K4XL's  BAMA

This manual is provided FREE OF CHARGE from the “BoatAnchor Manual Archive” as a service to the Boatanchor community.

It was uploaded by someone who wanted to help you repair and maintain your equipment.

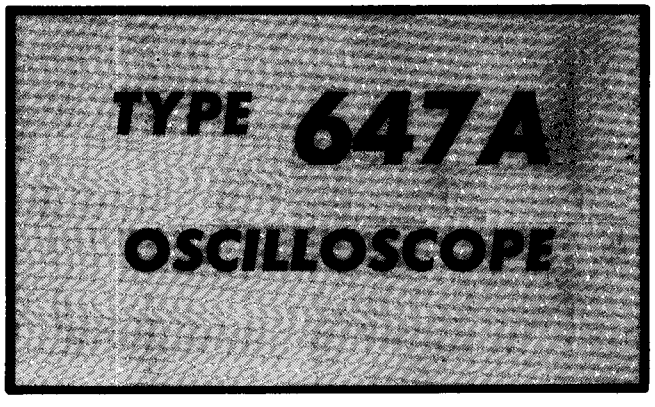
If you paid anyone other than BAMA for this manual, you paid someone who is making a profit from the free labor of others without asking their permission.

You may pass on copies of this manual to anyone who needs it. But do it without charge.

Thousands of files are available without charge from BAMA. Visit us at http://bama.sbc.edu

INSTRUCTION MANUAL

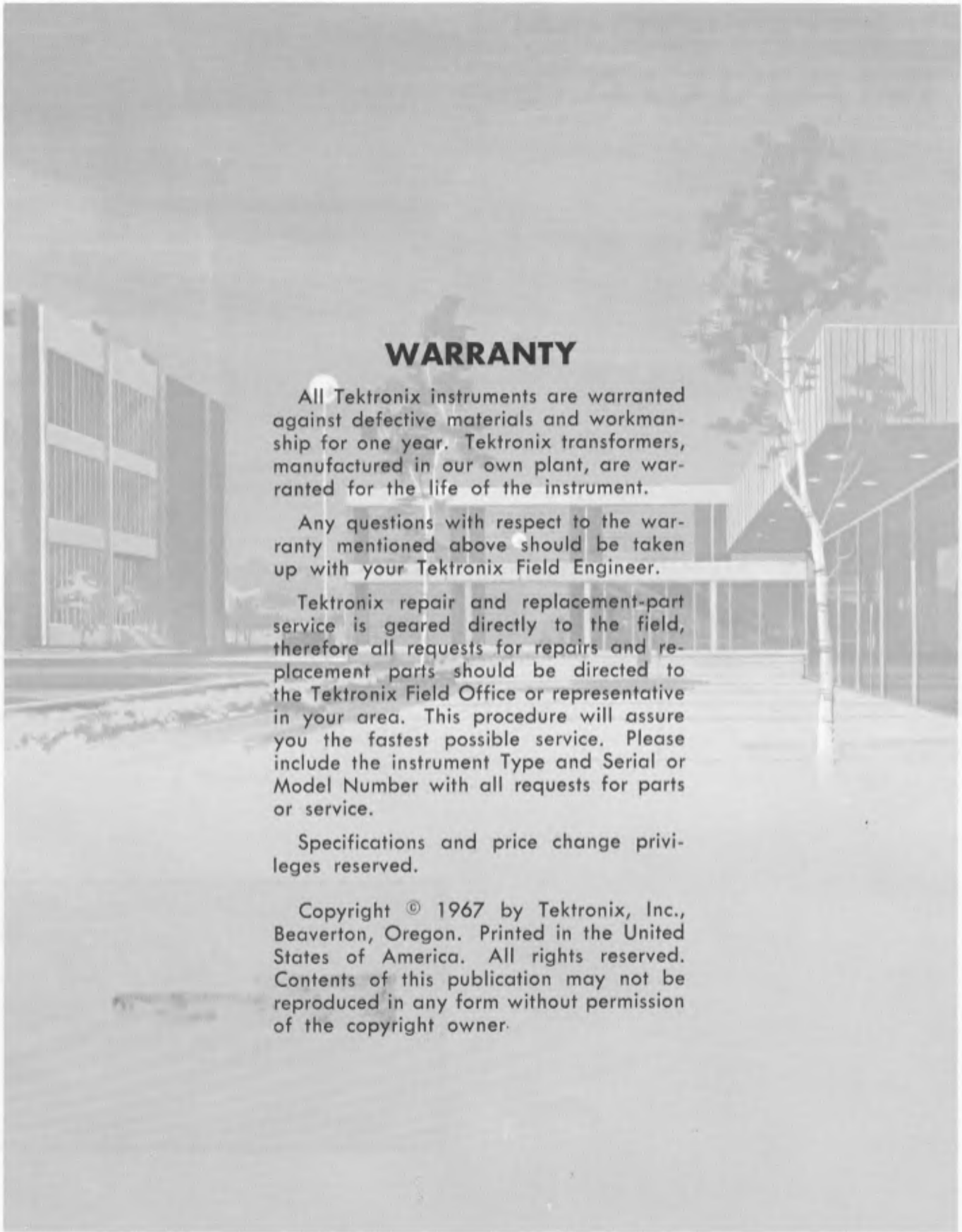
Serial Number _____



Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0614-00

1266



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own 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.

CONTENTS

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.

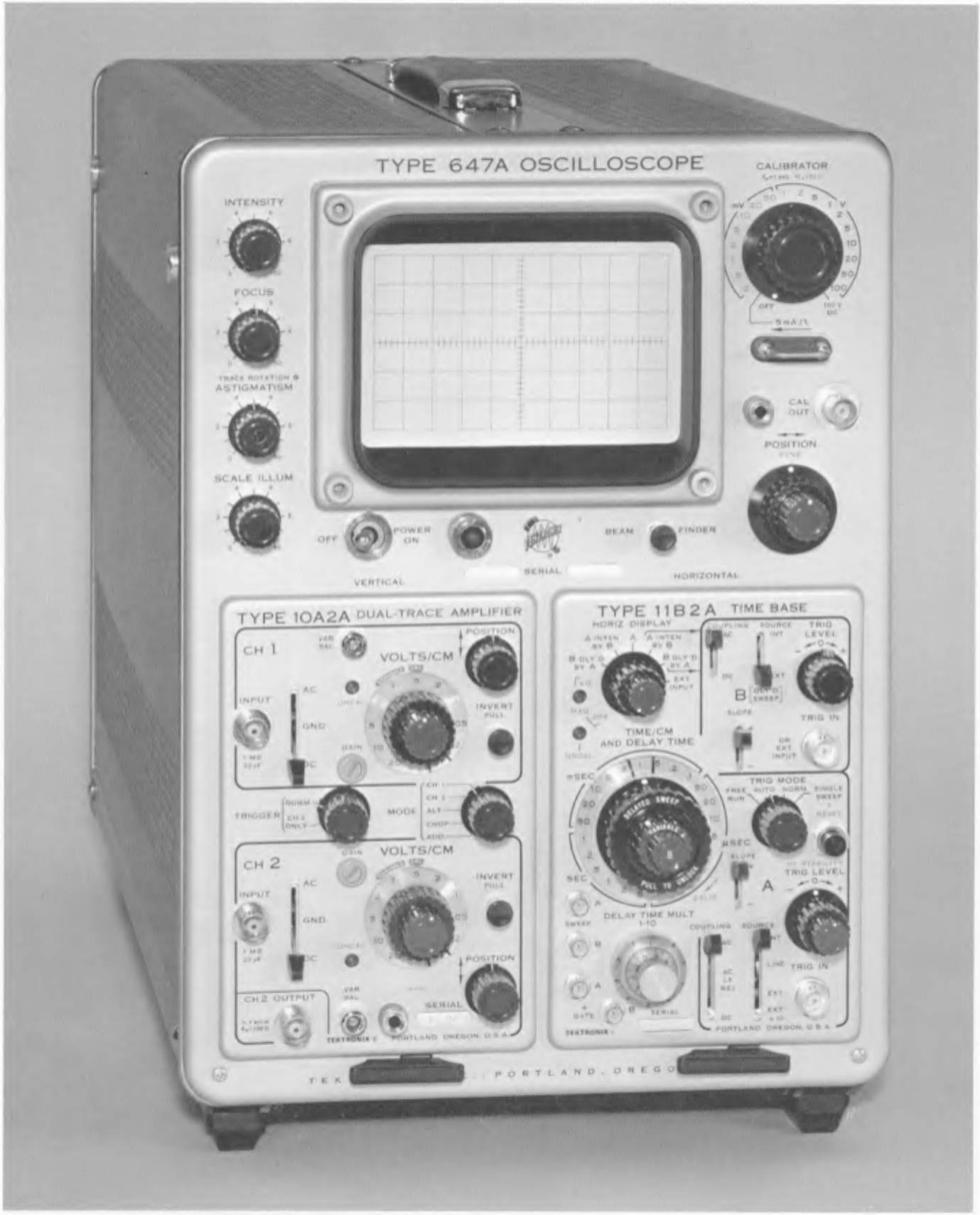


Fig. 1-1. The Type 647A Oscilloscope (shown with Type 10A2A and Type 11B2A plug-in units).

SECTION 1

CHARACTERISTICS

Introduction

The Tektronix Type 647A Oscilloscope is a general purpose, high-performance oscilloscope designed to operate in a wide range of environmental conditions. A Tektronix 10-series vertical plug-in unit is required in the left compartment and a Tektronix 11-series horizontal plug-in unit in the right compartment to form a complete measurement system. The following characteristics apply to the Type 647A only. Refer to the plug-in unit Instruction Manuals for characteristics of the complete system.

The electrical characteristics which follow are divided into two categories. Characteristics listed in the Performance Requirement column are checked in the Performance Check and Calibration sections of this manual. Items listed in the Supplemental Information column are provided for reference use and do not directly reflect the measurement capabilities of this instrument. The Performance Check procedure given in Section 5 of this manual provides a convenient method of checking the Performance Requirements listed in this section. The following electrical characteristics apply over a calibration interval of 1000 hours at an ambient temperature range of −30° C to +65° C, except as otherwise indicated. Warm-up time for given accuracy is 20 minutes.

ELECTRICAL CHARACTERISTICS

VERTICAL AMPLIFIER

Characteristics	Performance Requirement	Supplemental Information
Deflection Factor	300 millivolts/centimeter of CRT deflection	Open circuit voltage of 186-ohm source generator
Deflection Accuracy	Within ±1% at 25° C when driven from a 186 ohm push-pull source	
Bandwidth (at −3 dB point)	DC to 120 MHz or greater	Measured with Tektronix calibration fixture 067-0544-00
Risetime (calculated)	2.9 nanoseconds or less	
Low-Frequency Linearity	0.15 centimeter or less total amplitude variation of two-centimeter display when positioned over entire vertical display area.	Includes CRT linearity. Measured at center screen horizontally.
Delay Line		Approximately 140 nanoseconds

HORIZONTAL AMPLIFIER

Deflection Factor	0.347 milliampere/centimeter of CRT deflection, per side, push-pull	Short circuit current of source generator
Deflection Accuracy	Within ±1% at 25° C when driven from a 20-kilohm push-pull source	Measured over middle eight centimeters of graticule
Calibrated Sweep Deflection Rate	See 11-series time-base instruction manual	Type 647A capable of DC to 10 nanosecond/centimeter sweep deflection rate
Bandwidth	See 11-series time-base instruction manual for combined bandwidth of Type 647A and time-base unit	
Remote Single-Sweep Reset		Pin F of J101 (on rear panel) provides input for remote single-sweep reset to 11-series time-base units with compatible features

Z AXIS INPUT

Input to CRT GRID Binding Post Sensitivity	Four volt, or less, peak-to-peak signal produces noticeable modulation at normal intensity	

Z-AXIS INPUT (Cont)

Characteristics	Performance Requirement		Supplemental Information
Polarity of operation	Positive-going input signal decreases trace intensity		
Usable frequency range	DC to 10MHz or greater		
Input resistance			Approximately 22 kilohms
Input to CRT CATHODE Binding Post			
Sensitivity	Five volt, or less, peak-to-peak signal produces noticeable modulation at normal intensity		
Polarity of operation	Positive-going input signal decreases trace intensity		
Usable frequency range	500HZ to 100MHz or greater		
Input time constant			Approximately 330 microseconds (0.015 μF and 22 kΩ)

CALIBRATOR

Waveshape	Square wave		
Polarity			Positive going with baseline at zero volts
Output Voltages	0.2-millivolt to 100-volt square waves in 18 steps, and 100 volts DC		Steps in 1-2-5 sequence
Output Current	Five milliamperes through current loop		With one megohm or greater load
Repetition Rate	One kilohertz		
Accuracy	0° C to +40° C	−30 ° C to +65° C	
Voltage			
100 mV and 100 V	Within ±1%	Within ±1.5%	
All other voltages	Within ±2%	Within ±3%	
Current (Calculated)	Within ±1.5%		
Repetition rate	Within ±0.1%		
Risetime	One microsecond or less		With 20 pF or less load
Duty Cycle	49.9% to 50.1%		
Output Resistance (0° C to +40° C)			
0.2 mV to 100 mV			50 ohms, ±0.4%
200 mV			50 ohms, ±1.5%
0.5 V to 100 V			Varies with switch position to a maximum of approximately four kilohms

POWER SUPPLY

Line Voltage	115 volts nominal or 230 volts nominal	Line voltage and range selected by Line Voltage Selector assembly on rear panel. Voltage ranges apply for waveform distortion which reduces the peak line voltage 5% or less below the true sine-wave peak values.
Voltage Ranges (AC, RMS)		
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	45 to 440 hertz	
Power Consumption at 115 volts and 60 hertz		190 watts maximum. 2.0 amps maximum (includes plug-ins).

CATHODE-RAY TUBE (CRT)

Tube Type		Tektronix T6470-31-1 rectangular
Phosphor		P31 standard. Others available on special order

CATHODE-RAY TUBE *(Cont)*

Characteristics	Performance Requirement	Supplemental Information
Accelerating Potential		Approximately 14kv total (cathode potential —2.2 kV)
Graticule		
Type	Internal	
Area	Six divisions vertical by 10 divisions horizontal. Each division equals one centimeter	
Illumination	Variable edge lighting	
Unblanking	Bias-type, DC coupled to CRT grid	
Raster Distortion	0.1 division or less	
Beam Finder	Limits display within viewing area	

ENVIRONMENTAL CHARACTERISTICS

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the electrical performance requirements given in this section following environmental test. Complete details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

Characteristics	Performance Requirement	Supplemental Information
Temperature		
Operating	—30° C to +65° C	Automatic resetting thermal cutout protects instrument from overheating. Limit applies when instrument is not tipped more than 20° in any direction from level. Maximum operating temperature when operated on rear feet is +55° C.
Non-operating	—55° C to +75° C	
Altitude		
Operating	15,000 feet maximum	Derate maximum operating temperature by 1°/1000 feet change in altitude above 5000 feet
Non-operating	50,000 feet maximum	May be tested during non-operating temperature test
Humidity		
Non-operating	Five cycles (120 hours) of Mil-Std-202C, Method 106B	Exclude freezing and vibration
Vibration		
Operating and Non-operating	15 minutes vibration along each of the three major axes at a total displacement of 0.025-inch peak to peak (4 g at 55 c/s) from 10-55-10 c/s in one-minute cycles. Hold at 55 c/s for three minutes on each axis.	Instrument secured to vibration plateform during test. Total vibration time, about 55 minutes.
Shock		
Operating and non-operating	Two shocks of 20 g, one-half sine, 11 millisecond duration along each major axis	Guillotine-type shocks. Total of 12 shocks
Transportation	Meets National Safe Transit type of test when packaged as shipped from Tektronix, Inc.	
Package vibration	One hour vibration slightly in excess of 1 g	Package should just leave vibration surface
Package drop	30 inch drop on any corner, edge or flat surface	

MECHANICAL CHARACTERISTICS

Characteristics	Information
Construction	
Chassis	Aluminum alloy
Panel	Aluminum alloy with anodized finish
Cabinet	Aluminum alloy with painted finish
Circuit board	Glass-epoxy laminate
Overall Dimensions measured at maximum points)	
Height	14⅝ inches
Width	9⅞ inches
Length	22 inches including rear-panel feet
Weight (without plug-ins or accessories	Approximately 40 pounds
Connectors	
CAL OUT	BNC
CRT GRID, CRT CATHODE and GND	Binding post
J101	10-terminal connector. Mates with Cinch No. KPT06F12-10P

STANDARD ACCESSORIES

Standard accessories supplied with the Type 647A are listed on the last pullout page at the rear of this manual. For optional accessories available for use with this instrument, see the current Tektronix, Inc. catalog.

SECTION 2

OPERATING INSTRUCTIONS

General

To effectively use the Type 647A, 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.

Operating Voltage

The Type 647A 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 the instrument from one operating range to the other. In addition, this switch 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. When the instrument is converted from 115-volt to 230-volt nominal operation, or vice versa, the switch assembly connects or disconnects one of the fuses to provide the correct protection for the instrument. Use the following procedure to convert this instrument between nominal line voltages or regulating ranges.

1. Disconnect the instrument from the power source.

2. Loosen the two captive screws which hold the cover onto the switch asssembly; then pull to remove the cover.

3. To convert to a different nominal line voltage, pull out the Voltage Selector switch bar (see Fig. 2-1); turn it around and plug it back into the remaining holes. Change the line-cord power plug to match the power-source receptacle or use a 115- to 230-volt adapter.

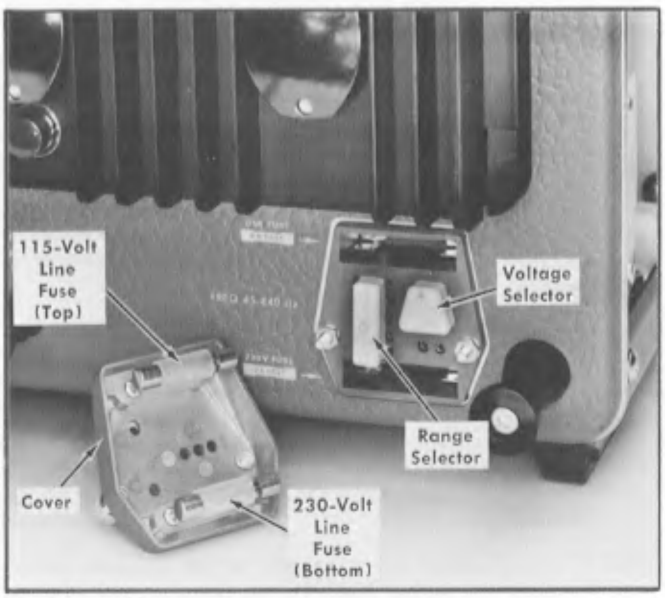


Fig. 2-1. Line Voltage Selector assembly on the rear panel (shown with cover removed).

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 will be connected (see Table 2-1).

5. Re-install the cover and tighten the two 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

The Type 647A should not be operated with the Voltage Selector and Range Selector switches in the wrong position for the line voltage applied. Operation of the instrument with the switches in the wrong positions will either provide incorrect operation or damage the instrument.

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

Operating Temperature

The Type 647A depends upon convection cooling to maintain a safe operating temperature. Adequate clearance on all sides must be provided to allow heat to be dissipated away from the instrument. Do not block or restrict the air flow through the holes in the cabinet. The clearance provided by the feet at the bottom and rear should be maintained. Provide at least three inches of clearance at the sides and top (more if possible).

A thermal cutout in the 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. The side panels of this instrument are designed to aid the convection cooling. Operation of the instrument for extended periods without the side panels may cause it to overheat and the thermal cutout to open more frequently.

The Type 647A can be operated where the ambient air temperature is between −30° C and +65° C. However, when the instrument is operated both at maximum altitude

and maximum line voltage within a given voltage range, the maximum operating temperature limit is +55° C. Also, when the ambient temperature is near +65° C, the instrument must not be tilted more than 20° in any direction from the level position. Maximum operating temperature when the instrument is sitting on the rear feet is +55° C.

The Type 647A 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.

Operating Position

A bail-type stand is mounted on the bottom of this instrument. This stand permits the Type 647A to be tilted up approximately 10° for more convenient viewing (see Fig. 2-2). The instrument may also be set on the rear feet either for operation (see limits given under Operating Temperature) or for storage.

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

Plug-In Installation

The Type 647A is designed to operate with a 10-series vertical plug-in unit in the Vertical plug-in compartment and an 11-series time-base unit in the Horizontal plug-in compartment. The system will not operate if the plug-ins are reversed. To install a plug-in, insert it into the compartment and push it in as far as possible. To remove a plug-in from a compartment, pull the release bar to unlatch the plug-in. Then, pull the plug-in partially out of the compartment and take hold of the plug-in by the support rods to remove it from the compartment.

When the Type 647A is calibrated in accordance with the calibration procedure given in this instruction manual, the vertical and horizontal gain are normalized so that calibrated plug-ins can be changed from one indicator unit to another without recalibration.

CONTROLS AND CONNECTORS

A brief description of the function and operation of the front- and rear-panel controls and connectors follows. Fig. 2-3 shows the front and rear panels of this instrument. More detailed information is given in this section under General Operating Information.

Front Panel

INTENSITY	Controls brightness of display.
FOCUS	Provides adjustment to obtain a well-defined display.
ASTIGMATISM	Used in conjunction with the FOCUS control to obtain a well-defined display.
TRACE ROTATION	Screwdriver adjustment concentric with the ASTIGMATISM control. Provides electronic alignment of the trace with the horizontal graticule lines.
SCALE ILLUM	Controls graticule illumination.
CALIBRATOR	Selects the peak-to-peak amplitude of the one-kilohertz square wave available at the CAL OUT connector.
5 mA ⎍	Current loop providing five-milliampere square-wave current from the Calibrator circuit when selected by the CALIBRATOR switch.
CAL OUT	Output connector for the square-wave voltage from the Calibrator circuit.
POSITION	Controls horizontal position of trace.
FINE	Provides more precise horizontal position adjustment.
BEAM FINDER	When pressed, returns the display to the screen by reducing vertical and horizontal deflection. Used to locate display which exceeds scan of display area.
POWER	Switch: Applies power to the instrument. Light: Indicates that POWER switch is on and the instrument is connected to a power source. Brightness of the light can be adjusted by turning the lens housing.

Rear Panel

CRT GRID	Input connector for applying intensity modulating signals to the grid of the CRT through the Z Axis Amplifier.
GND	Ground connector.
CRT CATHODE	Input connector for applying intensity modulating signals to the cathode of the CRT.
J101	Ten-pin connector which provides power output from the regulated power supplies and remote single-sweep reset (with compatible 11-series time-base plug-in units).

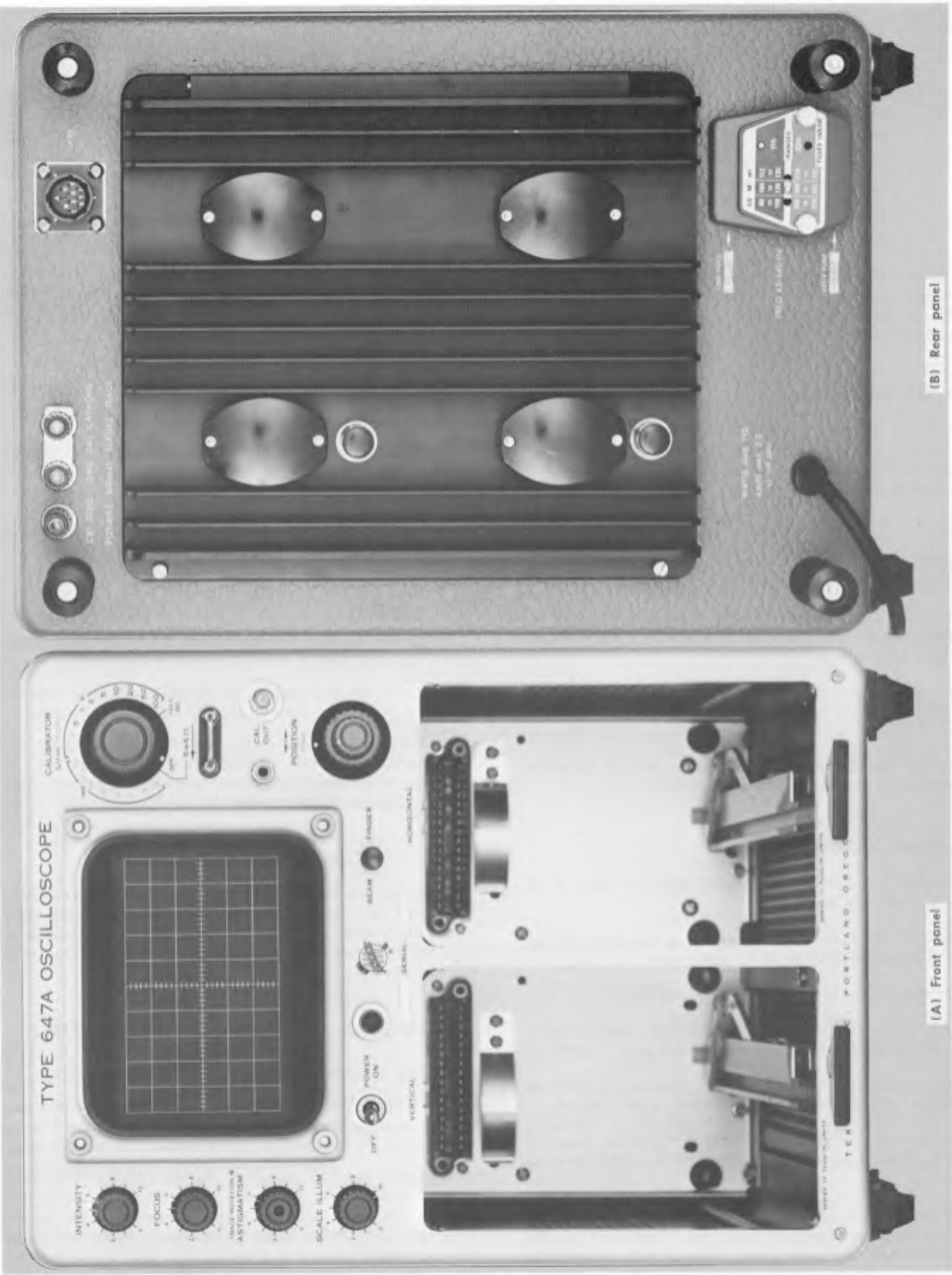


Fig. 2-3. Front- and rear-panel controls and connectors.

Line Voltage Selector — 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 V or 230 V).

Range Selector: Selects line voltage range (low, medium, high).

FIRST-TIME OPERATION

The following steps demonstrate the basic function of the controls and connectors of the Type 647A. It is recommended that this procedure be followed completely for first-time familiarization with the instrument.

Setup Information

1. With the POWER switch OFF, insert a Tektronix 10-series vertical plug-in unit into the Vertical plug-in compartment (left) and Tektronix 11-series time-base unit into the Horizontal plug-in compartment (right).

2. Set the INTENSITY control fully counterclockwise.

3. Connect the Type 647A to a power source which meets its voltage (see rear panel) and frequency requirements.

4. Set the POWER switch to ON. Allow about five minutes warm up so the units reach operating temperature before proceeding.

5. Set the vertical plug-in unit for a vertical deflection factor of 0.5 volts/division and center the vertical position control.

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

Front-Panel Adjustments

7. Advance the INTENSITY control until the trace is at the desired viewing level.

8. Connect the CAL OUT connector to the input of the vertical unit with a BNC to BNC patch cord.

9. Set the CALIBRATOR switch to 2 VOLTS.

10. Adjust the FOCUS and ASTIGMATISM controls for a sharp, well defined display over the entire trace length.

11. Disconnect the input signal and position the trace so it coincides with the horizontal graticule center line.

12. If the trace is not parallel with the graticule line, see Trace Alignment Adjustment (described in General Operating Information).

13. Rotate the SCALE ILLUM control throughout its range and note that the graticule lines are illuminated as the control is turned clockwise (most obvious with smoke-gray filter installed). Set control so graticule lines are illuminated as desired.

Calibrator

14. Connect the CAL OUT connector to the input of the amplifier unit with a BNC to BNC patch cord.

15. The display should be four divisions in amplitude with five complete cycles shown horizontally. An incorrect display indicates that either this instrument or the associated plug-in units need to be recalibrated.

Horizontal Position

16. Rotate the POSITION control throughout its range; this should move the display over most of the display area. Now turn the FINE control. The display moves a smaller amount and allows more precise positioning. Return the start of the trace to the left graticule line.

Beam Finder

17. Set the CALIBRATOR switch to 50 VOLTS.

18. Press the BEAM FINDER button. Note that the display is returned to the graticule area. While holding the BEAM FINDER button depressed, increase the deflection factor until the vertical deflection is reduced to about two divisions. Release the BEAM FINDER and note that the display remains on the screen.

Pilot Light

19. Rotate the lens housing of the pilot light fully clockwise. The pilot light is now at minimum brightness.

20. Rotate the lens housing of the pilot light fully counterclockwise. The pilot light is now at maximum brightness.

21. This completes the basic operating procedure for the Type 647A. Instrument operation not explained here, or operation which needs further explanation is discussed under General Operating Information.

CONTROL SETUP CHART

Fig. 2-4 shows the front and rear panels of the Type 647A. This chart can 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

Intensity Control

The setting of the INTENSITY control may affect the correct focus of the display. Slight readjustment of the FOCUS control may be necessary when the intensity level is changed.

To protect the CRT phosphor, do not turn the INTENSITY control 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 control to a setting that may burn the phosphor. When the highest intensity display is required, remove the filter and use the clear faceplate protector to obtain

TYPE 647A TEST SETUP CHART

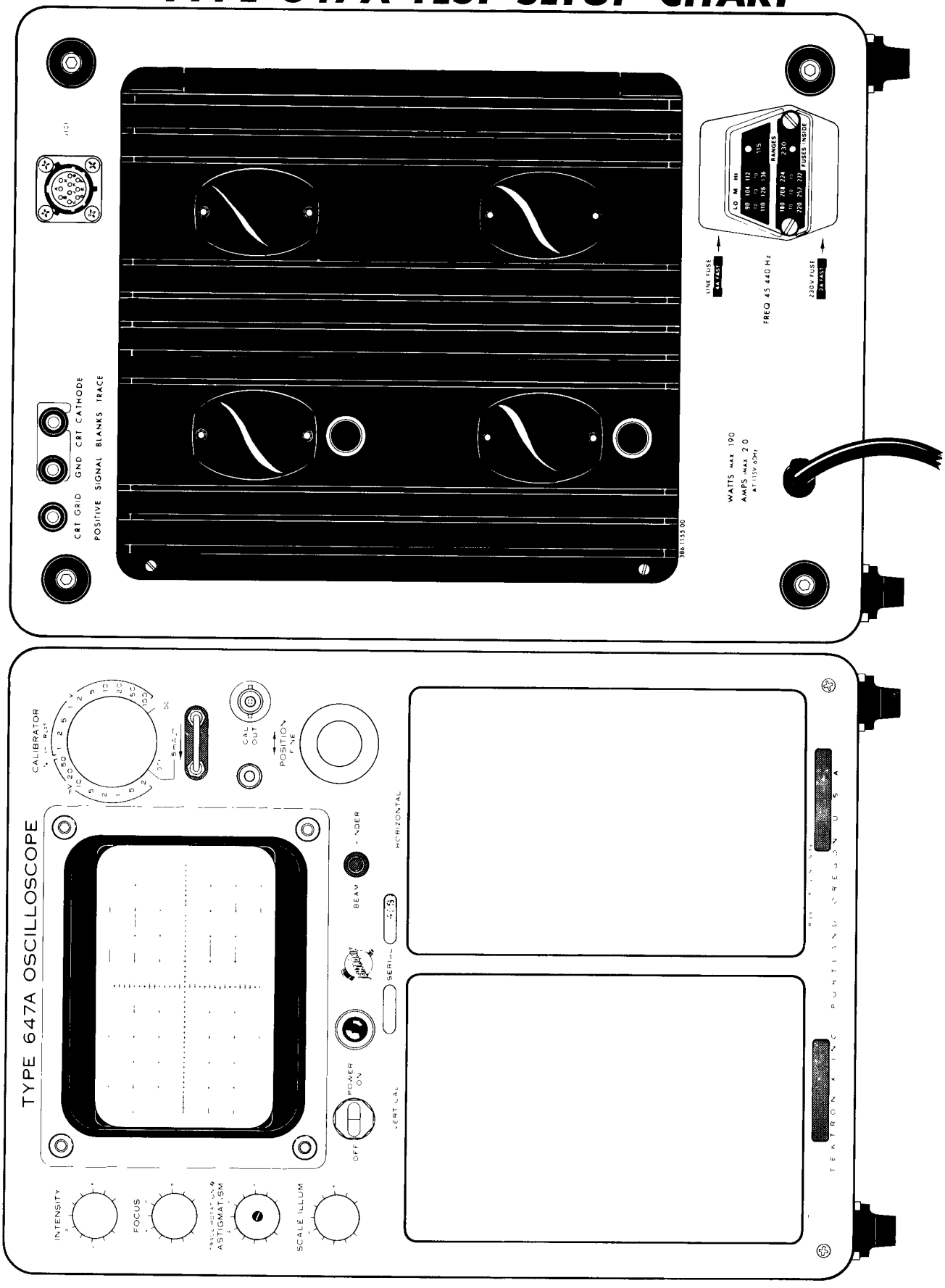


Fig. 2-4. Control setup chart for the Type 647A.

the maximum light output. Also, be careful that the INTENSITY control is not set too high when changing the time-base plug-in from a fast to a slow sweep rate, or when changing the horizontal display mode from external horizontal operation to the normal sweep mode.

Focus and Astigmatism Adjustment

The following procedure provides a convenient method of establishing optimum setting of the FOCUS and ASTIGMATISM controls.

1. Connect the CAL OUT connector to the input of the vertical unit with a BNC cable.

2. Set the CALIBRATOR switch to 2 VOLTS and 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 milliseconds/division.

4. With the FOCUS and ASTIGMATISM control set to midrange, adjust the INTENSITY control so the rising portion of the display can just be seen.

5. Set the ASTIGMATISM control so the vertical and horizontal portions of the display are equally focused, but not necessarily well focused.

6. Set the FOCUS control so the vertical portion of the trace is as thin as possible.

7. Repeat steps 5 and 6 for best overall focus. Make final check at normal intensity.

Trace Alignment Adjustment

If a free-running trace is not parallel to the horizontal graticule lines, set the TRACE ROTATION adjustment as follows:

1. Position the trace to the horizontal centerline.

2. Adjust the TRACE ROTATION adjustment so the trace is parallel to the horizontal centerline.

Light Filter

The tinted filter minimizes light reflections from the face of the CRT to improve contrast when viewing the display under high ambient light conditions. A clear plastic faceplate protector is also provided with this instrument for use when neither the tinted nor the optional mesh filter are used. The clear faceplate protector provides the best display for waveform photographs. It is also preferable for viewing high writing rate displays. A filter or the faceplate protector should be used at all times to protect the CRT faceplate from scratches. The faceplate protector and the tinted light filter mount in the same holder (see Fig. 2-5). To remove the light filter or faceplate protector from the holder, press it out to the rear. Snap the replacement back into the holder. Remove the red plastic inserts when installing the tinted filter.

The optional mesh filter available for the Type 647A (Tektronix Part No. 378-0574-00) 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

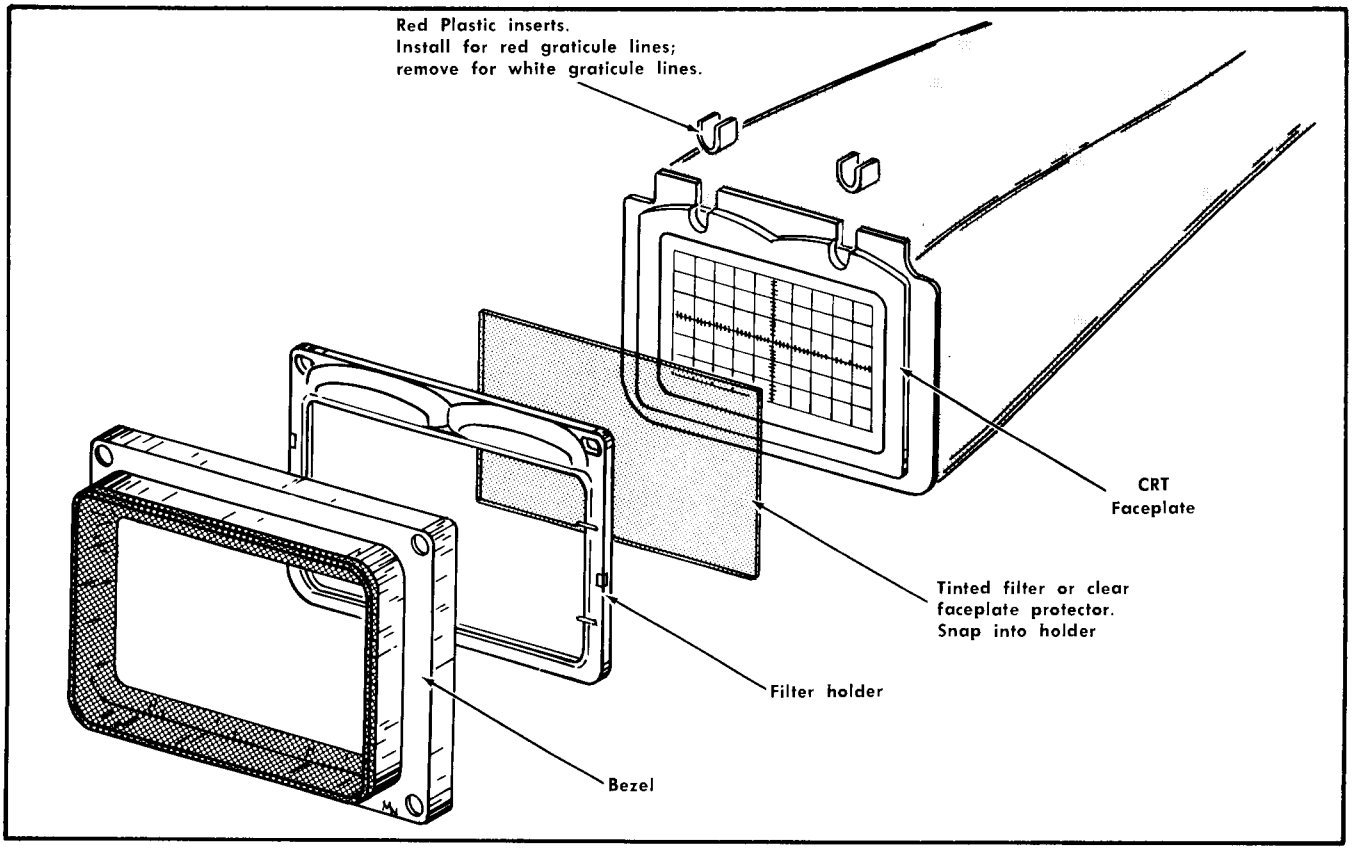


Fig. 2-5. Installation of light filters or faceplate protector on CRT.

more visible under high ambient light conditions. The mesh filter fits in place of the filter holder (see Fig. 2-5). Remove the red plastic inserts when installing the mesh filter.

Beam Finder

The BEAM FINDER button provides a means of locating a display which overscans the viewing area either vertically or horizontally. When the BEAM FINDER button is pressed, the display is compressed within the graticule area. To locate and reposition an overscanned display, use the following procedure:

1. Press the BEAM FINDER button.

2. While the BEAM FINDER button is held depressed, adjust the position controls and increase the vertical and horizontal deflection factors until the display is centered about the graticule centerlines with about two divisions vertical deflection and about six divisions horizontal deflection (the horizontal deflection needs to be reduced only when using external horizontal input). If the display cannot be centered about the centerline, the applied signal may have too great a DC level.

3. Release the BEAM FINDER button; the display should remain within the viewing area.

Graticule

The Graticule of the Type 647A is internally marked on the faceplate of the CRT to provide accurate, no-parallax measurements. The graticule is marked with six vertical and 10 horizontal one-centimeter divisions. In addition, the vertical and horizontal centerlines are marked in 0.2 division (two millimeter) minor divisions. The vertical and horizontal deflection factors of the respective plug-ins are adjusted to provide calibrated deflection on the CRT.

The illumination of the graticule lines can be varied with the SCALE ILLUM control. Also, the graticule lines can be made to appear red by installing the red plastic inserts (see Fig. 2-5). The inserts should not be used for trace photography or with the mesh and tinted filters.

Calibrator

The one-kilohertz square-wave Calibrator of the Type 647A provides a convenient signal source for checking basic vertical gain and horizontal timing. However, to provide maximum measurement accuracy, the adjustment procedure given in the Calibration section of the applicable plug-in instruction manual should be used when recalibrating the unit. 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 peak-to-peak square-wave voltages from 0.2 millivolts to 100 volts into high-impedance loads. Switch positions from 0.2 millivolts to 0.2 volts provide an output source resistance of 50 ohms for use with low-impedance loads. The actual voltage across an external load resistor is determined by voltage-divider action and can be calculated in the same manner as with any series resistor combination. For example, the voltage across a 50-ohm termination (or input resistor) would be one-half the voltage indicated by the CALIBRATOR switch.

The 100 V DC position of the CALIBRATOR switch provides an accurate positive 100 volt DC output level at the CAL OUT connector. The given voltage accuracy (see Characteristics section) applies for load resistance of 100 kilohms or higher. Lower impedance loads result in loss of accuracy. For example, with a load resistance of 35 kilohms, the output voltage drops to about 99 volts. The short circuit output current available is about 15 milliamps.

Current. The current loop, located above the CAL OUT connector, provides a five-milliamp peak-to-peak square-wave current which can be used to check and calibrate current-probe systems. This current signal is obtained by clipping the probe around the current loop and setting the CALIBRATOR switch to the first position clockwise from OFF (note line on panel leading to current loop). The arrow above the current loop indicates conventional current flow; i.e., from + to —.

Frequency. The Calibrator is crystal controlled to maintain an accurate frequency of one kilohertz and a constant duty cycle of 50%. Thus, the Calibrator output signal can be used as a time reference for checking the basic sweep timing of time-base units.

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 (true only when the vertical input compensation is correctly adjusted also).

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 changing the wave shape. The Z-Axis modulating signal applied to the CRT circuit changes the intensity of the displayed waveform to provide this information. '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 Z-Axis display is provided by signals with a fast rise and fall.

Time markers applied for intensity modulation provide a direct time reference on the display. With uncalibrated horizontal sweep or external horizontal deflection, 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 to provide a stable display.

Two modes of intensity modulation are provided in the Type 647A. The following discussions describe the use and limitations of each mode.

Input to CRT GRID Binding Posts. The CRT GRID input permits intensity modulation of the CRT display through the

Z-Axis Amplifier circuit. The voltage change for visible trace modulation depends upon the intensity level; typically a four-volt peak-to-peak signal produces a visible change in display brightness at normal intensity. 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 about 10 megahertz. This mode of intensity modulation is preferable for most applications since it provides DC coupling and better sensitivity.

Input to CRT CATHODE Binding Posts. Intensity modulation signals connected to the CRT CATHODE input are AC-coupled to the cathode circuit of the CRT. Typically at normal intensity level, a five-volt peak-to-peak signal produces a visible change in display brightness. Polarity of operation is the same as for the CRT GRID; negative-going signals increase display intensity and positive-going signals decrease display intensity. Bandwidth for this mode of intensity modulation is about 500 hertz to 100 megahertz.

TABLE 2-2

REAR-PANEL CONNECTIONS

J101 Terminal	Function	Maximum Current (milliamperes)
A	—75 volts	50
B	—15 volts	20
C	Ground	
D	+15 volts	200
E	+100 volts	20
F	Remote single-sweep reset	
G	No connection	
H	No connection	
J	No connection	
K	No connection	

Rear Panel Connector

The 10-terminal connector, J101, on the rear panel of the Type 647A provides power output from the regulated low-voltage supplies to operate external devices and an input connection for remote single-sweep reset with a compatible time-base plug-in unit. Table 2-2 lists the function and maximum current rating of each terminal of J101. The current listed is the maximum current available when plug-ins are used which also require maximum current. Plug-ins which require less current will allow more current to be available at J101. The mating connector for J101 is a Cinch #KPT-06F12-10P available from Tektronix, Inc. by Tektronix Part No. 131-0300-00.

Remote Single-Sweep Reset

Fig. 2-6 shows two methods of providing a remote single-sweep reset pulse for a 11-series time-base unit which has compatible features. Fig. 2-6A shows a circuit which derives the reset pulse from the voltage available at J101 and uses a pushbutton switch or a relay to produce the single-sweep reset pulse. Fig. 2-6B shows how a pulse generator can be used to provide remote single-sweep reset.

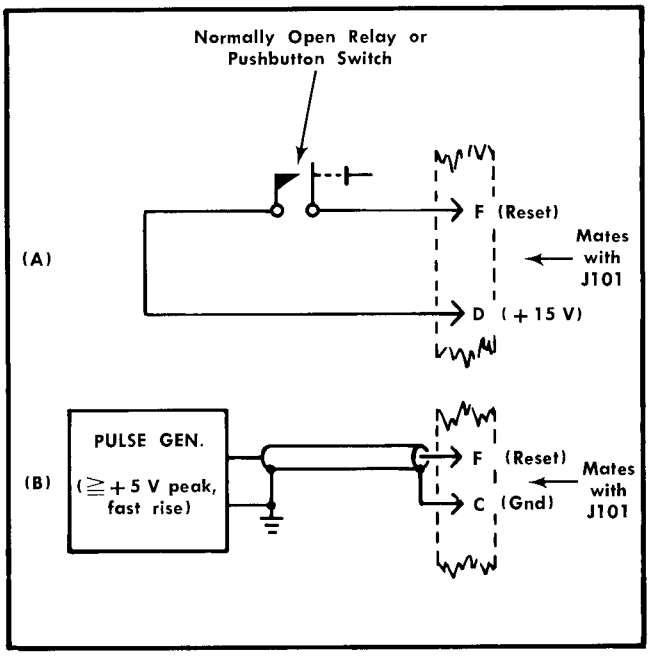


Fig. 2-6. Two methods of providing a remote single-sweep reset pulse.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section of the manual contains an electrical description of the circuitry used in the Type 647A. 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 a detailed block diagram 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 rear of this manual. This block diagram shows the overall relationship between all of the circuits in this instrument. 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 block diagram discussion is provided to aid in understanding the overall concept of the Type 647A before the individual circuits are discussed in detail. A basic block diagram of the Type 647A is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown in this diagram. Each block in this block diagram represents a major circuit within the instrument. The number on each block refers to the circuit diagram at the rear of this manual which shows the complete circuit.

Input signals to be displayed on the CRT are applied to the Vertical Amplifier from the vertical plug-in unit through the interconnecting plug. The Vertical Amplifier circuit amplifies this input signal to bring it to the level necessary to drive the CRT vertical deflection plates. Likewise, the Horizontal Amplifier circuit amplifies the signal connected to it from the time-base plug-in unit. The output of the Horizontal Amplifier circuit provides the horizontal deflection for the CRT. The internal trigger signal from the vertical unit is connected through the Type 647A to the time-base unit and the alternate trace sync pulse generated by the time-base unit is connected to the vertical unit.

The CRT Circuit provides the voltages and controls necessary for the operation of the cathode-ray tube. The Z Axis Amplifier stage in the CRT circuit determines the CRT intensity and unblanking level as controlled by the INTENSITY control, chopped blanking signal from the vertical unit, unblanking gate from the time-base unit or a signal connected to the CRT CATHODE or CRT GRID connectors.

The Power Supply circuit provides the low-voltage power necessary for operation of this instrument and the associated plug-ins. The Calibrator circuit produces a square-wave output signal with accurate amplitude and frequency which can be used to check the basic calibration of the associated plug-ins and for compensation of passive probes. The current probe loop provides an accurate current source for calibration of current-probe systems.

CIRCUIT OPERATION

General

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 shows how they are connected together to form the major circuit. The block diagrams also show the inputs and outputs for each major 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 of this manual. The names assigned to the individual stages on the detailed block diagrams are used throughout the following discussion.

This circuit analysis attempts to describe the electrical operation and relationship of all circuits in the Type 647A. The theory of operation for circuits which are commonly used in the electronics industry is not described here. Instead, references are given to textbooks or other source material where more complete information on these circuits can be found. Circuits which are unusual or are peculiar to this instrument are described in detail.

VERTICAL AMPLIFIER

General

The Vertical Amplifier circuit provides amplification for the vertical signal from the 10-series vertical plug-in unit and connects it to the vertical deflection plates of the CRT. The BEAM FINDER switch compresses an overscanned display within the viewing area when pushed in. Fig. 3-2 shows a detailed block diagram of the Vertical Amplifier circuit. A schematic of this circuit is shown on diagram 2 at the rear of this manual.

Delay Line

The Delay Line provides approximately 140 nanoseconds delay for the vertical signal to allow the time-base unit enough time to initiate a sweep before the vertical signal reaches the vertical deflection plates. This allows the instrument to display the leading edge of the signal originating the trigger pulse when using internal triggering.

Phase Equalizer Network

The Phase Equalizer Network, L405A-L405B-L405C-L405D-L405E-L405F-C405A-C405B-C405C, L407A-L407B-L407C-L407D-L407E-L407F-C407A-C407B-C407C and C406A-C406B-C406C,

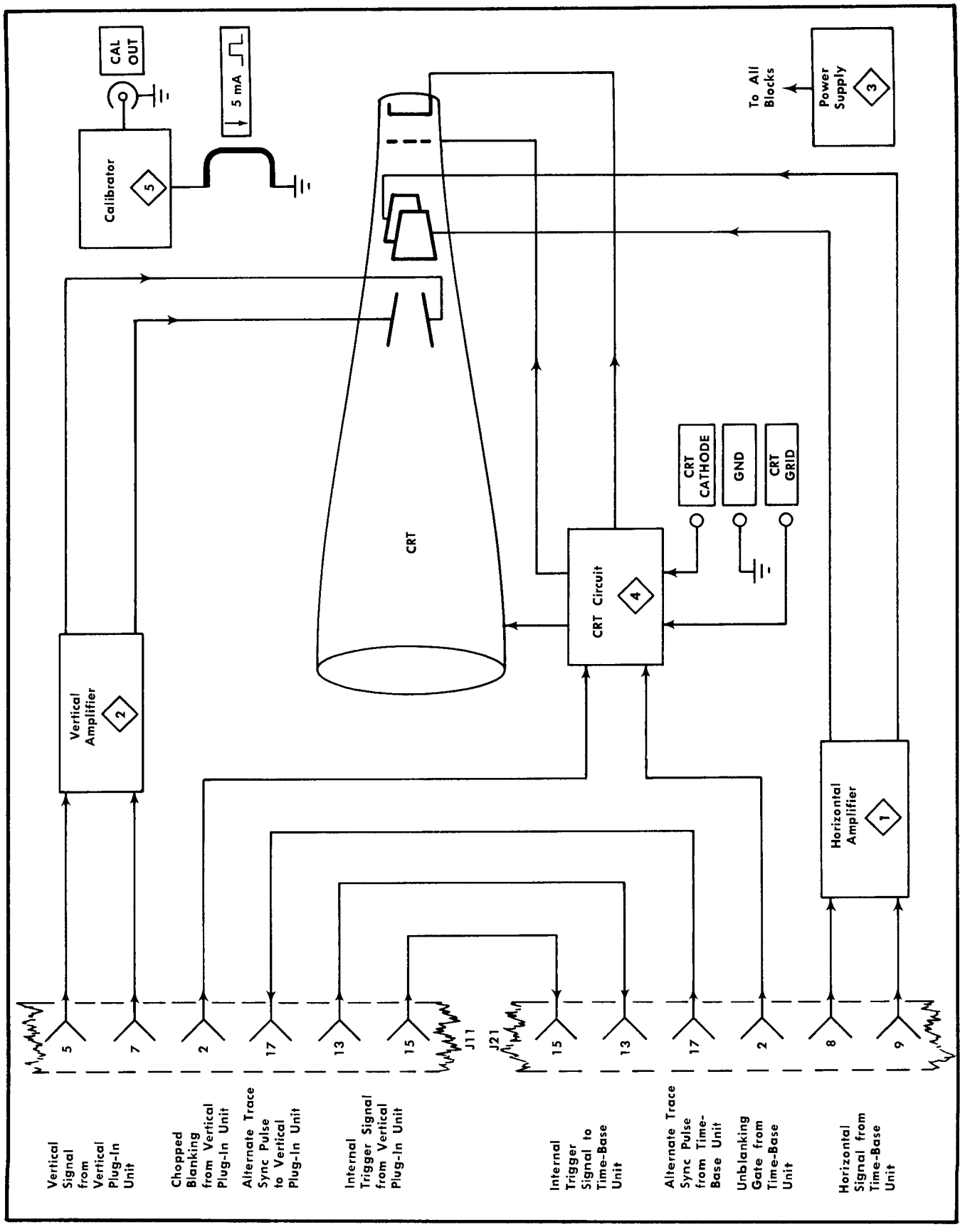


Fig. 3-1. Simplified block diagram of the Type 647A.

