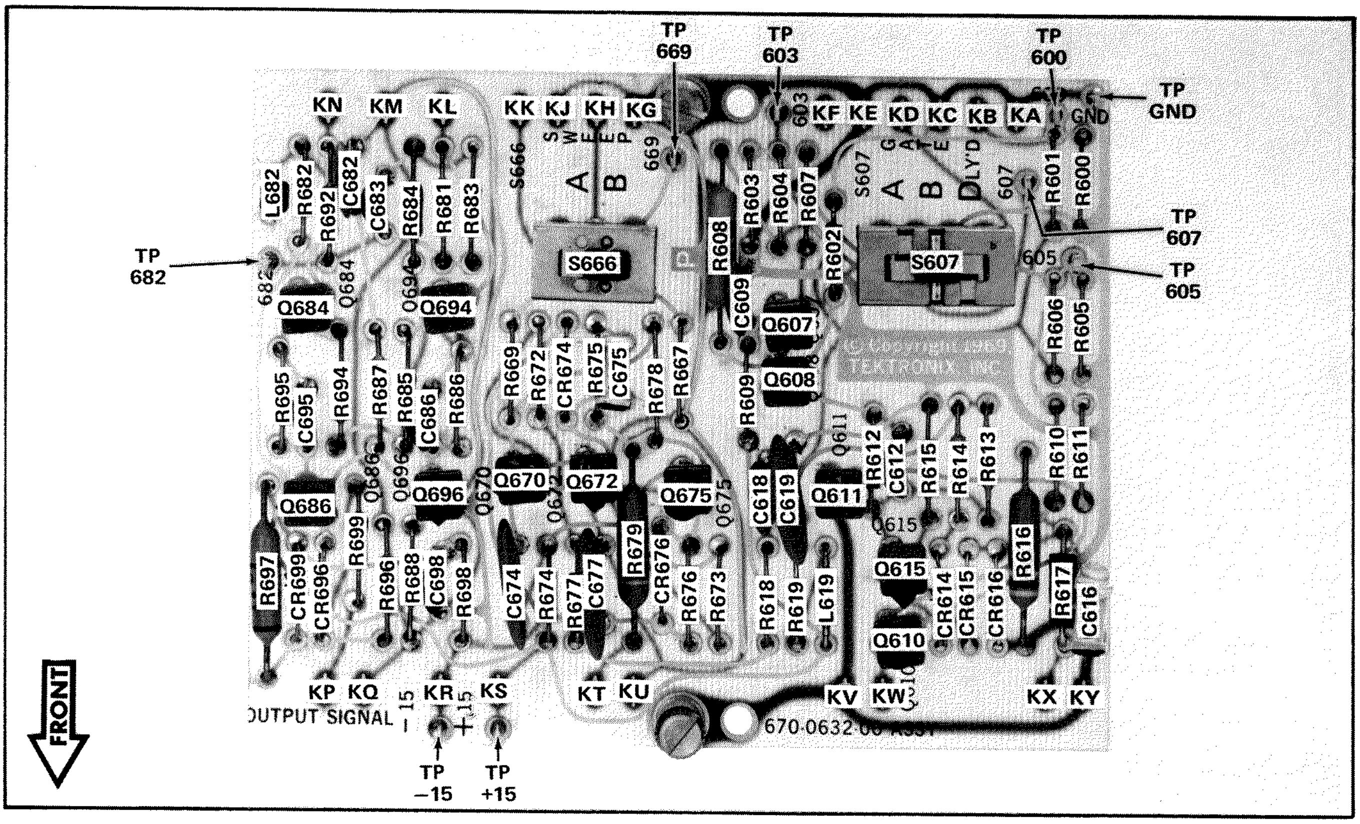


Fig. 4-16. Output Signal circuit board.

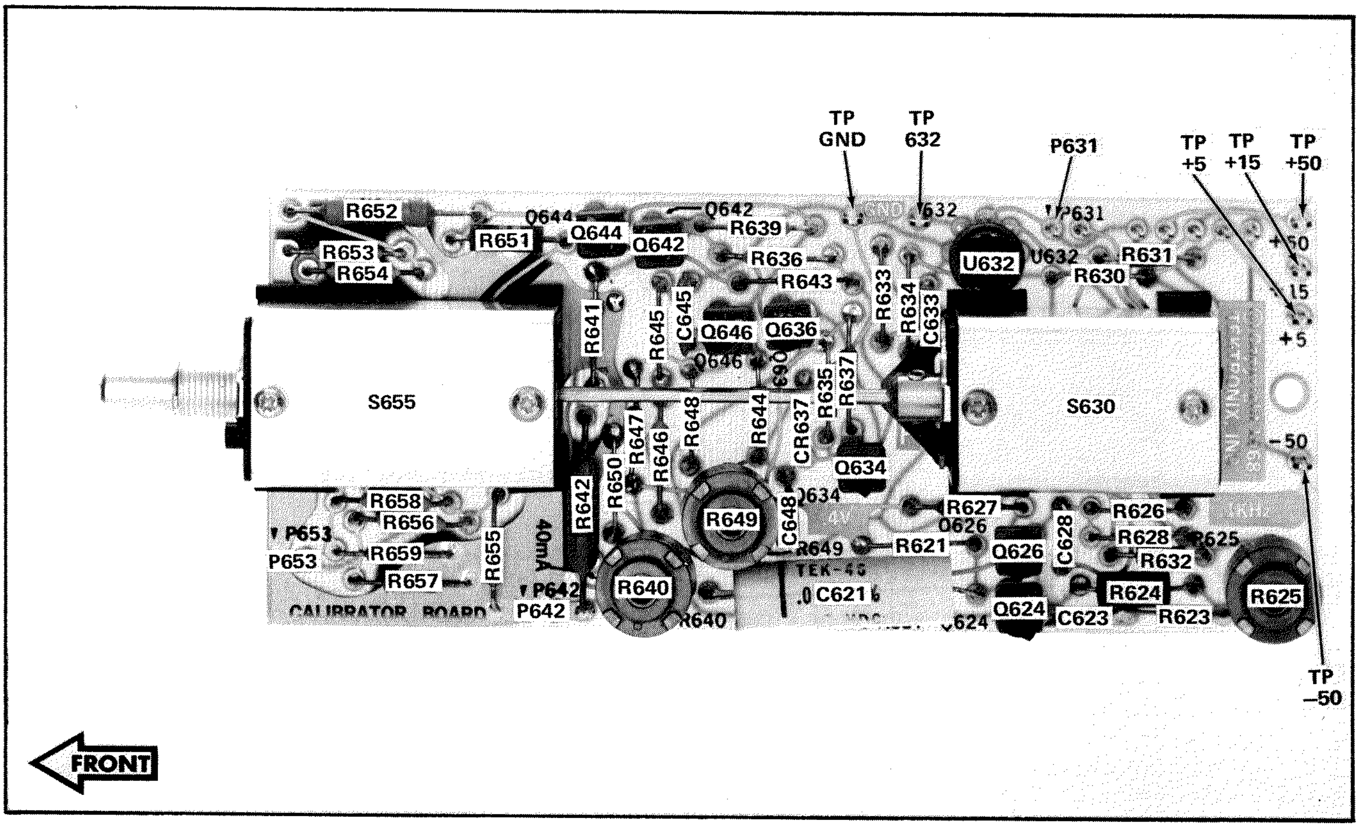


Fig. 4-17. Calibrator circuit board/switch assembly.

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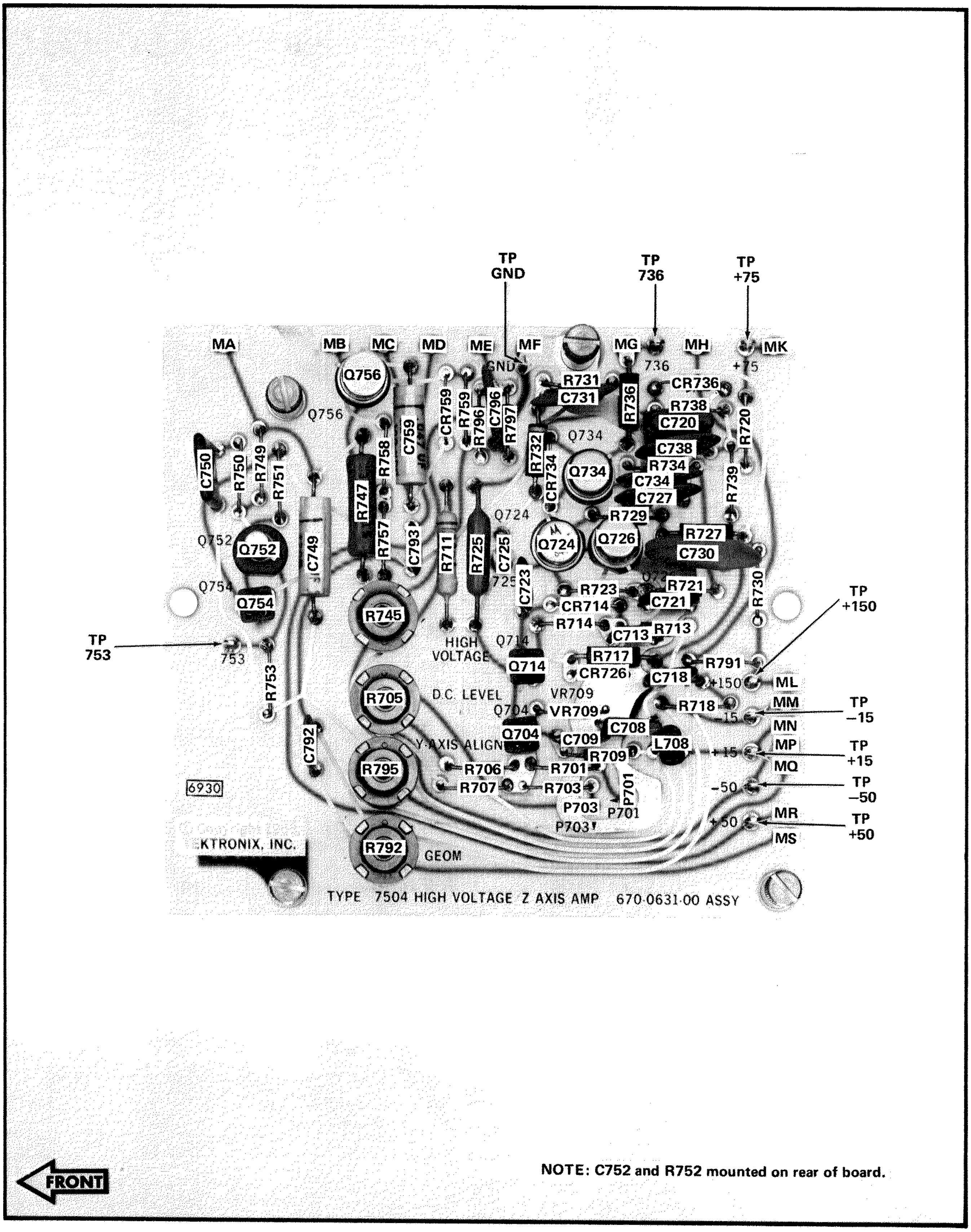

Fig. 4-18. High Voltage/Z-Axis Amplifier circuit board.

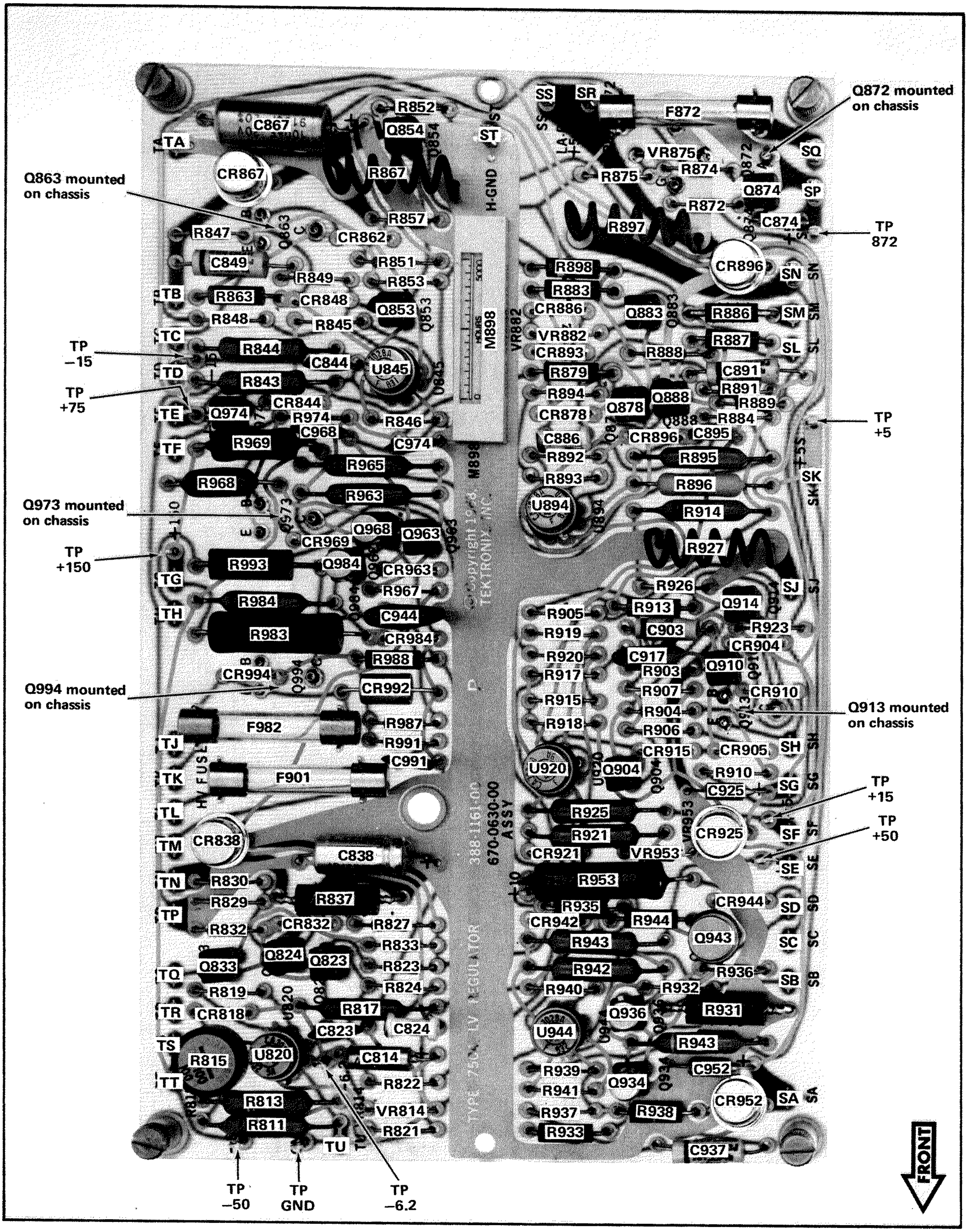

Fig. 4-19. LV Regulator circuit board.

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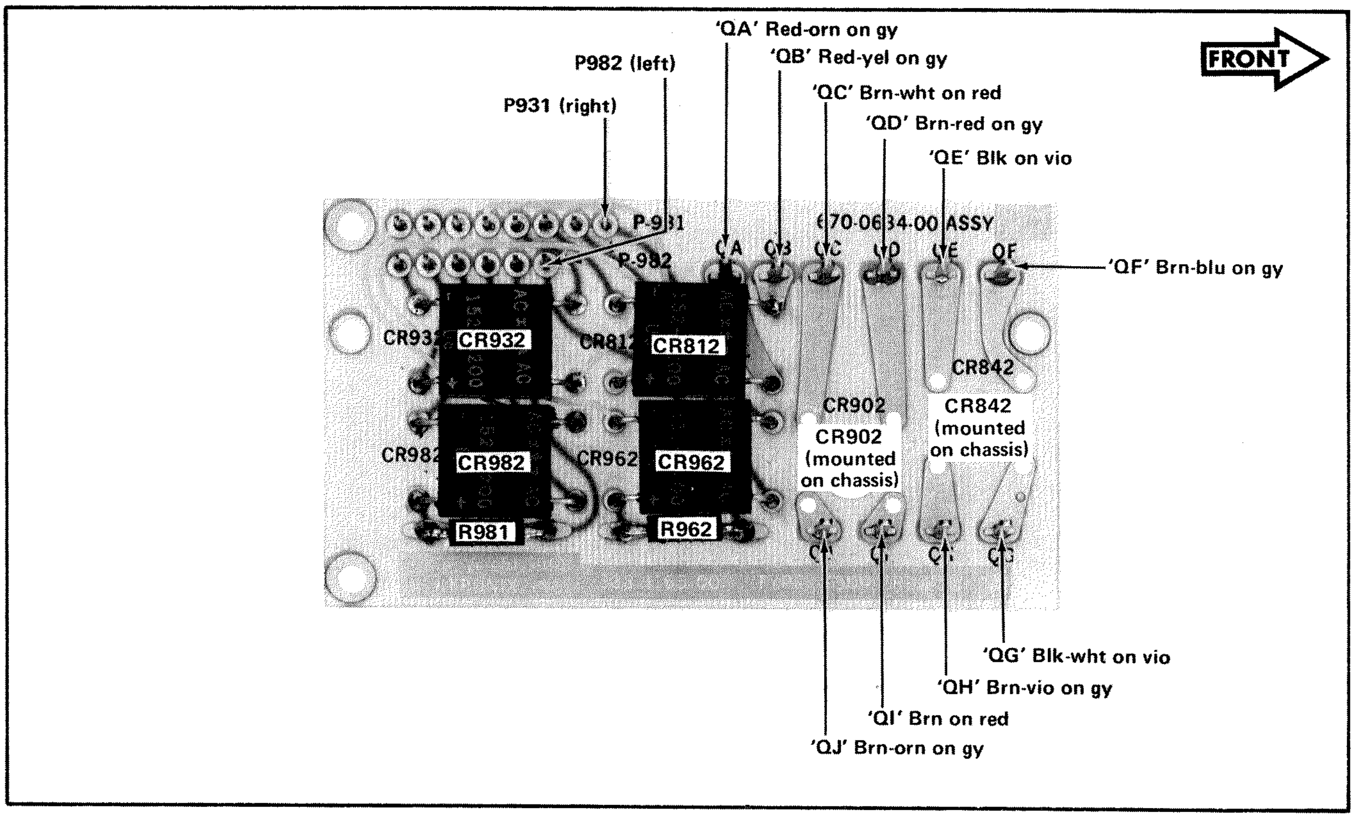

Fig. 4-20. Rectifier circuit board.

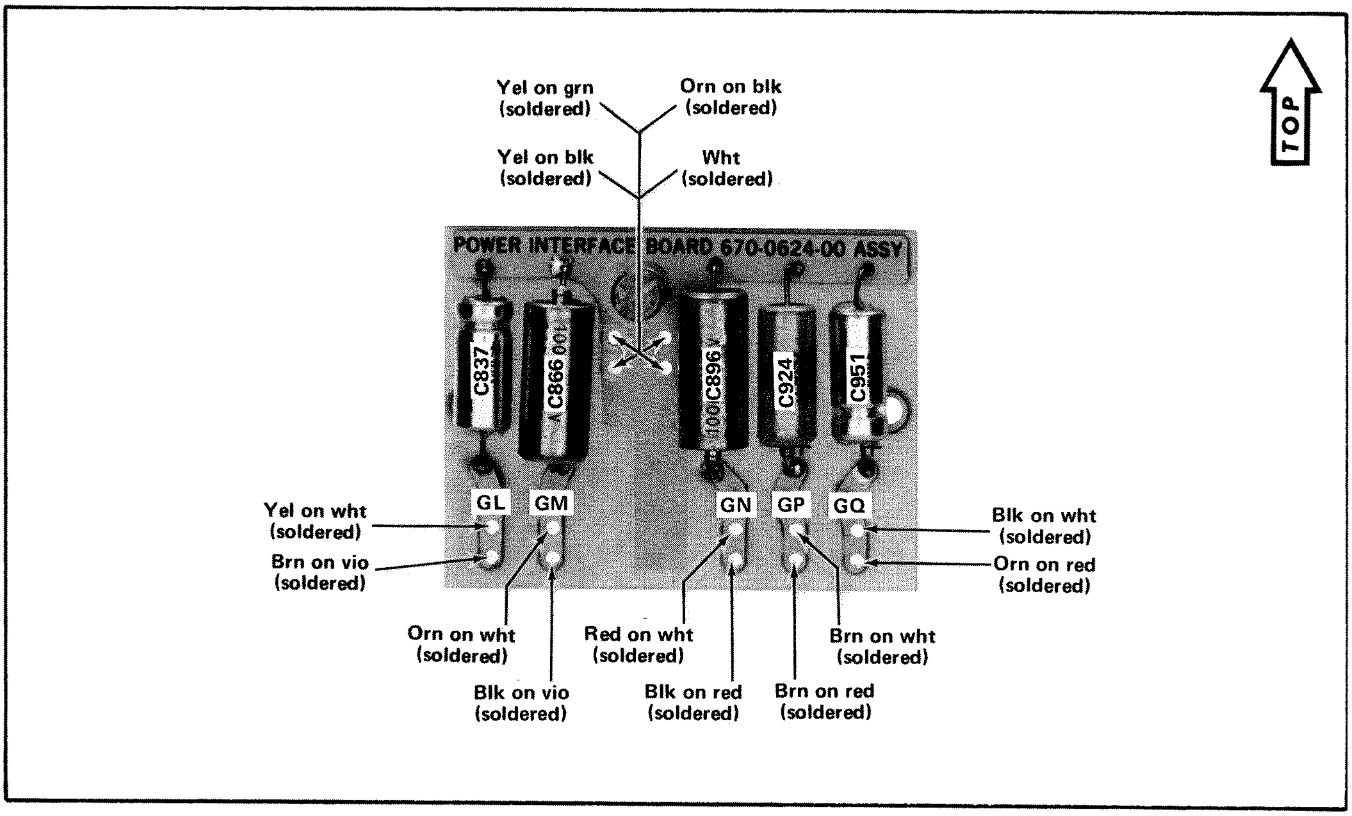

Fig. 4-21. Power Interface circuit board.

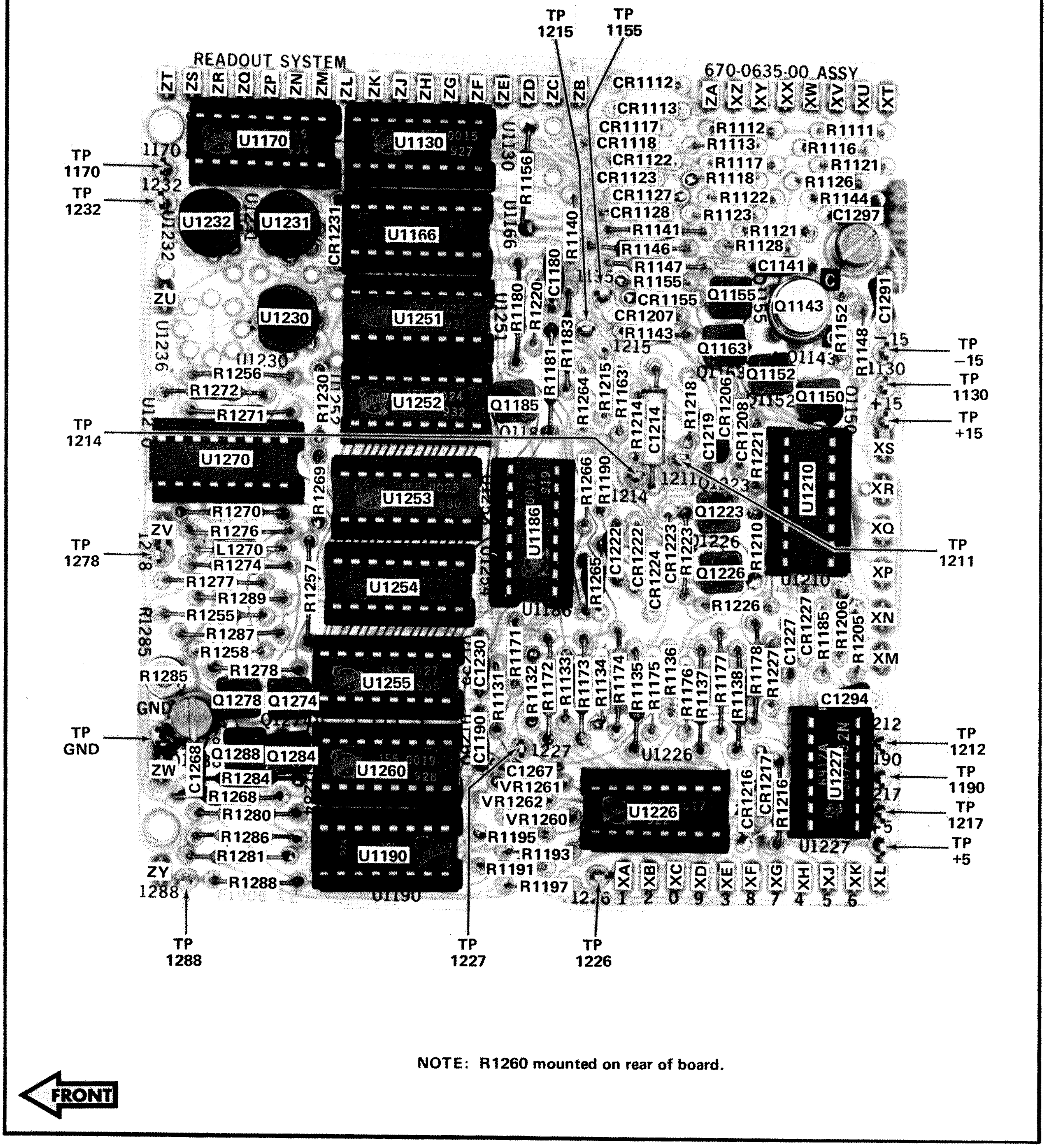

Fig. 4-22. Readout System circuit board.

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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 Type 7504 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.

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 particular circuit 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 their equivalents, are required for complete calibration of the Type 7504. Specifications given are those necessary for accurate calibration. Therefore, some of the recommended equipment may have specifications better than 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 given here.

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. Must be capable of supplying about 75 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

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. Test oscilloscope. Bandwidth, DC to 150 megahertz, minimum deflection factor, five millivolts/division; accuracy, within 3%. Tektronix Type 454 Oscilloscope recommended.

3. 1X probe with BNC connector. Tektronix P6011 Probe recommended.

4. 10X probe with BNC connector. Tektronix P6010 or P6047 recommended. Two required.

5. DC voltmeter: Minimum sensitivity rating 20,000 ohms/volt; range of 3,300 volts full scale with an accuracy of at least 3%.

6. Time-mark generator. Marker outputs, 10 nanoseconds to 1 millisecond; marker accuracy, within 0.1%. Tektronix Type 184 Time-Mark Generator recommended.

7. Square-wave generator. Must have the following output capabilities: 2 to 70 volts output amplitude at 100 kilohertz repetition rate. Tektronix Type 106 Square-Wave Generator recommended.

8. High frequency constant-amplitude sine wave generator. Frequency, 65 megahertz to above 100 megahertz; reference frequency, 3 megahertz; output amplitude, variable from 0.5 volt to five volts peak to peak into 50 ohms; amplitude accuracy, within 1% at three megahertz and from 65 megahertz to 100 megahertz. Tektronix calibration fixture 067-0532-00 recommended.

9. Low frequency sine wave generator. Frequency, 10 hertz to 100 kilohertz; output amplitude, variable from 0.5 volts to 40 volts peak to peak; amplitude accuracy, within 3% from 10 hertz to 100 kilohertz. For example, General Radio 1310-A Oscillator (use a General Radio Type 274QBJ Adapter to provide BNC output).

10. Precision DC voltmeter. Accuracy, within ±0.05%; meter resolution, 50 microvolts; range zero to two kilovolts. For example, Fluke Model 835A Differential DC Voltmeter.

11. Vertical plug-in Unit, Tektronix Type 7A16. Two required.

12. Time Base Unit, Tektronix Type 7B50.

13. Delaying Time Base Unit, Tektronix Type 7B51.

14. Calibration Fixture, Tektronix Part No. 067-0587-00.

Accessories

15. Cable (3) Impedance, 50 ohms; Type RG-58/U; length, 42 inches; connectors, BNC Tektronix Part No. 012-0057-01.

16. In-line termination. Impedance, 50 ohms; accuracy, ±2%; connectors, BNC. Tektronix Part No. 011-0049-01, two required.

17. 10X attenuator. Impedance, 50 ohms; accuracy ±2%; connectors, BNC. Tektronix Part No. 011-0059-01, two required.

18. BNC T connector. Tektronix Part No. 103-0030-00.

19. Adapter. Adapts GR874 connector to BNC Female connector. Tektronix Part No. 017-0063-00.

Adjustment Tools

20. Screwdriver. Three-inch shaft, 3/32-inch bit for slotted screws. Tektronix Part No. 003-0192-00.

21. Low-capacitance screwdriver. 1½-inch shaft. Tektronix Part No. 003-0000-00.

22. Tuning tool. Handle and insert for 5/64-inch (ID) hex cores. Tektronix Part Nos. 003-0307-00 and 003-0310-00.

SHORT-FORM PROCEDURE AND INDEX

Type 7504, Serial No. ________________

Calibration Date ________________

Elapsed-Time Reading ________________

Calibrated By ________________

1. Check Control and Graticule Illumination page 5-6

   REQUIREMENT: Rotation of the CONTROL ILLUM switch from OFF, to LOW then to HIGH the depressed DISPLAY pushbuttons and TRIGGER SELECTOR pushbuttons must illuminate first dimly then brightly. Each pushbutton should light as it is actuated.

   PERFORMANCE: Correct ____; Incorrect ____.

2. Adjust −50-Volt Power Supply (R815) page 5-7

   REQUIREMENT: −50-volts ±0.2% (0.01 volt).

   PERFORMANCE: −50-volts ± ____ volt.

3. Check Output of Remaining Supplies page 5-7

	REQUIREMENT: Voltage tolerance	PERFORMANCE: Output voltage
−50-volt supply	Set in step 2.	
+5-volt supply	±0.15 volt	____ volts
+15-volt supply	±0.3 volt	____ volts
+50-volt supply	±0.6 volt	____ volts
+75-volt supply	±2.25 volt	____ volts
+150-volt supply	±6.0 volt	____ volts
−15-volt supply	±0.3 volt	____ volts

4. Check Power Supply Ripple page 5-8

   See Table A

TABLE A

	REQUIREMENT: Maximum ripple	PERFORMANCE Measured ripple
−50-volt supply	5 millivolts	____ millivolts
+5-volt supply	2 millivolts	____ millivolts
+15-volt supply	2 millivolts	____ millivolts
+50-volt supply	5 millivolts	____ millivolts
+75-volt supply	200 millivolts	____ millivolts
+150-volt supply	300 millivolts	____ millivolts
−15-volt supply	2 millivolts	____ millivolts

5. Adjust Z Axis DC Level (R705) page 5-8

   REQUIREMENT: Voltage at the Z Axis output test point should read +5 volts ±0.25 volt.

   PERFORMANCE: +5 volts ± ____.

6. Adjust CRT Bias (R775) page 5-9

   REQUIREMENT: Slightly above +9 volts at TP736 when B INTENSITY control is rotated to show a visible spot on CRT.

   PERFORMANCE: Correct ____; Incorrect ____.

7. Adjust −2960 Volt Power Supply (R745) page 5-9

   REQUIREMENT: −2960 volts ±2% (±59 volts).

   PERFORMANCE: −2960 volts ± ____ volts.

8. Check/Adjust Trace Rotation (R790) page 5-9

   REQUIREMENT: Trace parallel to center horizontal line within 0.1 division/10 division.

   PERFORMANCE: Within ____ division.

9. Check/Adjust Y Axis Alignment page 5-9

   REQUIREMENT: Vertical trace aligned with the center graticule line within 0.1 division.

   PERFORMANCE: Within ____ division.

10. Check/Adjust CRT Geometry (R792) page 5-10

    REQUIREMENT: Bowing of markers at left and right edges of graticule within 0.1 division. Trace parallel to the top and bottom horizontal lines of the graticule within 0.1 division.

    PERFORMANCE: Left and right edges within division; top and bottom within ____ division.

11. Check/Adjust Maximum Intensity page 5-11

    REQUIREMENT: Within 35-45 volts at TP736 for A INTENSITY limit.

    PERFORMANCE: ____ volts.

    REQUIREMENT: Approximately 69 volts at TP736 for maximum A INTENSITY level.

    PERFORMANCE: ____ volts.

12. Intensified Trace Check page 5-11

    REQUIREMENT: Intensified portion should be clearly distinguishable for any intensity level except maximum.

PERFORMANCE: Correct ____ ; Incorrect ____ .

13. Adjust Z Axis Transient Response (C725) page 5-11

REQUIREMENT: Risetime or falltime not to exceed 30 nanoseconds.

PERFORMANCE: _____ nanosecond.

14. Check/Adjust Vertical Gain/Linearity page 5-12

REQUIREMENT: Second and sixth traces are six centimeters apart, within ±1% (±0.06 division).

PERFORMANCE: _____ division.

15. Check/Adjust Vertical Amplifier Centering (R405) page 5-13

REQUIREMENT: Trace at the center horizontal graticule line.

PERFORMANCE: Within _____ division.

16. Check/Adjust R406 with Readout System page 5-13

REQUIREMENT: Readout display does not move more than about 0.3 mm when the other trace is positioned.

PERFORMANCE: Within ____ mm.

17. Check/Adjust R406 Without Readout System page 5-13

REQUIREMENT; Trace does not shift when the other trace is positioned.

PERFORMANCE: Within ____ division.

18. Check/Adjust Vertical High-Frequency Compensation (R435-C435, R434-C434, L447-R446, L485-C450). page 5-13

REQUIREMENT: Optimum square-wave response, less than 3.5 nanoseconds.

PERFORMANCE: Correct ____ ; Incorrect ____ .

19. Check Upper Vertical Bandwidth Limit page 5-14

REQUIREMENT: Not more than −3 dB at 100 megahertz.

PERFORMANCE: −3 dB point, ____ megahertz. (LEFT VERT).
−3 dB point, _____ megahertz. (RIGHT VERT).

20. Check/Adjust Horizontal Amplifier Gain (R515) page 5-14

REQUIREMENT: Second and eighth trace are eight centimeters apart, with ±1% (0.08 division).

PERFORMANCE: _____ division.

21. Check/Adjust DC Center (R505) page 5-15

REQUIREMENT: Trace at the center vertical graticule line.

PERFORMANCE: Within ____ division.

22. Adjust DC Limit Center (R525) page 5-15

REQUIREMENT: Both baselines should have the same level and be approximately eight volts above ground reference.

PERFORMANCE: Correct ____ ; Incorrect ____ .

23. Check/Adjust R507 with Readout System page 5-16

REQUIREMENT: Readout horizontal jitter does not exceed appoximately 0.02 division.

PERFORMANCE: Within ____ division.

24. Check/Adjust R507 Without Readout System page 5-16

REQUIREMENT: Minimum jitter.

PERFORMANCE: Correct ____ ; Incorrect ____ .

25. Check/Adjust Normal Timing page 5-16

REQUIREMENT: Correct timing within 0.24 division over center eight divisions of display.

PERFORMANCE: Correct ____ ; Incorrect ____ .

26. Check/Adjust High Frequency Timing (C581, C591, C598, C588) page 5-17

REQUIREMENT: Correct timing within ±3% (0.24 division) at 0.05, 0.1 and 0.2 microsecond

PERFORMANCE: 0.05 microsecond, within ____ division.

0.1 microsecond, within ____ division.
0.2 microsecond, within ____ division.

27. High Sensitivity Z Axis Input Check page 5-17

REQUIREMENT: Inverted square-wave rises from 5 volts to +65 volts.

PERFORMANCE: Correct ____ ; Incorrect ____ .

28. High Speed Z Axis Input Check page 5-18

REQUIREMENT: V2-V1 is 30 volts, ±5 volts.

PERFORMANCE: ______ volts.

29. Check + Sawtooth Output (A and B) page 5-19

REQUIREMENT: 1 volt/division rate of rise, within ±10% and 50 millivolt/division rate of rise with 50-ohm termination, within ±15%.

PERFORMANCE: A HORIZ ____ volt/division. volt/division, terminated.

B HORIZ ____ volt/division. volt/division, terminated.

30. Check Sig Out page 5-19

REQUIREMENT: Vertical deflection of 5 divisions (within ±10%).

PERFORMANCE: ______ divisions.
divisions, terminated.

31. Check + Gate Output. A, B or Dly'd page 5-20

REQUIREMENT: 10 volts, within ±1 volt (10%).
0.5 volt, within ±0.05 volt (10%), terminated.

PERFORMANCE: ____ volts.
____ volts, terminated.

32. Check/Adjust Calibrator Amplitude (R649) page 5-20

REQUIREMENT: 0.4 volt DC output, within ±0.004 volt (1%).

PERFORMANCE: ______ volt.

33. Check/Adjust Calibrator Repetition Rate (R625) page 5-21

REQUIREMENT: One cycle of calibrator waveform for each marker, within ±0.05 division (±0.5%).

PERFORMANCE: Within ____ division.

34. Check Calibrator Risetime page 5-22

REQUIREMENT: Two and a half division or less (0.25 microsecond).

PERFORMANCE: ______ divisions.

35. Adjust Current Through Current Probe Cal Loop (R640) page 5-22

REQUIREMENT: Voltmeter reading of 30.64 volts.

PERFORMANCE: ______ volts.

36. Check X-Y Phasing page 5-22

REQUIREMENT: 0.28 division or less (2° or less), at 35 kilohertz.

PERFORMANCE: ______ division.

37. Check/Adjust X-Y Phasing With Correction (C55 and C75) page 5-23

REQUIREMENT: 0.28 division or less (2° or less), at 2 megahertz.

PERFORMANCE: ______ division.

38. Check Horizontal Bandwidth page 5-23

REQUIREMENT: Not more than −3 dB at 2 megahertz.

PERFORMANCE: −3 dB point, ____ megahertz. (A HORIZ).
−3 dB point, ______ megahertz. (B HORIZ).

39. Check/Adjust Readout Position (When Readout Option is Installed) page 5-24

REQUIREMENT: Readout is in the center of the top division of the CRT graticule when the displayed trace is exactly centered on the center horizontal graticule line.

PERFORMANCE: Correct ____ ; Incorrect ____ .

PERFORMANCE CHECK/CALIBRATION PROCEDURE

General

The following procedure is arranged so the Type 7504 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 Type 7504 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.

NOTE

This instrument should be calibrated at an ambient temperature of +25°C ±5°C for best overall accuracy. The performance of this instrument can be checked at any temperature within the 0°C to +50°C range. Refer to Section 1 for exceptions in this temperature range.

Preliminary Procedure for Performance Check Only

1. Connect the Type 7504 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 1.

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 Type 7504.

5. Check that the voltage selector and range selector switch bars in the LINE VOLTAGE SELECTOR assembly on the rear of the Type 7504 are set to correspond to the autotransformer output voltage.

6. Connect the Type 7504 to the autotransformer output.

Preliminary Control Settings

Set the Type 7504 controls as follows: (no plug-ins need be installed at this time).

CRT controls	
A INTENSITY	Counterclockwise
B INTENSITY	Counterclockwise
TRIGGER SOURCE switches	VERT MODE
GRAT ILLUM	Counterclockwise
CONTROL ILLUM	OFF
POWER	ON
Other Controls	As set

Turn on all equipment and allow at least 20 minutes warmup time at approximately 25°C before making any checks or adjustments. Test equipment required for steps 1 through 18 is shown in Fig. 5-1.

1. Check Control and Graticule Illumination

a. Turn the GRAT ILLUM control fully clockwise.

b. CHECK—The graticule must become smoothly illuminated to full brilliance as the control is rotated.

c. Return the GRAT ILLUM control fully counterclockwise.

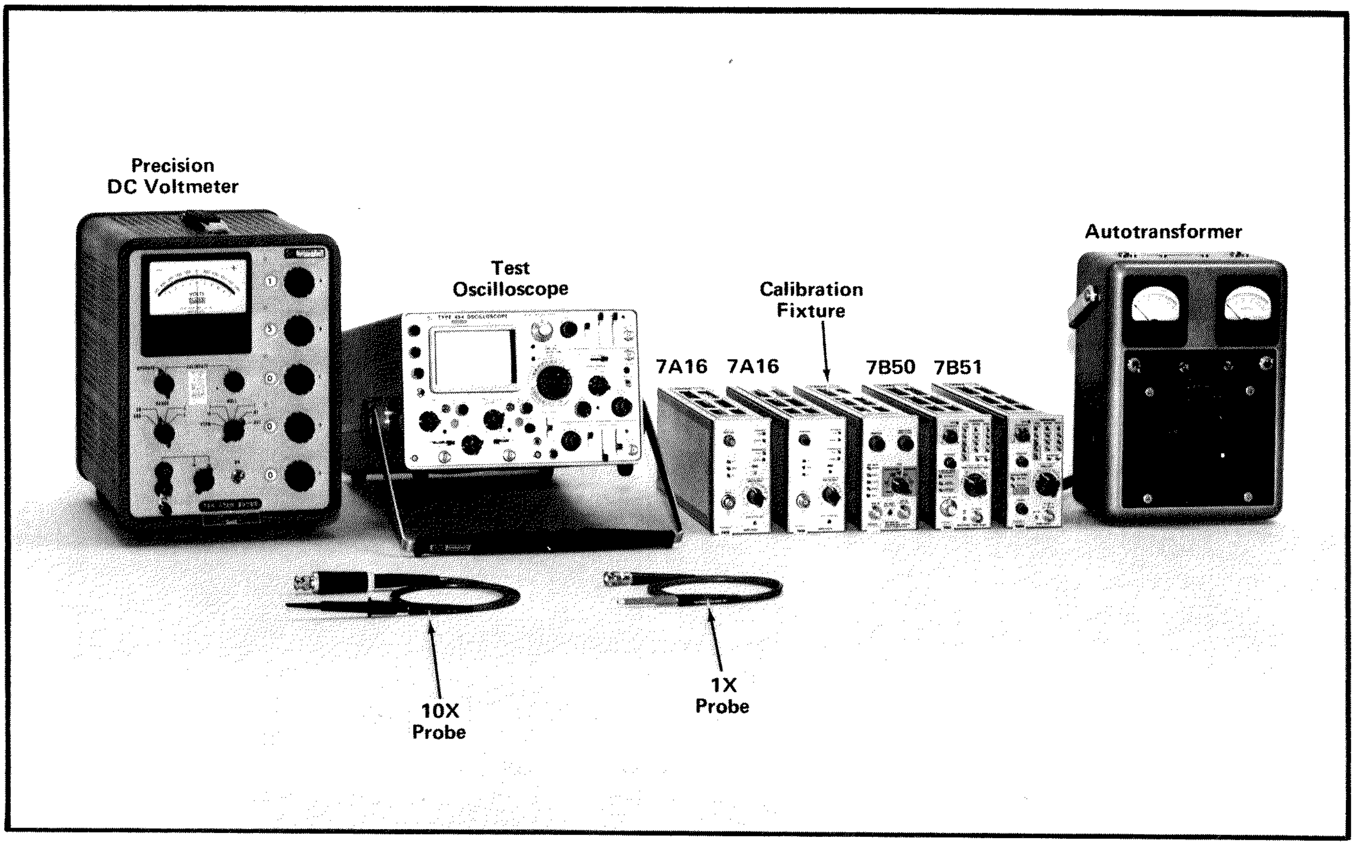

Fig. 5-1. Test equipment required for steps 1 through 18.

d. Rotate the CONTROL ILLUM switch clockwise from OFF to LOW and then to HIGH. The depressed pushbuttons must illuminate dimly with CONTROL ILLUM at LOW, then brightly with CONTROL ILLUM at HIGH.

e. Press each of the TRIGGER SOURCE and MODE pushbuttons in turn.

f. CHECK—Each pushbutton should light as it is actuated.

g. Return the CONTROL ILLUM control to OFF.

2. Adjust −50-Volt Power Supply

a. Connect the precision DC voltmeter from the −50-volt test point to the GND test point on the LV Regulator board (see Fig. 5-2).

b. CHECK—Meter reading; −50 volts ±0.1 volt.

c. ADJUST—−50 Volts adjustment R815 (see Fig. 5-2) for −50 volts.

NOTE

Steps 3 and 4 are internal checks which are performed only during calibration. They are not part of the Performance Check.

3. Remaining Output Supplies Check

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. 5-2.

TABLE 5-1

Power Supply Tolerance and Ripple

Power supply	Output voltage tolerance	Maximum ripple (peak to peak)
+5 volt	±0.15 volt	2 mv
+15 volt	±0.3 volt	2 mv
+50 volt	±0.6 volt	5 mv
+75 volt	±2.25 volt	200 mv
+150 volt	±6.0 volt	300 mv
−15 volt	±0.3 volt	2 mv
−50 volt	adjustable	5 mv

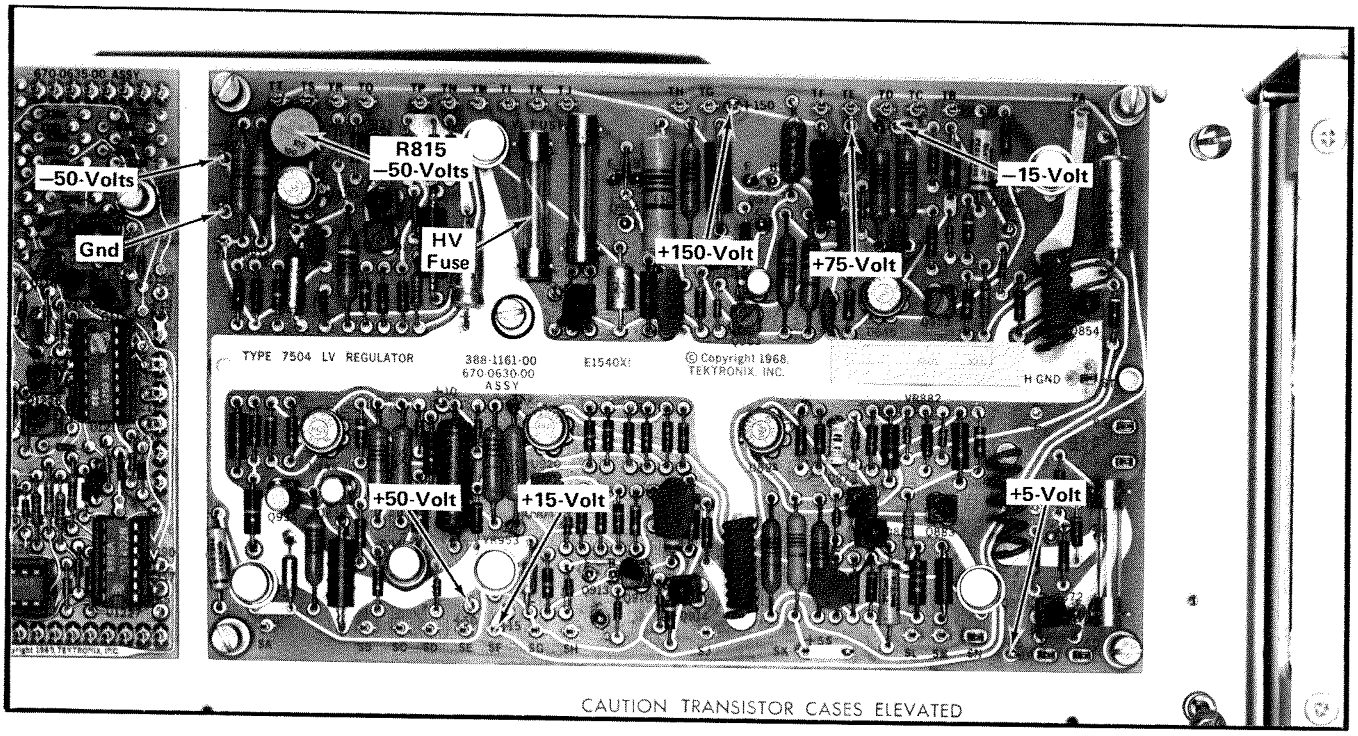

Fig. 5-2. Location of power supply test points and −50-Volt adjustment (LV Regulator board).

4. Power Supply Ripple Check

a. Connect the 1X probe to the test oscilloscope input connector.

b. Set the test oscilloscope for a vertical deflection factor of five millivolts/division at a sweep rate of 5 milliseconds/division (if operated from a power source with a frequency other than 60 hertz, set the test oscilloscope sweep rate to an applicable setting).

c. Install Type 7A16 plug-ins in the two vertical compartments, a Type 7B50 Time Base in the B HORIZ compartment, and a Type 7B51 in the A HORIZ compartment.

d. CHECK—Test oscilloscope display for maximum line-frequency ripple of each supply as listed in Table 5-1 while varying the autotransformer output voltage throughout the regulating range of the power supply.

NOTE

Ripple measurement must be made at the Low Voltage Regulator board using the test points provided with reference to the GND test points (see Fig. 5-2).

e. Remove all plug-ins except the Type 7B50 for the next step.

5. Adjust Z Axis DC Level (R705)

a. Install a Type 7B50 Time Base in the B HORIZ compartment.

b. Actuate pushbutton B on the HORIZONTAL MODE switch.

c. Set the Time Base triggering mode to NORM.

d. Set the B INTENSITY control fully counterclockwise.

e. Loosen three screws securing the hinged chassis at the right of the instrument and lower it out of the way to allow access to the High Voltage Z Axis Amplifier circuit board.

f. Connect the DC voltmeter from TP736 of the Z Axis Amp circuit board (see Fig. 5-3) to chassis ground.

g. CHECK—Voltage at the Z Axis output test point should read +5 volts, ±0.25 volt.

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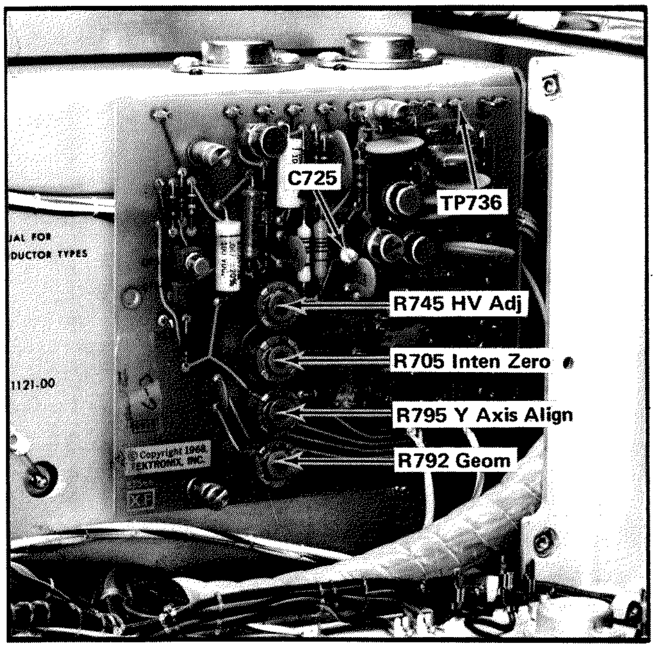


Fig. 5-3. Location of test point TP736 on the High Voltage/Z Axis Amp board, adjustments and C725.

h. ADJUST—Z Axis DC Level Adj. (R705; see Fig. 5-3) set to +5 volts.

6. Adjust CRT Bias (R775)

a. Set the Type 7B50 Time Base Display Mode to Amplifier.

b. Connect the DC voltmeter from TP736 of the Z Axis amplifier circuit board (see Fig. 5-3) to chassis ground.

c. Rotate the B INTENSITY control clockwise for a +10 volt reading on the DC voltmeter.

d. ADJUST—R775 (see Fig. 5-4) so the displayed spot is just extinguished. At this point, the CRT is properly biased.

e. Reset the Type 7B50 Time Base Display Mode to Time Base.

7. Adjust −2960 Volt Power Supply

a. Turn off the power to the Type 7504.

b. Connect a precision DC voltmeter between the high voltage test point (see Fig. 5-4) and chassis ground.