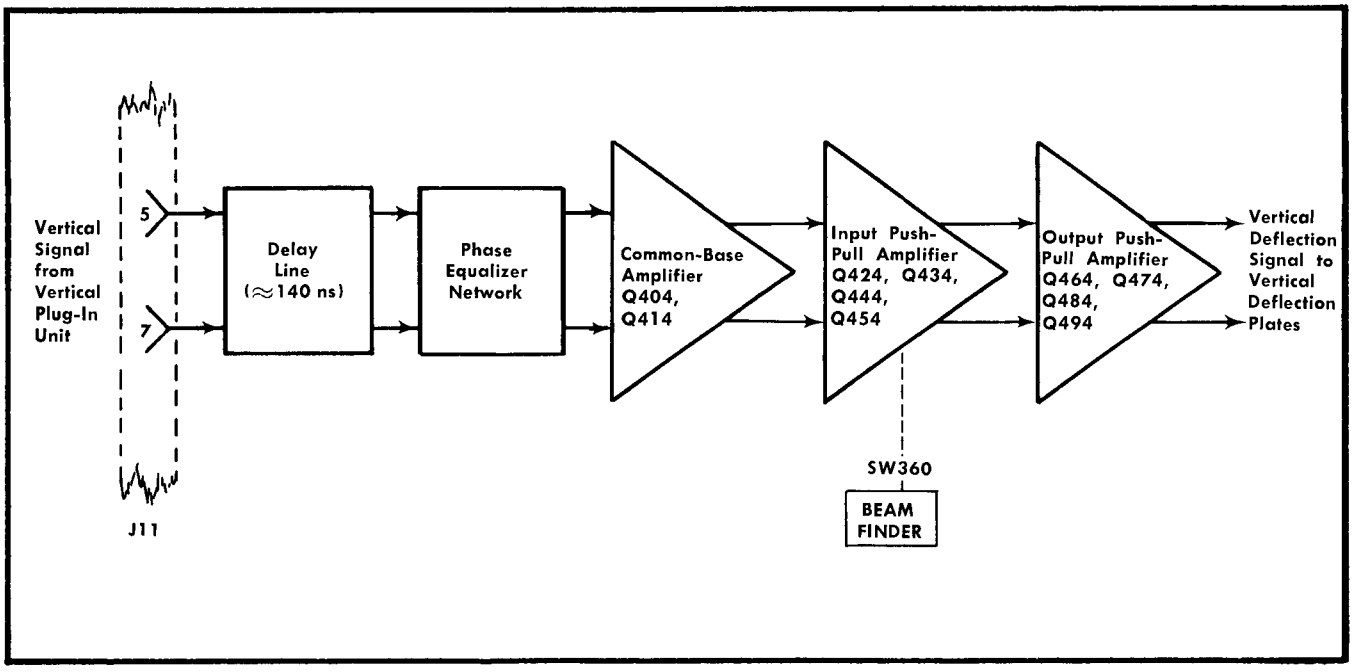


Fig. 3-2. Vertical Amplifier detailed block diagram.

corrects for the phase distortion of the delay line. R405 and R407 in series with the base-emitter resistance of Q404 and Q414 provide the forward termination for the delay line.

Common-Base Amplifier

The Common-Base Amplifier stage, Q404 and Q414, provides a low input impedance to properly terminate the Delay Line (along with the Phase Equalizer Network). It also provides isolation between the Delay Line stage and the following stages. The DC Centering adjustment, R409, is adjusted to balance the current at the output of the amplifier for a center-screen display when the associated amplifier unit position control is centered.

Input Push-Pull Amplifier

The vertical deflection signal from the Common-Base Amplifier stage is connected to the Input Push-Pull Amplifier stage, Q424-Q434-Q444-Q454. The network C435-C437-C438-C439-R428-R429-L428 provides high-frequency compensation for the vertical system. C435, C437, L428 and R429 are adjustable to provide optimum high-frequency response. The Gain adjustment, R427, varies the emitter degeneration between Q424 and Q434 to control the overall gain of the Vertical Amplifier. Zener diodes D440 and D450 limit the voltage swing across R440 and R450 to prevent Q424 and Q434 from saturating when the display is driven off the display area.

Transistors Q444 and Q454 operate in a similar manner to the Common-Base Amplifier stage. They provide a low-impedance load for Q424 and Q434 for maximum high-frequency response, and provide isolation between the Input and Output Push-Pull Amplifier stages.

When BEAM FINDER switch, SW360, in the emitter circuit of Q424-Q434 is pressed, it limits the dynamic range of this stage to compress the display within the viewing area. Normally, SW360 is closed and R423 is bypassed. When SW360 is pressed, the switch is open and R423 is connected into the circuit. This resistor limits the emitter current available to Q424-Q434 and the display is limited within the viewing area. Although the display is not linear, it provides a method of locating a signal that is overscanning the display area due to incorrect positioning or deflection factor.

Output Push-Pull Amplifier

The Output Push-Pull Amplifier stage is basically the same as the previous stage. The network C462-C463-C464-C465-C466-C468-R463-R464-R465-R466-R467-R468-R473-R474-R475 provides boosting for frequencies lower than those affected by the similar network in the preceding stage. C465, R465, R467 and R475 are adjustable to provide optimum response. Thermistor R461 provides bandwidth stabilization with temperature changes. Zener diodes D480 and D490 limit the voltage swing across R480 and R490 to prevent Q464 and Q474 from saturating when the display is driven off the display area. Diodes D483, D493 and D494 protect transistors Q484 and Q494 from damage if the +15-volt or —15-volt supplies are shorted to ground. The output of the amplifier is connected to the vertical deflection plates of the CRT. LR489 and LR499 provide damping for the leads connecting the output signal to the deflection plates.

HORIZONTAL AMPLIFIER

General

The Horizontal Amplifier circuit amplifies the push-pull horizontal deflection signal from the time-base unit and connects it to the horizontal deflection plates. Fig. 3-3 shows a detailed black diagram of the Horizontal Amplifier circuit. A schematic of this circuit is shown on diagram 1 at the rear of this manual.

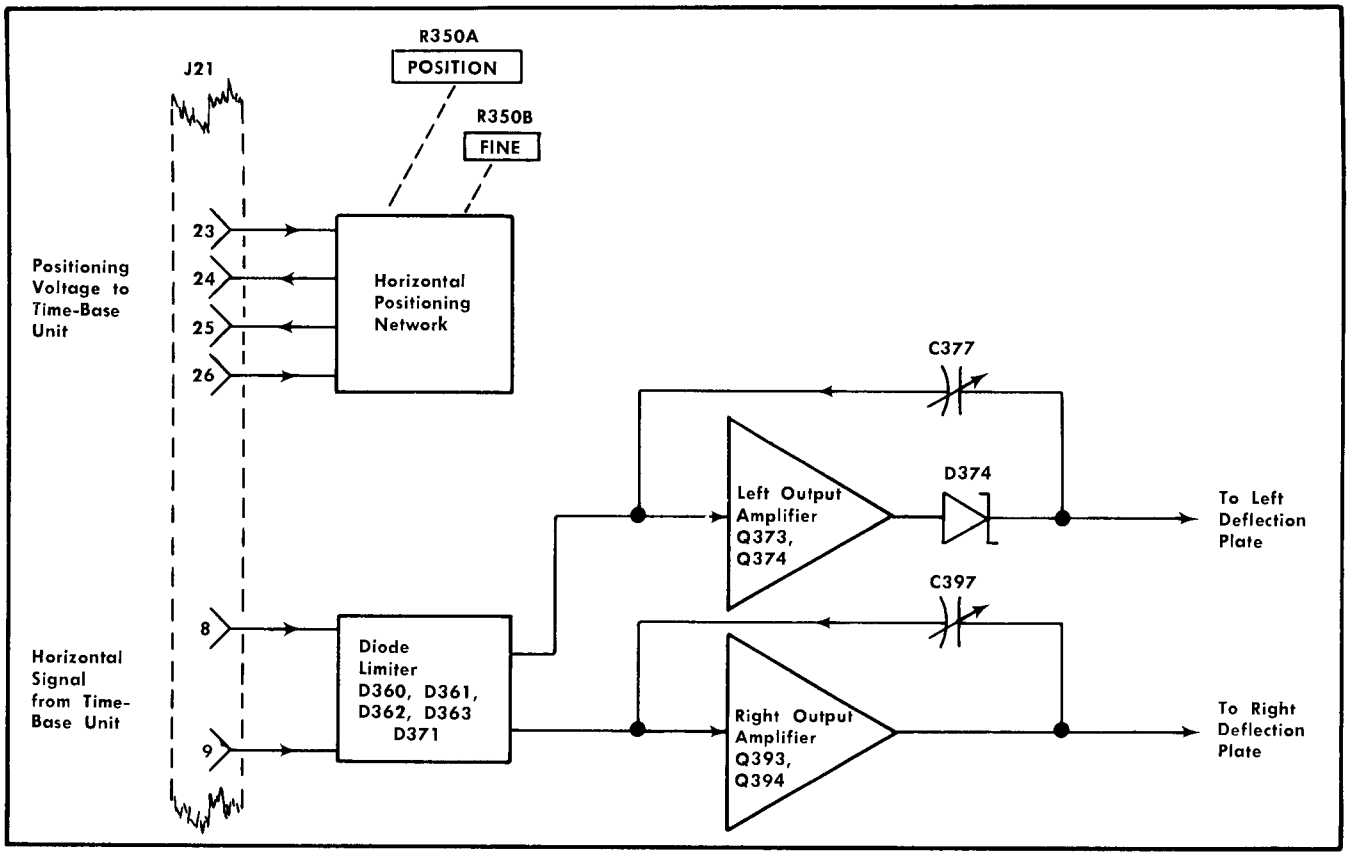


Fig. 3-3. Horizontal Amplifier detailed block diagram.

Diode Limiter

The Diode Limiter stage, D360-D361-D362-D363-D371, limits the dynamic range of the push-pull deflection signal current reaching the Horizontal Amplifier circuit so it cannot be overdriven with extreme horizontal POSITION control settings or when the sweep is magnified. This limiting network allows the Left and Right Output Amplifier stages to have a fast recovery when overdriven to provide good operation for fast sweep rates. The limiting action takes place as follows (example given for extreme positioning; operation is similar for magnified sweep): For on-screen displays, all diodes except D360 are forward biased. The forward current through diodes D361 and D362 is equal in the quiescent state. As the trace is positioned to the left side of the display area, the current through D361 and D362 decreases, and it drops to zero when the display is positioned off the left side of the screen. However, this current drops to zero before the Left Output Amplifier stage is turned off or the Right Output Amplifier stage is saturated. Further positioning current beyond the point of limiting to the left side flows through diode D360. This current holds the voltage bias of diodes D361 and D362 near zero so the diodes recover quickly (for fast, magnified sweeps). The Diode Limiter stage operates in a similar manner when the trace is positioned to the right side of the display area. Quiescent current through D363 and D371 is equal for an on-screen display and it decreases to zero as the display is positioned off the right side of the screen. This occurs before the Right Output Amplifier is cut off or the Left Output Amplifier is saturated.

Left Output Amplifier

Q373 and Q374 are connected as a current-driven feedback amplifier with a low input impedance. The Horiz Cent adjustment balances DC input current to the amplifier to produce a centered spot when a zero-deflection signal is applied to the input. Negative feedback is provided from the anode of zener diode D374 to the base of Q373 through R376 and R371 at DC and low sweep rates, and through C377 at fast sweep rates. C377 adjusts the feedback for optimum linearity at fast sweep rates.

Zener diode D397 and diodes D395 and D396 limit the positive-going output swing of Q374 and Q394. This limiting takes place only if some condition occurs which would otherwise damage Q374 or Q394. The current flow through R398, D397 and R397 sets a level of about +120 volts at the cathodes D395 and D396. If the collector of either Q374 or Q394 exceeds this voltage, the corresponding diode is forward biased and prevents the voltage from going any further positive.

The Horiz Gain adjustment, R377, varies the resistive feedback of the Left Output Amplifier stage and the Right Output Amplifier stage to control the overall gain of the Horizontal Amplifier circuit. C378 provides medium frequency compensation for optimum sweep linearity.

Right Output Amplifier

The Right Output Amplifier stage operates in basically the same manner as just described for the Left Output Amplifier stage. The deflection signal for the right deflection plate of the CRT is obtained directly from the collector of Q394. The high-frequency linearity is controlled by feedback capacitor C397.

The BEAM FINDER switch, SW360, limits the horizontal scan, when pressed, to present a display which is within the graticule area of the CRT. When SW360 is pressed, the horizontal deflection signal to the Right Output Amplifier stage is disconnected. The horizontal deflection of the CRT is now produced only by the Left Output Amplifier stage and this deflection is not sufficient to deflect the beam beyond the graticule limits.

Horizontal Positioning Network

The Horizontal Positioning Network (shown in Interconnecting Sockets diagram 6) provides the control voltages necessary to determine the horizontal position of the trace. These voltage levels are connected to the time-base unit through terminals 23, 24, 25 and 26 of the interconnecting plug, J21. The POSITION control, R350A, and FINE control, R350B, are connected in parallel. The POSITION control provides rapid positioning and the FINE control provides more precise positioning.

LOW-VOLTAGE POWER SUPPLY

General

The low-voltage Power Supply circuit provides the operating power for this instrument from four regulated supplies and one unregulated supply. Electronic regulation[1] is used to provide stable, low-ripple output voltages. Each regulated supply contains a short-protection circuit to prevent instrument damage if a supply is inadvertently shorted to ground. The Power Input block includes the power transformer and the Voltage Selector Assembly. The Voltage Selector Assembly allows selection of the nominal operating voltage and regulating range for the instrument. Fig. 3-4 shows a detailed block diagram of the Power Supply circuit. A schematic of this circuit is shown on diagram 3 at the rear of this manual.

Power Input

Power is applied to the primary of transformer T601 through the EMI (electro-magnetic interference) filter, 115-volt line fuse F601, POWER switch SW601, thermal cutout TK601, Voltage Selector switch SW602 and Range Selector Switch SW603. The Voltage Selector switch SW602 connects the split primaries of T601 in parallel for 115-volt nominal operation, or in series for 230-volt nominal operation. A second line fuse, F602, is connected into the circuit when the Voltage Selector switch is set to the 230 V position to provide the correct protection for 230-volt operation (F602 current rating is one-half of F601 rating). Each half of the primary winding has taps above and below the 115-volt (230) nominal point. The Range Selector switch, SW603, uses these taps to allow the instrument to regulate correctly on higher or lower than normal line voltages. As the Range Selector switch is switched from LO to M to HI, more turns are effectively added to the primary winding and the turns ratio is decreased. This provides a fairly constant voltage in the secondary of T601 even though the applied line voltage has increased.

Thermal cutout TK601 provides thermal protection for this instrument. If the internal temperature of the instrument exceeds a safe operating level, TK601 opens to interrupt the applied power. When the temperature returns below a safe level, TK601 automatically closes to reapply the power.

—75-Volt Supply

The —75-Volt Supply provides the reference voltage for the other regulated supplies. The output from the secondary of T601 is rectified by bridge rectifier D612A-D. The unregulated voltage across filter capacitor C612 is applied to the —75-Volt Series Regulator stage. The current through the Series Regulator stage is controlled by the Error Amplifier to provide the correct regulated output voltage.

The Error Amplifier is connected as a difference amplifier[2] (comparator). Reference voltage for the comparator is provided by zener diode D609 which sets the base of Q614A at about —9 volts. The base level of Q614B is determined by divider R630-R631-R632-R634 between the output of this supply and ground. R631 is adjustable to set the output voltage of this supply to —75 volts. R612 is the emitter resistor for both halves of the comparator and the current through it divides between Q614A and Q614B. The output current of the Error Amplifier stage controls the conduction of the Series Regulator stage (through Q623 and Q633). This output current changes to maintain nearly equal voltages at the bases of Q614A and Q614B to hold the output voltage constant. The output voltage is adjusted as follows: If the —75 Volts adjustment, R631, is turned clockwise, the current through Q614B increases (Q614B base voltage tends to go more positive than the base of Q614A) and the current through Q614A decreases. Decreased current through Q614A produces less voltage drop which results in increased base current to Q623. The emitter of Q623 rises positive and pulls the base and emitter of Q633 positive also to increase the conduction of the Series Regulator transistor, Q637. The increased current through the Series Regulator stage increases the current to the load and the output voltage increases. This places more voltage across divider R630-R631-R632-R634 and the divider action returns the base of Q614B to about —9 volts. A similar, but opposite, action takes place when R631 is turned counterclockwise.

The output voltage is regulated to provide a constant voltage to the load by feeding a portion of the output voltage back to the Series Regulator, Q637. For example, assume that the output voltage increases (more negative) because of a decrease in load or an increase in line voltage. This negative-going level at the output is applied across the voltage divider R630-R631-R632-R634 and causes the base of Q614B to go negative. The current flow through Q614B is reduced which makes Q614A conduct more, bringing its collector negative. When the collector of Q614A goes negative, it

[1] Phillip Cutler, "Semiconductor Circuit Analysis", McGraw-Hill, New York, 1964. pp. 559-625.

[2] Ibid., pp. 365-372.

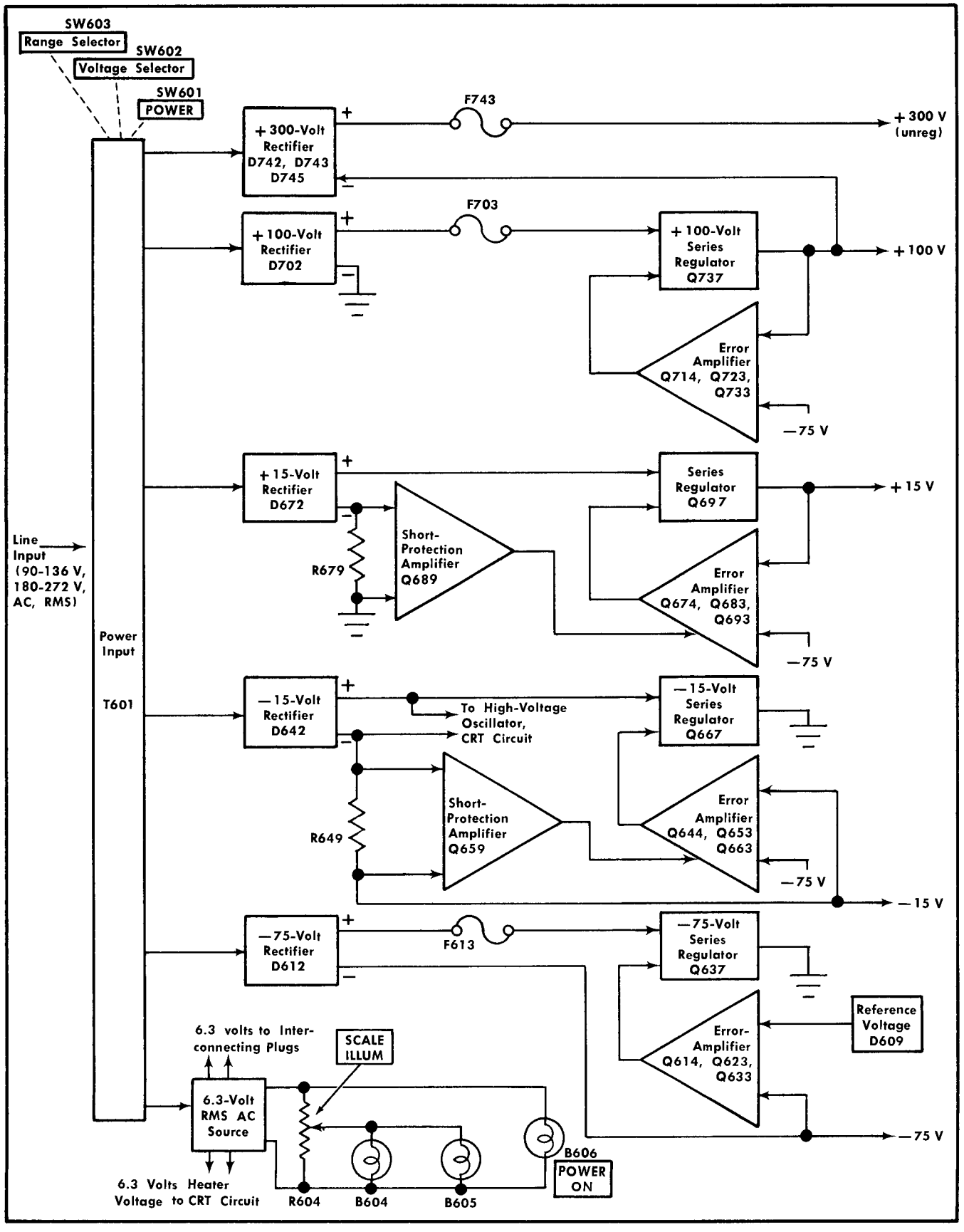


Fig. 3-4. Power Supply detailed block diagram.

results in reduced current through Q623, Q633 and Q637. Reduced current through Q637 means that there is less current through the load and the output voltage decreases (less negative) to correct the original voltage change. In a similar manner the Series Regulator and Error Amplifier stages compensate for output changes due to ripple.

Zener diode D636 and fuse F613 protect this supply if the —75-Volt output is shorted. For normal operation, D636 is not conducting and does not affect the circuit. However, when the output is shorted, the voltage across Q637 increases. D636 and R636 connect this increase in voltage back to the base of Q637, forcing it to conduct heavily. This arrangement turns Q637 on very quickly when the output is shorted to greatly increase its collector current. The increased current through Q637 causes fuse F613 to open and interrupt the unregulated voltage to this supply before the shorted condition can cause damage. The operating current for Q614A is supplied by the +100-Volt Supply. The +100-Volt Supply has a similar protection circuit which interrupts its output when it is shorted. Therefore, the —75-Volt Supply shuts off when the +100-Volt Supply is shorted. Since the —75-Volt Supply provides the reference voltage for the remaining supplies, all regulated outputs are reduced when the —75-Volt Supply or the +100-Volt Supply are shorted. Diode D611 protects Q614A and Q623 when the —75-Volt Supply is shorted to ground.

—15-Volt Supply

Rectified voltage for operation of the —15-Volt Supply is provided by D624A-D. The unregulated voltage across the filter capacitor C642 is connected to the —15-Volt Series Regulator and to the High-Voltage Oscillator in the CRT Circuit. Reference voltage for the —15-Volt Supply is provided by voltage divider R660-R661-R662 between the regulated —75 volts and ground. The —15-Volts adjustment, R661, varies the voltage at the base of Q644 to set the output level of this supply. The —75-volt level is held stable by the —75-Volt Supply as discussed previously. If the —15-volt output changes, this change appears at the emitter of Q644 as an error signal. Regulation of the output voltage is controlled by the —15-Volt Series Regulator stage, Q667, in a similar manner to that described for the —75-Volt Supply. Diode D669 provides thermal compensation for the base-emitter junction of Q644.

Shorting protection for this supply is provided by current limitation. For normal operation, the emitter-base voltage of the Short Protection Amplifier stage, Q659, is not enough to bias it on. However, when the output is shorted, high current is demanded from the Series Regulator, Q667, and this current flows through R649. The voltage drop across R649 becomes sufficient to forward bias Q659 and its collector current produces a control level which limits the conduction of the Series Regulator to protect it from exceeding its current rating. Diode D650 protects Q653 if the +15-Volt Supply is shorted to ground.

+15-Volt Supply

Diodes D672A-D provide the rectified voltage for the +15-Volt Supply. This supply operates in a similar manner to the —15-Volt Supply except that the negative side of the supply is connected to ground to provide a positive output voltage. Output level of this supply is set by the +15 Volts adjustment, R691.

+100-Volt Supply

Rectified voltage for operation of the +100-Volt Supply is provided by D702A-D. The unregulated voltage across C702 is connected to the +100-Volt Series Regulator. Reference voltage for this supply is provided by voltage-divider R730-R731-R732 between the regulated —75 volts and the output of this supply. Since the —75-volt level is held stable by the —75-Volt Regulator circuit, any change at the base of Error Amplifier Q714 is due to a change at the output of the +100-Volt Supply. Regulation of the output voltage is controlled by Error Amplifier Q714-Q723-Q733 and Series Regulator Q737 in a manner similar to that described for the —75-Volt Supply. The +100-Volts adjustment, R731, sets the quiescent conduction level of the Error Amplifier stage to provide an output level of +100 volts. R719 and zener diode D716 are connected between the +300-volt and +100-volt supplies to establish a stable +200 volts at the cathode of D716. This +200 volts is the collector supply voltage for Q714. R714, R716 and zener diode D714 set the DC operating level of Q714. Diode D712 protects Q714 if the output of the +100-Volt Supply is shorted. D743 and C743 provide the collector supply voltage for Q723 and Q733. Shorting protection for this supply is provided by zener diode D736 and R736 as in the —75-Volt Supply. D736 increases the conduction of the Series Regulator, Q737, when the output is shorted, to quickly open fuse F703 to interrupt the current flow. Diode D737 protects the +100-Volt Supply from damage if it is shorted to one of the negative supplies.

+300-Volt Unregulated Supply

Diodes D742 and D745 are connected as a full-wave center-tapped rectifier and the output is filtered by C742. The unregulated voltage across C742 (about +200 volts) is connected in series with the +100-Volt Supply to obtain the +300-volts unregulated output. Fuse F743 protects this supply if the output is shorted. R745 and C745 provide high-frequency filtering for the entire supply.

6.3-Volt RMS AC Sources

The four 6.3-volt RMS secondary windings of T601 provide power for the POWER ON light B606 and scale illumination lights B604 and B605, heater voltage for the CRT and 6.3 volts for the plug-in units. The 6.3-volt winding for the CRT is elevated to —2.2 kV. The SCALE ILLUM control, R604, controls the current through B604 and B605 to control the illumination of the graticule lines.

CRT CIRCUIT

General

The CRT Circuit provides the high voltage and control circuits necessary for operation of the cathode-ray tube (CRT). This circuit also contains the Z Axis Amplifier which determines the trace intensity. Fig. 3-5 shows a detailed block diagram of the CRT Circuit. A schematic of this circuit is shown on diagram 4 at the rear of this manual.

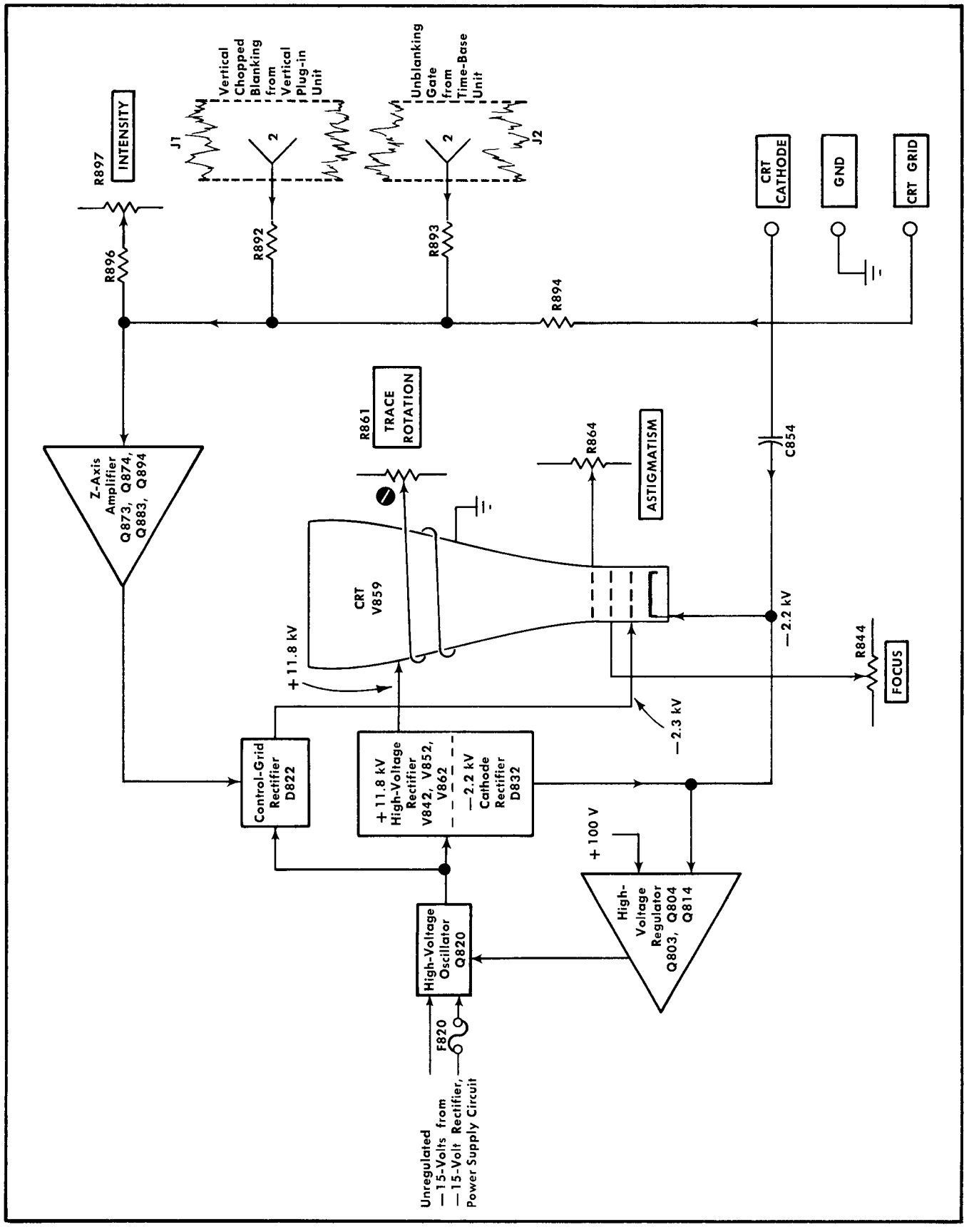


Fig. 3-5. CRT Circuit detailed block diagram.

High-Voltage Oscillator

Q820 with its associated circuitry comprises a class C oscillator[3] to produce the drive for the high-voltage transformer, T820. When the instrument is turned on, the current through R817 charges C821 positive and Q820 is forward biased. The collector current of Q820 increases and a voltage is developed across the collector winding of T820. This produces a corresponding voltage increase in the feedback winding of T820 which is connected to the base of Q820, and it conducts even harder. While Q820 is on, its base current exceeds the current through R817 and C821 charges negatively. Eventually the rate of collector current increase in Q820 becomes less than that required to maintain the voltage across the collector winding and the output voltage drops. This turns off Q820 by way of the feedback voltage to the base. The voltage waveform at the collector of Q820 is a sine wave at the resonant frequency of T820. Q820 remains off until a little less than one cycle later when C820 discharges sufficiently to raise the voltage at the base of Q820 positive enough to bias Q820 into conduction again. The cycle repeats at a frequency of 40 to 50 kilohertz. The amplitude of sustained oscillation depends upon the average current delivered to the base of Q820.

Fuse F820 protects the —15-Volt Supply if the High-Voltage Oscillator stage is shorted or the feedback path opens. The filter network, C820-L820, prevents the 50-kilohertz current changes in the High-Voltage Oscillator stage from affecting the —15-volt regulator circuit.

High-Voltage Regulator

The +100-volt supply is the reference voltage for the High-Voltage Regulator circuit. Feedback from the secondary of T820 is connected to the base of Q803 through the voltage dropping network R802A, B, C, D, E, F. This portion of the —2.2 kV Cathode Rectifier output voltage is amplified by Q803, Q804 and Q814 and becomes a controlling current into the base of Q820. This determines the amplitude of the oscillations at the collector of Q820.

Regulation takes place as follows: If the output voltage at the HV Test Point starts to go positive (less negative), a portion of this positive-going voltage is applied to the base of Q803. The current through Q803 increases and it, in turn, increases the current through Q804 and Q814. An increase in current through Q814 means that more average current is applied to the base of Q820. More base current in Q820 increases the collector current which produces a larger induced voltage in the secondary of T820. This increased voltage appears as a more negative voltage at the HV Test Point to correct the original positive-going change. This feedback regulates the output of the —2.2 kV Cathode Rectifier.

Output voltage level of the high-voltage supply is controlled by the High Voltage adjustment, R801, in the base circuit of Q803. This control permits a "fine" adjustment of the +100-volt reference voltage for the regulator applied through R803 and it sets the output level to which the circuit regulates.

[3]Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics", second edition, McGraw-Hill, New York, 1962. pp. 14-19 — 14-21.

High-Voltage Rectifiers

The high-voltage transformer, T820, has two high-voltage output windings and three low-voltage windings. The low-voltage windings provide filament voltage for V842, V852 and V862. The two high-voltage windings provide the negative and positive accelerating voltage, and the CRT grid bias voltage. All of these outputs are controlled by the High-Voltage Regulator stage.

Positive accelerating potential for the CRT anode is supplied by voltage tripler V842-V852-V862. This rectified voltage is filtered by the network C838-R838 to provide an output of about +11.8 kilovolts. The load return for this supply is through the resistive helix inside the CRT to pin 7 of the CRT, and then to ground through R850-R851 and the +100-volt supply.

The negative accelerating potential for the CRT cathode is supplied by the half-wave rectifier D832. Voltage output is about —2.2 kilovolts. A portion of this output voltage is connected to the High-Voltage Regulator stage to provide a regulated high-voltage output.

The half-wave rectifier D822 provides a negative voltage for the control grid of the CRT. The output level of this supply is adjustable to determine the control-grid to cathode bias. This adjustment determines the positive reference voltage of the —2.2 kV Cathode Rectifier which in turn controls the output of the Control-Grid Rectifier stage. This occurs as follows: The High Voltage adjustment, R801, is adjusted to provide —2.2 kV at the HV Test Point (referenced to ground) and the High-Voltage Regulator stage is designed to hold the output voltage constant at this level. When the setting of the CRT Grid Bias adjustment R832 is changed, the positive voltage of the supply (at the junction of C831-R831) is changed. For example if R832 is rotated counterclockwise, the voltage at the junction of C831-R831 rises more positive. This tends to shift the voltage level at the HV Test Point slightly positive. This error is sensed by the High-Voltage Regulator stage and a correcting signal is connected to the High-Voltage Oscillator stage to make it produce more current in the secondary of T820 to return the HV Test Point to —2.2 kV. The increased secondary voltage also increases the output of the Control-Grid Rectifier stage making the CRT grid bias more negative (cathode level regulated at —2.2 kV). The positive accelerating potential of the CRT anode changes also, although the change is insignificant in relation to the overall voltage output from the supply. Action is similar but opposite when the CRT Grid Bias control is rotated clockwise.

The neon bulbs B852-B853-B854 provide protection for the CRT if the voltage difference between the control grid and the cathode exceeds about 180 volts. The unblanking pulse from the Z-Axis Amplifier is connected to the positive side of the Control Grid Rectifier to change the control grid level and determine CRT intensity, trace unblanking, dual-trace blanking and intensity modulation level.

CRT Control Circuits

Focus of the CRT display is controlled by the FOCUS control, R844. The divider R840-R841-R842-R843-R844-R845 is connected between the CRT cathode supply and ground. The voltage applied to the focus grid is more positive (less negative) than the voltage on either the control grid or the

CRT cathode. The ASTIGMATISM control, R864, which is used in conjunction with the FOCUS control to provide a well-defined display, varies the positive level on the astigmatism grid.

The Geometry adjustment, R863, varies the 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 within the CRT. The Y Axis Alignment adjustment, R865, controls the current through L865 which affects the beam after vertical deflection but before horizontal deflection. The TRACE ROTATION adjustment, R861, controls the current through L861 and affects both vertical and horizontal rotation of the beam.

An external signal applied to the CRT CATHODE connector is connected to the cathode of the CRT through R855 and C854. C854 couples all but the low-frequency signals to the CRT cathode. This signal increases or decreases the display intensity, depending on polarity, to produce an intensity modulated display.

Z-Axis Amplifier

The input transistor, Q894, in the Z-Axis Amplifier circuit is a current-driven, low-impedance amplifier. It provides termination for the input signals as well as isolation between the input signals and the following stages. The current signals from the various control sources are connected to the emitter of Q894 and the sum of the signals determines the collector level. D884 and D886 in the collector provide overdrive limiting for the amplifier at minimum intensity. When the INTENSITY control is set fully counterclockwise (minimum), the collector current of Q894 is reduced and its collector rises positive. D886 is reverse biased and D884 is forward biased to limit the current to the base of Q883 and clamp the collector of Q894 about 0.6 volts more positive than the emitter level of Q883. At normal intensity levels, D884 is reverse biased and the signal from Q894 is coupled to the base of Q883 through D886.

The input signals vary the current drive to the emitter of Q894 which produces a collector current to determine the brilliance of the display. The INTENSITY control sets the quiescent level at the emitter of Q894. When R897 is turned in the clockwise direction, more current is added to the emitter of Q894, which increases the overall output from this circuit to provide a brighter display. However, the vertical chopped blanking, unblanking gate and the CRT GRID input signals determine whether the trace is visible. The vertical chopped blanking signal from the vertical plug-in unit blanks the trace during dual-trace switching. This positive pulse decreases the current through Q894 during trace switching time to blank the CRT display. The unblanking gate from the time-base unit blanks the CRT during sweep retrace and recovery time so there is no display on the screen. When the time-base unit is triggered to produce a sweep, a negative-going unblanking gate current is connected to the emitter of Q894 to allow the emitter current to reach the level established by the INTENSITY control and the other blanking inputs. An external blanking signal can be connected to the CRT GRID binding post to change the trace intensity. A positive-going signal connected to the CRT GRID connector decreases trace intensity and a negative-going signal increases trace intensity.

Q883 and Q874 are connected as a feedback amplifier with DC feedback provided by R878. Capacitors C877, C878 and C879 provide high-frequency feedback. Variable capacitor C879 is adjusted for optimum step response to provide an even unblanking level at fast sweep rates. For fast, positive-going changes (unblanking) C874-R874-D874-R871 serve as a bootstrapping circuit which provides extra current to charge the stray capacitance at the base of Q873 more rapidly. For negative-going changes, diode D873 is forward biased to pull the output rapidly negative in spite of the fact that Q873 is driven into cutoff. Diode D872 prevents the emitter level of Q873 from rising above +100 volts. The output unblanking pulse at the emitter of Q873 is connected to the CRT circuit through D870 and D871. These diodes protect the Z-Axis Amplifier stage if the Control-Grid Rectifier stage is shorted.

CALIBRATOR

General

The Calibrator circuit produces a square-wave output with accurate amplitude and frequency. This output is available as a square-wave voltage at the CAL OUT connector or as a square-wave current through the 5 mA probe current loop. An accurate +100 volts DC level is also available. The CALIBRATOR switch selects the attenuation of the output signal to provide square-wave voltage outputs between 100 volts and 0.2 millivolts peak to peak. Fig. 3-6 shows a detailed block diagram of the Calibrator circuit. A schematic of this circuit is shown on diagram 5 at the rear of this manual.

Calibrator Oscillator

The Calibrator Oscillator stage is a crystal-controlled oscillator with an oscillating frequency of four kilohertz as determined by crystal Y900. The signal at the collector of Q900 is connected to the base of Q924 through C914. Feedback from the collector of Q924 to crystal Y910 through R903 and R904 sustain the oscillation of the circuit. The collector signal of Q924 is connected to the Calibrator Multivibrator stage through C924 and C925. The CALIBRATOR switch, SW948, connects the emitter circuits of Q910 and Q924 to —15 volts in all positions except OFF and 100 V DC. In these two positions, the Calibrator Oscillator stage is inoperative.

Calibrator Multivibrator

The Calibrator Multivibrator stage is a bistable multivibrator[1]. The state of this multivibrator is switched with every other cycle from the Calibrator Oscillator stage to provide an output frequency of one kilohertz from a four kilohertz switching signal. This occurs as follows: For purposes of explanation, assume that Q935 has just switched off and Q945 has just switched on. When Q935 turns off, its collector goes positive and D933 is forward biased. C924 charges positive through R933 and D933, and this positive-going voltage across C924 holds D932 reverse biased. When Q945 turns on, its negative-going collector level reverse biases D943 and the charge path of C925 through R943 is interrupted. C925 begins to discharge

[1]Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms", McGraw-Hill, New York, 1965. pp. 362-389.

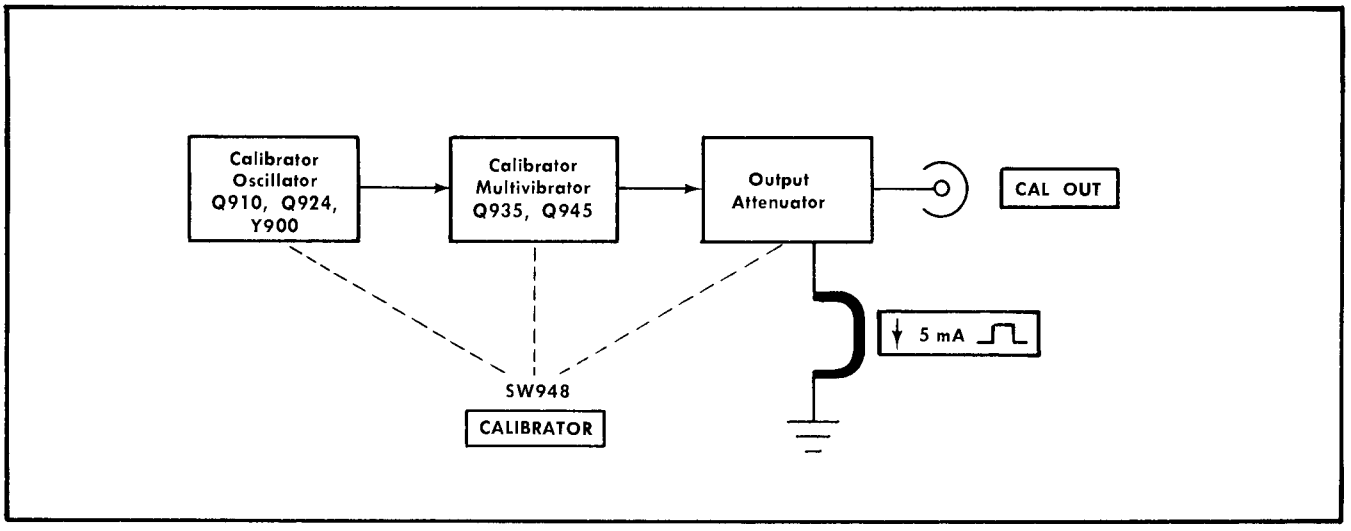


Fig. 3-6. Calibrator detailed block diagram.

through R942 and it holds D942 reverse biased. The steering diodes in this circuit, D932 and D942, accept negative-going trigger pulses. With the circuit conditions as described, both steering diodes are reverse biased to prevent any trigger signals from reaching the multivibrator. The discharge time of C925 determines when Q945 can be switched off and Q935 switched on. This discharge time is such that the first negative-going portion of the oscillator signal applied through C925 is blocked by D942. However, when the oscillator signal goes negative again, C925 has discharged enough to allow D942 to conduct. The negative signal is connected to the base of Q945 through D942 and Q945 is reverse biased. Its collector rises positive and C945-R945 couple this positive change to the base of Q935 to turn it on. The collector of Q935 goes negative and the coupling through C935-R935 to the base of Q945 aids the multivibrator in rapidly switching states.

Now conditions are reversed. D943 is forward biased and C925 is charged positive to hold D942 reverse biased. D932 is held reverse biased as C924 discharges through R932 and it cannot switch with the first negative-going signal from the Calibrator Oscillator stage. When the second negative-going signal arrives, C924 is discharged enough so D932 conducts and the multivibrator is switched to complete the cycle. Notice that the Calibrator Multivibrator stage completes one complete cycle with each four negative-going signals from the Calibrator Oscillator stage (four complete cycles). The —15-volt emitter voltage for Q935 and Q945 is disconnected by the CALIBRATOR switch in the OFF and 100 V DC positions to make the Calibrator Multivibrator inoperative.

Output Attenuator

When Q945 in the Calibrator Multivibrator stage is on, its collector drops to about —14 volts which reverse biases D948. Since there is no current through the divider resistors to the load, the output level drops to zero volts. When Q945 turns off, its collector rises positive to about +100.5 volts as set by R946-D947-R947 between +100 and +300 volts. D944 is reverse biased to disconnect this positive level from the base of Q935 and from ground through R944. D948 is forward biased and its junction voltage drop equals that of D947 to return the level at its cathode to +100 volts. The signal voltage available at the CAL OUT connector is determined by divider R948B-Z (made up of 13 precision resistors) and the setting of the CALIBRATOR switch. In the 100 V DC position, the Calibrator Oscillator and Calibrator Multivibrator stages are inoperative to produce a +100-volt DC output level. In the 100 VOLTS to .2 mV positions, precision divider resistors are switched into the circuit to provide the correct output square-wave voltage. The positions of .2 VOLTS and below have an accurate 50-ohm output resistance. In the 5 mA square-wave position, the square-wave voltage to the CAL OUT connector is disconnected. The +100-volt square-wave at the cathode of D948 is connected to the current probe loop through resistors R948B-K. These resistors provide an accurate 20 kilohm series resistance to set the current through the current probe loop to an accurate five-milliampere square wave.

INTERCONNECTING SOCKETS

General

Diagram 6 shows the interconnections between the Power Supply outputs and the vertical interconnecting plug, J11, and the horizontal interconnecting plug, J21. This diagram also shows the connection to rear-panel connector J101.

NOTES

SECTION 4

MAINTENANCE

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 647A.

Panel Removal

The side panels of the Type 647A are held in place by two slotted fasteners. To remove the panels, turn each fastener counterclockwise a quarter turn with a large screwdriver, coin or similar device. Then, pull the panel out at the top and lift away from the instrument. The bottom panel can be removed to reach the bottom areas of the instrument by removing the six screws which hold it in place. The panels protect this instrument from dust in the interior. The panels also direct the flow of cooling air and reduce the EMI radiation from the instrument.

Access to Rear Subpanel

The components and test points on the rear subpanel can be reached by swinging the radiator door aside. This door is held in place by the two securing screws on the left side.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regulator basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the Type 647A is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

The Type 647A 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.

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 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 647A 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.

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

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-velocity 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 connector, should receive special attention. Excessive dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be maintained if they are kept properly lubricated. Use a cleaning-type lubricant (e.g., Tektronix Part No. 006-0218-00) on switch contacts and the interconnecting plug contacts. Lubricate switch detents with a heavier grease (e.g., Tektronix Part No. 006-0219-00). Potentiometers which are not permanently sealed should be lubricated with a lubricant which does not affect electrical characteristics (e.g., Tektronix Part No. 006-0220-00). The pot lubricant can also be used on shaft bushings. Do not over lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order Tektronix Part No. 003-0342-00.

Visual Inspection

The Type 647A should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors or nuvistors, damaged 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 a recurrence of the damage.

Transistor Checks

Periodic checks of the transistors in the Type 647A are not recommended. The best check of transistor performance is its actual operation in the instrument. More details on checking transistor operation is 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 circuit. Complete calibration instructions are given in the Calibration section.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 647A, if trouble develops. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective components. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description section for complete information.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in Section 9. 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 647A and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams at the rear of this manual. The portion of the circuit mounted on the circuit board is enclosed with a blue line.

TABLE 4-1

Component Numbers

Component Numbers on diagrams	Diagram Number	Circuit
300-399	1	Horizontal Amplifier
400-499	2	Vertical Amplifier
600-799	3	Power Supply
800-899	4	CRT Circuit
900-999	5	Calibrator

Switch Wafer Identification. Switch wafers shown on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters F and R indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

Circuit Board. Fig. 4-5 shows the circuit board used in the Type 647A. Each electrical component on the board is identified by its circuit number. The circuit board is also outlined on the Vertical Amplifier diagram with a blue line. This picture used along with the diagram will aid in locating the components mounted on the circuit board.

Wiring Color-Code. All insulated wire and cable used in the Type 647A is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using the EIA resistor color code. A white background color indicates a positive voltage and a tan background indicates a negative voltage. The widest color stripe identifies the first color of the code. Table 4-2 gives the wiring color-code for the power-supply voltages used in the Type 647A.

TABLE 4-2

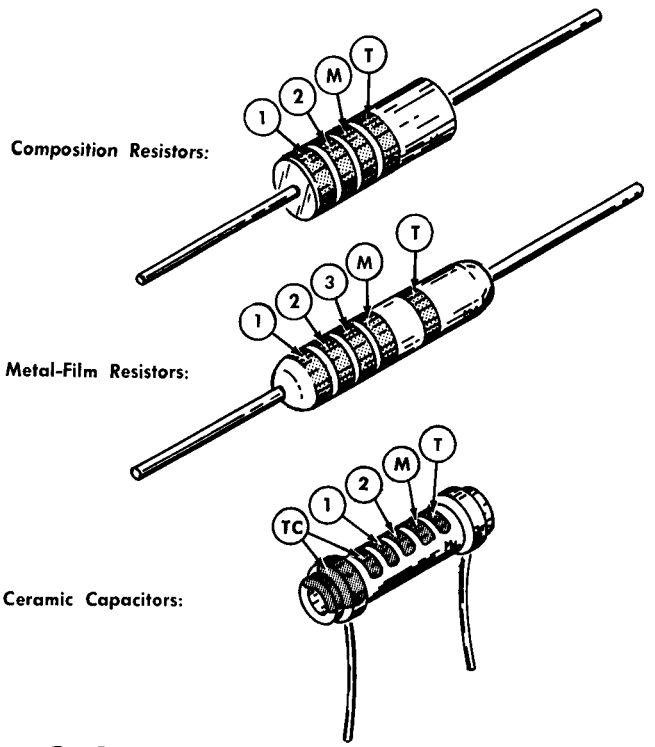
Power Supply Wiring Color Code

Supply	Background Color	First Stripe	Second Stripe	Third Stripe
−75 volt	Tan	Violet	Green	Black
−15 volt	Tan	Brown	Green	Black
+15 volt	White	Brown	Green	Black
+100 volt	White	Brown	Black	Brown
+300 volt	White	Orange	Black	Brown

Resistor Color-Code. In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the Type 647A. 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 (some metal-film resistors may have the value printed on the body) with EIA color-code. 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. 4-1). 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 647A are color coded in picofarads using a modified EIA code (see Fig. 4-1).

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 also indicates the type of diode and identifies the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded blue-brown-gray-green indicates diode type 6185 with Tektronix Part Number 152-0**185**-00. The cathode and anode end of metal-



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: 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.

(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

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

Fig. 4-1. Color-code for resistors and ceramic capacitors.

encased diodes can be identified by the diode symbol marked on the body.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 647A.

1. Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

2. Multi-ohmmeter

Description: VTVM, 10-megohm input impedance and 0 to 500 volts range; ohmmeter, 0 to 50 megohms. Accuracy, within 3% (0.1% accuracy necessary to check power supply voltages). Test prods must be insulated to prevent accidental shorting.

Purpose: To check operating 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 MHz frequency response, 50 millivolts to 50 volts/division deflection factor. Use a 10× probe.

Purpose: To check waveforms in the 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 of this manual.

2. Check Associated Equipment. Before proceeding with troubleshooting of the Type 647A, 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 647A 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 exists 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 of this manual.

5. Isolate Trouble to a Circuit. To isolate a trouble to a 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) is probably at fault. When trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings.

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. 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

Power Supply	Tolerance
—2200 volt	±44 volts
—75 volt	±0.56 volt
—15 volt	±0.15 volt
+15 volt	±0.15 volt
+100 volt	±1.0 volt

Fig. 4-2 provides a guide to aid in locating a defective circuit. This chart may 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 is not correct. 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). If the trouble has been isolated to the Vertical Amplifier circuit, check the pin connectors on the circuit board for correct connection. Fig. 4-5 shows the correct connections for this board.

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 647A. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. TRANSISTORS. The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can best be checked by substituting a new component 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 (such as Tektronix Type 575). Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

B. DIODES. A diode can be checked for an open or shorted condition by meansuring the resistance between terminals. With an ohmmeter scale having an internal source of between 800 millivolts and 3 volts, the resistance should be high in one direction and low when the leads are reversed.

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

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

E. CAPACITORS. A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Use an ohmmeter which will 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 whether the capacitor passes AC signals.

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

CORRECTIVE MAINTENANCE

General

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

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 647A 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 that 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 parts are used in the Type 647A. These parts 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 parts are indicated in the 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. Most components can be replaced without removing the boards from the instrument.

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.

3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint. 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 (if not clipped in step 3).

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

Ceramic Terminal Strips. Solder used on the ceramic terminal strips should contain about 3% silver. Use a 40- to 75-watt soldering iron with a 1/8-inch wide wedge-shaped tip. Ordinary solder can be used occasionally without damage to the ceramic terminal strips. However, if ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond may be broken.

A sample roll of 3% silver solder is mounted in this instrument. Additional silver solder should be available locally, or it can be purchased from Tektronix, Inc. in one-pound rolls; order by Tektronix Part No. 251-0514-00.

Observe the following precautions when soldering to ceramic terminal strips.

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.

2. Maintain a clean, properly tinned tip.

3. Avoid putting pressure on the ceramic terminal strip.

4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.

5. Clean the flux from the terminal strip with a flux-remover solvent.

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.

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.

Circuit Isolation Troubleshooting Chart

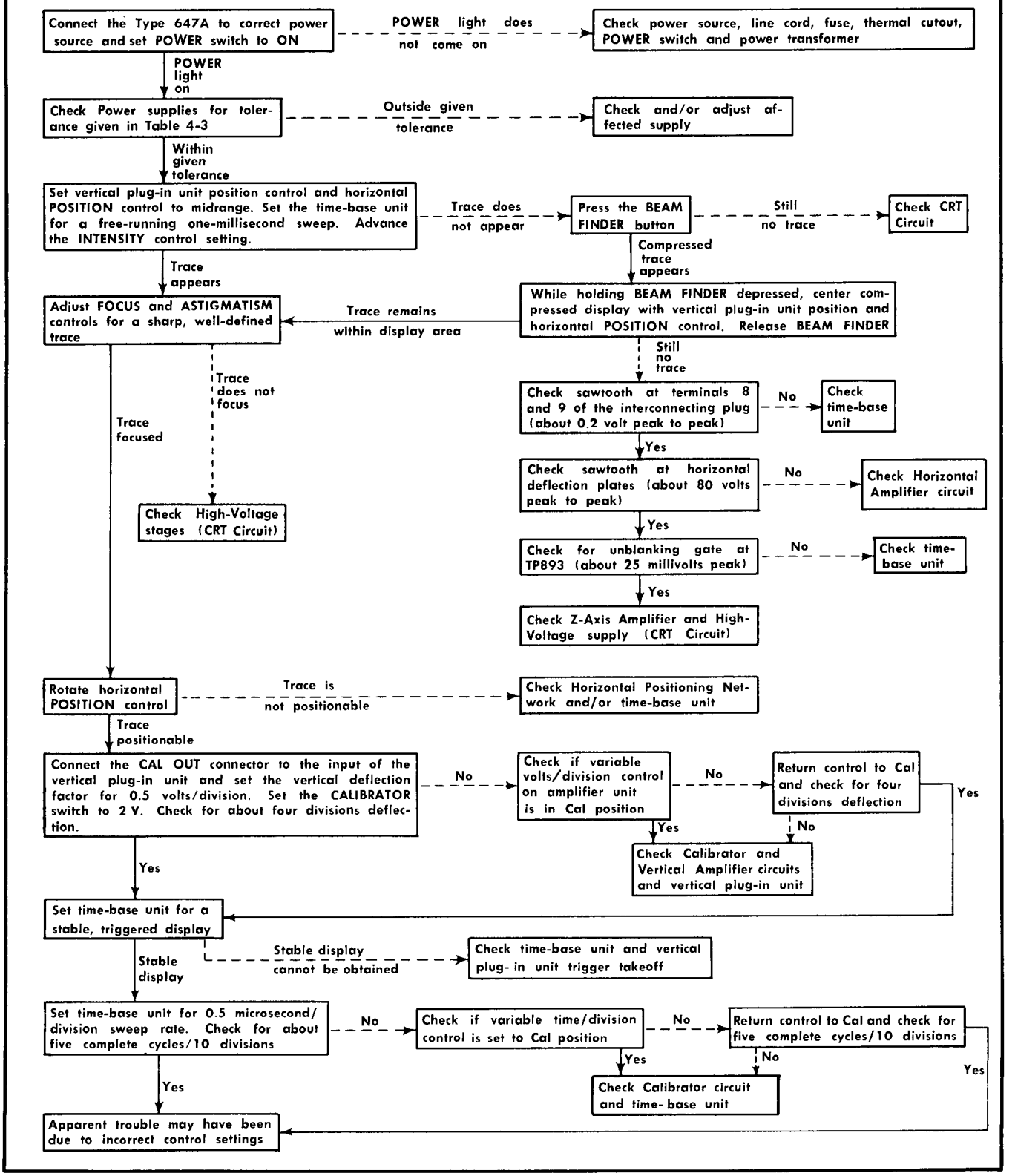


Fig. 4-2. Troubleshooting chart for Type 647A.