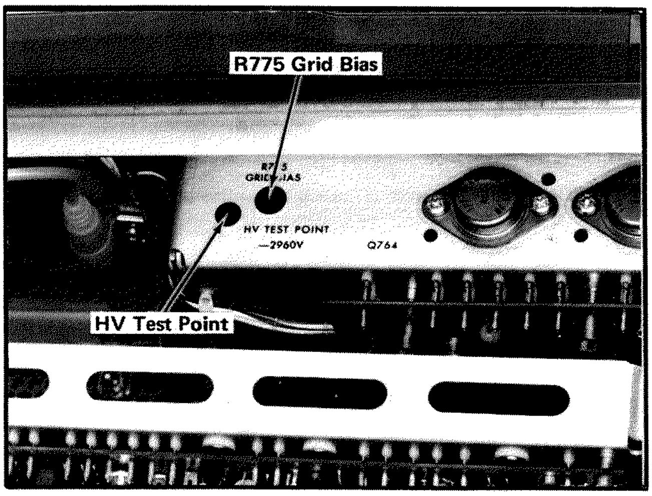


Fig. 5-4. Location of high voltage test point and grid-bias adjustment.

c. Turn the Type 7504 power on.

d. CHECK—Meter reading of −2960 volts, ±60 volts.

e. ADJUST—HV Adj. (R745) on the High Voltage/Z Axis Amp board (see Fig. 5-3) for a meter reading of −2960 volts.

f. Turn the power off and remove the meter leads.

g. Turn power on.

8. Check/Adjust Trace Rotation

a. Adjust FOCUS and ASTIGMATISM controls for a well defined display.

b. CHECK—Trace should be parallel to the center horizontal graticule line within 0.1 division over the sweep length of 10 divisions.

c. ADJUST—TRACE ROTATION front-panel adjustment R790.

d. Remove the Type 7B50 from the B HORIZ compartment.

9. Check/Adjust Y Axis Alignment

a. Install the Type 7B50 Time Base in the LEFT VERT compartment.

b. Actuate pushbutton LEFT on the VERTICAL MODE switch.

c. Install the calibration fixture in the B HORIZ compartment.

d. Position the stable trace to the center vertical graticule line.

e. CHECK—Precise aligning of the vertical trace parallel with the center graticule line, within 0.1 division.

f. ADJUST—Y Axis Align (R795) on the Z Axis Amp circuit board (see Fig. 5-3) so the displayed trace is precisely parallel with the center vertical graticule line.

10. Check/Adjust CRT Geometry

a. Set the calibration fixture Test position to Gain and the Rep Rate to 250 kHz.

b. Set the Type 7B50 Time Base Level control for a stable display and operate the Position control to position the traces to extend beyond the top and bottom of the graticule area.

c. CHECK—CRT display for 0.1 division or less bowing of the traces at the left and right edges of the graticule. See Fig. 5-5.

d. Inter-change the Type 7B50 with the Calibration Fixture in the Type 7504.

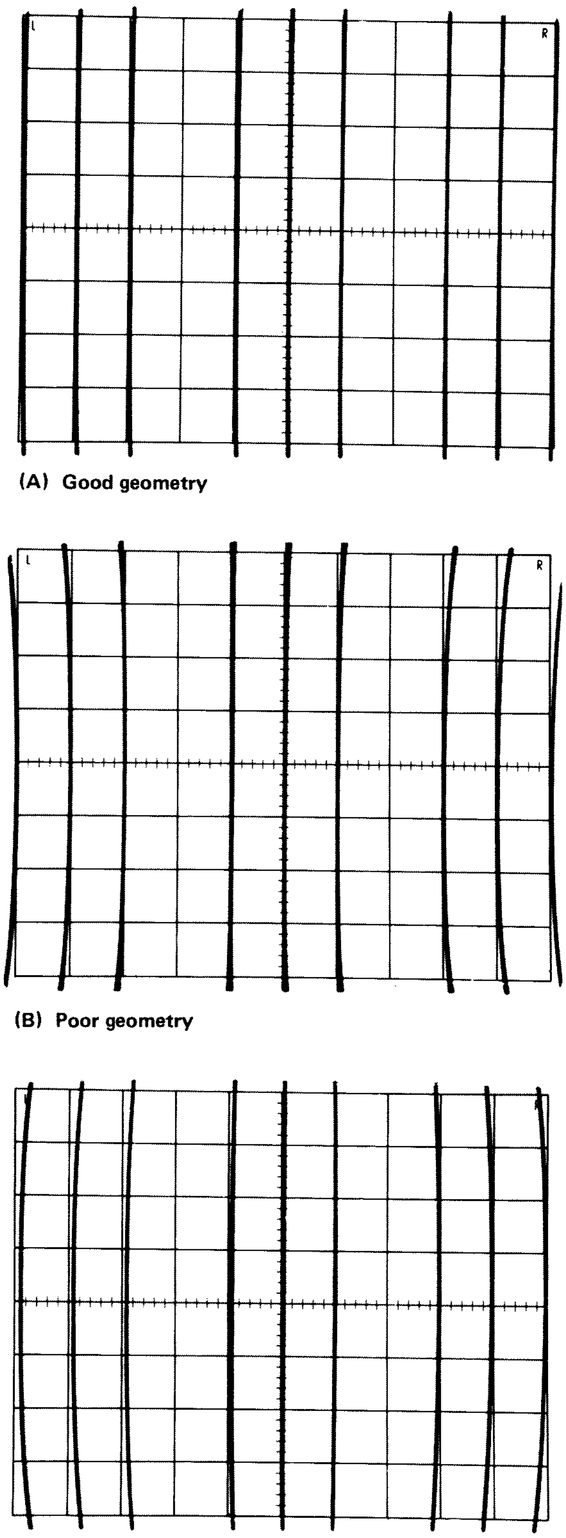
e. CHECK—CRT display for 0.1 division or less bowing of the traces at the top and bottom edges of the graticule.

f. ADJUST—Geom adjustment R792 (see Fig. 5-3). See Fig. 5-5A for minimum curvature of the markers displayed vertically and horizontally.

g. Some interaction may be noted between TRACE ROTATION, Y-Axis Align and Geom; repeat steps 8 and 9 as necessary.

NOTE

Steps 11 and 12 are Calibration steps and are not part of the Performance Check.



(A) Good geometry

(B) Poor geometry

(C) Poor geometry

Fig. 5-5. (A) Typical CRT display of good geometry; (B) and (C) poor geometry.

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11. Check/Adjust Maximum Intensity Level and Intensity Limit

a. With the calibration fixture in the LEFT AND VERT compartment, set the Test mode switch to Aux In.

b. Install the Type 7B50 Time Base in the A HORIZ compartment.

c. Actuate pushbutton A on the HORIZONTAL MODE switch.

d. Set the Type 7B50 Time/Div switch to 5s.

e. Connect the DC voltmeter to the Type 7504 Z Axis Amplifier output (TP736). See Fig. 5-3.

f. CHECK—Voltage at the Z Axis Amplifier output (TP736) to be within 35-45 volts.

g. Turn the Type 7504 power off.

h. Remove the high voltage fuse (see Fig. 5-2).

i. Turn the Type 7504 power on.

j. Rotate the A INTENSITY control full counterclockwise.

k. Set the Type 7B50 Display Mode to Amplifier.

l. CHECK—Voltage at the Z Axis output (TP736) must be approximately 69 volts.

m. ADJUST—R140 (Maximum Intensity Level) for an output of 69 volts at the Z Axis Amplifier output (TP736).

NOTE

R140 can be reached from the bottom by turning the Type 7504 on its side. R140 is located on the logic board.

n. Reduce the A intensity to a normal value.

o. Turn the Type 7504 power off.

p. Install the high voltage fuse in its original holder.

q. Remove the Type 7B50 Time Base from the A HORIZ compartment and install it into the B HORIZ compartment and set the Display Mode to Time Base.

r. Actuate pushbutton B on the HORIZONTAL MODE switch.

s. Turn the Type 7504 power on.

12. Check Intensified Trace

a. Install a Type 7B51 Delaying Time Base in the A HORIZ compartment.

b. Set both time base triggering modes to Auto, Source to Int.

c. Set the Calibration Fixture Test Switch to Aux In.

d. Set the Type 7B50 Time/Div to 50 μs and the Type 7B51 Time/Div to .5 ms.

e. Set the Type 7B51 B Delay Mode to B Starts After Delay.

f. Actuate pushbutton A on the HORIZONTAL MODE switch.

g. CHECK—That the intensified portion of the trace is clearly distinguishable for any intensity level except maximum.

h. Remove the Type 7B51 Delaying Time Base plug-in unit.

13. Adjust Z Axis Transient Response

a. Install the Type 7B50 Time Base in the B HORIZ compartment.

b. Set the Type 7B50 Time/Div to 0.05 microsecond.

c. Connect the test oscilloscope 10X probe tip to test

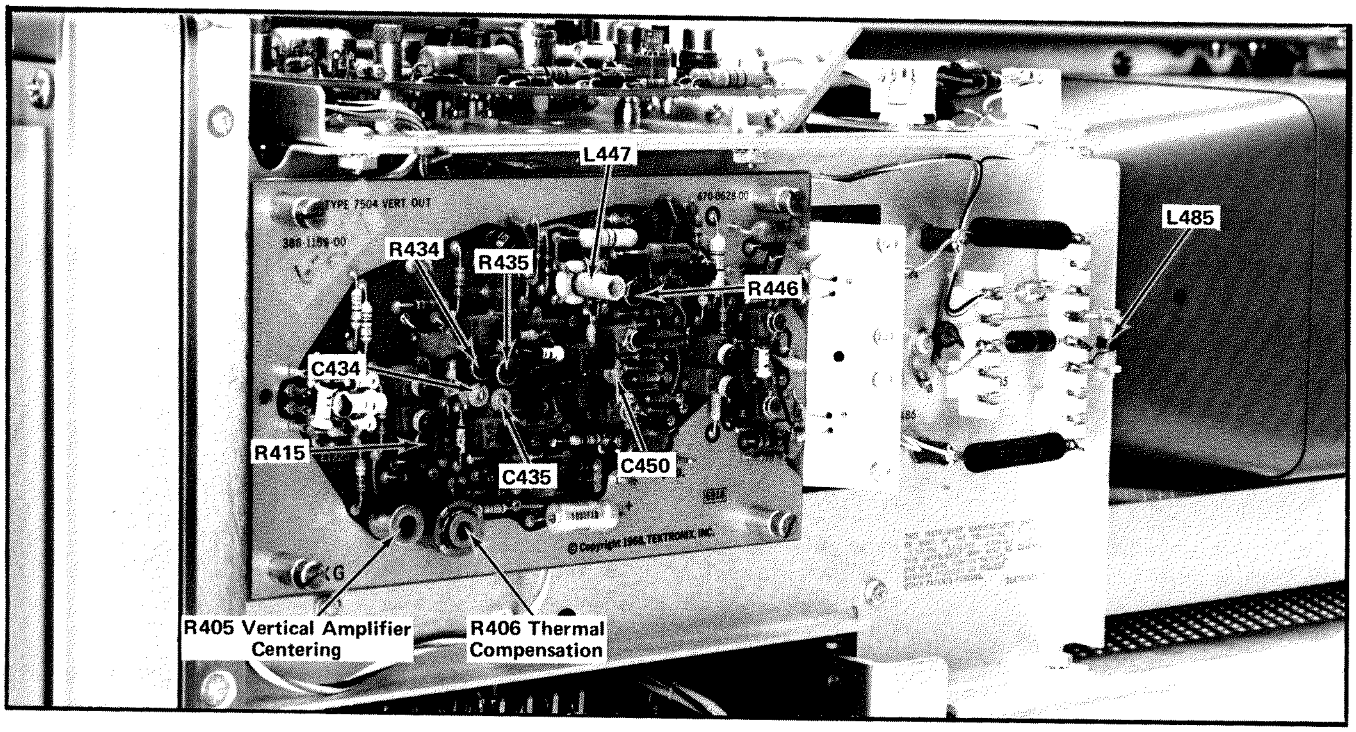

Fig. 5-6. Location of adjustments on the Vert Out board.

point, TP736 of the Z Axis Amp (see Fig. 5-3) and probe ground lead to chassis ground.

d. Set the test oscilloscope Volts/Div to 1 V and the Time/Div to .05 µs.

e. Adjust the B INTENSITY control for a test oscilloscope display 3 divisions high.

f. CHECK—Risetime of the displayed pulse should be no more than 40 nanoseconds. This means that from the 10% point to the 90% point on the rising portion of the displayed pulse, the horizontal distance on the test oscilloscope graticule must be no more than .8 div.

g. ADJUST—C725 (see Fig. 5-3) for optimum Flat top on the pulse with risetime of 40 nanoseconds or less.

14. Check/Adjust Vertical Gain/Linearity

a. Set the Calibration Fixture Test Vert or Horiz Switch to Gain.

b. Adjust the Type 7B50 Level/Slope control to display seven horizontal traces.

c. Position the display for centering of the middle trace on the center horizontal graticule line.

d. CHECK—That total separation of the traces corresponding to the center vertical 6-division area of the graticule is 6 divisions, ±0.06 divisions. Separation of traces over any 2 division area of the graticule must be 2 divisions, ±0.1 division.

e. ADJUST—Vertical Gain control R415 (see Fig. 5-6) for exactly six centimeters between the second and sixth traces (corresponding to the center 6 divisions) on the graticule. Use the calibration fixture position control as necessary.

f. Remove the calibration fixture from the LEFT VERT compartment and place it in the RIGHT VERT compartment.

g. Actuate the RIGHT VERTICAL MODE pushbutton.

h. Repeat Step d. The reading obtained must be the same as that obtained in step d, ±1%.

i. Remove the calibration fixture from the RIGHT VERT compartment.

15. Check/Adjust Vertical Amplifier Centering

a. Set the Type 7B50 Time Base triggering mode to Auto.

b. CHECK—That the displayed trace is centered on the center horizontal graticule line.

c. ADJUST—R405 (see Fig. 5-6) for exact centering of the displayed trace on the center horizontal graticule line.

NOTE

For a Type 7504 with Readout, omit step 17. For a Type 7504 without Readout, omit step 16.

16. Check/Adjust R406 (Thermal Compensation) with Readout System

a. Install the calibration fixture in the LEFT VERT compartment and set the Test mode switch to Step Res +. Set Amplitude Step or Aux fully counterclockwise.

b. Actuate pushbutton LEFT on the VERTICAL MODE switch.

c. Set the time base triggering Mode to Auto.

d. Adjust READOUT front-panel control for a display of the time base display factor.

e. CHECK—That the readout display does not move more than about 0.3 mm vertically as the Calibration Fixture position control is used to move the trace off screen from the top to the bottom of the graticule.

f. ADJUST—R406 (see Fig. 5-6) for minimum vertical readout shift as the Calibration Fixture position control is used to move the trace off screen above and below the graticule.

17. Check/Adjust R406 (Thermal Compensation) without Readout System

a. Install the calibration fixture in the LEFT VERT compartment and set the Test mode switch to Step Res +. Set Amplitude Step or Aux fully counterclockwise.

b. Actuate pushbutton CHOP on the VERTICAL MODE switch.

c. Set the time base triggering Mode to Auto.

d. CHECK—That the stationary trace does not shift position vertically when the calibration fixture position control is used to position the other trace off screen at the top and bottom of the graticule.

e. ADJUST—R406 (see Fig. 5-6) for minimum change in the stationary trace as the calibration fixture position control is used to position the other trace off screen above and below the graticule.

18. Check/Adjust Vertical High-Frequency Compensation

a. Set the calibration fixture Rep Rate to 250 kHz.

b. Actuate pushbutton LEFT on the VERTICAL MODE switch.

c. Set the Type 7B50 Time/Div to 5 nanoseconds (0.05 microsecond with X10 magnifier).

d. Set the time base Level/Slope control for a stable display.

e. Adjust the displayed waveform for an amplitude of six divisions.

f. CHECK—CRT display for optimum pulse square leading corner and flat top with aberrations not to exceed ±0.01 division peak to peak.

g. ADJUST—R435-C435 (major effect 20 - 50 ns after corner), R434-C434 (for best corner without ringing), L447 (major effect 5 ns after corner), R446 (major effect 8 ns after corner), L485 (major effect 5 ns after corner) and C450 (fast leading edge) for optimum square-wave response (use low-capacitance screwdriver for the capacitors and tuning tool for the inductors). Fig. 5-6 shows the location of these adjustments. Since these adjustments interact, readjust until optimum square-wave response is obtained, with rise time of less than 3.5 nanosecond. Use either X1 or X10 Magnifier on the Type 7B50 as required to best view the effect of each adjustment.

h. Insert the calibration fixture in the RIGHT VERT compartment.

i. Actuate pushbutton RIGHT on the VERTICAL MODE switch.

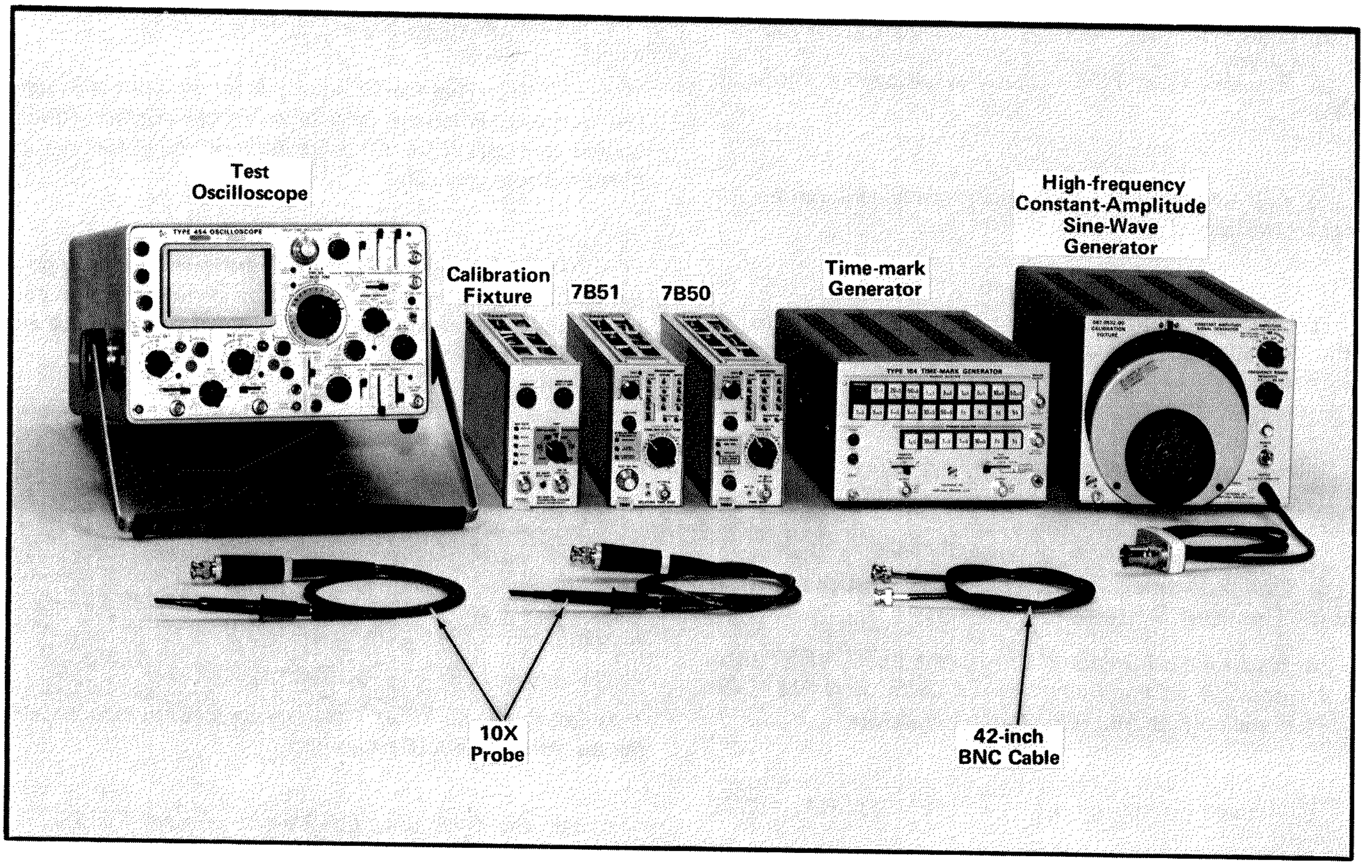

Fig. 5-7. Test equipment required for steps 19 through 26.

j. CHECK—CRT display for optimum square-wave response similar to LEFT VERT channel, with rise time less than 3.5 nanosecond.

k. ADJUST—If necessary, compromise the adjustments as given in step g.

Test equipment required for steps 19 through 26 is shown in Fig. 5-7.

19. Check Upper Vertical Bandwidth Limit

a. Insert the calibration fixture in the LEFT VERT compartment.

b. Actuate pushbutton LEFT on the VERTICAL MODE switch.

c. Set the Type 7B50 Time/Div to one millisecond.

d. Connect the high-frequency constant-amplitude signal generator (Tektronix Part No. 067-0532-00) to the CW In connector of the calibration fixture using a GR to BNC male adapter.

e. Set the Test mode switch of the calibration fixture to Freq Res.

f. Set the constant-amplitude generator for an eight-division display on the Type 7504, centered on the graticule, at its reference frequency (3 kHz).

g. Without changing the output amplitude, increase the output frequency of the constant-amplitude generator until the display is reduced to 5.6 divisions (−3 dB point).

h. CHECK—Frequency control of generator must be at 105 megahertz or higher.

i. Insert the calibration fixture in the RIGHT VERT compartment.

j. Actuate the pushbutton RIGHT on the VERTICAL MODE switch.

k. Repeat parts f, g and h.

l. CHECK—Output frequency of generator must be 105 megahertz or higher for a −3 dB point. Accuracy (difference between channels), within ±1%.

m. Remove both plug-ins from the Type 7504.

20. Check/Adjust Horizontal Gain

a. Install the Type 7B50 Time Base in the LEFT VERT compartment.

b. Actuate pushbutton LEFT on the VERTICAL MODE switch.

c. Install the calibration fixture in the B HORIZ compartment, check that pushbutton B on the HORIZONTAL MODE switch is actuated.

d. Set the calibration fixture Test Vert or Horiz to Gain and Rep Rate to 250 kHz.

e. Free-run the sweep with the Type 7B50 Level/Slope control to display nine vertical traces.

f. Position the display for centering of the middle trace on the center vertical graticule line.

g. CHECK—That total separation of the traces corresponding to the center eight divisions of the graticule is eight divisions, ±0.08 division.

h. ADJUST—Horizontal gain control R515 (see Fig. 5-8) for exactly eight centimeters total spacing between the traces corresponding to the center eight divisions on the graticule. Use the B HORIZ Position control as necessary.

i. Move the calibration fixture from the B HORIZ compartment to the A HORIZ compartment.

j. Actuate pushbutton A on the HORIZONTAL MODE switch.

k. Repeat step g. The reading obtained must be the same as that obtained in step g, ±1%.

21. Check/Adjust DC Center

a. Set the calibration fixture Test mode to any triggering mode.

b. CHECK—Free-running trace should be centered at the center vertical graticule line.

c. ADJUST—DC Center control (R505, see Fig. 5-6) for precise aligning of the free-running trace on the center vertical graticule line.

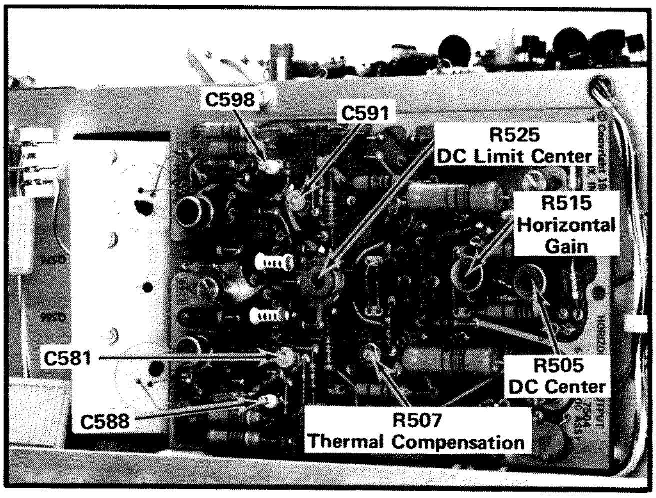

Fig. 5-8. Location of adjustments on the Horizontal board.

d. Remove both plug-ins from the Type 7504.

22. Adjust Limit Center

a. Install the Type 7B50 Time Base in the B HORIZ compartment.

b. Actuate pushbutton B on the HORIZONTAL MODE switch.

c. Set the Type 7B50 sweep rate to one millisecond/division, Magnifier to X10 and free-run the sweep with the Level/Slope control.

d. Connect one 10X probe to each vertical input connector of the test oscilloscope.

e. Connect one 10X probe tip to the RIGHT GREEN horizontal deflection plate lead on the Type 7504 (at the top of the CRT shield) and the other 10X probe tip to the RED LEFT horizontal deflection plate lead.

f. Set up the test oscilloscope for alternate display, vertical deflection factor of 0.5 volt/division (5 volts/division at 10X probe tip) at a sweep rate of one millisecond/division. Set the test oscilloscope input coupling switches to the ground position.

g. Position both test oscilloscope traces to the bottom horizontal line of the graticule to establish a zero reference level, then set the test oscilloscope input coupling switches to DC.

h. Trigger the test oscilloscope for a stable display.

i. CHECK—Both displayed baselines should have the same level, approximately eight volts (1.6 div) above ground reference.

j. ADJUST—Limit Center control (R525, see Fig. 5-6) for identical DC base line levels.

k. Remove both probe tips from the horizontal deflection plates.

NOTE

For a Type 7504 with Readout, omit Step 24. For a Type 7504 without Readout, omit Step 23.

23. Check/Adjust R507 (Thermal Compensation) With Readout System

a. Set the Type 7B50 Triggering Mode to Auto.

b. Set the Type 7B50 Time/Div switch to 5 milliseconds and the Magnifier to X10.

c. Adjust READOUT for a display of the time base display factor.

d. CHECK—That readout horizontal jitter does not exceed approximately 0.02 division.

e. ADJUST—R507 (see Fig. 5-8) for minimum horizontal shift as each horizontal sweep occurs.

24. Check/Adjust R507 (Thermal Compensation) Without Readout System

a. Install another time base in the A HORIZ compartment.

b. Actuate pushbutton CHOP on the HORIZONTAL MODE switch.

c. Install the calibration fixture in the LEFT VERT compartment and select the Aux In test mode.

d. Actuate pushbutton LEFT on the VERTICAL MODE switch.

e. Connect the time-mark generator (Type 184) to the Aux In connector with the 42-inch BNC cable.

f. Set the time-marker generator for output markers of 5 microseconds.

g. Set the A HORIZ time base for a sweep rate of 5 microseconds, magnifier X1, adjust the Level/Slope control for a stable signal and position the start of the sweep to the center vertical graticule line with the A HORIZ time base position control.

h. Set the B HORIZ time base for a sweep rate of 5 milliseconds, adjust the Level/Slope control for a stable signal and center the B HORIZ sweep horizontally on the graticule. Actuate the B HORIZ time base magnifier pushbutton.

i. CHECK—For minimum jitter of the markers being displayed on the A HORIZ sweep.

j. ADJUST—R507 (see Fig. 5-8) for minimum jitter of the markers being displayed on the A HORIZ sweep.

k. Remove the Time base from the A HORIZ compartment.

25. Check/Adjust Normal Timing

a. Actuate pushbutton B on the HORIZONTAL MODE switch.

b. Set the Type 7B50 Time/Div to one millisecond and magnifier to X1.

c. Set the time-marker generator for one millisecond markers.

d. Set the Type 7B50 Level/Slope control for a stable display.

e. With the Type 7B50 position control, position the first time mark to the farthest left vertical graticule line.

f. CHECK—CRT display for the center eight time intervals must coincide with the center eight graticule divisions (see Fig. 5-9).

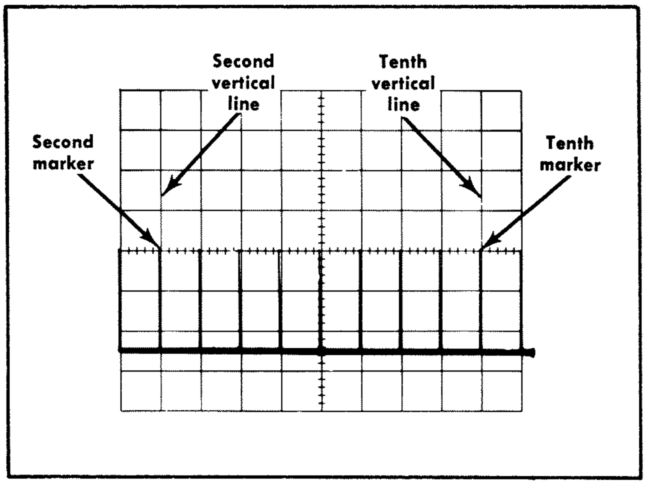

Fig. 5-9. Typical CRT display showing correct sweep calibration.

g. ADJUST—The Type 7B50 front panel Swp Cal for one marker each division. The center eight time intervals must coincide with their respective graticule lines.

26. Check/Adjust High Frequency Timing

a. Set the time-mark generator for 10 nanosecond markers.

b. Set the Type 7B50 Time/Div to 0.05 microsecond.

c. Center the display on the graticule area.

d. Actuate the Type 7B50 X10 Magnifier pushbutton and adjust the Level control for a stable display.

e. CHECK—CRT display for one marker every two divisions between the second and tenth vertical lines of the graticule.

f. ADJUST—C581 and C591 (see Fig. 5-8) for one marker every two division (use low-capacitance screwdriver). Adjust these capacitors a little at a time, trying to maintain equal capacitances.

g. Position the fourth marker of the display to the second vertical line with the B HORIZ time base position control.

h. CHECK—CRT display for one marker every two divisions over the center eight divisions.

i. Position the next to the last marker to the tenth vertical line.

j. CHECK—CRT display for one marker every two divisions over the center eight divisions.

k. ADJUST—C598 and C588 (see Fig. 5-8) for one marker every two divisions while maintaining the best linearity. Position the display back and forth and check linearity over the entire sweep while making these adjustments.

l. INTERACTION—Check steps 27e, h and j.

m. CHECK—Linearity at the 0.1 and 0.2 microsecond positions of the 7B50 Time/Div switch, using appropriate time markers.

n. ADJUST—C581, C591, C598 and C588 until tolerances are met as specified in the time base specification.

o. Return the Magnifier to the X1 position.

NOTE

Steps 27 and 28 are internal checks which are performed only during calibration. They are not part of the Performance Check.

27. High Sensitivity Z Axis Input Check

a. Test equipment required for steps 27 through 34 is shown in Fig. 5-10.

b. Turn the Type 7504 oscilloscope power off.

c. Lift the hinged chassis (temporarily) and remove the HV fuse. See Fig. 5-2.

d. Turn the Type 7504 Oscilloscope power on again.

e. Adjust the B INTENSITY control fully counterclockwise. See step 5.

f. Connect a 10X probe to channel 1 of the test oscilloscope and connect the probe tip to the Z Axis Amplifier output (TP736). See Fig. 5-3.

g. Connect a 1 kHz square wave output from the Type 106 to the High Sensitivity Z Axis Input connector (see

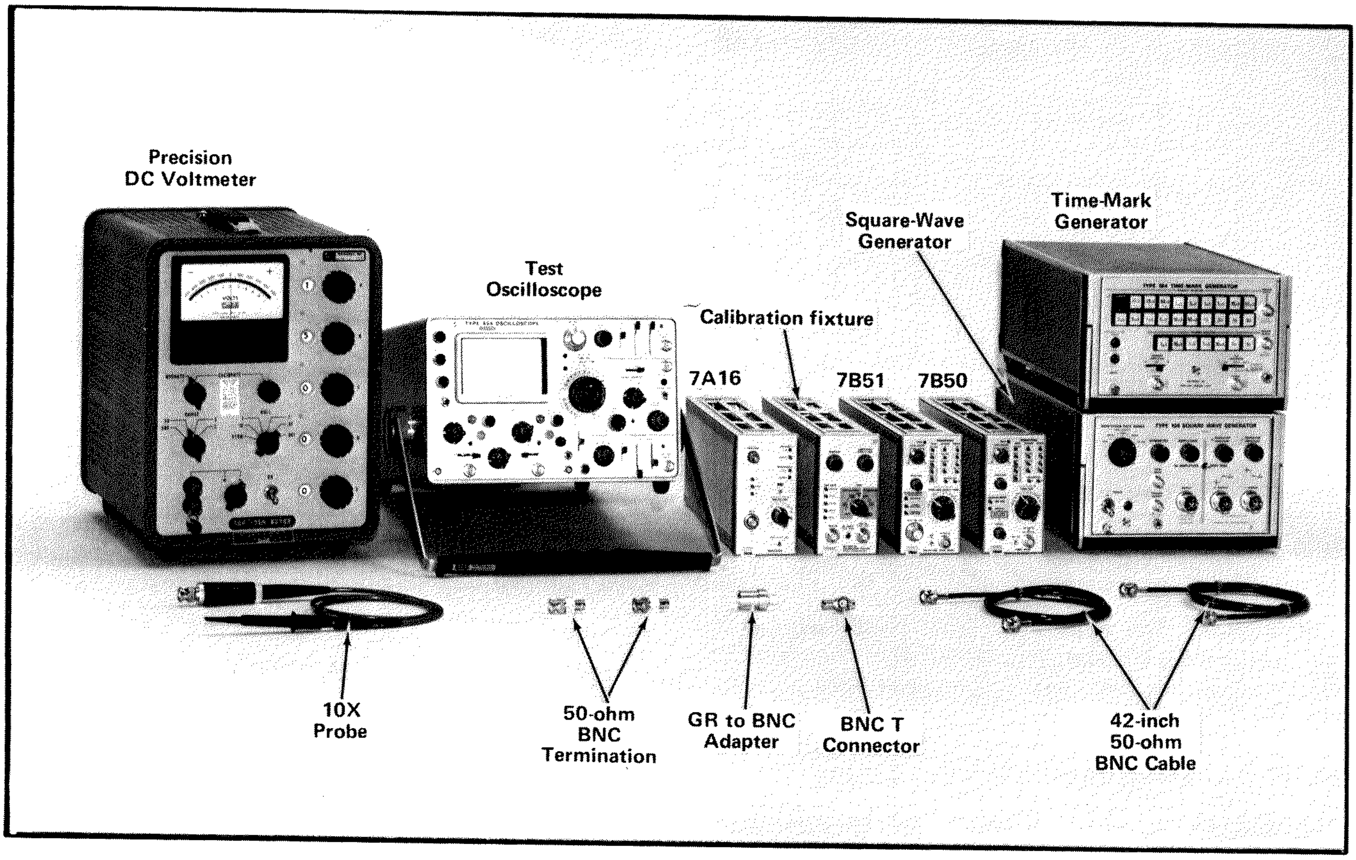

Fig. 5-10. Test equipment required for steps 27 through 34.

Fig. 5-3) and to channel two of the test oscilloscope. Use a GR to BNC adapter, a 50-ohm termination BNC T adapter and two coaxial cables.

h. Set the test oscilloscope channel 1 Volts/Div control to 1 Volt (10 volts/division at the 10X probe tip), channel 2 Volts/Div to 1 volt at a sweep rate of one millisecond/ division. Set the channel 2 input coupling switch to DC and channel 1 input coupling switch to the ground position.

i. Select channel 2 of the test oscilloscope and adjust the Type 106 output for a 2-volt peak-to-peak negative transition square wave.

j. Switch the test oscilloscope mode switch to channel 1, position the test oscilloscope trace to the bottom horizontal line of the graticule to estabilish a zero reference level, then set the test oscilloscope channel 1 input coupling switch to DC.

k. Trigger the test oscilloscope for a stable display.

l. CHECK—That the inverted square wave appears at the output of the Z Axis Amplifier with an excursion of approximately +5 volts to +65 volts. The bottom of the square wave display will appear 1/2-division up from the bottom line of the test oscilloscope graticule, and the tops will appear 2 1/2 divisions above the center horizontal line.

28. High Speed Z Axis Input Check

a. Remove the 50-ohm termination from the Type 106 Output connector and reconnect the BNC T adapter to the Type 106.

b. Remove the coaxial cable from the High Sensitivity Z Axis Input connector and connect it to the High Speed Z Axis Input connector (see Fig. 5-11).

c. Set the Type 7B50 Time/Div to 5 microsecond and Triggering source to Ext ÷ 10.

d. Set the test oscilloscope channel 1 Volts/Div switch to 1 volt (10 volts/division at the 10X probe tip), channel 2 Volts/Div to 10 volts at a sweep rate of 5 microseconds/ division. Set the channel 2 input coupling switch to DC and channel 1 input coupling switch to the ground position.

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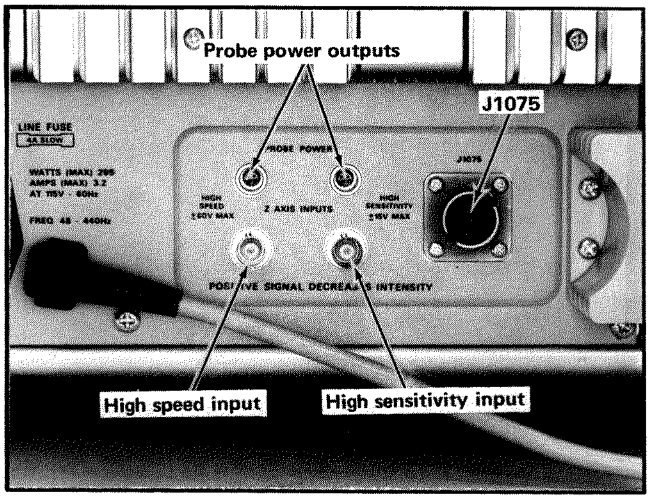

Fig. 5-11. Location of Probe Power outputs, Z Axis Inputs and J1075.

e. Select channel 2 of the test oscilloscope and switch the Type 106 Repetition Rate Range to 100 kHz. Adjust the output amplitude to 60 volts peak to peak as indicated by the channel 2 display on the test oscilloscope.

f. Remove the coaxial cable from the channel 2 input of the test oscilloscope and connect it to Type 7B50 Ext Trig In input.

g. Switch the test oscilloscope mode switch to channel 1, position the test oscilloscope trace to the bottom horizontal line of the graticule to establish a zero reference level, then set the test oscilloscope channel 1 input coupling switch to DC.

h. Trigger the test oscilloscope for a stable display.

i. CHECK —That the inverted square wave appears at the output of the Z Axis Amplifier with an excursion of approximately +5 volts to +65 volts.

j. Remove all connecting cables and probe.

k. Turn the Type 7504 power off and re-insert the HV fuse. Turn the power on again for the next steps.

29. Check + Sawtooth Output (A and B)

a. Remove the calibration fixture from the LEFT VERT compartment and replace it with a Type 7A16 plug-in.

b. Set the Type 7A16 front panel controls as follows:

Input	DC
Polarity	+UP
Volts/Div	1 V

c. Connect a coaxial cable from the + SAWTOOTH OUTPUT connector to the Type 7A16 input.

d. Set the Sweep Selector Switch on the Output Signal board to B, to agree with the location of the Type 7B50 in the B Horiz compartment.

e. Secure the hinged chassis in place and set the Gate Selector switch on the Output Signal board (see Fig. 5-12) to B position.

f. Set the Type 7B50 Time/Div to one millisecond and adjust the Level/Slope for a stable displayed ramp.

g. CHECK—For a 1 volt/division rate of rise of the displayed ramp (within ±10%).

h. Insert a 50-ohm termination between the + SAWTOOTH output connector and coaxial cable.

i. Set the Type 7A16 plug-in amplifier Volts/Div to 50 millivolts.

j. CHECK—For a 50 millivolt/division rate of rise (within ±15%).

k. Remove the Type 7B50 Time Base from the B HORIZ compartment and insert it into the A HORIZ compartment and repeat the check procedure, setting the Sweep Selector and Gate Selector switches to A.

l. CHECK—For a 1 volt/division rate of rise (within ±10%).

m. CHECK—For a 50 millivolt/division rate of rise (within ±15%).

n. Remove the Type 7B50 Time Base and install it in the B HORIZ compartment.

30. Check Sig Out

a. Set the Type 7A16 Amplifier Volts/Div to 0.1 Volt.

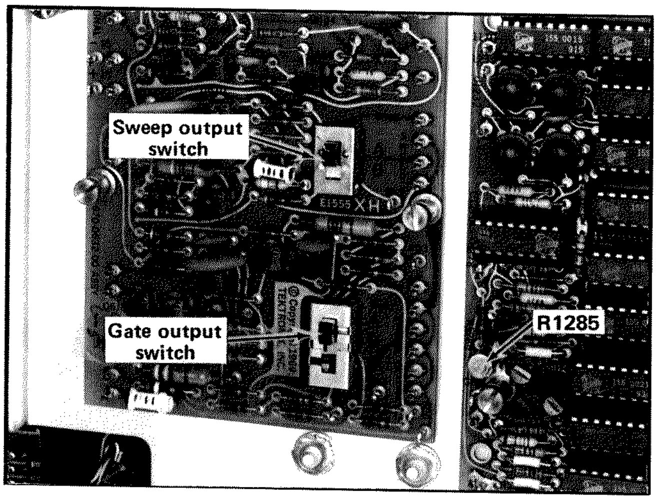

Fig. 5-12. Location of Sweep output switch and Gate output switch.

b. Connect the CALIBRATOR VOLTS output to the Type 7A16 Amplifier Input using a 42-inch coaxial cable.

c. Set the Calibrator Rate to 1 kHz and Calibrator Volts to 0.4 V.

d. Connect the SIG OUT output to one input of the test oscilloscope using a 42-inch coaxial cable.

e. Set the test oscilloscope for a vertical deflection factor of 0.5 volt/division at a sweep rate of one millisecond/division and adjust the Level control for a stable display.

f. CHECK—Test oscilloscope display for 5 division vertical deflection (within ±10%).

g. Insert a 50-ohm termination between the Sig Out output connector and coaxial cable. Set the test oscilloscope Volts/Div to 5 millivolts/division and adjust the Level control for a stable display.

h. CHECK—Test display for 5 division vertical deflection (within ±10%).

31. Check +Gate output A, B and Dly'd

a. Install a Type 7B51 Delaying Time Base in the A HORIZ compartment.

b. Connect the +Gate output to an input of the test oscilloscope using a BNC coaxial cable.

c. Set both Time Base Time/Div controls to 1 millisecond and both Triggering modes to Auto.

d. Actuate pushbutton A on the HORIZONTAL MODE switch.

e. Set the Gate Selector switch on the Output Signal board (see Fig. 5-12) to A position.

f. Set the test oscilloscope for a sweep rate of 2 milliseconds, Volts/Div to 5 V and adjust the Level control for a stable display.

g. CHECK—A GATE pulse amplitude of 10 volts (within ±10%). (Test oscilloscope display 2 divisions high).

h. Set the Gate Selector switch on the Output Signal Board (see Fig. 5-12) to B position.

i. CHECK—B GATE pulse amplitude of 10 Volts (within ±10%).

j. Set the Gate Selector switch on the Output Signal board (see Fig. 5-12) to Dly'd position and select the B Starts After Delay mode of the Type 7B51 Delaying Time Base.

k. CHECK—Dly'd Gate pulse amplitude of 10 volts (within ±10%).

l. Insert a 50-ohm termination between the +GATE output connector and coaxial cable. Set the test oscilloscope Volts/Div to 0.5 V.

m. CHECK—Repeat checks g, i, and k for a pulse amplitude of 0.5 volt (within ±10%).

n. Disconnect all cables from between the Type 7504 and the test oscilloscope. Remove the 50-ohm termination from the +GATE out connector.

32. Check/Adjust Calibrator Amplitude

a. Connect the precision DC voltmeter to the CALIBRATOR VOLTS output connector.

b. Set the CALIBRATOR VOLTS switch to 0.4 volt.

c. Set the RATE switch to DC VOLTS ONLY.

d. CHECK—For a 0.4 volt DC output (within ±1%).

e. CHECK—Remaining calibrator voltages as listed in Table 5-2. Connect a 50-ohm termination to the CALIBRATOR VOLTS output connector when checking the voltages shown within parentheses on the front panel.

f. ADJUST—R649 (see Fig. 5-13) for a meter reading of exactly 0.4 volt DC with the CALIBRATOR VOLTS set to 0.4 V.

TABLE 5-2

Calibrator	Meter Reading
40 V	+40 V, ±0.4 V
4 V	+4 V, ±0.04 V
0.4 V	+0.4 V, ±4 mV
40 mV	+40 mV, ±0.4 mV
4 mV	+4 mV, ±0.04 mV
Into 50Ω (Tolerance within 2%)	
0.4 V	+0.4 V, ±3%
0.2 V	+0.2 V, ±3%
20 mV	+20 mV, ±3%
2 mV	+2 mV, ±3%

33. Check/Adjust Calibrator Repetition Rate

a. Set the calibrator RATE switch to 1 kHz.

b. Connect the CALIBRATOR VOLTS output to the Channel 1 input connector of the test oscilloscope with a 42-inch 50-ohm BNC cable.

c. Connect the time-mark generator to the Channel 2 input connector of the test oscilloscope with a 42-inch 50-ohm BNC cable.

d. Set the time-mark generator for 1 ms markers.

e. Set the test oscilloscope for a sweep rate of 1 millisecond, alternate vertical mode, normal trigger and adjust the Level control for a stable display.

f. Position the test oscilloscope display so the tips of the markers fall just below the rising portions of the square wave (see Fig. 5-14).

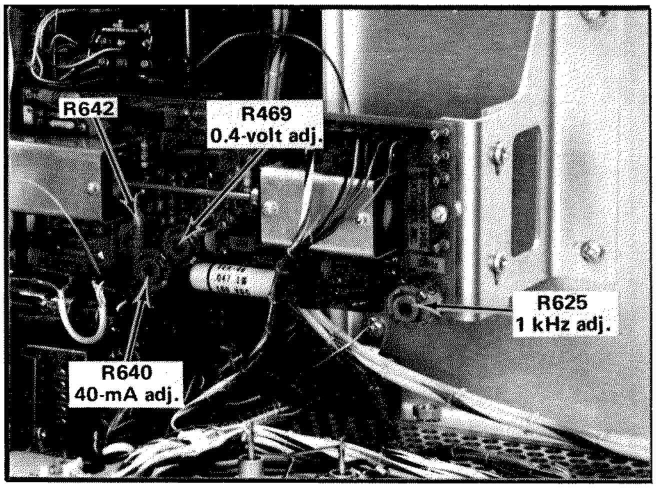

Fig. 5-13. Location of controls and R642 on the Calibrator board.

g. CHECK—For one cycle of calibrator waveform for each marker (see Fig. 5-14).

h. Switch the test oscilloscope to 10X magnifier and position the display horizontally to show the last marker at the center of the CRT graticule. (Use + slope triggering).

i. CHECK—For proper alignment of the last marker with the leading edge of the square wave (within ± 1 division).

j. Set the test oscilloscope trigger switch to Ch 1 Only.

k. ADJUST—1 kHz adjustment R625 (see Fig. 5-13) for minimum drift or no drift of the time markers.

l. Disconnect the time-marker generator and cable.

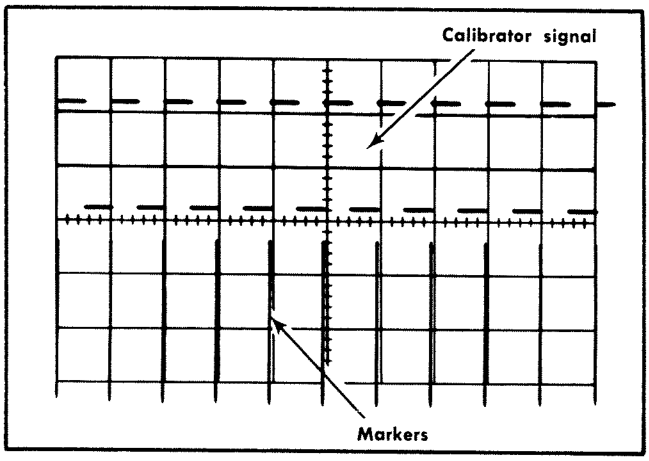

Fig. 5-14. Typical CRT display showing correct calibrator repetition rate.

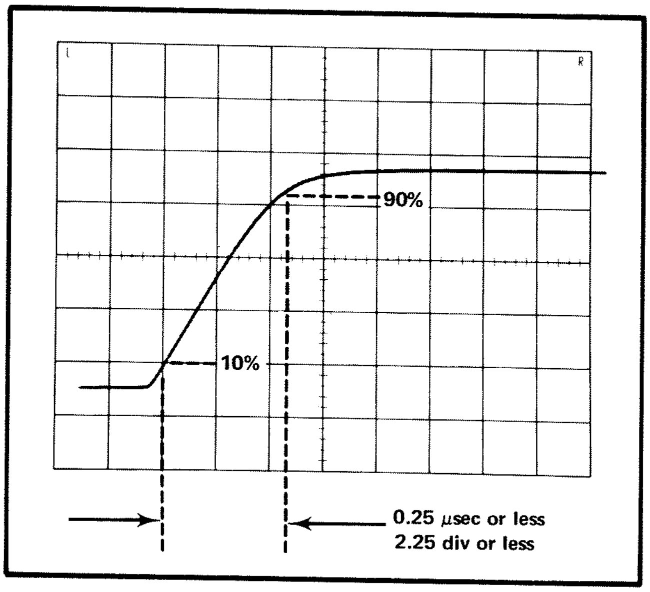

Fig. 5-15. Typical CRT display when checking calibrator risetime.

m. Return the test oscilloscope Vertical mode switch to CH 1 and turn the Magnifier to Off.

34. Check Calibrator Risetime

a. Set the CALIBRATOR VOLTS output to 4 volts.

b. Set the test oscilloscope for a sweep rate of 0.1 microsecond, Channel 1 Volts/Div to 1 Volt and adjust the Level control so all of the rising portion of the calibrator waveform is visible on the test oscilloscope.

c. Position the 10% point on the leading edge of the waveform to a vertical graticule line.

d. CHECK—CRT display for two and a half divisions or less horizontally between the 10% and 90% points on the leading edge of the calibrator waveform (0.25 microsecond or less risetime; see Fig. 5-15).

e. Disconnect the cable from the CALIBRATOR output and the test oscilloscope.

Test equipment required for steps 35 through 39 is shown in Fig. 5-16.

35. Adjust Current Through Current Probe Cal Loop

a. Set the CALIBRATOR RATE switch to DC CURRENT ONLY.

b. Connect the precision DC voltmeter across R642 (see Fig. 5-13).

c. ADJUST—40 mA adjustment R640 (see Fig. 5-13) for a reading on the precision voltmeter of 30.64 volts.

d. Remove all plug-ins for the next step.

36. Check X - Y Phasing

a. Set both Horizontal Phase Correction switches (see Fig. 5-17A) to off (down position).

b. Install two Type 7A16 vertical plug-ins, one in the LEFT VERT compartment and the other in the A HORIZ compartment.

c. Actuate pushbutton LEFT on the VERTICAL MODE switch and pushbutton A on the HORIZONTAL MODE switch.

d. Connect the output of the medium-frequency generator to both input connectors of the plug-ins using two 50-ohm terminations, two 50-ohm coaxial cables and a BNC T adapter.

e. Set the medium-frequency generator for an 8-division vertical and horizontal lissajous display on the Type 7504 at 35 kHz.

f. Center the display vertically and horizontally with both plug-in position controls.

g. CHECK—CRT display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift; see Fig. 5-17B).

h. Remove the plug-in from the A HORIZ compartment and install it into the B HORIZ compartment.

i. Actuate pushbutton B on the HORIZONTAL MODE switch.

j. CHECK—CRT display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift; see Fig. 5-17B).

k. Check all plug-in compartment combinations for two degrees or less phase shift.

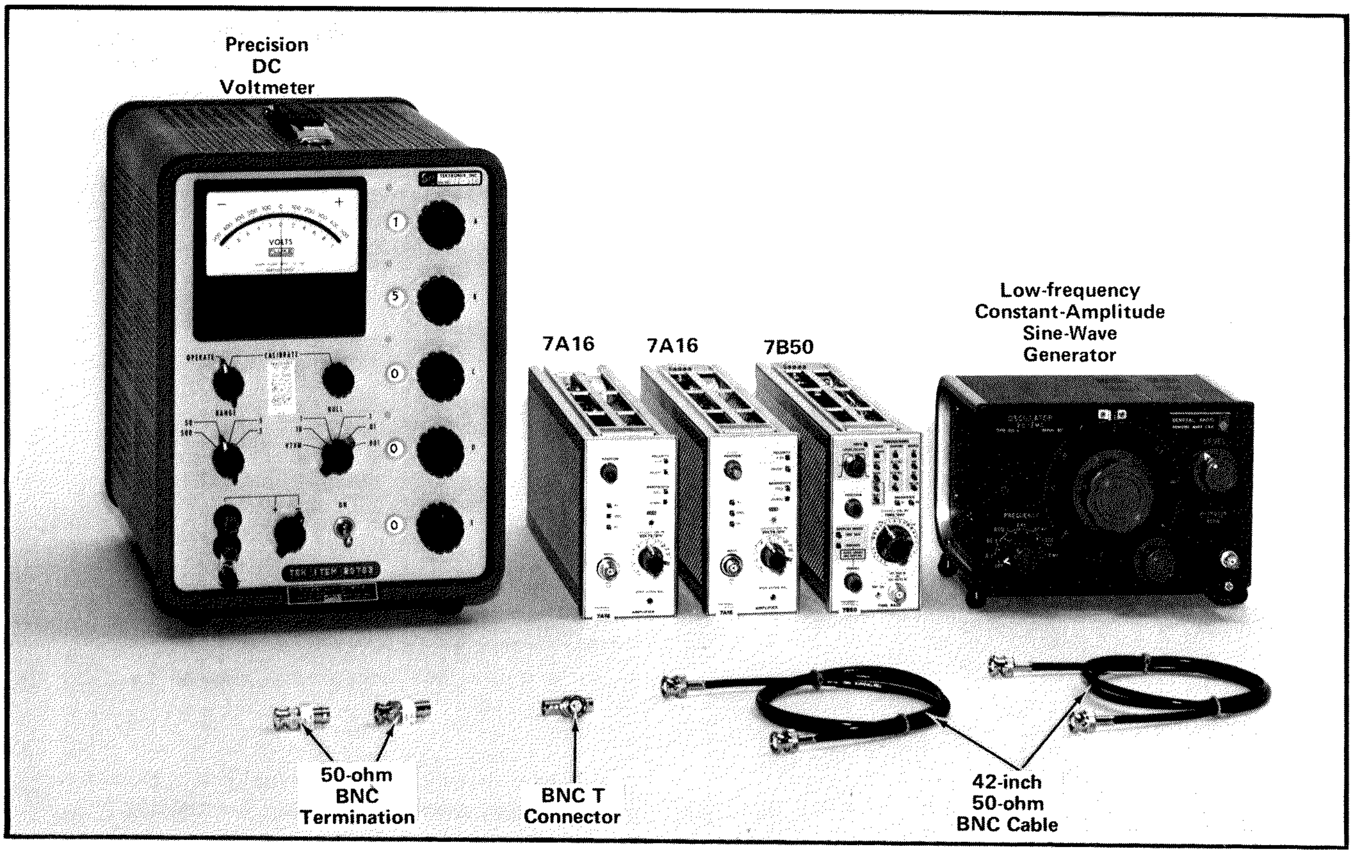

Fig. 5-16. Test equipment required for steps 35 through 39.

l. Place the plug-ins in the LEFT VERT and A HORIZ compartments.

37. Check/Adjust X - Y Phasing With Correction

a. Set both Horizontal Phase Correction switches (see Fig. 5-17A) to on (up position).

b. Set the medium-frequency generator for an 8-division vertical and horizontal display at 2 MHz.

c. CHECK—CRT display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift; see Fig. 5-17B).

d. ADJUST—Horizontal Phase Correction adjustment C55 (see Fig. 5-17B) for minimum opening of the display at the center of the vertical line.

e. Remove the plug-in from the A HORIZ compartment and install it into the B HORIZ compartment.

f. Actuate pushbutton B on the HORIZONTAL MODE switch.

g. CHECK—CRT display for an opening at the center vertical line of 0.28 division or less (2° or less phase shift; see Fig. 5-17B).

h. ADJUST—Horizontal phase correction adjustment C75 (see Fig. 5-17B) for minimum opening of the display at the center of the vertical line.

i. Check all plug-in compartment combinations for two degrees or less phase shift.

j. Place both plug-ins in the horizontal compartments.

38. Check Horizontal Bandwidth

a. Actuate pushbutton CHOP on the HORIZONTAL MODE switch.

b. Set the medium-frequency generator for an eight-

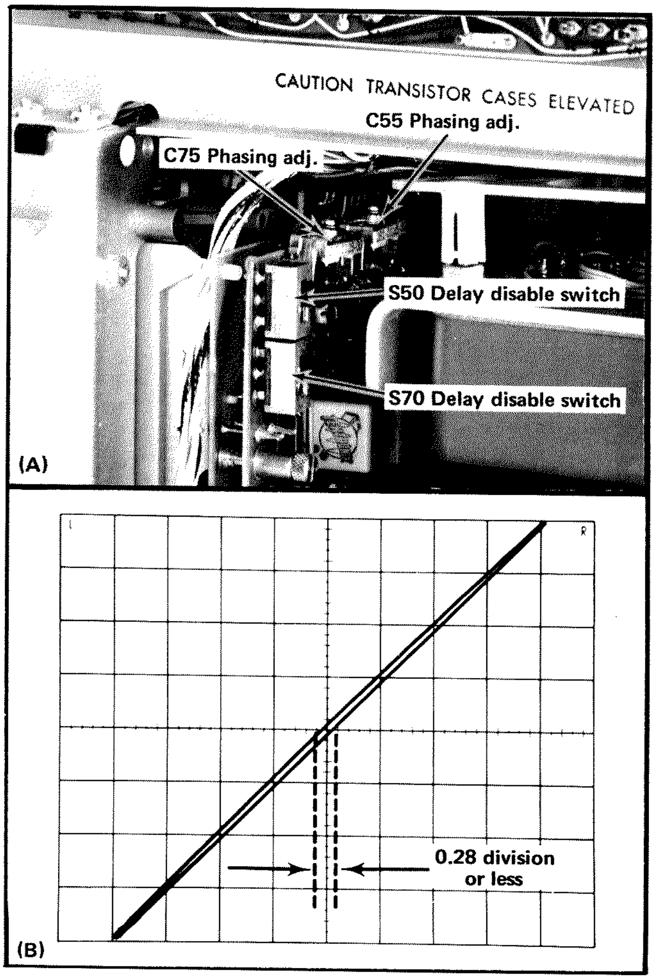

Fig. 5-17. (A) Location of Delay Disable switches, location of X-Y phasing adjustments, (B) Typical CRT display when checking X-Y phasing.

division horizontal display of both traces at a reference frequency of 30 kilohertz.

c. Without changing the output amplitude, increase the output frequency of the generator to 2 megahertz.

d. CHECK—Both horizontal amplitudes should not be reduced to less than 5.6 divisions (−3 dB point for a 2 MHz signal; see Fig. 5-18).

39. Check/Adjust Readout Position (When Readout Option is Installed)

a. Remove all plug-ins from the Type 7504 and install a Type 7B50 Time Base in the B HORIZ compartment.

b. Actuate pushbutton B on the HORIZONTAL MODE switch.

c. Adjust the Type 7B50 Level control for a stable trace.

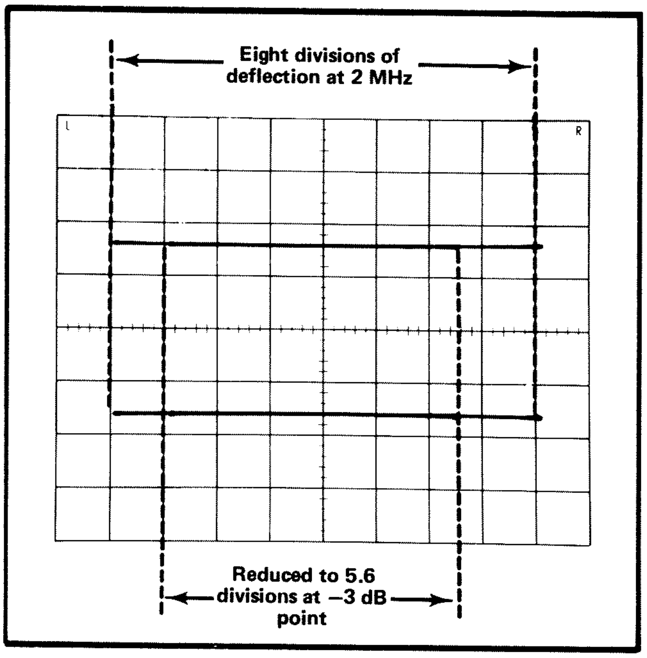

Fig. 5-18. Typical CRT display when checking horizontal bandwidth (double exposure).

d. Check that the displayed trace is exactly centered on the center horizontal graticule line. See step 15.

e. Rotate READOUT front panel control clockwise until a readout of the Type 7B50 is visible.

f. CHECK—That the readout is in the center of the top division of the CRT graticule.

g. ADJUST—R1285 on the Readout board (see Fig. 5-12), centering of the readout in the top division of the CRT graticule.

h. CHECK—That the displayed trace is still centered on the center horizontal graticule line.

i. Set the 7B50 Time/Div switch to 0.5 ms.

j. CHECK—Readout display for completeness of characters.

k. ADJUST—Full Character Scan adjustment R1219 for complete but not overdisplayed characters.

l. INTERACTION—Check step 15 and step 37g.

This completes the calibration/checkout procedure for the Type 7504. Secure the hinged chassis and replace the side and bottom panels. 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
BHS	binding head steel
cap.	capacitor
cer	ceramic
comp	composition
conn	connector
CRT	cathode-ray tube
csk	countersunk
DE	double end
dia	diameter
div	division
elect.	electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
ext	external
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
h	height or high
hex.	hexagonal
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
ID	inside diameter
inc	incandescent
int	internal
lg	length or long
met.	metal
mtg hdw	mounting hardware
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
P/O	part of
PHB	pan head brass
PHS	pan head steel
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
RHB	round head brass
RHS	round head steel
SE	single end
SN or S/N	serial number
S or SW	switch
TC	temperature compensated
THB	truss head brass
thk	thick
THS	truss head steel
tub.	tubular
var	variable
w	wide or width
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

×000	Part first added at this serial number
00×	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.

INDEX OF ELECTRICAL PARTS LIST

INSTRUMENT OPTIONS

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

CHASSIS

Bulbs

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
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			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C481	283-0000-00			0.001 μF	Cer	500 V	
C565	283-0002-00			0.01 μF	Cer	500 V	
C741	283-0177-00			1 μF	Cer	25 V	+80%—20%
C742	283-0021-00			0.001 μF	Cer	5000 V	
C762	290-0312-00			47 pF	Elect.	35 V	10%
C764	285-0629-00			0.047 μF	PTM	100 V	
C772	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C777	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C781	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C782[1]							
C783[1]							
C784[1]							
C785[1]							
C786	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C787	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C788	283-0082-00			0.01 μF	Cer	4000 V	+80%—20%
C789	283-0077-00			330 pF	Cer	500 V	5%
C811	285-0566-00			0.022 μF	PTM	200 V	10%
C812	290-0435-00			1300 μF	Elect.	100 V	+75%—10%
C841	285-0566-00			0.022 μF	PTM	200 V	10%
C842	290-0423-00			9500 μF	Elect.	30 V	+75%—10%
C871	285-0566-00			0.022 μF	PTM	200 V	10%
C872	290-0422-00			54,000 μF	Elect.	15 V	+75%—10%
C901	285-0566-00			0.022 μF	PTM	200 V	10%
C902	290-0423-00			9500 μF	Elect.	30 V	+75%—10%

[1]Furnished as a unit with Power Supply sub assembly (*119-0226-00).

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C931	285-0566-00			0.022 μF	PTM	200 V	10%
C932	290-0435-00			1300 μF	Elect.	100 V	+75%—10%
C961	285-0566-00			0.022 μF	PTM	200 V	10%
C962	290-0424-00			450 μF	Elect.	150 V	+75%—10%
C981	285-0566-00			0.022 μF	PTM	200 V	10%
C982	290-0424-00			450 μF	Elect.	150 V	+75%—10%
C1056	281-0645-00			8.2 pF	Cer	500 V	±0.25 pF
C1057	283-0636-00			36 pF	Mica	100 V	±0.5 pF
C1081	283-0177-00			1 μF	Cer	25 V	+80%—20%
C1082	283-0177-00			1 μF	Cer	25 V	+80%—20%
C1083	283-0177-00			1 μF	Cer	25 V	+80%—20%
				Semiconductor Device, Diodes			
CR565	152-0066-00			Silicon	1N3194		
CR741	152-0242-00			Silicon	225 V, 10 mA		
CR772	152-0408-00			Silicon	Rectifier, 10 kV, 5 mA fast reverse recovery		
CR781	152-0408-00			Silicon	Rectifier, 10 kV, 5 mA fast reverse recovery		
CR782[2]							
CR783[2]							
CR784[2]							
VR786	152-0100-00			Zener	1N3046B 1 W, 120 V, 5%		
CR842	152-0406-00			Silicon	Rectifier assembly, 3 A, 250 V		
CR870	*152-0274-00			Silicon	Replaceable by 1N1200		
CR871	*152-0274-00			Silicon	Replaceable by 1N1200		
CR872	*152-0274-00			Silicon	Replaceable by 1N1200		
CR873	*152-0274-00			Silicon	Replaceable by 1N1200		
CR902	152-0406-00			Silicon	Rectifier assembly, 3 A, 250 V		
CR1040	*152-0274-00			Silicon	Replaceable by 1N1200		
CR1041	*152-0274-00			Silicon	Replaceable by 1N1200		
				Fuses			
F801	159-0027-00			4 A 3 AG Slo-Blo			
F802	159-0005-00			3 A 3 AG Slo-Blo			
				Delay Line			
DL400	*119-0208-00			Delay Line			

[2]Furnished as a unit with Power Supply sub assy (*119-0226-00).

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CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
				Line Filter	
FL801	119-0113-05			3.25 A 250 V AC	
				Connectors	
J618	131-0818-00			BNC, receptacle, electrical	
J650	131-0818-00			BNC, receptacle, electrical	
J679	131-0818-00			BNC, receptacle, electrical	
J699	131-0818-00			BNC, receptacle, electrical	
J1055	131-0106-01			Coax, 1 contact, female	
J1060	131-0106-01			Coax, 1 contact, female	
J1075	136-0089-00			9 pin, chassis mounted	
J1080	131-0771-00			Receptacle, electrical, 4 contact	
J1085	131-0771-00			Receptacle, electrical, 4 contact	
				Inductors	
L485	*114-0159-00			0.7-1.5 μH, Var	Core 276-0506-00
L564	276-0507-00			Core, ferramic suppressor	
L566	*108-0156-00			300 μH	
L574	276-0507-00			Core, ferramic suppressor	
L576	*108-0156-00			300 μH	
L762	*108-0422-01			80 μH	
L764	*108-0231-00			4.5 μH	
L781	108-0553-00			47 μH	
L788	108-0553-00			47 μH	
L790	*108-0544-00			Trace rotator	
L795	*108-0546-00			Y Axis alignment	
L1055	276-0507-00			Core, ferramic suppressor	
LR486	*108-0006-00			0.13 μH (wound on a 100 Ω, ½ W resistor)	
LR487	*108-0006-00			0.13 μH (wound on a 100 Ω, ½ W resistor)	
				Transistors	
Q484	*151-0211-00			Silicon	Selected from 2N3866
Q486	*151-0211-00			Silicon	Selected from 2N3866
Q566	*151-0274-00			Silicon	Tek Spec
Q576	*151-0274-00			Silicon	Tek Spec
Q764	*151-0140-00			Silicon	Selected from 2N3055
Q766	*151-0140-00			Silicon	Selected from 2N3055
Q837	*151-0209-00			Silicon	Selected from 2N3442
Q863	*151-0148-00			Silicon	Selected from 40250 RCA
Q867	*151-0141-00			Silicon	Selected from 40251 RCA
Q872	151-0507-00			Silicon	2N3669 (silicon controlled rectifier)

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Transistors (cont)							
Q886	*151-0141-00			Silicon	Selected from 2N3055		
Q897	151-0275-00			Silicon	2N3771		
Q913	*151-0148-00			Silicon	Selected from 40250 RCA		
Q927	*151-0141-00			Silicon	Selected from 40251 RCA		
Q953	*151-0209-00			Silicon	Selected from 2N3442		
Q973	151-0149-00			Silicon	2N3441		
Q994	151-0201-00			Silicon	2N3739		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R481	303-0470-00			47 Ω	1 W		5%
R482	308-0430-00			500 Ω	8 W	WW	1%
R483	308-0430-00			500 Ω	8 W	WW	1%
R564	301-0101-00			100 Ω	½ W		5%
R565	302-0470-00			47 Ω	½ W		
R566	308-0632-00			2.5 kΩ	10 W	WW	1%
R574	301-0101-00			100 Ω	½ W		5%
R576	308-0632-00			2.5 kΩ	10 W	WW	1%
R740				180 kΩ			
R741				470 kΩ			
R742	*307-0205-00			29.45 MΩ	Film		
R743				80 MΩ			
R744				19 MΩ			
R773	316-0393-00			39 kΩ	¼ W		
R775	311-0990-00			5 MΩ, Var			
R777	316-0105-00			1 MΩ	¼ W		
R779	316-0156-00			15 MΩ	¼ W		
R780[3]							
R781[3]							
R782	323-0534-00			3.57 MΩ	½ W	Prec	1%
R785[4]	311-0945-00			5 MΩ, Var			
R786	316-0470-00			47 Ω	¼ W		
R787	301-0471-00			470 Ω	½ W		5%
R790	311-0964-00			2.5 kΩ, Var			
R793	311-0467-00			100 kΩ, Var			
R807	315-0561-00			560 Ω	¼ W		5%
R808	315-0121-00			120 Ω	¼ W		5%
R809	311-0939-00			25 Ω, Var			

[3]Furnished as a unit with Power Supply and sub assembly (*119-0226-00).
[4]Furnished as a unit with R1037.

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CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R973	308-0114-00			600 Ω	25 W	WW	5%
R982	303-0203-00			20 kΩ	1 W		5%
R994	308-0107-00			1 kΩ	5 W	WW	5%
R1035[5]	311-0973-00			5 kΩ, Var			
R1037[6]	311-0945-00			5 kΩ, Var			
R1040[7]				5 kΩ, Var			
R1045	311-0310-00			5 kΩ, Var			
R1046	315-0132-00			1.3 kΩ	¼ W		5%
R1056	301-0562-00			5.6 kΩ	½ W		5%
R1058	301-0113-00			11 kΩ	½ W		5%
R1060	315-0241-00			240 Ω	¼ W		5%
				Switches			
	Wired or Unwired						
S455A,B[8]	311-0973-00						
S801	260-1060-00			Lever	POWER ON		
S802[9]							
S803[9]							
S1040A,B[10]	260-1084-00			Rotary	READOUT		
				Thermal Cut-Out			
TK801	260-0907-00			Open 208° F, close 168° F			
				Transformers			
T703	276-0549-00			Core, ferrite			
T764	*120-0627-00			H. V. Power			
T801	*120-0626-00			L. V. Power			
				Electron Tube			
V799	*154-0608-00			T7500-31-1 CRT Standard Phosphor			

[5]Furnished as a unit with S455.

[6]Furnished as a unit with R785.

[7]Furnished as a unit with S1040A,B.

[8]Furnished as a unit with R1035.

[9]See Mechanical Parts List. Line Voltage Selector Body.

[10]Furnished as a unit with R1040.

MAIN INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0621-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C1	283-0177-00			1 μF	Cer	25 V	+80%—20%
C2	283-0177-00			1 μF	Cer	25 V	+80%—20%
C3	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C4	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C5	283-0177-00			1 μF	Cer	25 V	+80%—20%
C6	283-0177-00			1 μF	Cer	25 V	+80%—20%
C7	281-0605-00			200 μF	Cer	500 V	
C8	283-0177-00			1 μF	Cer	25 V	+80%—20%
C9	283-0177-00			1 μF	Cer	25 V	+80%—20%
C10	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C11	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C12	283-0177-00			1 μF	Cer	25 V	+80%—20%
C13	283-0177-00			1 μF	Cer	25 V	+80%—20%
C14	283-0000-00			0.001 μF	Cer	500 V	
C18	283-0177-00			1 μF	Cer	25 V	+80%—20%
C36	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C38	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C42	281-0529-00			1.5 pF	Cer	500 V	±0.25 pF

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
J1	131-0767-02			Receptacle, electrical, 76 contact
J2	131-0767-02			Receptacle, electrical, 76 contact
J3	131-0767-00			Receptacle, electrical, 76 contact
J4	131-0767-00			Receptacle, electrical, 76 contact

MAIN INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Transistors			
Q24	151-0190-00			Silicon	2N3904		
Q28	151-0190-00			Silicon	2N3904		
				Resistors			

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R1	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R3	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R4	321-0231-00			2.49 kΩ	1/8 W	Prec	1%
R5	321-0231-00			2.49 kΩ	1/8 W	Prec	1%
R7	315-0511-00			510 Ω	1/4 W		5%
R8	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R9	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R14	315-0242-00			2.4 kΩ	1/4 W		5%
R19	315-0202-00			2 kΩ	1/4 W		5%
R20	315-0202-00			2 kΩ	1/4 W		5%
R21	315-0302-00			3 kΩ	1/4 W		5%
R22	315-0103-00			10 kΩ	1/4 W		5%
R23	315-0562-00			5.6 kΩ	1/4 W		5%
R24	315-0302-00			3 kΩ	1/4 W		5%
R25	315-0513-00			51 kΩ	1/4 W		5%
R26	315-0103-00			10 kΩ	1/4 W		5%
R27	315-0562-00			5.6 kΩ	1/4 W		5%
R28	315-0302-00			3 kΩ	1/4 W		5%
R29	315-0513-00			51 kΩ	1/4 W		5%
R31	315-0132-00			1.3 kΩ	1/4 W		5%
R32	321-0204-00			1.3 kΩ	1/8 W	Prec	1%
R33	315-0510-00			51 Ω	1/4 W		5%
R34	315-0510-00			51 Ω	1/4 W		5%
R35	315-0132-00			1.3 kΩ	1/4 W		5%
R36	315-0104-00			100 kΩ	1/4 W		5%
R37	315-0152-00			1.5 kΩ	1/4 W		5%
R38	315-0104-00			100 kΩ	1/4 W		5%
R39	315-0152-00			1.5 kΩ	1/4 W		5%
R40	315-0243-00			24 kΩ	1/4 W		5%
R42	315-0511-00			510 Ω	1/4 W		5%
R43	315-0511-00			510 Ω	1/4 W		5%
R44	315-0472-00			4.7 kΩ	1/4 W		5%
R45	321-0222-00			2 kΩ	1/8 W	Prec	1%
R46	315-0510-00			51 Ω	1/4 W		5%
R47	315-0510-00			51 Ω	1/4 W		5%
R48	315-0511-00			510 Ω	1/4 W		5%
R49	315-0511-00			510 Ω	1/4 W		5%

VERTICAL INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0622-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

C207	281-0528-00		82 pF	Cer	500 V	10%
C214	281-0589-00		170 pF	Cer	500 V	5%
C220	283-0177-00		1 μF	Cer	25 V	+80%—20%

Semiconductor Device, Diodes

CR233 } CR234 }	*153-0025-00	Silicon	Tek Spec (matched pair)
CR292	*152-0185-00	Silicon	Replaceable by 1N4152
CR293	*152-0185-00	Silicon	Replaceable by 1N4152
CR296	*152-0185-00	Silicon	Replaceable by 1N4152

Transistors

Q224	151-0221-00	Silicon	2N4258
Q226	151-0221-00	Silicon	2N4258
Q234	*151-0212-00	Silicon	Tek Spec
Q236	*151-0212-00	Silicon	Tek Spec
Q244	151-0221-00	Silicon	2N4258
Q246	151-0221-00	Silicon	2N4258
Q254	151-0190-00	Silicon	2N3904
Q256	151-0190-00	Silicon	2N3904
Q273	151-0190-00	Silicon	2N3904
Q283	151-0190-00	Silicon	2N3904
Q293	151-0188-00	Silicon	2N3906

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R201	321-1068-02	50.5 Ω	1/8 W	Prec	1/2%
R202	321-1068-02	50.5 Ω	1/8 W	Prec	1/2%
R203	321-1068-02	50.5 Ω	1/8 W	Prec	1/2%
R204	321-1068-02	50.5 Ω	1/8 W	Prec	1/2%
R207	317-0393-00	39 kΩ	1/8 W		5%

VERTICAL INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Part No. Tektronix	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R209	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R210	322-0197-00			1.1 kΩ	1/4 W	Prec	1%
R211	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R212	322-0212-00			1.58 kΩ	1/4 W	Prec	1%
R214	317-0393-00			39 kΩ	1/8 W		5%
R217	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R218	322-0197-00			1.1 kΩ	1/4 W	Prec	1%
R219	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R221	317-0330-00			33 Ω	1/8 W		5%
R222	317-0330-00			33 Ω	1/8 W		5%
R223	317-0331-00			330 Ω	1/8 W		5%
R224	315-0200-00			20 Ω	1/4 W		5%
R225	315-0200-00			20 Ω	1/4 W		5%
R226	321-0097-00			100 Ω	1/8 W	Prec	1%
R227	321-0097-00			100 Ω	1/8 W	Prec	1%
R228	317-0134-00			130 kΩ	1/8 W		5%
R231	321-0097-00			100 Ω	1/8 W	Prec	1%
R233	322-0216-00			1.74 kΩ	1/4 W	Prec	1%
R234	322-0216-00			1.74 kΩ	1/4 W	Prec	1%
R236	321-0098-00			102 Ω	1/8 W	Prec	1%
R243	322-0126-00			200 Ω	1/4 W	Prec	1%
R244	322-0126-00			200 Ω	1/4 W	Prec	1%
R246	321-0195-00			1.05 kΩ	1/8 W	Prec	1%
R247	321-0195-00			1.05 kΩ	1/8 W	Prec	1%
R251	317-0100-00			10 Ω	1/8 W		5%
R252	317-0100-00			10 Ω	1/8 W		5%
R253	321-0164-00			499 Ω	1/8 W	Prec	1%
R254	321-0164-00			499 Ω	1/8 W	Prec	1%
R255	321-0164-00			499 Ω	1/8 W	Prec	1%
R257	317-0122-00			1.2 kΩ	1/8 W		5%
R271	321-0126-00			200 Ω	1/8 W	Prec	1%
R272	321-0126-00			200 Ω	1/8 W	Prec	1%
R276	317-0512-00			5.1 kΩ	1/8 W		5%
R277	317-0511-00			510 Ω	1/8 W		5%
R281	322-0207-00			1.4 kΩ	1/4 W	Prec	1%
R291	317-0103-00			10 kΩ	1/8 W		5%
R292	317-0512-00			5.1 kΩ	1/8 W		5%
R293	317-0512-00			5.1 kΩ	1/8 W		5%
R296	317-0153-00			15 kΩ	1/8 W		5%
				Transformer			
T236	*120-0628-00			Toroid, two 2 turn windings			
				Integrated Circuit			
U214	*155-0022-00			Monolithic M036			

HORIZONTAL INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0623-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

C381	281-0546-00			330 pF	Cer	500 V	10%
C388	281-0546-00			330 pF	Cer	500 V	10%
C395	283-0177-00			1 μF	Cer	25 V	+80%—20%

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R371	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R372	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R373	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R374	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R381	315-0153-00			15 kΩ	1/4 W		5%
R382	315-0512-00			5.1 kΩ	1/4 W		5%
RT383	307-0124-00			5 kΩ	Thermal		
R384	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R385	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R386	322-0189-00			909 Ω	1/4 W	Prec	1%
R387	322-0212-00			1.58 kΩ	1/4 W	Prec	1%
R388	315-0153-00			15 kΩ	1/4 W		5%
R389	315-0512-00			5.1 kΩ	1/4 W		5%
RT390	307-0124-00			5 kΩ	Thermal		
R391	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R392	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R393	322-0189-00			909 Ω	1/4 W	Prec	1%
R395	321-0076-00			60.4 Ω	1/8 W	Prec	1%
R396	321-0076-00			60.4 Ω	1/8 W	Prec	1%
R398	323-0158-00			432 Ω	1/2 W	Prec	1%
R399	323-0158-00			432 Ω	1/2 W	Prec	1%

Integrated Circuit

U384	*155-0022-00			Monolithic

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POWER INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0624-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C837	290-0271-00			9 μF	Elect.	125 V	+20%—15%
C866	290-0296-00			100 μF	Elect.	20 V	
C896	290-0296-00			100 μF	Elect.	20 V	
C924	290-0162-00			22 μF	Elect.	35 V	
C951	290-0271-00			9 μF	Elect.	125 V	+20%—15%

TRIG. SEL. Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
	*670-0625-00			Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C309	281-0541-00			6.8 pF	Cer	500 V	10%
C318	281-0616-00	XB020000		6.8 pF	Cer	200 V	
C319	281-0626-00	B010100	B019999	3.3 pF	Cer	500 V	5%
C319	281-0616-00	B020000		6.8 pF	Cer	200 V	
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 μF	Cer	500 V	
C346	283-0000-00			0.001 μF	Cer	500 V	

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
CR342	152-0141-02			Silicon	1N4152
CR346	152-0141-02			Silicon	1N4152

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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

TRIG. SEL. Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors			
Resistors are fixed, composition, ±10% unless otherwise indicated.							
R301	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R302	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R303	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R304	322-0184-00			806 Ω	1/4 W	Prec	1%
R305	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R306	321-0218-00			1.82 kΩ	1/8 W	Prec	1%
R307	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R308	322-0184-00			806 Ω	1/4 W	Prec	1%
R309	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R311	317-0330-00			33 Ω	1/8 W		5%
R312	317-0330-00			33 Ω	1/8 W		5%
R313	323-0155-00			402 Ω	1/2 W	Prec	1%
R314	323-0155-00			402 Ω	1/2 W	Prec	1%
R316	317-0331-00			330 Ω	1/8 W		5%
R318	321-0214-00			1.65 kΩ	1/8 W	Prec	1%
R319	321-0214-00			1.65 kΩ	1/8 W	Prec	1%
R321	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R322	321-1068-02			50.5 Ω	1/8 W	Prec	1/2%
R323	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R324	322-0184-00			806 Ω	1/4 W	Prec	1%
R325	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R326	321-0218-00			1.82 kΩ	1/8 W	Prec	1%
R327	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R328	322-0184-00			806 Ω	1/4 W	Prec	1%
R329	321-0741-02			40.9 Ω	1/8 W	Prec	1/2%
R331	321-0044-00			28 Ω	1/8 W	Prec	1%
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			

LOGIC Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0626-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C101	283-0177-00			1 μF	Cer	25 V	+80%—20%
C102	290-0134-00			22 μF	Elect.	15 V	
C103	283-0177-00			1 μF	Cer	25 V	+80%—20%
C104	283-0177-00			1 μF	Cer	25 V	+80%—20%
C115	283-0003-00			0.01 μF	Cer	150 V	
C117	283-0668-00			184 pF	Mica	500 V	1%
C119	281-0564-00			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 μF	Cer	25 V	+80%—20%
C144	283-0000-00			0.001 μF	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 μF	Cer	500 V	

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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
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
CR176	*152-0185-00			Silicon	Replaceable by 1N4152
CR177	*152-0185-00			Silicon	Replaceable by 1N4152
CR183	*152-0185-00			Silicon	Replaceable by 1N4152
CR184	*152-0185-00			Silicon	Replaceable by 1N4152

LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Inductors			
L101	108-0245-00			3.9 μH			
L102	108-0245-00			3.9 μH			
L103	108-0245-00			3.9 μH			
L104	108-0245-00			3.9 μH			
L115	108-0245-00			3.9 μH			
L136	108-0245-00			3.9 μH			
L138	108-0245-00			3.9 μH			
LR134	*108-0543-00			1.1 μH (wound on a 47 Ω, ¼ W, 5% resistor)			
LR151	*108-0543-00			1.1 μH (wound on a 47 Ω, ¼ W, 5% resistor)			
LR180	*108-0543-00			1.1 μH (wound on a 47 Ω, ¼ W, 5% resistor)			
LR190	*108-0543-00			1.1 μH (wound on a 47 Ω, ¼ 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, ±10% unless otherwise indicated.							
R104	315-0100-00			10 Ω	¼ W		5%
R110	315-0510-00			51 Ω	¼ W		5%
R111	315-0510-00			51 Ω	¼ W		5%
R112	301-0241-00			240 Ω	½ W		5%
R113	315-0510-00			51 Ω	¼ W		5%
R114	315-0510-00			51 Ω	¼ W		5%
R115	315-0101-00			100 Ω	¼ W		5%
R116	315-0622-00			6.2 kΩ	¼ W		5%
R117	315-0471-00			470 Ω	¼ W		5%
R118	315-0682-00			6.8 kΩ	¼ W		5%
R119	315-0512-00			5.1 kΩ	¼ W		5%
R120	315-0512-00			5.1 kΩ	¼ W		5%
R121	315-0101-00			100 Ω	¼ W		5%
R122	321-0289-00			10 kΩ	⅛ W	Prec	1%
R123	321-0193-00			1 kΩ	⅛ W	Prec	1%

LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R124	315-0223-00			22 kΩ	1/4 W		5%
R125	321-0193-00			1 kΩ	1/8 W	Prec	1%
R126	315-0223-00			22 kΩ	1/4 W		5%
R127	315-0332-00			3.3 kΩ	1/4 W		5%
R128	315-0202-00			2 kΩ	1/4 W		5%
R135	315-0752-00			7.5 kΩ	1/4 W		5%
R136	315-0271-00			270 Ω	1/4 W		5%
R137	315-0332-00			3.3 kΩ	1/4 W		5%
R138	315-0271-00			270 Ω	1/4 W		5%
R139	315-0332-00			3.3 kΩ	1/4 W		5%
R140	311-0807-00			1 kΩ, Var			
R141	315-0151-00			150 Ω	1/4 W		5%
R142	321-0231-00			2.49 kΩ	1/8 W	Prec	1%
R143	321-0251-00			4.02 kΩ	1/8 W	Prec	1%
R144	321-0215-00			1.69 kΩ	1/8 W	Prec	1%
R145	321-0251-00			4.02 kΩ	1/8 W	Prec	1%
R146	315-0242-00			2.4 kΩ	1/4 W		5%
R147	315-0512-00			5.1 kΩ	1/4 W		5%
R148	315-0303-00			30 kΩ	1/4 W		5%
R149	315-0682-00			6.8 kΩ	1/4 W		5%
R152	315-0332-00			3.3 kΩ	1/4 W		5%
R153	315-0512-00			5.1 kΩ	1/4 W		5%
R154	315-0512-00			5.1 kΩ	1/4 W		5%
R156	315-0332-00			3.3 kΩ	1/4 W		5%
R160	315-0201-00			200 Ω	1/4 W		5%
R161	315-0103-00			10 kΩ	1/4 W		5%
R162	315-0512-00			5.1 kΩ	1/4 W		5%
R163	315-0183-00			18 kΩ	1/4 W		5%
R164	315-0102-00			1 kΩ	1/4 W		5%
R165	315-0201-00			200 Ω	1/4 W		5%
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	321-0293-00			11 kΩ	1/8 W	Prec	1%
R176	315-0302-00			3 kΩ	1/4 W		5%
R177	315-0683-00			68 kΩ	1/4 W		5%
R178	315-0472-00			4.7 kΩ	1/4 W		5%

LOGIC Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R179	315-0302-00			3 kΩ	¼ W	5%
R180	315-0222-00			2.2 kΩ	¼ W	5%
R181	315-0332-00			3.3 kΩ	¼ W	5%
R182	315-0102-00			1 kΩ	¼ W	5%
R183	315-0202-00			2 kΩ	¼ W	5%
R191	315-0332-00			3.3 kΩ	¼ W	5%
R192	315-0103-00			10 kΩ	¼ W	5%
R193	315-0302-00			3 kΩ	¼ W	5%
R194	315-0303-00			30 kΩ	¼ W	5%
R195	315-0222-00			2.2 kΩ	¼ W	5%
R196	315-0102-00			1 kΩ	¼ W	5%
R197	315-0301-00			300 Ω	¼ W	5%
R198	315-0332-00			3.3 kΩ	¼ 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. OUTPUT Circuit Board Assembly

	*670-0628-00			Complete Board			
				Capacitors			

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C400	281-0547-00			2.7 pF	Cer	500 V	10%
C401	281-0612-00			5.6 pF	Cer	200 V	±0.5 pF
C402	281-0629-00			33 pF	Cer	600 V	5%
C407	281-0612-00			5.6 pF	Cer	200 V	±0.5 pF
C411	283-0088-00			1100 pF	Cer	500 V	5%
C412	283-0088-00			1100 pF	Cer	500 V	5%
C428	283-0088-00			1100 pF	Cer	500 V	5%
C429	283-0088-00			1100 pF	Cer	500 V	5%
C434	281-0161-00			5-15 pF, Var	Cer		
C435	281-0122-00			2.5-9 pF, Var	Cer		

VERT. OUTPUT Circuit Board Assemly (cont)

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C436	281-0657-00			13 pF	Cer	200 V	
C437	283-0615-00			33 pF	Mica	100 V	±0.5 pF
C439	283-0649-00			105 pF	Mica	300 V	1%
C450	281-0123-00			5-25 pF, Var	Cer		
C454	283-0177-00			1 μF	Cer	25 V	+80%—20%
C456	283-0088-00			1100 pF	Cer	500 V	5%
C459	283-0088-00			1100 pF	Cer	500 V	5%
C468	283-0177-00			1 μF	Cer	25 V	+80%—20%
C471	281-0616-00			6.8 pF	Cer	200 V	
C472	283-0000-00			0.001 μF	Cer	500 V	
C484	283-0000-00			0.001 μF	Cer	500 V	
C486	283-0000-00			0.001 μF	Cer	500 V	
C491	290-0309-00			100 μF	Elect.	25 V	
C496	283-0177-00			1 μF	Cer	25 V	
C497	283-0177-00			1 μF	Cer	25 V	+80%—20%
C498	283-0177-00			1 μF	Cer	25 V	+80%—20%

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
CR431	152-0422-00			Silicon	Voltage var. cap. 7 pF, 4 V
CR432	152-0422-00			Silicon	Voltage var. cap. 7 pF, 4 V
CR450	*152-0185-00			Silicon	Replaceable by 1N4152
CR451	*152-0185-00			Silicon	Replaceable by 1N4152
CR485	152-0242-00			Rectifier	225 V, 100 mA
CR491	*152-0185-00			Silicon	Replaceable by 1N4152
CR493	*152-0185-00			Silicon	Replaceable by 1N4152

Inductors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
L447	*114-0292-00			170-290 nH, Var	Core 276-0506-00
L454	*120-0382-00			Toroid, 14 turns single	
L474	*108-0420-00			60 nH	
L476	*108-0420-00			60 nH	
L496	*120-0382-00			Toroid, 14 turns single	
L497	*120-0382-00			Toroid, 14 turns single	

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q404	151-0225-00			Silicon	2N3563
Q406	151-0225-00			Silicon	2N3563
Q424	*151-0271-00			Silicon	Tek Spec
Q426	*151-0271-00			Silicon	Tek Spec
Q444	151-0221-00			Silicon	2N4258

VERT. OUTPUT Circuit Board Assemly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Transistors (cont)			
Q446	151-0221-00			Silicon	2N4258		
Q454	151-0222-00			Silicon	2N4251		
Q456	151-0222-00			Silicon	2N4251		
Q464	151-0225-00			Silicon	2N3563		
Q466	151-0225-00			Silicon	2N3563		
Q474	*151-0213-00			Silicon	Selected from 2N4251		
Q476	*151-0213-00			Silicon	Selected from 2N4251		
Q494	151-0190-00			Silicon	2N3904		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Value	Power	Type	Tolerance
R401	321-0065-00			46.4 Ω	⅛ W	Prec	1%
R402	317-0750-00			75 Ω	⅛ W		5%
R403	321-0164-00			499 Ω	⅛ W	Prec	1%
R404	321-0164-00			499 Ω	⅛ W	Prec	1%
R405	311-0732-00			1 kΩ, Var			
R406	311-0480-00			500 Ω, Var			
R407	321-0065-00			46.4 Ω	⅛ W	Prec	1%
R408	321-0197-00			1.1 kΩ	⅛ W	Prec	1%
R409	321-0153-00			383 Ω	⅛ W	Prec	1%
R411	315-0431-00			430 Ω	¼ W		5%
R412	315-0431-00			430 Ω	¼ W		5%
R413	321-0149-00			348 Ω	⅛ W	Prec	1%
R414	315-0101-00			100 Ω	¼ W		5%
R415	311-0622-00			100 Ω, Var			
R416	321-0149-00			348 Ω	⅛ W	Prec	1%
R421	321-0060-00			41.2 Ω	⅛ W	Prec	1%
R422	315-0272-00			2.7 kΩ	¼ W		5%
RT423	307-0124-00			5 kΩ	Thermal		
RT424	307-0124-00			5 kΩ	Thermal		
R426	321-0329-00			26.1 kΩ	⅛ W	Prec	1%
R427	315-0270-00			27 Ω	¼ W		5%
R428	315-0361-00			360 Ω	¼ W		5%
R429	315-0361-00			360 Ω	¼ W		5%
R431	321-0097-00			100 Ω	⅛ W	Prec	1%
R432	321-0097-00			100 Ω	⅛ W	Prec	1%
R434	311-0622-00			100 Ω, Var			
R435	311-0609-00			2 kΩ, Var			
R436	317-0272-00			2.7 kΩ	⅛ W		5%
R437	317-0512-00			5.1 kΩ	⅛ W		5%
R439	317-0133-00			13 kΩ	⅛ W		5%

VERT. OUTPUT Circuit Board Assemly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R441	317-0470-00			47 Ω	1/8 W		5%
R442	317-0470-00			47 Ω	1/8 W		5%
R443	315-0331-00			330 Ω	1/4 W		5%
R444	315-0562-00			5.6 kΩ	1/4 W		5%
R445	321-0097-00			100 Ω	1/8 W	Prec	1%
R446	311-0605-00			200 Ω, Var			
R447	317-0510-00			51 Ω	1/8 W		5%
R448	321-0097-00			100 Ω	1/8 W	Prec	1%
R449	323-0141-00			287 Ω	1/2 W	Prec	1%
R450	321-0041-00			26.1 Ω	1/8 W	Prec	1%
R451	321-0041-00			26.1 Ω	1/8 W	Prec	1%
R452	321-0227-00			2.26 kΩ	1/8 W	Prec	1%
R453	308-0387-00			178 Ω	3 W	WW	1%
R454	315-0182-00			1.8 kΩ	1/4 W		5%
R456	317-0470-00			47 Ω	1/8 W		5%
R457	315-0241-00			240 Ω	1/4 W		5%
R458	315-0241-00			240 Ω	1/4 W		5%
R459	317-0470-00			47 Ω	1/8 W		5%
R461	321-0193-00			1 kΩ	1/8 W	Prec	1%
R462	321-0193-00			1 kΩ	1/8 W	Prec	1%
R464	321-0181-00			750 Ω	1/8 W	Prec	1%
R465	321-0172-00			604 Ω	1/8 W	Prec	1%
R467	321-0097-00			100 Ω	1/8 W	Prec	1%
R468	322-0076-00			60.4 Ω	1/4 W	Prec	1%
R469	321-0097-00			100 Ω	1/8 W	Prec	1%
R471	321-0026-00			18.2 Ω	1/8 W	Prec	1%
R472	308-0451-00			91 Ω	3 W	WW	5%
R473	321-0026-00			18.2 Ω	1/8 W	Prec	1%
R474	301-0330-00			33 Ω	1/2 W		5%
R475	321-0201-00			1.21 kΩ	1/8 W	Prec	1%
R476	301-0330-00			33 Ω	1/2 W		5%
R477	321-0201-00			1.21 kΩ	1/8 W	Prec	1%
R484	315-0100-00			10 Ω	1/4 W		5%
R486	315-0100-00			10 Ω	1/4 W		5%
R491	315-0103-00			10 kΩ	1/4 W		5%
R492	315-0102-00			1 kΩ	1/4 W		5%
R493	315-0203-00			20 kΩ	1/4 W		5%
R494	321-0222-00			2 kΩ	1/8 W	Prec	1%

HORIZONTAL Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0629-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C506	283-0000-00			0.001 μF	Cer	500 V	
C509	290-0145-00			10 μF	Elect.	50 V	
C516	283-0000-00			0.001 μF	Cer	500 V	
C521	283-0003-00			0.01 μF	Cer	150 V	
C527	283-0065-00	XB020000		0.001 μF	Cer	100 V	5%
C541	281-0523-00			100 pF	Cer	350 V	
C547	290-0183-00			1 μF	Elect.	35 V	10%
C551	281-0523-00			100 pF	Cer	350 V	
C553	290-0183-00			1 μF	Elect.	35 V	10%
C563	283-0003-00			0.1 μF	Cer	150 V	10%
C573	283-0003-00			0.1 μF	Cer	150 V	10%
C581	281-0123-00			5-25 pF, Var	Cer		
C582	290-0183-00			1 μF	Elect.	35 V	10%
C588	281-0064-00			0.25-1.5 pF, Var	Tub.		
C591	281-0161-00			5-15 pF, Var	Cer		
C598	281-0064-00			0.25-1.5 pF, Var	Tub.		