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.

Ceramic Terminal Strip Replacement. A complete ceramic terminal strip assembly is shown in Fig. 4-3. Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be re-used if they are not damaged. The applicable Tektronix Part Numbers for the ceramic strips and spacers used in this instrument are given in the Mechancial Parts List.

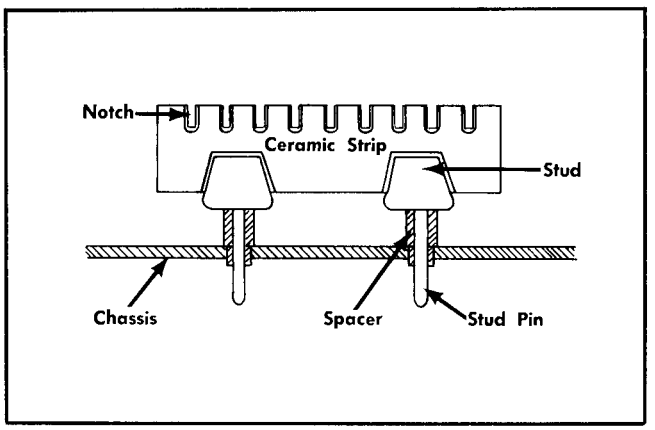


Fig. 4-3. Ceramic terminal strip assembly.

To replace a ceramic terminal strip, use the following procedure:

REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch to show location of the components and connections.

2. Pry or pull the damaged strip from the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

REPLACEMENT:

1. Place the spacers in the chassis holes.

2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft mallet and tap lightly, directly over the stud, to seat the strip completely.

3. If the stud extends through the spacers, cut off the excess.

4. Replace all components and connections. Observe the soldering precautions given under Soldering Techniques in this section.

Circuit Board Replacement. If the 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 or the unwired board. Most of the components mounted on the circuit board can be replaced without removing the board from the instrument. Observe the soldering precautions given under Soldering Techniques in this section. However, if the bottom side of the board must be reached or if the board must be moved to gain access to other areas of the instrument, only the mounting screws need to be removed. The interconnecting wires on the board are long enough to allow the board to be moved out of the way or turned over without disconnecting the pin connectors.

Most of the connections to the circuit board are made with pin connectors. Use the following procedure to remove a circuit board:

1. Disconnect all pin connectors from the board and unsolder the connections to the output transistors.

2. Remove all screws holding the board to the chassis.

3. Lift the circuit board out of the instrument. Do not force or bend the board.

4. To replace the board, reverse the order of removal. Correct location of the pin connectors is shown in Fig. 4-5. Replace the pin connectors carefully so they mate correctly with the pins. If forced into place incorrectly positioned, the pin connectors may be damaged.

Cathode-Ray Tube Replacement. 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 face down on a smooth surface with a protective cover or soft mat under the faceplate to protect it from scratches.

The following procedure outlines the removal and replacement of the cathode-ray tube:

REMOVAL:

1. Remove the side panels and open the rear radiator door as described previously.

2. Remove the CRT bezel.

3. Remove the light filter or faceplate protector.

4. Disconnect the CRT anode connector. Ground this lead and the anode connection to discharge any stored charge.

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

6. Remove the CRT socket.

7. Loosen the screw in the CRT clamp located by the rear subpanel.

8. Hold the left hand on the CRT faceplate and push forward on the CRT base with the right hand. As the CRT starts out of the shield, grasp it firmly with the left hand. When the CRT is free of the clamp, slide the CRT com-

pletely out of the shield. Be careful not to bend the neck pins.

REPLACEMENT:

1. Insert the CRT into the shield. Be careful not to bend the neck pins. Seat the CRT firmly against the front panel.

NOTE

All four edges of the flange around the CRT faceplate should touch the front panel of the instrument, but must not be forced. Instead, the CRT base clamp should be repositioned for correct alignment. The CRT base clamp is held in place by two allen-head machine screws which are accessible from the rear of the instrument through holes in the power-supply chassis. Loosen the screws and reposition the clamp as required. When the physical alignment of the CRT is corrected, tighten the machine screws and proceed to the next step. Do not tighten the base clamp at this time.

2. Replace the CRT socket.

3. Reconnect the anode connector. Align the jack on the CRT and the plug in the connector and press firmly on the insulated cover to snap the plug into place.

4. Reconnect the deflection-plate connectors. Correct location is indicated on the CRT shield.

5. Clean the CRT face and the filter or faceplate protector with denatured alcohol.

6. Re-mount the filter or faceplate protector and the bezel. Tighten the four bezel nuts.

7. Push lightly on the CRT base socket to be certain that the CRT is as far forward as it will go. Then tighten the CRT base clamp.

8. Check the calibration of the High Voltage, TRACE ROTATION, ASTIGMATISM, Y Axis Align and Geometry adjutsments. Adjustment procedure is given in the Calibration section.

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

Replacement transistors should be of the original type or a direct replacement. Re-mount the transistors in the same manner as the original. Transistors which have heat radiators or which 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.

Fig. 4-4 shows the lead configurations of the transistors used in this instrument. This view is as seen from the bottom of the transistor. Notice that there are two different lead configurations for plastic-case transistors. When replacing these transistors, check the manufacurer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the basing used for metal-case transistors.

Fuse Replacement. The power-line fuses are located on the rear panel. Low-voltage power-supply fuses are mounted on the rear subpanel behind the radiator door. Table 4-4 gives the value and location of the fuses used in this instrument.

TABLE 4-4

Fuse Ratings

Circuit Number	Rating	Location	Function
F601	4 A Fast	Voltage Selector Assembly	115-volt line
F602	2 A Fast	Voltage Selector Assembly	230-volt line
F613	0.5 A Fast	Rear Subpanel	−75 volts
F703	0.75 A Fast	Rear Subpanel	+100 volts
F743	0.75 A Fast	Rear Subpanel	+300 volts
F820	1 A Slow	Top side above high-voltage compartment	High voltage

Rotary Switches. Individual wafers or mechanical parts of rotary switches are normally not replaceable. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

When replacing a switch, tag the leads and switch terminals with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method is to draw a sketch of the switch layout and record the wire color at each terminal. When soldering to the new switch be careful that the solder does not flow beyond the rivets on the switch terminals. Spring tension of the switch contact can be destroyed by excessive solder.

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 is replaced, check the performance of the complete instrument using the Performance Check procedure.

High-Voltage Compartment. The components located in the high-voltage compartment can be reached for maintenance or replacement by using the following procedure.

1. Remove the right side panel of the instrument as described in this section.

2. Remove the five screws holding the high-voltage shield on the instrument.

3. Remove the two screws which hold the cover on the high-voltage compartment.

4. To remove the complete wiring assembly from the high-voltage compartment, unsolder the post-deflection anode lead (heavily insulated lead at front of compartment). The other leads are long enough to allow the assembly to be lifted out of the compartment to reach the parts on the under side. Then remove the remaining three screws which hold the box to the chassis.

5. To replace the high-voltage compartment, reverse the order of removal.

NOTE

All solder joints in the high-voltage compartment should have smooth surfaces. Any protrusions may cause high-voltage arcing at high altitudes.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that partcular 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 in Section 5 provides a quick and convenient means of checking instrument operation.

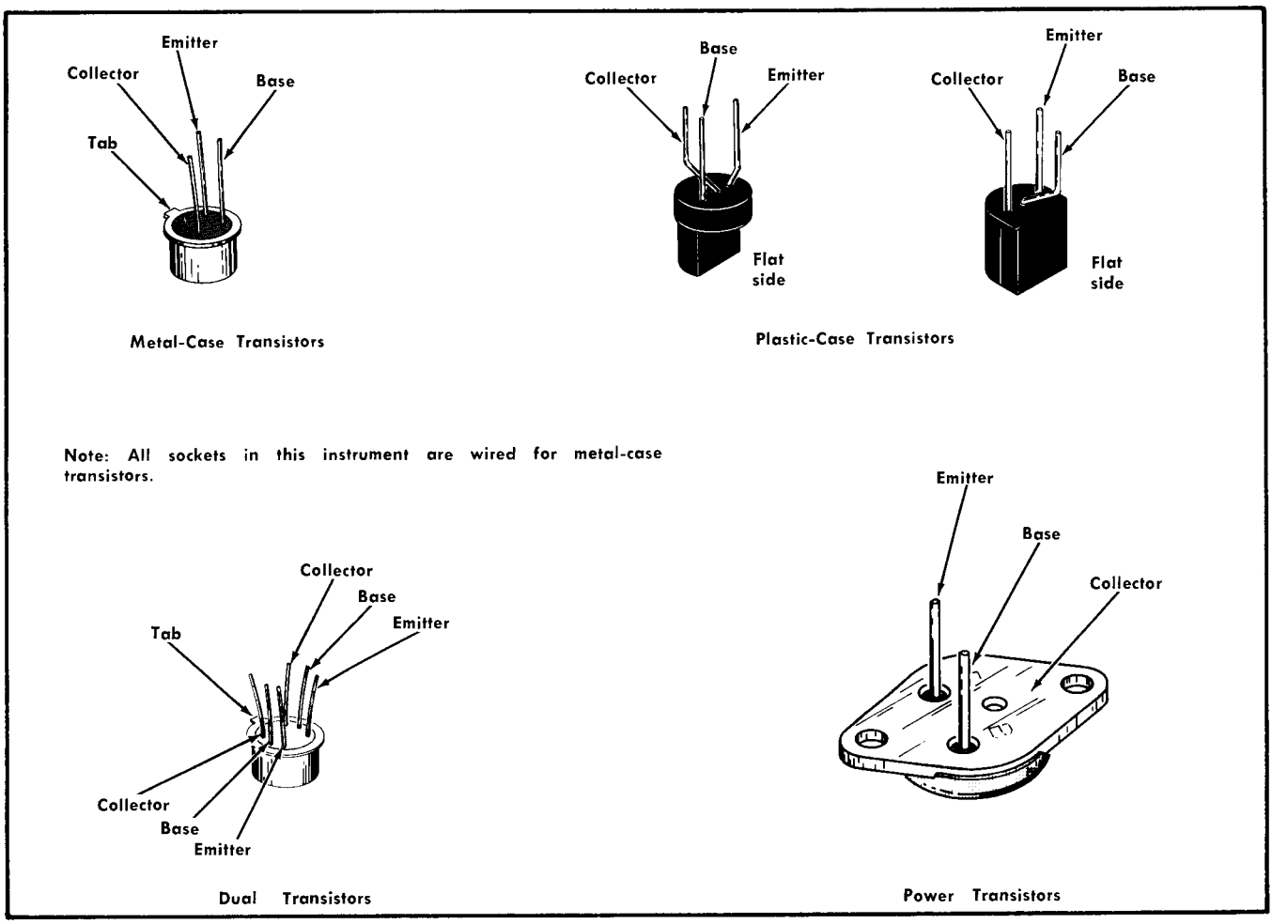


Fig. 4-4. Electrode configuration for transistors in this instrument (as viewed from bottom).

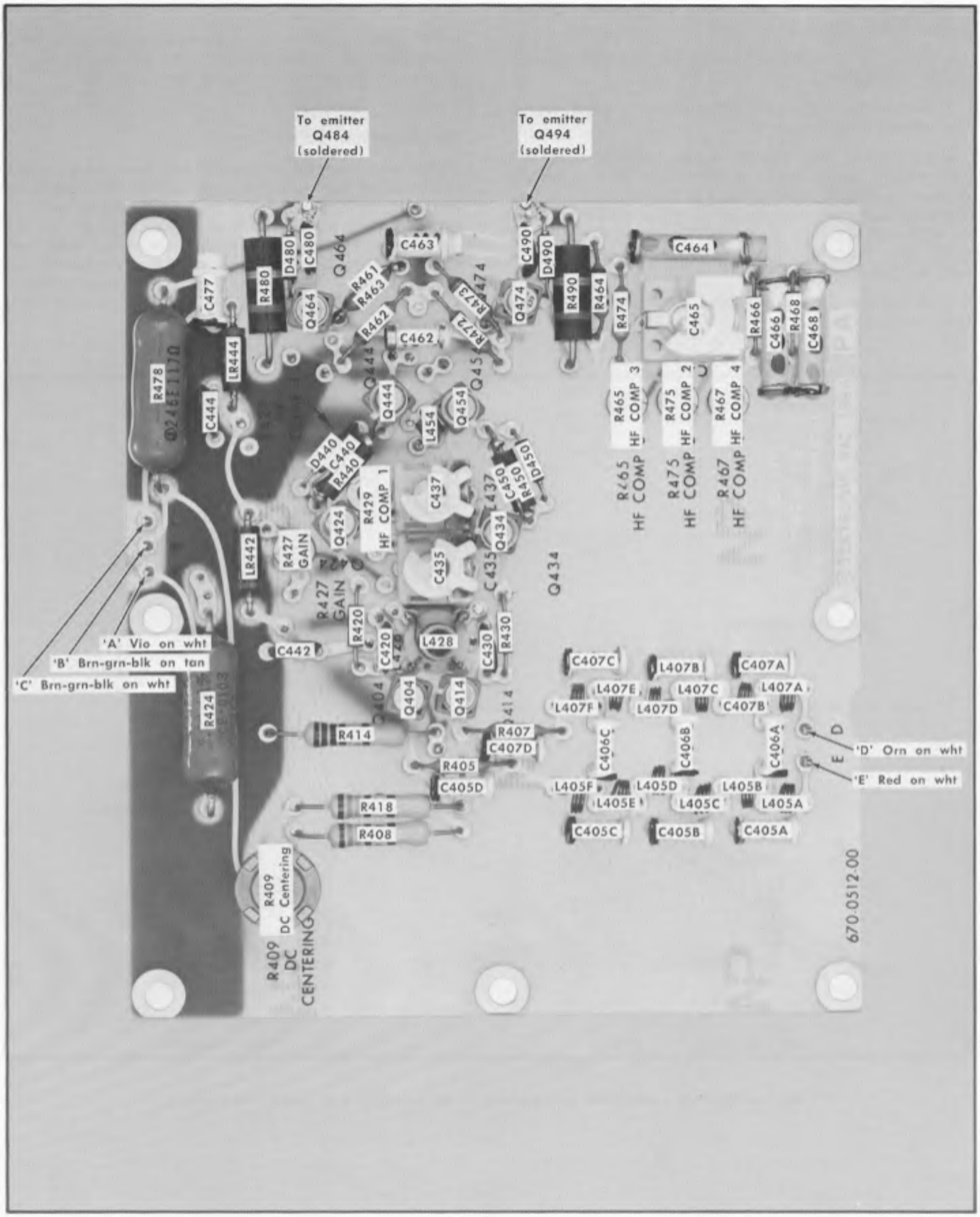


Fig. 4-5. Vertical Amplifier circuit board (front).

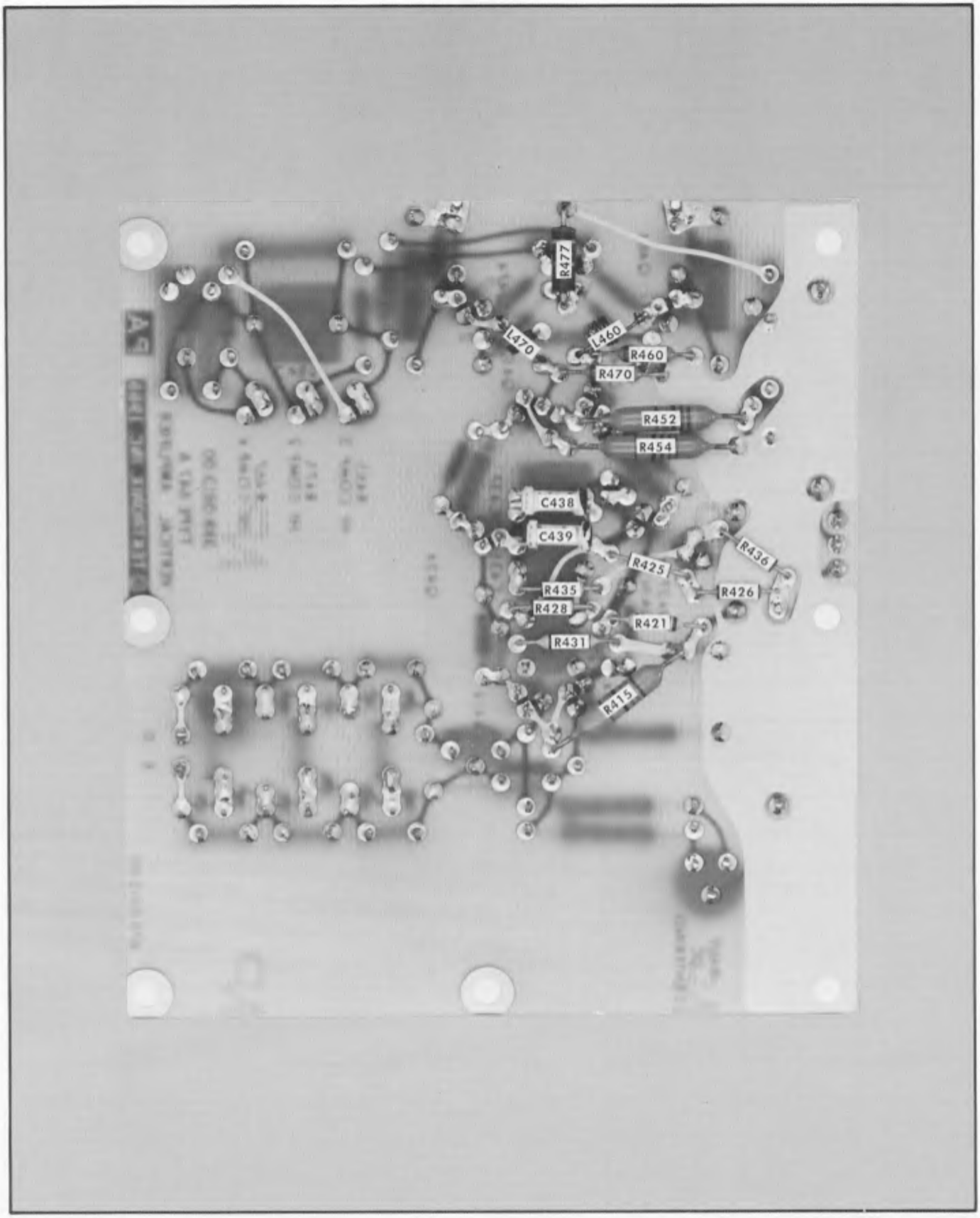


Fig. 4-6. Vertical Amplifier circuit board (rear).

NOTES

SECTION 5

PERFORMANCE CHECK

Introduction

This section of the manual provides a procedure for rapidly checking the performance of the Type 647A. This procedure checks the operation of the instrument without removing the covers or making internal adjustments. However, screwdriver adjustments which are located on the front panel are adjusted in this procedure.

If the instrument does not meet the performance requirements given in this procedure, internal checks and/or adjustments are required. See the Calibration section. All performance requirements given in this section correspond to those given in the Characteristics section.

NOTE

All waveforms shown in this section are actual waveform photographs taken with a Tektronix Oscilloscope Camera System.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Precision DC voltmeter. Accuracy, within ±0.05%; meter resolution, 50 μV; range, 0.1 to 100 V. For example, Fluke Model 825A.

2. Test oscilloscope[1]. Bandwidth, DC to at least 20 MHz; minimum deflection factor, 0.001 volt/division. Tektronix Type 647A Oscilloscope with Type 10A2A and 11-series Plug-In Units, recommended.

3. Variable autotransformer[2]. Must be capable of supplying at least 500 volt-amperes over a voltage range of 96 to 137 volts (192 to 274 volts for 230-volt nominal line). If autotransformer does not have an AC voltmeter to indicate output voltage, monitor output with an AC voltmeter (RMS) with a range of a least 137 (or 274) volts. For example, General Radio W10MT3W Metered Variac Autotransformer.

4. Time mark generator. Marker outputs 1 s to 1 μs; sine-wave output, 10 ns; accuracy 0.001%. Tektronix Type 184 Time-Mark Generator recommended.

5. Medium frequency constant amplitude signal generator. Frequency, 50 kHz and 350 kHz to 100 MHz; output amplitude, less than 4 volts to 5 volts; amplitude regulation accuracy, ±5%. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

6. High frequency constant amplitude sine wave generator. Frequency, 3 MHz and 65 MHz to 130 MHz; output amplitude, less than 4 volts to above 5 volts; amplitude regulation accuracy, ±1%. Tektronix Calibration Fixture 067-0532-00 recommended.

7. Test load plug-in. Used to normalize Type 647A regulated power supplies and vertical and horizontal amplifiers. Tektronix Calibration Fixture 067-0544-00 recommended.

8. Time base plug-in. Tektronix calibrated 11-series Time Base plug-in recommended. The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.

9. Amplifier plug-in. Tektronix calibrated Type 10A2A Base plug-in recommended.

10. Current probe and passive termination[3]. Sensitivity, 2 mA/mV; accuracy within 4%. Tektronix P6019 with passive termination (Tektronix Part No. 015-0065-00) recommended.

11. Cable. Impedance, 50 ohm; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-00.

12. Cable. Impedance, 50 ohm; length, 5 ns; connectors, GR. Tektronix Part No. 017-0502-00.

13. Adapter. Connectors, BNC female to alligator clips. Tektronix Part No. 013-0076-00.

14. Termination. Impedance, 50 ohm; accuracy, ±3%; connectors, GR one end, BNC other end. Tektronix Part No. 017-0083-00.

15. Termination. Impedance 50 ohm; accuracy ±3%; connectors, BNC. Tektronix Part No. 011-0049-00.

16. 10× passive probe. Tektronix P6047 probe recommended. Tektronix Part No. 010-0211-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, control settings or test equipment connections should not be changed except as noted. If only a partial check is desired, refer to the preceding

[1]**A deflection factor of 0.001 volt/division can be obtained using a Type 647A/10A2A/11-series test oscilloscope by cascading channels 1 and 2 of the Type 10A2A as follows:**

a. Set the Type 10A2A mode switch to CH 1. The channel 1 input coupling switch to AC, and the variable (volts/cm) to cal.

b. Set the channel 2 input coupling switch to AC, then connect an 8-inch cable from the ch 2 output connector to the ch 1 input connector.

c. Using the Type 647A calibrator and adjusting the Type 10A2A channel 2 volts/cm and variable (volts/cm) controls, obtain a 1 mV/cm deflection factor.

[2]**Used only to check power supply ripple. May be deleted if these check are not made.**

[3]**This equipment is used only to check for the presence of current in in the CURRENT PROBE CAL loop, see step 11.**

step(s) for setup information. Type 647A front-panel control titles referred to in this procedure are capitalized (e.g., POSITION).

The following procedure uses the equipment listed under Recommended Equipment. If equipment is substituted, control settings or setup may need to be altered to meet the requirements of the equipment used.

Preliminary Procedure

1. Install the 067-0544-00 Calibration Fixture in the horizontal plug-in compartment of the Type 647A.

2. Connect the autotransformer to a suitable power source.

3. Connect the Type 647A to the autotransformer output.

4. Set the autotransformer output voltage to the design center voltage to which the oscilloscope line voltage selector assembly has been set.

5. Set the front-panel controls of the Type 647A and the calibration fixture as follows:

Type 647A

INTENSITY	Fully counterclockwise
FOCUS	Midrange
TRACE ROTATION	As is
ASTIGMATISM	Midrange
SCALE ILLUM	Fully counterclockwise
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

067-0544-00

Vertical-Horiz Cal	5
Load	Zero
Source (voltage)	−75 V
(function)	Gnd
Pulse Rate	OFF

6. Set the Type 647A POWER switch to ON. Allow at least 20 minutes warm up at 25° C, ±5° C for checking the instrument to the given accuracy.

1. Check −75 Volt Power Supply

REQUIREMENT—Within ±0.75% of −75 volts.

a. Set the test oscilloscope for a vertical deflection of 10 mV/division, DC coupled, at a sweep rate of 1 ms/division with line frequency triggering.

b. Connect a 50 ohm coaxial cable from the ouput connector of the calibration fixture to the input connector on the plug-in of the test oscilloscope.

c. With the source function switch on the calibration fixture set at gnd, position the trace on the CRT of the test oscilloscope to a convenient reference point.

d. Set the source function switch on the calibration fixture to DC error.

e. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 37.5 millivolts of the reference point.

f. Change the load switch to full.

g. CHECK—Deflection of test oscilloscope trace away from the trace position found in part e of this step should not be more than an additional 5 mV.

2. Check −15 Volt Power Supply

REQUIREMENT—Within ±1% of −15 volts.

a. Set the source voltage switch on the calibration fixture to −15 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 50 millivolts of the reference point.

e. Change the load switch to full.

f. CHECK—Deflection of test oscilloscope trace away from the trace position found in part d of this step should not be more than an additional 5 mV.

3. Check +15 Volt Power Supply

REQUIREMENT—Within ±1% of +15 volts.

a. Set the source voltage switch on the calibration fixture to +15 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 50 millivolts of the reference point.

e. Change the load switch to full.

g. CHECK—Deflection of test oscilloscope trace away from the trace position found in part d of this step should not be more than an additional 5 mV.

4. Check +100 Volt Power Supply

REQUIREMENT—Within ±1% of +100 volts.

a. Set the source voltage switch on the calibration fixture to +100 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 50 millivolts of the reference point.

e. Change the load switch to full.

f. CHECK—Deflection of test oscilloscope trace away from the trace position found in part d of this step should not be more than an additional 5 mV.

g. Change the load switch to zero.

5. Check Low Voltage Power Supply Ripple

REQUIREMENT—Ripple amount for the —75 V, —15 V, +15 V and +100 V power supplies is 3 mV or less.

a. Set the test oscilloscope for a vertical deflection of 1 mV/division, AC coupled, at a sweep rate of 1 ms/division with line frequency triggering.

b. Set the source function switch on the calibration fixture to ripple and the source voltage switch to —75 V.

c. Set the autotransformer output voltage to the design center voltage for which the Type 647A line voltage selector assembly has been adjusted.

d. CHECK—Maximum ripple, less than or equal to 3 mV.

e. Set the load switch on the calibration fixture to full.

f. Set the autotransformer output voltage to the lower voltage listed for the range selector and voltage selector positions being used.

g. CHECK—Maximum ripple, less than or equal to 3 mV.

h. Change the load switch to zero.

i. Set the autotransformer output voltage to the higher voltage listed for the range selector and voltage selector positions being used.

j. CHECK—Maximum ripple, less than or equal to 3 mV.

k. Change the source voltage switch on the calibration fixture to —15 V.

l. Repeat parts c through j of this step.

m. Change the source voltage switch on the calibration fixture to +15 V.

n. Repeat parts c through j of this step.

o. Change the source voltage switch on the calibration fixture to +100 V.

p. Repeat parts c through j of this step.

q. Disconnect the test oscilloscope.

r. Set the autotransformer output voltage to the design center voltage for which the Type 647A line voltage selector assembly has been adjusted.

s. Set the source function switch on the calibration fixture to gnd.

6. Adjust Trace Rotation

REQUIREMENT—Trace should be parallel to horizontal graticule lines.

a. Remove the 067-0544-00 calibration fixture from the horizontal plug-in compartment.

b. Install a Type 10A2A plug-in into the vertical plug-in compartment and an 11-series plug-in into the horizontal plug-in compartment.

c. Set the controls of the Type 10A2A and 11-series plug-ins as follows:

Type 10A2A

Volts/Cm (both channels)	.01
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	AC
Invert (both channels)	Pushed in
Trigger	Norm
Mode	Ch 1

11-Series

Time/Cm	1 ms
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

d. Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for a well defined trace of moderate brightness.

e. Position the trace to the center horizontal graticule line.

f. CHECK—Trace is parallel to the horizontal graticule line.

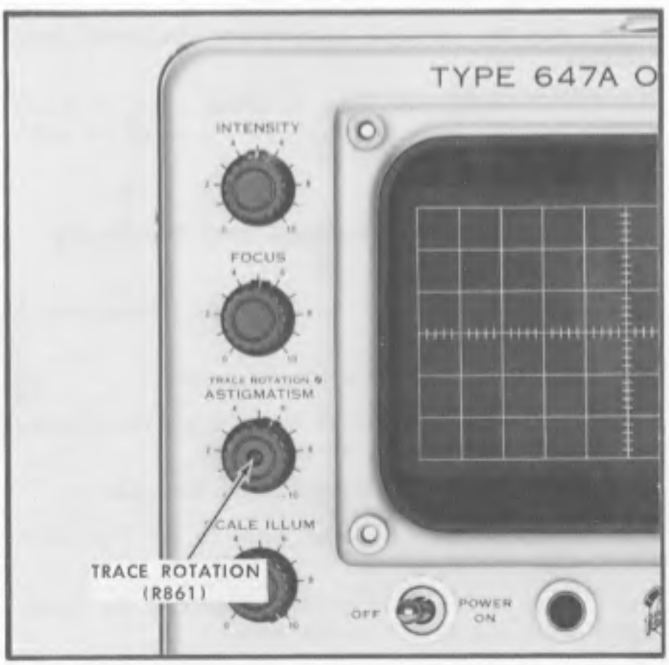


Fig. 5-1. Location of TRACE ROTATION control, R861.

h. ADJUST—TRACE ROTATION control, R861 (see Fig. 5-1), so the trace is parallel to the horizontal graticule line.

7. Check Vertical Geometry

REQUIREMENT—Vertical lines parallel to vertical graticule lines within 1 mm.

a. Connect a 50 ohm coaxial cable from the time mark generator marker output connector through a 50 ohm termination to the channel 1 input connector on the Type 10A2A plug-in.

b. Set the front-panel controls of the time mark generator so it will produce a mixed output of 1 ms and 0.1 ms time markers.

c. Adjust the Type 10A2A plug-in position, input coupling switch, volts/cm and variable (volts/cm) controls to obtain a display of time markers which completely cover the graticule area.

d. Adjust the 11-series plug-in triggering controls to obtain a stable display.

e. Adjust the 11-series plug-in variable (time/cm) control to obtain a display consisting of one 1 ms time marker per centimeter and ten 0.1 ms time markers per centimeter.

f. CHECK—Time markers (vertical lines) should be parallel within 1 mm to the vertical graticule lines over the height of the vertical graticule area.

g. Disconnect the time mark generator.

8. Check Horizontal Geometry

REQUIREMENT—Horizontal line parallel to horizontal graticule lines within 1 mm.

a. Adjust the 11-series plug-in triggering controls to obtain a free running trace.

b. Position the horizontal trace to each horizontal graticule line.

c. CHECK—Horizontal trace is within 1 mm of being parallel to each horizontal graticule line over the width of the horizontal graticule area.

9. Check Calibrator Voltage and Frequency Accuracy

REQUIREMENT—Voltage, see Table 5-1. Frequency; 1 kHz, ±0.1% or less.

a. Turn off the Type 647A POWER switch.

b. Remove transistor Q945 (to do this it will be necessary to momentarily remove the left side panel).

c. Turn the Type 647A POWER switch on again.

d. Connect a 50 ohm coaxial cable to the Type 647A CAL OUT connector.

e. Connect a BNC to clip lead adapter to the unconnected end of the 50 ohm coaxial cable.

f. Connect the red lead of the clip adapter to the positive input connector of the precision DC voltmeter.

g. Connect the black lead of the adapter to the negative input connector of the precision DC voltmeter.

h. Set the Type 647A CALIBRATOR switch to 100 V or 100 V DC.

i. CHECK—Precision DC voltmeter reading, 100 volts ±1 volt.

NOTE

The accuracy of the 100 V square wave or the 100 V DC positions of the CALIBRATOR switch is directly related to the accuracy of the +100 volt power supply.

j. Set the CALIBRATOR switch in turn to each position listed in Table 5-1.

k. CHECK—Precision DC voltmeter reading (refer to Table 5-1) for each CALIBRATOR switch position.

TABLE 5-1

Calibrator Voltage Check

CALIBRATOR Switch Position	Voltage and Tolerance
50 V	50 volts ±1 volt
20 V	20 volts ±0.4 volt
10 V	10 volts ±0.2 volt
5 V	5 volts ±0.1 volt
2 V	2 volts ±0.04 volt
1 V	1 volt ±0.02 volt
.5 V	0.5 volt ±0.01 volt
.2 V	0.2 volt ±0.004 volt
.1 V	0.1 volt ±0.001 volt

NOTE

Due to the design of the CALIBRATOR switch, the remaining CALIBRATOR switch positions are not checked.

l. Turn off the Type 647A POWER switch.

m. Disconnect the precision DC voltmeter.

n. Re-install Q945 (it will again be necessary to remove the left side panel momentarily).

o. Turn the Type 647A POWER switch on again.

p. Connect a 50 ohm coaxial cable from the time mark generator marker output connector through a 50 ohm termination to the channel 1 input connector on the Type 10A2A.

q. Set the front-panel controls of the time mark generator so it will produce a mixed output of 1 ms and 1 s time markers.

r. Adjust the Type 10A2A plug-in position, volts/cm and variable (volts/cm) controls to obtain a display of time markers about 3 cm high.

s. Set the 11-series plug-in trigger mode to norm, trigger coupling to AC Low Frequency Reject, trigger source to ext and the trigger level control to exactly 0.

t. Connect a 50 ohm coaxial cable from the Type 647A CAL OUT connector to the trig in connector on the 11-series plug-in.

u. Set the Type 647A CALIBRATOR switch to 5 V.

v. CHECK—Drift from a reference point. There should be no more than 10 cm of drift of any 1 ms time marker in a 10 second time period (frequency of 1 kHz, ±0.1% or less). Use the 1 s time markers to count the 10 second time period.

w. Disconnect the 50 ohm coaxial cables, the 50 ohm termination and the time mark generator.

10. Check Calibrator Risetime and Duty Cycle

REQUIREMENT—Risetime; 1 μs or less. Duty cycle; 49.9% to 50.1%.

a. Set the 11-series plug-in time/cm switch to 1 μs, the trigger slope switch to + and the source switch to int.

b. Connect a 50 ohm coaxial cable from the Type 647A CAL OUT connector to the Type 10A2A plug-in channel 1 input connector.

c. Set the Type 10A2A plug-in volts/cm switch to obtain a display 5 cm high.

d. Adjust the trigger level control to obtain a stable display.

e. CHECK—Risetime (see Fig. 5-2), equal to or less than 1 μs.

f. With the 11-series plug-in trigger slope switch set to +, adjust the 11-series plug-in trigger level so the displayed calibrator waveform is triggered at the mid, or 50% point of its rise.

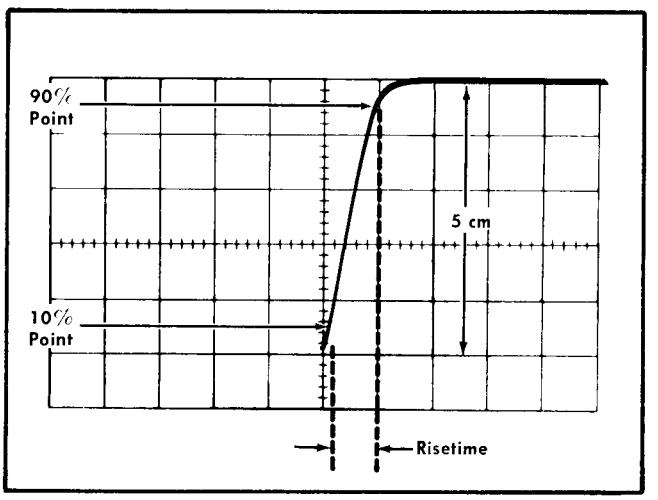


Fig. 5-2. Measuring calibrator risetime.

g. Set the 11-series plug-in time/cm switch to 50 μs and observe that one-half cycle of square wave display now occupies ten horizontal divisions.

h. Magnify the trailing edge of the displayed positive-going half cycle of the calibrator waveform by ×50.

i. Position the mid, or 50% point of the falling portion of the magnified calibrator waveform to the intersection of the center graticule lines.

j. Pull out the Type 10A2A channel 1 invert switch.

k. CHECK—Horizontal trace movement; not more than two centimeters (2 μs) of horizontal trace shift.

l. Push in the Type 10A2A channel 1 invert switch.

m. Disconnect the 50 ohm coaxial cable.

11. Check Calibrator Current Waveform

REQUIREMENT—5 mA square-wave signal output.

a. Connect a P6019 passive termination to the Type 10A2A plug-in channel 1 input connector.

b. Connect a P6019 probe from the unconnected end of the P6019 passive termination to the Type 647A calibrator 5 mA current loop.

c. Set the P6019 passive termination switch to 2 mA/mV.

d. Set the 11-series plug-in time/cm switch to 1 ms and the variable (time/cm) to calibrate.

e. Set the Type 10A2A plug-in volts/cm switch to .01.

f. Set the Type 647A CALIBRATOR switch to the 5 mA current loop position.

g. CHECK—Display for a square-wave display about 2.5 mm in amplitude.

NOTE

This step checks for the presence of current in the CURRENT PROBE CAL loop. This current will remain within the stated 1.5% accuracy due to the tolerance of the voltage divider resistors and tolerance of the calibrator output voltage. If it is necessary to verify the accuracy of the calibrator current, use a current measuring meter with an accuracy of at least 0.25%.

h. Disconnect the P6019 passive termination and the P6019 probe.

i. Turn the Type 647A CALIBRATOR switch to OFF.

12. Check Horizontal Gain and Centering

REQUIREMENT—Gain of circuit indicated by a horizontal spot deflection within 1% of 8 centimeters as the calibration fixture vertical-horiz cal switch is changed from 1 to 9.

a. Remove the Type 10A2A and 11-series plug-in from the Type 647A.

b. Install calibration fixture 067-0544-00 into the horizontal plug-in compartment of the Type 647A and set the vertical-horiz cal switch to 1 and the load switch to zero.

c. Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for a well defined dim spot.

d. CHECK—Spot location. It should be within 2 mm of the first centimeter vertical graticule line.

e. Set the calibration fixture vertical-horiz cal switch to 9.

f. CHECK—Gain; spot should be 8 centimeters, ±0.8 mm to the right of the position established in part d.

g. Set the calibration fixture vertical-horiz cal switch to each of its positions in succession to check linearity (part h).

h. CHECK—Linearity; the spot should be within 0.5 mm (plus any gain error observed in part f) of a vertical graticule line at each position of the calibration fixture vertical-horiz cal switch.

13. Check Vertical Gain and DC Centering

REQUIREMENT—Gain of circuit indicated by a vertical trace deflection of 6 cm within 1% as calibration fixture vertical-horiz cal switch is set from DC calibrate + 3 cm to DC calibrate — 3 cm. Centering: trace within 2 mm of center horizontal graticule line.

a. Remove the calibration fixture 067-0544-00 from the Type 647A horizontal plug-in compartment and install it into the vertical plug-in compartment.

b. Install an 11-series plug-in into the horizontal plug-in compartment.

c. Set the 11-series plug-in controls as follows:

11-Series

Time/Cm	1 ms
Magnification	1 time
Trigger Mode	Free Run
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

d. Set the calibration fixture vertical-horiz cal switch to DC calibrate + 3 cm and observe the trace location at the center vertical graticule line, then set the vertical-horiz cal switch to DC calibrate — 3 cm.

e. CHECK—Gain, trace shift (at center vertical graticule line) must be 6 centimeters ±0.6 mm.

f. Remove the calibration fixture from the Type 647A vertical plug-in compartment.

g. CHECK—Trace location; should be within 2 mm of the center horizontal graticule line.

h. Re-install the calibration fixture into the Type 647A vertical plug-in compartment.

14. Check Horizontal Compensations

REQUIREMENT—Timing; within 3%. Linearity; should be within 1 mm.

a. Remove the calibration fixture from the Type 647A vertical plug-in compartment.

b. Install a Type 10A2A into the vertical plug-in compartment of the Type 647A.

c. Connect a 10 ns waveform from the time-mark generator through a 50 ohm coaxial cable and a 50 ohm termination to the channel 1 input connector of the Type 10A2A.

d. Set the front-panel controls of the Type 10A2A and the 11-series plug-in as follows:

Type 10A2A

Volts/Cm (both channels)	.2
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	Gnd
Invert (both channels)	Pushed in
Trigger	Norm
Mode	Ch 1

11-Series

Time/Cm	.1 μs
Magnification	1 time
Trigger Mode	Norm
Trigger Slope	+
Trigger Coupling	AC Low Frequency Reject
Trigger Source	Int

e. Adjust the trig level control on the 11-series plug-in to obtain a stable display.

f. Center the display within the graticule area with the position controls.

g. Magnify the display ten times, using the proper 11-series plug-in control.

h. Adjust the POSITION control so there will be a cycle of the display crossing at the point where the first centimeter graticule line and the center horizontal graticule line cross.

i. CHECK—Timing and linearity; 8 cycles of the waveform should occupy 8 centimeters of the graticule within ±3% (2.5 mm) and the cycles should be spaced 1 centimeter apart ±1 mm.

j. Adjust the POSITION control so that all of the magnified display can be checked as part i of this step except for the first and last five centimeters of the display.

k. Disconnect the time mark generator connection.

15. Check Vertical Compensations

REQUIREMENT—4 centimeter step waveform should have less than 3% of overshoot, rolloff, tilt and ringing, and less than 2.5% or preshoot near middle of graticule area. When positioning a 6 centimeter waveform to the extremes of the graticule area, the overshoot, roll-off, tilt and ringing allowable is 6%. Any amplifier termination aberrations must be less than 0.5 mm in amplitude. Vertical amplifier compres-

sion or expansion of a 2 centimeter signal must be less than 1.5 mm at the graticule area extremes.

a. Remove the Type 10A2A from the Type 647A vertical plug-in compartment and install the calibration fixture in the plug-in compartment.

b. Set the front-panel controls of the calibration fixture and the 11-series plug-in as follows:

067-0544-00

Vertical-Horiz Cal	+ Pulse Polarity
Load	Zero
Pulse Rate	Set to mark just before high

11-Series

Time/Cm	.5 μs
Magnification	1 time
Trigger Mode	Norm
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

c. Adjust the trig level control on the 11-series plug-in to obtain a stable display.

d. Rotate the calibration fixture amplitude control to obtain a display 4 cm high on the Type 647A CRT.

e. With the calibration fixture position control, center the display vertically within the graticule area of the Type 647A.

f. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 3% of the total waveform amplitude; and waveform preshoot for an amount less than 2.5% of the total waveform amplitude, see Fig. 5-3. The checks should be made using sweep rates of 0.5 μs, 0.1 μs, 50 ns, 20 ns and 10 ns.

g. Change the calibration fixture vertical-horiz cal switch to —pulse polarity.

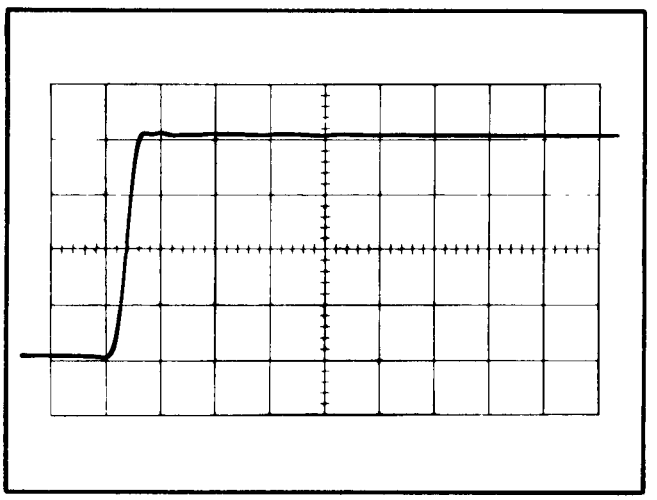


Fig. 5-3. Waveform of a correctly compensated vertical amplifier.

h. Re-center the waveform vertically within the graticule area.

i. CHECK—Waveform; re-check part f of this step.

j. Set the calibration fixture vertical-horiz cal switch to —pulse polarity and increase the displayed pulse amplitude to 6 cm with the calibration fixture amplitude control.

k. Position the bottom of the displayed pulse to the top graticule line.

l. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 6% of the total waveform amplitude.

m. Set the calibration fixture vertical-horiz cal switch to +pulse polarity.

n. Position the top of the displayed pulse to the bottom graticule line.

o. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 6% of the total waveform amplitude.

p. Set the 11-series time/cm switch to .1 μs.

q. Decrease the displayed pulse amplitude to 4 cm with the calibration fixture amplitude control.

r. Center the waveform vertically within the graticule area.

s. CHECK—Termination aberrations (located about 3 cm from the leading corner of pulse); less than 0.5 mm in amplitude.

t. Set the calibration fixture pulse rate switch one position counterclockwise, i.e., to the position that is one mark clockwise from the position marked low.

u. Center the waveform vertically within the graticule area.

v. Decrease the displayed pulse amplitude to exactly 2 cm with the calibration fixture amplitude control.

w. Position the top of the display to the top graticule line.

x. CHECK—Compression or expansion; less than 1.5 mm.

y. Position the bottom of the display to the bottom graticule line.

z. CHECK—Compression or expansion, less than 1.5 mm.

16. Check Vertical Bandwidth

REQUIREMENT—Not more than —3 dB at 130 MHz.

a. Connect the output of a high frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the calibration fixture cw in connector.

b. Set the 11-series plug-in trigger mode switch to free run and the time/cm switch to 1 ms.

c. Set the calibration fixture vertical-horiz cal switch to cw.

d. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).

e. Adjust the output amplitude control of the high frequency generator until the Type 647A CRT display is exactly 4 cm in amplitude.

f. Change the high frequency generator output frequency switch to its variable frequency position.

g. Rotate the frequency dial from its lower limit toward its highest limit, stopping when the displayed amplitude decreases to exactly 2.8 cm.

h. CHECK—Bandwidth; at least 130 MHz.

i. Disconnect the high frequency generator.

17. Check Multiple Trace and Chopped Blanking Operation

REQUIREMENT—Dual trace display having no chopped blanking transients.

a. Remove the 067-0544-00 calibration fixture from the Type 647A vertical plug-in compartment.

b. Install a Type 10A2A plug-in into the Type 647A vertical plug-in compartment.

c. Set the Type 10A2A and 11-series plug-in controls as follows:

Type 10A2A	
Volts/Cm (both channels)	.1
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	AC
Invert (both channels)	Pushed in
Trigger	Norm
Mode	Chop
11-Series	
Time/Cm	1 μs
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

d. CHECK—Display; chopped dual trace display which has no vertical lines (chopping transients) between the chopped segments of the two traces.

18. Check External CRT Grid Input

REQUIREMENT—Usable frequency range; DC to 10 MHz or more. Modulation signal amplitude; 4 volts or less.

a. Set the 10-series plug-in mode switch to ch 1.

b. Connect a 5 ns coaxial cable, a 50 ohm GR to BNC termination, and a clip lead adapter to a medium frequency constant amplitude signal generator.

c. Connect the red lead of the clip lead adapter to the Type 647A CRT GRID connector on the rear panel of the oscilloscope. The black lead of the clip adapter should be connected to a ground point.

d. Connect a 10× probe to the Type 10A2A plug-in channel 1 input connector.

e. Connect the unconnected end of the 10× probe to the red lead of the clip lead adapter.

f. Set the medium frequency generator controls for an output frequency of 10 MHz and an output amplitude of 4 volts peak to peak.

g. Set the 11-series plug-in time/cm switch to .1 μs and adjust the triggering controls for a stable display.

h. CHECK—Display for intensity modulation with 4 volts or less of 10 MHz signal.

i. Decrease the frequency of the generator toward DC, repeating part h of this step as the frequency is decreased.

19. Check External CRT Cathode Input

REQUIREMENT—Usable frequency range; 500 kHz to 100 MHz or more. Modulation signal amplitude; 5 volts or less.

a. Disconnect the shorting strap between the Type 647A CRT CATHODE connector and the GND connector which are both located on the rear panel.

b. Change the 10× probe and red lead of the clip lead adapter from the CRT GRID connector to the CRT CATHODE connector.

c. Set the medium frequency generator for an output frequency of 100 MHz and an output amplitude of 5 volts.

d. Adjust the 11-series plug-in controls for a stable display.

e. CHECK—Display for intensity modulation with 5 volts or less of 100 MHz signal.

f. Decrease the frequency of the generator toward 500 kHz, repeat part e of this step as the frequency is decreased.

g. Disconnect the low frequency generator and remove the 5 ns coaxial cable, 50 ohm GR to BNC termination, 10× probe, and clip lead adapter.

h. Reconnect the shorting strap between the CRT CATHODE connector and the GND connector.

20. Check Beam Finder

REQUIREMENT—Display must remain in graticule area.

a. Depress the Type 647A BEAM FINDER switch.

b. Rotate the Type 647A POSITION control throughout its range.

c. CHECK—Display; trace must remain within the graticule area no matter where the trace is moved by the positioning control.

d. Rotate the Type 10A2A plug-in position control throughout its range.

e. CHECK—Display; trace must remain within the graticule area no matter where the trace is moved by the positioning control.

This completes the performance check of the Type 647A. Disconnect all test equipment.

SECTION 6

CALIBRATION

Introduction

Complete calibration information for the Type 647A is given in this section. This procedure calibrates the instrument to the performance requirements listed in the Characteristics section. The Type 647A can be returned to original performance standards by completion of each step in this procedure. If it is desired to merely touch up the calibration, perform only those steps entitled "Adjust . . . ". A short-form calibration procedure is also provided in this section for the convenience of the experienced calibrator.

The Type 647A should be checked, and recalibrated if necessary, after each 1000 hours of operation, or every six months if used infrequently, to assure correct operation and accuracy. The Performance Check section of this manual provides a complete check of instrument performance without making internal adjustments. Use the performance check procedure to verify the calibration of the Type 647A and determine whether recalibration is required.

TEST EQUIPMENT REQUIRED

General

The following test equipment, or its equivalent, is required for complete calibration of the Type 647A (see Figs. 6-1 and 6-2). Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed here can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Precision DC voltmeter. Accuracy, within ±0.05%; meter resolution, 50 μV; range, 0.1 to 100 V. For example, Fluke Model 825A.

2. DC voltmeter[1] (V.O.M.). Minimum sensitivity, 20,000 ohms/volt; accuracy, checked to within 3% at 300 volts and within 1% at 2.2 kV. For example, Simpson Model 262.

[1]If a precision voltage divider (such as a Fluke 80E-5) is available for use with the precision DC voltmeter, it is recommended for more accurate adjustment of the High-Voltage Supply.

[2]A deflection factor of 0.001 volt/division can be obtained using a Type 647/10A2A/11-series test oscilloscope by cascading channels 1 and 2 of the Type 10A2A as follows:

a. Set the Type 10A2A mode switch to ch 1 and the channel 1 input coupling switch to AC and the variable (volts/cm) to cal.

b. Set the channel 2 input coupling switch to AC, then connect an 8-inch cable from the ch 2 output connector to the ch 1 input connector.

c. Using the Type 647A calibrator and adjusting the Type 10A2A channel 2 volts/cm and variable (volts/cm) controls, obtain a 1 mV/cm deflection factor.

3. Test oscilloscope[2]. Bandwidth, DC to at least 20 MHz; minimum deflection factor, 0.001 volt/division. Tektronix Type 647A Oscilloscope with Type 10A2A and 11-series Plug-In Units, and Tektronix P6047 and P6028 Probes recommended.

4. Variable autotransformer[3]. Must be capable of supplying at least 500 volt-amperes over a voltage range of 96 to 137 volts (192 to 274 volts for 230-volt nominal line). If autotransformer does not have an AC voltmeter to indicate output voltage, monitor output with an AC voltmeter (RMS) with a range of at least 137 (or 274) volts. For example, General Radio W10MT3W Metered Variac Autotransformer.

5. Time mark generator. Marker outputs 1 s to 1 μs; sine-wave output, 10 ns; accuracy 0.001%. Tektronix Type 184 Time-Mark Generator recommended.

6. Medium frequency constant amplitude signal generator. Frequency, 50 kHz and 350 kHz to 100 MHz; output amplitude, less than 4 volts to 5 volts; amplitude regulation accuracy, ±5%. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

7. High frequency constant amplitude sine wave generator. Frequency, 3 MHz and 65 MHz to 130 MHz; output amplitude, less than 4 volts to above 5 volts; amplitude regulation accuracy, ±1%. Tektronix Calibration Fixture 067-0532-00 recommended.

8. Test load plug-in. Purpose, normalizes Type 647A regulated power supplies and vertical and horizontal amplifiers. Tektronix Calibration Fixture 067-0544-00 recommended.

9. Time base plug-in. Tektronix calibrated 11-series Time Base plug-in recommended. The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.

10. Amplifier plug-in. Tektronix calibrated Type 10A2A Amplifier plug-in recommended.

11. Current probe and passive termination[4]. Sensitivity, 2 mA/mV; accuracy within 4%. Tektronix P6019 with passive termination (Tektronix Part No. 015-0065-00) recommended.

12. Cable. Impedance, 50 ohm; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-00.

13. Cable. Impedance, 50 ohm; length, 5 ns, connectors, GR. Tektronix Part No. 017-0502-00.

14. Adapter. Connectors, BNC female to alligator clips. Tektronix Part No. 013-0076-00.

[3]Used only to check power supply ripple and high voltage regulation. May be deleted if these checks are not made.

[4]This equipment is used only to check for the presence of current in the CURRENT PROBE CAL loop, see step 15.