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
CR508	*152-0153-00			Silicon	Tek Spec
CR518	*152-0153-00			Silicon	Tek Spec
CR523	*152-0153-00			Silicon	Tek Spec
CR533	*152-0153-00			Silicon	Tek Spec
CR563	*152-0185-00			Silicon	Replaceable by 1N4152
CR564	*152-0185-00			Silicon	Replaceable by 1N4152
CR573	*152-0185-00			Silicon	Replaceable by 1N4152
CR574	*152-0185-00			Silicon	Replaceable by 1N4152

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q504	151-0223-00			Silicon	2N4275
Q514	151-0223-00			Silicon	2N4275
Q524	151-0188-00			Silicon	2N3906
Q534	151-0188-00			Silicon	2N3906
Q543	151-0190-00			Silicon	2N3904
Q553	151-0190-00			Silicon	2N3904
Q564	*151-0103-00			Silicon	Replaceable by 2N2219
Q568	151-0223-00			Silicon	2N4275
Q574	*151-0103-00			Silicon	Replaceable by 2N2219
Q583	151-0188-00			Silicon	2N3906
Q593	151-0188-00			Silicon	2N3906

HORIZONTAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors			
Resistors are fixed, composition, ±10% unless otherwise indicated.							
R501	321-0184-00			806 Ω	1/8 W	Prec	1%
R502	321-0118-00	B010100	B019999	165 Ω	1/8 W	Prec	1%
R502	321-0108-00	B020000		130 Ω	1/8 W	Prec	1%
R503	321-0118-00	B010100	B019999	165 Ω	1/8 W	Prec	1%
R503	321-0128-00	B020000		210 Ω	1/8 W	Prec	1%
R504	323-0179-00			715 Ω	1/2 W	Prec	1%
R505	311-0884-00			100 Ω, Var			
R506	321-0112-00			143 Ω	1/8 W	Prec	1%
R507	311-0643-00			50 Ω, Var			
R508	324-0212-00			1.58 kΩ	1 W	Prec	1%
R509	301-0750-00			75 Ω	1/2 W		5%
R511	321-0184-00			806 Ω	1/8 W	Prec	1%
R512	321-0230-00			2.43 kΩ	1/8 W	Prec	1%
R514	323-0179-00			715 Ω	1/2 W	Prec	1%
R515	311-0884-00			100 Ω, Var			
R516	321-0119-00			169 Ω	1/8 W	Prec	1%
R518	324-0212-00			1.58 kΩ	1 W	Prec	1%
R521	323-0236-00			2.8 kΩ	1/2 W	Prec	1%
R523	322-0292-00	B010100	B019999	10.7 kΩ	1/4 W	Prec	1%
R523	323-0293-00	B020000		11 kΩ	1/2 W	Prec	1%
R525	311-0496-00			2.5 kΩ, Var			
R527	315-0270-00			27 Ω	1/4 W		5%
R528	315-0103-00			10 kΩ	1/4 W		5%
R529	315-0432-00			4.3 kΩ	1/4 W		5%
R531	323-0236-00			2.8 kΩ	1/2 W	Prec	1%
R533	322-0292-00	B010100	B019999	10.7 kΩ	1/4 W	Prec	1%
R533	323-0293-00	B020000		11 kΩ	1/2 W	Prec	1%
R537	315-0270-00			27 Ω	1/4 W		5%
R538	315-0103-00			10 kΩ	1/4 W		5%
R539	315-0432-00			4.3 kΩ	1/4 W		5%
R541	315-0100-00			10 Ω	1/4 W		5%
R543	301-0470-00			47 Ω	1/2 W		5%
R547	315-0432-00			4.3 kΩ	1/4 W		5%
R551	315-0100-00			10 Ω	1/4 W		5%
R553	301-0470-00			47 Ω	1/2 W		5%
R557	315-0432-00			4.3 kΩ	1/4 W		5%
R561	307-0061-00			7.5 Ω	1/2 W		5%
R563	315-0100-00			10 Ω	1/4 W		5%
R567	301-0151-00			150 Ω	1/2 W		5%
R568	315-0102-00			1 kΩ	1/4 W		5%
R569	315-0301-00			300 Ω	1/4 W		5%
R571	307-0061-00			7.5 Ω	1/2 W		5%
R573	315-0100-00			10 Ω	1/4 W		5%
R578	315-0682-00			6.8 kΩ	1/4 W		5%
R580	321-0172-00			604 Ω	1/8 W	Prec	1%

HORIZONTAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R581	315-0270-00			27 Ω	¼ W		5%
R582	315-0223-00			22 kΩ	¼ W		5%
R583	301-0120-00			12 Ω	½ W		5%
R586	321-0225-00			2.15 kΩ	⅛ W	Prec	1%
R587	321-0219-00			1.87 kΩ	⅛ W	Prec	1%
R588	323-0287-00			9.53 kΩ	½ W	Prec	1%
R589	323-0287-00			9.53 kΩ	½ W	Prec	1%
R590	321-0172-00			604 Ω	⅛ W	Prec	1%
R591	315-0270-00			27 Ω	¼ W		5%
R592	315-0223-00			22 kΩ	¼ W		5%
R593	301-0120-00			12 Ω	½ W		5%
R596	321-0225-00			2.15 kΩ	⅛ W	Prec	1%
R597	321-0219-00			1.87 kΩ	⅛ W	Prec	1%
R598	323-0287-00			9.53 kΩ	½ W	Prec	1%
R599	323-0287-00			9.53 kΩ	½ W	Prec	1%

L.V. REGULATOR Circuit Board Assembly

	*670-0630-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

C814	290-0297-00			39 μF	Elect.	10 V	10%
C823	283-0003-00			0.01 μF	Cer	150 V	
C824	281-0536-00			1000 pF	Cer	500 V	10%
C838	290-0271-00			9 μF	Elect.	125 V	+20%—15%
C844	283-0110-00			0.005 μF	Cer	150 V	
C849	285-0598-00			0.01 μF	PTM	100 V	5%
C867	290-0296-00			100 μF	Elect.	20 V	
C874	283-0192-00			0.47 μF	Cer	300 V	+80%—20%
C886	281-0536-00			1000 pF	Cer	500 V	10%
C891	285-0598-00			0.01 μF	PTM	100 V	5%
C895	283-0110-00			0.005 μF	Cer	150 V	
C903	285-0643-00			0.0047 μF	PTM	100 V	5%
C917	283-0010-00			0.05 μF	Cer	50 V	
C925	290-0267-00			1 μF	Elect.	35 V	
C937	285-0598-00			0.01 μF	PTM	100 V	5%
C952	290-0327-00			0.56 μF	Elect.	100 V	
C968	283-0003-00			0.01 μF	Cer	150 V	
C974	283-0003-00			0.01 μF	Cer	150 V	
C991	283-0004-00			0.02 μF	Cer	150 V	
C994	283-0079-00			0.01 μF	Cer	250 V	

L.V. REGULATOR Circuit Board Assembly (cont)

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
VR814	152-0317-00			Zener	1N3497 250 mW, 6.2 V, 5%
CR818	*152-0185-00			Silicon	Replaceable by 1N4152
CR832	*152-0185-00			Silicon	Replaceable by 1N4152
CR838	*152-0418-00			Silicon	Replaceable by 1N4999
CR844	*152-0185-00			Silicon	Replaceable by 1N4152
CR848	*152-0185-00			Silicon	Replaceable by 1N4152
CR862	*152-0185-00			Silicon	Replaceable by 1N4152
CR867	*152-0418-00			Silicon	Replaceable by 1N4999
VR875	152-0175-00			Zener	1N752A 400 mW, 5.6 V, 5%
CR878	*152-0185-00			Silicon	Replaceable by 1N4152
VR882	152-0127-00			Zener	1N755A 400 mW, 7.5 V, 5%
CR886	*152-0185-00			Silicon	Replaceable by 1N4152
CR893	*152-0185-00			Silicon	Replaceable by 1N4152
CR896	*152-0185-00			Silicon	Replaceable by 1N4152
CR898	*152-0418-00			Silicon	Replaceable by 1N4999
CR904	*152-0185-00			Silicon	Replaceable by 1N4152
CR906	*152-0185-00			Silicon	Replaceable by 1N4152
CR910	*152-0185-00			Silicon	Replaceable by 1N4152
CR915	*152-0185-00			Silicon	Replaceable by 1N4152
CR921	*152-0185-00			Silicon	Replaceable by 1N4152
CR925	*152-0418-00			Silicon	Replaceable by 1N4999
CR942	*152-0185-00			Silicon	Replaceable by 1N4152
CR944	*152-0185-00			Silicon	Replaceable by 1N4152
CR952	*152-0418-00			Silicon	Replaceable by 1N4999
VR953	152-0149-00			Zener	1N961B 400 mW, 10 V, 5%
CR963	*152-0185-00			Silicon	Replaceable by 1N4152
CR969	*152-0061-00			Silicon	Tek Spec
CR984	*152-0185-00			Silicon	Replaceable by 1N4152
CR992	152-0066-00			Silicon	1N3194
CR994	*152-0185-00			Silicon	Replaceable by 1N4152

Fuses

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
F872	159-0013-00			6 A 3 AG Fast-Blo
F901	159-0021-00			2 A 3 AG Fast-Blo
F982	159-0028-00			¼ A 3 AG Fast-Blo

Integrated Circuits

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
U820	156-0033-00			Linear, RF/IF ampl.	Replaceable by RCA CA3028A
U845	156-0033-00			Linear, RF/IF ampl.	Replaceable by RCA CA3028A
U894	156-0033-00			Linear, RF/IF ampl.	Replaceable by RCA CA3028A
U920	156-0033-00			Linear, RF/IF ampl.	Replaceable by RCA CA3028A
U944	156-0033-00			Linear, RF/IF ampl.	Replaceable by RCA CA3028A

L.V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Meter			
M898	149-0030-00			Elapsed time, DC			
				Transistors			
Q824	151-0223-00			Silicon	2N4275		
Q828	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q833	151-0223-00			Silicon	2N4275		
Q853	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q854	151-0223-00			Silicon	2N4275		
Q874	151-0508-00			Silicon	T098, D13T1		
Q878	151-0188-00			Silicon	2N3906		
Q883	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q888	151-0223-00			Silicon	2N4275		
Q904	151-0188-00			Silicon	2N3906		
Q910	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q914	151-0223-00			Silicon	2N4275		
Q934	151-0250-00			Silicon	2N5184		
Q936	151-0250-00			Silicon	2N5184		
Q943	*151-0096-00			Silicon	Selected from 2N1893		
Q963	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q968	151-0250-00			Silicon	2N5184		
Q974	151-0225-00			Silicon	2N3563		
Q984	151-0250-00			Silicon	2N5184		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Value	Wattage	Type	Tolerance
R811	323-0176-00			665 Ω	½ W	Prec	1%
R813	323-0260-08			4.99 kΩ	½ W	Prec	1%
R815	311-0514-00			100 Ω, Var			
R817	323-0267-00			5.9 kΩ	½ W	Prec	1%
R819	315-0223-00			22 kΩ	¼ W		5%
R821	315-0303-00			30 kΩ	¼ W		5%
R822	315-0204-00			200 kΩ	¼ W		5%
R823	315-0222-00			2.2 kΩ	¼ W		5%
R824	315-0682-00			6.8 kΩ	¼ W		5%
R827	321-0258-00			4.75 kΩ	⅛ W	Prec	1%
R829	315-0393-00			39 kΩ	¼ W		5%
R830	315-0201-00			200 Ω	¼ W		5%
R832	315-0104-00			100 kΩ	¼ W		5%
R833	315-0561-00			560 Ω	¼ W		5%
R837	*308-0087-00			0.5 Ω	1 W	WW	1%

L.V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R843	323-0193-07			1 kΩ	1/2 W	Prec	1/10%
R844	323-0193-07			1 kΩ	1/2 W	Prec	1/10%
R845	315-0113-00			11 kΩ	1/4 W		5%
R846	315-0622-00			6.2 kΩ	1/4 W		5%
R847	315-0203-00			20 kΩ	1/4 W		5%
R848	315-0333-00			33 kΩ	1/4 W		5%
R849	315-0391-00			390 Ω	1/4 W		5%
R851	321-0268-00			6.04 kΩ	1/8 W	Prec	1%
R852	315-0912-00			9.1 kΩ	1/4 W		5%
R853	315-0104-00			100 kΩ	1/4 W		5%
R857	315-0201-00			200 Ω	1/4 W		5%
R863	301-0300-00			30 Ω	1/2 W		5%
R867	*308-0554-00			0.1 Ω	5 W	WW	5%
R872	315-0510-00			51 Ω	1/4 W		5%
R874	315-0101-00			100 Ω	1/4 W		5%
R875	315-0101-00			100 Ω	1/4 W		5%
R878	301-0623-00			62 kΩ	1/2 W		5%
R883	301-0101-00			100 Ω	1/2 W		5%
R884	315-0563-00			56 kΩ	1/4 W		5%
R886	*308-0141-00			1 Ω	1/2 W	WW	5%
R887	301-0133-00			13 kΩ	1/2 W		5%
R888	321-0219-00			1.87 kΩ	1/8 W	Prec	1%
R889	315-0201-00			200 Ω	1/4 W		5%
R891	315-0821-00			820 Ω	1/4 W		5%
R892	315-0822-00			8.2 kΩ	1/4 W		5%
R893	315-0302-00			3 kΩ	1/4 W		5%
R894	315-0113-00			11 kΩ	1/4 W		5%
R895	323-0289-01			10 kΩ	1/2 W	Prec	1/2%
R896	323-0193-01			1 kΩ	1/2 W	Prec	1/2%
R897	*308-0570-00			0.05 Ω	5 W	WW	5%
R898	301-0395-00			3.9 MΩ	1/2 W		5%
R903	315-0472-00			4.7 kΩ	1/4 W		5%
R904	315-0153-00			15 kΩ	1/4 W		5%
R905	315-0303-00			30 kΩ	1/4 W		5%
R906	315-0181-00			180 Ω	1/4 W		5%
R907	315-0243-00			24 kΩ	1/4 W		5%
R910	315-0104-00			100 kΩ	1/4 W		5%
R913	301-0390-00			39 Ω	1/2 W		5%
R914	323-0291-00			10.5 kΩ	1/2 W	Prec	1%
R915	315-0243-00			24 kΩ	1/4 W		5%
R917	315-0101-00			100 Ω	1/4 W		5%
R918	315-0104-00			100 kΩ	1/4 W		5%
R919	315-0113-00			11 kΩ	1/4 W		5%
R920	315-0513-00			51 kΩ	1/4 W		5%
R921	323-0289-07			10 kΩ	1/2 W	Prec	1/10%

L.V. REGULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R923	315-0392-00			3.9 kΩ	¼ W		5%
R925	323-0758-07			3 kΩ	½ W	Prec	1/10%
R926	315-0201-00			200 Ω	¼ W		5%
R927	308-0554-00			0.1 Ω	5 W	WW	5%
R931	*308-0087-00			0.5 Ω	1 W	WW	1%
R932	315-0201-00			200 Ω	¼ W		5%
R933	301-0153-00			15 kΩ	½ W		5%
R934	323-0288-00			9.76 kΩ	½ W	Prec	1%
R935	301-0563-00			56 kΩ	½ W		5%
R936	315-0471-00			470 Ω	¼ W		5%
R937	315-0100-00			10 Ω	¼ W		5%
R938	301-0514-00			510 kΩ	½ W		5%
R939	315-0153-00			15 kΩ	¼ W		5%
R940	315-0393-00			39 kΩ	¼ W		5%
R941	315-0472-00			4.7 kΩ	¼ W		5%
R942	323-0289-07			10 kΩ	½ W	Prec	1/10%
R943	323-0289-07			10 kΩ	½ W	Prec	1/10%
R944	301-0222-00			2.2 kΩ	½ W		5%
R953	308-0091-00			2 kΩ	5 W	WW	5%
R963	323-0307-00			15.4 kΩ	½ W	Prec	1%
R965	323-0292-00			10.7 kΩ	½ W	Prec	1%
R967	315-0472-00			4.7 kΩ	¼ W		5%
R968	308-0077-00			1 kΩ	3 W	WW	5%
R969	308-0461-00			16 kΩ	4 W	WW	1%
R974	307-0110-00			3 Ω	¼ W		5%
R983	324-0335-00			30.1 kΩ	1 W	Prec	1%
R984	323-0290-00			10.2 kΩ	½ W	Prec	1%
R987	315-0822-00			8.2 kΩ	¼ W		5%
R988	301-0303-00			30 kΩ	½ W		5%
R991	315-0101-00			100 Ω	¼ W		5%
R993	303-0510-00			51 Ω	1 W		5%

HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly

*670-0631-00 Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description			
C708	283-0059-00	1 μF	Cer	25 V	+80%—20%
C709	283-0080-00	0.022 μF	Cer	25 V	+80%—20%
C713	283-0080-00	0.022 μF	Cer	25 V	+80%—20%
C718	283-0059-00	1 μF	Cer	25 V	+80%—20%
C720	283-0129-00	0.56 μF	Cer	100 V	

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HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C721	283-0002-00			0.01 μF	Cer	500 V	
C723	283-0001-00			0.005 μF	Cer	500 V	
C725	281-0064-00			0.25-1.5 pF, Var	Tub.		
C727	283-0092-00			0.03 μF	Cer	200 V	+80% −20%
C730	283-0057-00			0.1 μF	Cer	200 V	+80% −20%
C731	283-0092-00			0.03 μF	Cer	200 V	+80% −20%
C734	283-0092-00			0.03 μF	Cer	200 V	+80% −20%
C738	283-0092-00			0.03 μF	Cer	200 V	+80% −20%
C749	285-0629-00			0.047 μF	PTM	100 V	
C750	283-0059-00			1 μF	Cer	25 V	+80% −20%
C752	290-0135-00			15 μF	Elect.	20 V	
C759	285-0629-00			0.047 μF	PTM	100 V	
C792	283-0003-00			0.01 μF	Cer	150 V	
C793	283-0003-00			0.01 μF	Cer	150 V	
C796	283-0092-00			0.03 μF	Cer	200 V	+80% −20%
				Semiconductor Device, Diodes			
VR709	152-0279-00			Zener	1N751A 400 mW, 5.1 V, 5%		
CR714	*152-0185-00			Silicon	Replaceable by 1N4152		
CR726	*152-0185-00			Silicon	Replaceable by 1N4152		
CR734	*152-0185-00			Silicon	Replaceable by 1N4152		
CR736	152-0426-00			Silicon	400 mW, 400 V, 400 mA		
CR759	*152-0185-00			Silicon	Replaceable by 1N4152		
				Inductor			
L708	*120-0382-00			Toroid, 14 turns single			
				Transistors			
Q704	*151-0216-00			Silicon	Replaceable by MPS 6523		
Q714	*151-0192-00			Silicon	Replaceable by MPS 6521		
Q724	151-0214-00			Silicon	2N3495		
Q726	*151-0124-00			Silicon	Selected from 2N3119		
Q734	*151-0124-00			Silicon	Selected from 2N3119		
Q752	*151-0126-00			Silicon	Replaceable by 2N2484		
Q754	151-0188-00			Silicon	2N3906		
Q756	151-0136-00			Silicon	Replaceable by 2N3053		

HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R701	315-0470-00			47 Ω	1/4 W		5%
R703	315-0470-00			47 Ω	1/4 W		5%
R705	311-0463-00			5 kΩ, Var			
R706	315-0472-00			4.7 kΩ	1/4 W		5%
R707	315-0102-00			1 kΩ	1/4 W		5%
R709	315-0332-00			3.3 kΩ	1/4 W		5%
R711	323-0265-00			5.62 kΩ	1/2 W	Prec	1%
R713	315-0470-00			47 Ω	1/4 W		5%
R714	315-0301-00			300 Ω	1/4 W		5%
R717	301-0681-00			680 Ω	1/2 W		5%
R718	315-0470-00			47 Ω	1/4 W		5%
R720	315-0101-00			100 Ω	1/4 W		5%
R721	315-0470-00			47 Ω	1/4 W		5%
R723	315-0102-00			1 kΩ	1/4 W		5%
R725	323-0308-00			15.8 kΩ	1/2 W	Prec	1%
R727	301-0243-00			24 kΩ	1/2 W		5%
R729	315-0100-00			10 Ω	1/4 W		5%
R730	315-0471-00			470 Ω	1/4 W		5%
R731	315-0470-00			47 Ω	1/4 W		5%
R732	301-0473-00			47 kΩ	1/2 W		5%
R734	315-0470-00			47 Ω	1/4 W		5%
R736	301-0151-00			150 Ω	1/2 W		5%
R738	315-0683-00			68 kΩ	1/4 W		5%
R739	315-0470-00			47 Ω	1/4 W		5%
R745	311-0465-00			100 kΩ, Var			
R747	323-0737-00			3.935 MΩ	1/2 W	Prec	1%
R749	315-0103-00			10 kΩ	1/4 W		5%
R750	315-0681-00			680 Ω	1/4 W		5%
R752	315-0152-00			1.5 kΩ	1/4 W		5%
R751	315-0474-00			470 kΩ	1/4 W		5%
R753	315-0102-00			1 kΩ	1/4 W		5%
R754	315-0103-00			10 kΩ	1/4 W		5%
R757	315-0101-00			100 Ω	1/4 W		5%
R758	315-0104-00			100 kΩ	1/4 W		5%
R759	315-0302-00			3 kΩ	1/4 W		5%
R791	315-0223-00			22 kΩ	1/4 W		5%
R792	311-0465-00			100 kΩ, Var			
R795	311-0463-00			5 kΩ, Var			
R796	315-0242-00			2.4 kΩ	1/4 W		5%
R797	315-0103-00			10 kΩ	1/4 W		5%

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OUTPUT SIGNAL Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0632-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C609	283-0080-00			0.022 μF	Cer	25 V	+80%—20%
C612	283-0000-00			0.001 μF	Cer	500 V	
C616	281-0603-00			39 pF	Cer	500 V	5%
C618	283-0080-00			0.022 μF	Cer	25 V	+80%—20%
C619	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C674	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C675	281-0510-00			22 pF	Cer	500 V	
C677	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C682	283-0003-00			0.01 μF	Cer	150 V	
C683	283-0000-00			0.001 μF	Cer	500 V	
C686	283-0000-00			0.001 μF	Cer	500 V	
C695	283-0000-00			0.001 μF	Cer	500 V	
C698	283-0000-00			0.001 μF	Cer	500 V	

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
L619	*108-0245-00			3.9 μH
L682	*108-0440-00			8 μH

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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

OUTPUT SIGNAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Transistors (cont)			
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		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R600	315-0201-00			200 Ω	1/4 W		5%
R601	315-0752-00			7.5 kΩ	1/4 W		5%
R602	315-0101-00			100 Ω	1/4 W		5%
R603	315-0181-00			180 Ω	1/4 W		5%
R604	315-0123-00			12 kΩ	1/4 W		5%
R605	315-0181-00			180 Ω	1/4 W		5%
R606	315-0123-00			12 kΩ	1/4 W		5%
R607	315-0101-00			100 Ω	1/4 W		5%
R608	323-0193-00			1 kΩ	1/2 W	Prec	1%
R609	315-0821-00			820 Ω	1/4 W		5%
R610	315-0101-00			100 Ω	1/4 W		5%
R611	315-0822-00			8.2 kΩ	1/4 W		5%
R612	315-0561-00			560 Ω	1/4 W		5%
R613	321-0143-00			301 Ω	1/8 W	Prec	1%
R614	321-0180-00			732 Ω	1/8 W	Prec	1%
R615	321-0226-00			2.21 kΩ	1/8 W	Prec	1%
R616	323-0189-00			909 Ω	1/2 W	Prec	1%
R617	301-0390-00			39 Ω	1/2 W		5%
R618	315-0470-00			47 Ω	1/4 W		5%
R619	315-0220-00			22 Ω	1/4 W		5%
R667	315-0470-00			47 Ω	1/4 W		5%
R669	315-0101-00			100 Ω	1/4 W		5%
R672	315-0222-00			2.2 kΩ	1/4 W		5%
R673	315-0241-00			240 Ω	1/4 W		5%
R674	315-0101-00			100 Ω	1/4 W		5%
R675	315-0152-00			1.5 kΩ	1/4 W		5%
R676	315-0272-00			2.7 kΩ	1/4 W		5%
R677	315-0220-00			22 Ω	1/4 W		5%
R678	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R679	323-0190-00			931 Ω	1/2 W	Prec	1%

OUTPUT SIGNAL Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R681	321-0069-00			51.1 Ω	1/8 W	Prec	1%
R682	307-0106-00			4.7 Ω	1/4 W		5%
R683	321-0082-00			69.8 Ω	1/8 W	Prec	1%
R684	321-0091-00			86.6 Ω	1/8 W	Prec	1%
R685	321-0020-00			15.8 Ω	1/8 W	Prec	1%
R686	315-0151-00			150 Ω	1/4 W		5%
R687	321-0229-00			2.37 kΩ	1/8 W	Prec	1%
R688	321-0244-00			3.4 kΩ	1/8 W	Prec	1%
R692	321-0069-00			51.1 Ω	1/8 W	Prec	1%
R694	321-0020-00			15.8 Ω	1/8 W	Prec	1%
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

Ckt. No.	Part No.	Description	
	Wired or Unwired		
S607	260-0984-00	Slide	GATE
S666	260-0723-00	Slide	SWP

CALIBRATOR Circuit Board Assembly

*670-0633-00 Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Part No.	Description			
C621	285-0824-00	0.047 μF	PTM	100 V	1%
C623	283-0095-00	56 pF	Cer	200 V	10%
C628	283-0000-00	0.001 μF	Cer	500 V	
C633	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C645	283-0003-00	0.01 μF	Cer	150 V	
C648	283-0000-00	0.001 μF	Cer	500 V	

Semiconductor Device, Diode

Ckt. No.	Part No.	Description	
CR637	*152-0185-00	Silicon	Replaceable by 1N4152

CALIBRATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				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		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R621	321-0364-00			60.4 kΩ	1/8 W	Prec	1%
R623	315-0272-00			2.7 kΩ	1/4 W		5%
R624	308-0569-00			2.7 kΩ	3 W	WW	1%
R625	311-0480-00			500 Ω, Var			
R626	315-0153-00			15 kΩ	1/4 W		5%
R627	321-0374-00			76.8 kΩ	1/8 W	Prec	1%
R628	315-0472-00			4.7 kΩ	1/4 W		5%
R630	315-0302-00			3 kΩ	1/4 W		5%
R631	315-0302-00			3 kΩ	1/4 W		5%
R632	315-0123-00			12 kΩ	1/4 W		5%
R633	315-0560-00			56 Ω	1/4 W		5%
R634	315-0511-00			510 Ω	1/4 W		5%
R635	315-0513-00			51 kΩ	1/4 W		5%
R636	321-0315-00			18.7 kΩ	1/8 W	Prec	1%
R637	321-0356-00			49.9 kΩ	1/8 W	Prec	1%
R639	321-0195-00			1.05 kΩ	1/8 W	Prec	1%
R640	311-0510-00			10 kΩ, Var			
R641	321-0297-00			12.1 kΩ	1/8 W	Prec	1%
R642	323-0249-00			3.83 kΩ	1/2 W	Prec	1%
R643	321-1188-06			898 Ω	1/8 W	Prec	1/4%
R644	315-0103-00			10 kΩ	1/4 W		5%
R645	315-0102-00			1 kΩ	1/4 W		5%
R646	321-0281-06			8.25 kΩ	1/8 W	Prec	1/4%
R647	321-0820-06			42 Ω	1/8 W	Prec	1/4%
R648	315-0913-00			91 kΩ	1/4 W		5%
R649	311-0624-00			200 kΩ, Var			
R650	316-0101-00			100 Ω	1/4 W		
R651	301-0103-00			10 kΩ	1/2 W		5%
R652	323-0761-07			4.05 kΩ	1/2 W	Prec	1/10%
R653	321-0815-07			4.1 kΩ	1/8 W	Prec	1/10%

CALIBRATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R654	321-0812-07			455 Ω	1/8 W	Prec	1/10%
R655	321-0811-07			56.3 Ω	1/8 W	Prec	1/10%
R656	321-0813-07			495 Ω	1/8 W	Prec	1/10%
R657	321-0810-07			55 Ω	1/8 W	Prec	1/10%
R658	321-0816-07			5 kΩ	1/8 W	Prec	1/10%
R659	321-1068-07			50.5 Ω	1/8 W	Prec	1/10%
				Switches			
	Wired or Unwired						
S630[11]	*670-0633-00			Cam	RATE		
S655[11]	*670-0633-00			Cam	CALIBRATOR		
				Integrated Circuit			
U632	156-0012-00			Clocked J-K Flipflop	Replaceable by Fairchild μL923		

RECTIFIER Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0634-00			Complete Board			
				Semiconductor Device, Diodes			
CR812	152-0200-00			Rectifier Bridge	MDA 962-5		
CR932	152-0200-00			Rectifier Bridge	MDA 962-5		
CR962	152-0200-00			Rectifier Bridge	MDA 962-5		
CR982	152-0200-00			Rectifier Bridge	MDA 962-5		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R962	*308-0141-00			1 Ω	1/2 W	WW	5%
R981	*308-0141-00			1 Ω	1/2 W	WW	5%

[11]**See Mechanical Parts List for replacement parts.**

READOUT Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*670-0635-00			Complete Board			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
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 μF	Cer	500 V	
C1214	285-0698-00			0.0082 μF	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 μF	Cer	500 V	
C1267	283-0000-00			0.001 μF	Cer	500 V	
C1268	283-0177-00			1 μF	Cer	25 V	+80%—20%
C1291	283-0177-00			1 μF	Cer	25 V	+80%—20%
C1294	283-0177-00			1 μF	Cer	25 V	+80%—20%
C1297	283-0177-00			1 μF	Cer	25 V	+80%—20%

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
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
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	1 W, 15 V, 5% Tek Spec
VR1261	*152-0405-00			Zener	1 W, 15 V, 5% Tek Spec
VR1262	*152-0405-00			Zener	1 W, 15 V, 5% Tek Spec

Inductor

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
L1270	*108-0331-01			0.75 μH

READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	

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, ±10% unless otherwise indicated.

R1111	317-0102-00			1 kΩ	1/8 W		5%
R1112	317-0751-00			750 Ω	1/8 W		5%
R1113	317-0751-00			750 Ω	1/8 W		5%
R1116	317-0102-00			1 kΩ	1/8 W		5%
R1117	317-0751-00			750 Ω	1/8 W		5%
R1118	317-0751-00			750 Ω	1/8 W		5%
R1121	317-0102-00			1 kΩ	1/8 W		5%
R1122	317-0751-00			750 Ω	1/8 W		5%
R1123	317-0751-00			750 Ω	1/8 W		5%
R1126	317-0102-00			1 kΩ	1/8 W		5%
R1127	317-0751-00			750 Ω	1/8 W		5%
R1128	317-0751-00			750 Ω	1/8 W		5%
R1131	317-0513-00			51 kΩ	1/8 W		5%
R1132	317-0133-00			13 kΩ	1/8 W		5%
R1133	317-0133-00			13 kΩ	1/8 W		5%
R1134	317-0753-00			75 kΩ	1/8 W		5%
R1135	321-0310-00			16.5 kΩ	1/8 W	Prec	1%
R1136	317-0513-00			51 kΩ	1/8 W		5%
R1137	321-0321-00			21.5 kΩ	1/8 W	Prec	1%
R1138	321-0335-00			30.1 kΩ	1/8 W	Prec	1%
R1140	317-0752-00			7.5 kΩ	1/8 W		5%
R1141	321-0261-00			5.11 kΩ	1/8 W	Prec	1%
R1143	317-0133-00			13 kΩ	1/8 W		5%
R1144	317-0154-00			150 kΩ	1/8 W		5%
R1146	321-0181-00			750 Ω	1/8 W	Prec	1%

READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R1147	321-0301-00			13.3 kΩ	⅛ W	Prec	1%
R1148	317-0102-00			1 kΩ	⅛ W		5%
R1152	317-0152-00			1.5 kΩ	⅛ W		5%
R1155	317-0562-00			5.6 kΩ	⅛ W		5%
R1156	321-0297-00			12.1 kΩ	⅛ W	Prec	1%
R1163	317-0243-00			24 kΩ	⅛ W		5%
R1171	317-0154-00			150 kΩ	⅛ W		5%
R1172	321-0335-00			30.1 kΩ	⅛ W	Prec	1%
R1173	321-0344-00			37.4 kΩ	⅛ W	Prec	1%
R1174	321-0335-00			30.1 kΩ	⅛ W	Prec	1%
R1175	317-0513-00			51 kΩ	⅛ W		5%
R1176	317-0154-00			150 kΩ	⅛ W		5%
R1177	321-0335-00			30.1 kΩ	⅛ W	Prec	1%
R1178	321-0335-00			30.1 kΩ	⅛ W	Prec	1%
R1180	321-0262-00			5.23 kΩ	⅛ W	Prec	1%
R1181	321-0371-00			71.5 kΩ	⅛ W	Prec	1%
R1183	321-0401-00			147 kΩ	⅛ W	Prec	1%
R1185	317-0103-00			10 kΩ	⅛ W		5%
R1190	317-0303-00			30 kΩ	⅛ W		5%
R1191	317-0203-00			20 kΩ	⅛ W		5%
R1193	317-0203-00			20 kΩ	⅛ W		5%
R1195	317-0203-00			20 kΩ	⅛ W		5%
R1197	317-0203-00			20 kΩ	⅛ W		5%
R1205	317-0432-00			4.3 kΩ	⅛ W		5%
R1206	317-0683-00			68 kΩ	⅛ W		5%
R1210	317-0104-00			100 kΩ	⅛ W		5%
R1214	317-0393-00			39 kΩ	⅛ W		5%
R1215	317-0332-00			3.3 kΩ	⅛ W		5%
R1216	315-0152-00			1.5 kΩ	¼ W		5%
R1218	317-0183-00			18 kΩ	⅛ W		5%
R1219	311-0634-00			500 Ω, Var			5%
R1220	317-0103-00			10 kΩ	⅛ W		
R1221	317-0752-00			7.5 kΩ	⅛ W		5%
R1223	315-0242-00			2.4 kΩ	¼ W		5%
R1226	317-0152-00			1.5 kΩ	⅛ W		5%
R1227	317-0512-00			5.1 kΩ	⅛ W		5%
R1230	317-0512-00			5.1 kΩ	⅛ W		5%
R1255	321-0222-00			2 kΩ	⅛ W	Prec	1%
R1256	321-0176-00			665 Ω	⅛ W	Prec	1%
R1257	321-0250-00			3.92 kΩ	⅛ W	Prec	1%
R1258	317-0223-00			22 kΩ	⅛ W		5%
R1260	317-0102-00			1 kΩ	⅛ W		5%
R1264	317-0272-00			2.7 kΩ	⅛ W		5%
R1265	317-0512-00			5.1 kΩ	⅛ W		5%

READOUT Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
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 kΩ	1/4 W		5%
				Integrated Circuits			
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 μL923		
U1231	156-0012-00			Clocked J-K Flipflop	Replaceable by Fairchild μL923		
U1232	156-0012-00			Clocked J-K Flipflop	Replaceable by Fairchild μL923		
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

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-0702-00			Complete Board

Bulbs

DS807	150-0029-00			Incandescent GE349
DS808	150-0029-00			Incandescent GE349
DS809	150-0029-00			Incandescent GE349

HORIZ. MODE Circuit Board Assembly

	*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, ±10% unless otherwise indicated.

R1025	316-0270-00			27 Ω	¼ W

Switch

	Wired or Unwired				
S1031[12]	*670-0790-00			Pushbutton	HORIZ MODE

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

[12]See Mechanical Parts List for replacement parts.

VERT. MODE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				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, ±10% unless otherwise indicated.

R1023	315-0153-00			15 kΩ	1/4 W	5%

Switch

	Wired or Unwired				
S1021[10]	*670-0791-00			Pushbutton	VERT MODE

A TRIG. SOURCE Circuit Board Assembly

	*670-0792-00			Complete Board	

Bulb

DS1011	*150-0057-01			Incandescent	7153AS15, Selected

Switch

	Wired or Unwired				
S1011[10]	*670-0792-00			Pushbutton	A TRIG SOURCE

B TRIG. SOURCE Circuit Board Assembly

	*670-0821-00			Complete Board	

Bulb

DS1001	*150-0057-01			Incandescent	7153AS15, Selected

Switch

	Wired or Unwired				
S1001[10]	*670-0821-00			Pushbutton	B TRIG SOURCE

[10]See Mechanical Parts List for replacement parts.

INSTRUMENT OPTIONS

Option 1—without READOUT Circuit Board Assembly (*670-0635-00)

Option 2—with X-Y DELAY COMP Circuit Board Assembly (*670-0627-00)

X-Y DELAY COMP Circuit Board Assembly

*670-0627-00 Complete Board

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors			
Tolerance ±20% unless otherwise indicated.							
C53	283-0644-00			150 pF	Mica	500 V	1%
C55	281-0125-00			90-400 pF, Var	Mica		
C56	283-0672-00			200 pF	Mica	500 V	1%
C58	283-0673-00			455 pF	Mica	500 V	1%
C66	283-0672-00			200 pF	Mica	500 V	1%
C68	283-0673-00			455 pF	Mica	500 V	1%
C73	283-0644-00			150 pF	Mica	500 V	1%
C75	281-0125-00			90-400 pF, Var	Mica		
C76	283-0672-00			200 pF	Mica	500 V	1%
C78	283-0673-00			455 pF	Mica	500 V	1%
C86	283-0672-00			200 pF	Mica	500 V	1%
C88	283-0673-00			455 pF	Mica	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	*108-0547-00			1.95 μH			
L55	*108-0548-00			2 μH			
L56	*108-0549-00			4.55 μH			
L61	*108-0547-00			1.95 μH			
L65	*108-0548-00			2 μH			

X-Y DELAY COMP Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Inductors *(cont)*			
L66	*108-0549-00			4.55 μH		
L71	*108-0547-00			1.95 μH		
L75	*108-0548-00			2 μH		
L76	*108-0549-00			4.55 μH		
L81	*108-0547-00			1.95 μH		
L85	*108-0548-00			2 μH		
L86	*108-0549-00			4.55 μH		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R51	321-0068-00			49.9 Ω	1/8 W	Prec	1%
R61	321-0068-00			49.9 Ω	1/8 W	Prec	1%
R71	321-0068-00			49.9 Ω	1/8 W	Prec	1%
R81	321-0068-00			49.9 Ω	1/8 W	Prec	1%

Switches

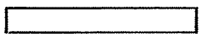
Wired or Unwired

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
S50	260-0723-00			Slide	DELAY DISABLE B
S70	260-0723-00			Slide	DELAY DISABLE A

SECTION 7
DIAGRAMS
and
MECHANICAL PARTS ILLUSTRATIONS

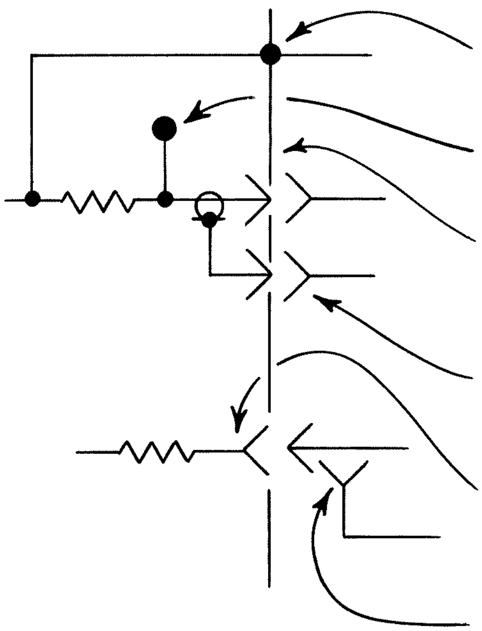
The following special symbols are used on the diagrams:

Screwdriver adjustment.



Front- or rear-panel control or connector.

Refers to the indicated diagram.



Connection soldered to circuit board.

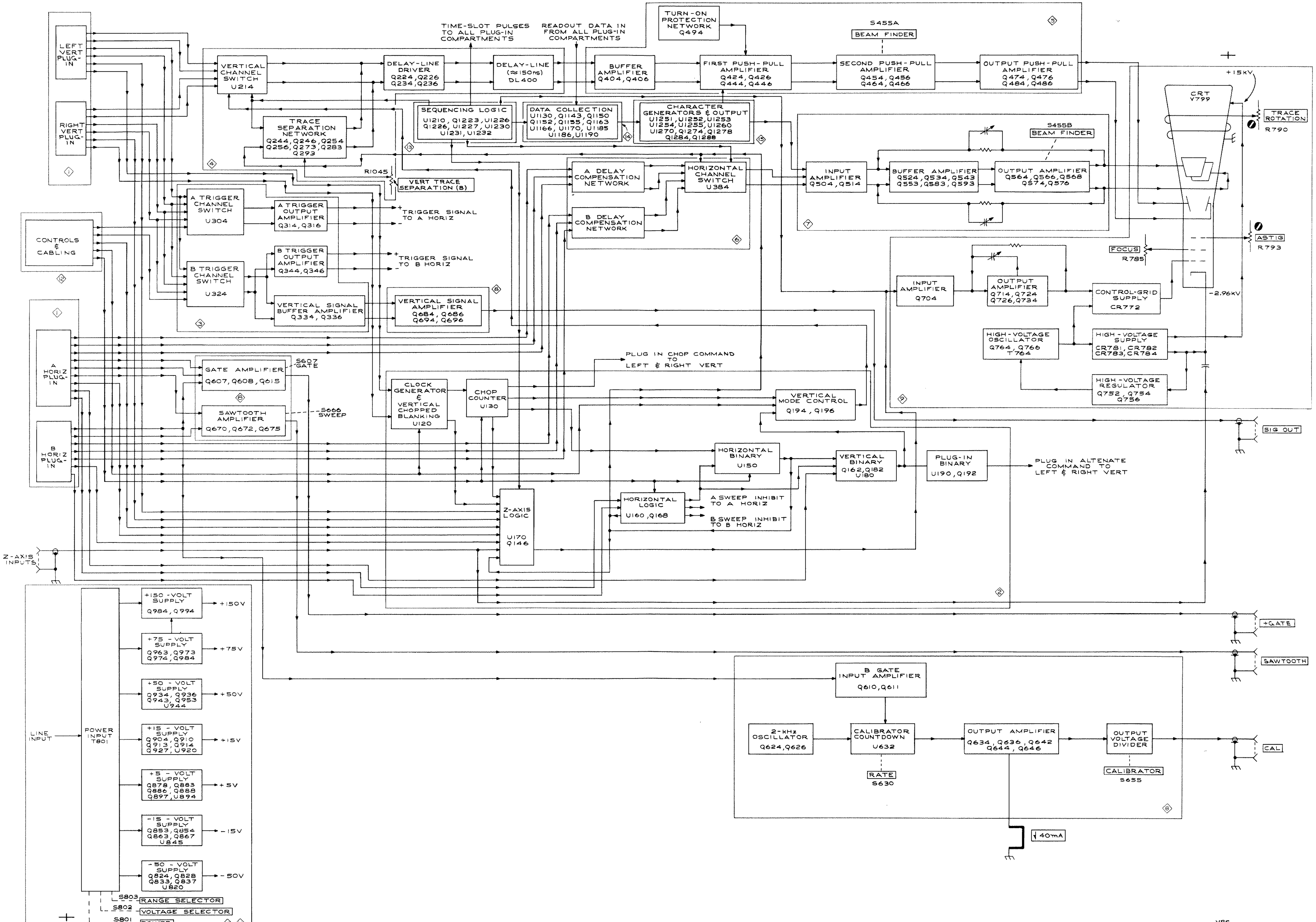
Test point.

Blue line encloses components located on circuit board.

Connection made to circuit board with interconnecting pin.

Connection made to circuit board with pin socket.

Connection made to chassis mounted interconnecting pin with an end-lead pin connector.



7504

VRS 1065

BLOCK DIAGRAM

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 waveforms on diagrams)	Tektronix 7504 with 7A16 and 7B50 plug-in units

Voltmeter

Type	Non-loading digital multimeter
Input impedance	0 to 1.5 volts; ⩾1 kMΩ 15 to 1000 volts; 10 MΩ
Range	0 to 1000 volts
Reference voltage	7704 chassis ground
Recommended type (as used for voltages on diagrams)	Fairchild Model 7050

7504 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.

7504

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 SEPARATION (B)	Midrange
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

Left Vertical Plug-In (7A22 cont)

+ 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

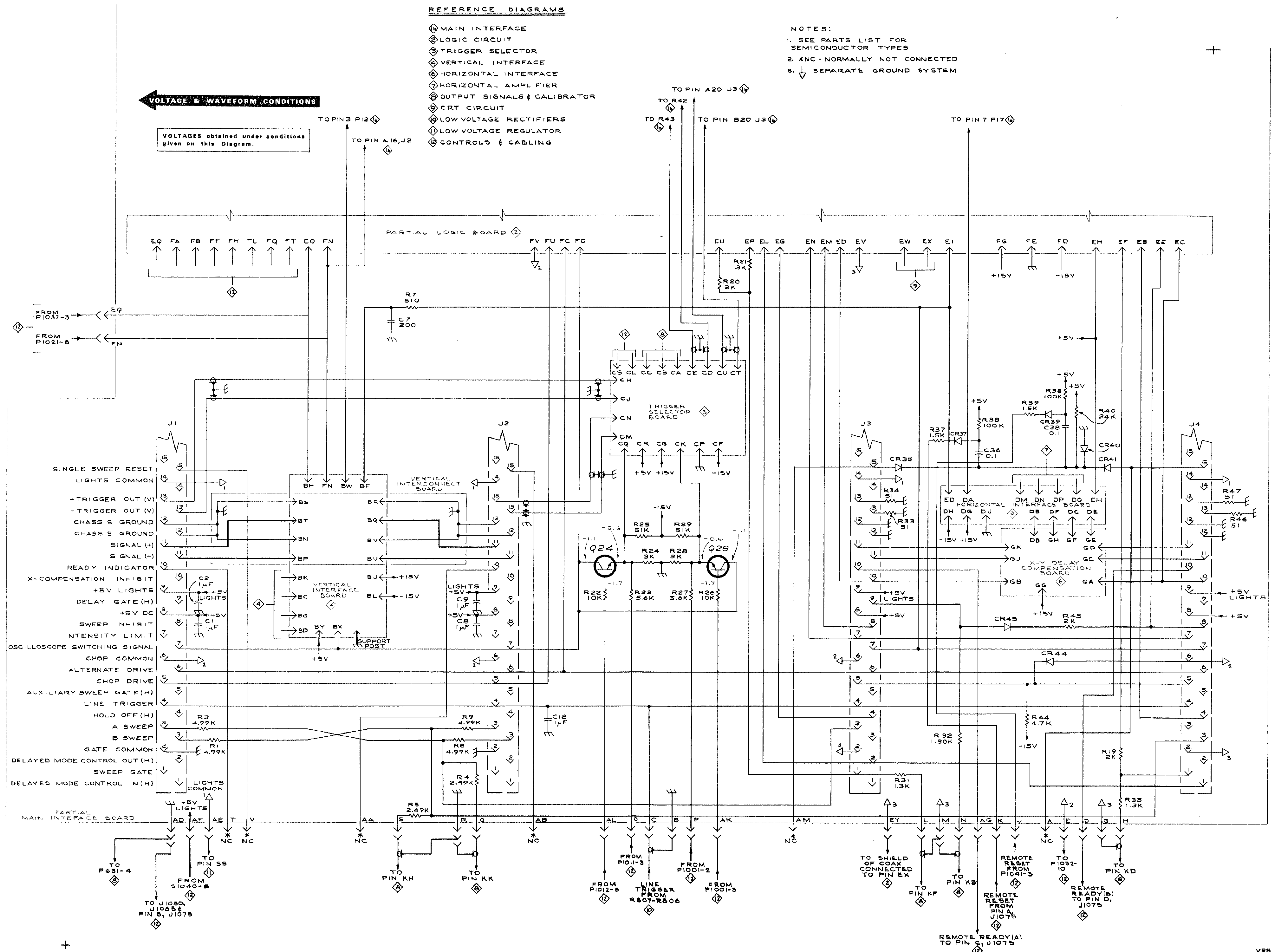
B Horiz (7B50)

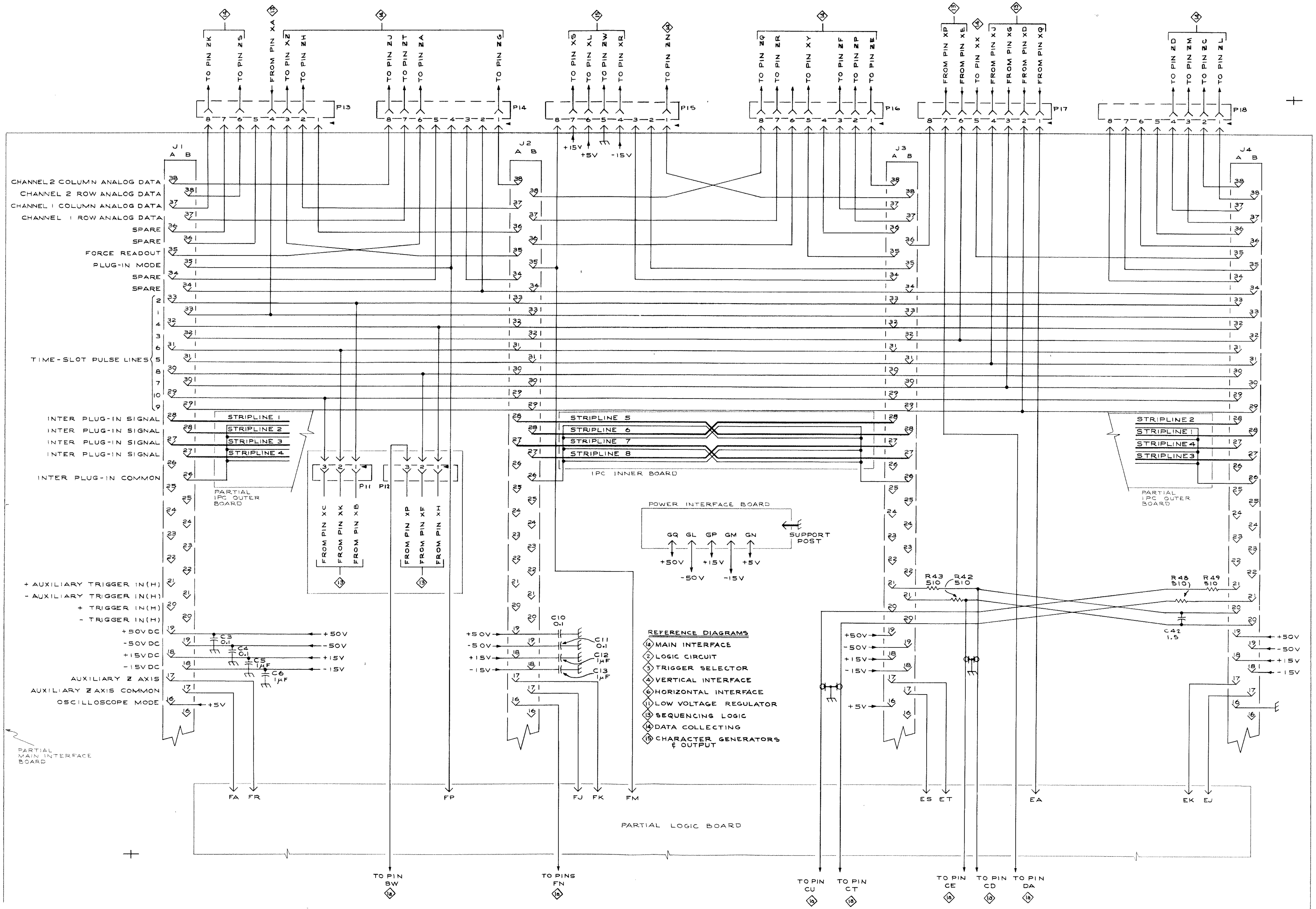
Triggering Mode	P-P Auto

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 very between instruments because of differing component tolerances, internal calibration or front-panel control settings.

NOTE

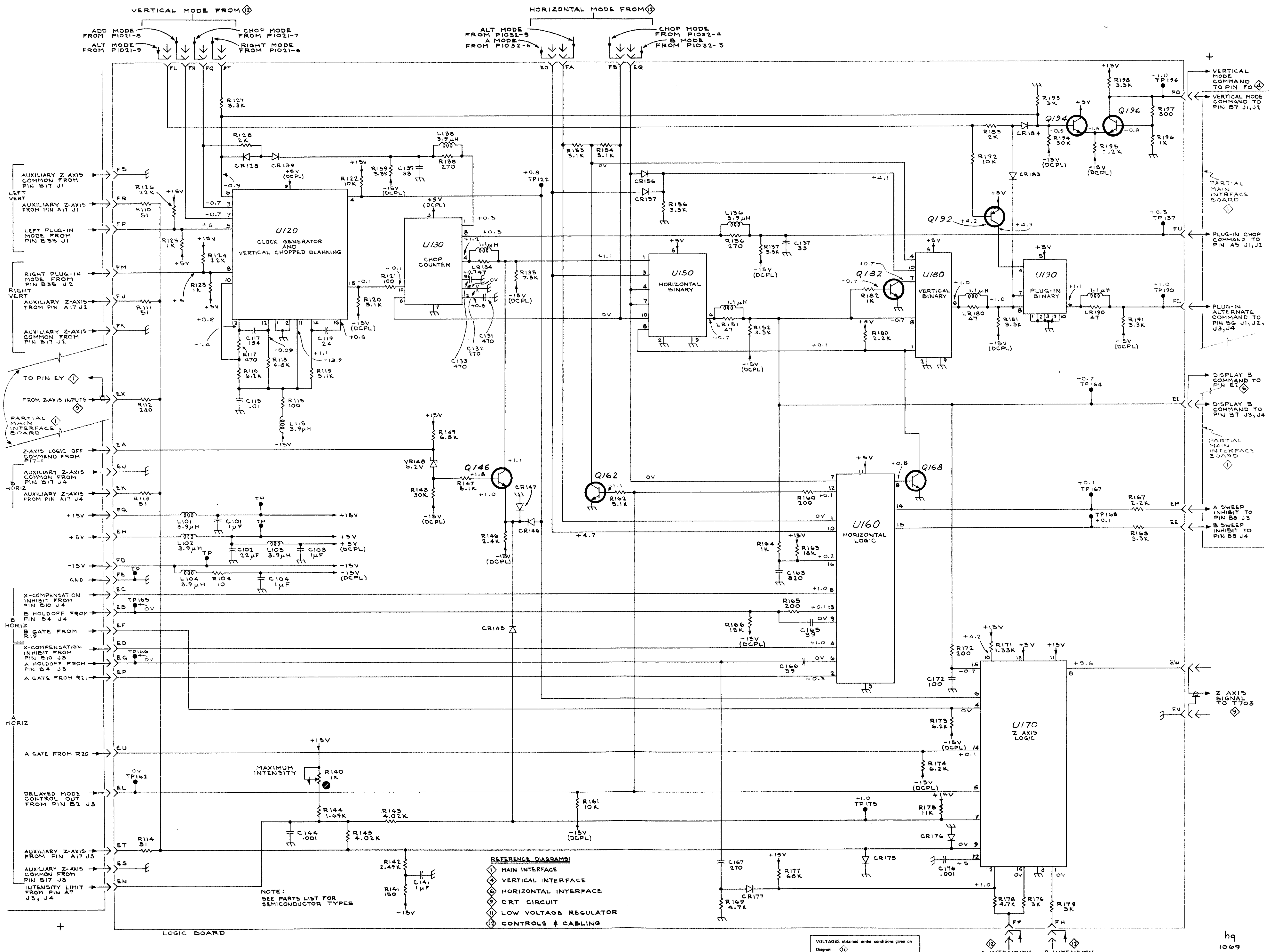
The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.


REFERENCE DIAGRAMS
1 MAIN INTERFACE
2 LOGIC CIRCUIT
3 TRIGGER SELECTOR
4 VERTICAL INTERFACE
6 HORIZONTAL INTERFACE
7 HORIZONTAL AMPLIFIER
8 OUTPUT SIGNALS & CALIBRATOR
9 CRT CIRCUIT
10 LOW VOLTAGE RECTIFIERS
11 LOW VOLTAGE REGULATOR
12 CONTROLS & CABLING
NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. *NC - NORMALLY NOT CONNECTED
3. SEPARATE GROUND SYSTEM
VOLTAGE & WAVEFORM CONDITIONS
VOLTAGES obtained under conditions given on this Diagram.
PARTIAL LOGIC BOARD
TRIGGER SELECTOR BOARD
VERTICAL INTERCONNECT BOARD
VERTICAL INTERFACE BOARD
HORIZONTAL INTERFACE BOARD
X-Y DELAY COMPENSATION BOARD
PARTIAL MAIN INTEFACE BOARD
SINGLE SWEEP RESET
LIGHTS COMMON
+TRIGGER OUT (V)
-TRIGGER OUT (V)
CHASSIS GROUND
CHASSIS GROUND
SIGNAL (+)
SIGNAL (-)
READY INDICATOR
X-COMPENSATION INHIBIT
+5V LIGHTS
DELAY GATE (H)
+5V DC
SWEEP INHIBIT
INTENSITY LIMIT
OSCILLOSCOPE SWITCHING SIGNAL
CHOP COMMON
ALTERNATE DRIVE
CHOP DRIVE
AUXILIARY SWEEP GATE (H)
LINE TRIGGER
HOLD OFF (H)
A SWEEP
B SWEEP
GATE COMMON
DELAYED MODE CONTROL OUT (H)
SWEEP GATE
DELAYED MODE CONTROL IN (H)
TO PIN 3 P12
TO PIN A16, J2
TO PIN A20 J3
TO R42
TO R43
TO PIN B20 J3
TO PIN 7 P17
FROM P1032-3
FROM P1021-8
TO P631-4
TO J1080, J1085 & PIN B, J1075
FROM S1040-B
TO PIN 55
TO PIN KH
TO PIN KK
FROM P1012-5
FROM P1011-3
LINE TRIGGER FROM R807-R808
FROM P1001-2
FROM P1001-3
TO SHIELD OF COAX CONNECTED TO PIN EX
TO PIN KF
TO PIN KB
REMOTE RESET FROM PIN A, J1075
REMOTE RESET FROM P1041-3
REMOTE READY (A) TO PIN C, J1075
TO P1032-10
REMOTE READY (B) TO PIN D, J1075
TO PIN KD
VRS 1069



MAIN INTERFACE 1b

VRS 1069



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LOGIC CIRCUIT 2

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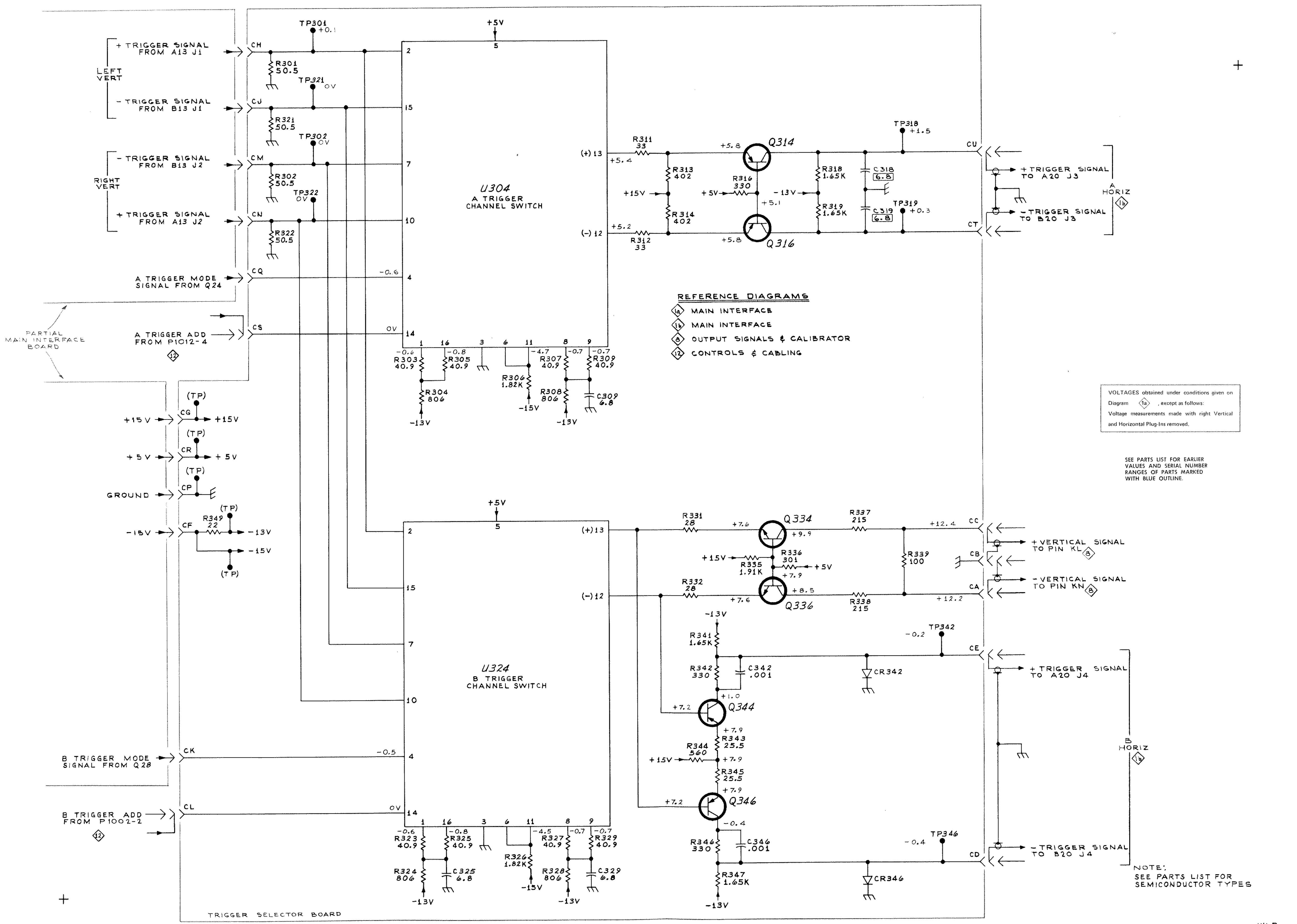
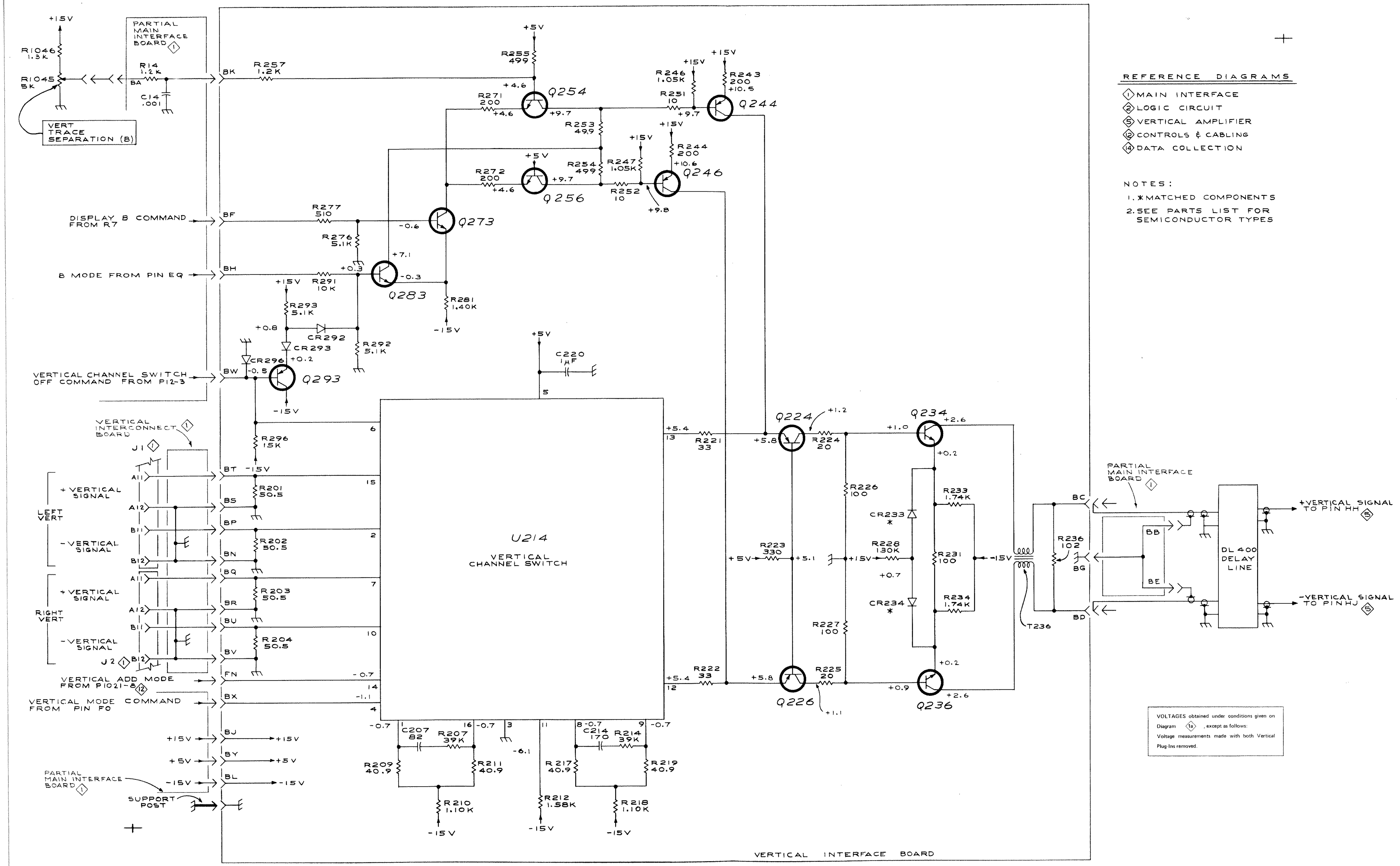
LOGIC CIRCUIT 2


+ TRIGGER SIGNAL FROM A13 J1
LEFT VERT
- TRIGGER SIGNAL FROM B13 J1
- TRIGGER SIGNAL FROM B13 J2
RIGHT VERT
+ TRIGGER SIGNAL FROM A13 J2
A TRIGGER MODE SIGNAL FROM Q24
A TRIGGER ADD FROM P1012-4
PARTIAL MAIN INTERFACE BOARD
U304
A TRIGGER CHANNEL SWITCH
U324
B TRIGGER CHANNEL SWITCH
Q314
Q316
Q334
Q336
Q344
Q346
+ TRIGGER SIGNAL TO A20 J3
- TRIGGER SIGNAL TO B20 J3
A HORIZ
+ VERTICAL SIGNAL TO PIN KL
- VERTICAL SIGNAL TO PIN KN
+ TRIGGER SIGNAL TO A20 J4
- TRIGGER SIGNAL TO B20 J4
B HORIZ
B TRIGGER MODE SIGNAL FROM Q28
B TRIGGER ADD FROM P1002-2
GROUND
TRIGGER SELECTOR BOARD
REFERENCE DIAGRAMS
1a MAIN INTERFACE
1b MAIN INTERFACE
8 OUTPUT SIGNALS & CALIBRATOR
12 CONTROLS & CABLING
VOLTAGES obtained under conditions given on Diagram 1a, except as follows: Voltage measurements made with right Vertical and Horizontal Plug-Ins removed.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
NOTE: SEE PARTS LIST FOR SEMICONDUCTOR TYPES



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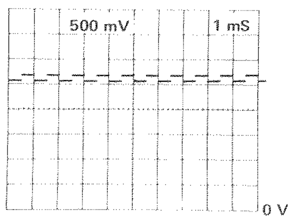
VERTICAL INTERFACE 4

VRS 1069

1



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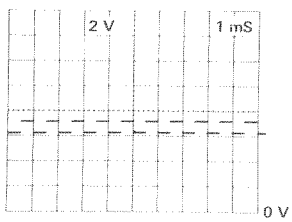

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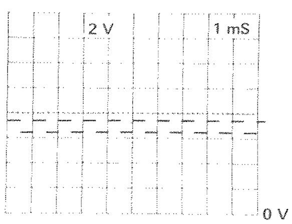

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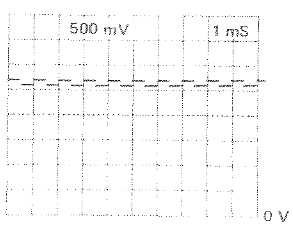

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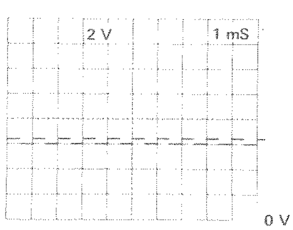

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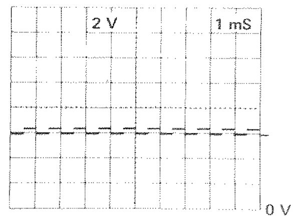

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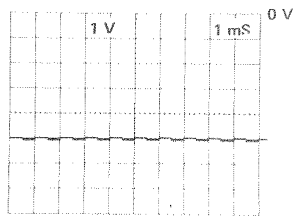

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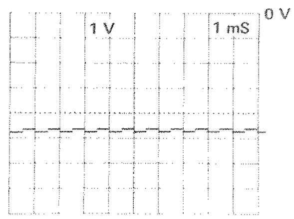

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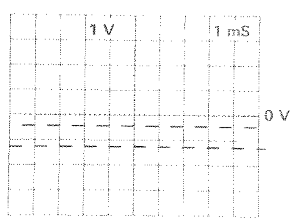

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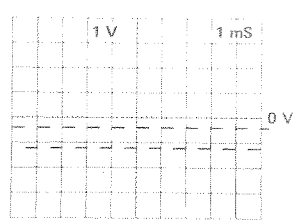

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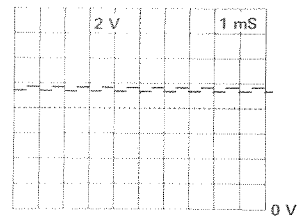

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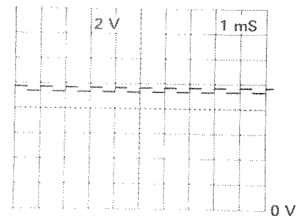

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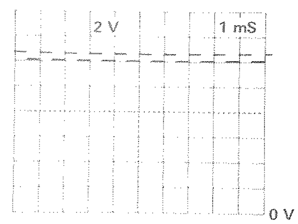

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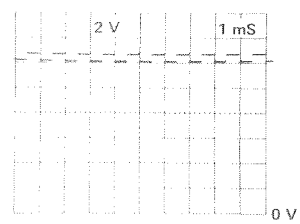

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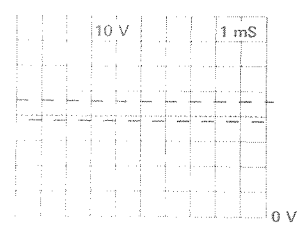

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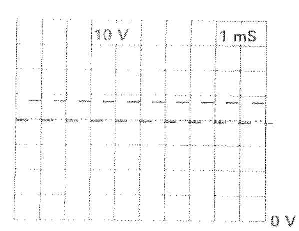
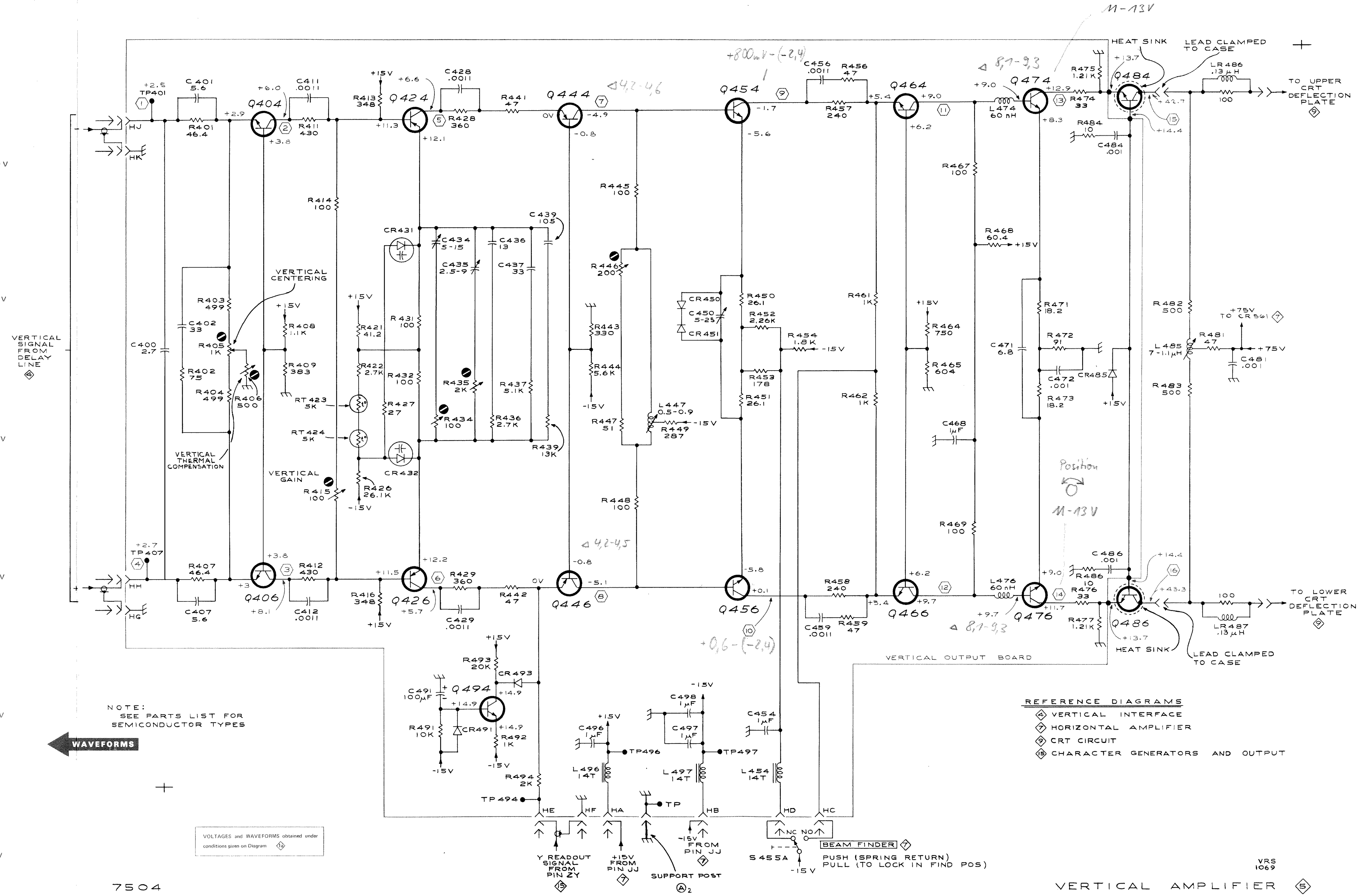


VERTICAL SIGNAL FROM DELAY LINE
4



NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

WAVEFORMS

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 14

REFERENCE DIAGRAMS
- 4 VERTICAL INTERFACE
- 7 HORIZONTAL AMPLIFIER
- 9 CRT CIRCUIT
- 15 CHARACTER GENERATORS AND OUTPUT

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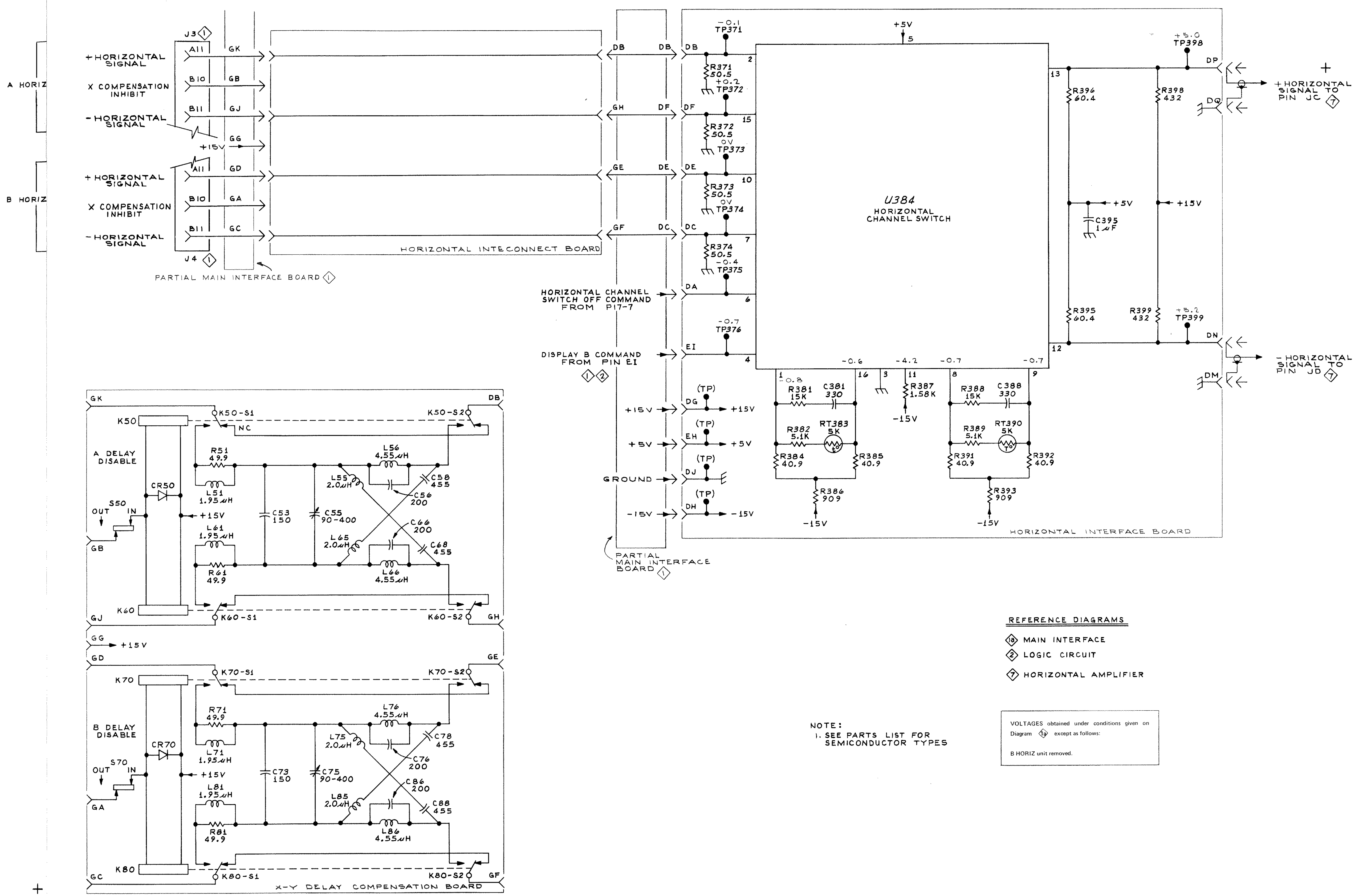
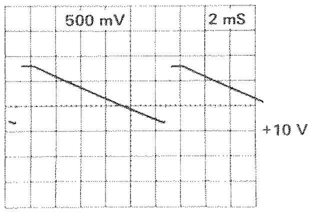
VERTICAL AMPLIFIER 5


A HORIZ
B HORIZ
J3
J4
+HORIZONTAL SIGNAL
X COMPENSATION INHIBIT
-HORIZONTAL SIGNAL
+15V
HORIZONTAL INTECONNECT BOARD
PARTIAL MAIN INTERFACE BOARD
HORIZONTAL CHANNEL SWITCH OFF COMMAND FROM P17-7
DISPLAY B COMMAND FROM PIN EI
+15V
+5V
GROUND
-15V
PARTIAL MAIN INTERFACE BOARD
U384
HORIZONTAL CHANNEL SWITCH
TP371
TP372
TP373
TP374
TP375
TP376
TP398
TP399
R371 50.5
R372 50.5
R373 50.5
R374 50.5
R381 15K
C381 330
R382 5.1K
RT383 5K
R384 40.9
R385 40.9
R386 909
R387 1.58K
R388 15K
C388 330
R389 5.1K
RT390 5K
R391 40.9
R392 40.9
R393 909
R395 60.4
R396 60.4
R398 432
R399 432
C395 1µF
+HORIZONTAL SIGNAL TO PIN JC
-HORIZONTAL SIGNAL TO PIN JD
HORIZONTAL INTERFACE BOARD
A DELAY DISABLE
B DELAY DISABLE
K50
K60
K70
K80
S50
S70
OUT
IN
CR50
CR70
R51 49.9
L51 1.95µH
L61 1.95µH
R61 49.9
C53 150
C55 90-400
L55 2.0µH
L56 4.55µH
C56 200
C58 455
L65 2.0µH
L66 4.55µH
C66 200
C68 455
R71 49.9
L71 1.95µH
L81 1.95µH
R81 49.9
C73 150
C75 90-400
L75 2.0µH
L76 4.55µH
C76 200
C78 455
L85 2.0µH
L86 4.55µH
C86 200
C88 455
X-Y DELAY COMPENSATION BOARD
REFERENCE DIAGRAMS
1a MAIN INTERFACE
2 LOGIC CIRCUIT
7 HORIZONTAL AMPLIFIER
NOTE:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
VOLTAGES obtained under conditions given on Diagram 1a except as follows:
B HORIZ unit removed.

1



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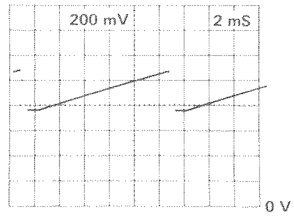

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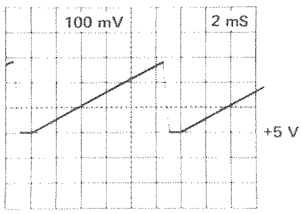

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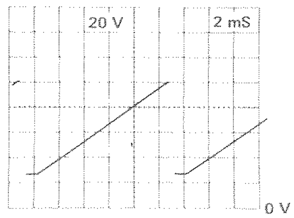

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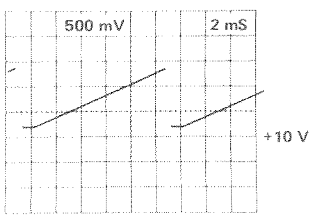

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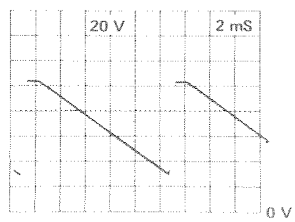

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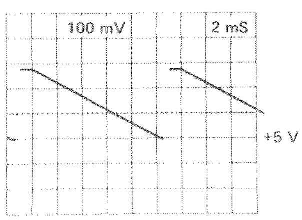

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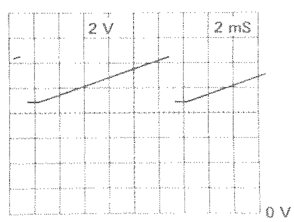

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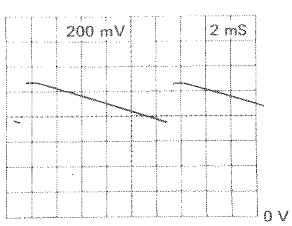

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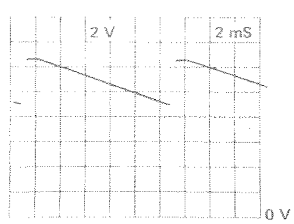

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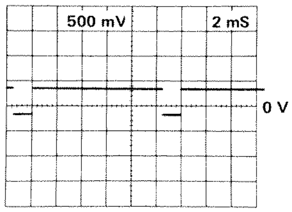

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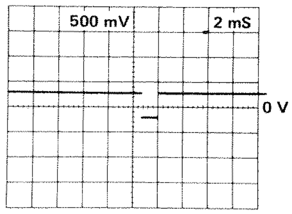

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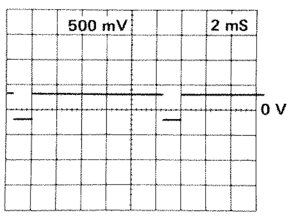

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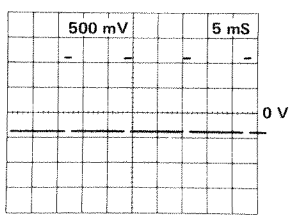

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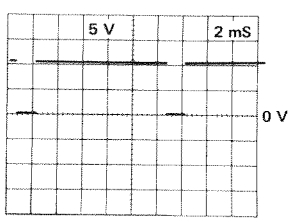

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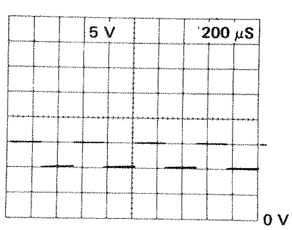

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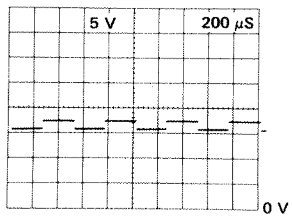

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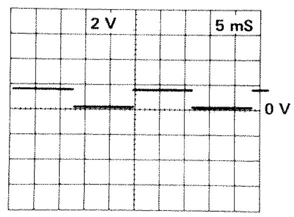

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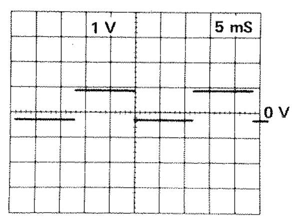

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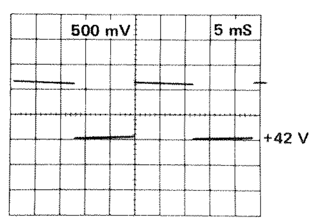

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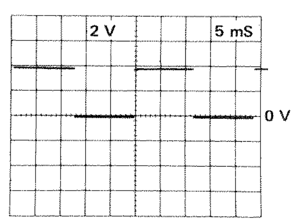

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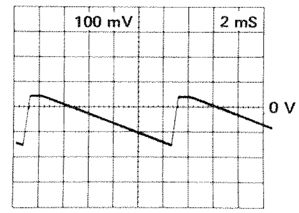

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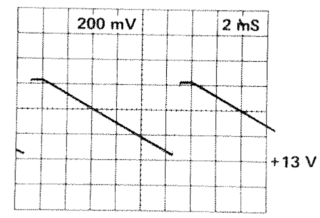

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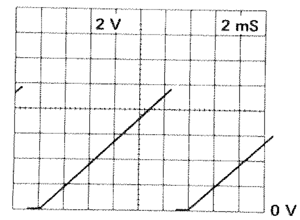

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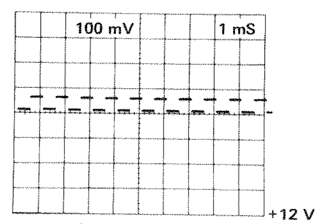

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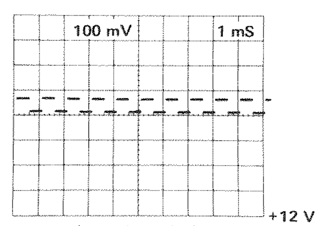

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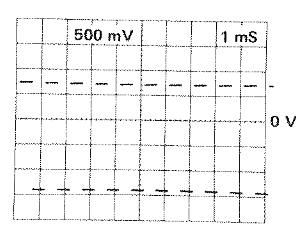
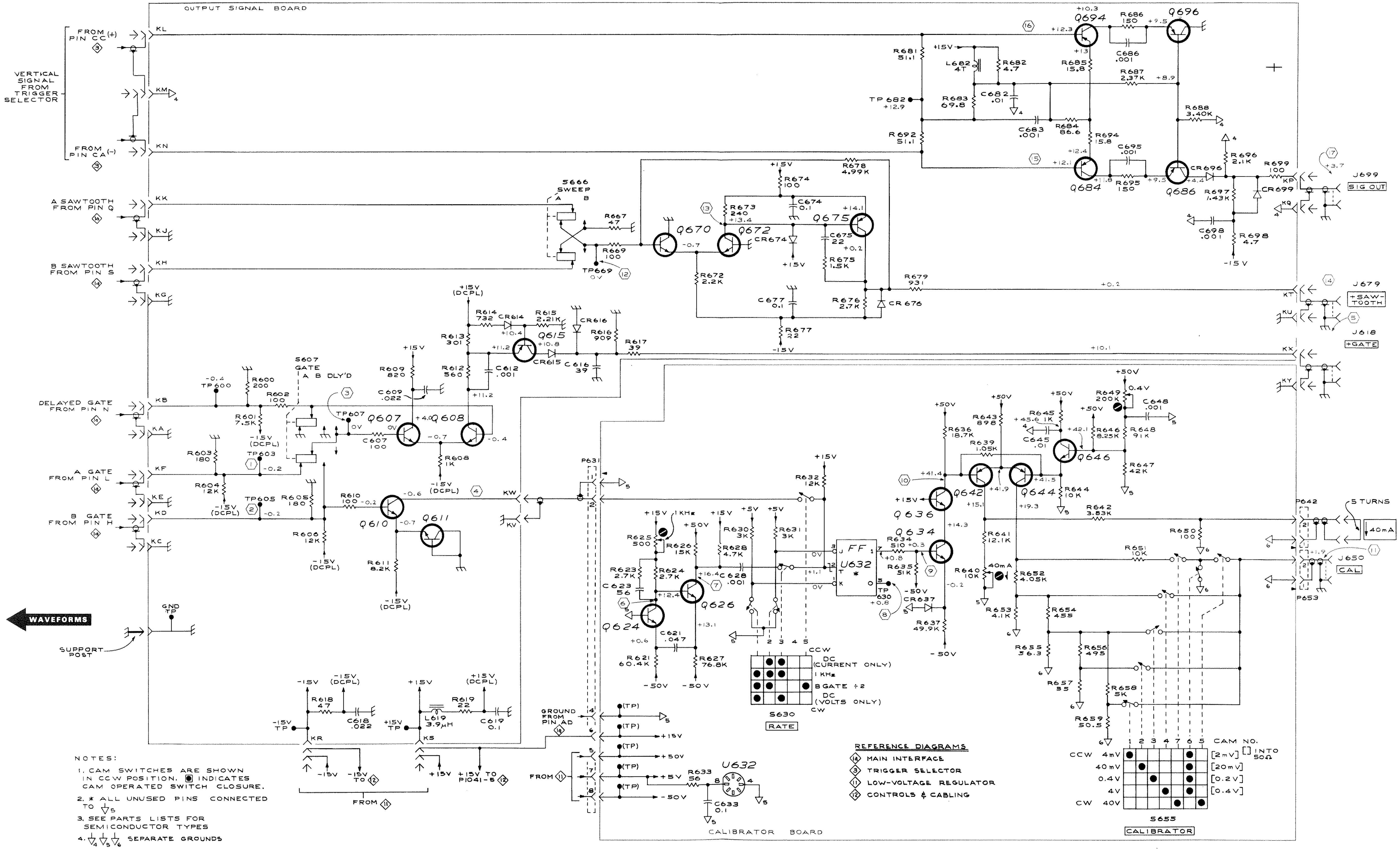
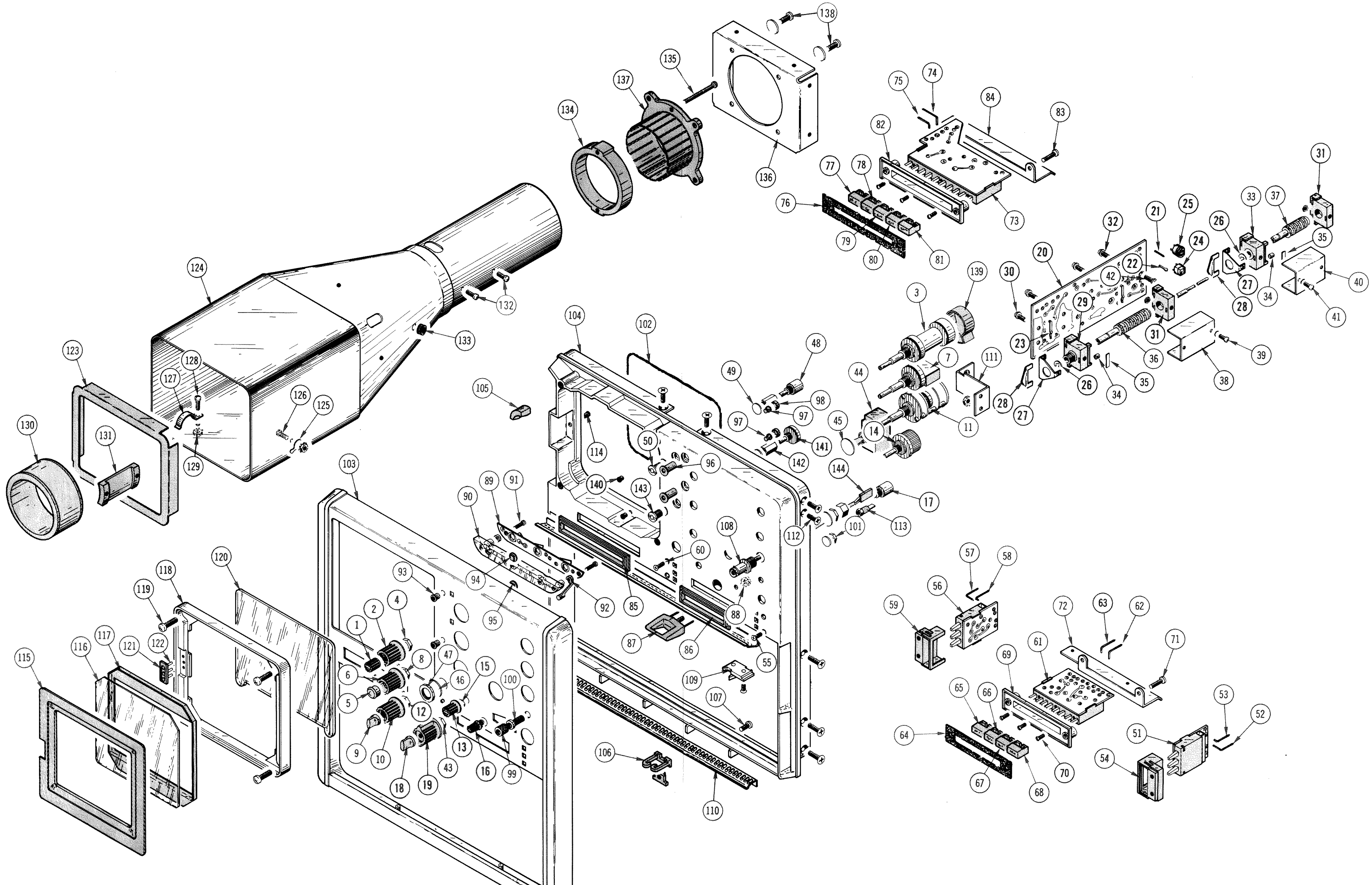




VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1a

FIG. 1 FRONT



TYPE 7504 OSCILLOSCOPE

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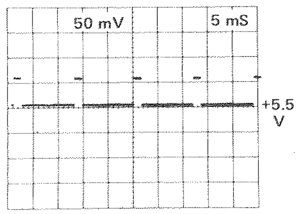

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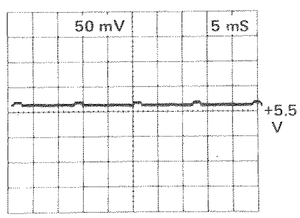

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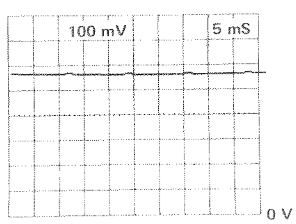

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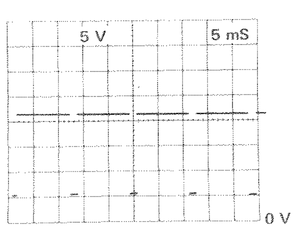

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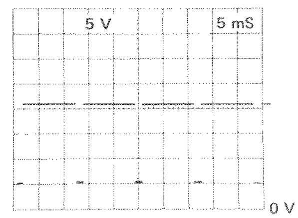

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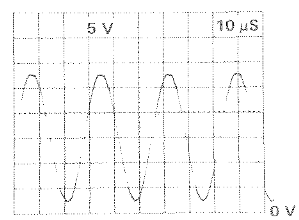
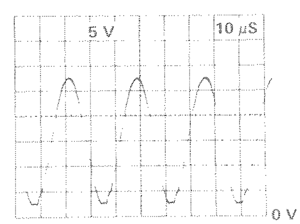
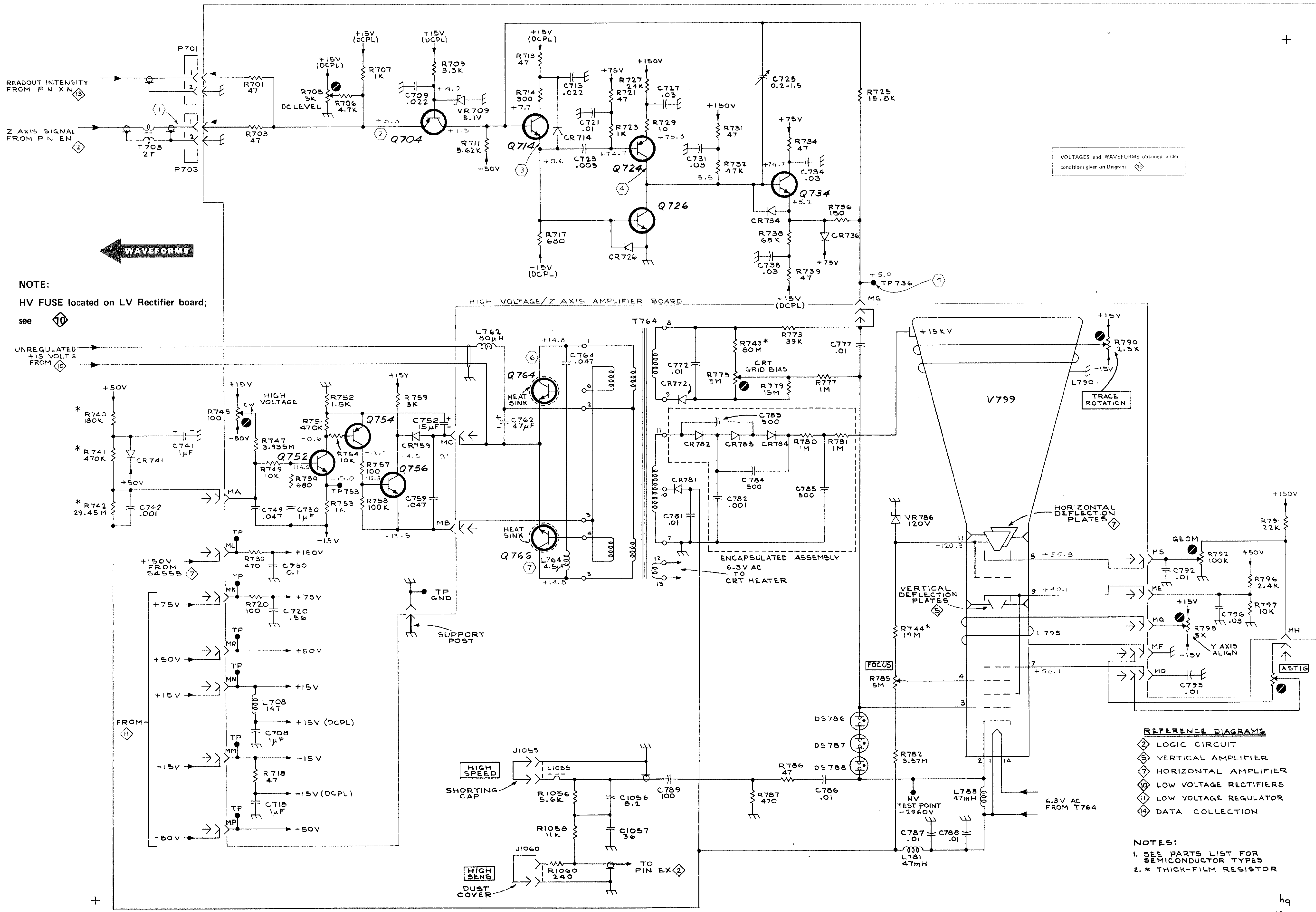


7





NOTE:

HV FUSE located on LV Rectifier board; see 10

REFERENCE DIAGRAMS

2 LOGIC CIRCUIT
5 VERTICAL AMPLIFIER
7 HORIZONTAL AMPLIFIER
10 LOW VOLTAGE RECTIFIERS
11 LOW VOLTAGE REGULATOR
14 DATA COLLECTION

NOTES:

1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. * THICK-FILM RESISTOR

hq 1069

7504

CRT CIRCUIT 9

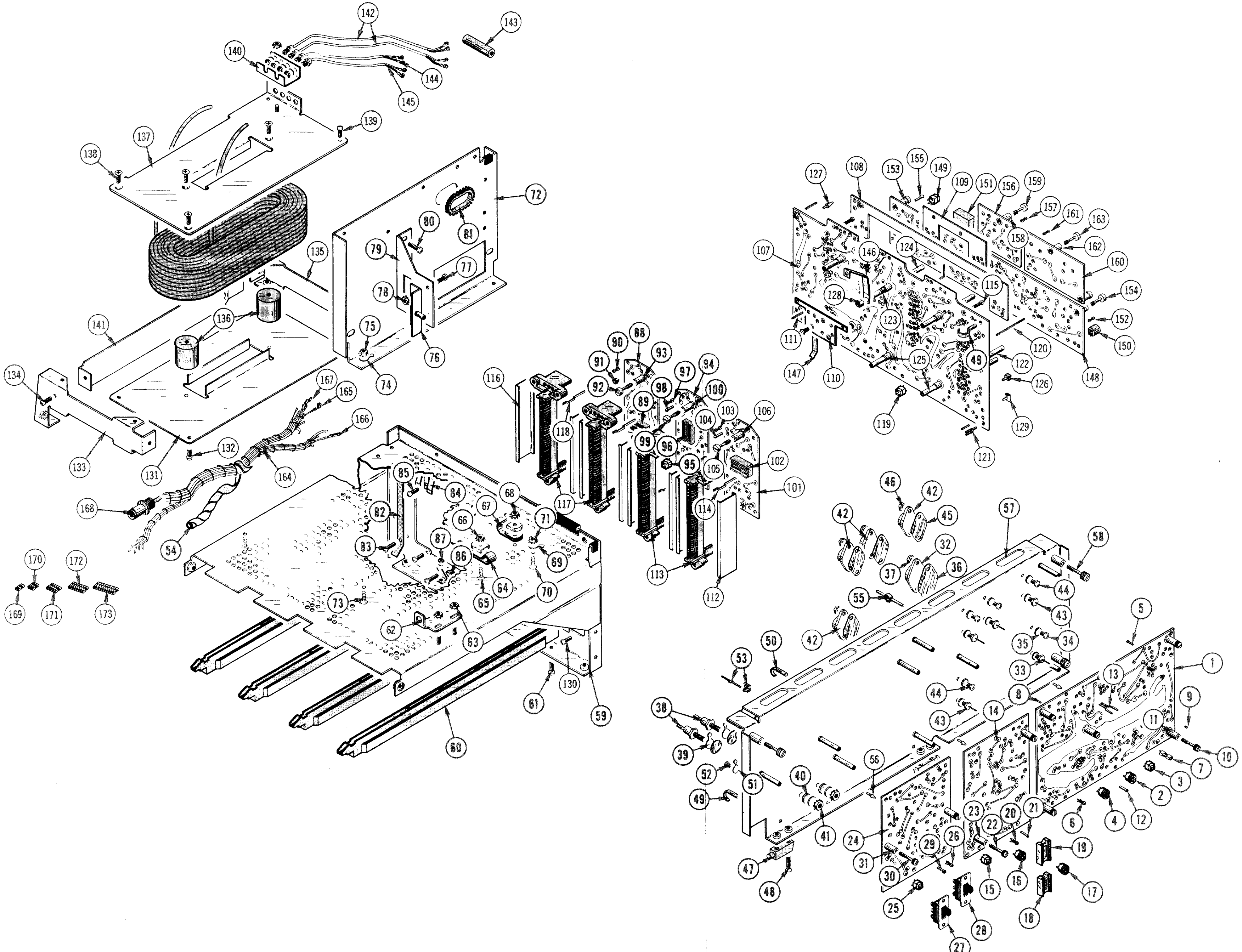
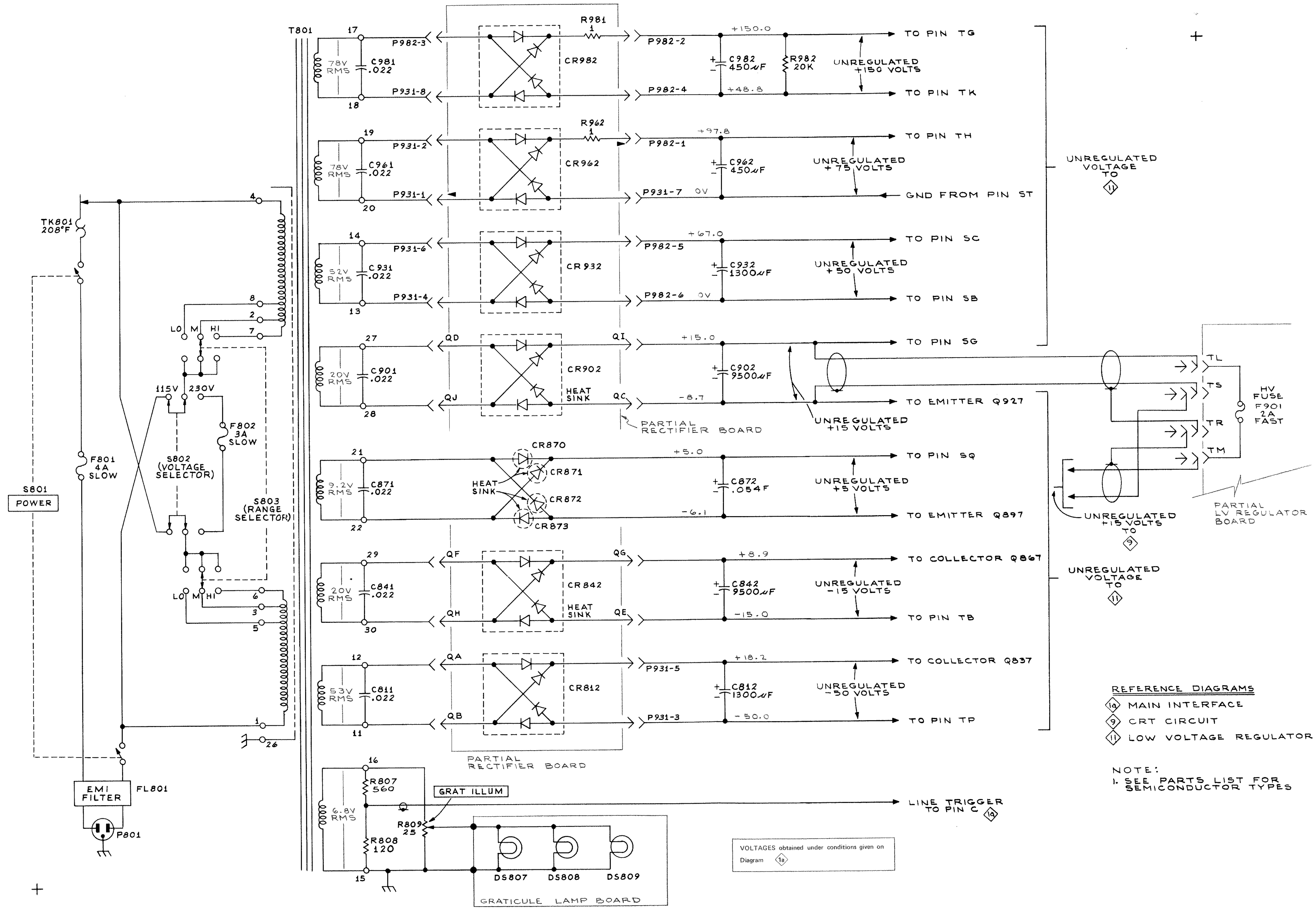


FIG. 2 CHASSIS



REFERENCE DIAGRAMS
1a MAIN INTERFACE
9 CRT CIRCUIT
11 LOW VOLTAGE REGULATOR

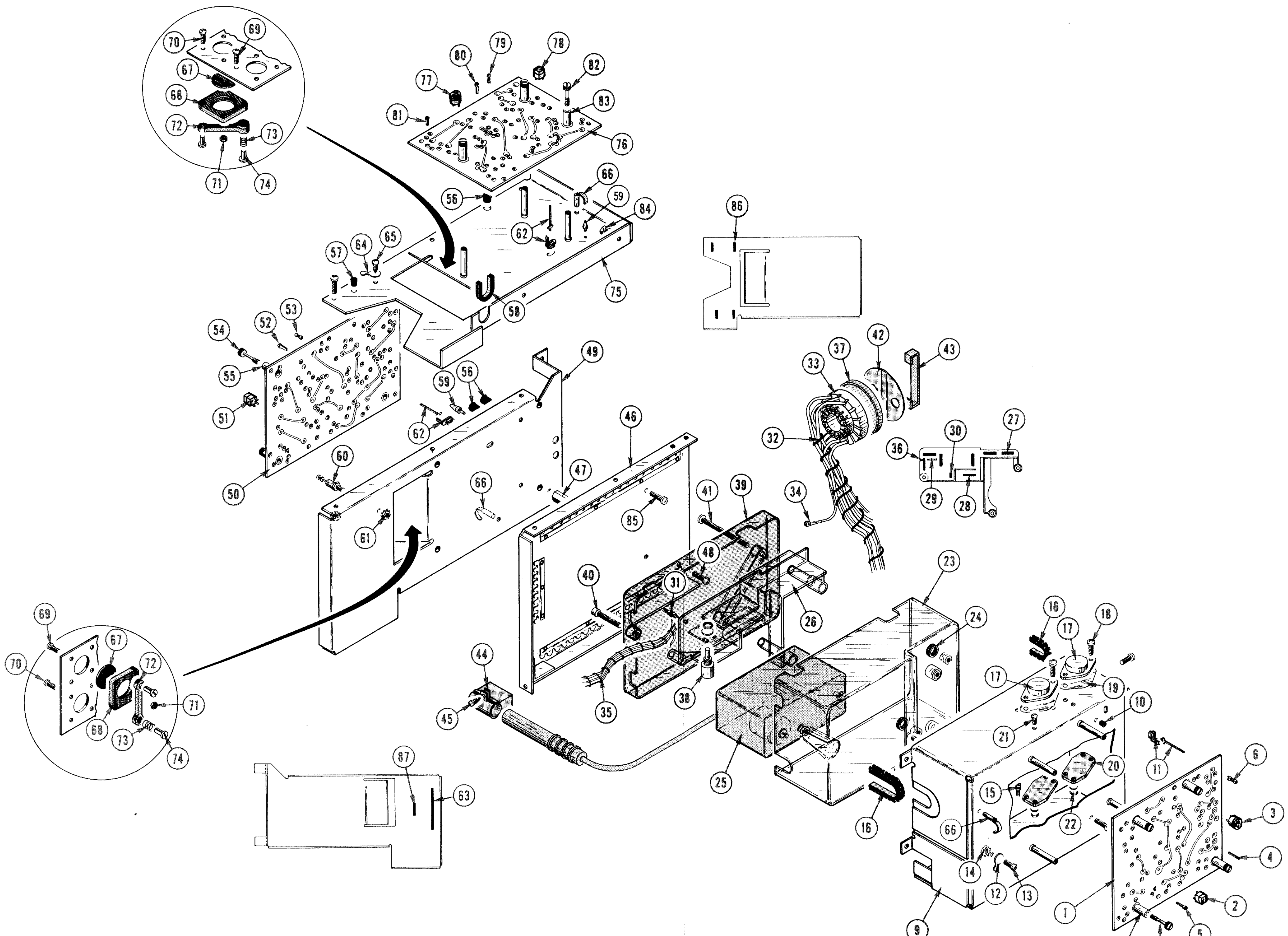
NOTE:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES obtained under conditions given on Diagram 1a