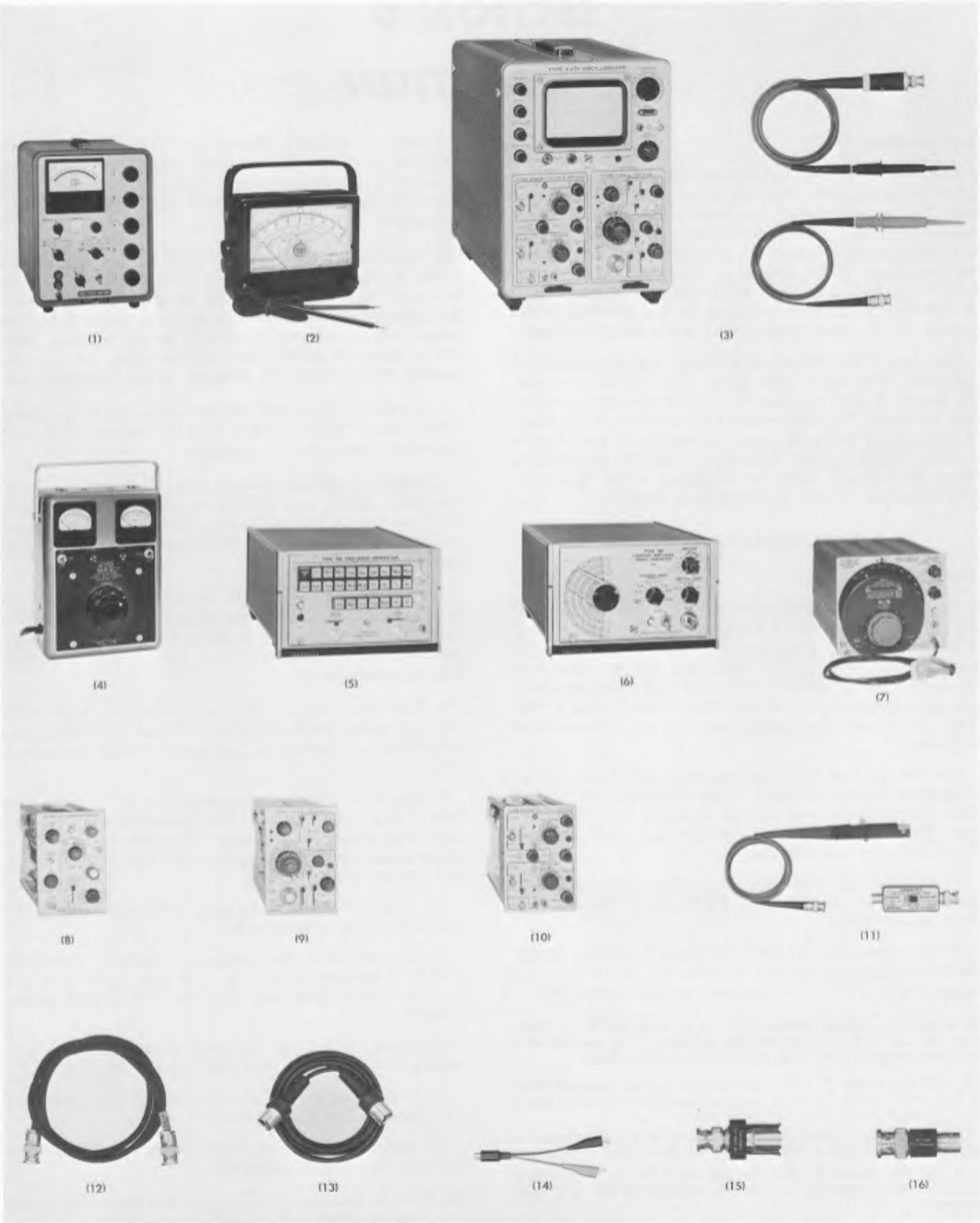


Fig. 6-1. Recommended calibration equipment. Items 1 through 16.

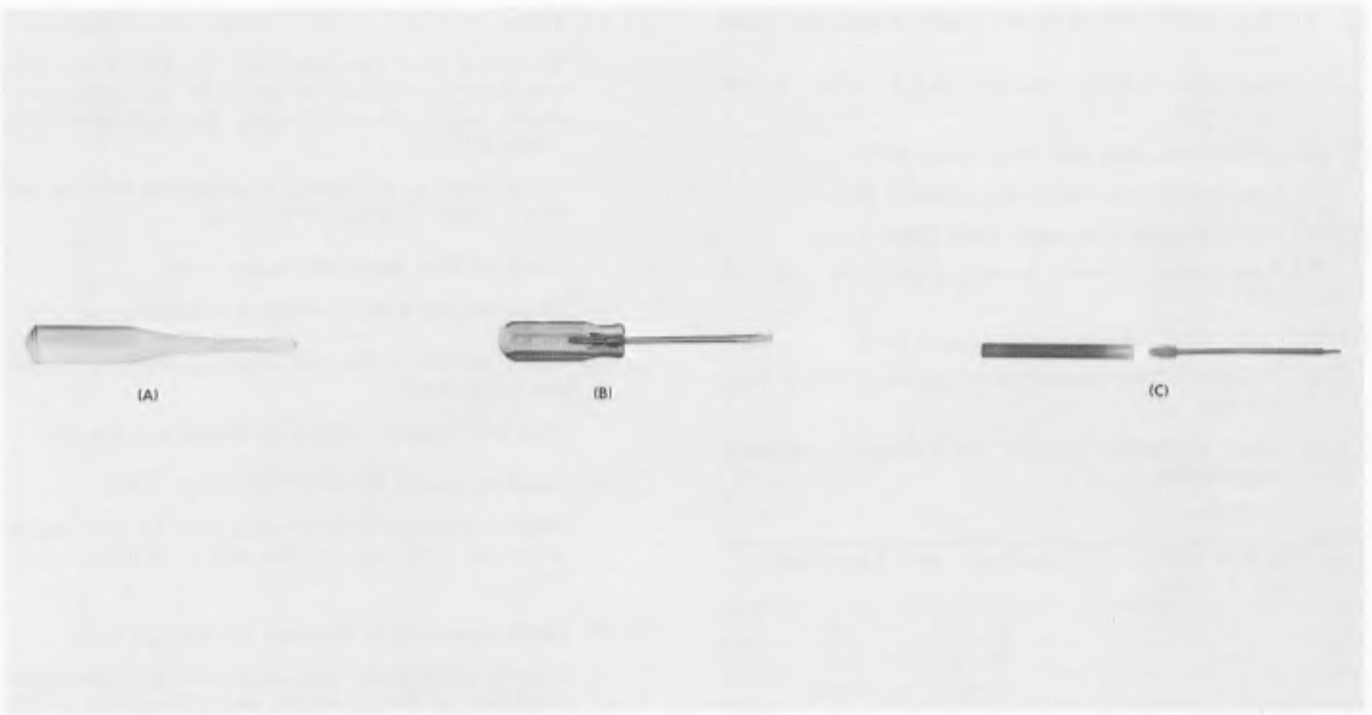


Fig. 6-2. Adjustment tools.

15. Termination. Impedance, 50 ohm; accuracy, ±3%, connectors, GR one end, BNC other end. Tektronix Part No. 017-0083-00.

16. Termination. Impedance, 50 ohm; accuracy, ±3%, connectors, BNC. Tektronix Part No. 011-0049-00.

17. Adjustment tools (see Fig. 6-2).

Description	Tektronix Part No.
a. Insulated screwdriver, 1½-inch shaft, non-metallic	003-0000-00
b. Screwdriver, 3-inch shaft	003-0192-00
c. Tuning tool	
Handle	003-0307-00
Insert, for 5/64-inch (ID) hex cores	003-0310-00

CALIBRATION RECORD AND INDEX

This short-form calibration procedure is provided to aid in checking the operation of the Type 647A. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristics section.

Type 647A, Serial No. _____

Calibration Date _____

Calibration Technician _____

☐ 1. Adjust −75 Volt Power Supply, R631 (page 6-6)
Deflection within 17.5 millivolts of reference point.

☐ 2. Adjust −15 Volt Power Supply, R661 (page 6-7)
Deflection within 17.5 millivolts of reference point.

☐ 3. Adjust +15 Volt Power Supply, R691 (page 6-7)
Deflection within 17.5 millivolts of reference point.

☐ 4. Adjust +100 Volt Power Supply, R731 (page 6-7)
Deflection within 17.5 millivolts of reference point.

☐ 5. Check +300 Volt Power Supply (page 6-8)
+300 volts, +30 volts.

☐ 6. Check Low Voltage Power Supply Ripple (page 6-8)

Power Supply	Max Ripple
+300 volt	10 volts
+100 volt	3 millivolts
+15 volt	3 millivolts
−15 volt	3 millivolts
−75 volt	3 millivolts

☐ 7. Adjust High Voltage Power Supply, R801 and CRT Grid Bias, R832 (page 6-9)
High Voltage—2.2 kV, ±66 volts (when using 20,000 ohm/volt DC voltmeter)
CRT Grid Bias—INTENSITY control +20 volts; CRT Grid Bias to make trace visible.

☐ 8. Adjust Z-Axis Amplifier High Frequency Response, C879 (page 6-9)
Flat topped pulse with no more than 3% overshoot and having a risetime of about 50 ns.

☐ 9. Check High Voltage Power Supply Regulation (page 6-11)

Negligible voltage change always within 2.2 kV, ±66 volts.

☐ 10. Adjust Trace Rotation, R861 (page 6-12)

Trace parallel to horizontal graticule lines.

☐ 11. Adjust Vertical Geometry, R863 (page 6-12)

Time markers parallel to vertical graticule lines, ±1 mm.

☐ 12. Check Horizontal Geometry (page 6-13)

Horizontal trace parallel to horizontal graticule lines, ±1 mm.

☐ 13. Check Calibrator Voltage and Frequency Accuracy page (6-13)

Voltage—

CALIBRATOR Switch Position	Voltage and Tolerance
100 V	100 volts ±1 volt
50 V	50 volts ±1 volt
20 V	20 volts ±0.4 volt
10 V	10 volts ±0.2 volt
5 V	5 volts ±0.1 volt
2 V	2 volts ±0.4 volt
1 V	1 volt ±0.02 volt
.5 V	0.5 volt ±0.01 volt
.2 V	0.2 volt ±0.004 volt
.1 V	0.1 volt ±0.001 volt

Freguency—No more than 10 cm of drift in a 10 second period.

☐ 14. Check Calibrator risetime and Duty Cycle (page 6-14)

Risetime—Equal to or less than 1 μs.

Duty Cycle—One-half cycle must occupy at least 4.99 cm and not more than 5.01 cm.

☐ 15. Check Calibrator Current Waveform (page 6-15)

Square-wave display amplitude of about 2.5 mm.

☐ 16. Adjust Horizontal Gain, R377 and Centering, R364 (page 6-16)

Centering—Spot should be within 2 mm of first centimeter vertical graticule line.

Gain—Spot should be 8 centimeters, ±0.8 mm to the right of spot location for the centering.

☐ 17. Adjust Vertical Gain, R427 and DC Centering, R409 (page 6-18)

Gain—Trace shift should be 6 centimeters, ±0.6 mm.

Centering—Trace should be on the center horizontal graticule line.

☐ 18. Adjust Horizontal Compension, C377, C397 and C378 (page 6-20)

Timing and linearity of 10 ns waveform should be within ±3% (2.5 mm) of 8 cycles per 8 centimeters and the cycles should be spaced 1 centimeter apart ±1 mm.

☐ 19. Adjust and Check Vertical Compensations (page 6-21)

Waveform must have less than 3% (6% or less with waveform positioned to graticule extremes) overshoot, rolloff, tilt and ringing and less than 2.5% preshoot.

Compression or expansion of waveform must be less than 1.5 mm at graticule extremes.

☐ 20. Check Vertical Bandwidth (page 6-23)

Down not more than —3 dB at 130 MHz.

☐ 21. Check Multiple Trace and Chopped Blanking Operation (page 6-24)

Dual trace display having no chopping transients.

☐ 22. Check External CRT Grid Input (page 6-24)

Intensity modulation must occur with an input signal amplitude of 4 volts or less and a frequency of 10 MHz.

☐ 23. Check External CRT Cathode Input (page 6-25)

Intensity modulation must occur with an input signal amplitude of 5 volts or less and a frequency of 100 MHz.

☐ 24. Check Beam Finder (page 6-25)

Trace must remain within the graticule area no matter where the trace is positioned to by the positioning controls.

CALIBRATION PROCEDURE

General

The following procedure is arranged in a sequence which allows the Type 647A to be calibrated with the least interaction of adjustments and reconnection of equipment. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts of the instrument. When a step interacts with others, the steps which need to be checked are noted in the "INTERACTION— . . . . " step.

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section.

The steps titled "Adjust . . . ◐" in the following procedure provide a check of instrument performance, whenever possible, before the adjustment is made. The symbol ◐ is used to identify the steps in which an adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met. However, when performing a complete calibration, best overall performance will be provided if each adjustment is made to the exact setting, even if the "CHECK— . . . " is within the allowable tolerance.

In the following procedure, a test equipment setup picture is shown for each major group of adjustments and checks. Following each setup picture is a complete list of front-panel control settings for the Type 647A, test load calibration fixture and 10- and 11-series plug-ins. To aid in locating individual controls which have been changed during complete calibration, these control names are printed in bold type. If only a partial calibration is performed, start with the nearest setup preceding the desired portion. Type 647A front-panel control titles referred to in this procedure are capitalized (e.g., POSITION). Internal adjustment titles are initial capitalized only (e.g., Horiz Gain).

The following procedure uses the equipment listed under Equipment Required. If equipment is substituted, control settings or test equipment setup may need to be altered to meet the requirements of the equipment used.

NOTE

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera System.

Preliminary Procedure

1. Remove the side covers from the Type 647A.

2. Disengage the captive screws which hold the heat-sink door closed.

3. Install the 067-0544-00 Calibration Fixture in the horizontal plug-in compartment of the Type 647A.

4. Connect the autotransformer to a suitable power source.

5. Connect the Type 647A to the autotransformer output.

6. Set the autotransformer output voltage to the design center voltage to which the oscilloscope line voltage selector assembly has been set.

7. Set the front-panel controls of the Type 647A and the calibration fixture as follows.

8. Set the Type 647A POWER switch to ON. Allow at least 20 minutes warm up at 25° C, ±5° C for checking the instrument to the given accuracy.

NOTES

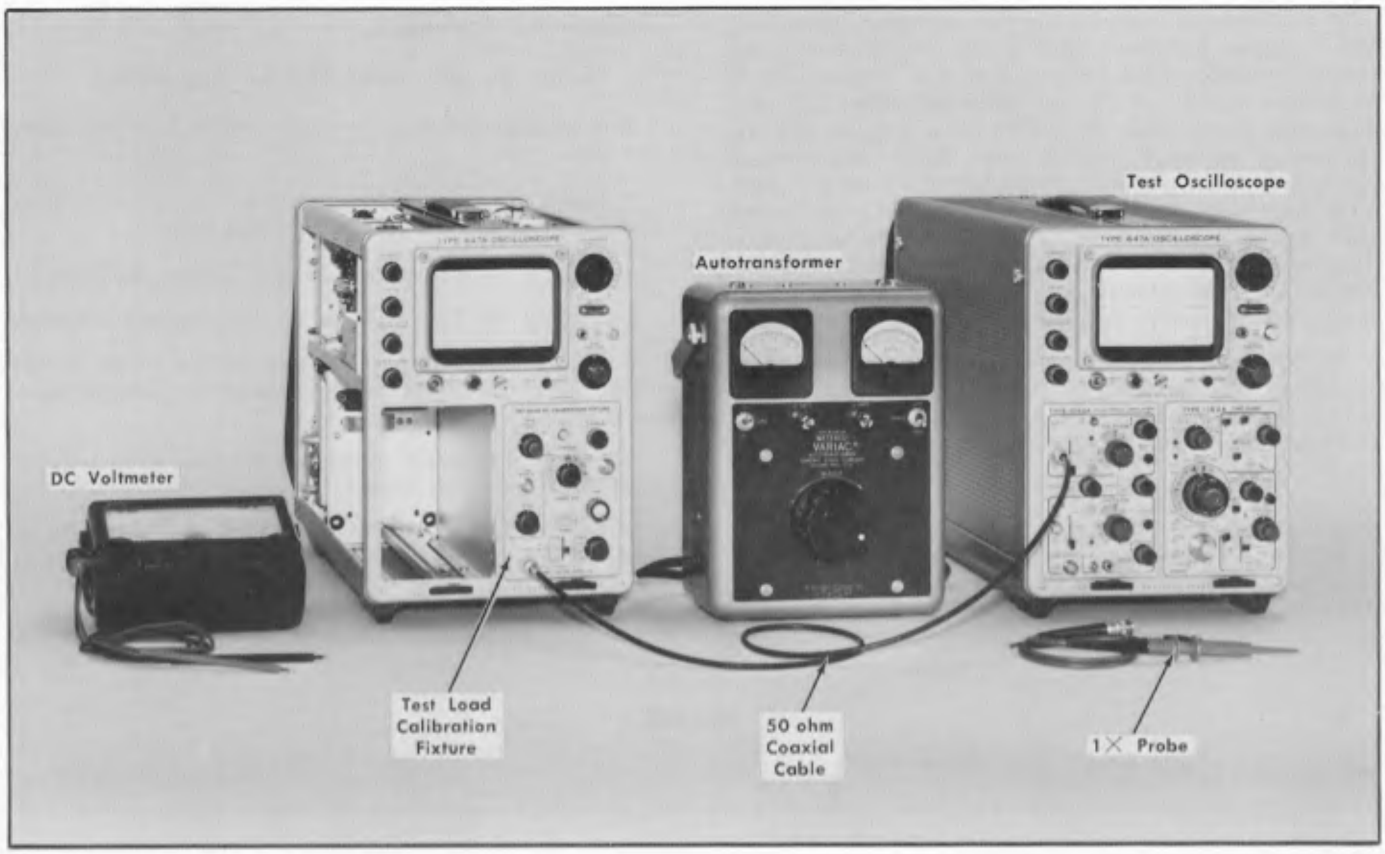


Fig. 6-3. Initial test equipment setup for steps 1 through 6.

Type 647A

INTENSITY	Fully counterclockwise
FOCUS	Midrange
TRACE ROTATION	As is
ASTIGMATISM	Midrange
SCALE ILLUM	Fully counterclockwise
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

067-0544-00

Vertical—Horiz Cal	5
Load	Zero
Source (voltage)	—75 V
(function)	Gnd
Pulse Rate	OFF

NOTE

The power-supply adjustments in this instrument have lock nuts to hold them in the adjusted position and maintain more stable calibration. Use a #10 nutdriver to loosen these lock nuts so the adjustment can be made. Retighten the lock nuts after calibration.

1. Adjust —75 Volt Power Supply

a. Test equipment setup is shown in Fig. 6-3.

b. Set the test oscilloscope for a vertical deflection of 10 mV/division, DC coupled, at a sweep rate of 1 ms/division with line frequency triggering.

c. Connect a 50 ohm coaxial cable from the output connector of the calibration fixture to the input connector on the plug-in of the test oscilloscope.

d. With the source function switch on the calibration fixture set at gnd, postion the trace on the CRT of the test oscilloscope to a convenient reference point.

e. Set the source function switch on the calibration fixture to DC error.

f. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 17.5 millivolts of the reference point.

g. ADJUST— —75 Volts adjustment, R631 (see Fig. 6-4) until there is no deflection of the test oscilloscope trace as the source function switch on the calibration fixture is switched between the DC error and gnd positions.

h. Change the load switch to full.

i. CHECK—Deflection of test oscilloscope trace away from the trace position found in either part f or g of this step should not be more than an additional 5 mV.

j. INTERACTION—May affect operation of most circuits within the Type 647A.

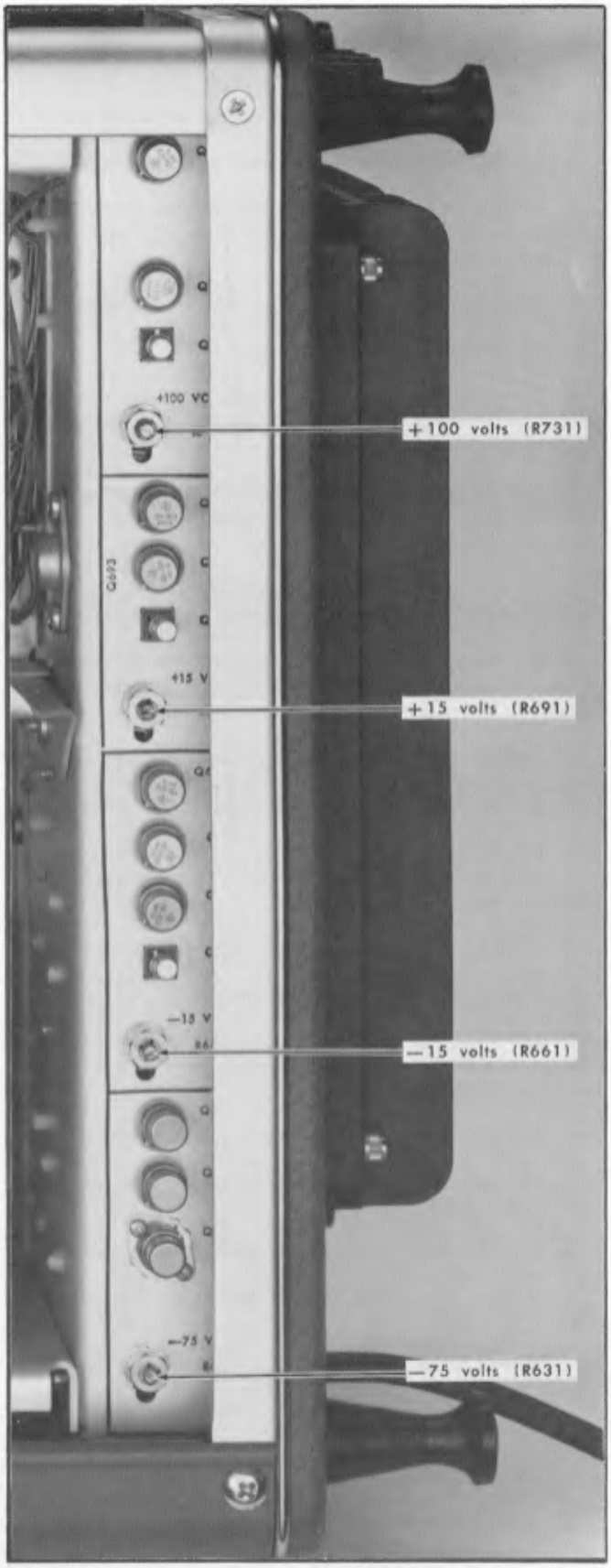


Fig. 6-4. Location of −75 Volts adjustment R631, −15 Volts adjustment R661, +15 Volts adjustment R691, and +100 Volts adjustment R731.

2. Adjust −15 Volt Power Supply

a. Set the source voltage switch on the calibration fixture to −15 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 17.5 millivolts of the reference point.

e. ADJUST— −15 Volts adjustment, R661 (see Fig. 6-4) until there is no deflection of the test oscilloscope trace as the source function switch on the calibration fixture is switched between the DC error and gnd positions.

f. Change the load switch to full.

g. CHECK—Deflection of test oscilloscope trace away from the trace position found in either part d or e of this step should not be more than an additional 5 mV.

h. INTERACTION—May affect operation of most circuits within the Type 647A.

3. Adjust +15 Volt Power Supply

a. Set the source voltage switch on the calibration fixture to +15 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 17.5 millivolts of the reference point.

e. ADJUST— +15 Volts adjustment, R691 (see Fig. 6-4) until there is no deflection of the test oscilloscope trace as the source function switch on the calibration fixture is switched between the DC error and gnd positions.

f. Change the load switch to full.

g. CHECK—Deflection of test oscilloscope trace away from the trace position found in either part d or e of this step should not be more than an additional 5 mV.

h. INTERACTION—May affect operation of most circuits within the Type 647A.

4. Adjust +100 Volt Power Supply

a. Set the source voltage switch on the calibration fixture to +100 V, the source function switch to gnd and the load switch to zero.

b. Position the trace on the CRT of the test oscilloscope to a convenient reference point.

c. Set the source function switch on the calibration fixture to DC error.

d. CHECK—Deflection of test oscilloscope trace away from reference point. It must be within 17.5 millivolts of the reference point.

e. ADJUST— +100 Volts adjustment, R731 (see Fig. 6-4) until there is no deflection of the test oscilloscope trace as the source function switch on the calibration fixture is switched between the DC error and gnd positions.

f. Change the load switch to full.

g. CHECK—Deflection of test oscilloscope trace away from the trace position found in either part d or e of this step should not be more than an additional 5 mV.

h. Change the load switch to zero.

i. INTERACTION—May affect operation of most circuits within the Type 647A.

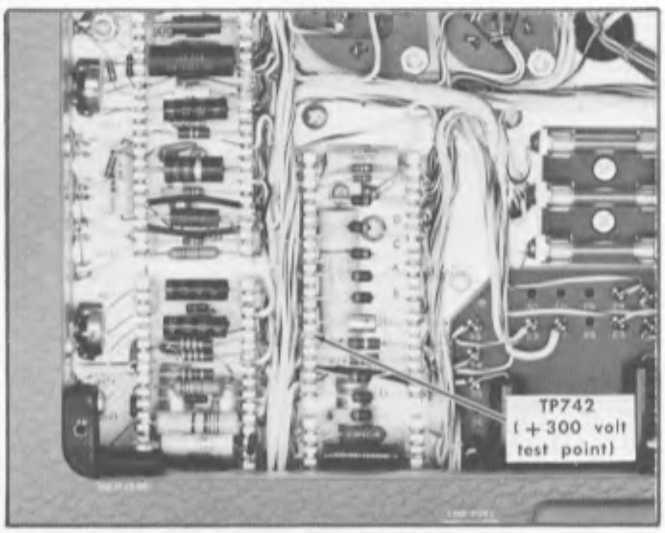


Fig. 6-5. Location of TP742 (+300 volt test point).

5. Check +300 Volt Power Supply

a. Connect a DC voltmeter between TP742 (+300 volt test point), see Fig. 6-5, and ground.

b. CHECK—Meter reading +300 volts, ±30 volts.

c. Disconnect DC voltmeter.

6. Check Low Voltage Power Supply Ripple

a. Set the test oscilloscope for a vertical deflection of 2 volts/division, AC coupled, at a sweep rate of 1 ms/division with line frequency triggering.

b. Connect a 1× probe from the input connector on the plug-in of the test oscilloscope to TP742 (+300 volt test point), see Fig. 6-5.

c. CHECK—Ripple amount; less than or equal to 10 V.

d. Set the calibration fixture load switch to full.

e. Set the autotransformer output voltage to the lower voltage listed for the range selector and voltage selector positions being used.

f. CHECK—Ripple amount; less than or equal to 10 V.

g. Set the calibration fixture load switch to zero.

h. Set the autotransformer output voltage to the higher voltage listed for the range selector and voltage selector positions being used.

i. CHECK—Ripple amount; less than or equal to 10 V.

j. Disconnect the 1× probe from TP742.

k. Connect a 50 ohm coaxial cable from the output connector of the calibration fixture to the test oscilloscope input connector.

l. Set the test oscilloscope for a vertical deflection of 1 mV/division, AC coupled, at a sweep rate of 1 ms/division with line frequency triggering.

m. Set the source function switch on the calibration fixture to ripple and the source voltage switch to —75 V.

n. Set the autotransformer output voltage to the design center voltage that the Type 647A line voltage selector assembly has been adjusted.

o. CHECK—Ripple amount, less than or equal to 3 mV.

p. Set the load switch on the calibration fixture to full.

q. Set the autotransformer output voltage to the lower voltage listed for the range selector and voltage selector positions being used.

r. CHECK—Ripple amount, less than or equal to 3 mV.

s. Change the load switch to zero.

t. Set the autotransformer output voltage to the higher voltage listed for the range selected and voltage selector positions being used.

u. CHECK—Ripple amount, less than or equal to 3 mV.

v. Change the source voltage switch on the calibration fixture to —15 V.

w. Repeat parts p through u of this step.

x. Change the source voltage switch on the calibration fixture to +15 V.

y. Repeat parts p through u of this step.

z. Change the source voltage switch on the calibration fixture to +100 V.

aa. Repeat parts p through u of this step.

ab. Disconnect the test oscilloscope.

ac. Set the autotransformer output voltage to the design center voltage for which the Type 647A line voltage selector assembly has been adjusted.

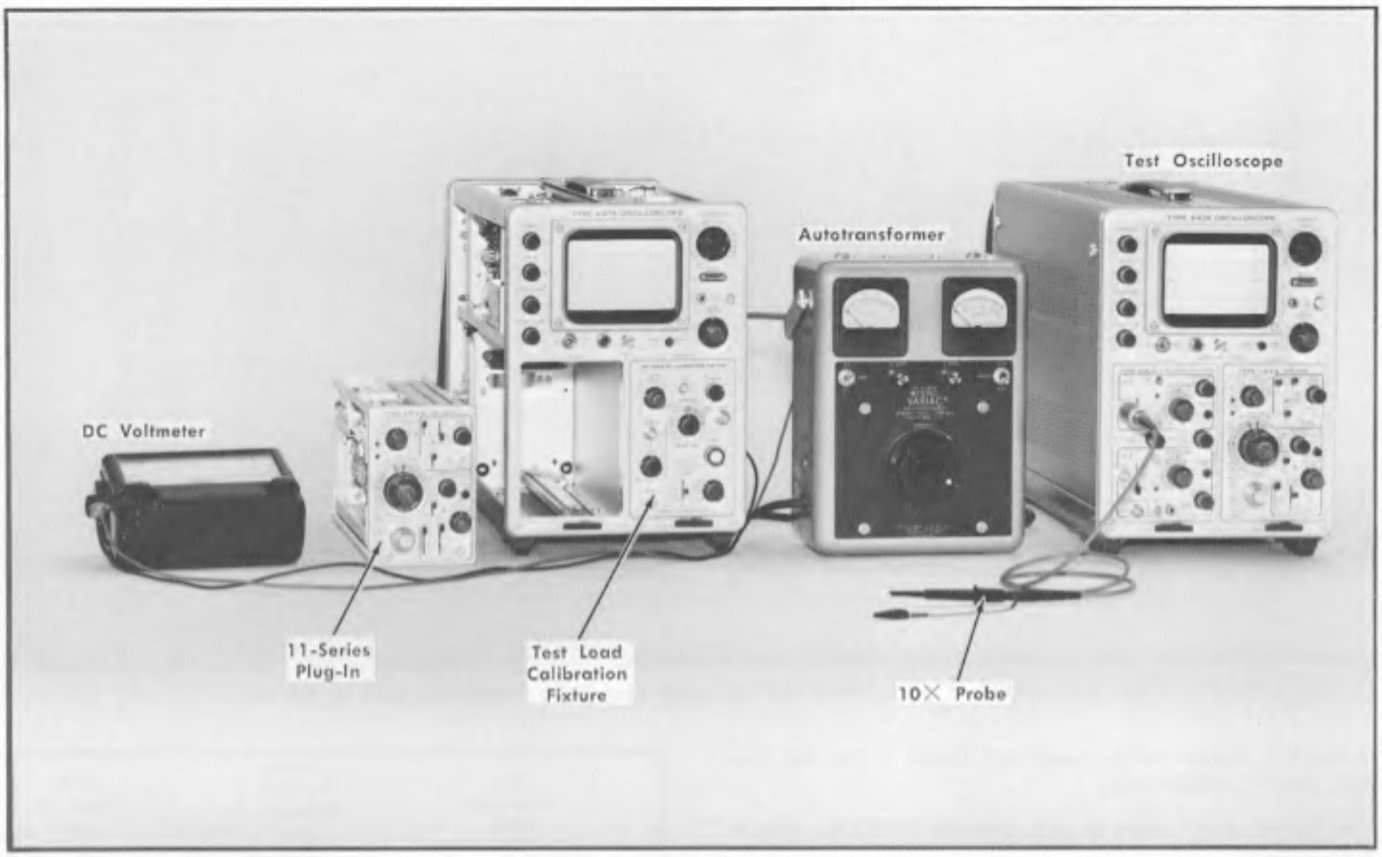


Fig. 6-6. Initial test equipment setup for steps 7 through 9.

Type 647A

INTENSITY	Fully counterclockwise
FOCUS	Midrange
TRACE ROTATION	As is
ASTIGMATISM	Midrange
SCALE ILLUM	Fully counterclockwise
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

067-0544-00

Vertical - Horiz Cal	5
Load	Zero
Source (voltage)	**+100 V**
(function)	**Gnd**
Pulse Rate	OFF

7. Adjust High Voltage Power Supply and CRT Grid Bias ◐

a. Test equipment setup is shown in Fig. 6-6.

b. Connect a DC voltmeter between ground and the HV test point, TP833, see Fig. 6-7.

c. CHECK—Voltage, —2.2 kV, ±66 volts[5].

d. ADJUST—High voltage control, R801 (see Fig. 6-8), for an exact 2.2 kV DC voltmeter indication.

[5]If the precision DC voltmeter and precision divider are used for this step, meter reading should be —2.2 kV, ±22 volts.

e. Set the test oscilloscope for a vertical deflection of 1 volt/division, DC coupled, at a sweep rate of 1 ms/division with internal triggering.

f. Set the Type 647A CRT Grid Bias control fully counterclockwise, see Fig. 6-8.

g. Connect a 10× probe from the input connector on the plug-in of the test oscilloscope to TP873 (emitter test point on Q873), see Fig. 6-7.

h. Set the input coupling switch on the test oscilloscope plug-in unit to gnd, then position the trace on the CRT of the test oscilloscope to a convenient reference point.

i. Return the input coupling switch on the test oscilloscope plug-in unit to DC.

j. Rotate the INTENSITY control until the test oscilloscope trace is positioned exactly two centimeters (+20 volts) above the reference point (ground) found in part h of this step.

k. ADJUST—CRT Grid Bias, R832 so the Type 647A CRT beam is just visible.

l. Disconnect the DC voltmeter, but not the test oscilloscope.

8. Adjust Z-Axis Amplifier High-Frequency Response ◐

a. Remove the 067-0544-00 calibration fixture from the

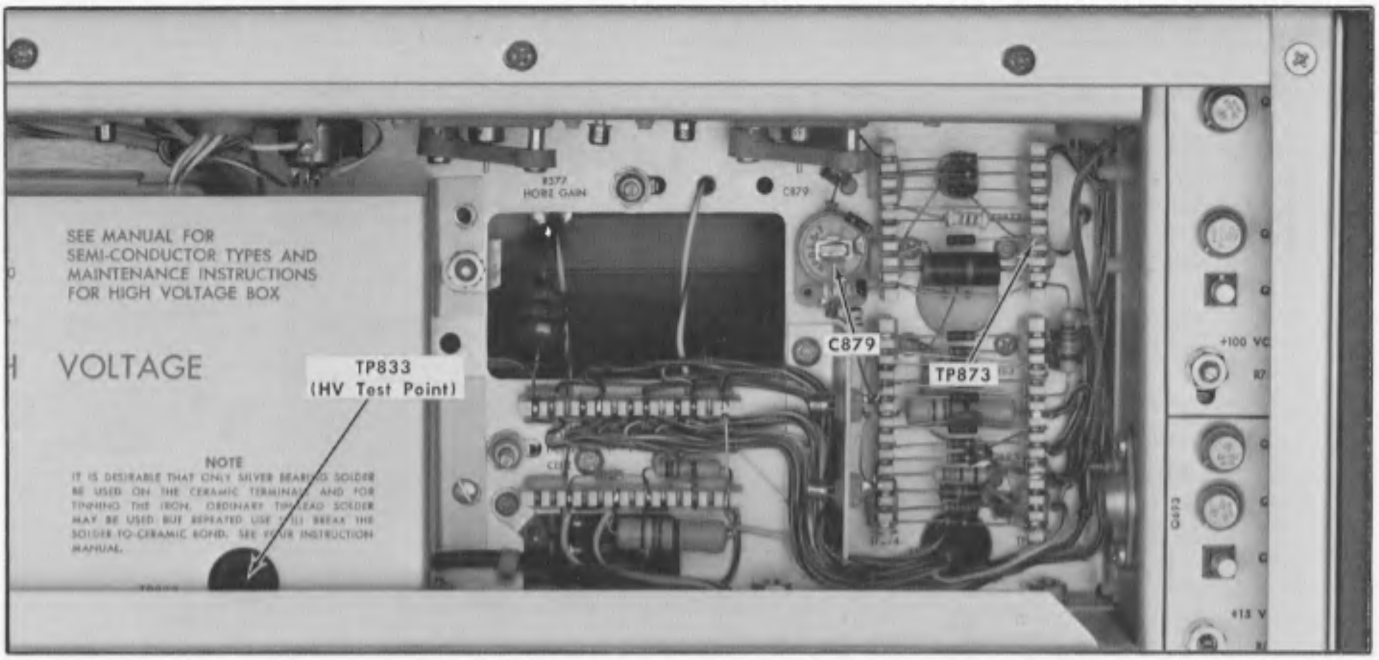


Fig. 6-7. Location of C879, TP833 (HV test point) and TP873 (emitter test point on Q873).

horizontal plug-in compartment and install it into the vertical plug-in compartment.

b. Install an 11-series plug-in into the horizontal plug-in compartment.

c. Set the 11-series plug-in trigger mode switch to free run.

d. Change the test oscilloscope time/division switch to 1 μs.

e. With the 10× probe from the oscilloscope still connected to TP873, rotate the Type 647A INTENSITY control until the displayed pulse amplitude on the test oscilloscope is exactly 30 volts high.

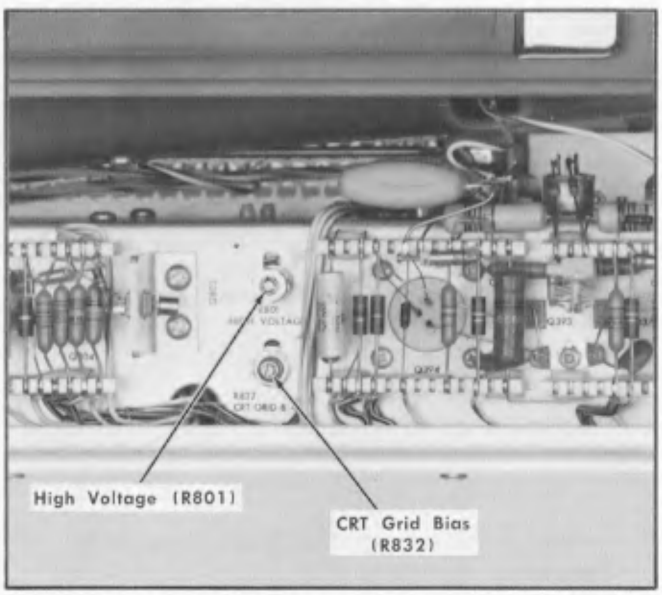


Fig. 6-8. Location of High Voltage control, R801 and CRT Grid Bias, R832.

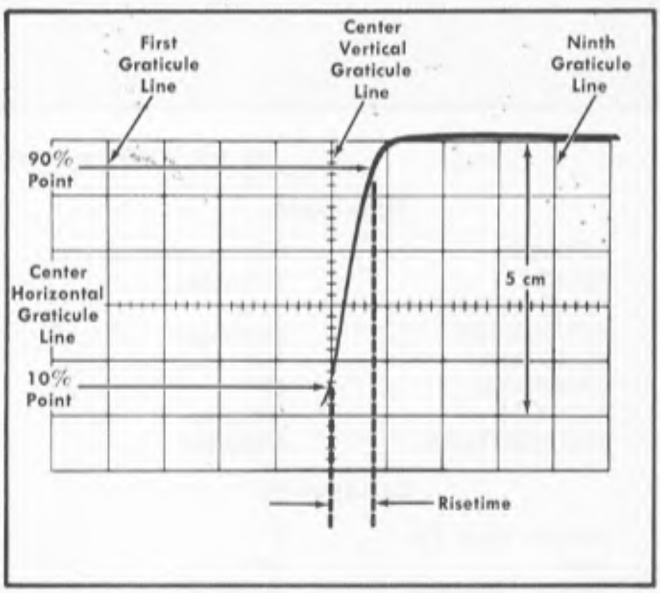


Fig. 6-9. Measuring z-axis amplifier pulse risetime.

f. CHECK—Pulse top for a flat top with no more than 3% overshoot.

g. ADJUST—C879 (see Fig. 6-7) for an optimum flat topped pulse.

h. Set the test oscilloscope time/division switch to 0.5 μs and the sweep magnifier switch to ×10.

i. Adjust the volts/division and the variable (volts/division) controls on the test oscilloscope to obtain a display exactly 5 cm high.

j. CHECK—Pulse risetime (see Fig. 6-9) about 50 ns.

k. Disconnect test oscilloscope.

9. Check High Voltage Power Supply Regulation

a. Remove the 11-series plug-in from the horizontal plug-in compartment.

b. Remove the 067-0544-00 calibration fixture from the vertical plug-in compartment and install it into the horizontal plug-in compartment.

c. Connect a DC voltmeter between ground and the HV test point, TP833, see Fig. 6-7.

d. Rotate the Type 647A POSITION and INTENSITY controls to their fully clockwise positions.

e. CHECK—Meter reading, 2.2 kV, ±66 volts[6]. Note the exact meter reading.

f. Set the autotransformer output voltage to the lower voltage listed for the range selector and voltage selector positions being used.

g. CHECK—Meter reading, negligible change from meter reading noted in part e of this step (less than 5 volts).

h. Set the autotransformer output voltage to the higher voltage listed for the range selector and voltage selector positions being used.

i. CHECK—Meter reading, negligible change from meter reading noted in part e of this step (less than 5 volts).

j. Set the autotransformer output voltage to the design center voltage for which the Type 647A line voltage selector assembly has been adjusted.

k. Rotate the INTENSITY control slowly to its fully counterclockwise position from its fully clockwise position.

l. CHECK—Meter reading, negligible change from meter reading noted in part e of this step for any position of INTENSITY control.

m. Disconnect the DC voltmeter.

[6]**If precision DC voltmeter and precision divider are used for this step, meter reading should be —2.2 kV, ±22 volts.**

NOTES

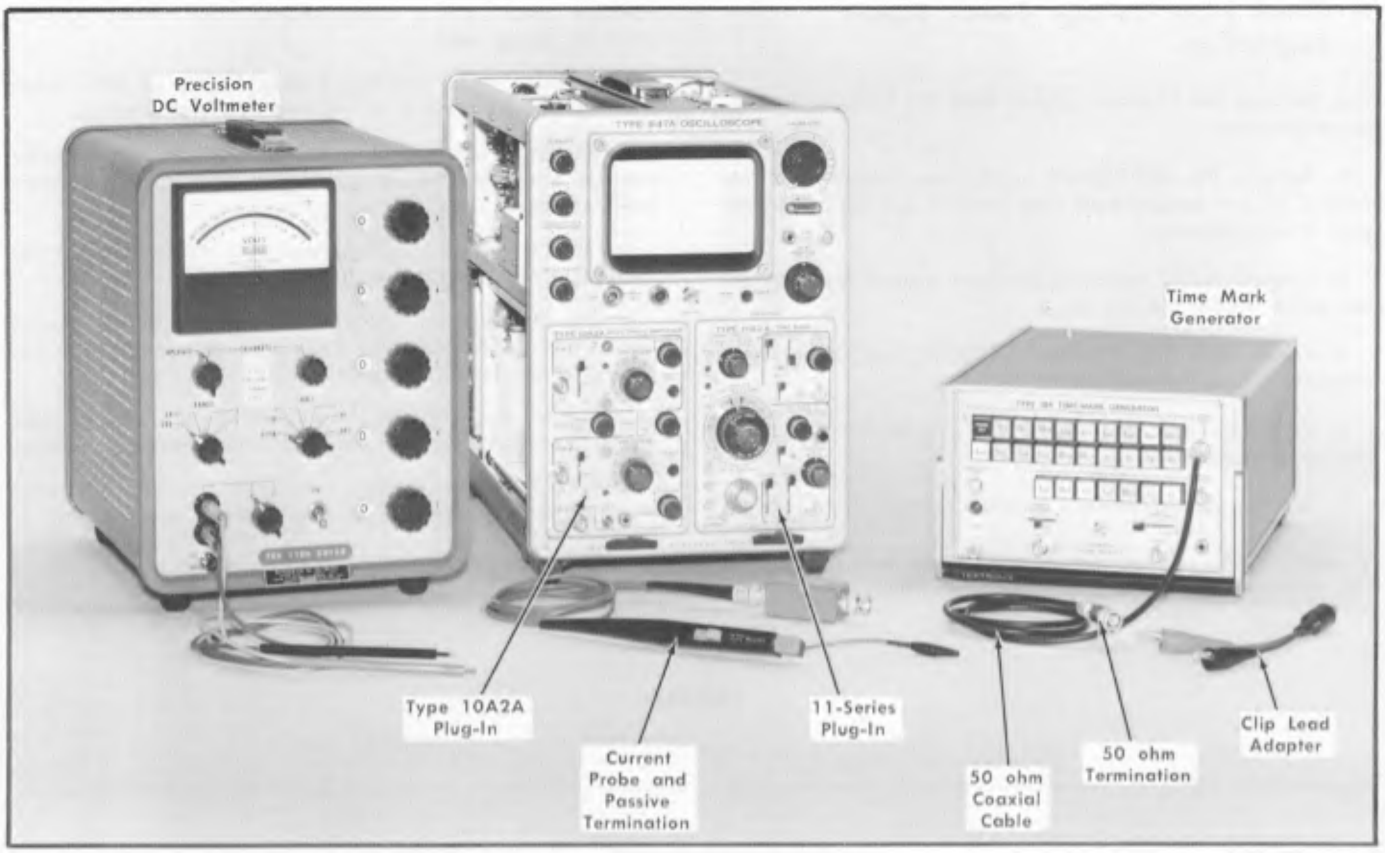


Fig. 6-10. Initial test equipment setup for steps 10 through 15.

Type 647A

INTENSITY	**Usable trace brightness**
FOCUS	**Well defined display**
TRACE ROTATION	As is
ASTIGMATISM	**Well defined display**
SCALE ILLUM	Fully counterclockwise
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

Type 10A2A

Volts/Cm (both channels)	.01
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	AC
Invert (both channels)	Pushed in
Trigger	Norm
Mode	CH 1

11-Series

Time/Cm	1 ms
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

10. Adjust Trace Rotation

a. Test equipment setup is shown in Fig. 6-10.

b. Remove the 067-0544-00 calibration fixture from the horizontal plug-in compartment.

c. Install a Type 10A2A plug-in into the vertical plug-in compartment and an 11-series plug-in into the horizontal plug-in compartment.

d. Set the controls of the Type 10A2A and 11-Series plug-in as described above.

e. Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for a well defined trace of moderate brightness.

f. Position the trace to the center horizontal graticule line.

g. CHECK—Trace is parallel to the horizontal graticule line.

h. ADJUST—TRACE ROTATION control, R861 (see Fig. 6-11), so the trace is parallel to the horizontal graticule line.

11. Adjust Vertical Geometry

a. Connect a 50 ohm coaxial cable from the time mark generator marker output connector through a 50 ohm termination to the channel 1 input connector on the Type 10A2A plug-in.

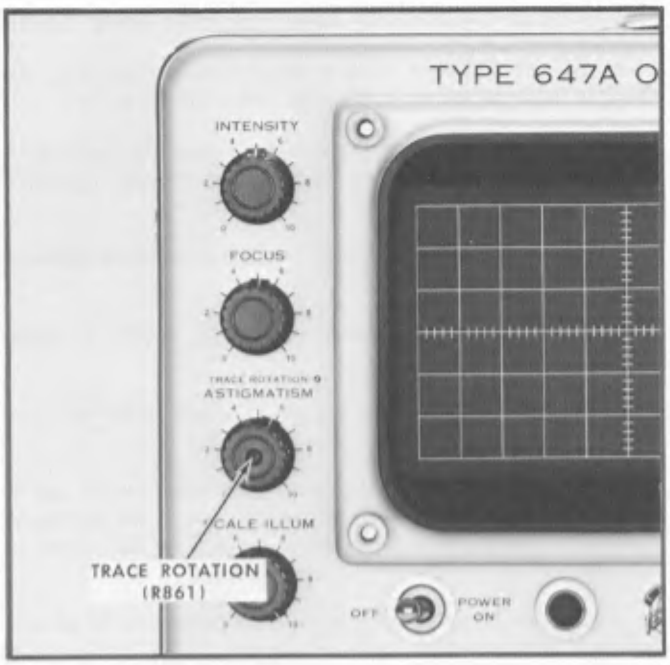


Fig. 6-11. Location of TRACE ROTATION control, R861.

b. Set the front-panel controls of the time mark generator so it will produce a mixed output of 1 ms and 0.1 ms time markers.

c. Adjust the Type 10A2A plug-in position, input coupling switch, volts/cm and variable (volts/cm) controls to obtain a display of time markers which completely cover the graticule area.

d. Adjust the 11-series plug-in triggering controls to obtain a stable display.

e. Adjust the 11-series plug-in variable (time/cm) control to obtain a display consisting of one 1 ms time markers per centimeter and ten 0.1 ms time markers per centimeter.

f. CHECK—Time markers (vertical lines) should be paralled within 1 mm to the vertical graticule lines over the height of the vertical graticule area.

g. ADJUST—Geometry control, R863 and Y Axis Alignment control, R865 (see Fig. 6-12) so the time markers (vertical lines) are paralled within 1 mm to the vertical graticule lines over the height of the vertical graticule area.

h. Disconnect the time mark generator.

12. Check Horizontal Geometry

a. Adjust the 11-series plug-in triggering controls to obtain a free running trace.

b. Position the horizontal trace to each horizontal graticule line.

c. CHECK—Horizontal trace is within 1 mm of being parallel to each horizontal graticule line over the width of the horizontal graticule area. If the trace is not within this requirement, repeat step 11.

13. Check Calibrator Voltage and Frequency Accuracy

a. Turn off the Type 647A POWER switch.

b. Remove transistor Q945.

c. Turn the Type 647A POWER switch on again.

d. Connect a 50 ohm coaxial cable to the Type 647A CAL OUT connector.

e. Connect a BNC to clip lead adapter to the unconnected end of the 50 ohm coaxial cable.

f. Connect the red lead of the clip lead adapter to the positive input connector of the precision DC voltmeter.

g. Connect the black lead of the adapter to the negative input connector of the precision DC voltmeter.

h. Set the Type 647A CALIBRATOR switch to 100 V or 100 V DC.

i. CHECK—Precision DC voltmeter reading, 100 volts ±1 volt.

NOTE

The accuracy of the 100 V square wave or the 100 V DC positions of the CALIBRATOR switch is directly related to the accuracy of the +100 volt power supply.

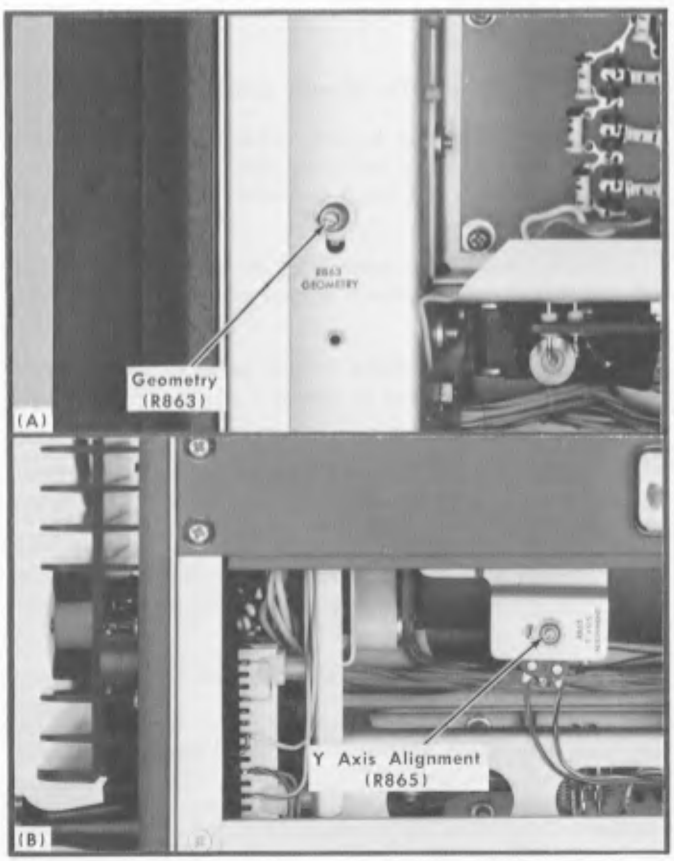


Fig. 6-12. (A) Location of Geometry control, R863. (B) Location of Y Axis Alignment control, R865.

j. Set the CALIBRATOR switch in turn to each position listed in Table 6-1.

k. CHECK—Precision DC voltmeter reading (refer to Table 6-1) for each CALIBRATOR switch position.

TABLE 6-1

Calibrator Voltage Check

CALIBRATOR Switch Position	Voltage and Tolerance
50 V	50 volts ±1 volt
20 V	20 volts ±0.4 volt
10 V	10 volts ±0.2 volt
5 V	5 volts ±0.1 volt
2 V	2 volts ±0.04 volt
1 V	1 volt ±0.02 volt
.5 V	0.5 volt ±0.01 volt
.2 V	0.2 volt ±0.004 volt
.1 V	0.1 volt ±0.001 volt

NOTE

Due to the design of the CALIBRATOR switch, the remaining CALIBRATOR switch positions are not checked.

l. Turn off the Type 647A POWER switch.

m. Disconnect the precision DC voltmeter.

n. Re-install Q945.

o. Turn the Type 647A POWER switch on again.

p. Connect a 50 ohm coaxial cable from the time mark generator marker output connector through a 50 ohm termination to the channel 1 input connector on the Type 10A2A plug-in.

q. Set the front-panel controls of the time mark generator so it will produce a mixed output of 1 ms and 1 s time markers.

r. Adjust the Type 10A2A plug-in position, volts/cm and variable (volts/cm) control to obtain a display of time markers about 3 cm high.

s. Set the 11-series plug-in trigger mode to norm, trigger coupling to AC Low Frequency Reject, trigger source to ext and the trigger level control to exactly 0.

t. Connect a 50 ohm coaxial cable from the Type 647A CAL OUT connector to the trig in connector on the 11-series plug-in.

u. Set the Type 647A CALIBRATOR switch to 5 V.

v. CHECK—Drift from a reference point. There should be no more than 10 cm of drift of any one 1 ms time marker in a 10 second time period (frequency of 1 kHz, ±0.1% or less). Use the 1 s time markers to count the 10 second time period.

w. Disconnect the 50 ohm coaxial cables, the 50 ohm termination and the time mark generator.