A2

LOW-VOLTAGE RECTIFIER 10

WLB 1069



TYPE 7504 OSCILLOSCOPE

FIG. 3 HIGH VOLTAGE POWER

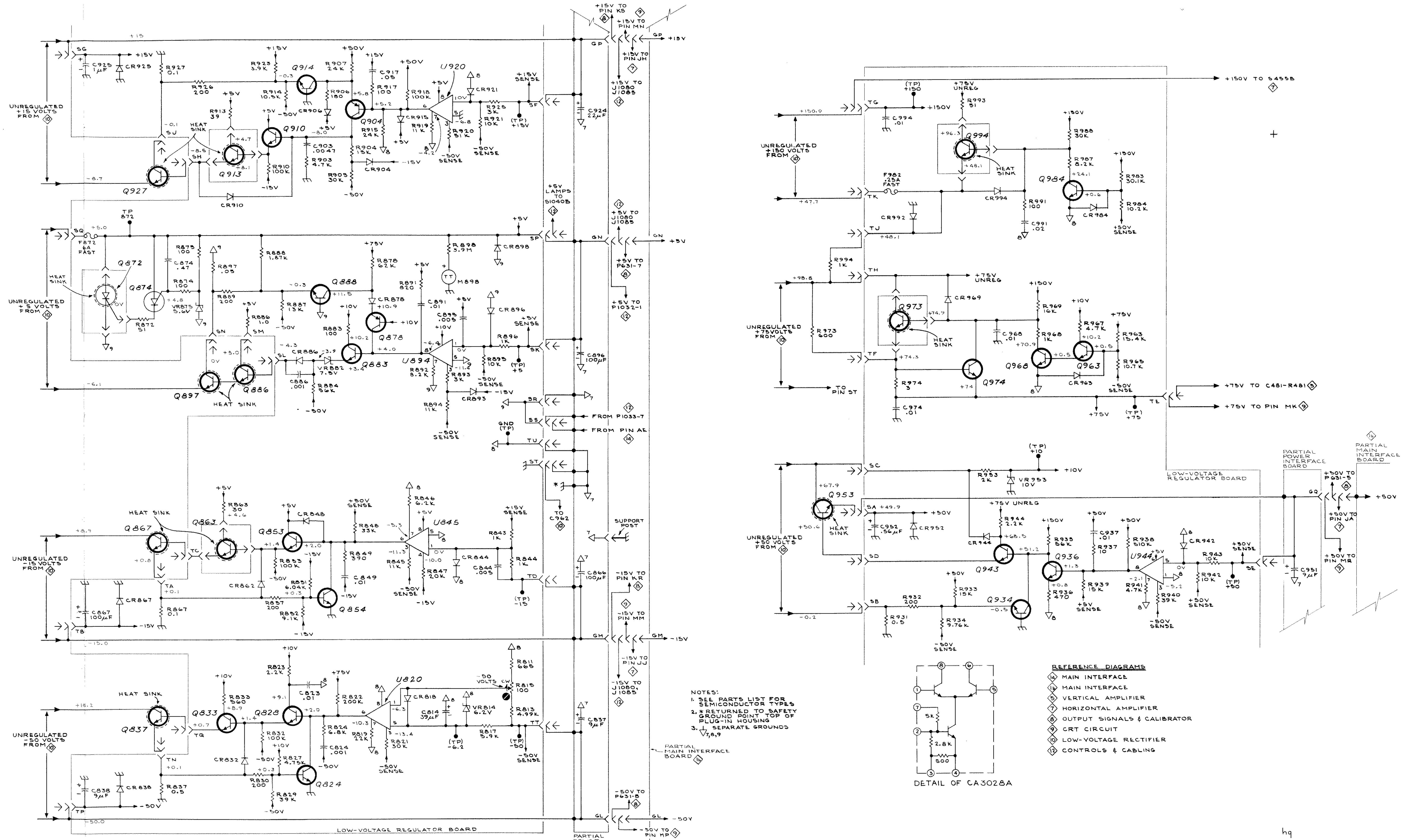
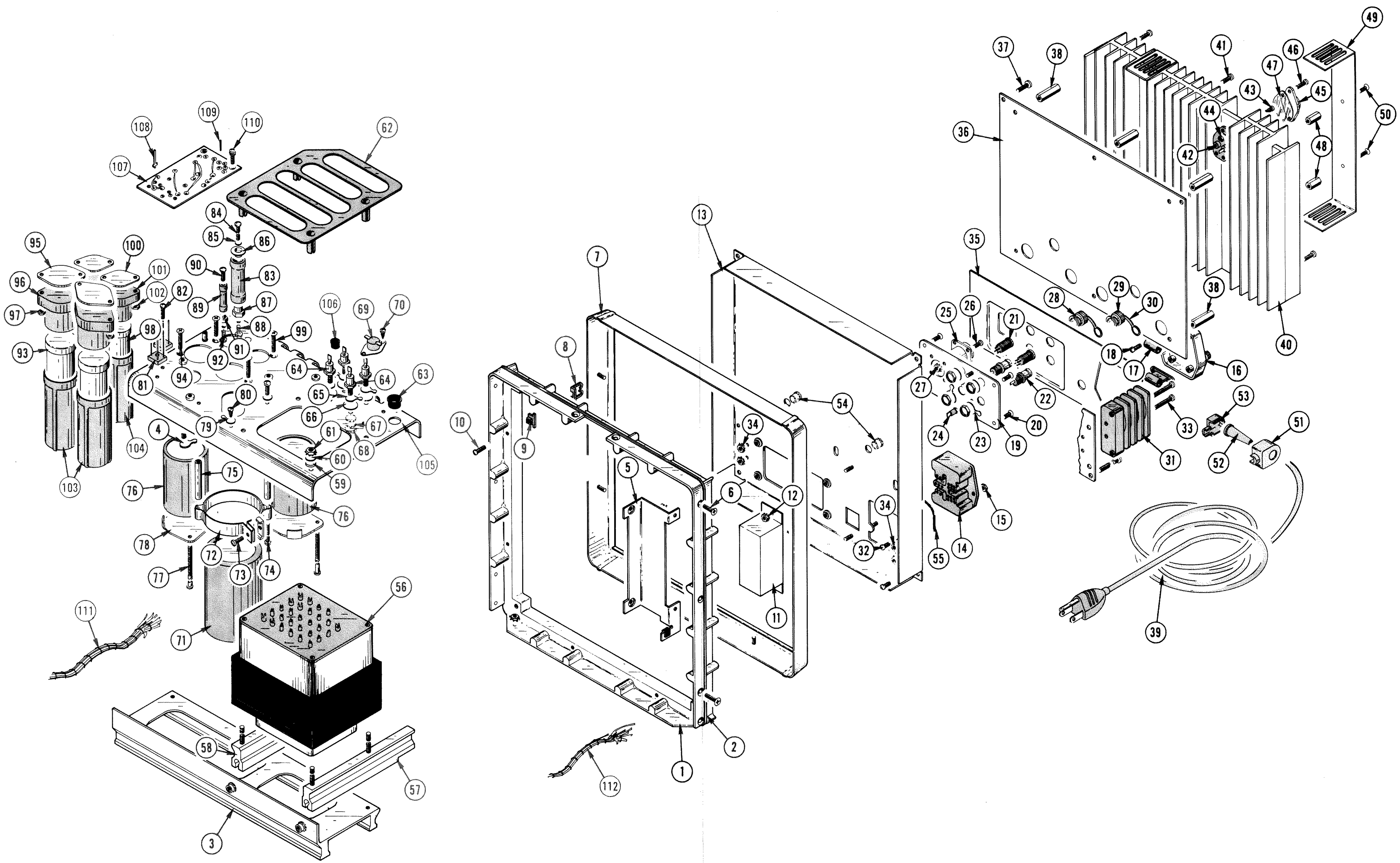
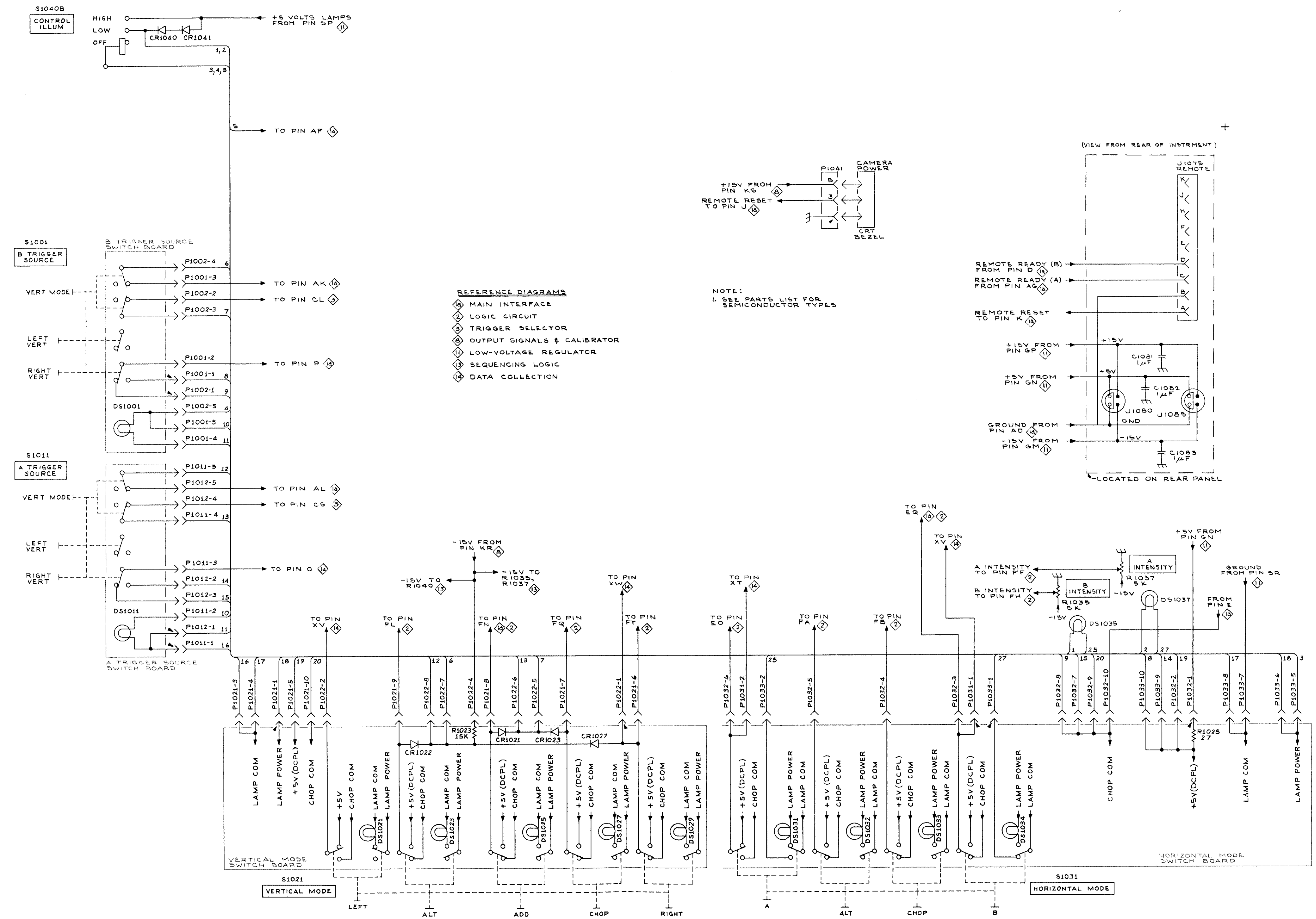
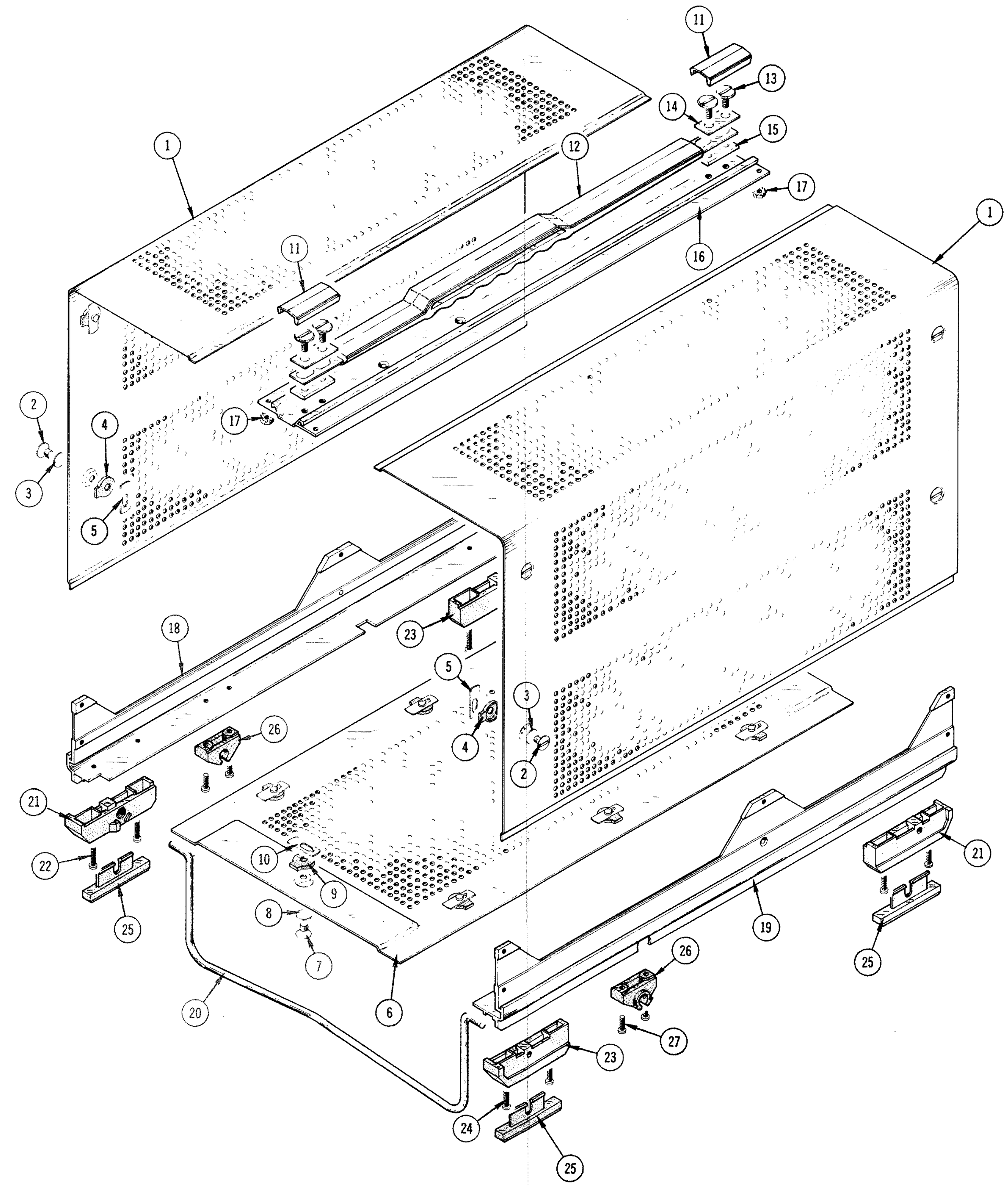

UNREGULATED +15 VOLTS FROM 10
UNREGULATED +5 VOLTS FROM 10
UNREGULATED -15 VOLTS FROM 10
UNREGULATED -50 VOLTS FROM 10
UNREGULATED +150 VOLTS FROM 10
UNREGULATED +75VOLTS FROM 10
UNREGULATED +50 VOLTS FROM 10
HEAT SINK
Q927
Q913
Q910
Q914
Q904
U920
Q872
Q874
Q897
Q886
Q888
Q878
Q883
U894
Q867
Q863
Q853
Q854
U845
Q837
Q833
Q828
Q824
U820
Q994
Q984
Q973
Q974
Q968
Q963
Q953
Q943
Q936
Q934
U944
+15V TO PIN KS 8
+15V TO PIN MN 9
+15V TO PIN JH 7
+15V TO J1080 J1085 12
+5V LAMPS TO S1040B 12
+5V TO J1080 J1085 12
+5V TO P631-7 8
+5V TO P1032-1 12
FROM P1033-7
FROM PIN AE 14
GND (TP)
SUPPORT POST
TO C962 10
-15V TO PIN KR 8
-15V TO PIN MM 9
-15V TO PIN JJ 7
-15V TO J1080, J1085 12
-50V TO P631-8 8
-50V TO PIN MP 9
PARTIAL MAIN INTERFACE BOARD 14
PARTIAL POWER INTERFACE BOARD
LOW-VOLTAGE REGULATOR BOARD
+150V TO S455B 7
+75V TO C481-R481 5
+75V TO PIN MK 9
+50V TO P631-5 8
+50V TO PIN JA 7
+50V TO PIN MR 9
NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. * RETURNED TO SAFETY GROUND POINT TOP OF PLUG-IN HOUSING
3. SEPARATE GROUNDS 7,8,9
DETAIL OF CA3028A
REFERENCE DIAGRAMS
14 MAIN INTERFACE
14 MAIN INTERFACE
5 VERTICAL AMPLIFIER
7 HORIZONTAL AMPLIFIER
8 OUTPUT SIGNALS & CALIBRATOR
9 CRT CIRCUIT
10 LOW-VOLTAGE RECTIFIER
12 CONTROLS & CABLING
hq 1069

FIG. 4 REAR


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112



CONTROLS & CABLING 12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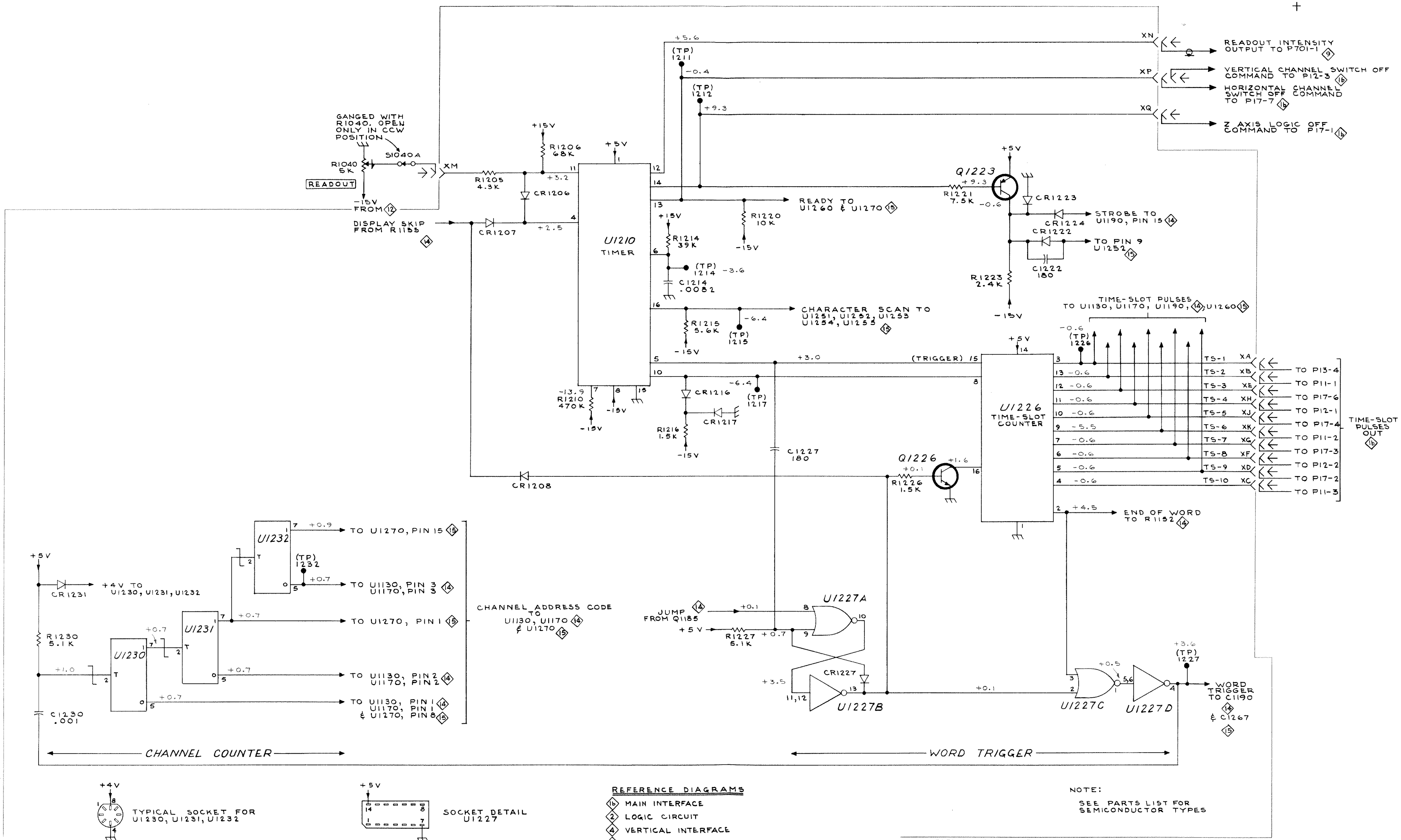


REFERENCE DIAGRAMS
1b MAIN INTERFACE
2 LOGIC CIRCUIT
4 VERTICAL INTERFACE
6 HORIZONTAL INTERFACE
9 CRT CIRCUIT
12 CONTROLS & CABLING
14 DATA COLLECTION
15 CHARACTER GENERATORS & OUTPUT

NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

PARTIAL READOUT SYSTEM BOARD

VOLTAGES obtained under conditions given on Diagram 1b

See Section 3 for operating waveforms.

hq 1069

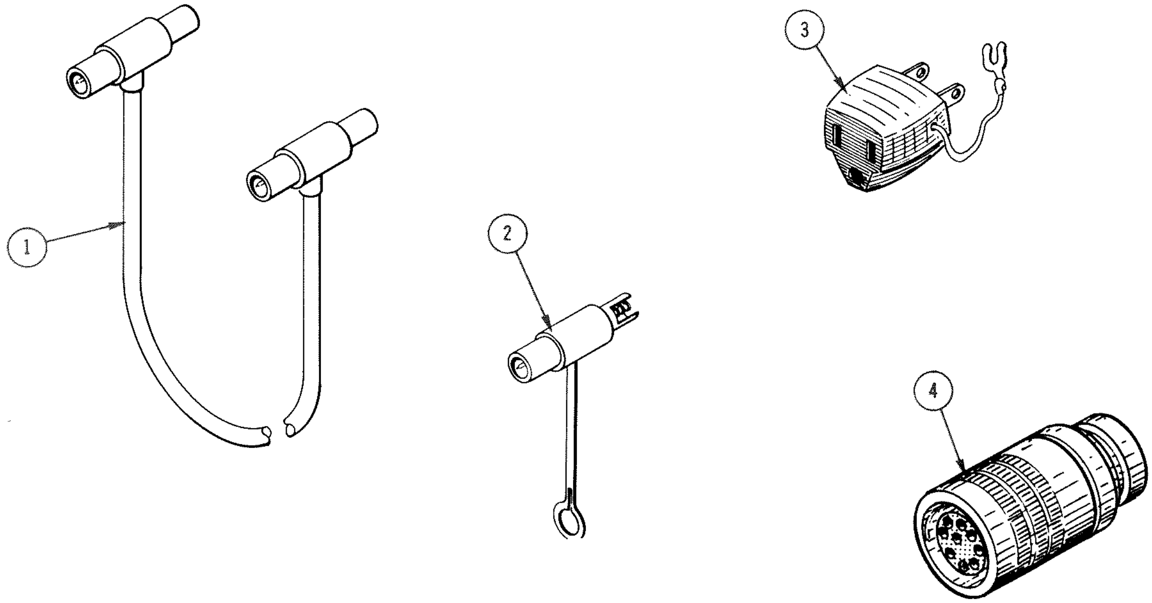
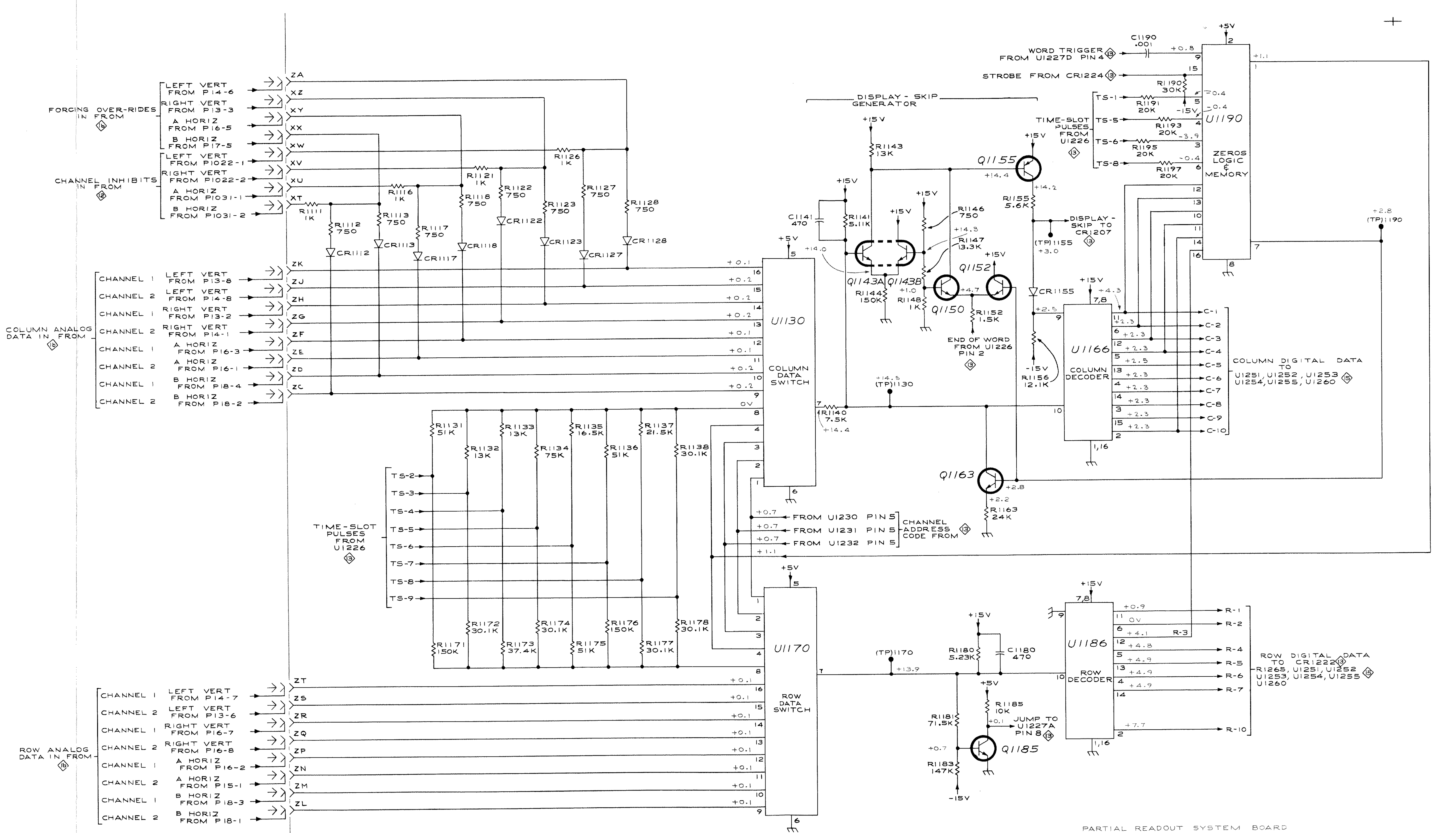


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty 1 2 3 4 5	Description
6-1	012-0087-00			2	PATCH CORD, BNC-BNC, 18 inches long
-2	012-0092-00			1	JACK, BNC-post
~~-3~~	~~103-0013-00~~			~~1~~	~~ADAPTER, power cord, 3 wire to 2 wire~~
-4	134-0049-00			1	PLUG, 9 pin, w/male insert
	070-0932-00			1	MANUAL, instruction (not shown)

Ⓐ



VOLTAGES obtained under conditions given on Diagram ⑭

See Section 3 for operating waveforms.

NOTES:

1. C= COLUMN DIGITAL DATA
2. R= ROW DIGITAL DATA
3. TS=TIME SLOT PULSE
4. SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS

⑪ MAIN INTERFACE
⑫ CONTROLS & PANELING
⑬ SEQUENCING LOGIC
⑮ CHARACTER GENERATOR & OUTPUT

1069
VRS

OPTION 1
without READOUT Circuit Board Assembly

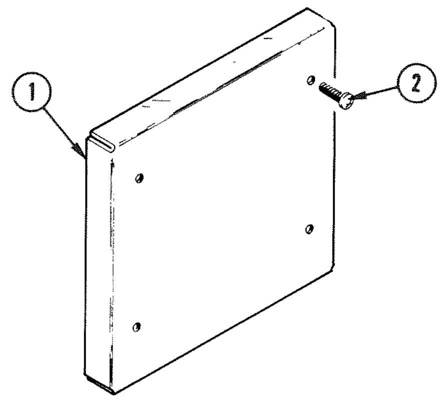


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	200-1066-00			1	COVER, readout board pins
2	211-0012-00			2	SCREW, 4-40 x 0.375 inch, PHS

STANDARD ACCESSORIES same as Type 7504

Ⓐ

OPTION 2
X-Y Delay Compensation Network

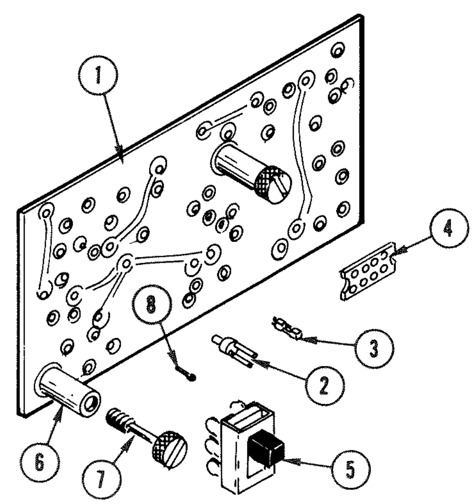


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	670-0627-00			1	ASSEMBLY, circuit board—X-Y DELAY COMP
	- - - - - -			-	assembly includes:
	388-1158-00			1	BOARD, circuit
2	129-0024-00			4	POST, connecting
3	136-0263-03			11	SOCKET, terminal pin
4	136-0337-00			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 Type 7504

Ⓐ

OPTION 3
Electromagnetic Interference (EMI)

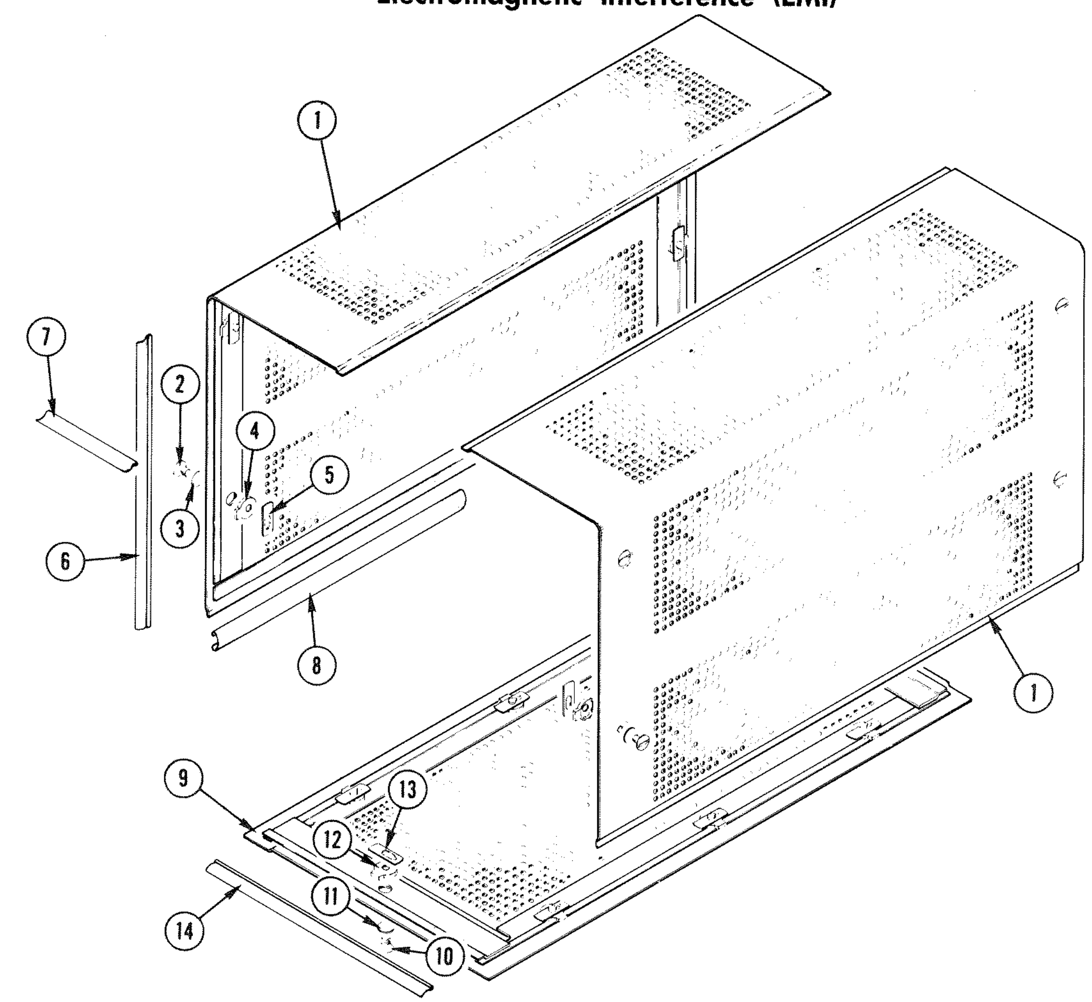
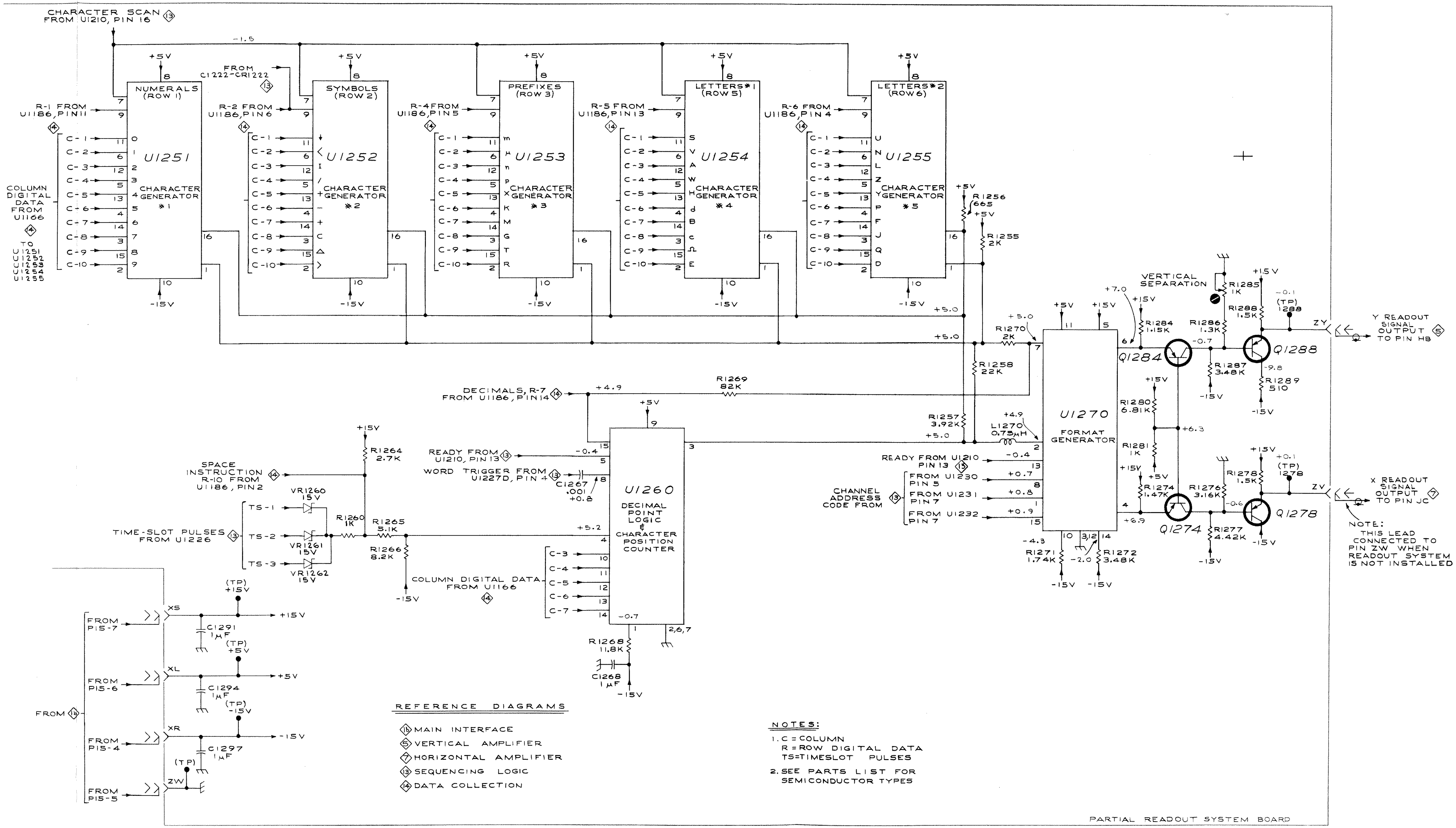


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1	390-0123-00			2	CABINET SIDE
	- - - - - -			-	each cabinet side includes:
2	214-0603-01			6	PIN, securing
3	214-0604-00			6	SPRING
4	386-1634-00			6	PLATE, index, plastic
5	386-1633-00			6	PLATE, locking
6	348-0210-00			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	214-0603-01			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)

STANDARD ACCESSORIES same as Type 7504— also includes:

	378-0625-00			1	FILTER, light, CRT (not shown)
	426-0514-00			1	FRAME, mask, plastic (not shown)

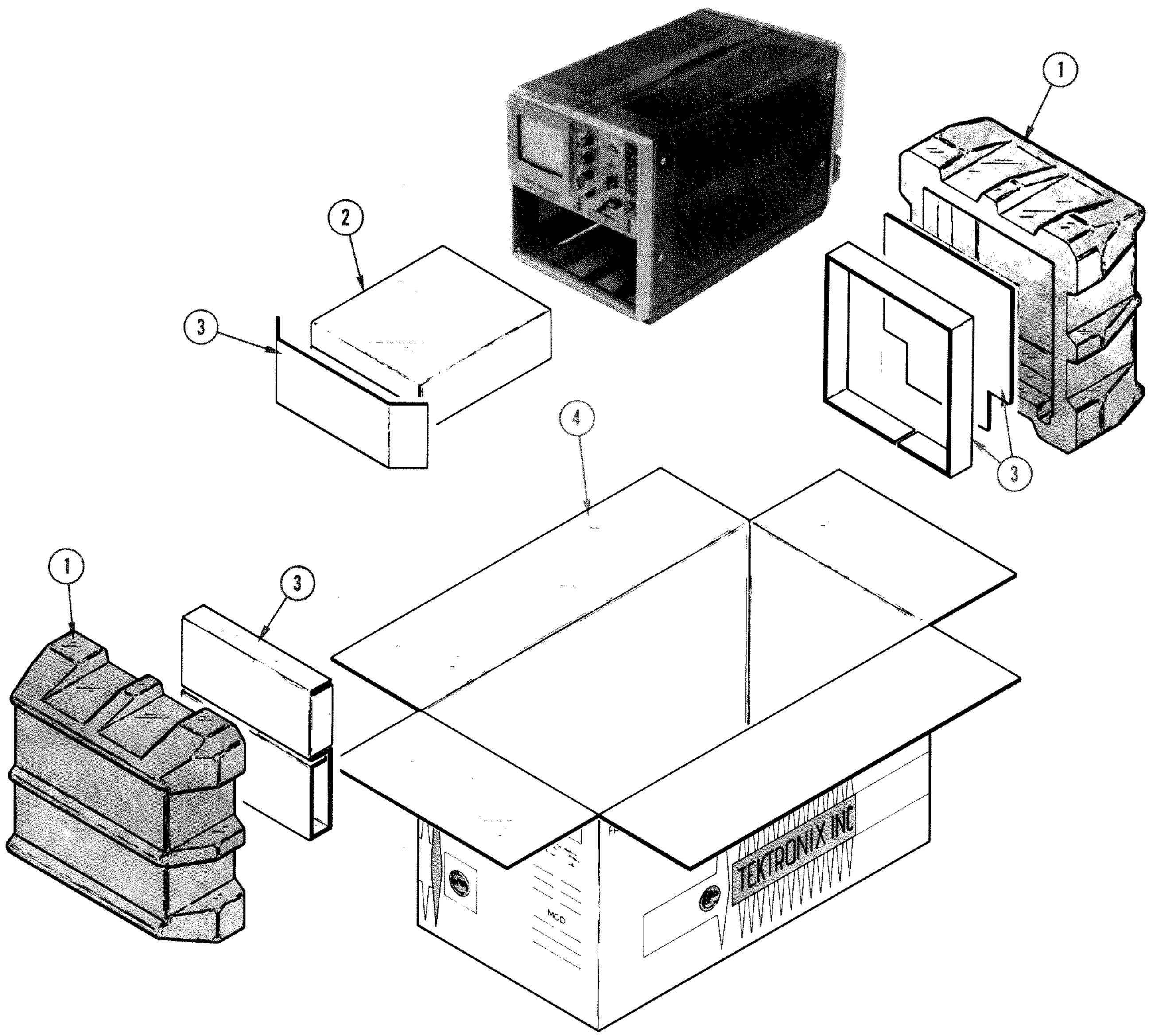
Ⓑ



VOLTAGES obtained under conditions given on Diagram 15

See Section 3 for operating waveforms.

CARTON ASSEMBLY
(Part No. 065-0122-00)



Ⓐ1

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
	065-0122-00			1	ASSEMBLY, carton
	- - - - - -			-	assembly includes:
1	004-0246-00			2	END CAP, plastic
2	004-0657-00			1	CARTON, accessory
3	004-1057-00			1	PAD SET, 4 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.

INDEX OF MECHANICAL PARTS ILLUSTRATION

SECTION 8
MECHANICAL PARTS LIST

FIGURE 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
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)
	210-0207-00			1	LUG, solder, 0.375 ID x 0.625 inch OD SE (not shown)
	210-0012-00			1	WASHER, lock, internal, 0.375 ID x 0.500 inch OD (not shown)
-4	210-0590-00			1	NUT, hex., $^3/_8$-32 x $^7/_{16}$ 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., $^3/_8$-32 x $^7/_{16}$ 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., $^3/_8$-32 x $^7/_{16}$ inch
-13	366-1189-00			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 (not shown)
-15	210-0583-00			1	NUT, hex., $^1/_4$-32 x $^5/_{16}$ inch
-16	366-0392-00			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 $^1/_8$ inch, HSS (not shown)

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
-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, 0.50 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 5/16 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 5/16 inch, PHB
	210-0591-00			2	NUT, hex., 4-40 x 3/16 inch
-33	401-0058-00			1	BEARING, front
	- - - - - -			-	mounting hardware: (not included w/bearing)
	211-0116-00			2	SCREW, sems, 4-40 x 5/16 inch, PHB
-34	214-1127-00			2	ROLLER, detent
-35	214-1126-00[1]			-	SPRING, flat, gold
	214-1126-01[1]			-	SPRING, flat, green
	214-1126-02[1]			-	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 3/32 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 3/16 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 3/16 inch
	- - - - - -			-	mounting hardware: (not included w/assembly)
-42	211-0116-00			1	SCREW, sems, 4-40 x 5/16 inch, PHB
-43	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch

[1] Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-44	260-1060-00			1	SWITCH, toggle, w/hardware—POWER
	- - - - - -			-	mounting hardware: (not included w/switch)
-45	354-0055-00			1	RING, locking
-46	210-0902-00			1	WASHER, flat, 0.470 ID x $^{21}/_{32}$ inch, OD
-47	210-0473-00			1	NUT, 12 sided, $^{15}/_{32}$-32 x 0.634 inch
-48	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0471-00			1	NUT, hex., $^{1}/_{4}$-32 x $^{5}/_{16}$ inch
-49	210-1026-00			1	WASHER, lock, external, $^{1}/_{4}$ 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, 0.64 inch long
-54	352-0195-00			1	HOLDER, plastic
	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)
	386-1371-00			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, 0.64 inch long
-59	352-0195-00			1	HOLDER, plastic
	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)
	386-1371-00			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			10	TERMINAL, pin, 0.885 inch long
-63	131-0787-00			12	TERMINAL, pin, 0.64 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 $^{1}/_{2}$ inch, PHS
-72	407-0700-00			1	BRACKET, switch

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	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, 0.64 inch long
-76	337-1157-00			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 1/2 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	MAGNET, permanent
	- - - - - -			-	mounting hardware: (not included w/magnet)
-88	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-89	670-0702-00			1	ASSEMBLY, circuit board—GRATICULE LIGHT
	- - - - - -			-	assembly includes:
	388-1274-00			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 5/16 inch, RHS
-92	344-0179-00			2	CLIP, reflector
-93	358-0301-02			2	BUSHING, plastic
-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., 1/4-28 x 3/8 inch
-102	348-0216-00			1	SHIELDING GASKET, electrical
-103	333-1265-00			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 3/8 inch, PHS

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
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	GASKET, shielding, 10.632 inches long
-111	386-1518-00			1	SUPPORT, chassis
	- - - - - -			-	mounting hardware: (not included w/support)
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-112	211-0559-00			2	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
-113	131-0761-00			1	TERMINAL, post
-114	348-0031-00			2	GROMMET, plastic, 3/32 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	212-0008-00			4	SCREW, 8-32 x 0.500 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	337-1126-01			1	SHIELD, CRT
-125	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
-126	211-0142-00			1	SCREW, 4-40 x 0.250 inch, PHS
	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-127	131-0807-00			1	CONTACT, CRT grounding
	- - - - - -			-	mounting hardware: (not included w/contact)
-128	211-0142-00			1	SCREW, 4-40 x 0.250 inch, PHS
-129	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-130	- - - - - -			1	COIL
	- - - - - -			-	mounting hardware: (not included w/coil)
-131	343-0217-00			1	CLAMP
-132	213-0138-00			2	SCREW, thread forming, 4-40 x 3/16 inch, PHS
-133	348-0002-00			2	GROMMET, rubber, 1/4 inch diameter
-134	354-0347-00			1	RING, clamp, CRT
	- - - - - -			-	mounting hardware: (not included w/ring)
	214-0333-00			2	SPRING, helical compression (not shown)
-135	211-0170-00			2	SCREW, 4-40 x 2.750 inches, PHS

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-136	407-0585-00			1	BRACKET, CRT
-137	343-0205-00			1	RETAINER, CRT
	- - - - - -			-	mounting hardware: (not included w/retainer)
	210-0949-00			4	WASHER, flat, $^{9}/_{64}$ ID x $^{1}/_{2}$ inch OD
-138	211-0507-00			4	SCREW, 6-32 x $^{5}/_{16}$ inch, PHS
-139	200-0745-00			1	COVER, resistor, plastic
-140	134-0119-00			3	PLUG, hole, plastic
-141	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting harwdware: (not included w/resistor)
	210-0562-00			1	NUT, hex., 8-32 x $^{1}/_{2}$ x $^{23}/_{64}$ inch
-142	210-0471-00			1	NUT, hex., $^{1}/_{4}$-32 x 0.312 inch
	210-1026-00			1	WASHER, lock, internal, 0.250 inch ID
-143	358-0377-00			1	BUSHING, hex., 0.275 inch long
-144	352-0169-00			1	HOLDER, terminal connector, 2 wire

FIGURE 2 CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-1	670-0630-00			1	ASSEMBLY, circuit board—LOW VOLTAGE REGULATOR
	- - - - - -			-	assembly includes:
	388-1161-00			1	BOARD, circuit
-2	136-0183-00			1	SOCKET, transistor, 3 pin
-3	136-0220-00			18	SOCKET, transistor, 3 pin, square
-4	136-0237-00			5	SOCKET, transistor, 8 contact
-5	136-0254-01			7	SOCKET, connector pin, 0.145 inch long
-6	136-0263-03			31	SOCKET, pin terminal
-7	136-0286-00			6	SOCKET, terminal pin
-8	136-0338-01			8	SOCKET, terminal pin
-9	166-0292-00			2	SLEEVE, support
-10	211-0155-00			5	SCREW, 4-40 x 0.375 inch, PHS
-11	361-0238-00			5	SPACER, sleeve
-12	214-0579-00			10	PIN, test point
-13	344-0154-00			6	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, PHS
-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, PHS
-31	361-0238-00			2	SPACER, sleeve
-32	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: (not included w/transistor)
-33	131-0739-00			1	TERMINAL, feedthru
-34	211-0537-00			1	SCREW, 6-32 x 3/8 inch, THS
-35	210-0967-00			2	WASHER, plastic, shouldered, 0.157 ID x 0.375 inch OD
-36	386-0978-00			1	PLATE, insulator, plastic
-37	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-38	- - - - - -			2	DIODE
	- - - - - -			-	mounting hardware for each: (not included w/diode)
-39	210-0224-00			1	LUG, solder, #10
	210-0909-00			1	WASHER, plastic, insulator
-40	210-0813-00			1	WASHER, fiber, shouldered, #10
	210-0805-00			1	WASHER, flat, 0.204 ID x 0.438 inch OD
-41	220-0410-00			1	NUT, keps, 10-32 x 3/8 inch

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-42	- - - - - -			4	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
-43	131-0739-00			1	TERMINAL, feedthru
-44	211-0537-00			1	SCREW, 6-32 x 3/8 inch, THS
	210-0967-00			2	WASHER, plastic, shouldered, 0.157 ID x 0.375 inch OD
-45	386-0143-00			1	PLATE, insulator, plastic
-46	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-47	214-1186-00			2	PIN, hinge
	- - - - - -			-	mounting hardware for each: (not included w/pin)
-48	211-0102-00			2	SCREW, 4-40 x 1/2 inch, 100° csk, FHS
-49	343-0089-00			4	CLAMP, cable, plastic, large
-50	343-0213-00			3	CLAMP, cable, plastic, medium
-51	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
-52	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-53	131-0682-03			100	TERMINAL, feed-thru, 0.89 inch long
-54	162-0579-00			ft.	INSULATING SLEEVING, spiral, 24 inches long
-55	131-0737-00			6	TERMINAL, feedthru
-56	386-1556-00			8	SUPPORT, circuit board
-57	441-0853-00			1	CHASSIS, low voltage regulator
	- - - - - -			-	chassis includes:
-58	213-0172-00			3	THUMBSCREW, 6-32 x 0.812 inch
-59	380-0146-00			1	HOUSING, plug-in
-60	351-0181-00			4	GUIDE, plug-in
	- - - - - -			-	mounting hardware for each: (not included w/guide)
-61	213-0104-00			1	SCREW, thread forming, 6-32 x 3/8 inch, THS
	213-0229-00			1	SCREW, thread forming, #6 x 0.375 inch, FHS
-62	214-1179-00			1	BRACKET, hinge pin
	- - - - - -			-	mounting hardware: (not included w/bracket)
-63	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-64	343-0004-00			1	CLAMP, cable, plastic, 0.312 inch dimeter
	- - - - - -			-	mounting hardware: (not included w/clamp)
-65	211-0538-00			1	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 x 33/64 inch long
-66	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-67	343-0007-00			1	CLAMP, cable, plastic, 5/8 inch diameter
	- - - - - -			-	mounting hardware: (not included w/clamp)
	211-0538-00			1	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 x 33/64 inch long
-68	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
2-69	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-70	211-0538-00			1	SCREW, 6-32 x $^5/_{16}$ inch, 100° csk, FHS
-71	210-0457-00			1	NUT, keps, 6-32 x $^5/_{16}$ inch
-72	386-1631-00			1	SUPPORT, plug-in housing
	- - - - - -			-	mounting hardware: (not included w/support)
-73	211-0538-00			3	SCREW, 6-32 x $^5/_{16}$ inch, 100° csk, FHS
-74	210-0202-00			1	LUG, solder, SE #6
-75	210-0457-00			3	NUT, keps, 6-32 x $^5/_{16}$ inch
-76	407-0679-00			1	BRACKET, support
	- - - - - -			-	mounting hardware: (not included w/bracket)
-77	211-0507-00			2	SCREW, 6-32 x $^5/_{16}$ inch, PHS
-78	210-0457-00			2	NUT, keps, 6-32 x $^5/_{16}$ inch
-79	407-0704-00			1	BRACKET, angle
	- - - - - -			-	mounting hardware: (not included w/bracket)
-80	211-0504-00			2	SCREW, 6-32 x 0.250 inch, PHS
-81	255-0334-00			ft	CHANNEL, plastic, $3^3/_8$ inches long
-82	131-0800-00			2	CONTACT, electrical, side
	- - - - - -			-	mounting hardware for each: (not included w/contact)
-83	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-84	131-0800-00			3	CONTACT, electrical, upper
	- - - - - -			-	mounting hardware for each: (not included w/contact)
-85	211-0008-00			1	SCREW, 4-40 x $^1/_4$ inch, PHS
	210-0586-00			1	NUT, keps, 4-40 x $^1/_4$ inch
-86	131-0801-00			3	CONTACT, electrical, lower
	- - - - - -			-	mounting hardware for each: (not included w/contact)
	211-0022-00			2	SCREW, 2-56 x $^3/_{16}$ inch, RHS
	210-0001-00			2	WASHER, lock, internal #2
-87	210-0405-00			2	NUT, hex., 2-56 x $^3/_{16}$ inch
-88	670-0622-00			1	ASSEMBLY, circuit board—VERTICAL INTERFACE
	- - - - - -			-	assembly includes:
	388-1153-00			1	BOARD, circuit
-89	136-0260-01			1	SOCKET, integrated circuit, 16 pin
-90	136-0263-03			19	SOCKET, pin terminal
-91	136-0350-00			11	SOCKET, transistor, 3 pin
-92	211-0155-00			2	SCREW, 4-40 x 0.375 inch, PHS
-93	361-0238-00			2	SPACER, sleeve