14. Check Calibrator Risetime and Duty Cycle

a. Set the 11-Series plug-in time/cm switch to .5 μs, the trigger slope switch to + and the source switch to int.

b. Connect a 50 ohm coaxial cable from the Type 647A CAL OUT connector to the Type 10A2A plug-in channel 1 input connector.

c. Set the Type 10A2A plug-in volts/cm switch to obtain a display 5 cm high.

d. Adjust the trigger level control to obtain a stable display.

e. CHECK—Risetime (see Fig. 6-13), equal to or less than 1 μs.

f. With the 11-series plug-in trigger slope switch set to +, adjust the 11-series plug-in trigger level so the displayed calibrator waveform is triggered at the mid, or 50% point of its rise.

g. Set the 11-series plug-in time/cm switch to 50 μs and observe that one-half cycle of square wave display now occupies ten horizontal divisions.

h. Magnify the trailing edge of the displayed positive-going half cycle of the calibrator waveform by ×50.

i. Position the mid, or 50% point of the falling portion of the magnified calibrator waveform to the intersection of the center graticule lines.

j. Pull out the Type 10A2A channel 1 invert switch.

k. CHECK—Horizontal trace movement; not more than two centimeters (2 μs) of horizontal trace shift.

l. Push in the Type 10A2A channel 1 invert switch.

m. Disconnect the 50 ohm coaxial cable.

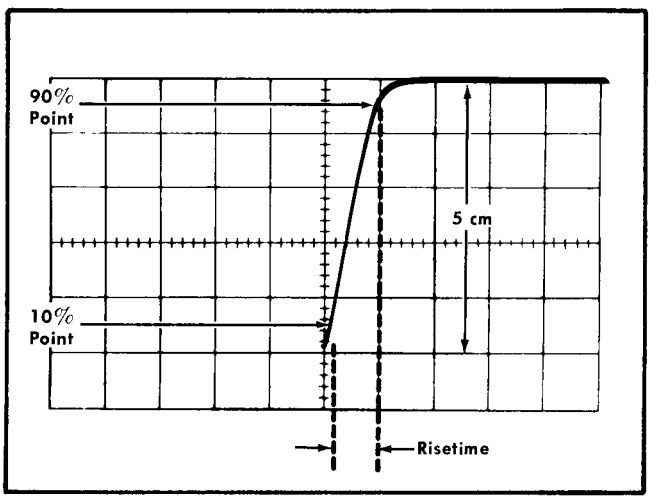


Fig. 6-13. Measuring calibrated risetime with a sweep rate of 0.5 μs/cm.

15. Check Calibrator Current Waveform

a. Connect a P6019 passive termination to the Type 10A2A plug-in channel 1 input connector.

b. Connect a P6019 probe from the unconnected end of the P6019 passive termination to the Type 647A calibrator 5 mA current loop.

c. Set the P6019 passive termination switch to 2 mA/mV.

d. Set the 11-series plug-in time/cm switch to 1 ms and the variable (time/cm) to calibrate.

e. Set the Type 10A2A plug-in volts/cm switch to .01.

f. Set the Type 647A CALIBRATOR switch to the 5 mA current loop position.

g. CHECK—Display for a square-wave display about 2.5 mm in amplitude.

NOTE

This step checks for the presence of current in the CURRENT PROBE CAL loop. This current will remain within the stated 1.5% accuracy due to the tolerance of the voltage divider resistors and tolerance of the calibrator output voltage (adjusted in step 4). If it is necessary to verify the accuracy of the calibrator current, use a current measuring meter with an accuracy of at least 0.25%.

h. Disconnect the P6019 passive termination and the P6019 probe.

i. Turn the Type 647A CALIBRATOR switch to OFF.

NOTES

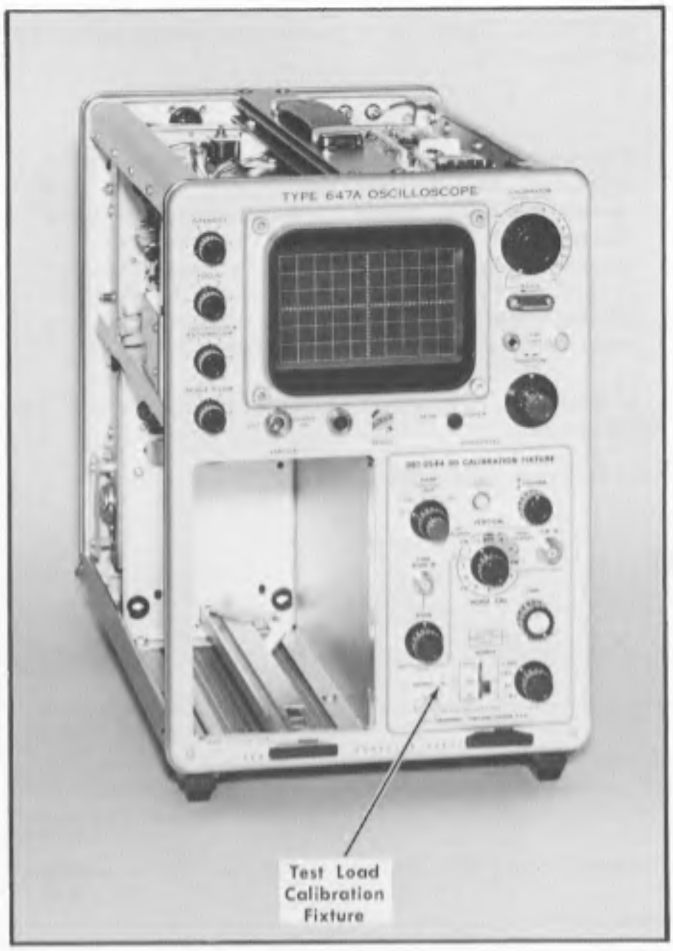


Fig. 6-14. Initial test equipment setup for step 16.

Type 647A	
INTENSITY	**Adjust for dim spot**
FOCUS	Well defined spot
TRACE ROTATION	As is
ASTIGMATISM	Well defined spot
SCALE ILLUM	**As desired**
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange
067-0544-00	
Vertical-Horiz Cal	1
Load	Zero

16. Adjust Horizontal Gain and Centering ❶

a. Test equipment setup is shown in Fig. 6-14.

b. Remove the Type 10A2A and 11-series plug-ins from the Type 647A.

c. Install calibration fixture 067-0544-00 into the horizontal plug-in compartment of the Type 647A and set the vertical-horiz cal switch to 1.

d. Adjust the INTENSITY, FOCUS and ASTIGMATISM control for a well defined dim spot.

e. CHECK—Spot location. It should be within 2 mm of the first centimeter vertical graticule line.

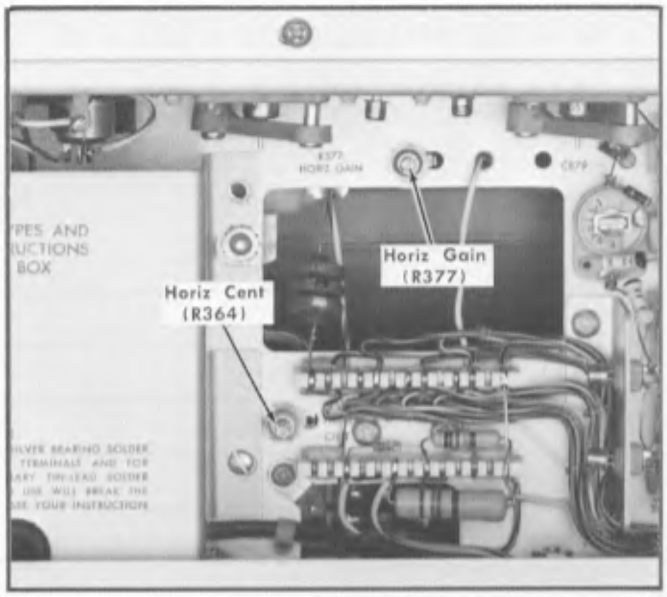


Fig. 6-15. Location of Horiz Cent control, R364 and Horiz Gain control, R377.

f. ADJUST—Horiz Cent control, R364 (see Fig. 6-15), so the spot rests on the first centimeter vertical graticule line.

g. Set the calibration fixture vertical-horiz cal switch to 9.

h. CHECK—Gain; spot should be 8 centimeters, ±0.8 mm to the right of the position established in either part e or f.

i. ADJUST—Horiz Gain control, R377 (see Fig. 6-15), to correct for one-half the error observed in part h, then repeat parts e through i of this step until exactly 8 centimeters of deflection is observed between the 1 and 9 positions of the vertical-horiz cal switch on the 067-0544-00.

j. Set the calibration fixture vertical-horiz cal switch to each of its positions in succession to check linearity (step k).

k. CHECK—Linearity; the spot should be within 0.5 mm of a vertical graticule line at each position of the calibration fixture vertical-horiz cal switch, after the spot has been adjusted for no error at the 1st and 9th centimeter vertical graticule lines.

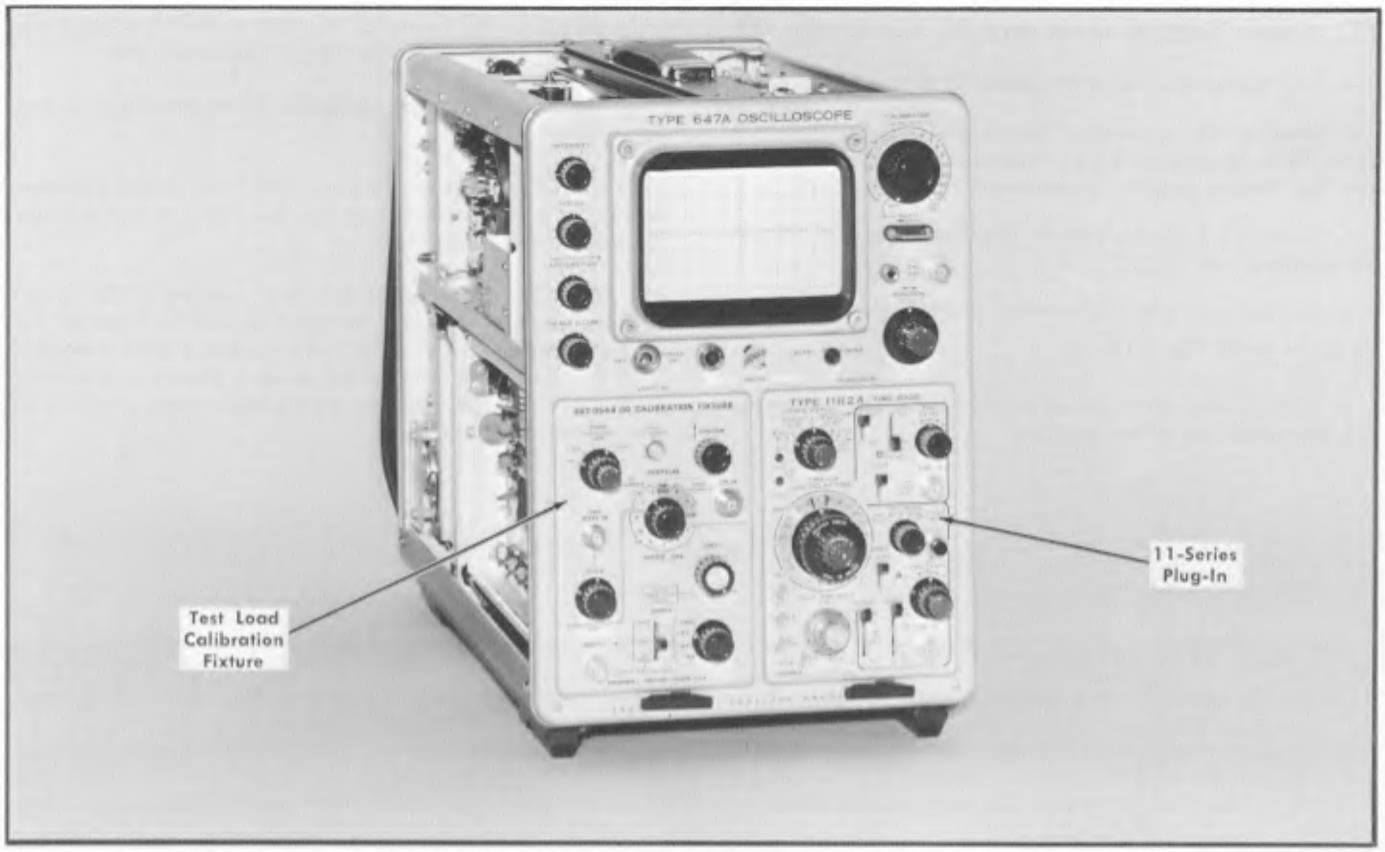


Fig. 6-16. Initial test equipment setup for step 17.

Type 647A	
INTENSITY	Adjust for dim spot
FOCUS	Well defined spot
TRACE ROTATION	As is
ASTIGMATISM	Well defined spot
SCALE ILLUM	As desired
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange
067-0544-00	
Vertical-Horiz Cal	**+3**
Load	Zero
11-Series Plug-In	
Time/Cm	1 ms
Magnification	1 time
Trigger Mode	Free run
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

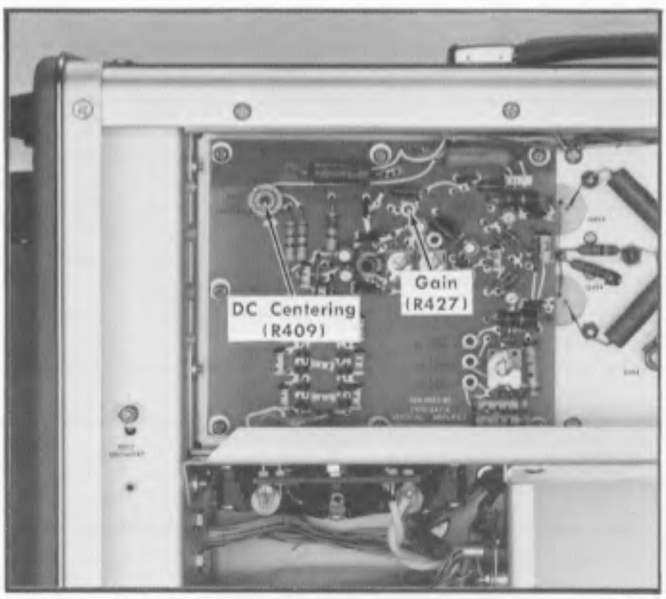


Fig. 6-17. Location of DC centering control, R409 and Gain control, R427.

17. Adjust Vertical Gain and DC Centering ◐

a. Test equipment setup is shown in Fig. 6-16.

b. Remove the calibration fixture 067-0544-00 from the Type 647A horizontal plug-in compartment and install it into the vertical plug-in compartment.

c. Install an 11-series plug-in into the horizontal plug-in compartment.

d. Set the calibration fixture and 11-series plug-in controls as given below Fig. 6-16.

e. CHECK—The trace should be within 0.2 divisions of the top horizontal line of the graticule.

f. ADJUST—DC Centering adjustment, R409 (see Fig. 6-17), so the trace is positioned to the top horizontal line.

g. Set the vertical-horiz cal switch of the calibration fixture to −3 cm.

h. CHECK—Trace should be six divisions, ±0.06 divisions, below the position established in either part e or f of this step (at bottom horizontal line).

i. ADJUST—Gain adjustment, R427 (see Fig. 6-17), to correct for one-half the error observed in part h. Then set the vertical-horiz cal switch to +3 cm and repeat parts e through i of this step until exactly six division change is observed when switching between the +3 cm and −3 cm positions of the vertical-horiz cal switch.

NOTES

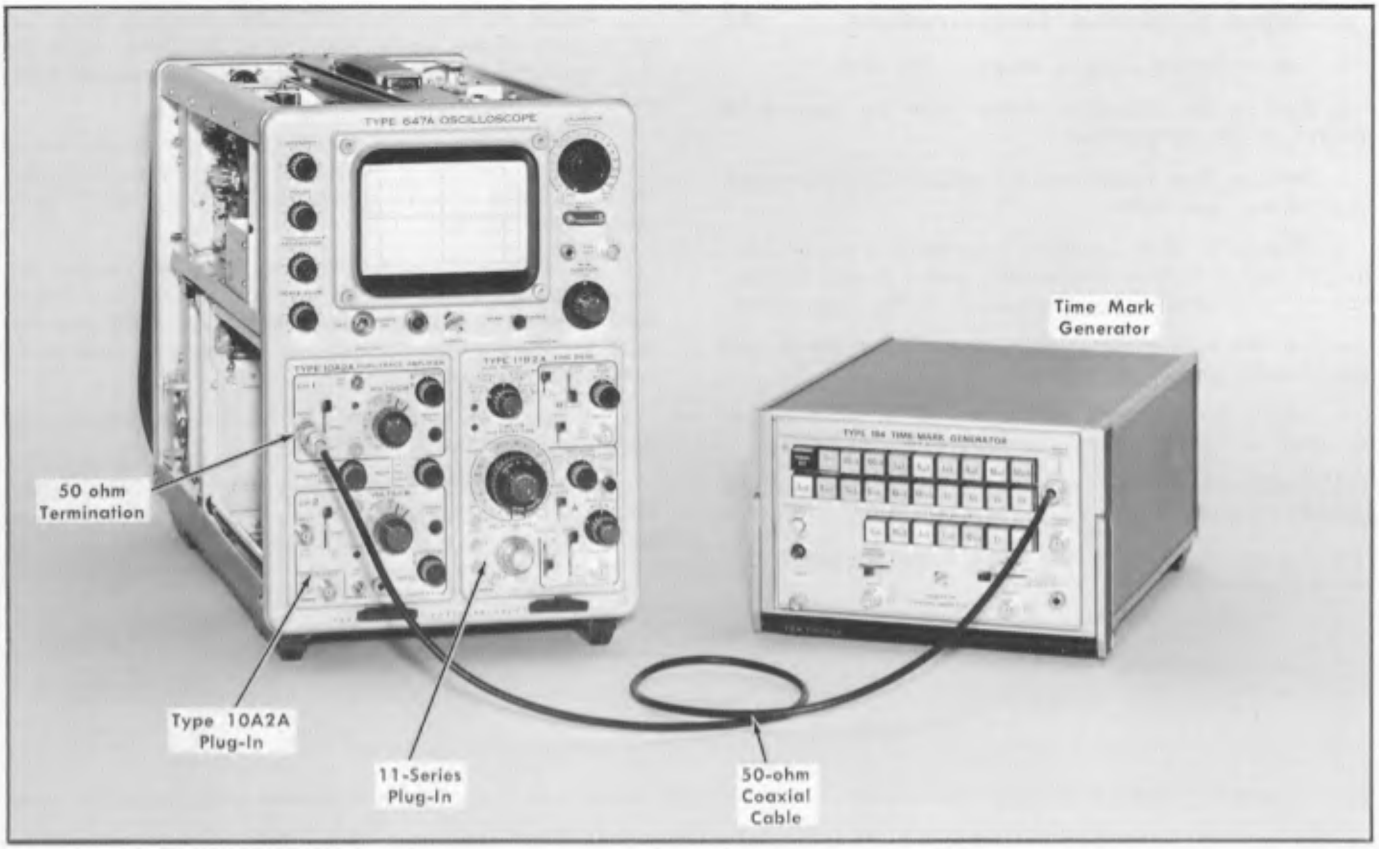


Fig. 6-18. Initial test equipment setup for step 18.

Type 647A

INTENSITY	**Usable trace brightness**
FOCUS	Well defined display
TRACE ROTATION	As is
ASTIGMATISM	Well defined display
SCALE ILLUM	As desired
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

Type 10A2A

Volts/Cm (both channels)	.2
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	AC
Invert (both channels)	Pushed in
Trigger Mode	Norm Ch 1

11-Series

Time/Cm	**.1 μs**
Magnification	1 time

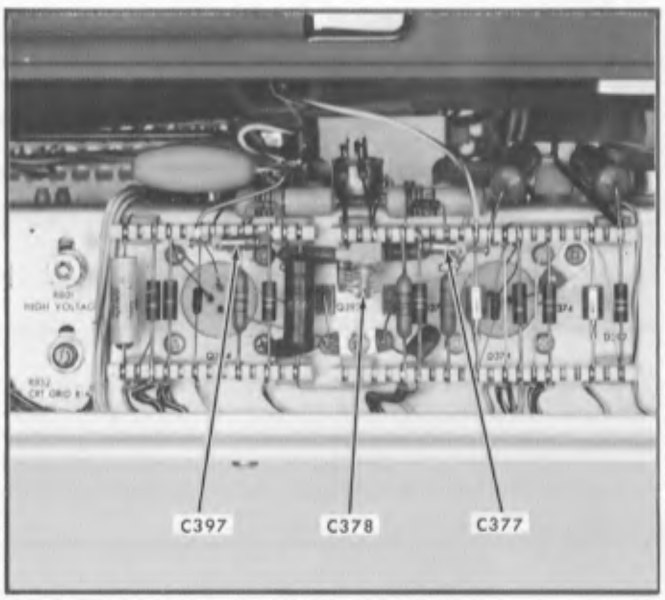


Fig. 6-19. Location of C377, C397 and C378.

Trigger Mode	**Norm**
Trigger Slope	+
Trigger Coupling	**AC Low Frequency Reject**
Trigger Source	Int

18. Adjust Horizontal Compensations ◐

a. Test equipment setup is shown in Fig. 6-18.

b. Remove the calibration fixture from the Type 647A vertical plug-in compartment.

c. Install a Type 10A2A into the vertical plug-in compartment of the Type 647A.

d. Connect a 10 ns waveform from the time-mark generator through a 50 ohm coaxial cable and a 50 ohm termination to the channel 1 input connector of the Type 10A2A.

e. Set the front-panel controls of the Type 10A2A and the 11-series plug-in as indicated above.

f. Adjust the trig level control on the 11-series plug-in to obtain a stable display.

g. Center the display within the graticule area with the position controls.

h. Magnify the display ten times, using the proper 11-series plug-in control.

i. Adjust the horizontal POSITION control so there will be a cycle of the display crossing at the point where the first centimeter graticule line and the center horizontal graticule line cross.

j. CHECK—Timing and linearity; 8 cycles of the waveform should occupy 8 centimeters of the graticule within ±3% (2.5 mm) and the cycles should be spaced 1 centimeter apart ±1 mm.

k. ADJUST—C377 and C397 (see Fig. 6-19) for best linearity from the center vertical graticule line to the first and ninth centimeter graticule lines, then adjust C378 (see Fig. 6-19) for exactly 8 cycles between the first and ninth centimeter graticule lines.

l. Repeat parts g through k of this step several times to obtain optimum linearity and timing.

m. Adjust the POSITION control so that all of the magnified display can be checked as per part j of this step except for the first and last five centimeters of the display.

n. Disconnect the time mark generator connection.

NOTES

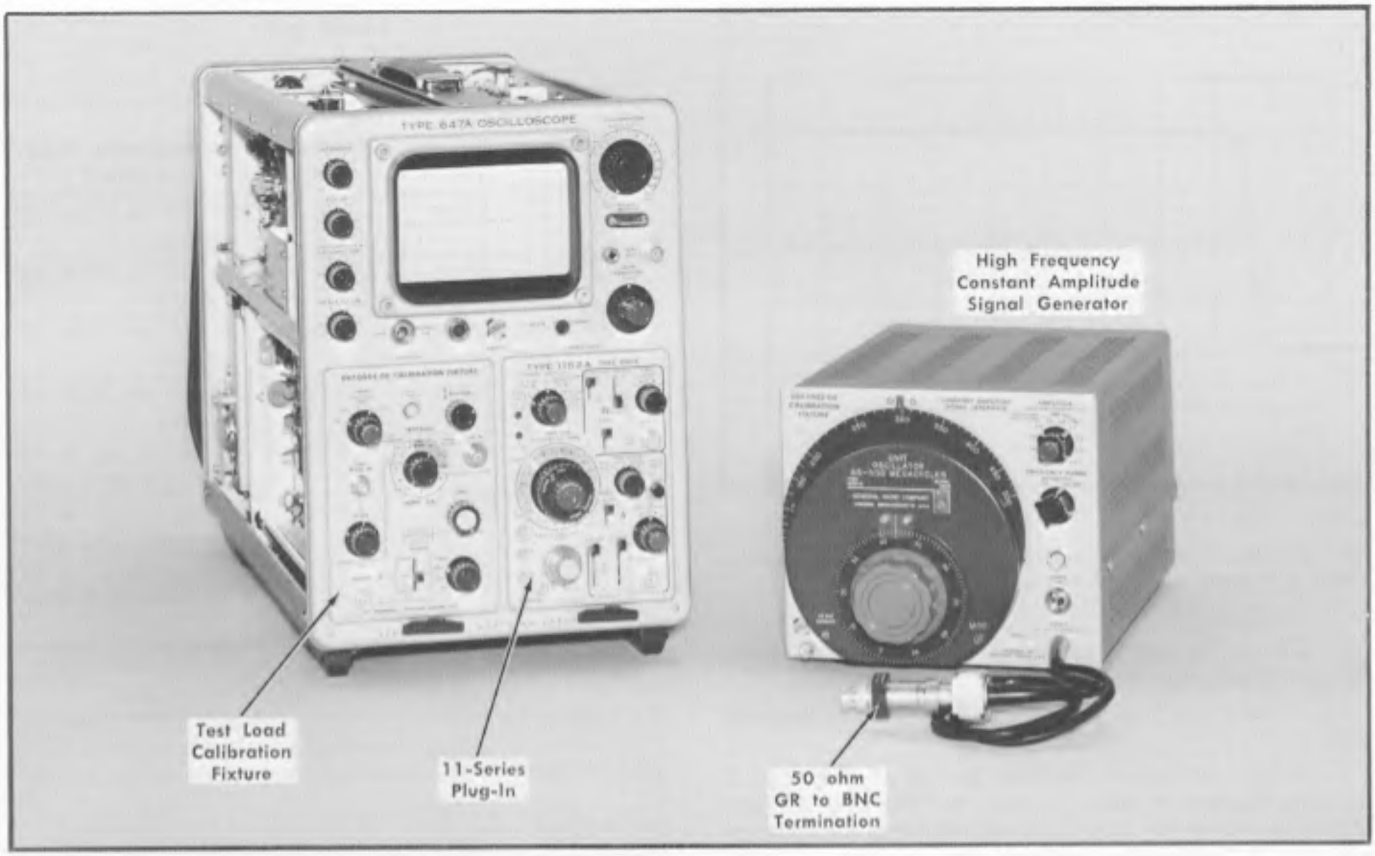


Fig. 6-20. Initial test equipment setup for steps 19 and 20.

Type 647A

INTENSITY	Usable trace brightness
FOCUS	Well defined display
TRACE ROTATION	As is
ASTIGMATISM	Well defined display
SCALE ILLUM	As desired
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

067-0544-00

Vertical-Horiz Cal	**+ Pulse Polarity**
Load	Zero
Pulse Rate	**Set to mark just before high**

11-Series

Time/Cm	**.5 μs**
Magnification	**1 time**
Trigger Mode	Norm
Trigger Slope	+
Trigger Coupling	**AC**
Trigger Source	**Int**

19. Adjust and Check Vertical Compensations

a. Test equipment setup is shown in Fig. 6-20.

b. Remove the Type 10A2A from the Type 647A vertical plug-in compartment and install the calibration fixture in the plug-in compartment.

c. Set the front-panel controls of the calibration fixture and the 11-series plug-in as indicated above.

d. Adjust the trigger level control on the 11-series plug-in to obtain a stable display.

e. Rotate the calibration fixture amplitude control to obtain a display 4 cm high on the Type 647A CRT.

f. With the calibration fixture position control, center the display vertically within the graticule area of the Type 647A.

g. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 3% of the total waveform amplitude and waveform preshoot for an amount less than 2.5% of the total waveform amplitude, see Fig. 6-21. The checks should be made using the time/cm switch and the approximate area of effect columns in Table 6-2.

h. ADJUST—HF Comp 1, R429; HF Comp 2, R467; HF Comp 3, R465, C465; HF Comp 4, R475, C475, C435 and L428 (see Fig. 6-22) as shown in Table 6-2 for a waveform having an optimum risetime with minimum (less than 3%) overshoot, rolloff, tilt and ringing, and minimum (less than 2.5%) preshoot. Repeat the adjustments in Table 6-2 until all adjustments are correctly made.

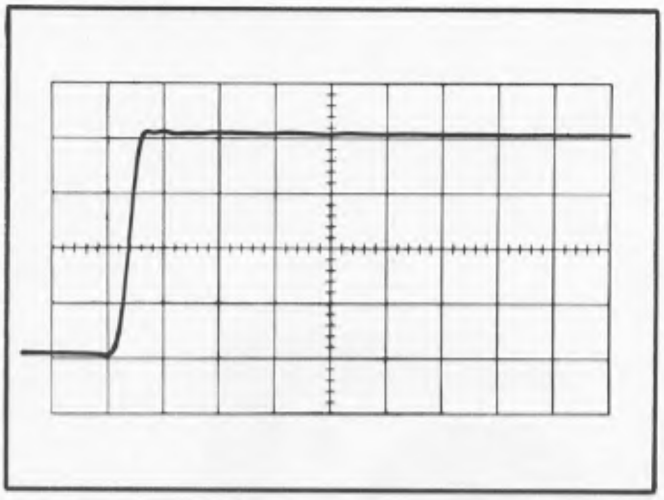


Fig. 6-21. Waveform of a correctly compensated vertical amplifier shown at a sweep rate of 10 ns/cm.

i. Change the calibration fixture vertical-horiz cal switch to —pulse polarity.

j. Re-center the waveform vertically within the graticule area.

k. CHECK—Waveform, re-check part g of this step. If anything checked in part g is over the allowable amount, repeat part h of this step; this time, adjusting the components for a compromise between the + and — pulse polarities.

l. Set the calibration fixture vertical-horiz cal switch to —pulse polarity and increase the displayed pulse amplitude to 6 cm with the calibration fixture amplitude control.

m. Position the bottom of the displayed pulse to the top graticule line.

n. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 6% of the total waveform amplitude.

o. Set the calibration fixture vertical-horiz cal switch to +pulse polarity.

p. Position the top of the displayed pulse to the bottom graticule line.

q. CHECK—Waveform overshoot, rolloff, tilt and ringing for an amount less than 5% of the total waveform amplitude.

r. Set the 11-series time/cm switch to .1 μs.

s. Decrease the displayed pulse amplitude to 4 cm with the calibration fixture amplitude control.

t. Center the waveform vertically within the graticule area.

u. CHECK—Termination aberrations (located about 3 cm from leading corner of pulse); less than 0.5 mm in amplitude.

v. Set the calibration fixture pulse rate switch one position counterclockwise, i.e., to the position that is one mark clockwise from the position marked low.

w. Set the 11-series time/centimeter switch to one millisecond. Readjust the trigger level control for a stable display if necessary.

x. Center the waveform vertically within the graticule area with the calibration fixture position control and decrease the displayed pulse amplitude to exactly two divisions with the amplitude control.

y. Position the top of the display to the top horizontal line of the graticule.

z. CHECK—Compression or expansion at the center vertical line of the graticule is less than 0.15 division.

aa. Position the bottom of the display to the bottom horizontal line of the graticule.

ab. CHECK—Compression or expansion at the vertical center line of the graticule is less than 0.15 division.

TABLE 6-2

Vertical Compensations

Adjustment	Time/Cm Switch Setting	Magnified Sweep Rate	Approximate Area of Effect
R467	0.5 μs	×1	First 0.1 to 0.3 μs of display
R465	0.1 μs	×1	First 25 to 75 ns of display
C465	0.5 μs	×10	First 25 to 125 ns of display
R475	0.2 μs	×10	First 10 to 30 ns of display
R429 and C437	0.1 μs	×10	Leading corner to 10 ns point of display
C435	0.1 μs	×10	Leading corner to 10 ns point of display
L428[1]	0.1 μs	×10	Leading corner to 10 ns point of display

[1]L428 is adjusted for minimum amount of ringing on the waveform.

Fig. 6-22. Location of vertical compensation adjustments.

20. Check Vertical Bandwidth

a. Connect the output of a high frequency constant amplitude sine wave generator through a 50 ohm GR to BNC termination to the calibration fixture cm in connector.

b. Set the 11-series plug-in trigger mode switch to free run.

c. Set the calibration fixture vertical-horiz cal switch to cw.

d. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).

e. Adjust the output amplitude control of the high frequency generator until exactly 4 cm of display are obtained on the CRT of the Type 647A.

f. Change the high frequency generator output frequency switch to its variable frequency position.

g. Rotate the frequency dial from its lower limit toward its highest limit, stopping when the displayed amplitude decreases to exactly 2.8 cm.

h. CHECK—Bandwidth; at least 130 MHz.

i. Disconnect the high frequency generator.

NOTES

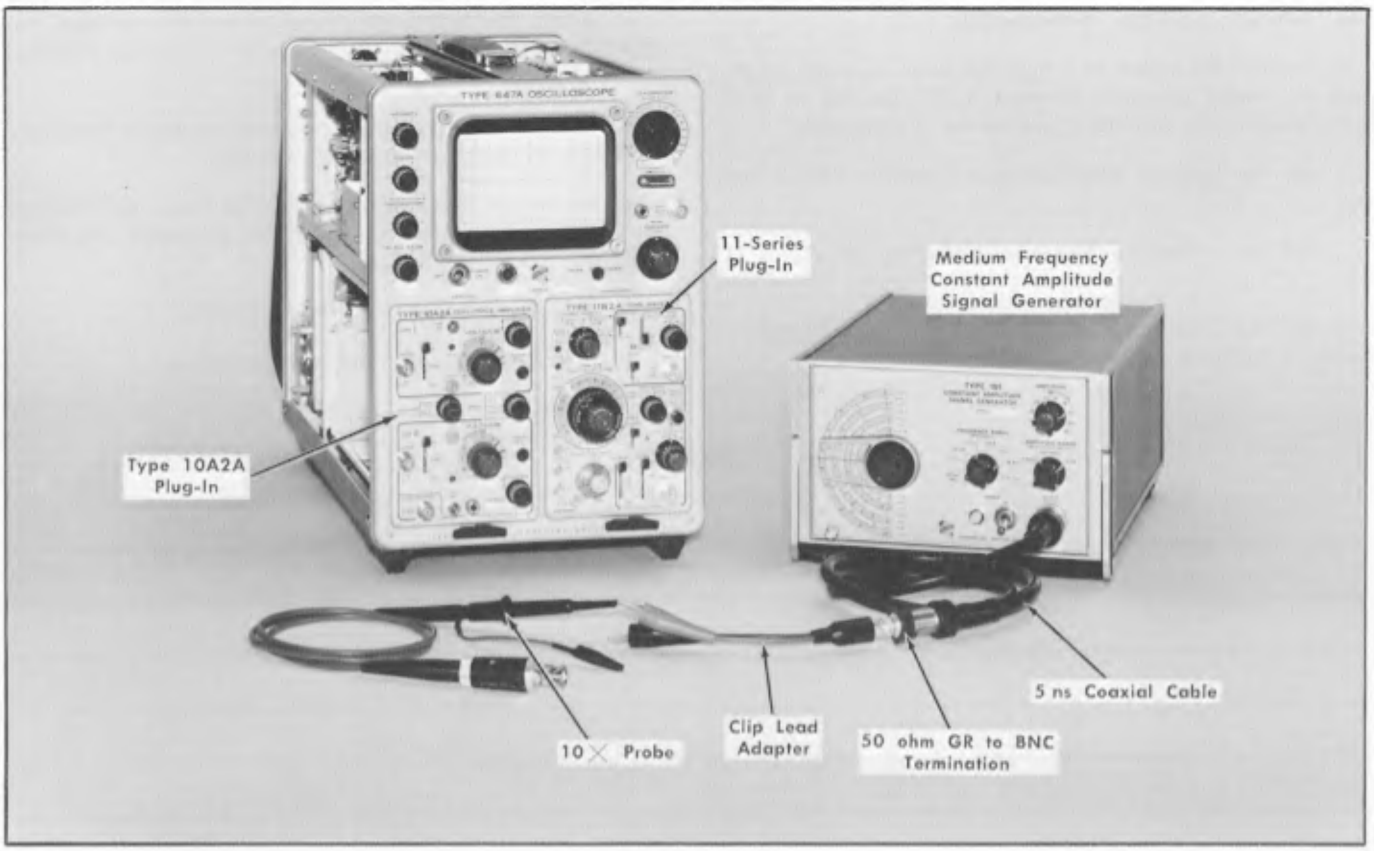


Fig. 6-23. Initial test equipment setup for steps 21 through 24.

Type 647A

INTENSITY	Usable trace brightness
FOCUS	Well defined display
TRACE ROTATION	As is
ASTIGMATISM	Well defined display
SCALE ILLUM	As desired
CALIBRATOR	OFF
POSITION	Midrange
FINE (POSITION)	Midrange

Type 10A2A

Volts/Cm (both channels)	.1
Variable (Volts/Cm) (both channels)	Cal
Position (both channels)	Midrange
Input Coupling (both channels)	AC
Invert (both channels)	Pushed in
Trigger	Norm
Mode	Chop

11-Series

Time/Cm	**1 μs**
Magnification	1 time
Trigger Mode	**Auto**
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

21. Check Multiple Trace and Chopped Blanking Operation

a. Test equipment setup is shown in Fig. 6-23.

b. Remove the 067-0544-00 calibration fixture from the Type 647A vertical plug-in compartment.

c. Install a Type 10A2A plug-in into the Type 647A vertical plug-in compartment.

d. Set the Type 10A2A and 11-series plug-in controls as listed above.

e. CHECK—Display, chopped dual trace display which will have no vertical lines (chopping transients) between the chopped segments of the two traces.

22. Check External CRT Grid Input

a. Set the 10-series plug-in mode switch to ch 1.

b. Connect a 5 ns coaxial cable, a 50 ohm GR to BNC termination and a clip lead adapter to a medium frequency constant amplitude signal generator.

c. Connect the red lead of the clip lead adapter to the Type 647A CRT GRID connector on the rear panel of the oscilloscope. The black lead of the clip lead adapter should be connected to a ground point.

d. Connect a 10× probe to the Type 10A2A plug-in channel 1 input connector.

e. Connect the unconnected end of the 10× probe to the red lead of the clip lead adapter.

f. Set the medium frequency generator controls for an output frequency of 10 MHz and an output amplitude of 4 volts peak to peak.

g. Set the 11-series plug-in time/cm switch to .1 μs and adjust the triggering controls for a stable display.

h. CHECK—Display for intensity modulation with 4 volts or less of 10 MHz signal.

i. Decrease the frequency of the generator toward DC, repeating part h of this step as the frequency is decreased.

23. Check External CRT Cathode Input

a. Disconnect the shorting strap between the Type 647A CRT CATHODE connector and the GND connector which are both located on the rear panel.

b. Change the 10× probe and red lead of the clip lead adapter from the CRT GRID connector to the CRT CATHODE connector.

c. Set the medium frequency generator for an output frequency of 100 MHz and an output amplitude of 5 volts.

d. Adjust the 11-series plug-in controls for a stable display.

e. CHECK—Display for intensity modulation with 5 volts or less of 100 MHz signal.

f. Decrease the frequency of the generator toward 500 kHz, repeating part e of this step as the frequency is decreased.

g. Disconnect the low frequency generator and remove the 5 ns coaxial cable, 50 ohm GR to BNC termination, 10× probe and clip lead adapter.

h. Reconnect the shorting strap between the CRT CATHODE connector and the GND connector.

24. Check Beam Finder

a. Depress the Type 647A BEAM FINDER switch.

b. Rotate the Type 647A POSITION control throughout its range.

c. CHECK—Display, trace must remain within the graticule area no matter where the trace is moved by the positioning control.

d. Rotate the Type 10A2A plug-in position control throughout its range.

e. CHECK—Display, trace must remain within the graticule area no matter where the trace is moved by the positioning control.

This completes the calibration of the Type 647A. Disconnect all test equipment and replace the side panels.

NOTES

ABBREVIATIONS AND SYMBOLS

A or amp	amperes
AC or ac	alternating current
AF	audio frequency
α	alpha—common-base current amplification factor
AM	amplitude modulation
$\approx$	approximately equal to
β	beta—common-emitter current amplification factor
BHB	binding head brass
BHS	binding head steel
BNC	baby series "N" connector
$\times$	by or times
C	carbon
C	capacitance
cap.	capacitor
cer	ceramic
cm	centimeter
comp	composition
conn	connector
$\sim$	cycle
c/s or cps	cycles per second
CRT	cathode-ray tube
csk	countersunk
Δ	increment
dB	decibel
dBm	decibel referred to one milliwatt
DC or dc	direct current
DE	double end
°	degrees
°C	degrees Celsius (degrees centigrade)
°F	degrees Fahrenheit
°K	degrees Kelvin
dia	diameter
$\div$	divide by
div	division
EHF	extremely high frequency
elect.	electrolytic
EMC	electrolytic, metal cased
EMI	electromagnetic interference (see RFI)
EMT	electrolytic, metal tubular
ε	epsilon—2.71828 or % of error
$\geq$	equal to or greater than
$\leq$	equal to or less than
ext	external
F or f	farad
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
FM	frequency modulation
ft	feet or foot
G	giga or 10^9
g	acceleration due to gravity
Ge	germanium
GHz	gigahertz
GMV	guaranteed minimum value
GR	General Radio
$>$	greater than
H or h	henry
h	height or high
hex.	hexagonal
HF	high frequency
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
HV	high voltage
Hz	hertz (cycles per second)
ID	inside diameter
IF	intermediate frequency
in.	inch or inches
incd	incandescent
∞	infinity
int	internal
$\int$	integral
k	kilohms or kilo (10^3)
k Ω	kilohm
kc	kilocycle
kHz	kilohertz
L	inductance
λ	lambda—wavelength
$\gg$	large compared with
$<$	less than
LF	low frequency
lg	length or long
LV	low voltage
M	mega or 10^6
m	milli or 10^{-3}
MΩ or meg	megohm
μ	micro or 10^{-6}
mc	megacycle
met.	metal
MHz	megahertz
mm	millimeter
ms	millisecond
—	minus
mtg hdw	mounting hardware
n	nano or 10^{-9}
no. or #	number
ns	nanosecond
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
Ω	omega—ohms
ω	omega—angular frequency
p	pico or 10^{-12}
/	per
%	percent
PHB	pan head brass
ϕ	phi—phase angle
π	pi—3.1416
PHS	pan head steel
+	plus
$\pm$	plus or minus
PIV	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
pwr	power
Q	figure of merit
RC	resistance capacitance
RF	radio frequency
RFI	radio frequency interference (see EMI)
RHB	round head brass
ρ	rho—resistivity
RHS	round head steel
r/min or rpm	revolutions per minute
RMS	root mean square
s or sec.	second
SE	single end
Si	silicon
SN or S/N	seriol number
$\ll$	small compared with
T	tera or 10^{12}
TC	temperature compensated
TD	tunnel diode
THB	truss head brass
θ	theta—angular phase displacement
thk	thick
THS	truss head steel
tub.	tubular
UHF	ultra high frequency
V	volt
VAC	volts, alternating current
var	variable
VDC	volts, direct current
VHF	very high frequency
VSWR	voltage standing wave ratio
W	watt
w	wide or width
w/	with
w/o	without
WW	wire-wound
xmfr	transformer

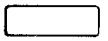
PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

SECTION 7

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Bulbs		
B604	150-0029-00			Incandescent GE #349		
B605	150-0029-00			Incandescent GE #349		
B606	150-0029-00			Incandescent GE #349		
B852	150-0030-00			Neon NE-2 V		
B853	150-0030-00			Neon NE-2 V		
B854	150-0030-00			Neon NE-2 V		
				Capacitors		
Tolerance ±20% unless otherwise indicated.						
C365	283-0068-00			0.01 μF	Cer	500 V
C366	283-0068-00			0.01 μF	Cer	500 V
C377	281-0095-00			0.2-1.5 pF, Var	Teflon	
C378	281-0077-00			1.3-5.4 pF, Var	Air	
C397	281-0095-00			0.2-1.5 pF, Var	Teflon	
C398	285-0572-00			0.1 μF	PTM	200 V
C405A	281-0547-00			2.7 pF	Cer	500 V 10%
C405B	281-0547-00			2.7 pF	Cer	500 V 10%
C405C	281-0547-00			2.7 pF	Cer	500 V 10%
C405D	281-0547-00			2.7 pF	Cer	500 V 10%
C406A	281-0592-00			4.7 pF	Cer	±0.5 pF
C406B	281-0592-00			4.7 pF	Cer	±0.5 pF
C406C	281-0592-00			4.7 pF	Cer	±0.5 pF
C407A	281-0547-00			2.7 pF	Cer	500 V 10%
C407B	281-0547-00			2.7 pF	Cer	500 V 10%
C407C	281-0547-00			2.7 pF	Cer	500 V 10%
C407D	281-0547-00			2.7 pF	Cer	500 V 10%
C420	283-0114-00			0.0015 μF	Cer	200 V
C430	283-0114-00			0.0015 μF	Cer	200 V
C435	281-0081-00			1.8-13 pF, Var	Air	
C437	281-0081-00			1.8-13 pF, Var	Air	
C438	281-0577-00			14 pF	Cer	500 V 5%
C439	281-0534-00			3.3 pF	Cer	±0.25 pF
C440	283-0114-00			0.0015 μF	Cer	200 V
C442	283-0114-00			0.0015 μF	Cer	200 V

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C444	283-0114-00			0.0015 μF	Cer	200 V	
C450	283-0114-00			0.0015 μF	Cer	200 V	
C462	281-0544-00			5.6 pF	Cer	500 V	10%
C463	281-0622-00			47 pF	Cer	500 V	1%
C464	281-0574-00			82 pF	Cer	500 V	10%
C465	281-0111-00			2-27 pF, Var	Air		
C466	281-0530-00			100 pF	Cer	500 V	10%
C468	281-0574-00			82 pF	Cer	500 V	10%
C477	281-0600-00			35 pF	Cer		10%
C480	283-0114-00			0.0015 μF	Cer	200 V	
C482	281-0598-00			1000 pF	Cer		
C490	283-0114-00			0.0015 μF	Cer	200 V	
C494	281-0598-00			1000 pF	Cer		
C609	290-0171-00			100 μF	Elect.	12 V	
C610	285-0644-00			0.033 μF	PTM	600 V	
C611	285-0572-00			0.1 μF	PTM	200 V	
C612	290-0169-01			400 μF	Elect.	250 V	
C615	285-0623-00			0.47 μF	PTM	100 V	
C622	283-0078-00			0.001 μF	Cer	500 V	
C631	290-0198-00			17 μF	Elect.	150 V	+30%—15%
C642	290-0186-01			3900 μF	Elect.	30 V	
C650	285-0622-00			0.1 μF	PTM	100 V	
C660	283-0078-00			0.001 μF	Cer	500 V	
C661	290-0162-00			22 μF	Elect.	35 V	
C663	283-0078-00			0.001 μF	Cer	500 V	
C672	290-0186-01			3900 μF	Elect.	30 V	
C675	285-0598-00	B010100	B049999	0.01 μF	PTM	100 V	5%
C675	285-0622-00	B050000		0.1 μF	PTM	100 V	20%
C690	283-0078-00			0.001 μF	Cer	500 V	
C691	290-0162-00			22 μF	Elect.	35 V	
C701	285-0644-00			0.033 μF	PTM	600 V	
C702	290-0169-01			400 μF	Elect.	250 V	
C714	285-0622-00			0.1 μF	PTM	100 V	
C715	285-0622-00			0.1 μF	PTM	100 V	
C731	290-0198-00			17 μF	Elect.	150 V	+30%—15%
C739	283-0078-00			0.001 μF	Cer	500 V	
C740	285-0644-00			0.033 μF	PTM	600 V	
C741	285-0644-00			0.033 μF	PTM	600 V	
C742	290-0315-00			170 μF	Elect.	250 V	+50%—10%
C743	290-0171-00			100 μF	Elect.	12 V	
C744	283-0078-00			0.001 μF	Cer	500 V	
C745	285-0587-00			0.1 μF	PTM	600 V	
C802	290-0244-00			0.47 μF	EMT	35 V	5%
C820	290-0312-00			47 μF	Elect.	35 V	10%
C821	285-0629-00			0.047 μF	PTM	100 V	
C822	283-0042-00			0.015 μF	Cer	3000 V	

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
C827	283-0042-00			0.015 μF	Cer	3000 V
C831	285-0572-00			0.1 μF	PTM	200 V
C832	283-0042-00			0.015 μF	Cer	3000 V
C833	283-0044-00			0.001 μF	Cer	3000 V
C835	281-0556-00			500 pF	Cer	10,000 V
C836	281-0556-00			500 pF	Cer	10,000 V
C837	281-0556-00			500 pF	Cer	10,000 V
C838	283-0096-00			500 pF	Cer	20,000 V
C844	283-0042-00			0.015 μF	Cer	3000 V
C845	283-0042-00			0.015 μF	Cer	3000 V
C846	283-0042-00			0.015 μF	Cer	3000 V
C851	285-0572-00			0.1 μF	PTM	200 V
C854	283-0042-00			0.015 μF	Cer	3000 V
C863	283-0079-00			0.01 μF	Cer	250 V
C864	285-0572-00			0.1 μF	PTM	200 V
C870	283-0079-00			0.01 μF	Cer	250 V
C874	281-0543-00			270 pF	Cer	500 V 10%
C877	281-0534-00			3.3 pF	Cer	±0.25 pF
C878	281-0500-00			2.2 pF	Cer	500 V ±0.5 pF
C882	285-0569-00			0.01 μF	PTM	200 V
C879	281-0005-00			1.5-7 pF, Var	Cer	
C891	283-0080-00			0.022 μF	Cer	25 V +80%—20%
C902	285-0627-00			0.0033 μF	PTM	100 V 5%
C903	285-0626-00			0.0015 μF	PTM	100 V 10%
C914	285-0622-00			0.1 μF	PTM	100 V
C916	290-0187-00			4.7 μF	EMT	35 V
C923	283-0081-00			0.1 μF	Cer	25 V +80%—20%
C924	285-0627-00			0.0033 μF	PTM	100 V 5%
C925	285-0627-00			0.0033 μF	PTM	100 V 5%
C926	290-0187-00			4.7 μF	EMT	35 V
C935	281-0519-00			47 pF	Cer	500 V 10%
C936	283-0081-00			0.1 μF	Cer	25 V +80%—20%
C937	283-0081-00			0.1 μF	Cer	25 V +80%—20%
C945	281-0504-00			10 pF	Cer	500 V 10%
C946	285-0572-00			0.1 μF	PTM	200 V
C948A	281-0534-00			3.3 pF	Cer	±0.25 pF
C948K	281-0525-00			470 pF	Cer	500 V
C948Z	281-0523-00			100 pF	Cer	350 V

Diodes

D360	*152-0185-00	Silicon, Replaceable by	1N4152
D361	152-0141-00	Silicon	1N4152
D362	152-0141-00	Silicon	1N4152
D363	152-0141-00	Silicon	1N4152
D371	*152-0185-00	Silicon Replaceable by	1N4152

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
D374	152-0126-00			Zener	1N3024A	1 W, 15 V, 10%
D395	*152-0061-00			Silicon	Tek Spec	
D396	*152-0061-00			Silicon	Tek Spec	
D397	152-0060-00			Zener	1N3027A	1 W, 20 V, 10%
D440	152-0195-00			Zener	1N751A	0.4 W, 5.1 V, 5%
D450	152-0195-00			Zener	1N751A	0.4 W, 5.1 V, 5%
D480	152-0195-00			Zener	1N751A	0.4 W, 5.1 V, 5%
D483	*152-0185-00			Silicon	Replaceable by 1N4152	
D490	152-0195-00			Zener	1N751A	0.4 W, 5.1 V, 5%
D493	*152-0185-00			Silicon	Replaceable by 1N4152	
D494	152-0311-00			Zener	1N2999B	10 W, 56 V, 5%
D609	152-0124-00			Zener	1N938A	0.5 W, 9 V, 5%, TC
D611	*152-0061-00			Silicon	Tek Spec	
D612A,B,C,D	152-0066-00			Silicon	1N3194	
D636	152-0311-00			Zener	1N2999B	10 W, 56 V, 5%
D642A,B,C,D	152-0113-00	B010100	B039999	Silicon	RCA 40108	
D642A,B,C,D	*152-0274-00	B040000		Silicon	Replaceable by 1N1200	
D650	152-0141-00			Silicon	1N4152	
D669	*152-0185-00			Silicon	Replaceable by 1N4152	
D672A,B,C,D	152-0113-00	B010100	B039999	Silicon	RCA 40108	
D672A,B,C,D	*152-0274-00	B040000		Silicon	Replaceable by 1N1200	
D699	*152-0185-00			Silicon	Replaceable by 1N4152	
D702A,B,C,D	152-0066-00			Silicon	1N3194	
D712	*152-0061-00			Silicon	Tek Spec	
D714	152-0135-00			Zener	1N3042A	1 W, 82 V, 10%
D716	152-0134-00			Zener	1N3044A	1 W, 100 V, 10%
D736	152-0312-00			Zener	1N3002B	10 W, 75 V, 5%
D737	152-0066-00			Silicon	1N3194	
D739	*152-0185-00			Silicon	Replaceable by 1N4152	
D742	152-0066-00			Silicon	1N3194	
D743	152-0066-00			Silicon	1N3194	
D745	152-0066-00			Silicon	1N3194	
D822	152-0192-00			Silicon	7701-5X Varo	
D832	152-0192-00			Silicon	7701-5X Varo	
D870	152-0002-00			Silicon	1N1329	
D871	152-0002-00			Silicon	1N1329	
D872	*152-0061-00			Silicon	Tek Spec	
D873	*152-0185-00			Silicon	Replaceable by 1N4152	
D874	*152-0061-00			Silicon	Tek Spec	
D884	*152-0185-00			Silicon	Replaceable by 1N4152	
D886	*152-0185-00			Silicon	Replaceable by 1N4152	
D891	*152-0185-00			Silicon	Replaceable by 1N4152	
D932	*152-0185-00			Silicon	Replaceable by 1N4152	
D933	*152-0185-00			Silicon	Replaceable by 1N4152	
D942	*152-0185-00			Silicon	Replaceable by 1N4152	
D943	*152-0185-00			Silicon	Replaceable by 1N4152	
D944	*152-0061-00			Silicon	Tek Spec	
D947	*152-0061-00			Silicon	Tek Spec	
D948	152-0141-00			Silicon	1N4152	

Fuses

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
F601	159-0017-00			4A 3AG Fast-Blo
F602	159-0021-00			2A 3AG Fast-Blo
F613	159-0025-00			0.5A 3 AG Fast-Blo
F703	159-0042-00			0.75A 3AG Fast-Blo
F743	159-0042-00			0.75A 3AG Fast-Blo
F820	159-0019-00			1A 3AG Slo-Blo

Filter

FL601	119-0113-00	B010100	B019999	275 V AC at 400 cycle
FL601	119-0113-01	B020000	B029999	275 V AC at 400 cycle
FL601	119-0113-03	B030000		275 V AC at 400 cycle

Connectors

J11	131-0097-00			32 contact, female
J21	131-0097-00			32 contact, female
J101	131-0299-00			10 pin, female
J950	131-0274-00			BNC

Inductors

L394	108-0254-00			600 μH
L403	*119-0129-00			Delay Line Assembly
L405A	*108-0420-00			60 nH
L405B	*108-0420-00			60 nH
L405C	*108-0420-00			60 nH
L405D	*108-0420-00			60 nH
L405E	*108-0420-00			60 nH
L405F	*108-0420-00			60 nH
L407A	*108-0420-00			60 nH
L407B	*108-0420-00			60 nH
L407C	*108-0420-00			60 nH
L407D	*108-0420-00			60 nH
L407E	*108-0420-00			60 nH
L407F	*108-0420-00			60 nH
L428	*114-0228-00			84-104 nH Core 276-0506-00
L454	276-0528-00			Core, Ferramic Suppressor
L460	*108-0421-00			60 nH
L470	*108-0421-00			60 nH
L820	*108-0422-00			80 μH
L861	*108-0279-00			Beam Rotator
L865	*108-0295-00			Y Axis Alignment
LR442	*108-0329-00			2.5 μH (wound on a 75 Ω, $\frac{1}{2}$ W, 5% resistor)
LR444	*108-0329-00			2.5 μH (wound on a 75 Ω, $\frac{1}{2}$ W, 5% resistor)
LR482	*108-0329-00			2.5 μH (wound on a 75 Ω, $\frac{1}{2}$ W, 5% resistor)
LR489	*108-0425-00			0.2 μH (wound on a 300 Ω, $\frac{1}{4}$ W, 5% resistor)
LR499	*108-0425-00			0.2 μH (wound on a 300 Ω, $\frac{1}{4}$ W, 5% resistor)

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Q373	*151-0133-00			Silicon Selected from 2N3251
Q374	*151-0124-00			Silicon Selected from 2N3119
Q393	*151-0133-00			Silicon Selected from 2N3251
Q394	*151-0124-00			Silicon Selected from 2N3119
Q404	*151-0127-00			Silicon Selected from 2N2369
Q414	*151-0127-00			Silicon Selected from 2N2369
Q424	151-0202-00			Silicon 2N4261
Q434	151-0202-00			Silicon 2N4261
Q444	*151-0167-00			Silicon Selected from XF737
Q454	*151-0167-00			Silicon Selected from XF737
Q464	*151-0213-00			Silicon Selected from 2N4251
Q474	*151-0213-00			Silicon Selected from 2N4251
Q484	*151-0211-00			Silicon Selected from 2N3866
Q494	*151-0211-00			Silicon Selected from 2N3866
Q614	*151-0104-00			Silicon Replaceable by 2N2913
Q623	*151-0096-00			Silicon Selected from 2N1893
Q633	*151-0096-00			Silicon Selected from 2N1893
Q637	*151-0209-00			Silicon Selected from 2N3442
Q644	*151-0126-00			Silicon Replaceable by 2N2484
Q653	*151-0103-00			Silicon Replaceable by 2N2219
Q659	*151-0103-00			Silicon Replaceable by 2N2219
Q663	*151-0103-00			Silicon Replaceable by 2N2219
Q667	*151-0140-00			Silicon Selected from 2N3055
Q674	*151-0126-00			Silicon Replaceable by 2N2484
Q683	*151-0103-00			Silicon Replaceable by 2N2219
Q689	*151-0103-00			Silicon Replaceable by 2N2219
Q693	*151-0148-00			Silicon Selected RCA 40250
Q697	*151-0140-00			Silicon Selected from 2N3055
Q714	*151-0126-00			Silicon Replaceable by 2N2484
Q723	*151-0103-00			Silicon Replaceable by 2N2219
Q733	*151-0103-00			Silicon Replaceable by 2N2219
Q737	*151-0209-00			Silicon Selected from 2N3442
Q803	*151-0126-00			Silicon Replaceable by 2N2484
Q804	*151-0133-00			Silicon Selected from 2N3251
Q814	*151-0103-00			Silicon Replaceable by 2N2219
Q820	*151-0140-00			Silicon Selected from 2N3055
Q873	*151-0124-00			Silicon Selected from 2N3119
Q874	*151-0124-00			Silicon Selected from 2N3119
Q883	*151-0108-00			Silicon Replaceable by 2N2501
Q894	*151-0108-00			Silicon Replaceable by 2N2501
Q910	*151-0126-00			Silicon Replaceable by 2N2484
Q924	*151-0103-00			Silicon Replaceable by 2N2219
Q935	*151-0103-00			Silicon Replaceable by 2N2219
Q945	*151-0124-00			Silicon Selected from 2N3119

Resistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Resistors are fixed, composition, ±10% unless otherwise indicated.							
R350A,B	311-0272-00			2 X 5 kΩ, Var			
R360	324-0317-00			19.6 kΩ	1 W	Prec	1%
R361	323-0302-00			13.7 kΩ	½ W	Prec	1%
R362	323-0347-00			40.2 kΩ	½ W	Prec	1%
R363	323-0338-00			32.4 kΩ	½ W	Prec	1%
R364	311-0400-00			2 X 500 kΩ, Var			
R365	302-0274-00			270 kΩ	½ W		
R366	302-0274-00			270 kΩ	½ W		
R367	301-0153-00			15 kΩ	½ W		5%
R370	323-0352-00			45.3 kΩ	½ W	Prec	1%
R371	323-0237-00			2.87 kΩ	½ W	Prec	1%
R373	301-0222-00			2.2 kΩ	½ W		5%
R374	308-0178-00			15 kΩ	8 W	WW	5%
R376	324-0296-00			11.8 kΩ	1 W	Prec	1%
R377	311-0326-00			10 kΩ, Var			
R378	321-0251-00			4.02 kΩ	⅛ W	Prec	1%
R379	321-0251-00			4.02 kΩ	⅛ W	Prec	1%
R390	324-0289-00			10 kΩ	1 W	Prec	1%
R391	323-0237-00			2.87 kΩ	½ W	Prec	1%
R393	301-0822-00			8.2 kΩ	½ W		5%
R394[1]	*310-0607-00			8.8 kΩ	10 W	WW	1%
R394[2]	*310-0615-00			8.8 kΩ	10 W	WW	1%
R396	324-0296-00			11.8 kΩ	1 W	Prec	1%
R397	302-0104-00			100 kΩ	½ W		
R398	301-0270-00			27 Ω	½ W		5%
R405	321-0092-00			88.7 Ω	⅛ W	Prec	1%
R407	321-0092-00			88.7 Ω	⅛ W	Prec	1%
R408	323-0216-00			1.74 kΩ	½ W	Prec	1%
R409	311-0480-00			500 Ω, Var			
R414	323-0193-00			1 kΩ	½ W	Prec	1%
R415	323-0167-00			536 Ω	½ W	Prec	1%
R418	323-0216-00			1.74 kΩ	½ W	Prec	1%
R420	315-0101-00			100 Ω	¼ W		5%
R421	321-0115-00			154 Ω	⅛ W	Prec	1%
R423	303-0153-00			15 kΩ	1 W		5%
R424	308-0103-00			2.5 kΩ	5 W	WW	1%
R425	315-0470-00			47 Ω	¼ W		5%
R426	315-0360-00			36 Ω	¼ W		5%
R427	311-0605-00			200 Ω, Var			

[1]647A

[2]647A—165K

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R428	315-0221-00			220 Ω	1/4 W	5%
R429	311-0605-00			200 Ω, Var		
R430	315-0101-00			100 Ω	1/4 W	5%
R431	321-0115-00			154 Ω	1/8 W Prec	1%
R435	315-0470-00			47 Ω	1/4 W	5%
R436	315-0360-00			36 Ω	1/4 W	5%
R440	301-0221-00			220 Ω	1/2 W	5%
R450	301-0221-00			220 Ω	1/2 W	5%
R452	323-0156-00			412 Ω	1/2 W Prec	1%
R454	323-0123-00			187 Ω	1/2 W Prec	1%
R460	321-0082-00			69.8 Ω	1/8 W Prec	1%
R461	307-0122-00			50 Ω		5%
R462	321-0027-00			18.7 Ω	1/8 W Prec	1%
R463	321-0056-00			37.4 Ω	1/8 W Prec	1%
R464	321-0093-00			90.9 Ω	1/8 W Prec	1%
R465	311-0609-00			2 kΩ, Var		
R466	315-0241-00			240 Ω	1/4 W	5%
R467	311-0644-00			20 kΩ, Var		
R468	315-0102-00			1 kΩ	1/4 W	5%
R470	321-0082-00			69.8 Ω	1/8 W Prec	1%
R472	321-0027-00			18.7 Ω	1/8 W Prec	1%
R473	321-0033-00			21.5 Ω	1/8 W Prec	1%
R474	321-0062-00			43.2 Ω	1/8 W Prec	1%
R475	311-0605-00			200 Ω, Var		
R477	301-0130-00			13 Ω	1/2 W	5%
R478	308-0079-00			117 Ω	5 W WW	5%
R480	303-0560-00			56 Ω	1 W	5%
R484	323-0119-00			169 Ω	1/2 W Prec	1%
R485	323-0131-00			226 Ω	1/2 W Prec	1%
R487	308-0430-00			500 Ω	8 W WW	1%
R490	303-0560-00			56 Ω	1 W	5%
R494	308-0232-00			320 Ω	5 W WW	5%
R497	308-0430-00			500 Ω	8 W WW	1%
R601	302-0105-00			1 MΩ	1/2 W	
R604	311-0377-00			25 Ω, Var		
R607	304-0333-00			33 kΩ	1 W	
R609	324-0284-00			8.87 kΩ	1 W Prec	1%
R610	316-0333-00			33 kΩ	1/4 W	
R611	316-0101-00			100 Ω	1/4 W	
R612	323-0368-00			66.5 kΩ	1/2 W Prec	1%
R613	307-0009-00			4.7 Ω	1 W	
R614	323-0418-00			221 kΩ	1/2 W Prec	1%
R615	302-0102-00			1 kΩ	1/2 W	
R622	302-0331-00			330 Ω	1/2 W	
R623	302-0333-00			33 kΩ	1/2 W	
R630	308-0254-00			1.37 kΩ	1/2 W WW	1%
R631	311-0421-00			1 kΩ, Var		

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R632	308-0259-00			10.7 kΩ	1 W	WW	1%
R633	302-0333-00			33 kΩ	½ W		
R634	322-0147-00			332 Ω	¼ W	Prec	1%
R636	304-0470-00			47 Ω	1 W		
R637	308-0123-00			20 Ω	5 W	WW	5%
R642	302-0103-00			10 kΩ	½ W		
R644	316-0224-00			220 kΩ	¼ W		
R649	*308-0087-00			0.5 Ω	1 W	WW	1%
R650	315-0681-00			680 Ω	¼ W		5%
R653	316-0683-00			68 kΩ	¼ W		
R660	308-0257-00			5.11 kΩ	½ W	WW	1%
R661	311-0378-00			250 Ω, Var			
R662	308-0263-00			15.4 kΩ	½ W	WW	1%
R663	306-0271-00			270 Ω	2 W		
R664	302-0223-00			22 kΩ	½ W		
R669	323-0391-00			115 kΩ	½ W	Prec	1%
R672	302-0103-00			10 kΩ	½ W		
R674	316-0184-00			180 kΩ	¼ W		
R675	315-0122-00			1.2 kΩ	¼ W		5%
R679	308-0090-00			0.25 Ω	1 W	WW	
R683	302-0223-00			22 kΩ	½ W		
R690	308-0255-00			3.65 kΩ	½ W	WW	1%
R691	311-0378-00			250 Ω, Var			
R692	308-0261-00			15 kΩ	1 W	WW	1%
R693	302-0273-00			27 kΩ	½ W		
R699	323-0385-00			100 kΩ	½ W	Prec	1%
R702	304-0473-00			47 kΩ	1 W		
R703	308-0179-00			5 Ω	5 W	WW	5%
R714	302-0103-00			10 kΩ	½ W		
R715	315-0561-00			560 Ω	¼ W		5%
R716	316-0224-00			220 kΩ	¼ W		
R719	302-0473-00			47 kΩ	½ W		
R723	302-0333-00			33 kΩ	½ W		
R730	308-0264-00			21.5 kΩ	1 W	WW	1%
R731	311-0380-00			500 Ω, Var			
R732	308-0260-00			13.3 kΩ	1 W	WW	1%
R733	302-0333-00			33 kΩ	½ W		
R736	308-0223-00			35 Ω	3 W	WW	5%
R737	308-0279-00			20 Ω	5 W	WW	5%
R739	323-0387-00			105 kΩ	½ W	Prec	1%
R742	304-0104-00			100 kΩ	1 W		
R744	302-0121-00			120 Ω	½ W		
R745	302-0270-00			27 Ω	½ W		
R800	323-0498-00			1.5 MΩ	½ W	Prec	1%
R801	311-0408-00			20 kΩ, Var			

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R802A	324-0531-00			3.32 MΩ	1 W	Prec	1%
R802B	324-0531-00			3.32 MΩ	1 W	Prec	1%
R802C	324-0531-00			3.32 MΩ	1 W	Prec	1%
R802D	324-0531-00			3.32 MΩ	1 W	Prec	1%
R802E	324-0531-00			3.32 MΩ	1 W	Prec	1%
R802F	324-0531-00			3.32 MΩ	1 W	Prec	1%
R803	323-0489-00			1.21 MΩ	½ W	Prec	1%
R804	316-0103-00			10 kΩ	¼ W		
R805	323-0218-00			1.82 kΩ	½ W	Prec	1%
R806	323-0342-00			35.7 kΩ	½ W	Prec	1%
R808	316-0101-00			100 Ω	¼ W		
R809	316-0103-00			10 kΩ	¼ W		
R817	302-0333-00			33 kΩ	½ W		
R824	316-0183-00			18 kΩ	¼ W		
R825	316-0105-00			1 MΩ	¼ W		
R826	306-0106-00			10 MΩ	2 W		
R827	306-0106-00			10 MΩ	2 W		
R828	306-0106-00			10 MΩ	2 W		
R829	306-0106-00			10 MΩ	2 W		
R831	302-0102-00			1 kΩ	½ W		
R832	311-0329-00			50 kΩ, Var			
R833	302-0103-00			10 kΩ	½ W		
R834	302-0103-00			10 kΩ	½ W		
R838	302-0105-00			1 MΩ	½ W		
R840	306-0395-00			3.9 MΩ	2 W		
R841	306-0395-00			3.9 MΩ	2 W		
R842	306-0395-00			3.9 MΩ	2 W		
R843	306-0395-00			3.9 MΩ	2 W		
R844	311-0121-00	B010100	B039999	5 MΩ, Var			
R844	311-0121-01	B040000		5 MΩ, Var			
R845	302-0185-00			1.8 MΩ	½ W		
R850	316-0473-00			47 kΩ	¼ W		
R851	316-0563-00			56 kΩ	¼ W		
R852	302-0101-00			100 Ω	½ W		
R853	301-0223-00			22 kΩ	½ W		5%
R854	302-0105-00			1 MΩ	½ W		
R855	302-0101-00			100 Ω	½ W		
R856	302-0104-00			100 kΩ	½ W		
R861[3]	311-0412-00			2 X 1 kΩ, Var			
R863	311-0110-00			100 kΩ, Var			
R864[3]	311-0412-00			100 kΩ, Var			
R865	311-0458-00			5 kΩ, Var			
R870	316-0101-00			100 Ω	¼ W		
R871	316-0102-00			1 kΩ	¼ W		
R873	306-0333-00			33 kΩ	2 W		
R874	305-0622-00			6.2 kΩ	2 W		5%

[3]R861 and R864 furnished as a unit.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R875	308-0178-00			15 kΩ	8 W	WW	5%
R876	316-0470-00			47 Ω	1/4 W		
R878	323-0335-00			30.1 kΩ	1/2 W	Prec	1%
R882	315-0202-00			2 kΩ	1/4 W		5%
R884	316-0332-00			3.3 kΩ	1/4 W		
R885	321-0379-00			86.6 kΩ	1/8 W	Prec	1%
R886	324-0317-00			19.6 kΩ	1 W	Prec	1%
R891	316-0682-00			6.8 kΩ	1/4 W		
R892	316-0470-00			47 Ω	1/4 W		
R893	316-0470-00			47 Ω	1/4 W		
R894	301-0223-00			22 kΩ	1/2 W		5%
R895	322-0264-00			5.49 kΩ	1/4 W	Prec	1%
R896	321-0253-00			4.22 kΩ	1/8 W	Prec	1%
R897	311-0364-00			20 kΩ, Var			
R902	316-0183-00			18 kΩ	1/4 W		
R903	316-0183-00			18 kΩ	1/4 W		
R904	316-0332-00			3.3 kΩ	1/4 W		
R911	316-0103-00			10 kΩ	1/4 W		
R914	316-0222-00			2.2 kΩ	1/4 W		
R916	316-0472-00			4.7 kΩ	1/4 W		
R921	316-0103-00			10 kΩ	1/4 W		
R923	316-0470-00			47 Ω	1/4 W		
R924	315-0222-00			2.2 kΩ	1/4 W		5%
R926	315-0272-00			2.7 kΩ	1/4 W		5%
R931	316-0683-00			68 kΩ	1/4 W		
R932	323-0483-00			1.05 MΩ	1/2 W	Prec	1%
R933	316-0103-00			10 kΩ	1/4 W		
R934	316-0152-00			1.5 kΩ	1/4 W		
R935	316-0392-00			3.9 kΩ	1/4 W		
R937	302-0100-00			10 Ω	1/2 W		
R941	316-0683-00			68 kΩ	1/4 W		
R942	323-0483-00			1.05 MΩ	1/2 W	Prec	1%
R943	316-0103-00			10 kΩ	1/4 W		
R944	316-0152-00			1.5 kΩ	1/4 W		
R945	316-0392-00			3.9 kΩ	1/4 W		
R946	302-0100-00			10 Ω	1/2 W		
R947	308-0025-00			20 kΩ	10 W	WW	5%
R948B	323-0289-01			10 kΩ	1/2 W	Prec	1/2%
R948C	323-0635-01			6.667 kΩ	1/2 W	Prec	1/2%
R948D	323-0634-01			1.789 kΩ	1/2 W	Prec	1/2%
R948E	323-0633-01			801 Ω	1/2 W	Prec	1/2%
R948F	323-0632-01			452 Ω	1/2 W	Prec	1/2%
R948G	323-0631-01			146.1 Ω	1/2 W	Prec	1/2%
R948H	323-0630-01			72.4 Ω	1/2 W	Prec	1/2%
R948J	323-0629-01			43.1 Ω	1/2 W	Prec	1/2%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R948K	323-0628-01			28.6 Ω	½ W	Prec	½%
R948L	323-0627-01			21.4 Ω	½ W	Prec	½%
R948X	323-0636-01			50 kΩ	½ W	Prec	½%
R948Y	323-0638-00			50 kΩ	½ W	Prec	¼%
R948Z	323-0637-00			50 Ω	½ W	Prec	¼%
R949	*308-0090-00			0.25 Ω	1 W	WW	
R950	315-0100-00			10 Ω	¼ W		5%

Switches

	Unwired	Wired			
SW360A	260-0516-00		Push	BEAM FINDER	
SW360B	260-0516-00		Push	BEAM FINDER	
SW601	260-0515-00		Toggle	POWER	
SW602†					
SW603†					
SW948	260-0536-00	*262-0569-02	Rotary	CALIBRATOR	

Thermal Cut-Out

TK601	260-0551-00		187°

Test Points

TP742	344-0105-00	Clip, Test Point
TP827	344-0105-00	Clip, Test Point
TP833	344-0105-00	Clip, Test Point

Transformers

T601	*120-0461-00	L. V. Power
T820	*120-0332-00	H. V. Power

Electron Tubes

V842	154-0051-00	5642
V852	154-0051-00	5642
V859	*154-0448-00	T6470-31-1 CRT Standard Phosphor
V862	154-0051-00	5642

Crystal

Y900	158-0015-00	4 kHz

†See Mechanical Parts List. Line Voltage Selector Body

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this 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 LIST ILLUSTRATIONS

(Located behind diagrams)

SECTION 8

MECHANICAL PARTS LIST

FIG. 1 FRONT & SWITCHES

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-1	200-0556-00			1	COVER, graticule
	- - - - - -			-	mounting hardware: (not included w/cover)
-2	210-0571-00			4	NUT, knurled
-3	426-0223-00			1	FRAME, implosion shield
-4	- - - - - -			1	FILTER, (see standard accessories)
-5	354-0227-00			1	RING, CRT mounting
-6	333-0965-01			1	PANEL, front
	- - - - - -			-	mounting hardware: (not included w/panel)
	213-0088-00			2	SCREW, thread forming, #4 x 1/4 inch, PHS
-7	366-0220-00			1	KNOB, charcoal—INTENSITY
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-8	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0207-00			1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
-9	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-10	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-11	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-12	366-0220-00			1	KNOB, charcoal—FOCUS
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-13	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-14	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
-15	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-16	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-17	366-0254-00			1	KNOB, charcoal—ASTIGMATISM
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-18	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-19	210-0207-00			1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-20	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-21	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-22	366-0220-00			1		KNOB, charcoal—SCALE ILLUM
	- - - - - -			-		knob includes:
	213-0020-00			1		SCREW, set, 6-32 x 1/8 inch, HSS
-23	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: (not included w/resistor)
-24	210-0012-00			1		LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1		WASHER, flat, 3/8 ID x 1/2 inch OD
-25	210-0590-00			1		NUT, hex., 3/8-32 x 7/16 inch
-26	260-0515-00			1		SWITCH, toggle—OFF ON
	- - - - - -			-		switch includes:
-27	210-0414-00			1		NUT, hex., 15/32-32 x 9/16 inch
	- - - - - -			-		mounting hardware: (not included w/switch)
-28	354-0055-00			1		RING, locking
-29	210-0902-00			1		WASHER, flat, 0.470 ID x 21/32 inch OD
-30	210-0473-00			1		NUT, 12 sided, 15/32-32 x 0.634
-31	366-0117-00			1		KNOB, charcoal—1 KC CALIBRATOR
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch, HSS
-32	262-0569-02			1		SWITCH, wired—CALIBRATOR
	- - - - - -			-		switch includes:
	260-0536-00			1		SWITCH, unwired
	210-0207-00			1		LUG, solder, 3/8 ID x 5/8 inch OD, SE
	- - - - - -			-		mounting hardware: (not included w/switch)
-33	210-0012-00			1		LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-34	210-0840-00			1		WASHER, flat, 0.390 ID x 9/16 inch OD
-35	210-0413-00			1		NUT, hex., 3/8-32 x 1/2 inch
-36	214-0335-00			1		BOLT, current loop
	- - - - - -			-		mounting hardware: (not included w/bolt)
-37	361-0059-00			1		SPACER, current loop
-38	210-0593-00			2		NUT, hex., current loop, 3-48 x 1/4 inch
-39	210-0849-00			2		WASHER, fiber, #4
-40	210-0201-00			2		LUG, solder, SE #4
-41	210-0442-00			2		NUT, hex., 3-48 x 3/16 inch
-42	366-0146-00			1		KNOB, charcoal—HORIZ POSITION
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch
-43	366-0177-00			1		KNOB, red—VERNIER
	- - - - - -			-		knob includes:
	213-0004-00			1		SCREW, set, 6-32 x 3/16 inch
-44	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: (not included w/resistor)
-45	210-0012-00			1		LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-46	210-0840-00			1		WASHER, flat, 0.390 ID x 9/16 inch OD
-47	210-0413-00			1		NUT, hex., 3/8-32 x 1/2 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-48	136-0244-00			1		SOCKET, indicator light
	- - - - - -			-		mounting hardware: (not included w/socket)
-49	210-0241-00			1		LUG, ground
-50	210-0414-00			1		NUT, hex., $^{15}/_{32}$-32 x $^{9}/_{16}$ inch
-51	384-0293-00			1		ROD, extension, switch, w/charcoal knob
-52	129-0035-00			1		ASSEMBLY, binding post
	- - - - - -			-		assembly includes:
	355-0507-00			1		STEM
	200-0103-00			1		CAP
	210-0046-00			1		LOCKWASHER, internal, $^{1}/_{4}$ ID x 0.400 inch OD
	210-0455-00			1		NUT, hex., $^{1}/_{4}$-28 x $^{3}/_{8}$ inch
-53	131-0274-00			1		CONNECTOR, coaxial, 1 contact, BNC
	- - - - - -			-		mounting hardware: (not included w/connector)
	210-0241-00			1		LUG, ground
-54	387-0775-00			1		PLATE, front casting
	- - - - - -			-		mounting hardware: (not included w/plate)
	213-0123-00			10		SCREW, 6-32 x $^{3}/_{8}$ inch, FHS
-55	214-0384-00			2		SPRING, latch bar
-56	426-0204-00			1		FRAME, front
	- - - - - -			-		frame includes:
-57	354-0057-00			1		RING, ornamental
-58	200-0269-00			1		COVER, variable resistor
-59	352-0063-00			2		HOLDER, graticule lamp
	- - - - - -			-		mounting hardware for each: (not included w/holder)
-60	213-0123-00			1		SCREW, 6-32 x $^{3}/_{8}$ inch, FHS
-61	214-0459-00			4		SPRING, plug-in ground
	- - - - - -			-		mounting hardware for each: (not included w/spring)
-62	212-0023-00			1		SCREW, 8-32 x $^{3}/_{8}$ inch, PHS
	210-0458-00			1		NUT, keps, 8-32 x $^{11}/_{32}$ inch
-63	214-0459-00			4		SPRING, plug-in housing
	- - - - - -			-		mounting hardware for each: (not included w/spring)
	210-0005-00			1		LOCKWASHER, external, #6
	213-0104-00			1		SCREW, thread forming, #6 x $^{3}/_{8}$ inch, THS

FIG. 2 CRT SHIELD & BRACKET

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
2-1	337-0572-00			1		SHIELD, Cathode Ray Tube
	- - - - - -			-		shield includes:
-2	252-0565-00			ft		NEOPRENE, foam w/adhesive (3 four & 1 two inch length)
	- - - - - -			-		mounting hardware: (not included w/shield)
-3	211-0590-00			4		SCREW, 6-32 x 1/4 inch, PHB
-4	211-0589-00			2		SCREW, 6-32 x 5/16 inch, PHB
-5	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch
-6	407-0028-00			1		BRACKET, CRT shield
	- - - - - -			-		mounting hardware: (not included w/bracket)
	211-0507-00			2		SCREW, 6-32 x 5/16 inch, PHS
	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch
-7	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: (not included w/resistor)
-8	210-0223-00			1		LUG, solder, 1/4 ID x 7/16 inch OD, SE
-9	210-0940-00			1		WASHER, flat, 1/4 ID x 3/8 inch OD
-10	210-0583-00			1		NUT, hex., 1/4-32 x 5/16 inch
-11	252-0562-00			ft		CHANNEL, extruded plastic, (specify 0.323 inch length)
-12	348-0049-00			1		GROMMET, rubber, CRT shield
-13	211-0504-00			2		SCREW, 6-32 x 1/4 inch, PHS
-14	131-0301-00			1		CONNECTOR, anode
	- - - - - -			-		connector includes:
	200-0544-00			1		COVER
-15	175-0587-00			1		WIRE, CRT lead, 0.500 foot stripped red, w/connector
	175-0591-00			1		WIRE, CRT lead, .0417 foot, stripped green, w/connector
-16	343-0110-00			1		CLAMP, CRT coil form

FIG. 3 PLUG-IN HOUSING & CAPACITOR CHASSIS

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
3-1	387-0770-00			1	PLATE, frame center
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0583-00			4	SCREW, 6-32 x 1 inch, FIL HS
	210-0592-00			4	NUT, rod, 6-32 x 5/16 inch
	212-0004-00			2	SCREW, 8-32 x 5/16 inch, PHS
	211-0538-00			1	SCREW, 6-32 x 5/16 inch, FHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-2	351-0060-00			2	GUIDE, rail plug-in top
	- - - - - -			-	mounting hardware for each: (not included w/guide)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-3	211-0531-00			1	SCREW, 6-32 x 3/8 inch, FIL HS
-4	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-5	214-0396-00			2	ASSEMBLY, plug-in latch
	- - - - - -			-	each assembly includes:
-6	351-0069-00			1	GUIDE, rail
-7	351-0071-00			1	GUIDE, plastic, latch release bar
-8	214-0372-00			1	LATCH, plastic
	214-0374-00			1	SPRING, latch
	210-0694-00			1	RIVET, latch hinge
	358-0230-00			1	BUSHING, latch hinge
-9	366-0258-00			1	KNOB, plastic, w/release bar
-10	214-0369-00			1	PIN, latch
	- - - - - -			-	mounting hardware for each: (not included w/assembly)
	211-0522-00			1	SCREW, 6-32 x 5/8 inch, FHS
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-11	348-0050-00			1	GROMMET, plastic, 3/4 inch diameter
-12	348-0056-00			2	GROMMET, plastic, 0.354 ID x 0.406 inch OD
-13	348-0055-00			2	GROMMET, plastic, 1/4 inch diameter
-14	387-0774-00			1	PLATE, plug-in housing, right
	- - - - - -			-	mounting hardware: (not included w/plate)
-15	212-0004-00			3	SCREW, 8-32 x 5/16 inch, PHS
-16	212-0039-00			1	SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			3	NUT, keps, 8-32 x 11/32 inch
-17	214-0376-00			2	SPRING, plug-in rail
-18	214-0373-00			2	SPRING, plug-in release
	- - - - - -			-	mounting hardware for each: (not included w/spring)
-19	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-20	406-0947-00			2	BRACKET, guide rail
	- - - - - -			-	mounting hardware for each: (not included w/bracket)
-21	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-22	358-0224-00			4	BUSHING, plastic, pin

FIG. 3 PLUG-IN HOUSING & CAPACITOR CHASSIS *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
3-23	131-0097-00			2		CONNECTOR, 32 pin
	- - - - - -			-		mounting hardware for each: (not included w/connector)
-24	211-0014-00			2		SCREW, 4-40 x 1/2 inch, PHS
-25	166-0029-00			2		TUBE, spacer
-26	210-0586-00			2		NUT, keps, 4-40 x 1/4 inch
-27	210-0202-00			4		LUG, solder, SE #6
	- - - - - -			-		mounting hardware for each: (not included w/lug)
-28	211-0504-00			1		SCREW, 6-32 x 1/4 inch, PHS
-29	210-0407-00			1		NUT, hex., 6-32 x 1/4 inch
-30	387-0773-00			1		PLATE, plug-in housing, left
	- - - - - -			-		mounting hardware: (not included w/plate)
-31	212-0004-00			3		SCREW, 8-32 x 5/16 inch, PHS
	212-0039-00			1		SCREW, 8-32 x 3/8 inch, THS
-32	441-0706-00			1		CHASSIS
	- - - - - -			-		mounting hardware: (not included w/chassis)
	212-0004-00			6		SCREW, 8-32 x 5/16 inch, PHS
	210-0458-00			4		NUT, keps, 8-32 x 11/32 inch
-33	- - - - - -			8		DIODE
	- - - - - -			-		mounting hardware for each: (not included w/diode)
-34	210-0224-00			1		LUG, solder, non-locking, #10
-35	210-0909-00			2		WASHER, mica, 0.196 ID x 0.625 inch OD
-36	210-0910-00			1		WASHER, plastic, insulator, 3/16 ID x 5/16 inch OD
-37	210-0805-00			1		WASHER, flat, 0.204 ID x 0.438 inch OD
-38	210-0010-00			1		LOCKWASHER, internal, #10
-39	220-0411-00			1		NUT, hex., 10-32 x 3/8 inch

FIG. 3 PLUG-IN HOUSING & CAPACITOR CHASSIS *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
3-40	200-0548-00			8	COVER, plastic
-41	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
-42	432-0048-00			1	BASE, large capacitor mounting
-43	386-0254-00			1	PLATE, fiber
-44	211-0514-00			2	SCREW, 6-32 x 3/4 inch, PHS
-45	210-0006-00			2	LOCKWASHER, internal, #6
-46	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-47	200-0293-00			2	COVER, plastic, 1.365 ID x 2 9/16 inches long
-48	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
-49	432-0048-00			1	BASE, large capacitor mounting
-50	386-0254-00			1	PLATE, fiber
-51	211-0588-00			2	SCREW, 6-32 x 3/4 inch, HHS
-52	210-0006-00			2	LOCKWASHER, internal, #6
-53	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-54	200-0259-00			1	COVER, plastic, 1.369 ID x 3 9/16 inches
-55	119-0129-00			1	ASSEMBLY, delay line
	- - - - - -			-	assembly includes:
	380-0049-00			1	HOUSING, delay line
	200-0482-01			1	COVER, delay line housing
	211-0513-00			5	SCREW, 6-32 x 5/8 inch, PHS
	210-0407-00			5	NUT, hex., 6-32 x 1/4 inch
	131-0271-00			1	CONNECTOR, right hand
	131-0272-00			1	CONNECTOR, left hand
	210-0202-00			1	LUG, solder, SE #6
	210-0201-00			1	LUG, solder, SE #4
	211-0097-00			1	SCREW, 4-40 x 5/16 inch, PHS
	210-0406-00			1	NUT, hex., 4-40 x 3/16 inch
	131-0157-00			2	CONNECTOR, terminal stand-off
	210-1014-00			2	WASHER, plastic, 0.094 ID x 0.312 inch OD
	343-0002-00			1	CLAMP, cable, plastic
	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

FIG. 4 CALIBRATOR, F & I, VERTICAL & HORIZONTAL AMPLIFIER

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
4-1	441-0704-00			1		CHASSIS, calibrator, focus & intensity
	- - - - - -			-		mounting hardware: (not included w/chassis)
	211-0504-00			6		SCREW, 6-32 x 1/4 inch, PHS
	212-0004-00			3		SCREW, 8-32 x 5/16 inch, PHS
	210-0457-00			3		NUT, keps, 6-32 x 5/16 inch
	210-0458-00			1		NUT, keps, 8-32 x 11/32 inch
-2	348-0064-00			1		GROMMET, plastic, 5/8 inch diameter
-3	348-0063-00			1		GROMMET, plastic, 1/2 inch diameter
-4	- - - - - -			1		RESISTOR
	- - - - - -			-		mounting hardware: (not included w/resistor)
-5	211-0553-00			1		SCREW, 6-32 x 1 1/2 inches, RHS
-6	210-0601-00			1		EYELET, tapered barrel
-7	210-0478-00			1		NUT, hex., 5/16 x 21/32 inch long
-8	211-0507-00			1		SCREW, 6-32 x 5/16 inch, PHS
-9	352-0066-00			3		HOLDER, capacitor
	- - - - - -			-		mounting hardware for each: (not included w/holder)
-10	361-0008-00			2		SPACER, plastic, 0.281 inch long
-11	210-0201-00			20		LUG, solder, SE #4
	- - - - - -			-		mounting hardware for each: (not included w/lug)
-12	213-0044-00			1		SCREW, thread forming, 5-32 x 3/16 inch, PHS
-13	136-0181-00			5		SOCKET, transistor, 3 pin
	- - - - - -			-		mounting hardware for each: (not included w/socket)
-14	354-0234-00			1		RING, socket mounting
-15	136-0218-00			1		SOCKET, transistor, 3 pin
	- - - - - -			-		mounting hardware: (not included w/socket)
	354-0285-00			1		RING, socket mounting
-16	136-0153-00			1		SOCKET, crystal, 2 pin
	- - - - - -			-		mounting hardware: (not included w/socket)
-17	213-0055-00			2		SCREW, thread cutting, 2-32 x 3/16 inch, PHS
-18	441-0705-00			1		CHASSIS, vertical amplifier output
	- - - - - -			-		mounting hardware: (not included w/chassis)
-19	211-0504-00			5		SCREW, 6-32 x 1/4 inch, PHS
-20	- - - - - -			2		CAPACITOR
	- - - - - -			-		mounting hardware for each: (not included w/capacitor)
-21	210-0046-00			1		LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-22	210-0465-00			1		NUT, hex., 1/4-32 x 3/8 inch

FIG. 4 CALIBRATOR, F & I, VERTICAL & HORIZONTAL AMPLIFIER *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
4-23	214-0317-00			5	HEAT SINK, insulator disc
	- - - - - -			-	mounting hardware for each: (not included w/heat sink)
-24	352-0062-00			1	HOLDER, transistor
-25	343-0097-00			1	CLAMP, transistor
-26	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-27	211-0012-00			2	SCREW, 4-40 x 3/8 inch, PHS
	210-0406-00			4	NUT, hex., 4-40 x 3/16 inch
-28	210-0599-00			2	NUT, sleeve
-29	214-0368-00			1	SPRING, sleeve
	210-0627-00			1	RIVET
-30	670-0512-00			1	ASSEMBLY, circuit board—VERTICAL AMPLIFIER
	- - - - - -			-	assembly includes:
	388-0813-00			1	BOARD, circuit
	- - - - - -			-	board includes:
-31	214-0506-00			5	PIN, connector
-32	136-0220-00			8	SOCKET, transistor, 3 pin
	- - - - - -			-	mounting hardware: (not included w/assembly)
-33	211-0116-00			7	SCREW, sems, 4-40 x 5/16 inch, PHB
-34	352-0031-00			1	HOLDER, fuse, single
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-35	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: (not included w/transistor)
-36	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS
-37	210-0935-00			2	WASHER, fiber, 0.140 ID x 0.375 inch OD
-38	214-0559-00			1	HEAT SINK
-39	210-0202-00			1	LUG, solder, SE #6
-40	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-41	260-0516-00			1	SWITCH, push—TRACE FINDER
	- - - - - -			-	mounting hardware: (not included w/switch)
	211-0100-00			2	SCREW, 2-56 x 3/4 inch, RHS
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-42	406-0905-00			1	BRACKET, switch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-43	384-0291-00			1	ROD, extension, switch
-44	214-0333-00			1	SPRING, switch extension
-45	407-0314-00			1	BRACKET, mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
-46	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-47	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch

FIG. 4 CALIBRATOR, F & I, VERTICAL & HORIZONTAL AMPLIFIER *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
4-48	343-0001-00			1	CLAMP, cable, 1/8 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
-49	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
-50	210-0863-00			1	WASHER, "D" type
-51	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-52	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-53	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-54	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-55	210-0598-00			1	NUT, hex., 1/4-32 x 5/16 x 1/8 inch thick
-56	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-57	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-58	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-59	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-60	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-61	407-0313-00			1	BRACKET, transistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
-62	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-63	136-0218-00			6	SOCKET, transistor, 3 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-64	354-0285-00			1	RING, socket mounting
-65	210-0204-00			2	LUG, solder, #6 DE
	- - - - - -			-	mounting hardware for each: (not included w/lug)
-66	213-0044-00			1	SCREW, 6-32 x 1/4 inch, 100° csk, FHS
-67	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
-68	214-0153-00			1	FASTENER, snap, double pronged

FIG. 4 CALIBRATOR, F & I, VERTICAL & HORIZONTAL AMPLIFIER *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
					1 2 3 4 5
4-69	358-0166-00			1	BUSHING, plastic
-70	348-0063-00			2	GROMMET, plastic, 1/2 inch diameter
-71	348-0031-00			4	GROMMET, plastic, 1/4 inch diameter
-72	348-0064-00			1	GROMMET, plastic, 5/8 inch diameter
-73	441-0707-00			1	CHASSIS, horizontal amplifier
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0504-00			6	SCREW, 6-32 x 1/4 inch, PHS
	212-0070-00			3	SCREW, 8-32 x 5/16 inch, FHS
	212-0004-00			2	SCREW, 8-32 x 5/16 inch, PHS
	210-0458-00			5	NUT, keps, 8-32 x 11/32 inch
-74	387-0771-00			1	PLATE, plug-in roof
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0541-00			2	SCREW, 6-32 x 1/4 inch, 100° csk, FHS
-75	212-0004-00			9	SCREW, 8-32 x 5/16 inch, PHS
-76	380-0048-00			1	HOUSING, high voltage
	- - - - - -			-	mounting hardware: (not included w/housing)
	211-0504-00			3	SCREW, 6-32 x 1/4 inch, PHS
-77	381-0225-00			1	BAR, heat sink, high voltage
-78	392-0151-00			1	BOARD, high voltage
	- - - - - -			-	board includes:
-79	124-0163-00			4	STRIP, ceramic, 2 notches
-80	124-0164-00			2	STRIP, ceramic, 4 notches
-81	124-0162-00			1	STRIP, ceramic, 7/16 x 4 notches
	- - - - - -			-	strip includes:
-82	355-0046-00			1	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0007-00			1	SPACER, plastic, 0.188 inch long

FIG. 4 CALIBRATOR, F & I, VERTICAL & HORIZONTAL AMPLIFIER *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
4-83	- - - - - -			1		CAPACITOR
	- - - - - -			-		mounting hardware: (not included w/capacitor)
-84	210-0966-00			1		WASHER, rubber, 5/16 ID x 7/8 inch OD
-85	210-0261-00			2		LUG, solder, high voltage
-86	211-0587-00			1		SCREW, 6-32 x 3/16 inch, HHS
-87	- - - - - -			1		TRANSFORMER
	- - - - - -			-		mounting hardware: (not included w/transformer)
-88	211-0553-00			2		SCREW, 6-32 x 1 1/2 inches, RHS
-89	358-0228-00			2		BUSHING, insulator
-90	358-0231-00			4		BUSHING, high voltage housing
-91	200-0475-00			1		COVER, high voltage housing
	- - - - - -			-		mounting hardware: (not included w/cover)
-92	211-0553-00			2		SCREW, 6-32 x 1 1/2 inches, RHS
-93	166-0320-00			1		SLEEVE, plastic
-94	166-0319-00			1		SLEEVE, plastic, high voltage lead
-95	337-0895-00			1		SHIELD, high voltage
	- - - - - -			-		mounting hardware: (not included w/shield)
-96	211-0007-00			5		SCREW, 4-40 x 3/16 inch, PHS
-97	348-0050-00			1		GROMMET, plastic, 3/4 inch diameter
-98	131-0475-00			1		ASSEMBLY, upper deflection lead
	- - - - - -			-		assembly includes:
	131-0049-00			1		CONNECTOR, deflection plate
	131-0476-00			1		ASSEMBLY, lower deflection lead
	- - - - - -			-		assembly includes:
	131-0049-00			1		CONNECTOR, deflection plate
-99	214-0210-00			1		ASSEMBLY, solder spool
	- - - - - -			-		assembly includes:
	214-0209-00			1		SPOOL, solder
	- - - - - -			-		mounting hardware: (not included w/assembly)
	361-0007-00			1		SPACER, plastic
-100	337-0576-00			1		SHIELD, calibrator chassis
	- - - - - -			-		mounting hardware: (not included w/shield)
	211-0007-00			4		SCREW, 4-40 x 3/16 inch, PHS
-101	131-0382-00			2		CONNECTOR, stand-off
-102	131-0235-00			1		CONNECTOR, stand-off
	- - - - - -			-		mounting hardware: (not included w/connector)
	358-0136-00			1		BUSHING, plastic

FIG. 5 POWER CHASSIS

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description
					1 2 3 4 5
5-1	- - - - - -			1	TRANSFORMER
	- - - - - -			-	transformer includes:
-2	212-0565-00			4	SCREW, 10-32 x 4¼ inches, HHS
-3	210-0812-00			4	WASHER, fiber, #10
	- - - - - -			-	mounting hardware: (not included w/transformer)
-4	212-0079-00			2	SCREW, 8-32 x ½ inch, HSS
-5	220-0410-00			4	NUT, keps, 10-32 x ⅜ inch
-6	387-0807-00			1	PLATE, transformer support
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0004-00			2	SCREW, 8-32 x 5/16 inch, PHS
	212-0045-00			2	SCREW, 8-32 x ½ inch, THS
	385-0172-00			2	ROD, support, spacer
-7	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
-8	406-0904-00			1	BRACKET, rear, CRT support
	- - - - - -			-	mounting hardware: (not included w/bracket)
-9	211-0504-00			4	SCREW, 6-32 x ¼ inch, PHS
-10	354-0215-00			1	ASSEMBLY, CRT clamping ring
	- - - - - -			-	assembly includes:
-11	354-0211-00			1	RING, clamping
-12	211-0585-00			1	SCREW, 6-32 x 1 inch, RHS
	220-0419-00			1	NUT, square, 6-32 x 5/16 inch
-13	124-0160-00			1	STRIP, liner, CRT clamp
	- - - - - -			-	mounting hardware: (not included w/assembly)
-14	214-0207-00			1	NUT, adjusting
-15	210-0949-00			2	WASHER, flat, 9/64 ID x ½ inch OD
-16	211-0576-00			2	SCREW, 6-32 x ⅞ inch, socket head
-17	- - - - - -			1	THERMAL CUTOUT
	- - - - - -			-	mounting hardware: (not included w/thermal cutout)
-18	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-19	387-0870-00			1	PLATE, plexiglas
	- - - - - -			-	mounting hardware: (not included w/plate)
-20	385-0080-00			2	ROD, hex.
-21	211-0504-00			2	SCREW, 6-32 x ¼ inch, PHS
-22	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-23	210-0046-00			1	LOCKWASHER, internal, ¼ ID x 0.400 inch OD
	210-0940-00			1	WASHER, flat, ¼ ID x ⅜ inch OD
-24	210-0223-00			1	LUG, solder, ¼ ID x 7/16 inch OD
-25	210-0583-00			1	NUT, hex., ¼-32 x 5/16 inch

FIG. 5 POWER CHASSIS *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
5-26	441-0709-00			1		CHASSIS, power
	- - - - - -			-		mounting hardware: (not included w/chassis)
	211-0504-00			6		SCREW, 6-32 x 1/4 inch, PHS
	212-0004-00			1		SCREW, 8-32 x 5/16 inch, PHS
	210-0458-00			1		NUT, keps, 8-32 x 11/32 inch
-27	348-0050-00			2		GROMMET, plastic, 3/4 inch diameter
-28	348-0063-00			1		GROMMET, plastic, 1/2 inch diameter
-29	348-0067-00			2		GROMMET, plastic, 5/16 inch diameter
-30	348-0055-00			2		GROMMET, plastic, 1/4 inch diameter
-31	348-0031-00			1		GROMMET, plastic, 5/32 inch diameter
-32	343-0089-00			6		CLAMP, plastic, cable size D
-33	- - - - - -			1		TRANSISTOR
	- - - - - -			-		mounting hardware: (not included w/transistor)
-34	386-0143-00			1		PLATE, mica
-35	211-0510-00			2		SCREW, 6-32 x 3/8 inch, PHS
-36	210-0935-00			2		WASHER, fiber, shouldered
-37	210-0803-00			2		WASHER, flat, 0.150 ID x 3/8 inch OD
-38	210-0202-00			1		LUG, solder, SE #6
-39	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch
-40	352-0073-00			1		HOLDER, fuse, triple
	- - - - - -			-		mounting hardware: (not included w/holder)
-41	211-0559-00			2		SCREW, 6-32 x 3/8 inch, FHS
-42	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch
-43	352-0066-00			2		HOLDER, capacitor
	- - - - - -			-		mounting hardware for each: (not included w/holder)
-44	361-0007-00			2		SPACER, plastic, 0.188 inch long
-45	- - - - - -			1		RESISTOR
	- - - - - -			-		mounting hardware: (not included w/resistor)
-46	211-0544-00			1		SCREW, 6-32 x 3/4 inch, THS
-47	210-0478-00			1		NUT, hex., 5/16 x 21/32 inch long
-48	211-0507-00			1		SCREW, 6-32 x 5/16 inch, PHS
-49	- - - - - -			1		CAPACITOR
	- - - - - -			-		mounting hardware: (not included w/capacitor)
-50	432-0047-00			1		BASE, small capacitor mounting
-51	386-0252-00			1		PLATE, fiber
-52	211-0514-00			2		SCREW, 6-32 x 3/4 inch, PHS
-53	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch
-54	- - - - - -			1		CAPACITOR
	- - - - - -			-		mounting hardware: (not included w/capacitor)
-55	432-0048-00			1		BASE, large capacitor mounting
-56	386-0254-00			1		PLATE, fiber
-57	211-0514-00			2		SCREW, 6-32 x 3/4 inch, PHS
-58	210-0457-00			2		NUT, keps, 6-32 x 5/16 inch

FIG. 5 POWER CHASSIS *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
5-59	- - - - - -			4	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-60	210-0583-00			2	NUT, hex., 1/4-32 x 5/16 inch
-61	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-62	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-63	210-0598-00			1	NUT, hex., 1/4-32 x 5/16 x 1/8 inch wide
-64	136-0235-00			1	SOCKET, transistor, 6 pin
	- - - - - -			-	mounting hardware: (not included w/socket)
-65	354-0234-00			1	RING, socket mounting
-66	136-0218-00			3	SOCKET, transistor, 3 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-67	354-0285-00			1	RING, socket mounting
-68	136-0181-00			9	SOCKET, transistor, 3 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-69	354-0234-00			1	RING, socket mounting
-70	210-0201-00			6	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: (not included w/lug)
-71	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-72	200-0255-00			1	COVER, capacitor
-73	200-0259-00			1	COVER, capacitor

FIG. 6 CABINET & RAILS

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
6-1	387-0772-00			2	PLATE, cabinet side, left & right
	- - - - - -			-	each plate includes:
-2	214-0361-00			2	ASSEMBLY, latch, quarter turn
	- - - - - -			-	each assembly includes:
-3	214-0400-00			1	PIN, securing, index
-4	358-0218-00			1	BUSHING, latch bearing
-5	387-0871-00			1	PLATE, latch index
-6	387-0804-00			1	PLATE, latch, locking
-7	214-0359-00	B010100	B020299	1	SPRING, latch
	220-0486-00	B020300		1	NUT, push-on
-8	387-0797-00			1	PLATE, bottom
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0075-00			4	SCREW, 8-32 x 1/4 inch, THS
	211-0542-00			2	SCREW, 6-32 x 5/16 inch, THS
-9	122-0113-00			1	ANGLE, frame, top left
	- - - - - -			-	mounting hardware: (not included w/angle)
-10	211-0538-00			4	SCREW, 6-32 x 5/16 inch, FHS
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-11	122-0112-00			1	ANGLE, frame, top right
	- - - - - -			-	mounting hardware: (not included w/angle)
-12	211-0538-00			4	SCREW, 6-32 x 5/16 inch, FHS
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
-13	122-0118-00			2	ANGLE, frame, bottom
	- - - - - -			-	mounting hardware for each: (not included w/angle)
-14	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch

FIG. 6 CABINET & RAILS *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
6-15	381-0218-00			1		ASSEMBLY, bar, top support
	- - - - - -			-		assembly includes:
-16	344-0098-00			2		CLIP, chrome
-17	212-0507-00			2		SCREW, 10-32 x 3/8 inch, BHS
-18	367-0037-00			1		HANDLE
	- - - - - -			-		mounting hardware: (not included w/assembly)
	381-0073-00			2		BAR, retaining
-19	212-0039-00			4		SCREW, 8-32 x 3/8 inch, THS
-20	391-0057-00			1		BLOCK, flip stand pivot, left
	- - - - - -			-		mounting hardware: (not included w/block)
-21	212-0023-00			1		SCREW, 8-32 x 3/8 inch, PHS
-22	214-0408-00			1		NUT, cam locking
-23	391-0058-00			1		BLOCK, flip stand pivot, right
	- - - - - -			-		mounting hardware: (not included w/block)
-24	212-0023-00			1		SCREW, 8-32 x 3/8 inch, PHS
-25	214-0408-00			1		NUT, cam locking
-26	348-0057-00			1		FOOT, flip stand bail
-27	348-0052-00			4		FOOT, anti-slide
	- - - - - -			-		mounting hardware for each: (not included w/foot)
-28	212-0071-00			2		SCREW, 8-32 x 1 inch, FIL HS
	210-0458-00			2		NUT, keps, 8-32 x 11/32 inch

FIG. 7 REAR

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
7-1	386-1156-00			1	PLATE, rear sub-panel
	- - - - - -			-	plate includes:
	354-0057-00			1	RING, ornamental
-2	386-1155-00			1	PLATE, rear overlay
-3	- - - - - -			1	LINE FILTER
	- - - - - -			-	mounting hardware: (not included w/line filter)
-4	211-0538-00			2	SCREW, 6-32 x 5/16 inch, FHS
-5	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-6	348-0053-00			4	FOOT, body & cord holder
-7	348-0054-00			4	FOOT, cap
	- - - - - -			-	mounting hardware for each: (not included w/foot)
-8	213-0125-00			1	SCREW, 10-32 x 1 1/2 inches socket head cap
-9	131-0299-00			1	CONNECTOR, 10 pin
	- - - - - -			-	mounting hardware: (not included w/connector)
-10	211-0071-00			4	SCREW, 4-40 x 3/8 inch, PHS
-11	210-0586-00			4	NUT, keps, 4-40 x 1/4 inch
-12	129-0066-00			3	POST, binding
	- - - - - -			-	mounting hardware for each: (not included w/post)
-13	358-0213-00			1	BUSHING, plastic
-14	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-15	346-0027-00			1	STRAP, ground
-16	204-0279-00			1	BODY, voltage selector (hi, med, low)
	- - - - - -			-	mounting hardware: (not included w/body)
-17	210-0006-00			1	LOCKWASHER, internal, #6
-18	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-19	200-0704-00			1	COVER, voltage selector
	- - - - - -			-	cover includes:
-20	352-0102-00			2	HOLDER, plastic, fuse
	- - - - - -			-	mounting hardware for each: (not included w/holder)
-21	213-0088-00			2	SCREW, thread forming, #4 x 1/4 inch, PHS
-22	- - - - - -			2	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
	387-0345-00			1	PLATE, insulating
	211-0511-00			2	SCREW, 6-32 x 1/2 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0935-00			2	WASHER, fiber, shouldered
	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-23	343-0089-00			1	CLAMP, plastic, snapin
-24	343-0013-00			1	CLAMP, cable, 3/8 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
-25	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-26	210-0863-00			1	WASHER, "D" type