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-94	670-0625-00			1	ASSEMBLY, circuit board—TRIG. SEL.
	- - - - - -			-	assembly includes:
	388-1156-00			1	BOARD, circuit
-95	136-0220-00			6	SOCKET, transistor, 3 pin, square
-96	136-0260-01			2	SOCKET, integrated circuit, 16 pin
-97	136-0263-03			19	SOCKET, pin terminal
-98	214-0579-00			13	PIN, test point
-99	211-0155-00			2	SCREW, 4-40 x 0.375 inch, PHS
-100	361-0238-00			2	SPACER, sleeve
-101	670-0623-00			1	ASSEMBLY, circuit board—HORIZONTAL INTERFACE
	- - - - - -			-	assembly includes:
	388-1154-00			1	BOARD, circuit
-102	136-0260-01			1	SOCKET, integrated circuit, 16 pin
-103	136-0263-03			14	SOCKET, pin connector
-104	214-0579-00			12	PIN, test point
-105	211-0155-00			2	SCREW, 4-40 x 0.375 inch, PHS
-106	361-0238-00			2	SPACER, sleeve
	670-0621-00			1	ASSEMBLY, circuit board—MAIN INTERFACE
	- - - - - -			-	assembly includes:
-107	388-1152-00			1	BOARD, circuit
-108	388-1381-00			1	BOARD, circuit—IPC OUTER
-109	388-1380-00			1	BOARD, circuit—IPC INNER
-110	388-1382-00			1	BOARD, circuit—INTERCONNECT
	- - - - - -			-	mounting hardware: (not included w/board)
	211-0148-00			2	SCREW, 4-40 x 0.312 inch, PHS
-111	131-0787-00			24	TERMINAL, pin, 0.64 inch long
	131-0767-00			2	CONNECTOR, receptacle, 76 contact
	- - - - - -			-	each connector includes:
-112	200-0950-00			2	COVER, plastic
-113	204-0365-00			1	BODY, plastic
-114	131-0726-00			2	CONTACT SET, electrical, straight (19 contacts each set)
	131-0727-00			2	CONTACT SET, electrical, offset (19 contacts each set)
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-115	213-0232-00			2	SCREW, thread forming, 2-56 x 5/16 inch, PHS
	137-0767-02			2	CONNECTOR, receptacle, 76 contact
	- - - - - -			-	each connector includes:
-116	200-0950-00			2	COVER, plastic
-117	204-0365-00			1	BODY, plastic
-118	131-0726-00			2	CONTACT SET, electrical, straight (19 contacts each set)
	131-0727-00			2	CONTACT SET, electrical, offset (19 contacts each set)
	- - - - - -			-	mounting hardware for each: (not included w/connector)
	213-0232-00			2	SCREW, thread formming, 2-56 x 5/16 inch, PHS
-119	136-0220-00			2	SOCKET, transistor, 3 pin, square
-120	131-0595-00			4	TERMINAL, pin, 1.37 inches long
	131-0608-00			60	TERMINAL, pin, 0.365 inch long
	131-0589-00			38	TERMINAL, pin, 0.50 inch long
	131-0590-00			39	TERMINAL, pin, 0.71 inch long
	131-0592-00			49	TERMINAL, pin, 0.882 inch long
	131-0665-00			17	TERMINAL, pin, 0.88 inch long

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FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-121	351-0155-00			65	GUIDE, terminal lead, plastic
-122	351-0185-00			3	GUIDE-POST, lock, 0.65 inch long
-123	351-0227-00			2	GUIDE-POST, lock, 0.84 inch long
	351-0213-00			2	GUIDE-POST, lock, 0.285 inch long (not shown)
-124	351-0188-00			3	GUIDE-POST, lock, 0.65 inch long
-125	351-0186-00			4	GUIDE-POST, lock, 0.84 inch long
-126	352-0213-00			4	HOLDER, cable, plastic
-127	385-1557-00			6	SUPPORT, circuit board, plastic
-128	220-0561-00			2	NUT, hex., 10-32 x 0.25 inch
-129	352-0212-00			8	HOLDER, coaxial, grounding
	- - - - - -			-	mounting hardware: (not included w/assembly)
-130	213-0119-00			12	SCREW, thread forming, 4-24 x 3/8 inch, PHS
	119-0208-00			1	ASSEMBLY, delay line
	- - - - - -			-	assembly includes:
-131	200-0971-00			1	COVER, bottom
	- - - - - -			-	mounting hardware: (not included w/cover)
-132	211-0504-00			4	SCREW, 6-32 x 1/4 inch, PHS
	213-0229-00			4	SCREW, thread forming, #6 x 0.375 inch, FHS (not shown)
-133	386-1553-00			1	SUPPORT, front
	- - - - - -			-	mounting hardware: (not included w/support)
-134	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-135	386-1552-00			1	SUPPORT, rear
-136	129-0215-00			2	POST, plastic
-137	200-0972-00			1	COVER, top
	- - - - - -			-	mounting hardware: (not included w/cover)
-138	211-0541-00			4	SCREW, 6-32 x 1/4 inch, 100° csk, FHS
-139	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch (not shown)
-140	407-0613-00			1	BRACKET
	- - - - - -			-	mounting hardware: (not included w/bracket)
	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-141	124-0229-00			1	STRIP, trim
-142	175-1144-00			1	COAXIAL ASSEMBLY
	- - - - - -			-	coaxial assembly includes:
	131-0512-00			2	CONNECTOR, terminal
	131-0755-00			2	CONNECTOR, terminal
-143	385-0113-00			1	ROD, plastic, 1 1/8 inches long
-144	175-1142-00			1	COAXIAL ASSEMBLY
	- - - - - -			-	coaxial assembly includes:
	131-0512-00			1	CONNECTOR, terminal
	131-0755-00			1	CONNECTOR, terminal
-145	175-1143-00			1	COAXIAL ASSEMBLY
	- - - - - -			-	coaxial assembly includes:
	131-0512-00			1	CONNECTOR, terminal
	131-0755-00			1	CONNECTOR, terminal
	- - - - - -			-	mounting hardware: (not included w/assembly)
	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS (not shown)
	211-0538-00			1	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-146	131-0804-00			1	LINK, terminal connector, 1.15 inches long
-147	131-0805-00			1	LINK, terminal connector, 0.90 inch long

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-148	670-0626-00			1	ASSEMBLY, circuit board—LOGIC
	- - - - - -			-	assembly includes:
	388-1157-00			1	BOARD, circuit
-149	136-0220-00			7	SOCKET, transistor, 3 pin, square
-150	136-0241-00			4	SOCKET, integrated circuit, 10 pin
-151	136-0260-01			3	SOCKET, integrated circuit, 16 pin
-152	136-0263-03			43	SOCKET, pin terminal
-153	361-0238-00			3	SPACER, sleeve
-154	211-0155-00			3	SCREW, 4-40 x 0.375 inch, PHS
-155	214-0579-00			14	PIN, test point
-156	670-0624-00			1	ASSEMBLY, circuit board—POWER INTERFACE
	- - - - - -			-	assembly includes:
	388-1155-00			1	BOARD, circuit
-157	136-0263-03			5	SOCKET, pin terminal
-158	361-0238-00			1	SPACER, sleeve
-159	211-0155-00			1	SCREW, 4-40 x 0.375 inch, PHS
-160	670-0878-00			1	ASSEMBLY, circuit board—HORIZONTAL INTERCONNECT
	- - - - - -			-	assembly includes:
	388-1531-00			1	BOARD, circuit
-161	136-0263-03			8	SOCKET, pin terminal
-162	361-0238-00			2	SPACER, sleeve
-163	211-0155-00			2	SCREW, 4-40 x 0.375 inch, PHS
-164	179-1432-00			1	WIRING HARNESS, interface
	- - - - - -			-	wiring harness includes:
-165	131-0512-00			134	CONNECTOR, terminal
-166	131-0621-00			101	CONNECTOR, terminal (for large wire)
	131-0622-00			3	CONNECTOR, terminal (for small wire)
	131-0707-00			3	CONNECTOR, terminal (for large wire)
-167	131-0738-00			2	CONNECTOR, terminal (for large wire)
	131-0740-00			2	CONNECTOR, terminal (for large wire)
	131-0755-00			30	CONNECTOR, terminal (for small wire)
-168	131-0818-00			3	CONNECTOR, receptacle, BNC, w/hardware
	131-0819-00			1	CONNECTOR, terminal (for large wire)
-169	352-0198-00			3	HOLDER, terminal connector, 2 wire
-170	352-0199-00			2	HOLDER, terminal connector, 3 wire
-171	352-0201-00			4	HOLDER, terminal connector, 5 wire
-172	352-0204-00			8	HOLDER, terminal connector, 8 wire
-173	352-0206-00			3	HOLDER, terminal connector, 10 wire

FIGURE 3 HIGH VOLTAGE POWER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-1	670-0631-00			1	ASSEMBLY, circuit board—HIGH VOLTAGE/Z AXIS AMP
	- - - - - -			-	assembly includes:
	388-1162-00			1	BOARD, circuit
-2	136-0220-00			3	SOCKET, transistor, 3 pin, square
-3	136-0183-00			5	SOCKET, transistor, 3 pin
-4	131-0589-00			4	CONNECTOR, terminal pin
-5	214-0579-00			8	PIN, test point
-6	136-0263-03			16	SOCKET, terminal pin
-7	211-0155-00			4	SCREW, 4-40 x 0.375 inch, PHS
-8	361-0238-00			4	SPACER, sleeve
	621-0442-00			1	ASSEMBLY, High Voltage Box
	- - - - - -			-	assembly includes:
-9	337-1121-00			1	SHIELD, high voltage
-10	348-0031-00			1	GROMMET, plastic, 3/16 inch diameter
-11	131-0682-02			16	TERMINAL, feed-thru, 0.82 inch long
-12	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-13	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-14	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-15	131-0309-00			4	CONNECTOR, terminal
	358-0241-00			4	BUSHING, plastic
-16	255-0334-00			ft	CHANNEL, plastic, 2 lengths of 2 1/2 inches each
-17	- - - - - -			2	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
-18	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS
-19	386-0978-00			1	PLATE, insulator, plastic
-20	136-0135-00			2	SOCKET, transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-21	211-0159-00			2	SCREW, 2-56 x 3/8 inch, RHS
	210-0001-00			2	WASHER, lock, internal #2
-22	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-23	380-0166-00			1	HOUSING, High Voltage
-24	210-1093-00			2	WASHER, plastic, 0.187 ID x 0.312 inch OD
-25	119-0226-00			1	POWER SUPPLY, HV
-26	441-0879-00			1	CHASSIS, high voltage
	- - - - - -			-	chassis includes:
-27	124-0164-00			5	STRIP, ceramic, 4 notches
-28	124-0176-00			2	STRIP, ceramic, 4 notches
-29	124-0175-00			1	STRIP, ceramic, 2 notches
-30	124-0163-00			1	STRIP, ceramic, 2 notches
-31	131-0403-00			1	CONNECTOR, feed-thru
-32	136-0363-00			1	ASSEMBLY, CRT socket & cable
	- - - - - -			-	assembly includes:
-33	136-0304-02			1	SOCKET, CRT
-34	131-0621-00			7	CONNECTOR, terminal

FIGURE 3 HIGH VOLTAGE POWER (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-35	179-1435-00			1	WIRING HARNESS, High Voltage
-36	131-0864-00			1	CONTACT, electrical
-37	200-0917-01			1	COVER, CRT socket
-38	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0583-00			1	NUT, hex., $\frac{1}{4}$-32 x $\frac{5}{16}$ inch
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.400 inch OD
-39	200-0988-00			1	COVER, High Voltage Box
	- - - - - -			-	mounting hardware: (not included w/cover)
-40	211-0529-00			1	SCREW, 6-32 x 1 $\frac{1}{4}$ inches, Fil HS
-41	211-0530-00			2	SCREW, 6-32 x 1 $\frac{3}{4}$ inches, Fil HS
-42	343-0254-00			1	CLAMP, CRT socket
-43	367-0117-00			1	HANDLE, CRT socket
	- - - - - -			-	mounting hardware: (not included w/assembly)
	211-0507-00			5	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS
-44	352-0217-00			1	HOLDER, anode connector
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0008-00			2	SCREW, 4-40 x $\frac{1}{4}$ inch, PHS
-45	213-0113-00			1	SCREW, thread forming, 2-32 x $\frac{5}{16}$ inch, RHS
-46	407-0586-00			1	BRACKET, High Voltage
-47	129-0218-00			1	POST, hex., 0.250 x 4.299 inches long
	- - - - - -			-	mounting hardware: (not included w/post)
-48	211-0504-00			2	SCREW, 6-32 x 0.250 inch, PHS
-49	441-0855-00			1	CHASSIS, vertical output
-50	670-0628-00			1	ASSEMBLY, circuit board—VERTICAL OUTPUT
	- - - - - -			-	assembly includes:
	388-1159-00			1	BOARD, circuit
-51	136-0220-00			13	SOCKET, transistor, 3 pin, square
-52	214-0579-00			6	PIN, test point
-53	136-0263-03			10	SOCKET, terminal pin
-54	211-0155-00			4	SCREW, 4-40 x 0.375 inch, PHS
-55	361-0238-00			4	SPACER, sleeve
-56	348-0055-00			3	GROMMET, plastic, $\frac{1}{4}$ inch diameter
-57	343-0031-00			1	GROMMET, plastic, $\frac{5}{32}$ inch diameter
-58	348-0115-00			1	GROMMET, U-shape
-59	386-1558-00			6	SUPPORT, circuit board
-60	131-0382-00			2	CONNECTOR, stand off
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-61	210-0586-00			1	NUT, keps, 4-40 x $\frac{1}{4}$ inch
-62	131-0682-02			19	TERMINAL, feed-thru, 0.82 inch long

FIGURE 3 HIGH VOLTAGE POWER (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-63	124-0095-00			1	STRIP, ceramic, $^7/_{16}$ inch h, w/9 notches
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0007-00			2	SPACER, plastic, 0.188 inch long
-64	210-0201-00			2	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: (not included w/lug)
-65	213-0044-00			1	SCREW, thread forming, 5-32 x $^3/_{16}$ inch, PHS
-66	343-0088-00			2	CLAMP, cable, plastic, small
	343-0213-00			1	CLAMP, cable, plastic, medium
-67	214-1138-00			4	HEATSINK
-68	352-0062-00			4	HOLDER, heatsink
-69	211-0008-00			8	SCREW, 4-40 x $^1/_4$ inch, PHS
-70	211-0012-00			8	SCREW, 4-40 x $^3/_8$ inch, PHS
-71	210-0406-00			16	NUT, hex., 4-40 x $^3/_{16}$ inch
-72	343-0097-00			4	CLAMP
	210-0627-00			4	RIVET, (not shown)
-73	214-0368-00			4	SPRING, helical compression
-74	210-0599-00			8	NUT, sleeve
-75	441-0878-00			1	CHASSIS, horizontal output
-76	670-0629-00			1	ASSEMBLY, circuit board—HORIZONTAL OUTPUT
	- - - - - -			-	assembly includes:
	388-1160-00			1	BOARD, circuit
-77	136-0183-00			2	SOCKET, transistor, 3 pin
-78	136-0220-00			9	SOCKET, transistor, 3 pin, square
-79	136-0263-03			9	SOCKET, terminal pin
-80	214-0579-00			6	PIN, test point
-81	344-0119-00			6	CLIP
-82	211-0155-00			3	SCREW, 4-40 x 0.375 inch, PHS
-83	361-0238-00			3	SPACER, sleeve
-84	210-0457-00			3	NUT, keps, 6-32 x $^5/_{16}$ inch
-85	211-0510-00			5	SCREW, 6-32 x $^1/_4$ inch, PHS
-86	124-0162-00			4	STRIP, ceramic, $^7/_{16}$ inch h, w/4 notches
	- - - - - -			-	each strip includes:
	355-0046-00			1	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0007-00			1	SPACER, plastic, 0.188 inch long
-87	124-0093-00			1	STRIP, ceramic, $^7/_{16}$ inch h, w/5 notches
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0007-00			2	SPACER, plastic, 0.188 inch long

FIGURE 4 REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
4-1	426-0443-01			1	FRAME, cabinet, rear
	- - - - - -			-	frame includes:
-2	354-0345-00			1	RING, ornamental
-3	386-1620-00			1	SUPPORT, transformer
	- - - - - -			-	mounting hardware: (not included w/support)
	212-0011-00			4	SCREW, 8-32 x 0.750 inch, 100° csk, FHS
	210-0458-00			4	NUT, hex., keps, 8-32 x 0.344 inch
-4	210-0206-00			6	LUG, solder, SE #10
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	212-0518-00			1	SCREW, 10-32 x 0.312 inch, PHS
-5	386-1548-00			1	SUPPORT, chassis
	- - - - - -			-	mounting hardware: (not included w/support)
-6	211-0538-00			2	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-7	200-0938-00			1	COVER, frame rear
-8	105-0151-00			8	CATCH, panel
	- - - - - -			-	mounting hardware for each: (not included w/catch)
-9	343-0248-00			1	RETAINER, panel catch
-10	213-0088-00			1	SCREW, thread forming, #4 x 0.250
-11	- - - - - -			1	LINE FILTER
	- - - - - -			-	mounting hardware: (not included w/line filter)
	210-0006-00			1	WASHER, lock, internal, #6 (not shown)
	210-0202-00			1	LUG, solder, SE #6 (not shown)
-12	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-13	386-1529-00			1	SUBPANEL, rear
-14	204-0279-00			1	BODY, line voltage selector
	- - - - - -			-	mounting hardware: (not included w/body)
-15	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-16	200-0764-00			1	COVER, line voltage selector
	- - - - - -			-	cover includes:
-17	352-0102-00			2	HOLDER, fuse, plastic
	- - - - - -			-	mounting hardware for each: (not included w/holder)
-18	213-0088-00			2	SCREW, thread forming, #4 x 1/4 inch, PHS
-19	386-1607-00			1	PLATE, component mounting
	- - - - - -			-	mounting hardware: (not included w/plate)
-20	211-0038-00			4	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
-21	131-0771-00			2	CONNECTOR, receptacle, 4 contact, w/hardware
-22	131-0106-01			2	CONNECTOR, coaxial, 1 contact, BNC, w/hardware
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-23	210-0255-00			1	LUG, solder
-24	131-0761-00			6	TERMINAL POST
-25	136-0089-00			1	SOCKET, 9 pin, female
	- - - - - -			-	mounting hardware: (not included w/socket)
-26	211-0008-00			4	SCREW, 4-40 x 0.250 inch, PHS
-27	210-0586-00			4	NUT, keps, 4-40 x 1/4 inch

FIGURE 4 REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
4-28	200-0991-00			1	COVER, connector, BNC, shorting
-29	200-0678-00			1	COVER, connector, BNC, non-shorting
-30	346-0045-00			2	STRAP, connector cover
-31	352-0172-00			2	HOLDER, power cable
	- - - - - -			-	mounting hardware for each: (not included w/holder)
-32	211-0008-00			2	SCREW, 4-40 x $^1/_4$ inch, PHS
-33	211-0514-00			2	SCREW, 6-32 x $^3/_4$ inch, PHS
-34	210-0457-00			2	NUT, keps, 6-32 x $^5/_{16}$ inch
-35	386-1530-00			1	PANEL, rear, lower
	- - - - - -			-	mounting hardware: (not included w/panel)
	212-0008-00			1	SCREW, 8-32 x 0.500 inch, PHS
-36	386-1568-00			1	PANEL, rear, upper
	- - - - - -			-	mounting hardware: (not included w/panel)
	212-0008-00			2	SCREW, 8-32 x 0.500 inch, PHS
-38	129-0089-00			6	POST, hex., 0.250 x 0.830 inch long
-39	161-0033-03			1	CABLE ASSEMBLY, power
-40	214-1193-00			1	HEAT SINK
	- - - - - -			-	mounting hardware: (not included w/heat sink)
-41	211-0507-00			6	SCREW, 6-32 x $^5/_{16}$ inch, PHS
-42	136-0135-00			6	SOCKET, transistor, 2 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-43	211-0159-00			2	SCREW, 2-56 x $^3/_8$ inch, PHS
	210-0001-00			2	WASHER, lock, external #2
-44	210-0405-00			2	NUT, hex., 2-56 x $^3/_{16}$ inch
-45	- - - - - -			6	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
-46	211-0511-00			2	SCREW, 6-32 x $^1/_2$ inch, PHS
-47	386-0978-00			1	PLATE, insulator, plastic
-48	361-0076-00			4	SPACER, hex., $^1/_4$ x 0.650 inch long
-49	200-1046-00			2	COVER, transistor
	- - - - - -			-	mounting hardware: (not included w/cover)
-50	211-0538-00			2	SCREW, 6-32 x $^5/_{16}$ inch, 100° csk, FHS
-51	358-0372-00			1	BUSHING, strain relief, bottom
-52	200-1004-00			1	CABLE NIPPLE
-53	358-0371-00			1	BUSHING, strain relief, top
-54	348-0056-00			2	GROMMET, plastic, $^3/_8$ inch diameter
-55	214-0776-00			1	GASKET, line voltage selector
-56	- - - - - -			1	TRANSFORMER
	- - - - - -			-	transformer includes:
-57	351-0196-00			1	SLIDE, right
-58	351-0197-00			1	SLIDE, left
	- - - - - -			-	mounting hardware: (not included w/transformer)
-59	210-0813-00			4	WASHER, fiber, shouldered, #10
-60	210-0805-00			4	WASHER, flat, 0.204 ID x 0.438 inch OD
-61	220-0410-00			4	NUT, keps, 10-32 x $^3/_8$ inch
	212-0592-00			2	SCREW, 10-32 x 6.375 inch, FilHS (not shown)

FIGURE 4 REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
4-62	337-1201-00			1	SHIELD
-63	348-0063-00			1	GROMMET, plastic, 1/2 inch diameter
-64	- - - - - -			4	DIODE
	- - - - - -			-	mounting hardware for each: (not included w/diode)
-65	210-0224-00			1	LUG, solder, #10
-66	210-0909-00			1	WASHER, plastic insulator
	210-0813-00			1	WASHER, fiber, shouldered #10
-67	210-0805-00			1	WASHER, flat, 0.204 ID x 0.438 inch OD
-68	220-0410-00			1	NUT, keps, 10-32 x 3/8 inch
-69	- - - - - -			1	THERMAL CUTOUT
	- - - - - -			-	mounting hardware: (not included w/thermal cutout)
-70	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-71	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
-72	343-0252-00			1	CLAMP, loop
-73	212-0008-00			1	SCREW, 8-32 x 0.500 inch, PHS
	211-0510-00			2	SCREW, 6-32 x 0.500 inch, PHS
-74	211-0516-00			2	SCREW, 6-32 x 7/8 inch, PHS
-75	385-0024-00			2	ROD, 1/4 x 1 3/8 inches long
-76	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
-77	212-0095-00			2	SCREW, 8-32 x 3 1/2 inches, PHS
-78	343-0214-00			1	RETAINER
-79	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-80	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-81	- - - - - -			2	DIODE BRIDGE
	- - - - - -			-	mounting hardware for each: (not included w/diode bridge)
-82	211-0012-00			1	SCREW, 4-40 x 0.375 inch, PHS
-83	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-84	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches FilHS
-85	210-0008-00			1	WASHER, lock, internal, #8
-86	210-0309-00			1	WASHER, centering
-87	210-0462-00			1	NUT, hex., 8-32 x 1/2 inch
-88	212-0004-00			1	SCREW, 8-32 x 5/16 inch, PHS
-89	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-90	211-0544-00			1	SCREW, 6-32 x 3/4 inch THS
-91	210-0478-00			1	NUT, hex., 5/16 x 21/32 inch long
-92	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS

FIGURE 4 REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
4-93	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
-94	211-0588-00			2	SCREW, 6-32 x 0.750 inch, 100° csk, FHS
-95	386-0254-00			1	PLATE, fiber, large
-96	432-0048-00			1	BASE, large
-97	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
-98	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
-99	211-0588-00			2	SCREW, 6-32 x 0.750 inch, 100° csk, FHS
-100	386-0252-00			1	PLATE, fiber, small
-101	432-0047-00			1	BASE, small
-012	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
-103	200-0258-00			2	COVER, capacitor, plastic, 1.365 ID x $3\frac{1}{32}$ inches long
-104	200-0255-00			2	COVER, capacitor, plastic, 1 ID x $3\frac{1}{32}$ inches long
-105	441-0354-00			1	CHASSIS low voltage power
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0023-00			4	SCREW, 8-32 x 0.375 inch, PHS
-106	348-0056-00			1	GROMMET, plastic, $\frac{3}{8}$ inch diameter
-107	670-0634-00			1	ASSEMBLY, circuit board—RECTIFIER
	- - - - - -			-	assembly includes:
	388-1165-00			1	BOARD, circuit
-108	131-0784-00			10	TERMINAL PIN, 0.80 inch long
-109	131-0589-00			14	TERMINAL PIN, 0.50 inch long
	- - - - - -			-	mounting hardware: (not included w/assembly)
-110	211-0116-00			2	SCREW, sems, 4-40 x $\frac{5}{16}$ inch, PHB
-111	179-1433-00			1	WIRING HARNESS, power
-112	179-1436-00			1	WIRING HARNESS, line voltage

FIGURE 5 CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
5-1	390-0086-00			2	CABINET SIDE
	- - - - - -			-	each cabinet side includes:
	214-0812-00			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
	- - - - - -			-	cabinet bottom includes:
	214-0812-00			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
	- - - - - -			-	mounting hardware: (not included w/frame section)
	212-0040-00			4	SCREW, 8-32 x 3/8 inch, 100° csk, FHS (not shown)
-17	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
-18	426-0485-00			1	FRAME SECTION, cabinet, lower left
	- - - - - -			-	mounting hardware: (not included w/frame section)
	211-0507-00			1	SCREW, 6-32 x 0.312 inch, PHS
	212-0070-00			4	SCREW, 8-32 x 3/8 inch, 100° csk, FHS (not shown)
-19	426-0486-00			1	FRAME SECTION, cabinet, lower right
	- - - - - -			-	mounting hardware: (not included w/frame section)
	211-0507-00			1	SCREW, 6-32 x 0.312 inch, PHS
	212-0070-00			4	SCREW, 8-32 x 0.312 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 5/8 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 5/8 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, FilHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 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

MAIN INTERFACE Circuit Board Assembly

CHANGE:

R14	315-0242-00	2.4 kΩ	1/4 W		5%

VERT. OUTPUT Circuit Board Assembly

CHANGE:

R439	317-0133-00	13 kΩ	1/8 W		5%

HORIZONTAL Circuit Board Assembly

ADD:

R578	315-0682-00	6.8 kΩ	1/4 W		5%

CHANGE:

C563	283-0003-00	0.01 μF		150 V	
C573	283-0003-00	0.01 μF		150 V	
C581	281-0123-00	5-25 pF, Var			

HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly

CHANGE:

R736	301-0151-00	150 Ω	1/2 W		5%

ADD:

C752	290-0135-00	15 μF	Elect.	20 V	
R752	315-0152-00	1.5 kΩ	1/4 W		5%

LOW VOLTAGE REGULATOR Circuit Board Assembly

CHANGE:

C874	283-0192-00	0.47 μF			

C1/1169

READOUT Circuit Board Assembly

DELETE:

CR1260	152-0185-00	Silicon		Replaceable by 1N4152
CR1261	152-0185-00	Silicon		Replaceable by 1N4152
CR1262	152-0185-00	Silicon		Replaceable by 1N4152

CHANGE:

R1214	317-0393-00	39 kΩ	1/8 W	5%

ADD:

VR1261	152-0405-00	Zener	1 W, 15 V, 5%	Tek Spec
VR1262	152-0405-00	Zener	1 W, 15 V, 5%	Tek Spec
R1260	317-0012-00	1 kΩ	1/8 W	5%

HORIZONTAL Circuit Board Assembly

CHANGE:

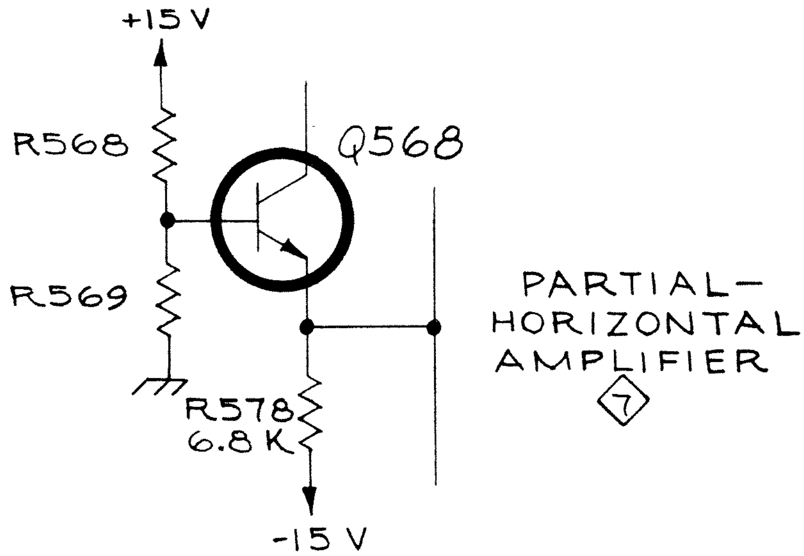
DS1031	150-0057-01	Incandescent
DS1032	150-0057-01	Incandescent
DS1033	150-0057-01	Incandescent
DS1034	150-0057-01	Incandescent

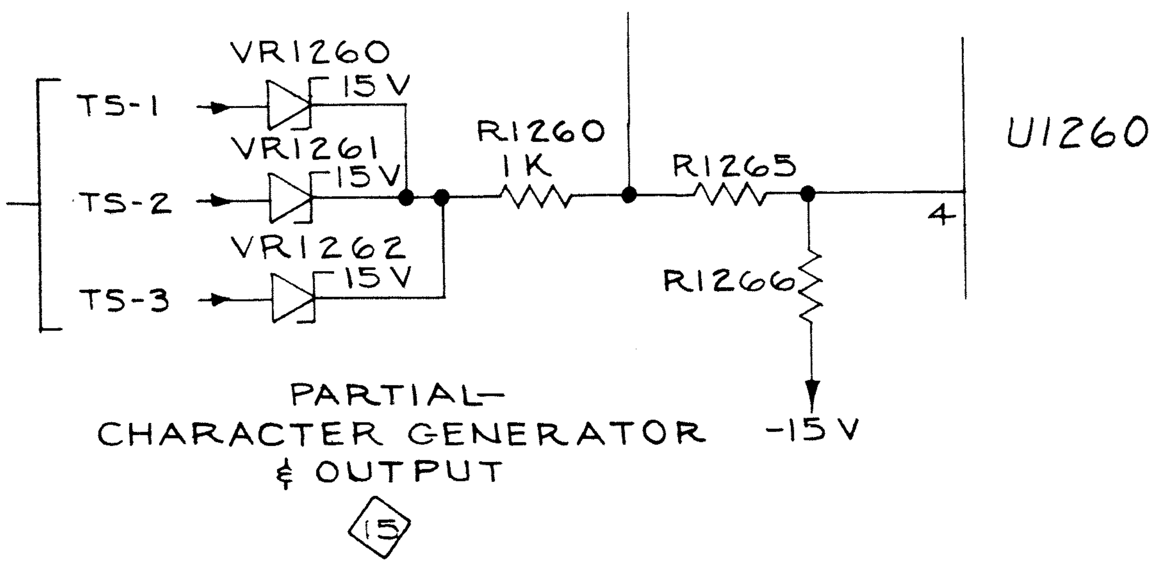
VERT. MODE Circuit Board Assembly

CHANGE:

DS1021	150-0057-01	Incandescent
DS1025	150-0057-01	Incandescent
DS1027	150-0057-01	Incandescent
DS1029	150-0057-01	Incandescent

SCHEMATIC CORRECTIONS





ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

HIGH VOLTAGE - Z AXIS Circuit Board Assembly

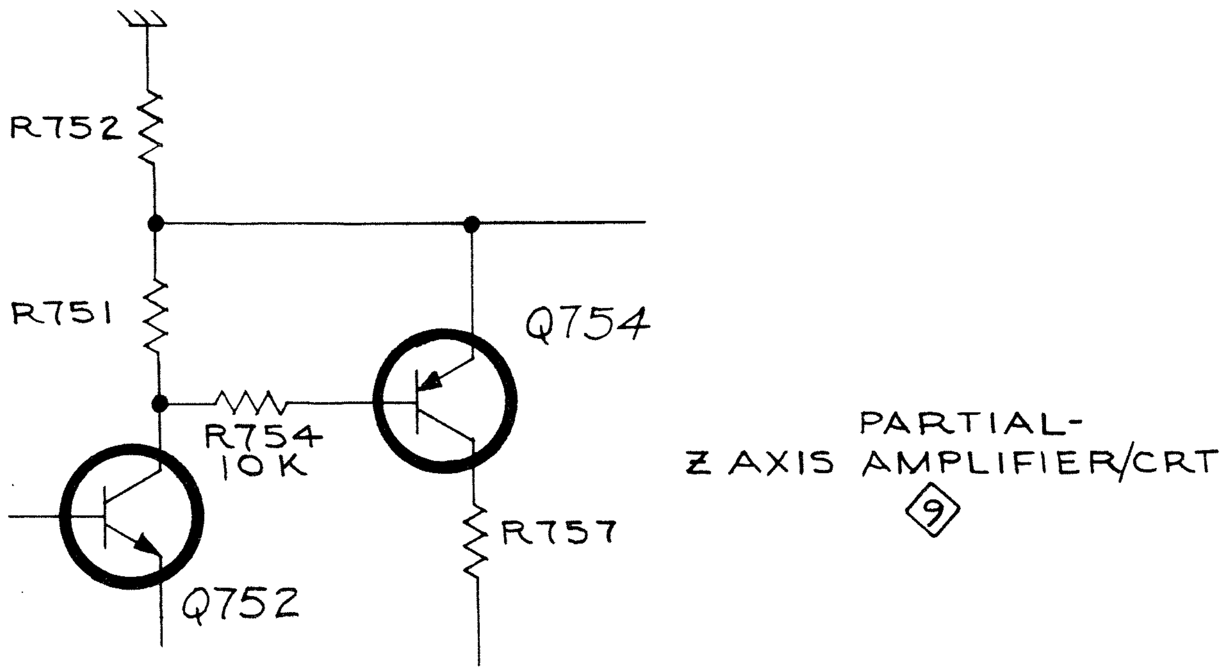
ADD:

R754	315-0103-00	10 kΩ	1/4 W	5%

CHASSIS (Low Voltage Rectifier)

CHANGE TO:

R807	315-0561-00	560 Ω	1/4 W	5%



ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHASSIS

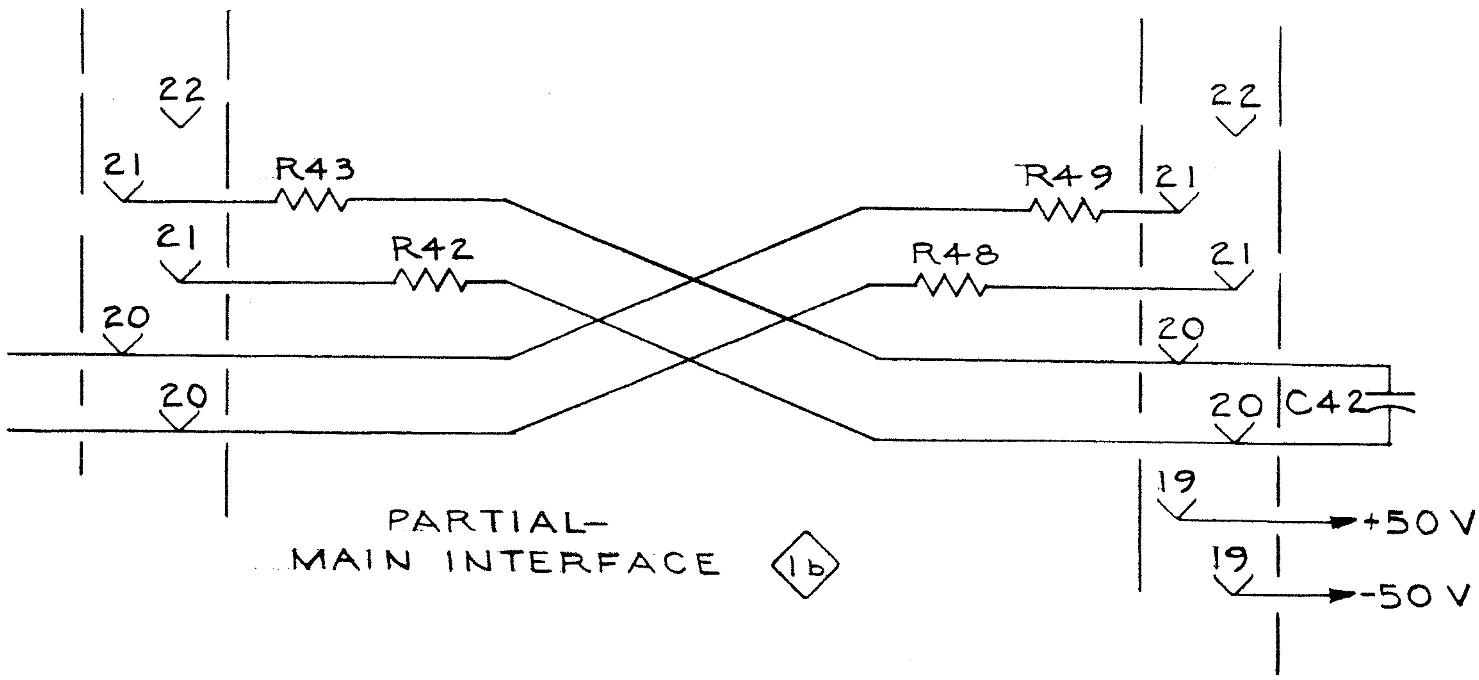
CHANGE TO:

C785	283-0037-00	500 pF	Cer	30,000 V
Q886	151-0140-00	Silicon	Selected from 2N3055	

HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly

CHANGE TO:

Q704	151-0216-00	Silicon	Replaceable by MPS 6523
Q714	151-0192-00	Silicon	Replaceable by MPS 6521



C3/1269

TEXT CORRECTION

Section 4 Maintenance

Page 4-3

REPLACE: the third sentence of the first full paragraph with the one below:

> Each minor division on the elapsed-time meter used in this instrument indicates 200 hours of operation.

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

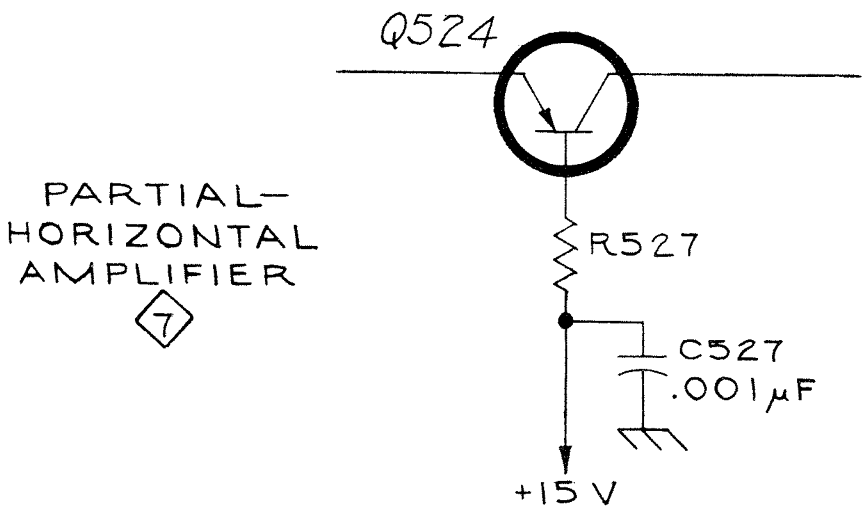
HORIZONTAL Circuit Board Assembly

CHANGE TO:

R502	321-0108-00	130 Ω	1/8 W	Prec	1%
R503	321-0128-00	210 Ω	1/8 W	Prec	1%
R523	323-0293-00	11 kΩ	1/2 W	Prec	1%
R533	323-0293-00	11 kΩ	1/2 W	Prec	1%

ADD:

C527	283-0065-00	0.001 μF	Cer	100 V	5%



TEXT CORRECTION

Section 5 Performance Check/Calibration

Page 5-24 Step 39

REPLACE: part i with the following:

i. Set the Type 7B50 Time/Div switch to .5 ms.

ADD: the following parts after part i.

j. CHECK--Readout display for completeness of characters.

k. ADJUST--Full Character Scan adjustment R1219 for complete but not overdisplayed characters.

l. INTERACTION--Check step 15 and step 37g.

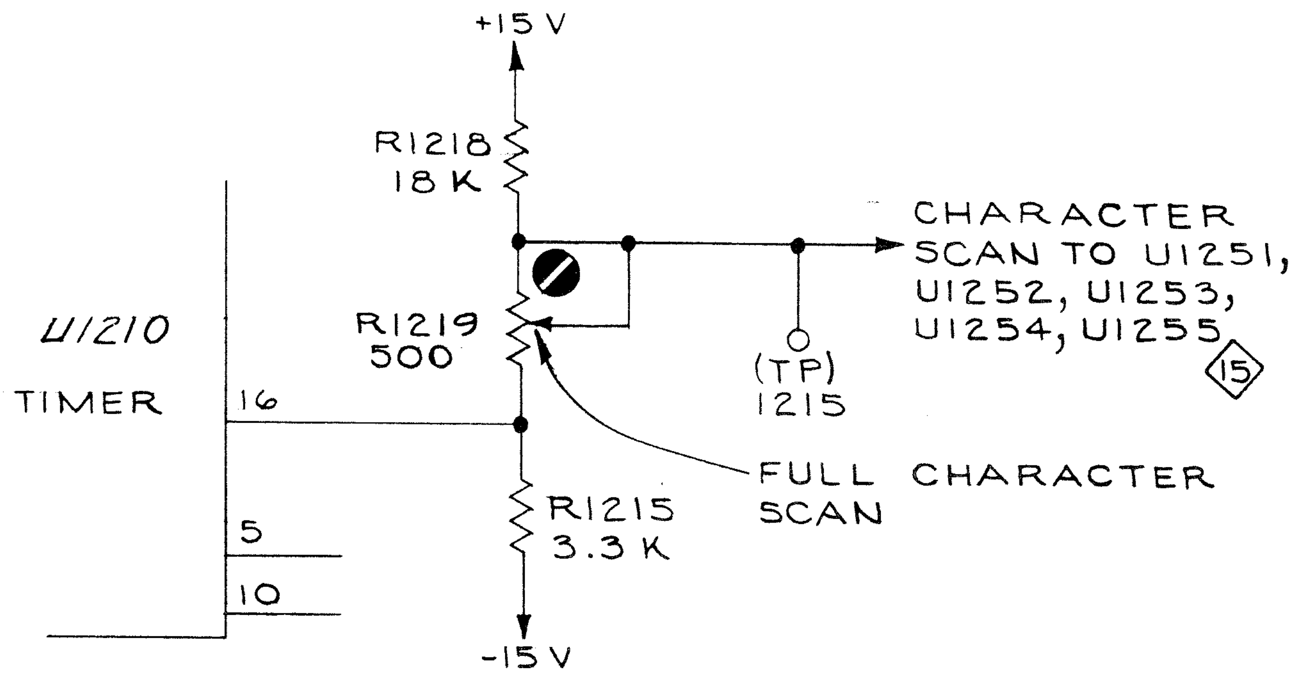
ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE TO:

R1215	317-0332-00	3.3 kΩ	1/8 W	5%

ADD:

R1218	317-0183-00	18 kΩ	1/8 W	5%
R1219	311-0634-00	500 Ω, Var		



PARTIAL—
SEQUENCING LOGIC 13

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

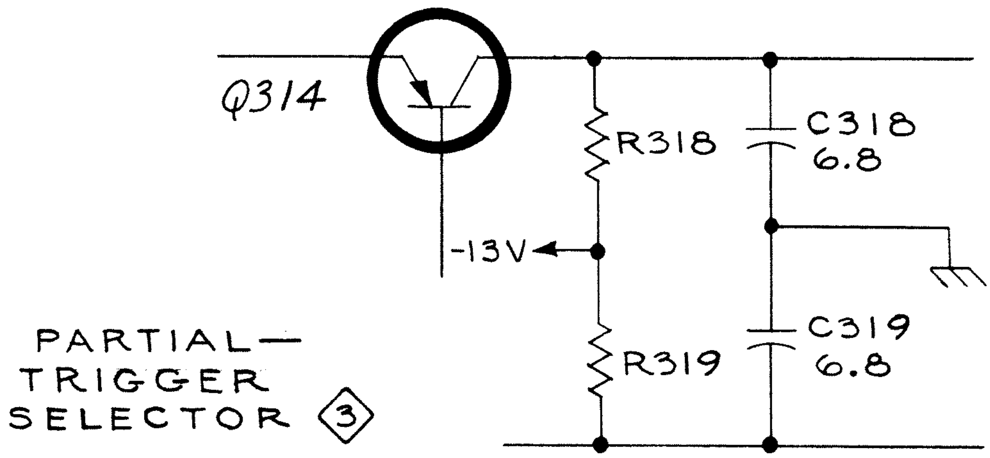
TRIG. SEL. Circuit Board Assembly

CHANGE TO:

C319	281-0616-00	6.8 pF	Cer	200 V

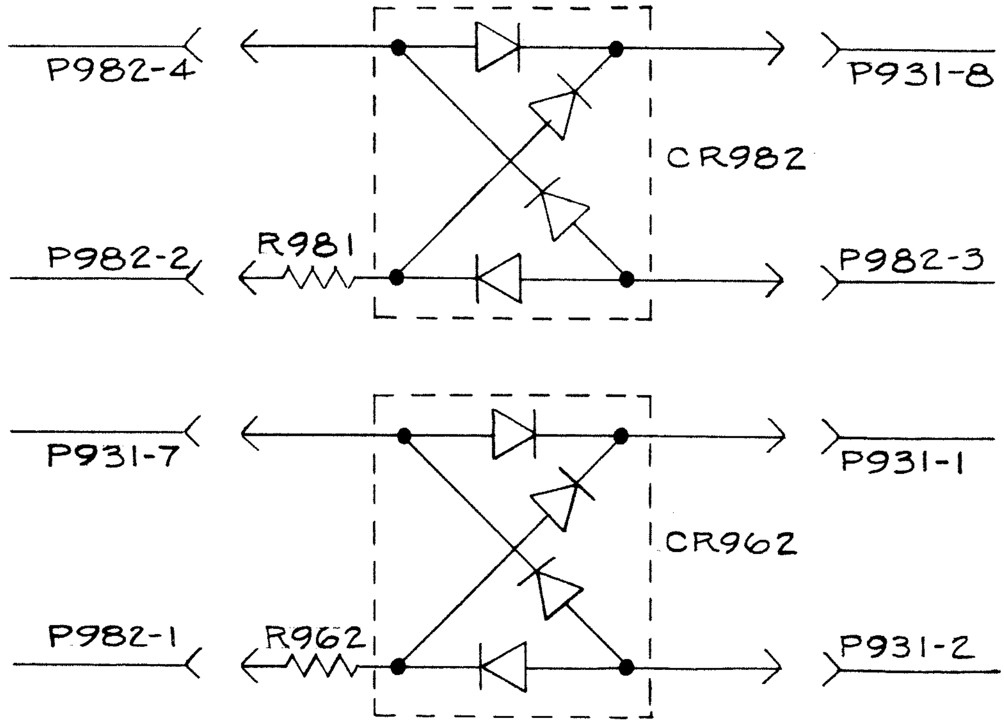
ADD:

C318	281-0616-00	6.8 pF	Cer	200 V



M16,177/270

SCHEMATIC CORRECTION



PARTIAL—
LOW-VOLTAGE RECTIFIERS ⟨10⟩

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

LOGIC Circuit Board Assembly

CHANGE TO:

R116	315-0562-00	5.6 kΩ	1/4 W	5%
R118	315-0752-00	7.5 kΩ	1/4 W	5%

M16,341/370

ELECTRICAL PARTS LIST CORRECTION

READOUT Circuit Board Assembly

CHANGE TO:

R1147	321-0299-00	12.7 kΩ	1/8 W	Prec	1%
R1148	321-0212-00	1.58 kΩ	1/8 W	Prec	1%

M16,397/470

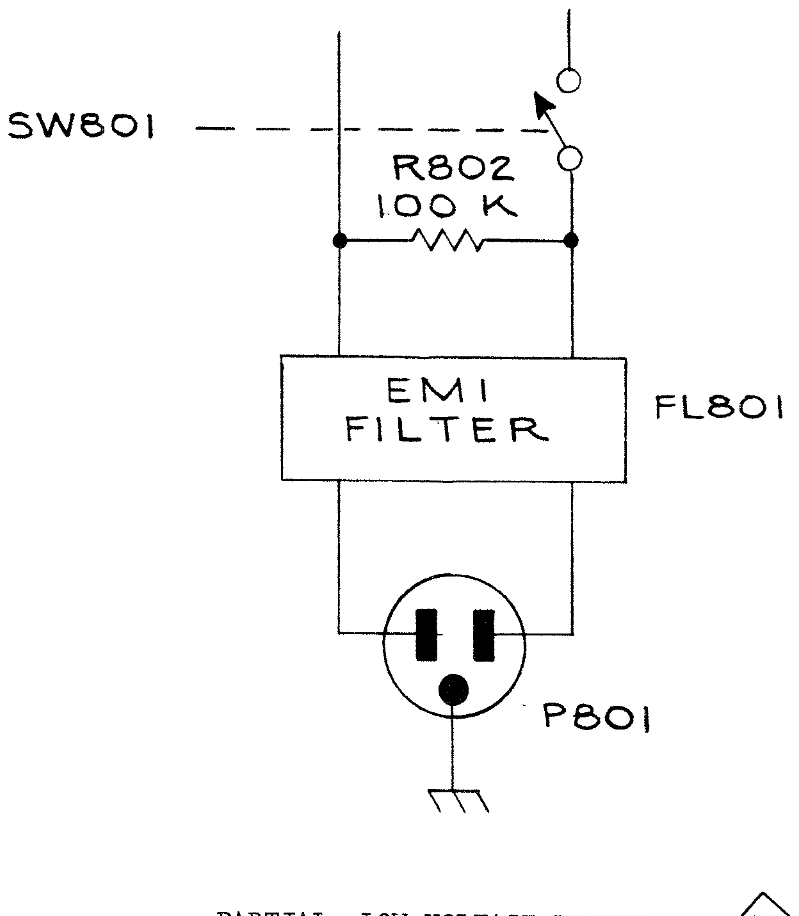
ELECTRICAL PARTS LIST CORRECTION

CHASSIS

ADD:

R802	301-0104-00	100 kΩ	1/2 W	5%

SCHEMATIC CORRECTION



PARTIAL--LOW VOLTAGE RECTIFIER ⟨10⟩

M16,497/470

ELECTRICAL PARTS LIST CORRECTION

CHASSIS

CHANGE TO:

L762	108-0422-00	80 μH

READOUT Circuit Board Assembly

CHANGE TO:

L1270	108-0331-00	0.75 μH

S16,063/270

ELECTRICAL PARTS LIST CORRECTION

CHASSIS

CHANGE TO:

R740	307-0205-01	180 kΩ
R741		470 kΩ
R742		29.45 MΩ
R743		80 MΩ
R744		19 MΩ

S16,166/470

ELECTRICAL PARTS LIST CORRECTION

L. V. REGULATOR Circuit Board Assembly

CHANGE TO:

F872	159-0096-00	7 1/2 A	3 AG	Fast-Blo
F901	159-0015-00	3 A	3 AG	Fast-Blo

M16,075/570

ELECTRICAL PARTS LIST CORRECTION

L. V. REGULATOR Circuit Board Assembly

CHANGE TO:

F872	159-0096-00	7 1/2 A	3 AG	Fast-Blo
F901	159-0015-00	3 A	3 AG	Fast-Blo

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

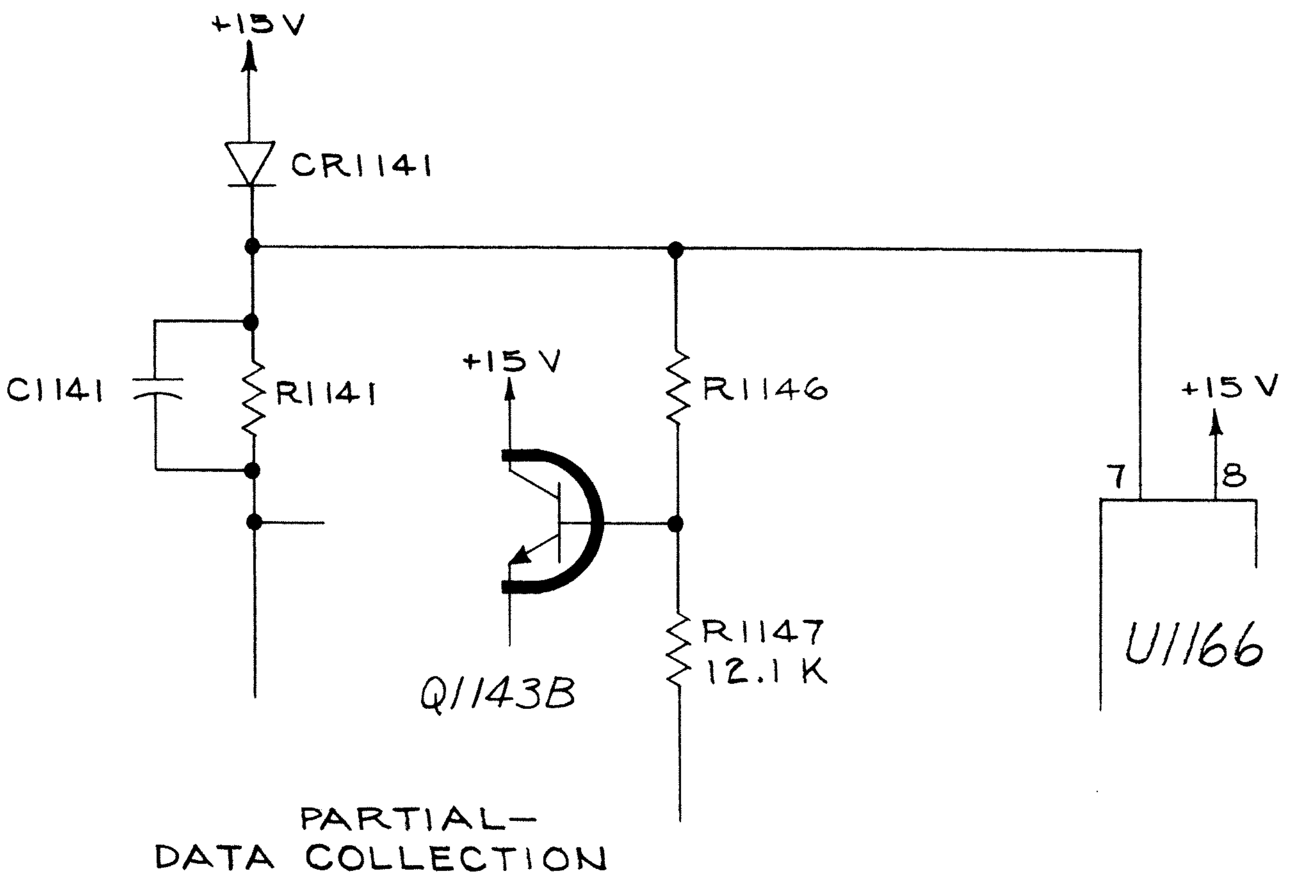
READOUT Circuit Board Assembly

CHANGE TO:

R1147	321-0297-00	12.1 kΩ	1/8 W	1%

ADD:

CR1141	152-0185-00	Silicon	Replaceable by 1N4152



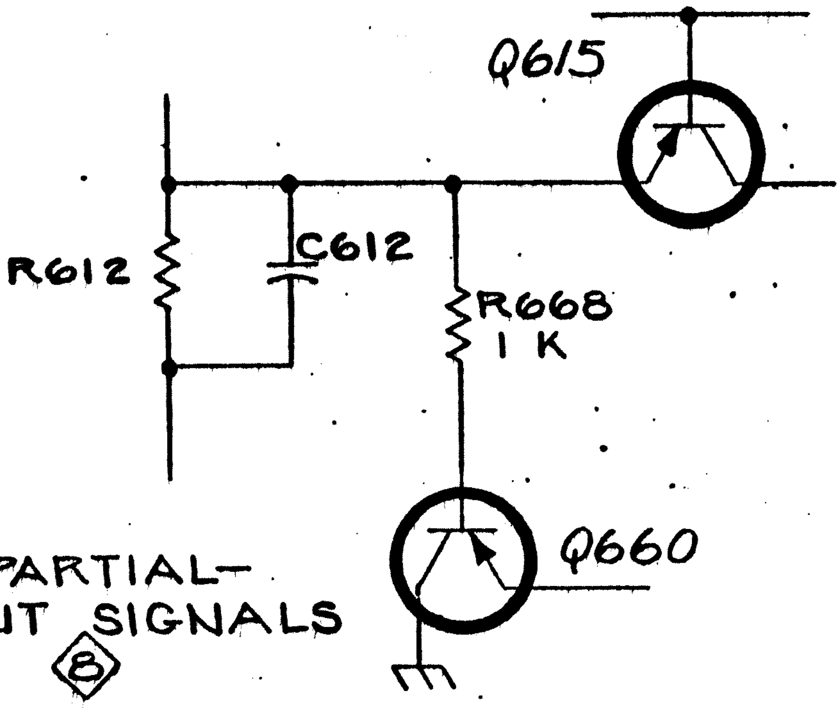
M16,673/670

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

OUTPUT SIGNAL Circuit Board Assembly

ADD:

R668	315-0102-00	1 kΩ	1/4 W	5%



PARTIAL-
OUTPUT SIGNALS
8

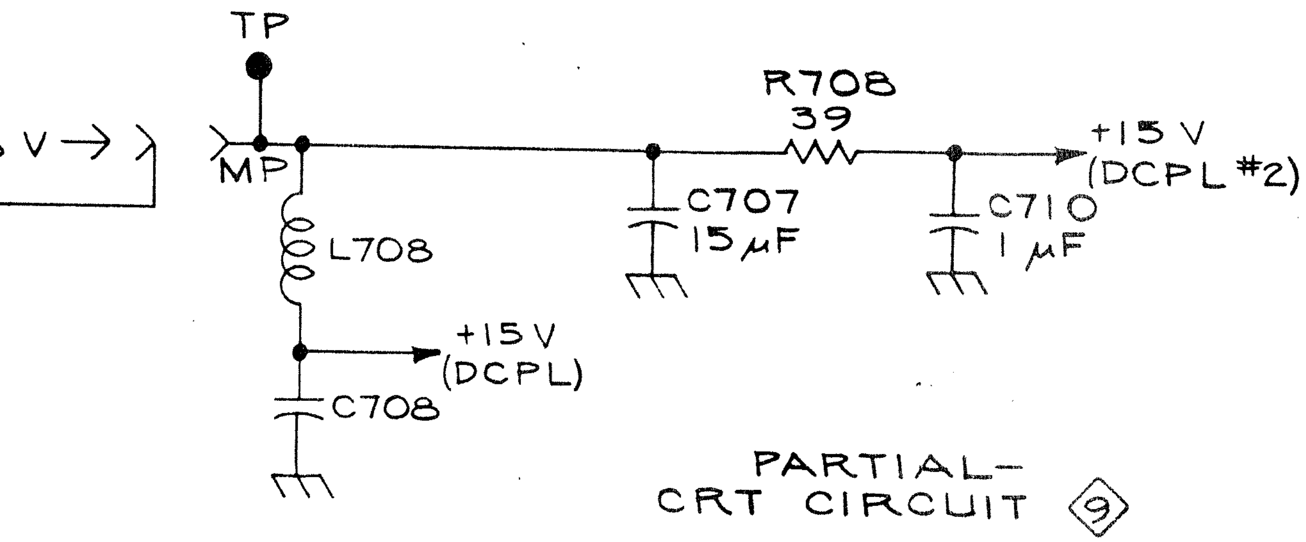
ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

HIGH VOLTAGE - Z AXIS AMP. Circuit Board Assembly

670-0631-02 Complete Board

ADD:

C707	290-0135-00	15 μF	EMT	20 V	
C710	283-0059-00	1 μF	Cer	25 V	
R708	317-0390-00	39 Ω	1/8 W		5%



ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

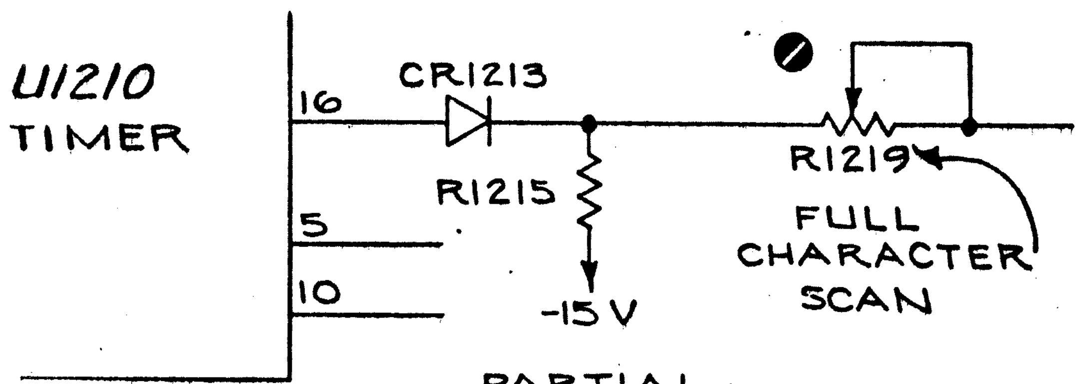
READOUT Circuit Board Assembly

CHANGE TO:

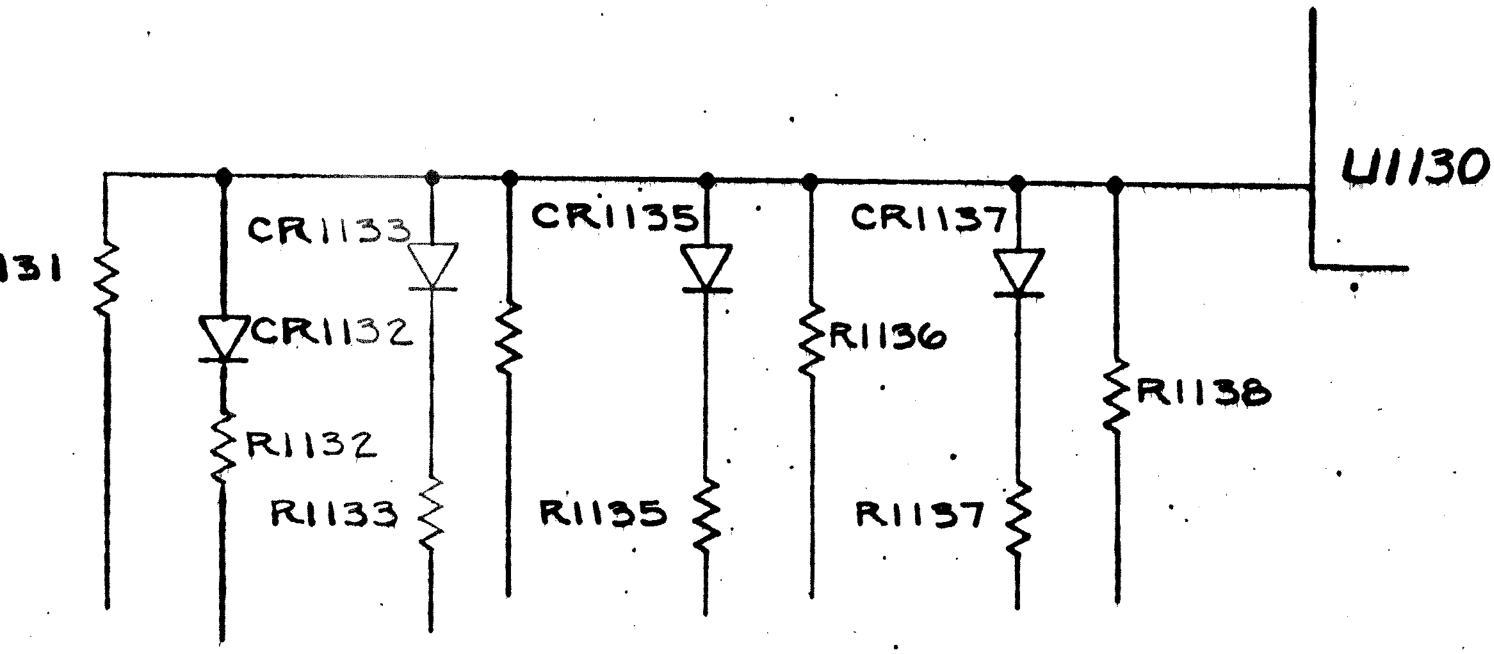
R1135	321-0308-00	15.8 kΩ	1/8 W	Prec	1%
R1137	321-0319-00	20.5 kΩ	1/8 W	Prec	1%
R1163	317-0243-00	24 kΩ	1/8 W		5%
R1180	321-0264-00	5.49 kΩ	1/8 W	Prec	1%
R1215	317-0302-00	3 kΩ	1/8 W		5%
R1219	311-0635-00	1 kΩ, Var			
R1266	317-0912-00	9.1 kΩ	1/8 W		5%

ADD:

CR1132	152-0185-00	Silicon	Replaceable by 1N4152
CR1133	152-0185-00	Silicon	Replaceable by 1N4152
CR1135	152-0185-00	Silicon	Replaceable by 1N4152
CR1137	152-0185-00	Silicon	Replaceable by 1N4152
CR1213	152-0185-00	Silicon	Replaceable by 1N4152



PARTIAL-SEQUENCING LOGIC ⟨10⟩



PARTIAL-DATA COLLECTION ⟨11⟩

TEXT CORRECTION

Section 2 Operating Instructions

Page 2-18, Readout

REPLACE: the last two sentences of first paragraph with the following:

The Readout Mode switch (located behind right side panel) determines the operating mode of the Readout System. When this switch is in the Free-Run Remote position, the Readout System operates in a free-running mode to randomly interrupt the waveform display to present characters. However, the waveform display is interrupted for only about 20 microseconds for each character that is displayed. The Readout System can also be remotely switched to the single-shot mode when in this position (see Remote Readout for further information). In the Gate Trig'd position, the Readout System is locked out so no characters are displayed during the sweep. At the end of the sweep, the Readout System is triggered and a complete frame of all applicable readout words are displayed. The single-shot trigger for the Readout System is produced from the sweep gate selected by the Gate switch (located on same board as Remote Readout switch) and is the same as the gate signal connected to the front-panel +GATE connector (time-base unit must be installed in selected horizontal compartment).

Page 2-18

ADD: the following, Remote Readout, preceding Vertical and Horizontal Mode Switch Logic:

Remote Readout

The operating mode of the Readout System can be remotely controlled through the rear-panel REMOTE CONTROL connector J1075. Requirements for remote readout operation are:

REMOTE READOUT LOCKOUT

Pin of J1075	E
Signal Required	Closure to ground (within 0.1 volt) from a positive level locks out Readout System
Maximum current required	Two milliamperes
Maximim open circuit voltage	+2 volts
Maximum input voltage	+5 volts, -1 volt (DC + peak AC)

REMOTE SINGLE-SHOT READOUT

Pin of J1075	F
Signal required	Closure to ground (within 0.4 volts) from a positive level with Pin E grounded allows Readout System to display one complete frame. Rate of change must be at least 0.1 volt/microsecond.
Maximum current required	Three milliamperes
Maximum open circuit voltage	+10 volts
Maximum input voltage	+10 volts, -5 volts (DC + peak AC)

Section 5

ADD: the following step 13A. preceding step 14.

13A. Adjust Auto Focus Operation

a. Set the 7B50 for a sweep rate of 0.05 microsecond/division.

b. Connect the test oscilloscope probe to TP794; connect the probe to chassis ground with a short ground strap.

c. Set the test oscilloscope for a vertical deflection factor of five volts/division (50 volts/division at probe tip) at a sweep rate of 0.5 microsecond/division. Set the triggering controls for a stable display triggered on the negative-going slope.

d. Establish the ground reference level on the test oscilloscope. Then, set the test oscilloscope for DC input coupling.

e. Change the following control settings:

B INTENSITY	Counterclockwise
READOUT	OFF

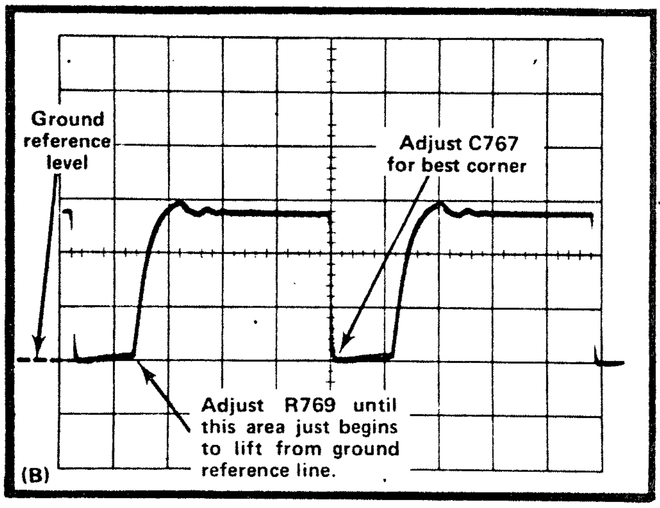
f. CHECK-DC level of trace +140 volts ±7 volts.

NOTE

This tolerance is provided as a guide to correct instrument operation and is not an instrument specification.

g. Set the B INTENSITY control fully clockwise.

h. ADJUST-Focus Gain adjustment R769 until the baseline of the waveform just begins to lift from the zero-volt level (see typical waveform).



i. Turn the B INTENSITY control counterclockwise until the baseline of the waveform raises about 0.5 division from the zero-volt level.

j. ADJUST-Focus Compensation adjustment C767 for best square corner on the negative portion of the displayed waveform. Rotate the B INTENSITY control between midrange and maximum; if necessary, compromise the adjustment of C767 for best square corner throughout the rotation of the B INTENSITY control.

k. Disconnect the test oscilloscope.

l. Set the 7B50 for a sweep rate of one millisecond/division.

m. Set the B INTENSITY control for low trace intensity.

n. Set the FOCUS control for the thinnest displayed trace.

o. Set the B INTENSITY control fully clockwise.

p. ADJUST-Focus Level adjustment R761 for the thinnest displayed trace.

q. Repeat parts m through p until no interaction is noted.

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHASSIS

CHANGE:

R740	R740A	307-0271-00	180 kΩ	Film		
R741	R740B	307-0271-00	470 kΩ	Film		
R742	R740C	307-0271-00	29.45 MΩ	Film		
R743	R740D	307-0271-00	80 MΩ	Film		
R744	R740E	307-0271-00	19 MΩ	Film		
ADD:	R740F	307-0271-00	30 MΩ	Film		
C798		283-0021-00	27 pF	Cer	200 V	
R784		301-0225-00	2.2 MΩ	1/2 W		5%
R788		301-0682-00	6.8 kΩ	1/2 W		5%

REMOVE:

L781	108-0553-00	47 µF		Fixed

MAIN INTERFACE Circuit Board Assembly

ADD:

R10	315-0101-00	100 Ω	1/4 W	5%

HIGH VOLTAGE - Z AXIS AMP Circuit Board Assembly

CHANGE TO:

	670-0631-01	Complete Board			
C749	283-0650-00	0.027 µF	PTM	100 V	
C750	283-0650-00	0.027 µF	PTM	100 V	
R750	315-0332-00	3.3 kΩ	1/4 W		5%

ADD:

C712	283-0010-00	0.05 µF	Cer	50 V
C733	283-0092-00	0.03 µF	Cer	200 V
C767	281-0095-00	0.2-1.5 pF, Var		

ADD (cont):

C774	283-0111-00	0.1 μF	Cer	50 V	
C776	283-0111-00	0.1 μF	Cer	50 V	
C778	281-0504-00	10 pF	Cer	500 V	
CR730	152-0333-00	Silicon	High Speed and Conductance		
VR749	152-0282-00	Silicon	Zener 1N972B 400 mW, 30 V, 5%		
CR770	152-0185-00	Silicon	Replaceable by 1N4152		
CR777	152-0185-00	Silicon	Replaceable by 1N4152		
CR794	152-0185-00	Silicon	Replaceable by 1N4152		
CR798	152-0107-00	Silicon	Replaceable by 1N647		
Q761	151-0280-00	Silicon	MM4003		
Q765	151-0280-00	Silicon	MM4003		
Q774	151-0223-00	Silicon	2N4275		
Q777	151-0274-00	Silicon	Selected from 2N3501		
Q794	151-0274-00	Silicon	Selected from 2N3501		
R712	315-0331-00	330 Ω	1/4 W		5%
R730	322-0385-00	100 kΩ	1/4 W	Prec	1%
R733	315-0181-00	180 Ω	1/4 W		5%
R755	321-0349-00	42.2 kΩ	1/8 W	Prec	1%
R760	315-0624-00	620 kΩ	1/4 W		5%
R761	311-0698-00	1 MΩ, Var			
R765	315-0625-00	6.2 MΩ	1/4 W		5%
R766	315-0625-00	6.2 MΩ	1/4 W		5%
R767	315-0272-00	2.7 kΩ	1/4 W		5%
R768	321-0335-00	30.1 kΩ	1/8 W	Prec	1%
R769	311-1035-00	50 kΩ, Var			
R772	322-0396-00	130 kΩ	1/4 W	Prec	1%
R773	321-0359-00	53.6 kΩ	1/8 W	Prec	1%
R774	315-0220-00	22 Ω	1/4 W		5%
R775	315-0332-00	3.3 kΩ	1/4 W		5%
R776	315-0101-00	100 Ω	1/4 W		5%
R777	315-0562-00	5.6 kΩ	1/4 W		5%
R778	305-0123-00	12 kΩ	2 W		5%
R794	301-0154-00	150 kΩ	1/2 W		5%
R798	301-0101-00	100 Ω	1/2 W		5%
TP794	214-0579-00	Test Point			

OUTPUT SIGNAL Circuit Board Assembly

CHANGE TO:

	670-0632-02	Complete Board			

ADD:

C660	281-0546-00	330 pF	Cer	500 V	
C661	283-0004-00	0.02 µF	Cer	150 V	
C666	283-0204-00	0.01 µF	Cer	50 V	
Q660	151-0221-00	Silicon	2N4258		
Q664	151-0223-00	Silicon	2N4275		
R660	315-0102-00	1 kΩ	1/4 W		5%
R661	315-0682-00	6.8 kΩ	1/4 W		5%
R662	315-0103-00	10 kΩ	1/4 W		5%
R663	315-0333-00	33 kΩ	1/4 W		5%
R664	315-0153-00	15 kΩ	1/4 W		5%
R665	315-0510-00	51 Ω	1/4 W		5%
R666	315-0221-00	220 Ω	1/4 W		5%
S664	260-0723-00	Raw Slide	DPDT		

READOUT Circuit Board Assembly

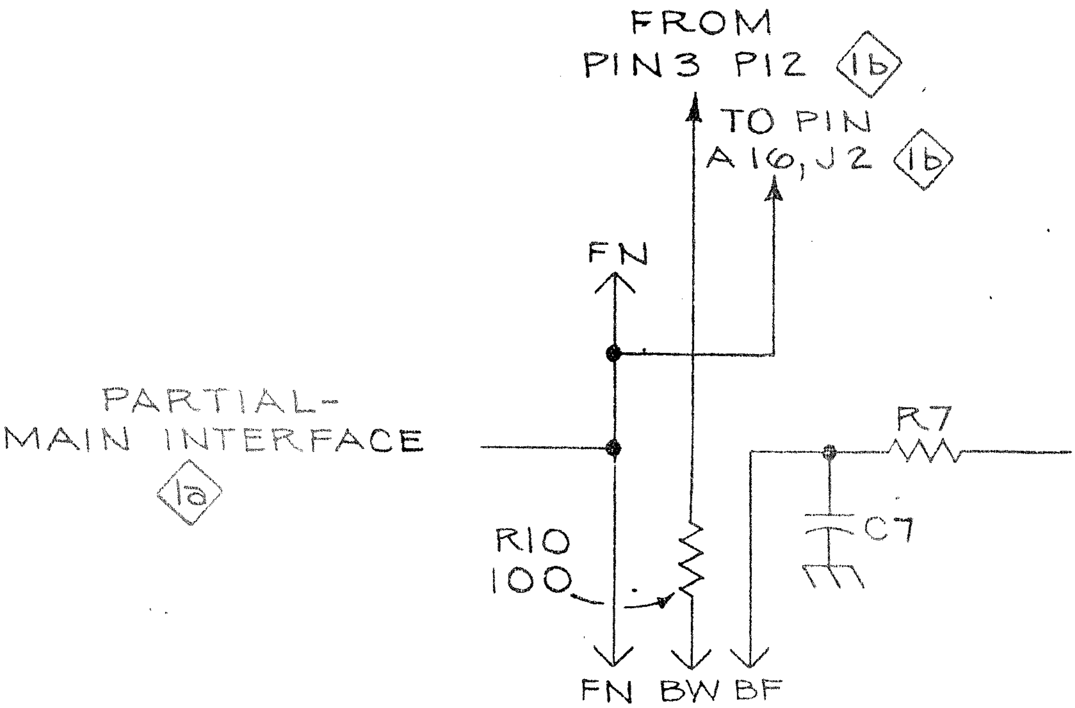
CHANGE TO:

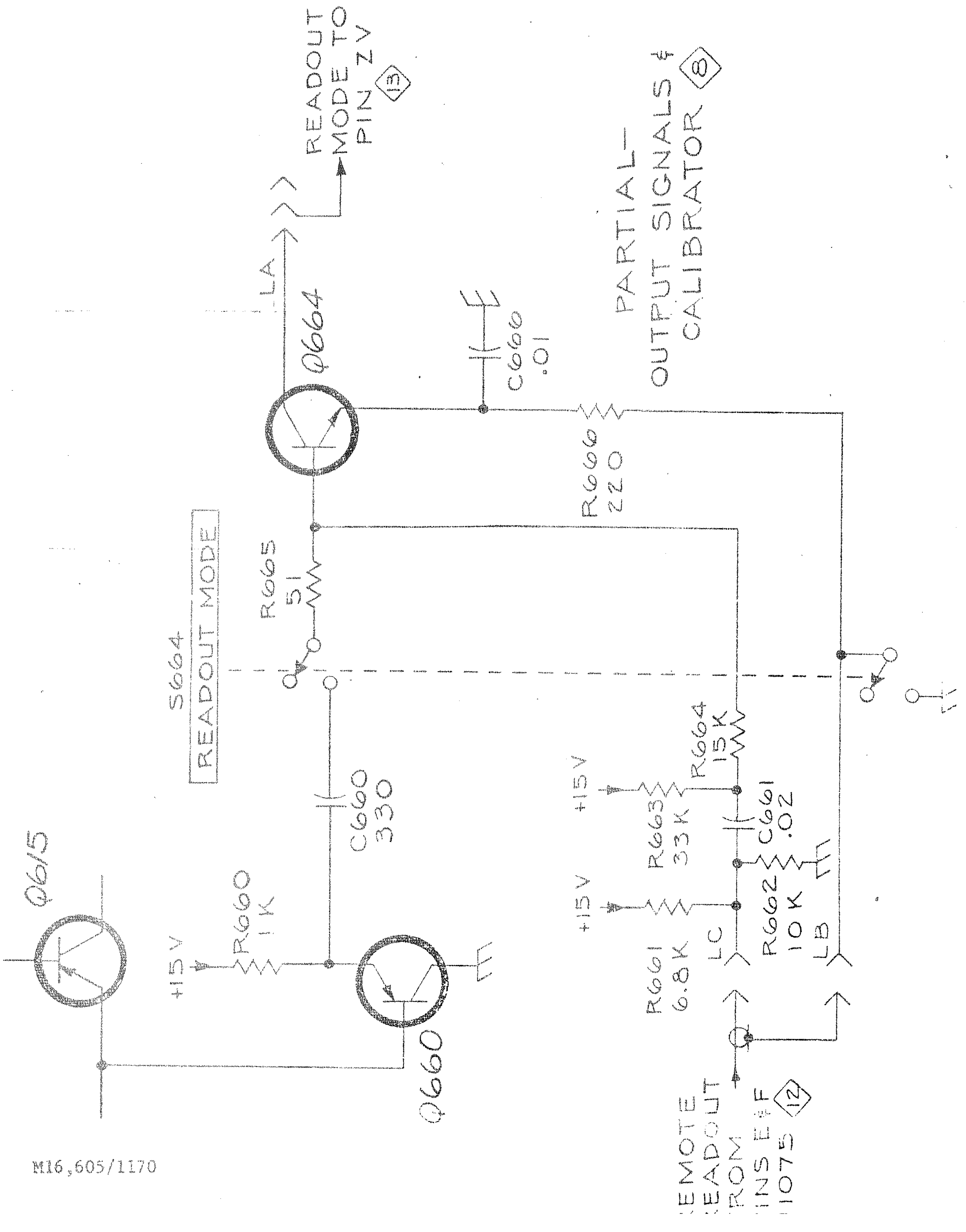
	670-0635-03	Complete Board			
R1155	317-0222-00	2.2 kΩ	1/8 W		5%
R1156	321-0268-00	6.04 kΩ	1/8 W	Prec	1%
R1255	321-0176-00	665 Ω	1/8 W	Prec	1%
R1256	321-0153-00	383 Ω	1/8 W	Prec	1%

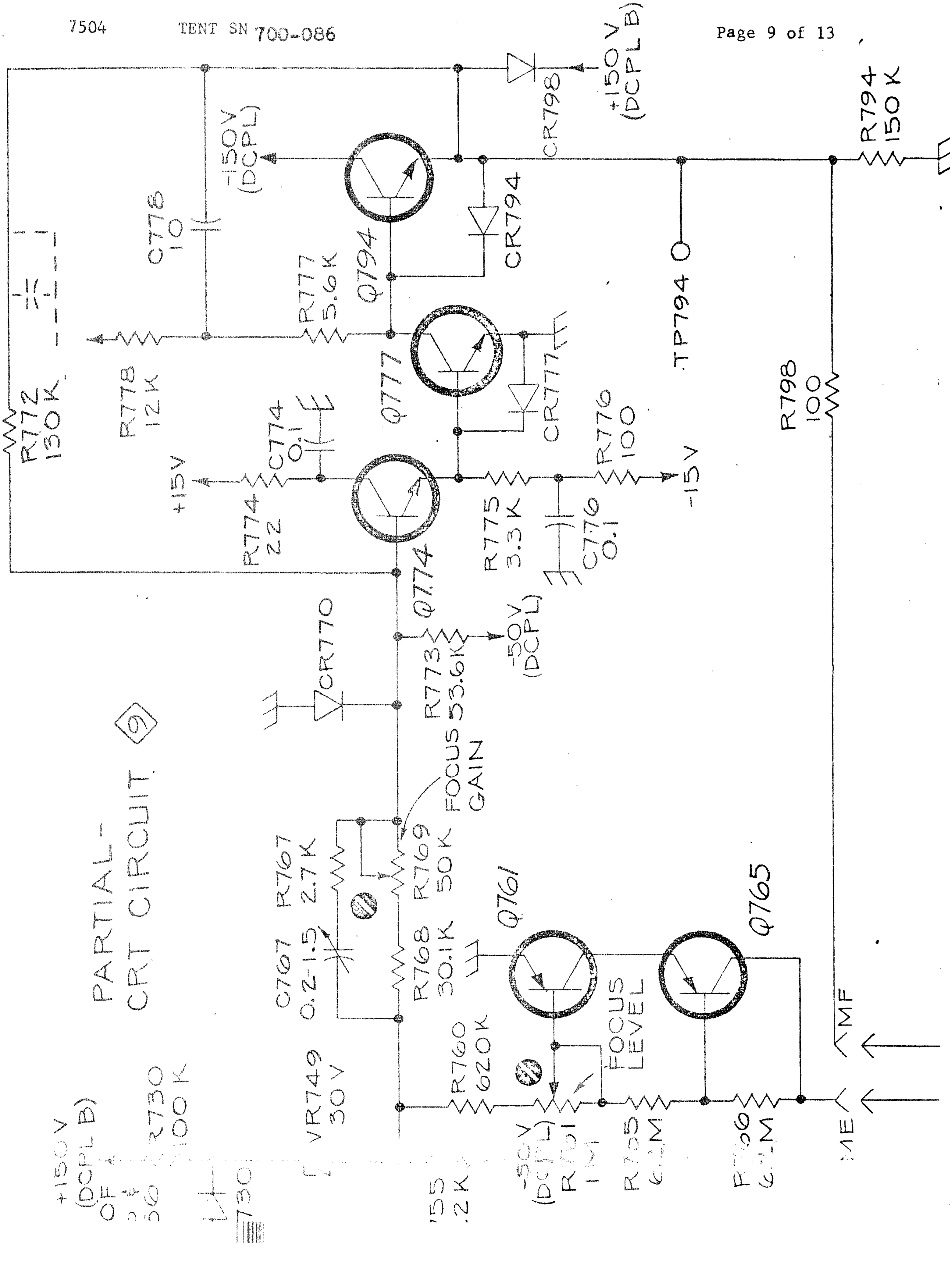
ADD:

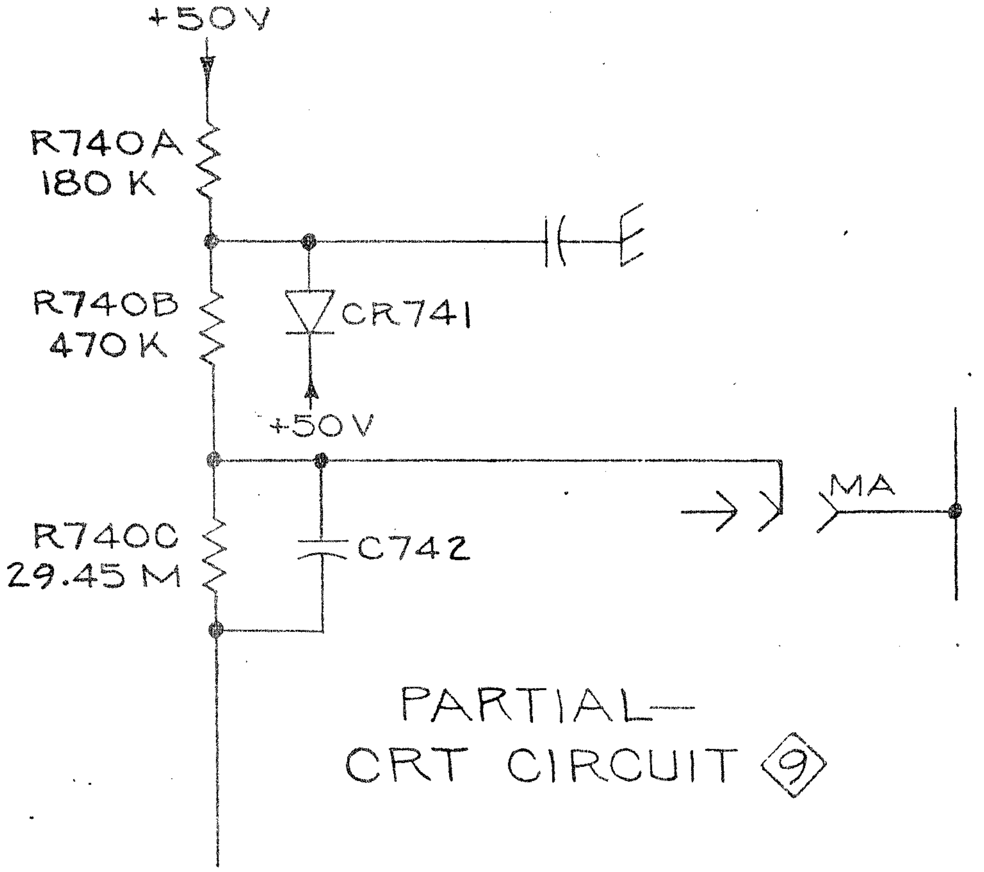
C1237	283-0000-00	0.001 µF	Cer	500 V	
R1235	317-0512-00	5.1 kΩ	1/8 W		5%
R1237	317-0222-00	2.2 kΩ	1/8 W		5%
U1236	156-0011-00	Medium Power Dual 2 Input Gate Replaceable by Fairchild µL914			

SCHEMATIC CORRECTIONS

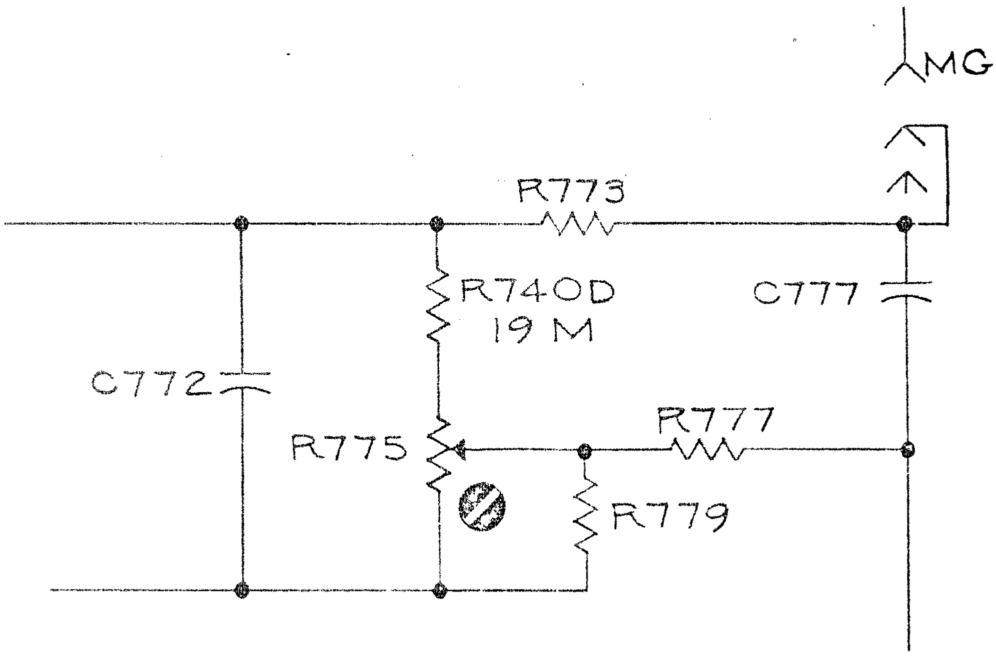


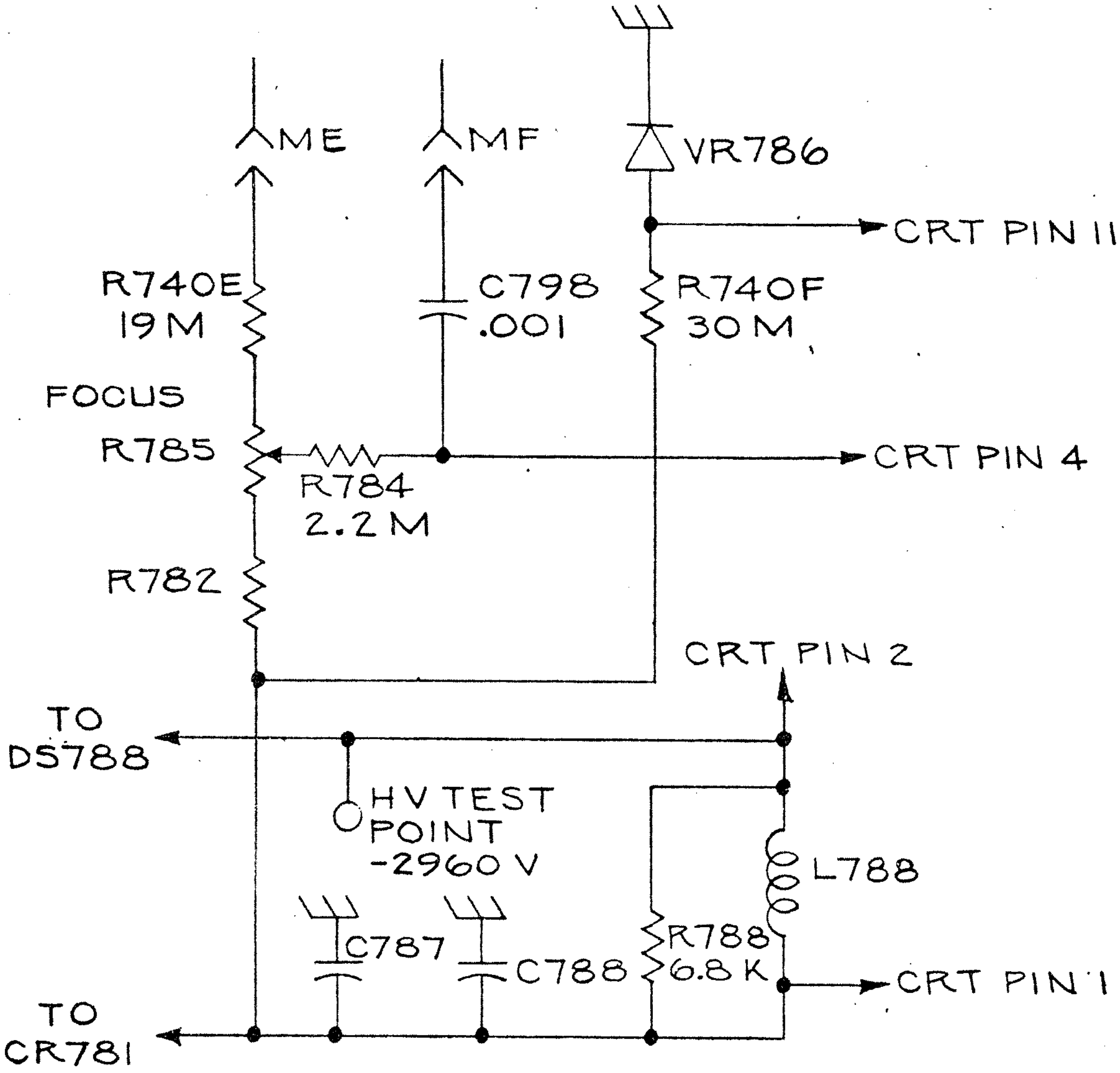

READOUT MODE TO PIN ZV 13
PARTIAL— OUTPUT SIGNALS & CALIBRATOR 8
LA
Q664
C666 .01
R666 220
R665 51
S664
READOUT MODE
C660 330
R664 15K
+15 V
R663 33K
C661 .02
R662 10K
+15 V
R661 6.8K
LC
LB
Q615
+15 V
R660 1K
Q660
REMOTE READOUT FROM PINS E&F J1075 12


PARTIAL-
CRT CIRCUIT 9
+150 V (DCPL B)
CR798
-150V (DCPL)
Q794
CR794
TP794
R794 150 K
C778 10
R777 5.6 K
R778 12 K
R772 130 K
Q777
CR777
R798 100
+15V
R774 22
C774 0.1
Q774
R775 3.3 K
C776 0.1
R776 100
-15V
CR770
R773 53.6K
-50V (DCPL)
FOCUS GAIN
R767 2.7 K
R769 50 K
C767 0.2-1.5
R768 30.1K
Q761
Q765
VR749 30 V
R760 620 K
FOCUS LEVEL
MF
ME

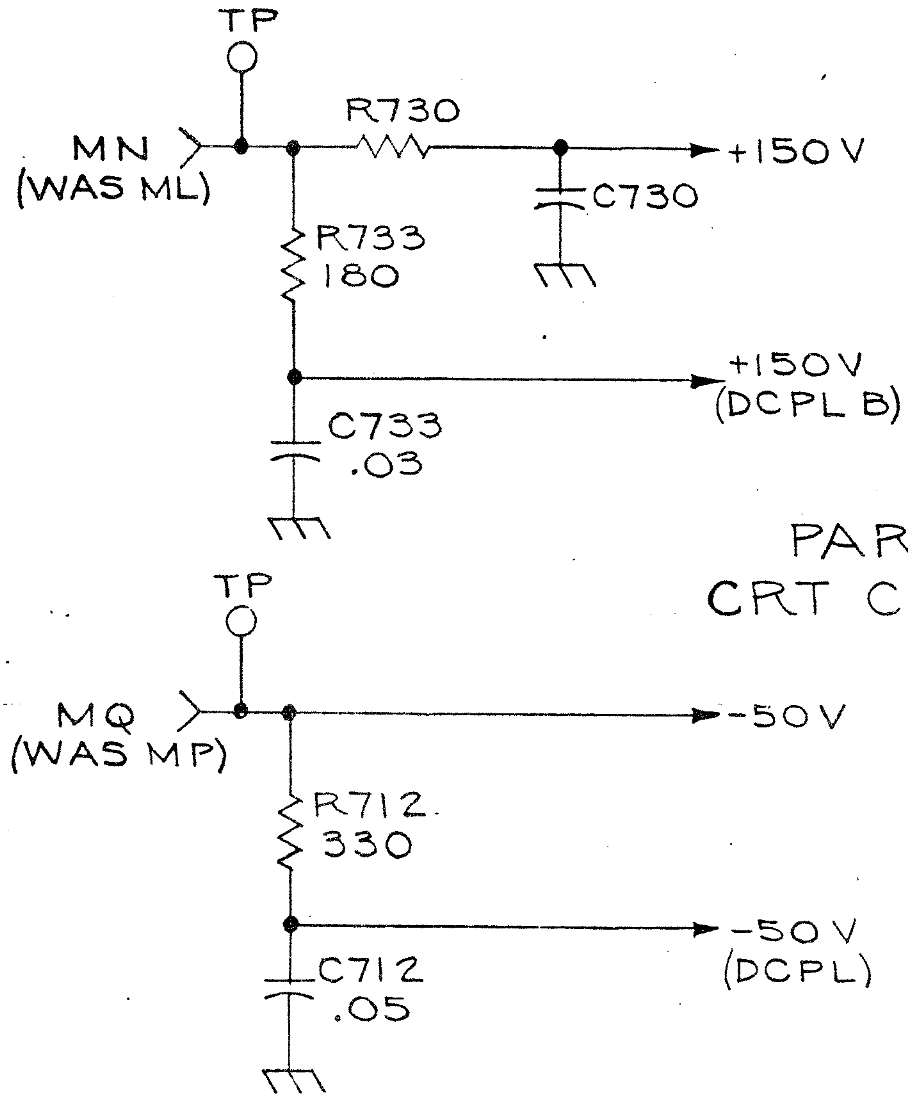


PARTIAL—
CRT CIRCUIT 9

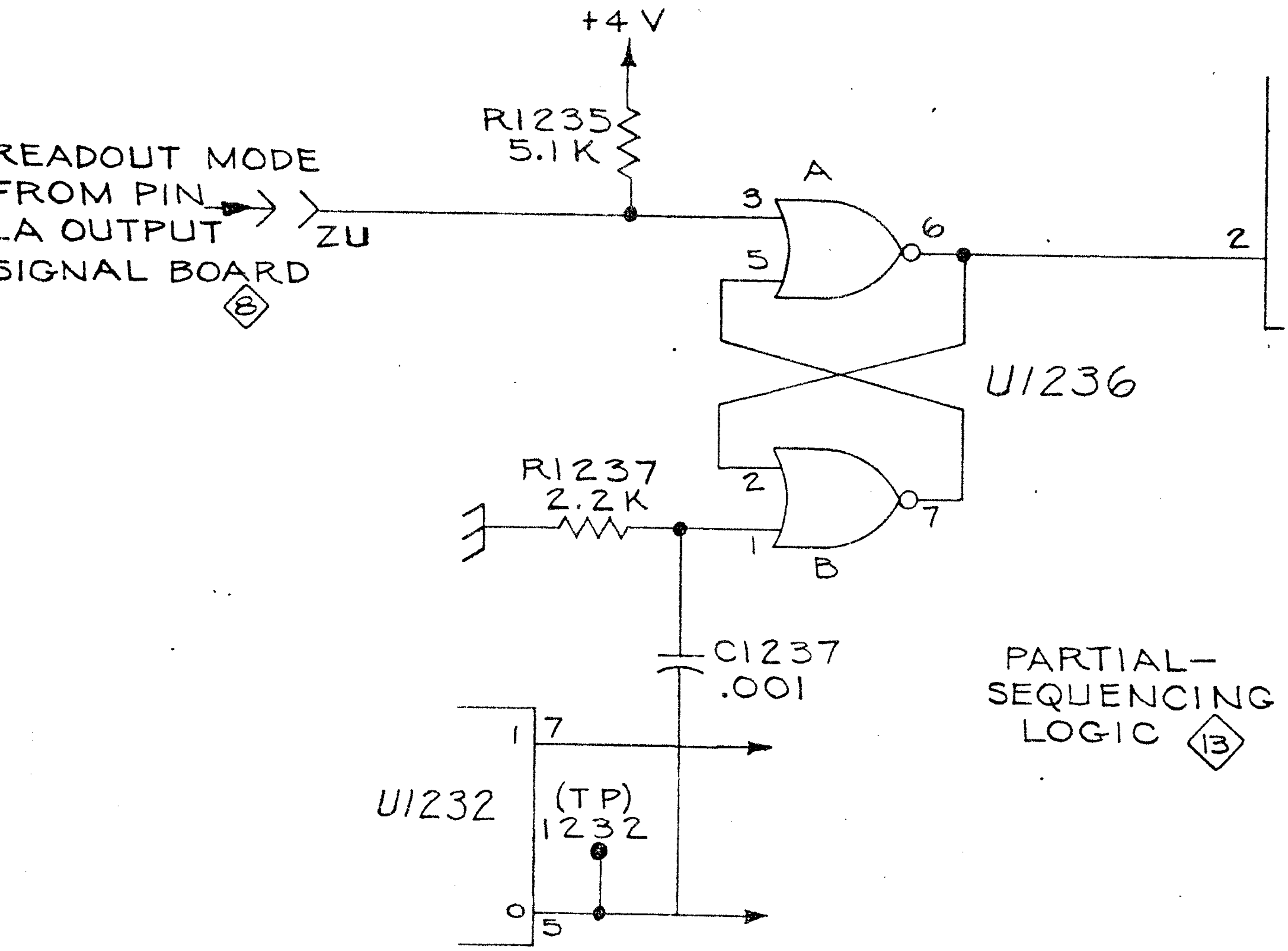




PARTIAL-
CRT CIRCUIT 9



PARTIAL-
CRT CIRCUIT 9


+4 V
R1235
5.1 K
READOUT MODE
FROM PIN
LA OUTPUT
SIGNAL BOARD
8
ZU
A
3
5
6
2
U1236
R1237
2.2 K
2
1
7
B
C1237
.001
PARTIAL-
SEQUENCING
LOGIC
13
U1232
1
7
(TP)
1232
0
5