FIG. 7 REAR *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
-27	105-0048-00			1	STOP, bottom
	- - - - - -			-	mounting hardware: (not included w/stop)
-28	212-0010-00			1	SCREW, 8-32 x 5/8 inch, PHS
-29	212-0033-00			1	SCREW, 8-32 x 3/4 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-30	105-0046-00			1	STOP, top
	- - - - - -			-	mounting hardware: (not included w/stop)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch, PHS
	212-0033-00			1	SCREW, 8-32 x 3/4 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-31	214-0365-00			1	HINGE, bottom
	- - - - - -			-	mounting hardware: (not included w/hinge)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch, PHS
	212-0033-00			1	SCREW, 8-32 x 3/4 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-32	214-0366-00			1	HINGE, top
	- - - - - -			-	mounting hardware: (not included w/hinge)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch, PHS
	212-0033-00			1	SCREW, 8-32 x 3/4 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-33	386-1157-00			1	PLATE, back, heat sink
	- - - - - -			-	mounting hardware: (not included w/plate)
-34	211-0504-00			4	SCREW, 6-32 x 1/4 inch, PHS
-35	214-0825-00			1	HEAT SINK
	- - - - - -			-	mounting hardware: (not included w/heat sink)
-36	213-0128-00			2	SCREW, 6-32 x 0.625 long, captive
-37	354-0233-00			2	RING, retaining
-38	- - - - - -			2	DIODE
	- - - - - -			-	mounting hardware for each: (not included w/diode)
	220-0411-00			1	NUT, hex., 10-32 x 3/8 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0805-00			1	WASHER, flat, 0.204 ID x 0.438 inch OD
	210-0910-00	B010100	B030549	1	WASHER, plastic, 3/16 ID x 5/16 inch OD
	166-0103-00	B030550		1	TUBE, plastic, 0.250 ID x 0.132 inch OD
	210-0909-00			2	WASHER, mica, 0.196 ID x 0.625 inch OD
	210-0224-00			1	LUG, solder, SE #10 long
-39	200-0548-00			2	COVER, plastic, nut
-40	200-0500-00			4	COVER, plastic, transistor
	- - - - - -			-	mounting hardware for each: (not included w/cover)
-41	211-0093-00			2	SCREW, 4-40 x 3/4 inch, Hex. H Socket
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-42	161-0033-00			1	CORD, power
-43	358-0161-00			1	BUSHING, strain relief

FIG. 8 CABLE HARNESS & CERAMIC STRIP DETAIL

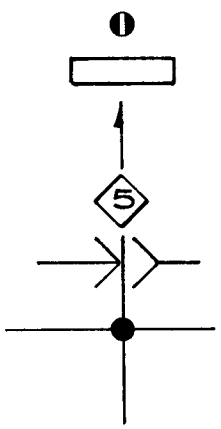
Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
8-1	179-0752-00			1		CABLE HARNESS, CRT socket
	- - - - - -			-		cable harness includes:
-2	136-0162-00			1		SOCKET, CRT assembly
	- - - - - -			-		socket includes:
	136-0117-00			1		SOCKET, CRT
	131-0178-00			11		CONNECTOR, cable end
	387-0393-00			1		PLATE, back
	213-0087-00			2		SCREW, thread cutting, 2-32 x 1/2 inch, PHS
-3	179-0747-00			1		CABLE HARNESS, power
-4	179-1113-00			1		CABLE HARNESS, heat sink
-5	179-1114-00			1		CABLE HARNESS, vertical amplifier
-6	179-0748-00			1		CABLE HARNESS, connector
-7	179-0973-00			1		CABLE HARNESS, high voltage
-8	179-0754-00			1		CABLE HARNESS, unblanking
-9	179-1112-00			1		CABLE HARNESS, focus & intensity
-10	179-1111-00			1		CABLE HARNESS, calibrator
-11	124-0147-00			3		STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0009-00			2		SPACER, plastic, 0.406 inch long
-12	124-0145-00			8		STRIP, ceramic, 7/16 inch h, w/20 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0008-00			2		SPACER, plastic, 0.281 inch long
-13	124-0148-00			2		STRIP, ceramic, 7/16 inch h, w/9 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0009-00			2		SPACER, plastic, 0.406 inch long
-14	124-0162-00			1		STRIP, ceramic, 7/16 inch h, w/4 notches
	- - - - - -			-		strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware: (not included w/strip)
	361-0009-00			2		SPACER, plastic, 0.406 inch long
-15	124-0147-00			2		STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long

FIG. 8 CABLE HARNESS & CERAMIC STRIP DETAIL *(cont)*

Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
8-16	124-0146-00			4		STRIP, ceramic, 7/16 inch h, w/16 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0008-00			2		SPACER, plastic, 0.281 inch long
-17	124-0147-00			6		STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long
-18	124-0145-00			2		STRIP, ceramic, 7/16 inch h, w/20 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long
-19	124-0148-00			2		STRIP, ceramic, 7/16 inch h, w/9 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long
-20	124-0092-00			1		STRIP, ceramic, 7/16 inch h, w/3 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
-21	124-0145-00			2		STRIP, ceramic, 7/16 inch h, w/20 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long
-22	124-0147-00			4		STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0007-00			2		SPACER, plastic, 0.188 inch long
-23	124-0149-00			3		STRIP, ceramic, 7/16 inch h, w/7 notches
	- - - - - -			-		each strip includes:
	355-0046-00			2		STUD, plastic
	- - - - - -			-		mounting hardware for each: (not included w/strip)
	361-0008-00			2		SPACER, plastic, 0.281 inch long

SECTION 9
DIAGRAMS

The following symbols are used on the diagrams:



Screwdriver adjustment

Front- or rear panel control or connector

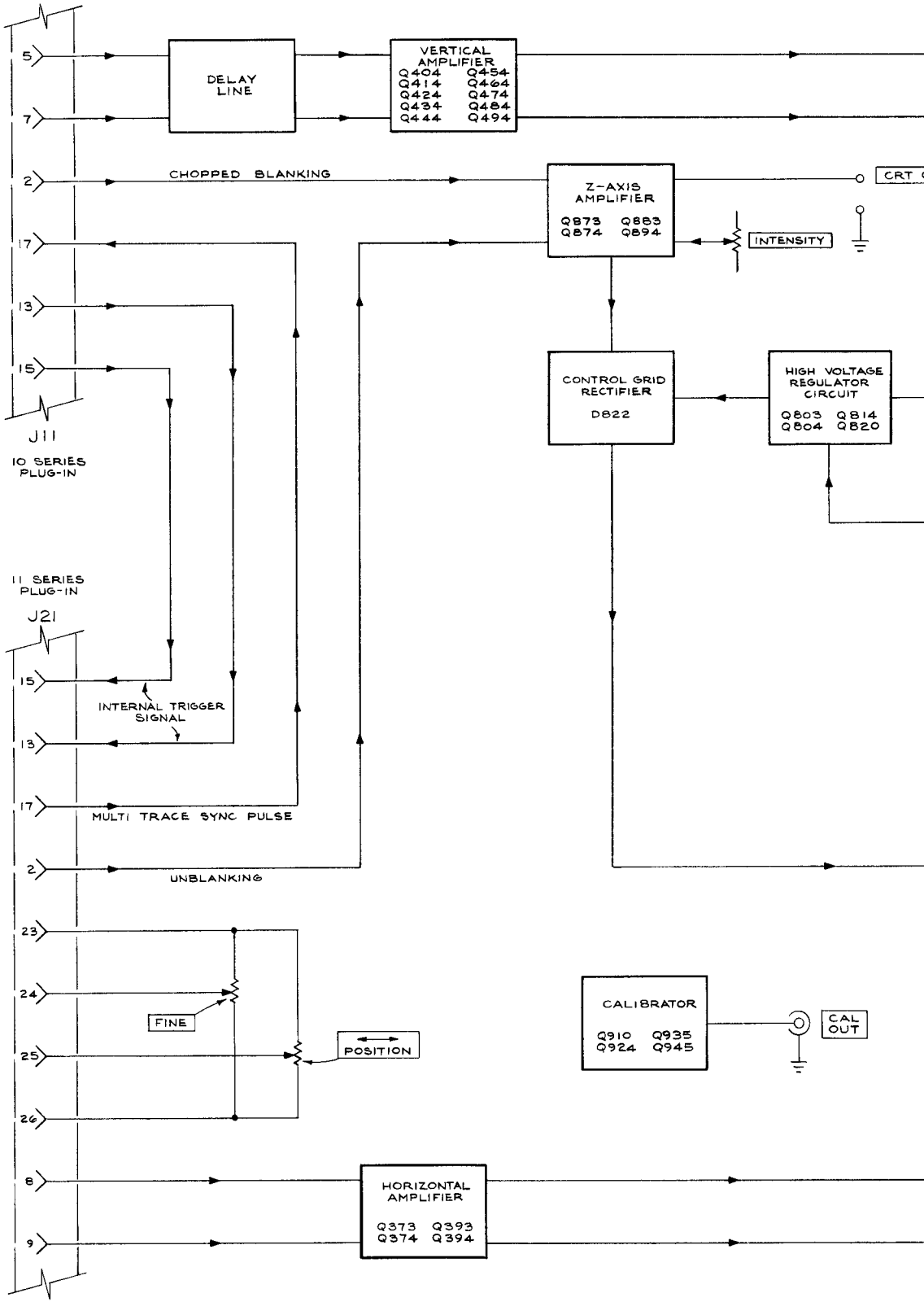
Clockwise control rotation in direction of arrow

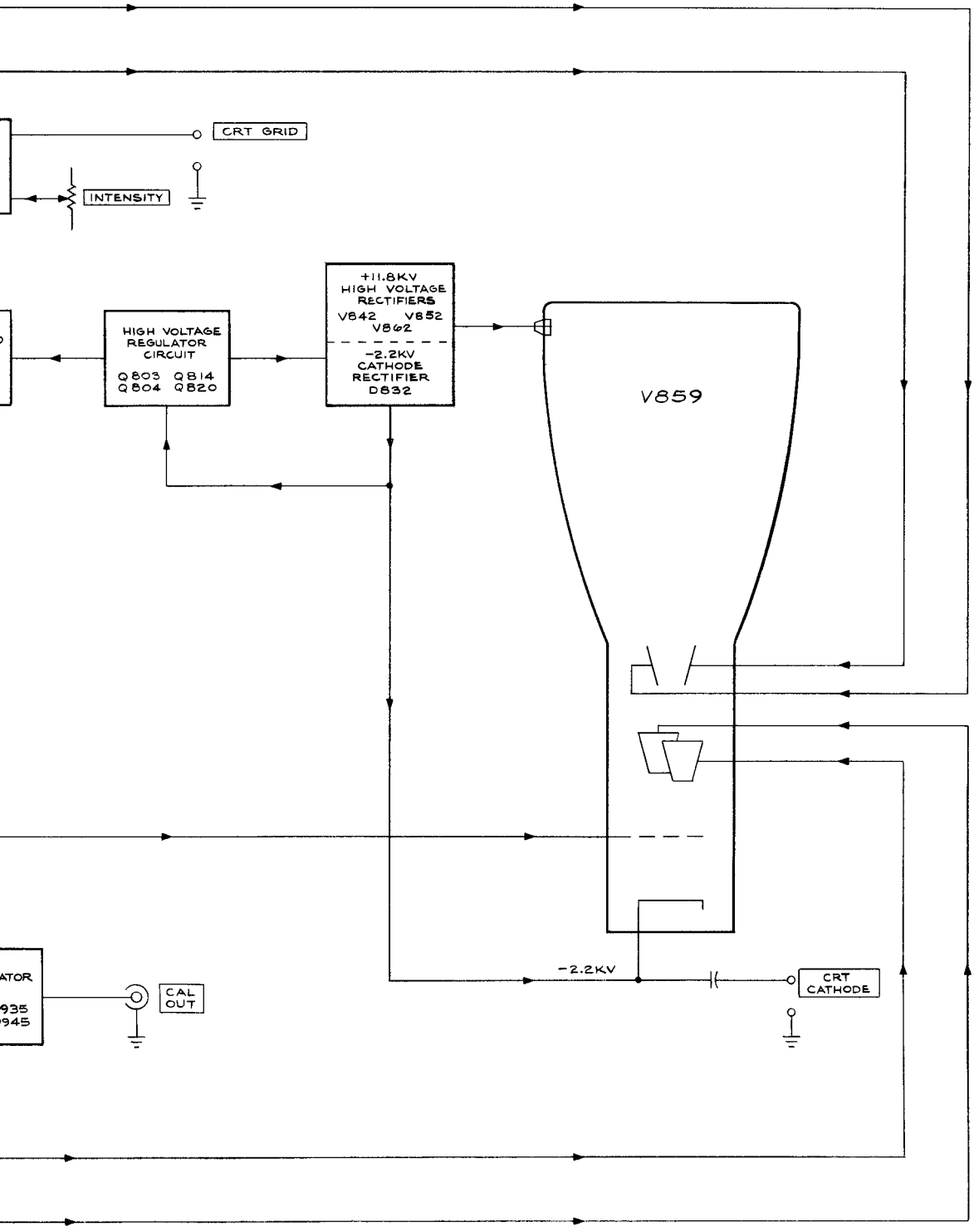
Refer to indicated diagram

Connection to circuit board made with pin connector at indicated pin

Connection soldered to circuit board

Blue line encloses components located on circuit board


5
7
DELAY LINE
VERTICAL AMPLIFIER
Q404 Q454
Q414 Q464
Q424 Q474
Q434 Q484
Q444 Q494
2
CHOPPED BLANKING
Z-AXIS AMPLIFIER
Q873 Q883
Q874 Q894
CRT
17
INTENSITY
13
15
CONTROL GRID RECTIFIER
D822
HIGH VOLTAGE REGULATOR CIRCUIT
Q803 Q814
Q804 Q820
J11
10 SERIES PLUG-IN
11 SERIES PLUG-IN
J21
15
INTERNAL TRIGGER SIGNAL
13
17
MULTI TRACE SYNC PULSE
2
UNBLANKING
23
24
FINE
25
POSITION
26
CALIBRATOR
Q910 Q935
Q924 Q945
CAL OUT
8
9
HORIZONTAL AMPLIFIER
Q373 Q393
Q374 Q394



1266

A

BLOCK DIAGRAM

VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements and waveform photographs were obtained under the following conditions unless noted otherwise on the individual diagrams:

Test Oscilloscope (with 10× Probe)

Frequency response	DC to 50 MHz
Deflection factor (with 10× probe)	0.5 to 50 volts/division
Input impedance (with 10× probe)	10 Megohms, 7.5 picofarads
Probe ground	Type 647A chassis ground
Trigger Source	External from A +Gate output connector of time-base unit to indicate true time relationship between signals
Recommended type (as used for waveforms on diagrams)	Type 544 with Type 1A1 plug-in unit

Voltmeter

Type	Nulling-type VTVM
Input impedance	10 megohms
Range	0 to 500 volts
Reference voltage	Type 647A chassis ground
Recommended type	Fluke Model 825A

Type 647A Conditions

Line voltage	115 volts
Trace position	Centered
Signal applied	Calibrator output signal connected to input of vertical unit for waveforms only.
Control settings	As follows except as noted otherwise on individual diagrams:
INTENSITY	Visible display
FOCUS	Adjust for optimum display
ASTIGMATISM	Adjust for optimum display
SCALE ILLUM	As desired
CALIBRATOR	5 V
POSITION	Midrange
FINE	Midrange

Vertical Unit Conditions

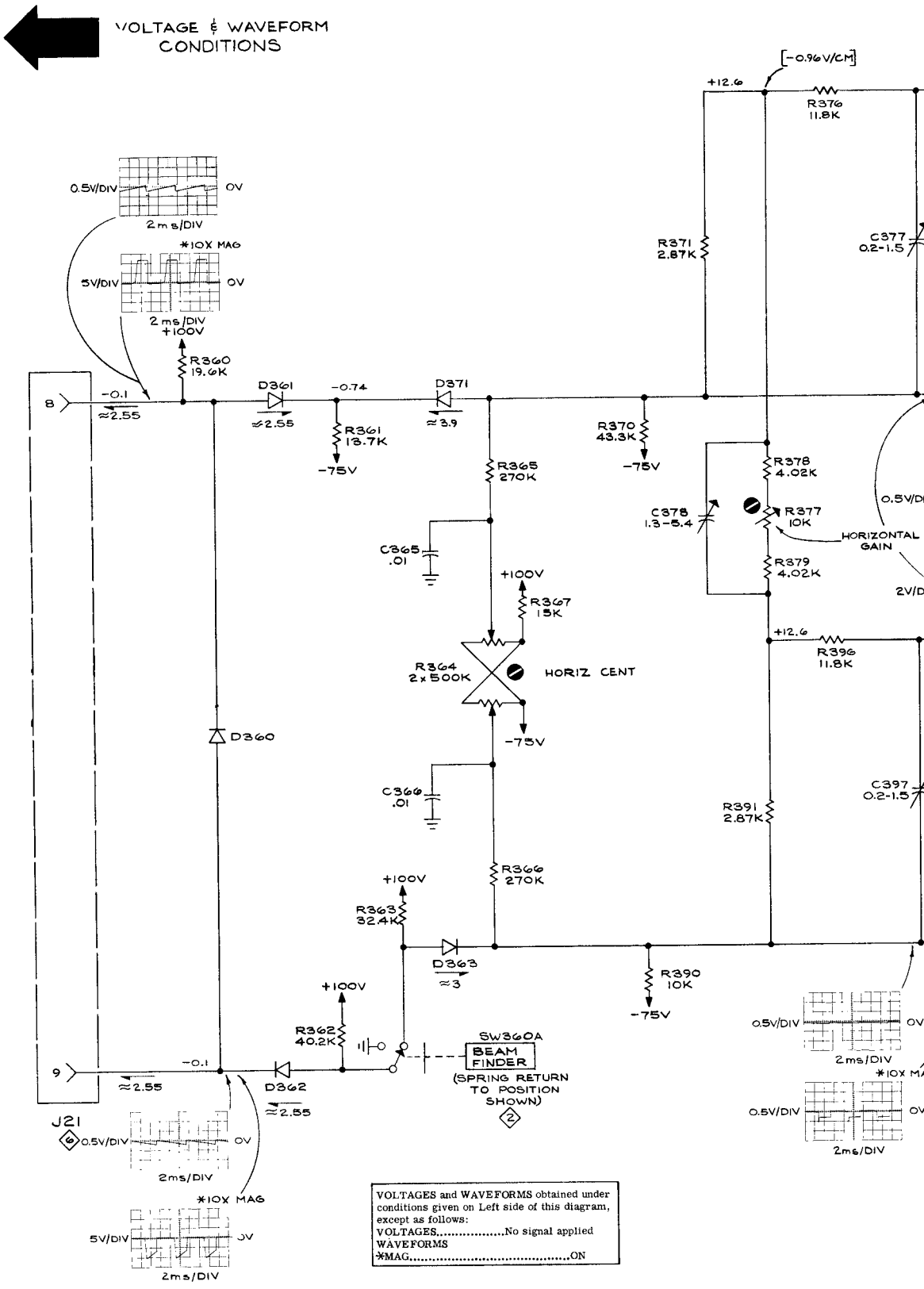
Input Coupling	DC
Volts/Cm	1
Variable	Cal
Position	Adjust for centered display
Invert	Pushed in
Mode	CH 1

Time-Base Unit Conditions

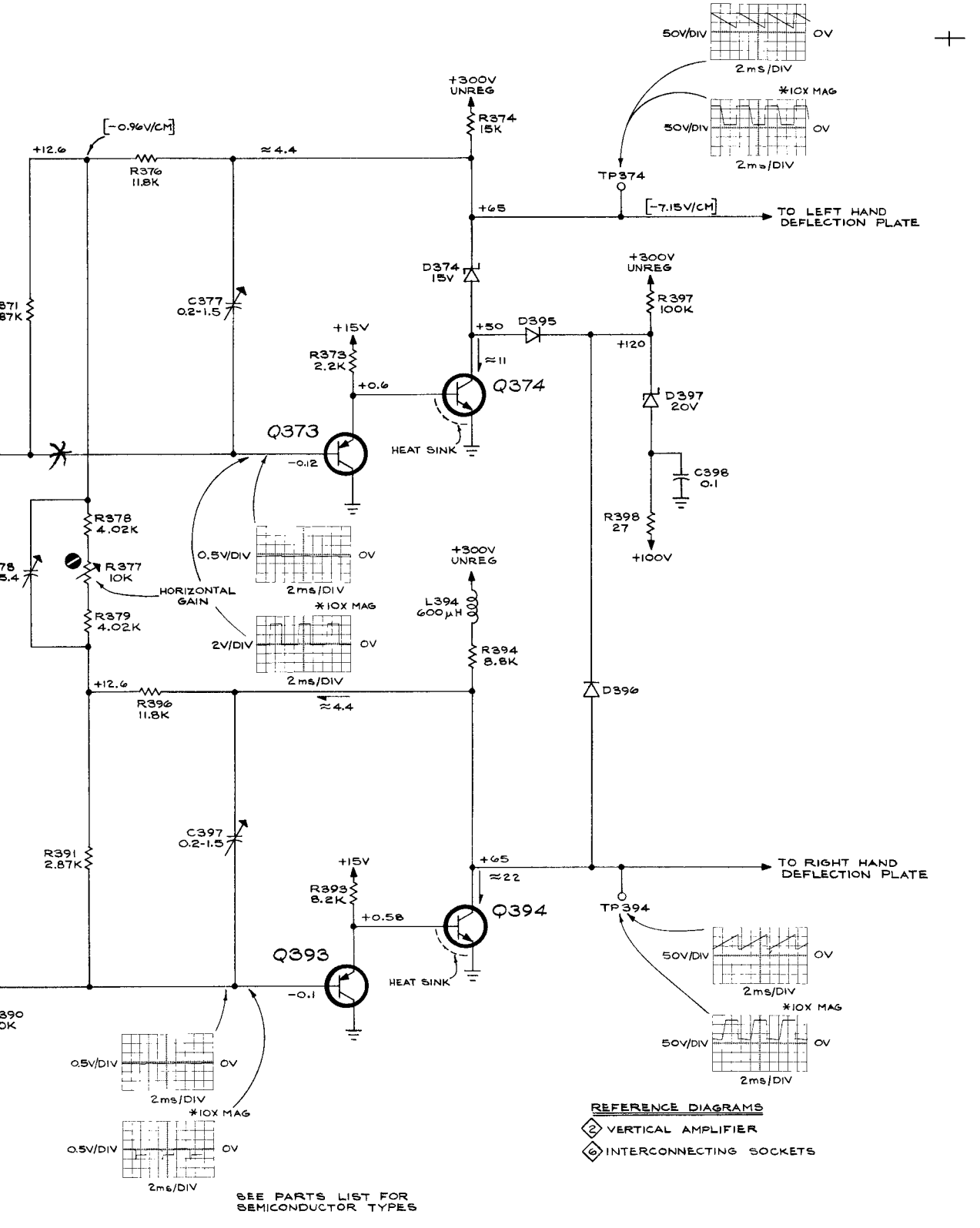
Coupling	AC
Source	Int
Slope	+
Level	Midrange
Trig Mode	Auto
Time/Cm	0.5 millisecond
Horiz Display	A

Voltages given on the diagrams are in volts, currents are in milliamps. Current flow shown in conventional current; i.e., + to —. Signal amplitudes given in volts/centimeter (in brackets), are the nominal amplitude with respect to ground. Differential amplitude is 2× the value shown. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration, front-panel control settings, meter loading or meter accuracy.

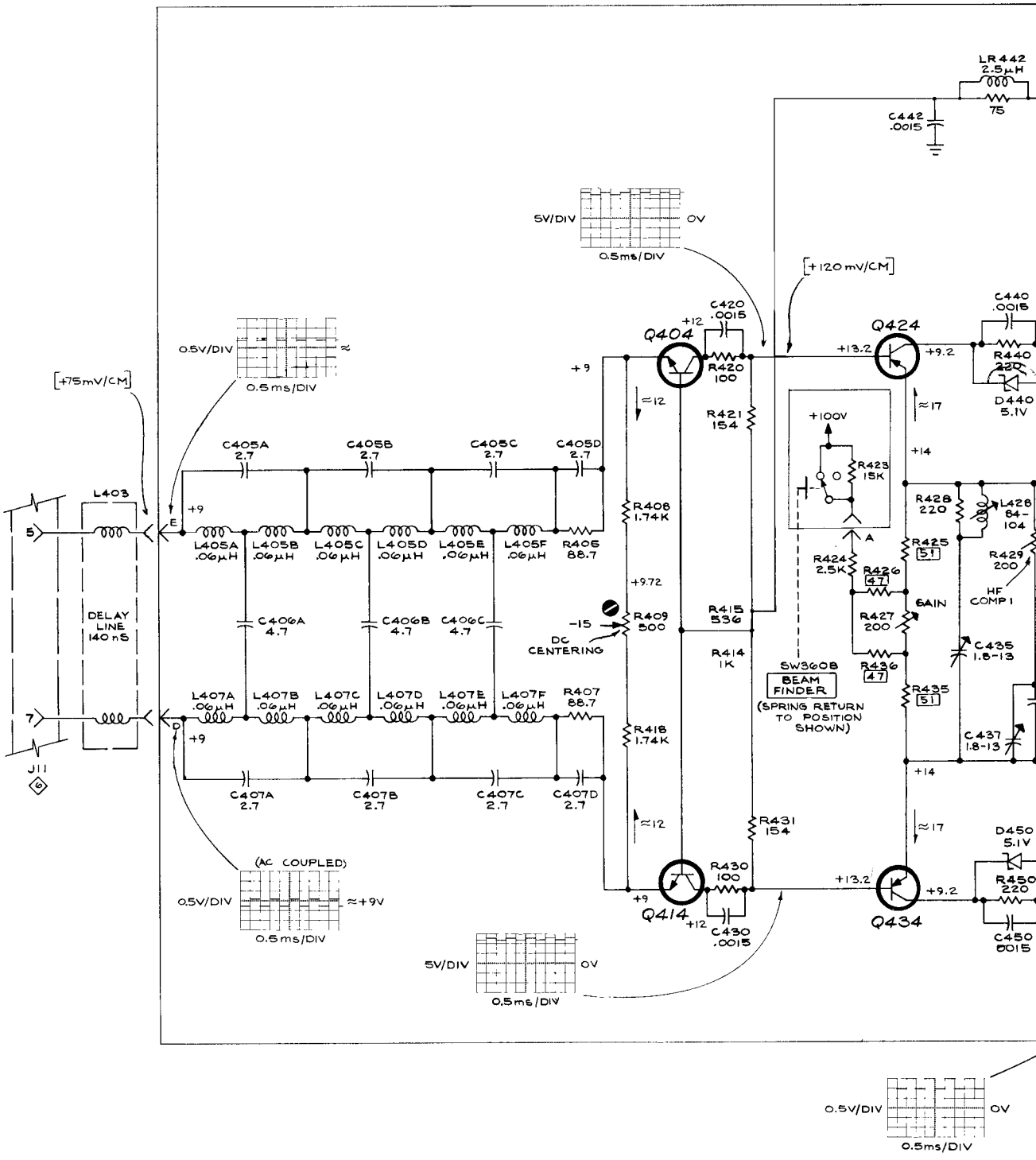


TYPE 647A OSCILLOSCOPE



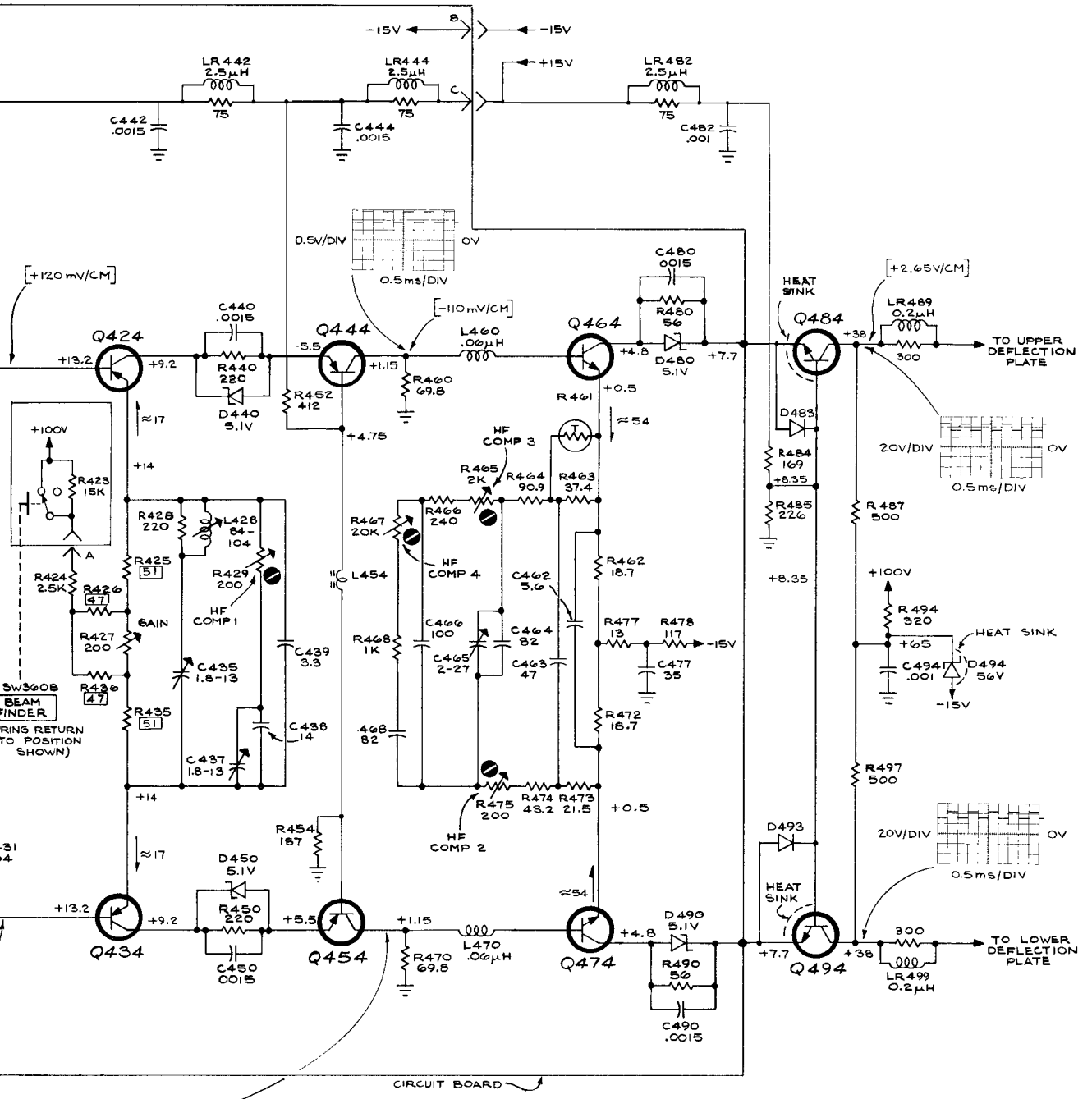
1266

HORIZONTAL AMPLIFIER 1



VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1, except as follows:
VOLTAGES.....No signal applied

SEE PA
SEMICO



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS

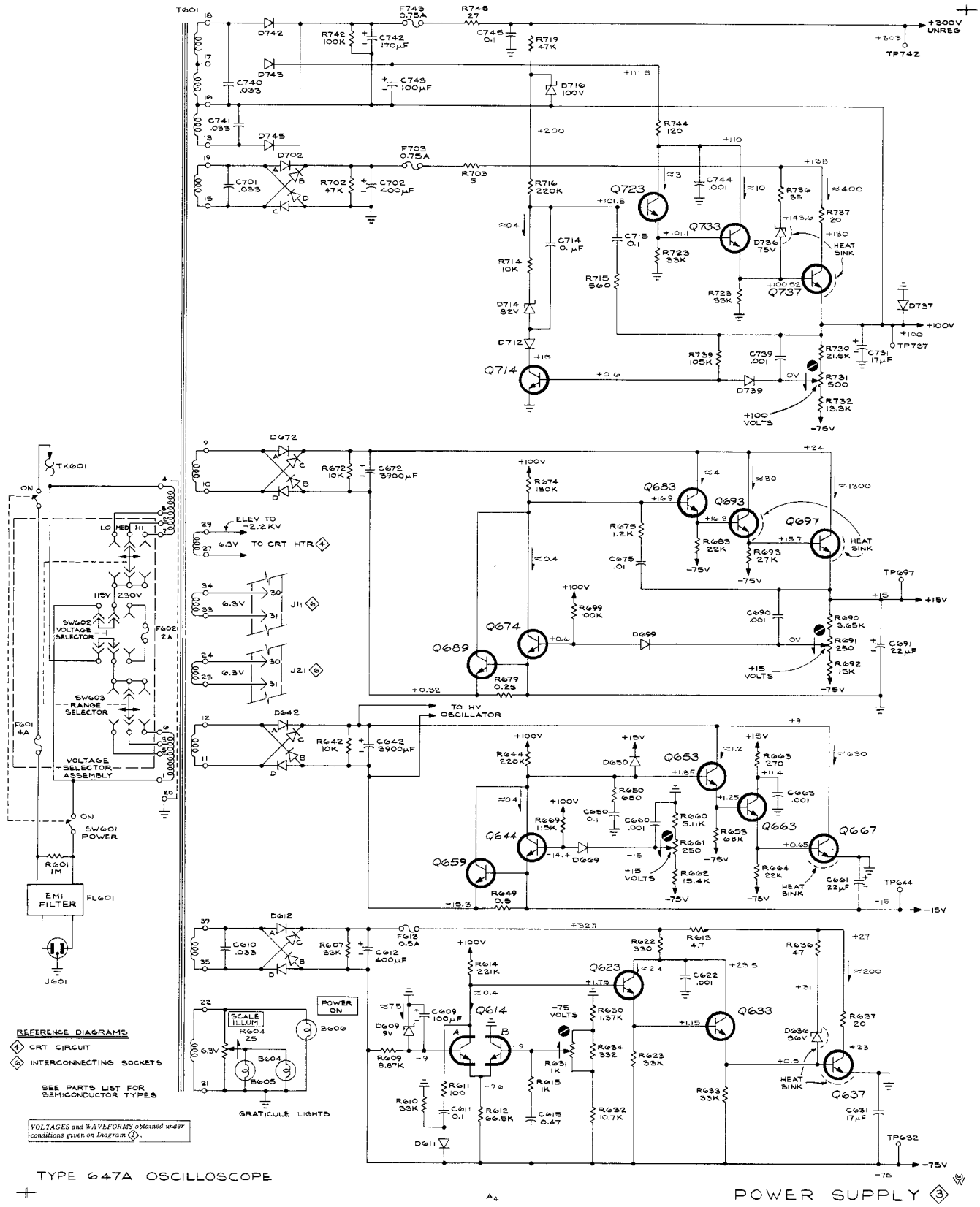
◇1 HORIZONTAL AMPLIFIER

◇6 INTERCONNECTING SOCKETS

868

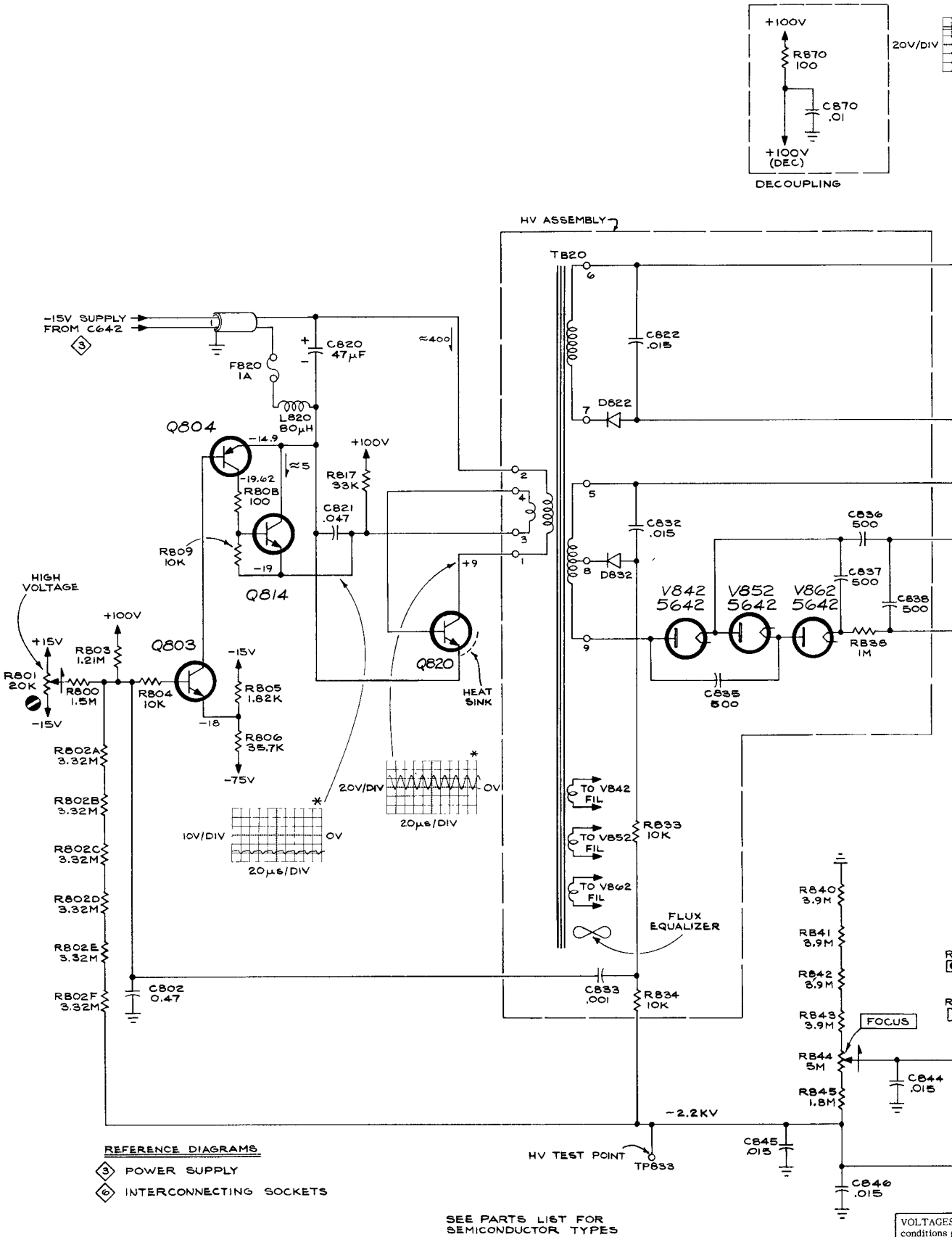
B

VERTICAL AMPLIFIER ◇2



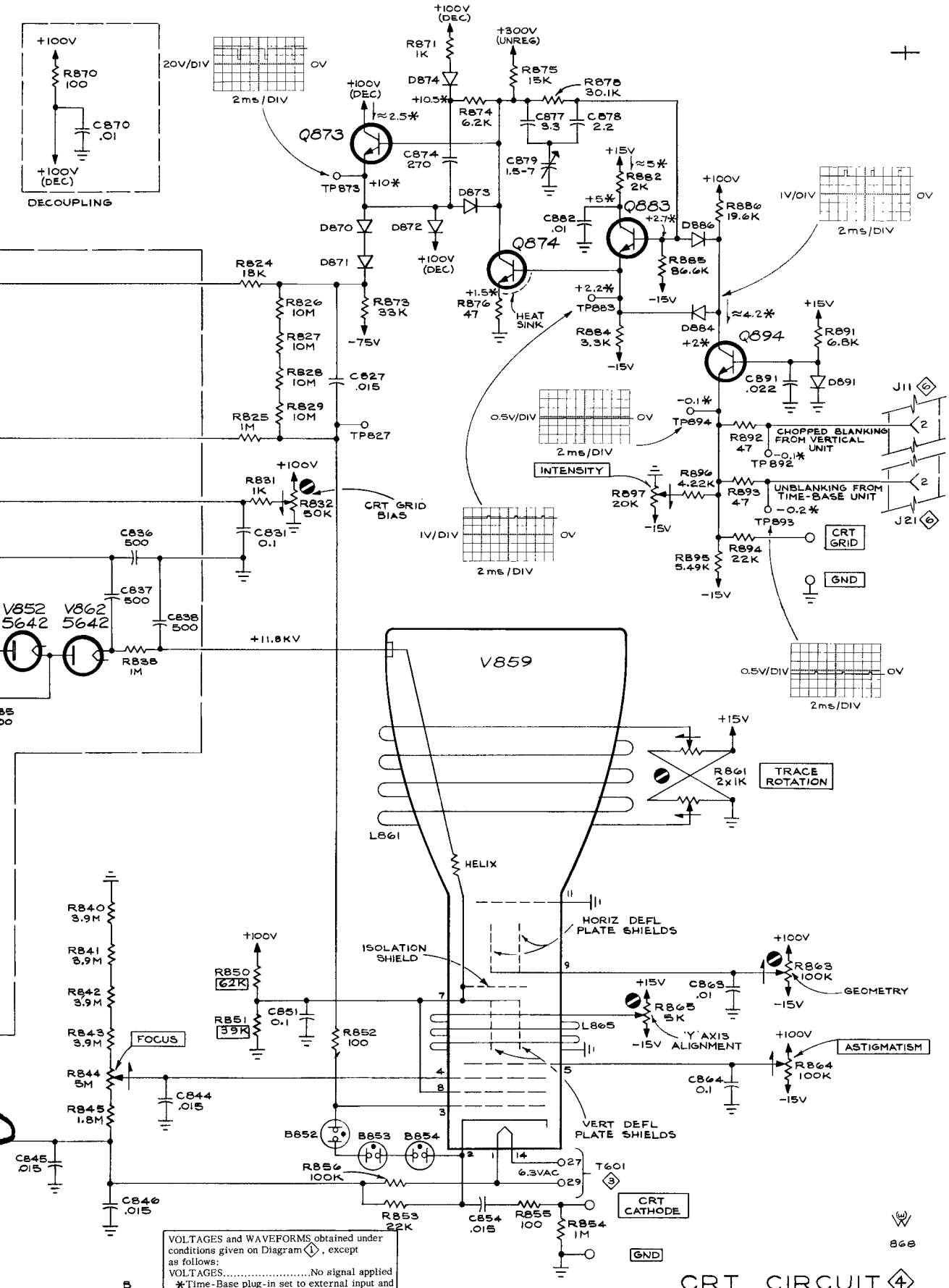
TYPE 647A OSCILLOSCOPE

POWER SUPPLY 3



TYPE 647A OSCILLOSCOPE

B

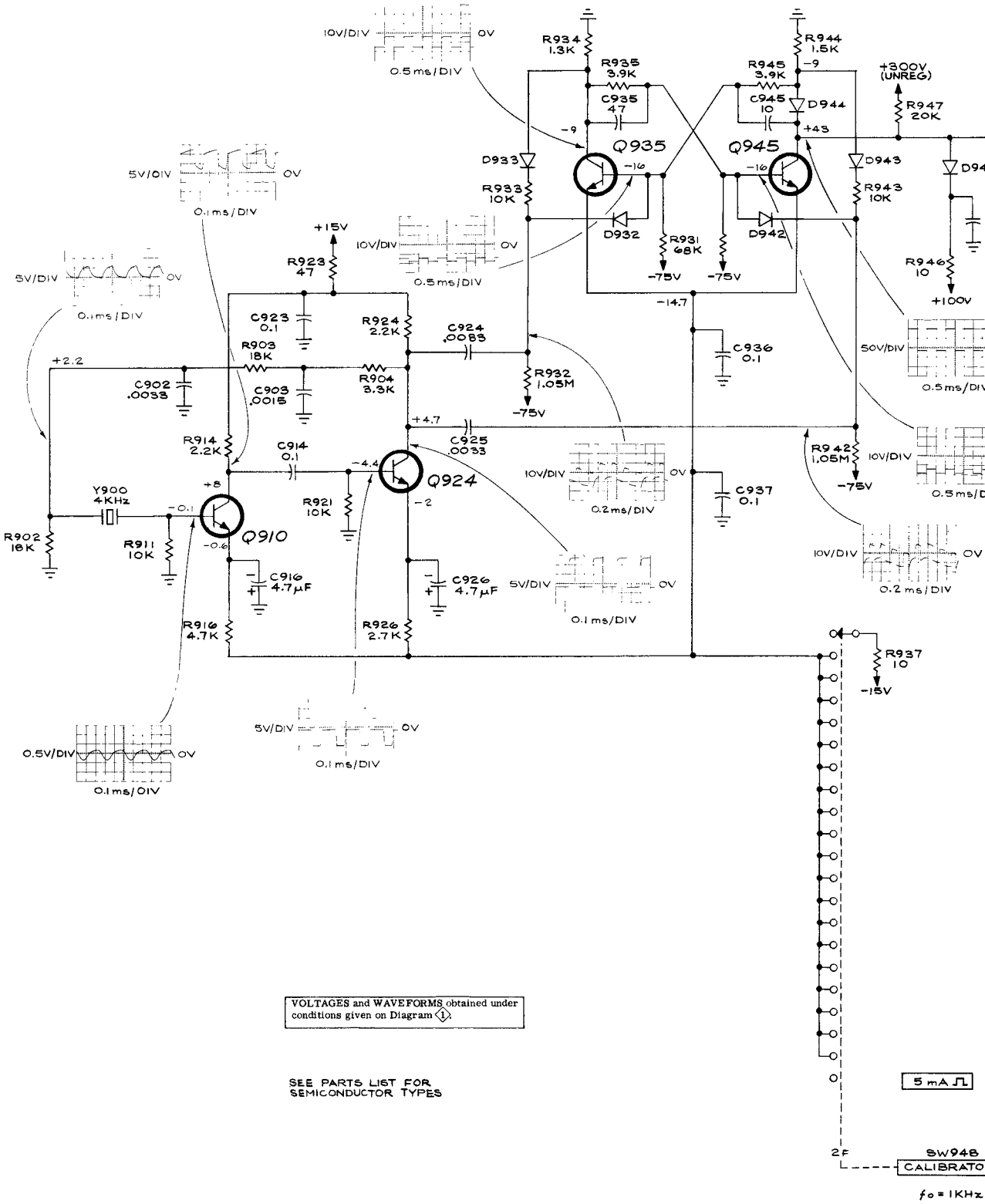


VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1, except as follows:
VOLTAGES.....No signal applied
*Time-Base plug-in set to external input and INTENSITY control set fully CCW.
WAVEFORMS
*Test oscilloscope triggered internally.

B

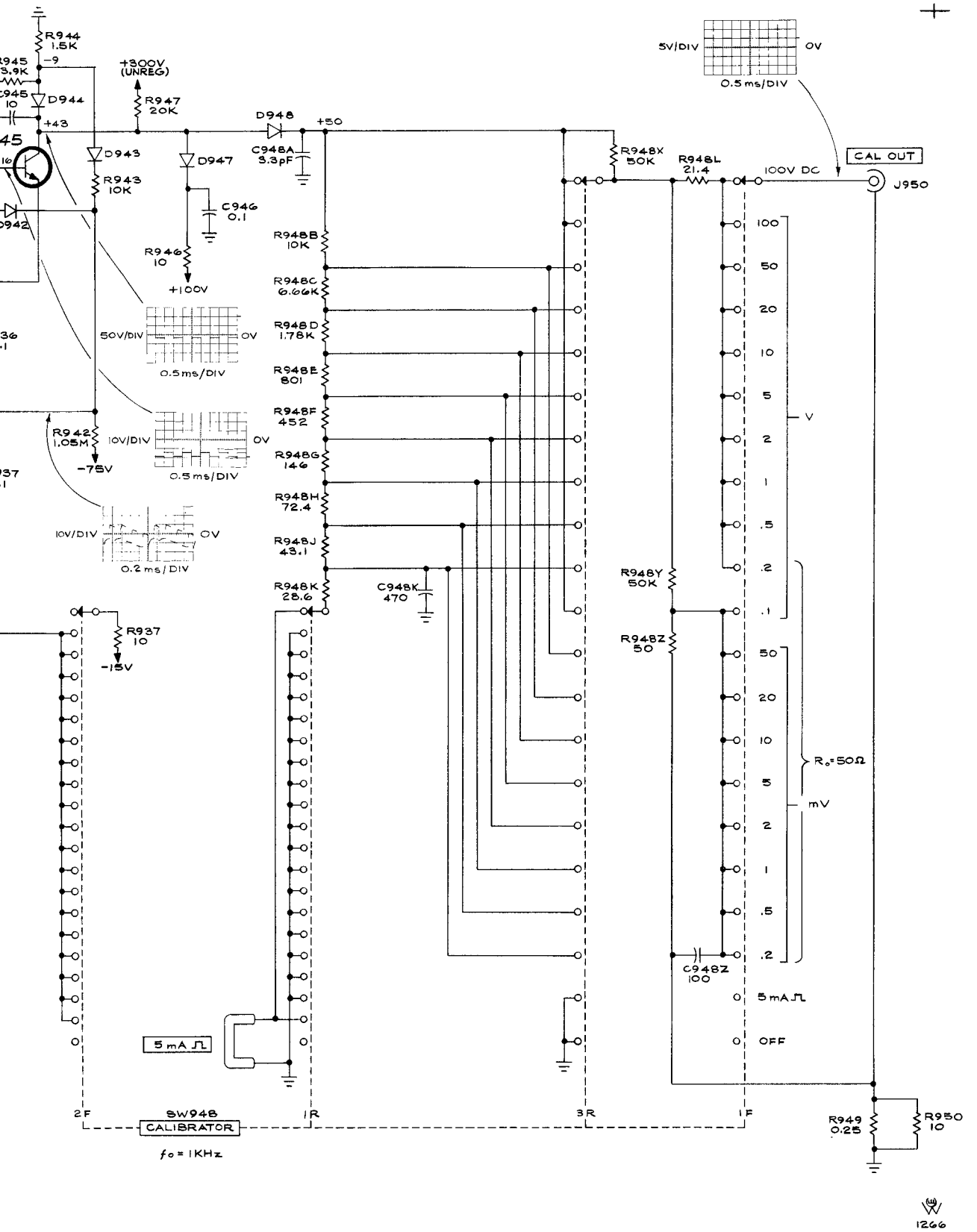
868

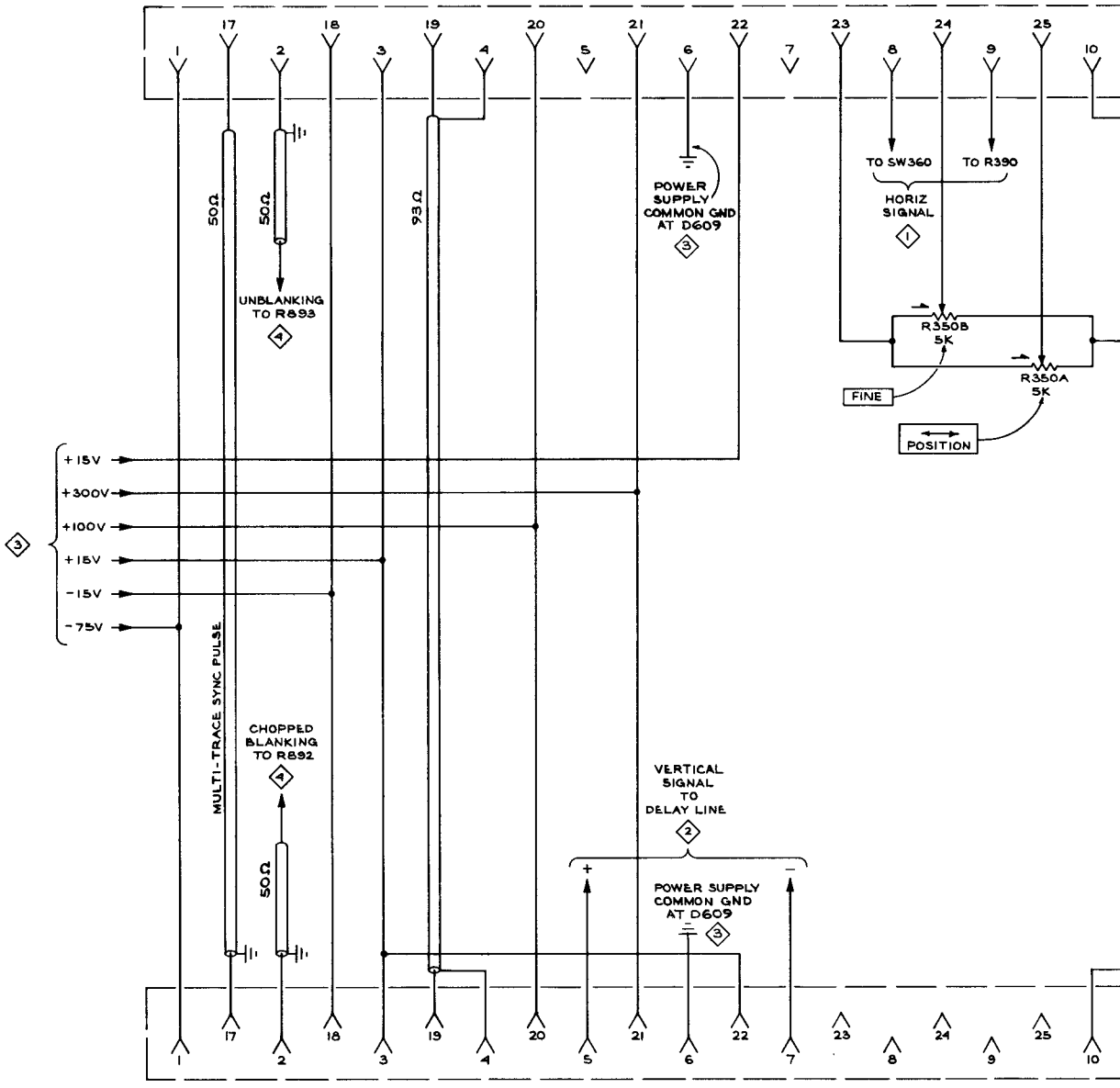
CRT CIRCUIT 4



VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1.

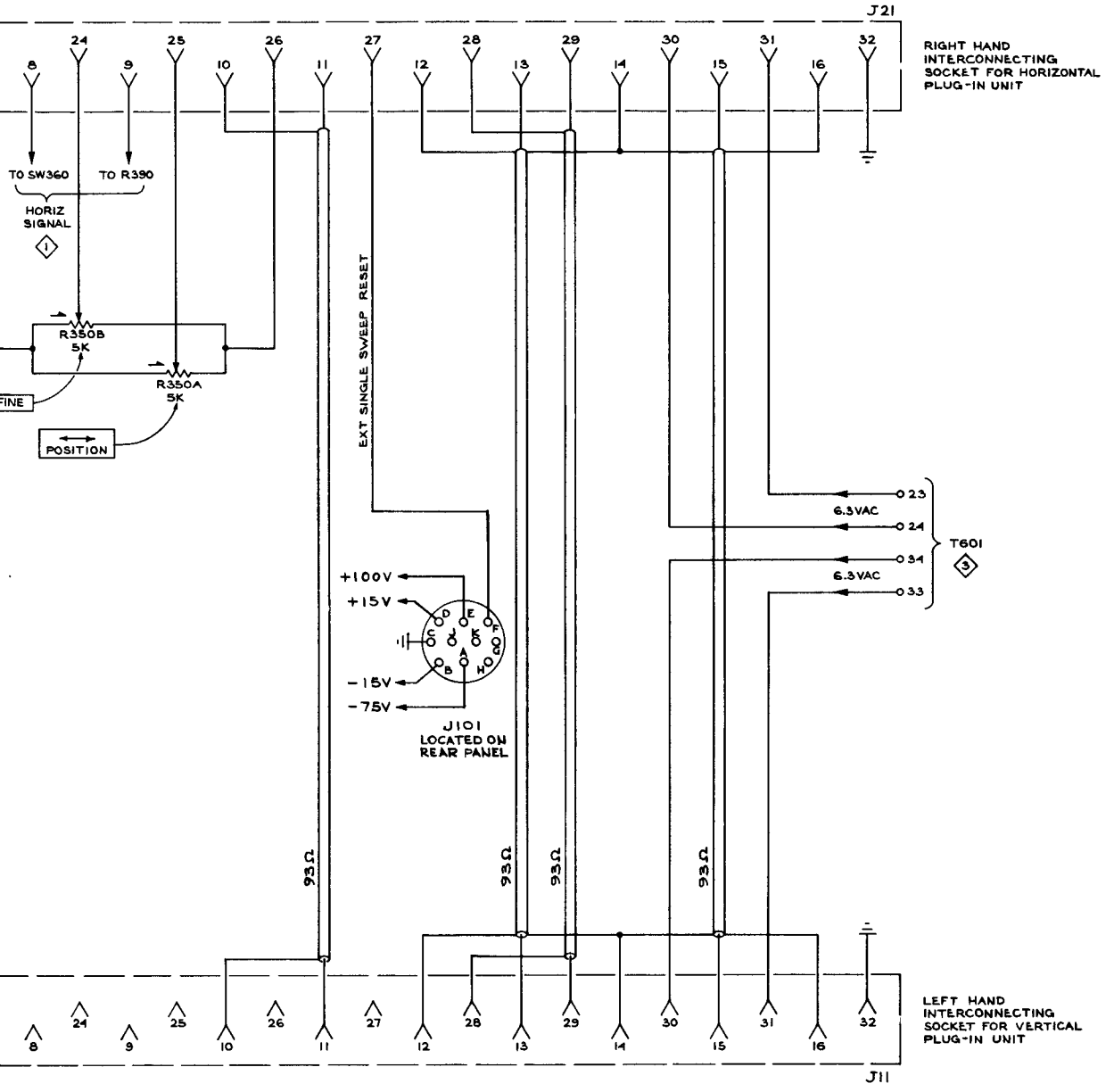
SEE PARTS LIST FOR SEMICONDUCTOR TYPES


R944 1.5K
+300V (UNREG)
R947 20K
D944
D943
D947
D948
C948A 3.3pF
+50
R943 10K
C946 0.1
R946 10
+100V
R948X 50K
R948L 21.4
100V DC
CAL OUT
J950
5V/DIV
0V
0.5ms/DIV
50V/DIV
0.5ms/DIV
R948B 10K
R948C 6.66K
R948D 1.78K
R948E 801
R948F 452
R948G 146
R948H 72.4
R948J 43.1
R948K 25.6
C948K 470
R942 1.05M
10V/DIV
-75V
0.5ms/DIV
0.2ms/DIV
R937 10
-15V
R948Y 50K
R948Z 50
C948Z 100
100
50
20
10
5
2
1
.5
.2
.1
V
mV
R_o=50Ω
5mA⎍
OFF
5mA⎍
SW948
CALIBRATOR
f_o=1KHz
2F
1R
3R
1F
R949 0.25
R950 10
1266
A
CALIBRATOR 5



REFERENCE DRAWINGS

1. HORIZONTAL AMPLIFIER
2. VERTICAL AMPLIFIER
3. POWER SUPPLY
4. CRT CIRCUIT

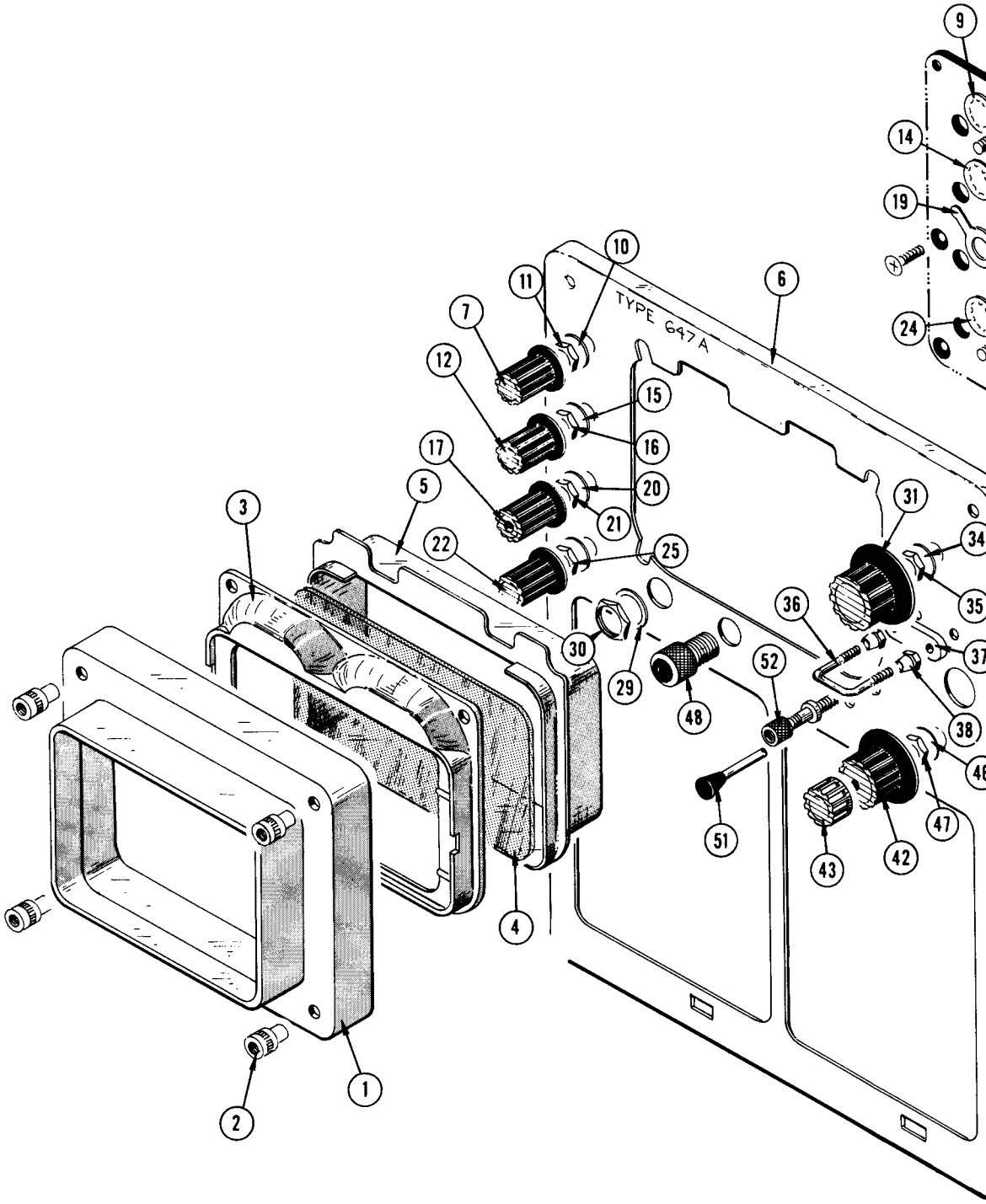


INTERCONNECTING SOCKETS 6

1266

A

FIG. 1 FRONT & SWITCHE



4A

FIG. 1 FRONT & SWITCHES

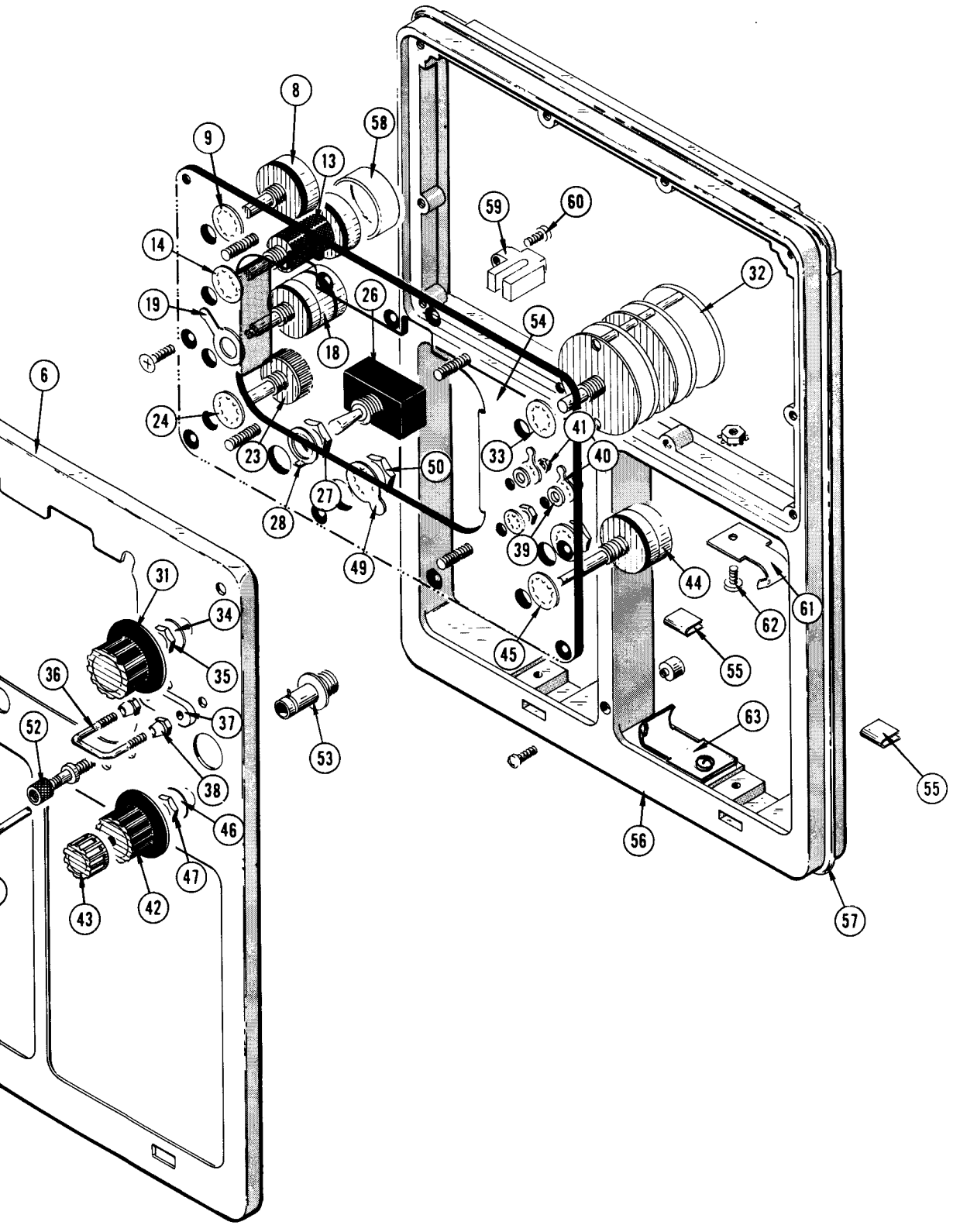


FIG. 2 CRT SHIELD & BRAC

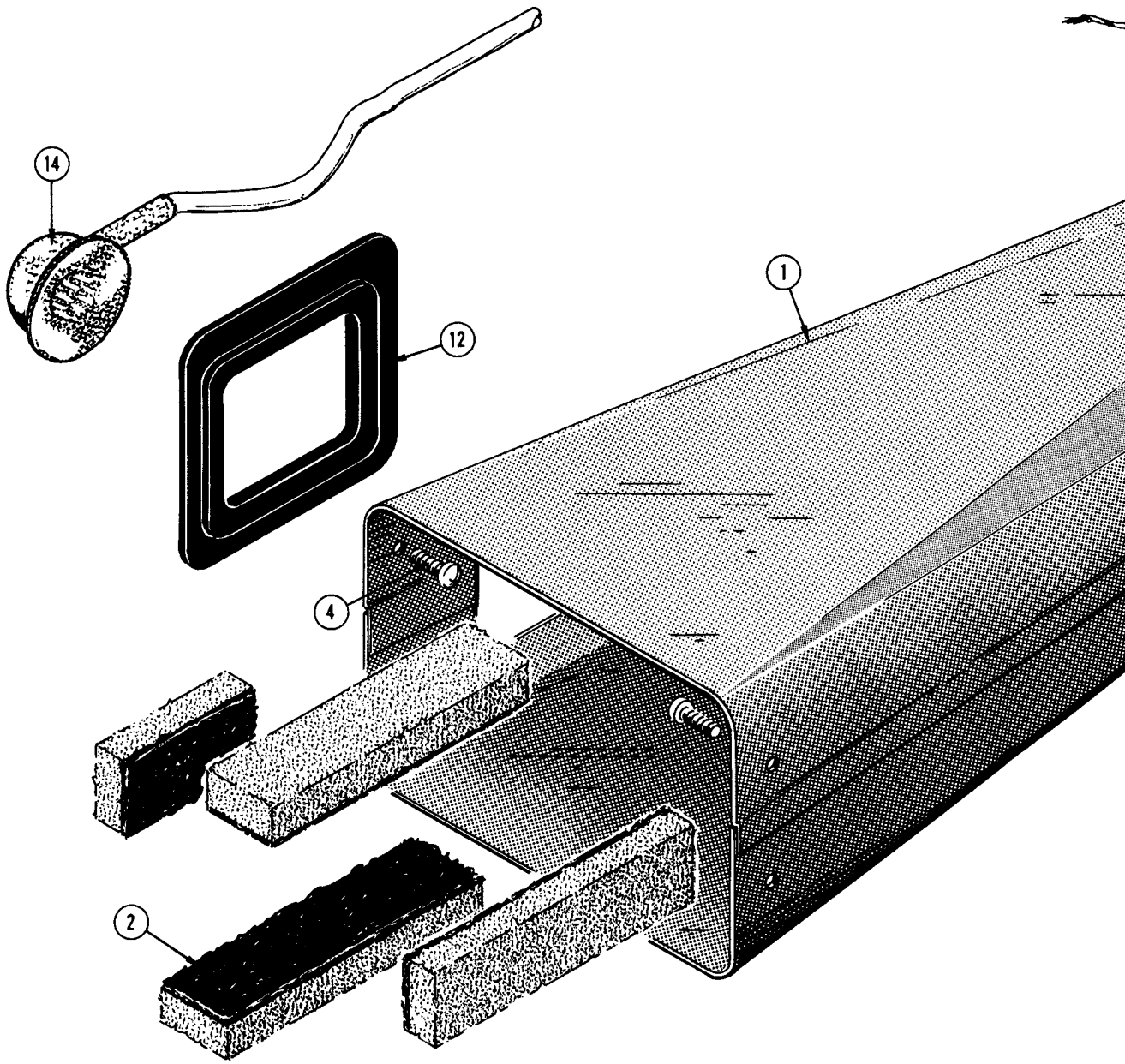


FIG. 2 CRT SHIELD & BRACKET

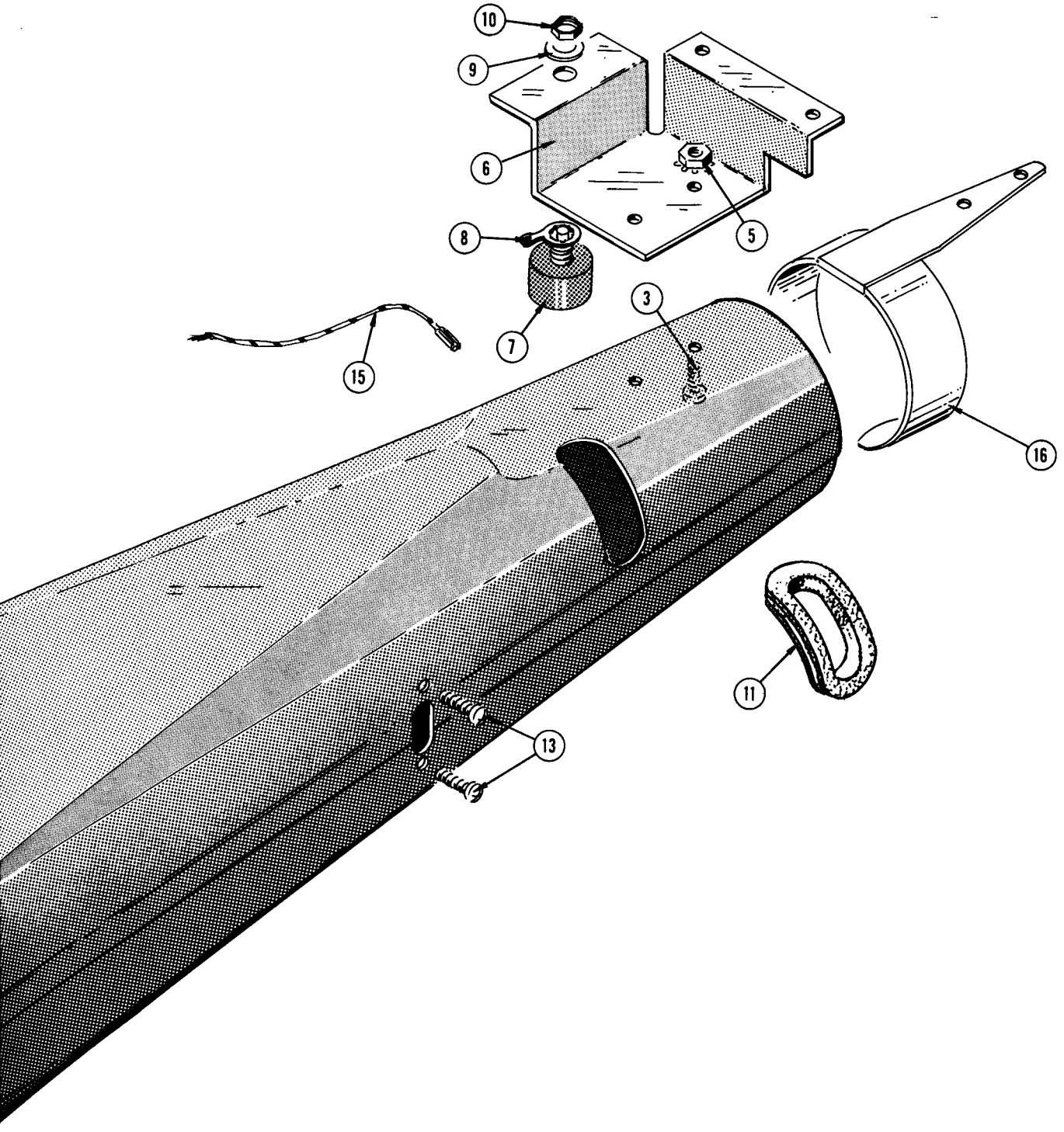
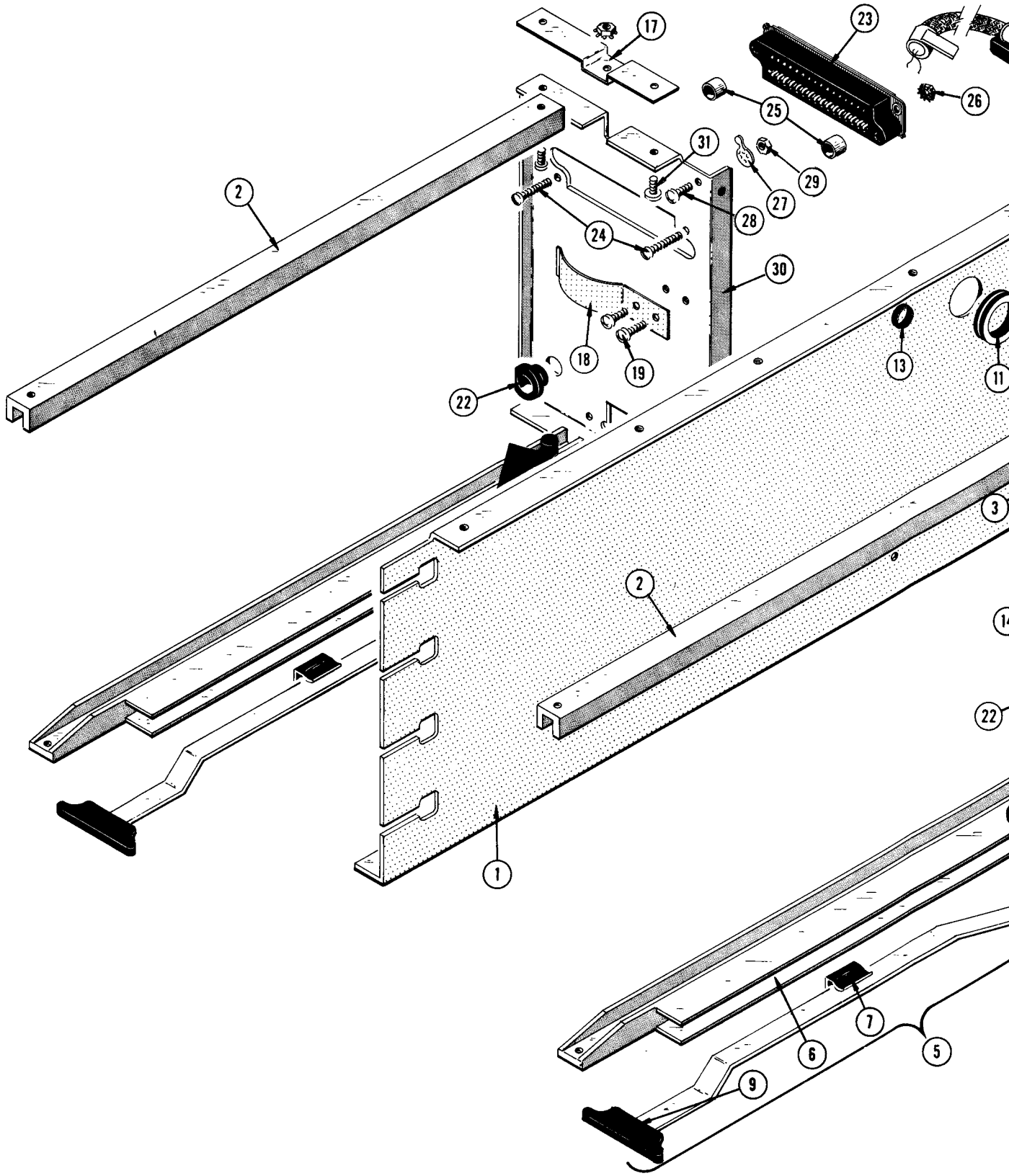


FIG. 3 PLUG-IN HOUSING & CAPAC



#A1

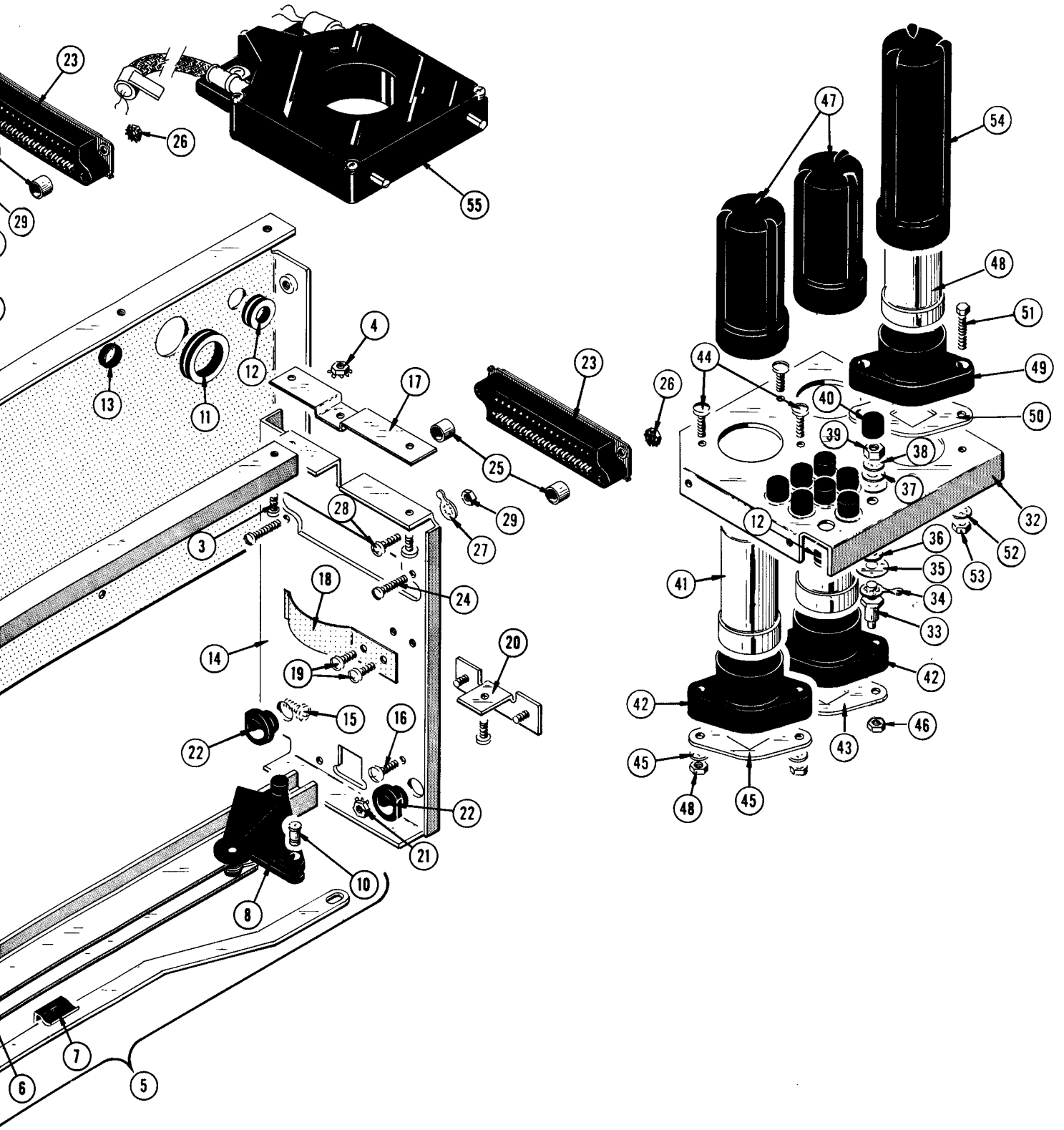
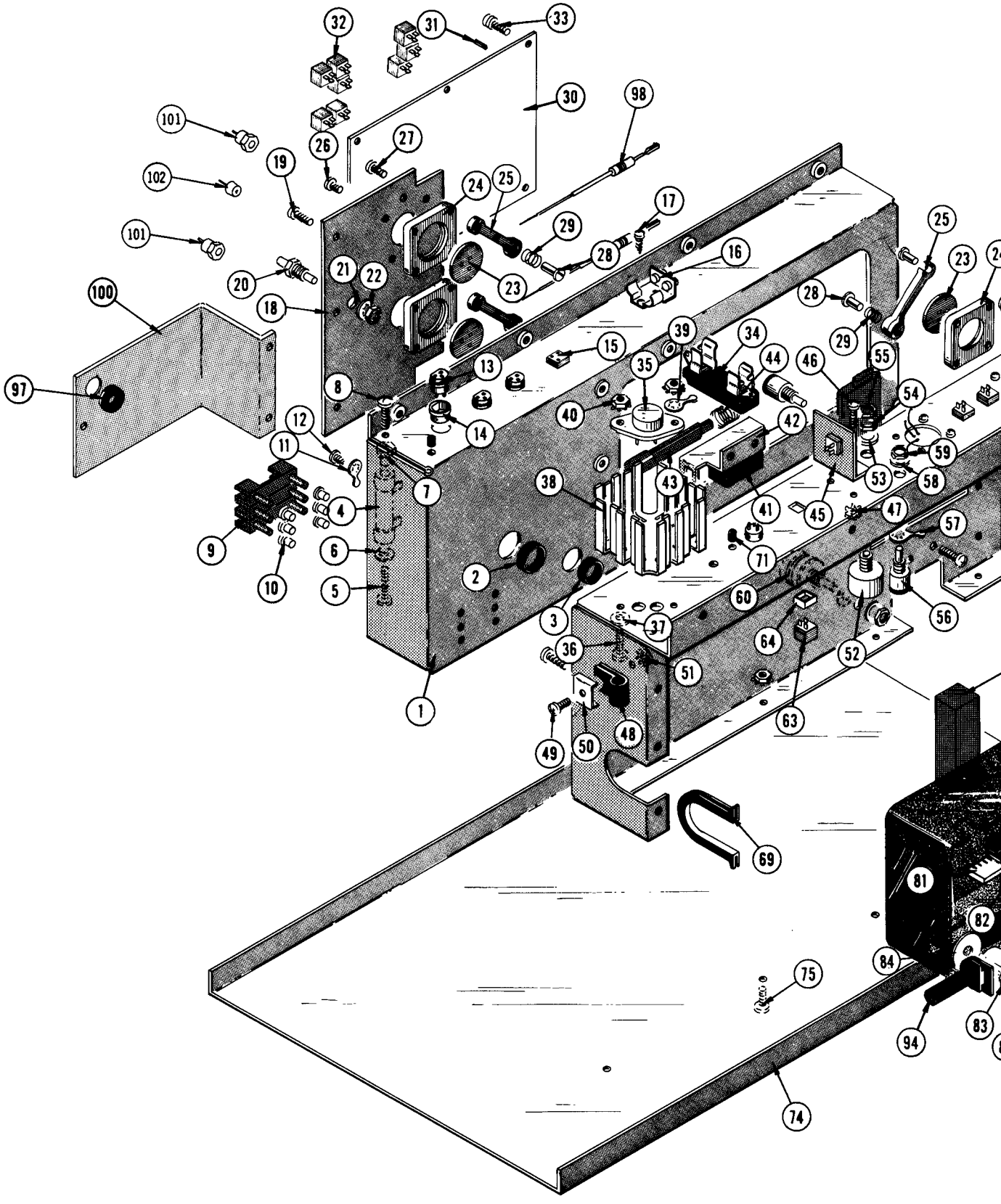
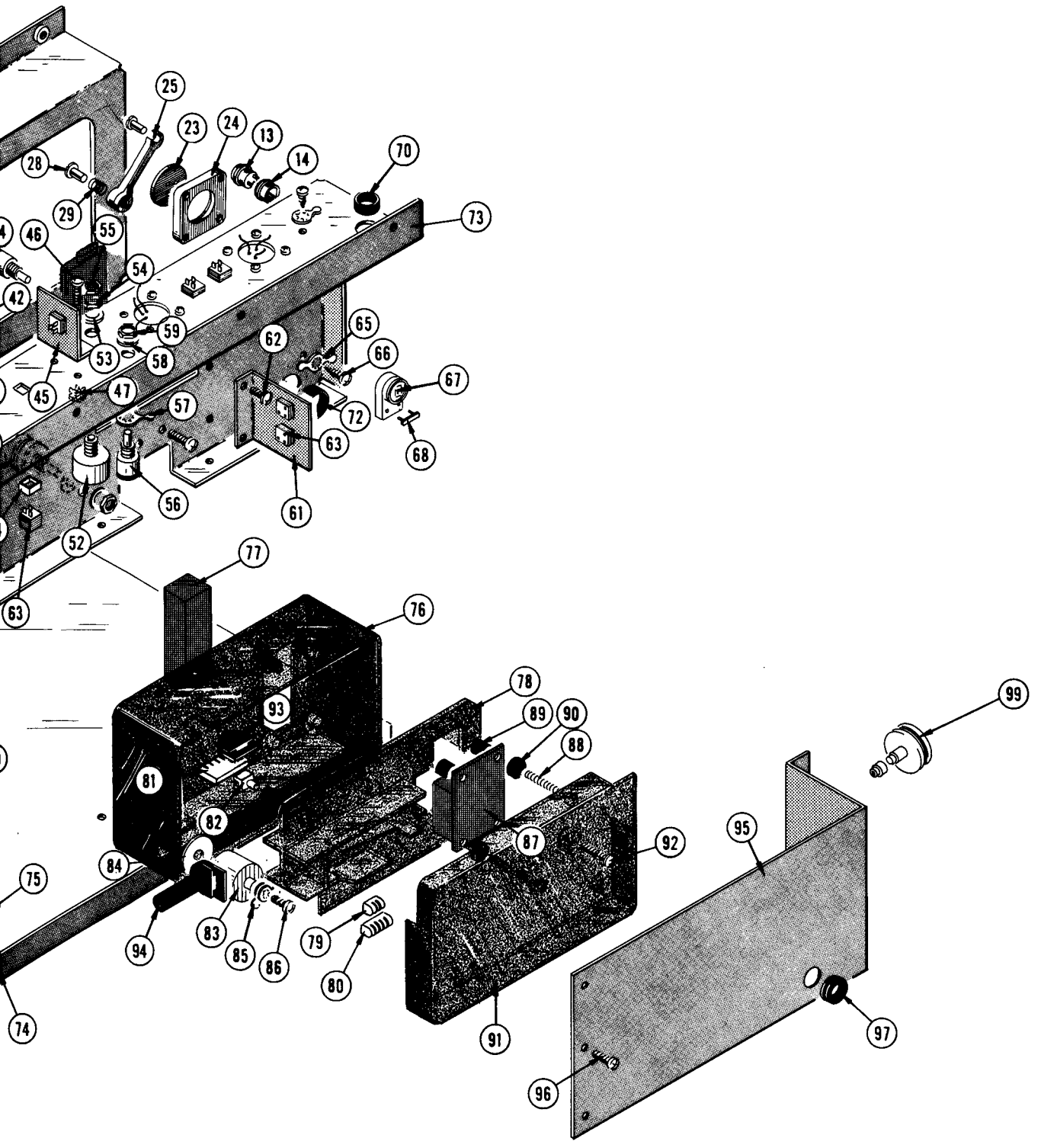

23
26
55
29
4
17
23
26
47
54
48
51
49
44
40
50
39
38
37
32
12
36
52
53
35
34
33
42
41
42
46
43
45
48
45
13
11
12
25
28
29
27
3
18
24
14
19
20
15
16
22
22
21
10
8
7
6
5

FIG. 4 CALIBRATOR, F & I, VERTICAL & HC

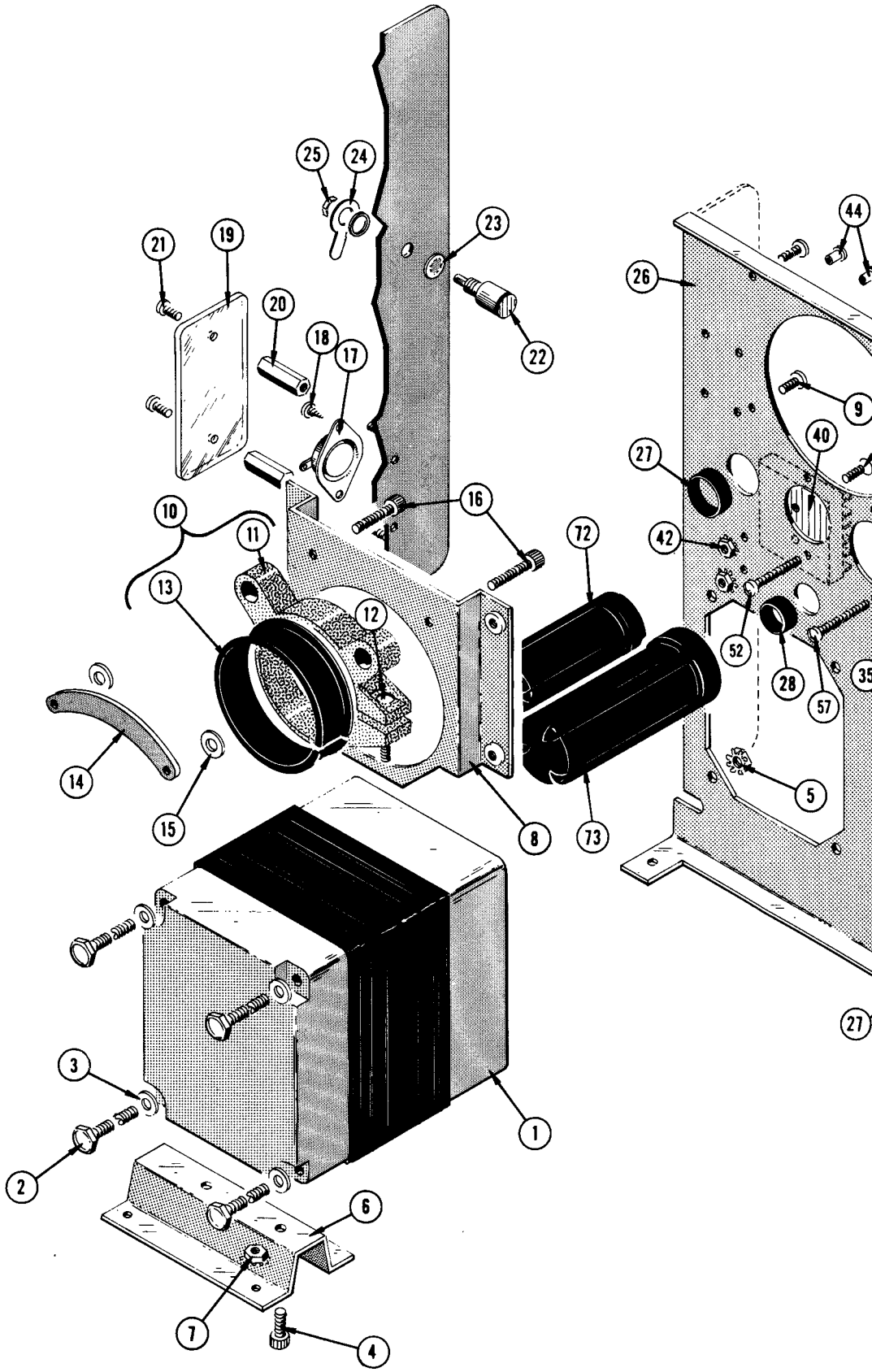


A1



TYPE 647A OSCILLOSCOPE

FIG. 5 POWER CHASSIS



+A1

FIG. 5 POWER CHASSIS

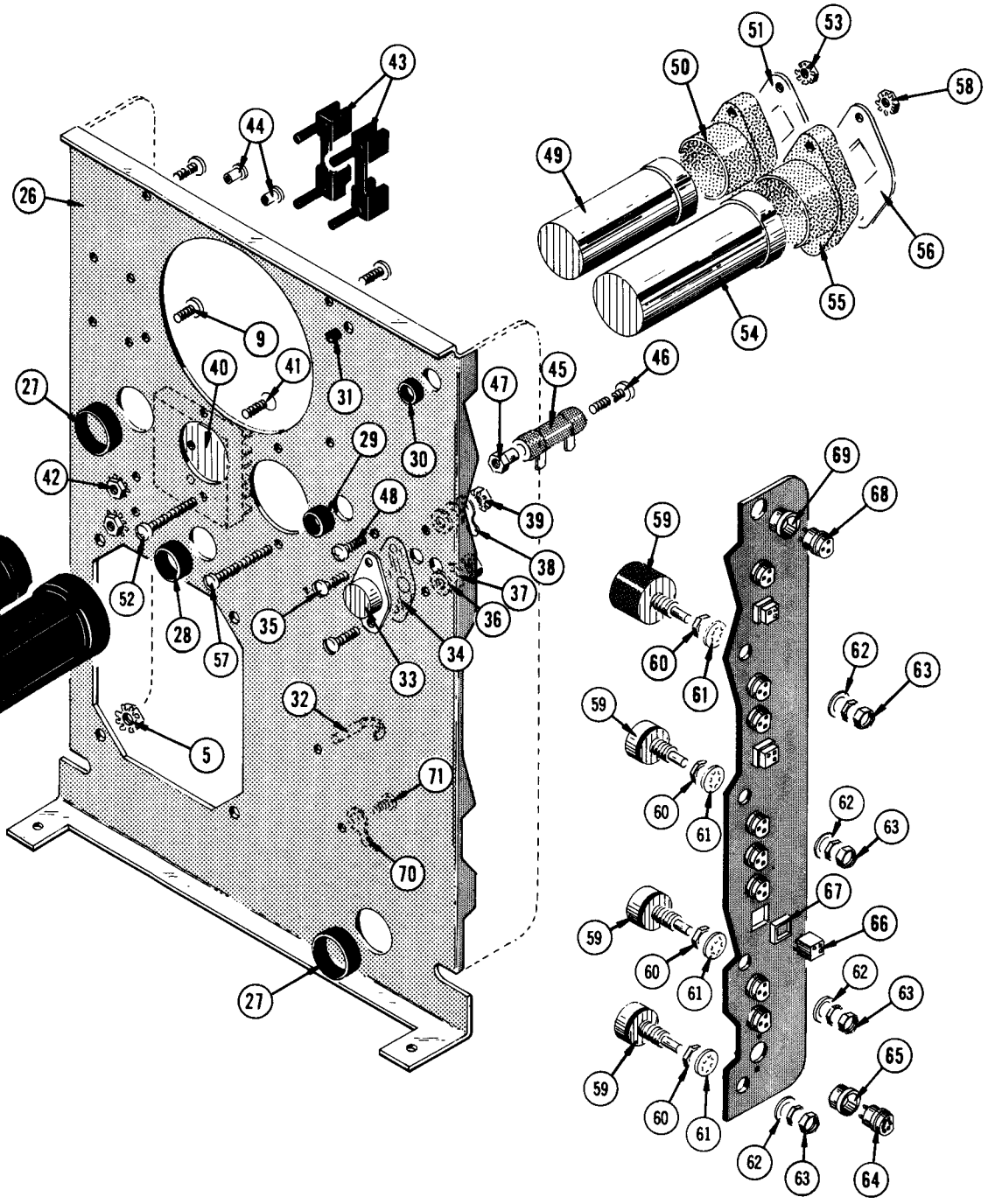
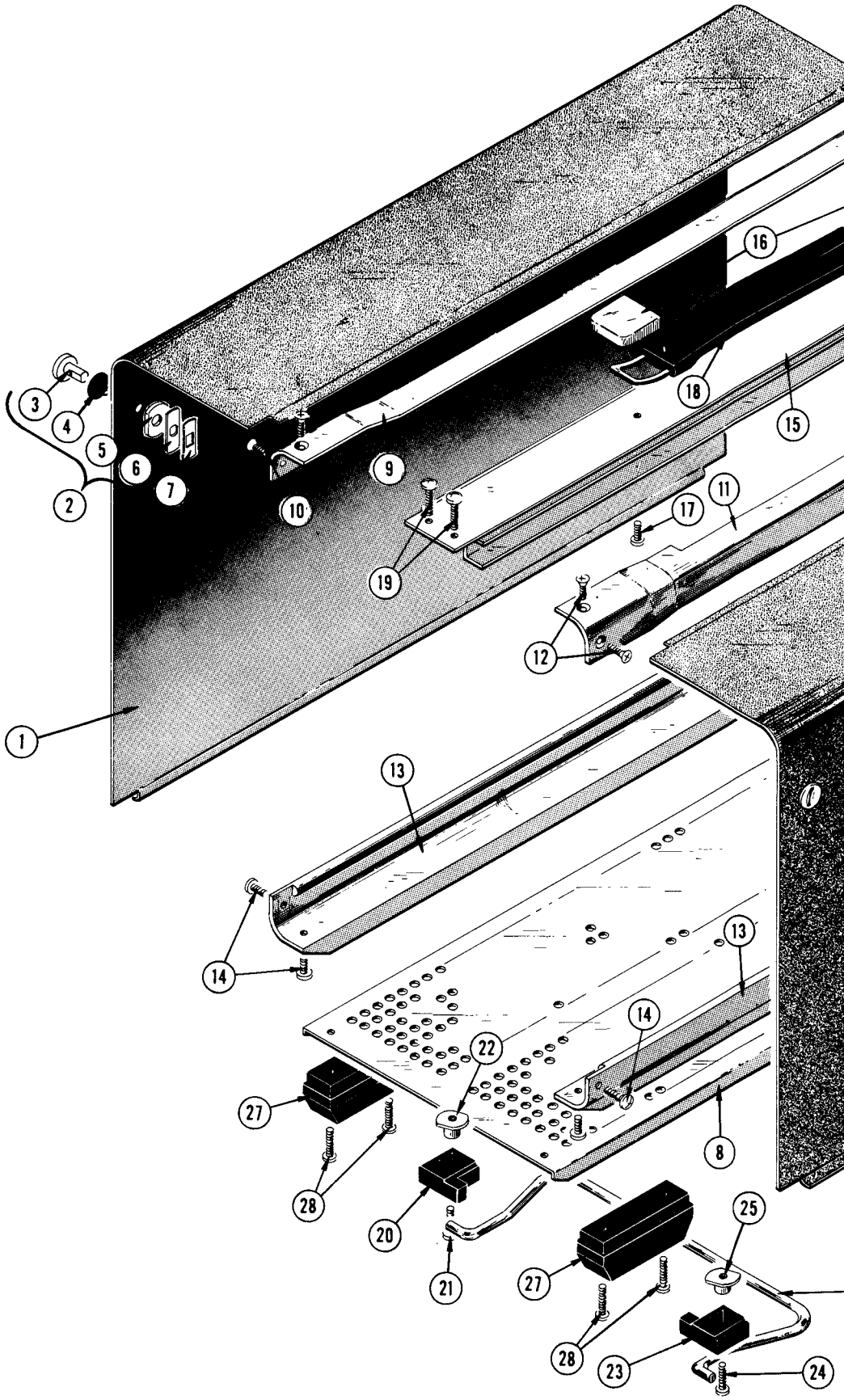


FIG. 6 CABINET & RAILS



+A

FIG. 6 CABINET & RAILS

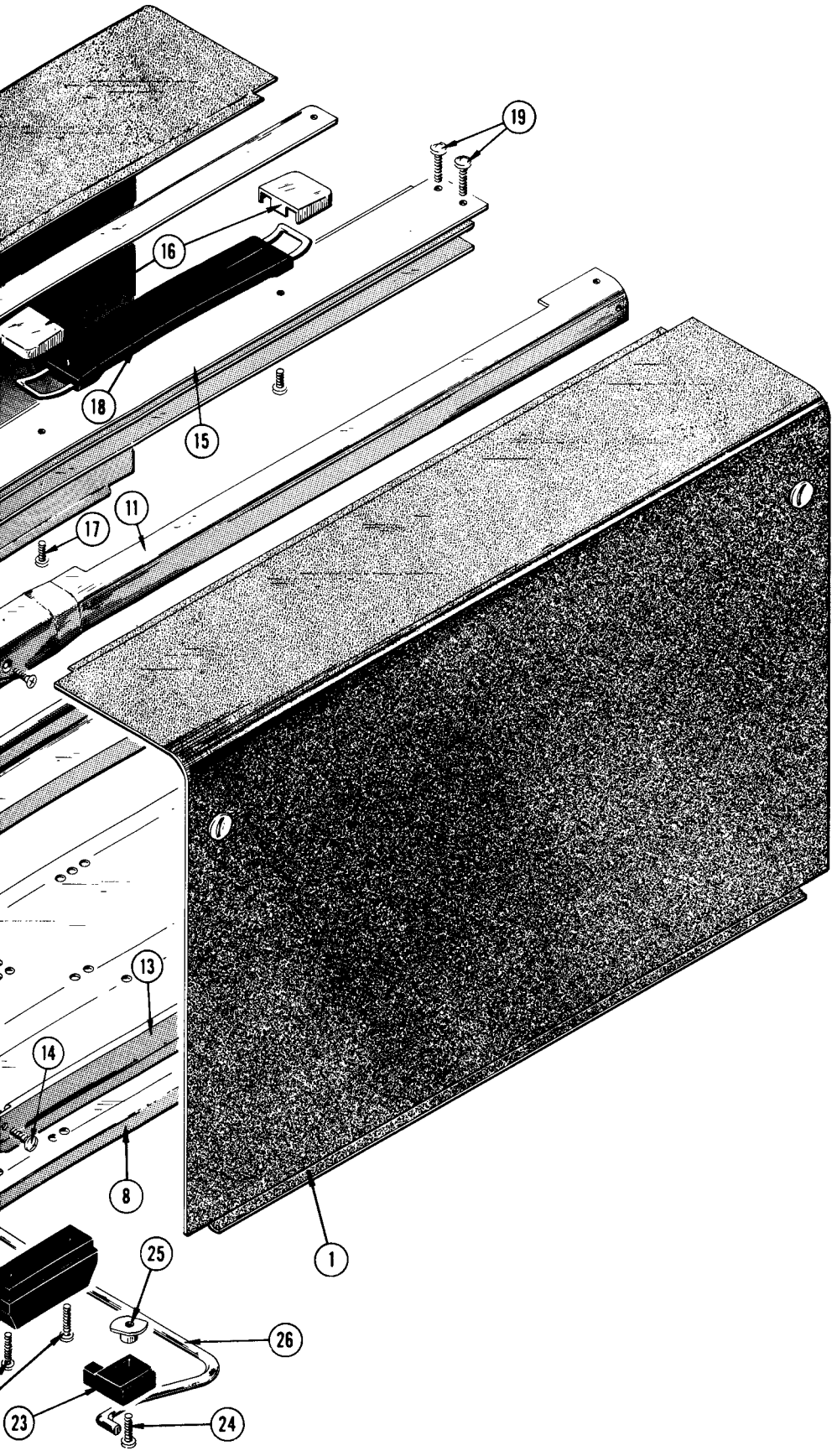


FIG. 7 REAR

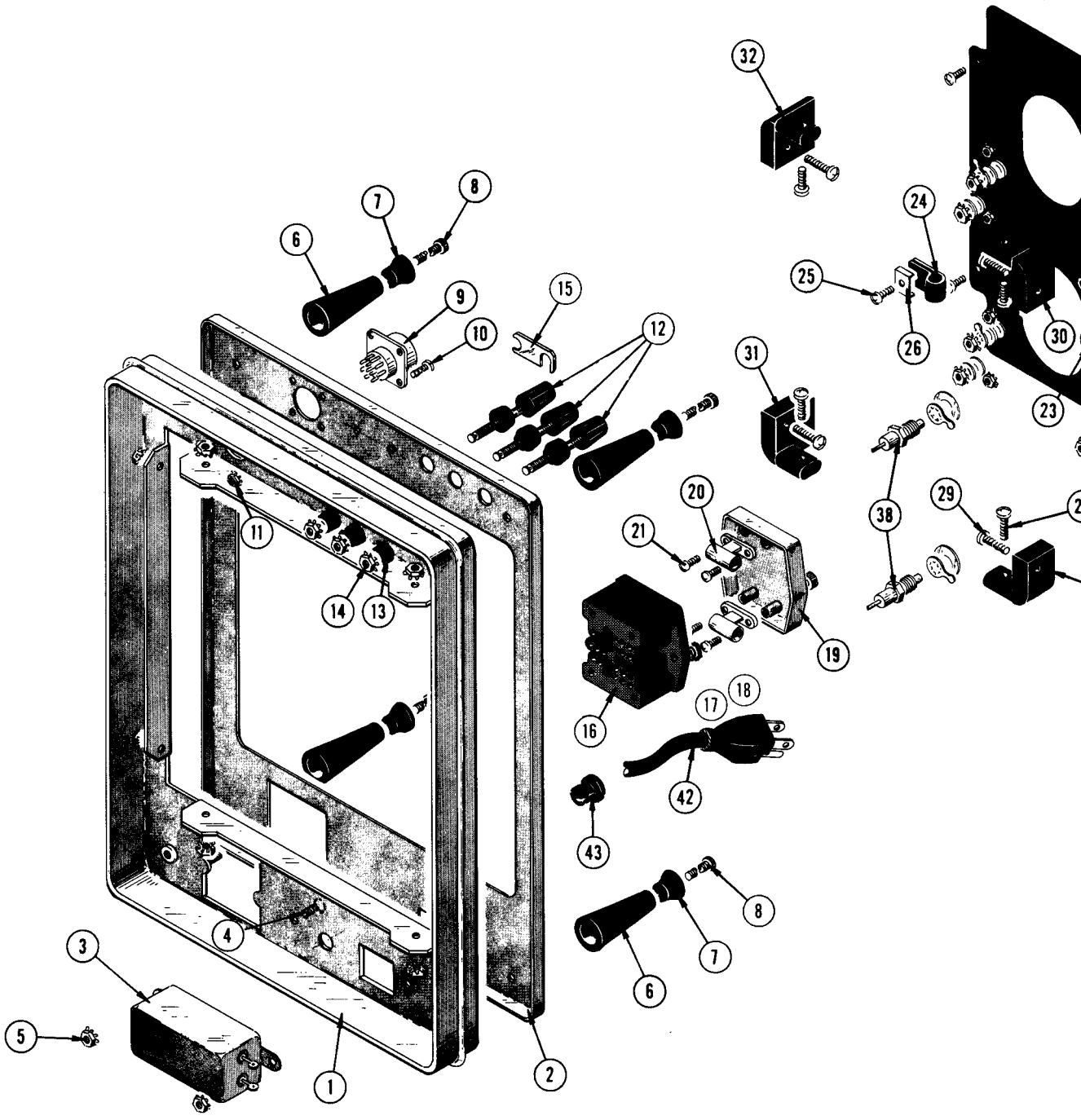

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
23
24
25
26
29
30
31
32
38
42
43

FIG. 7 REAR

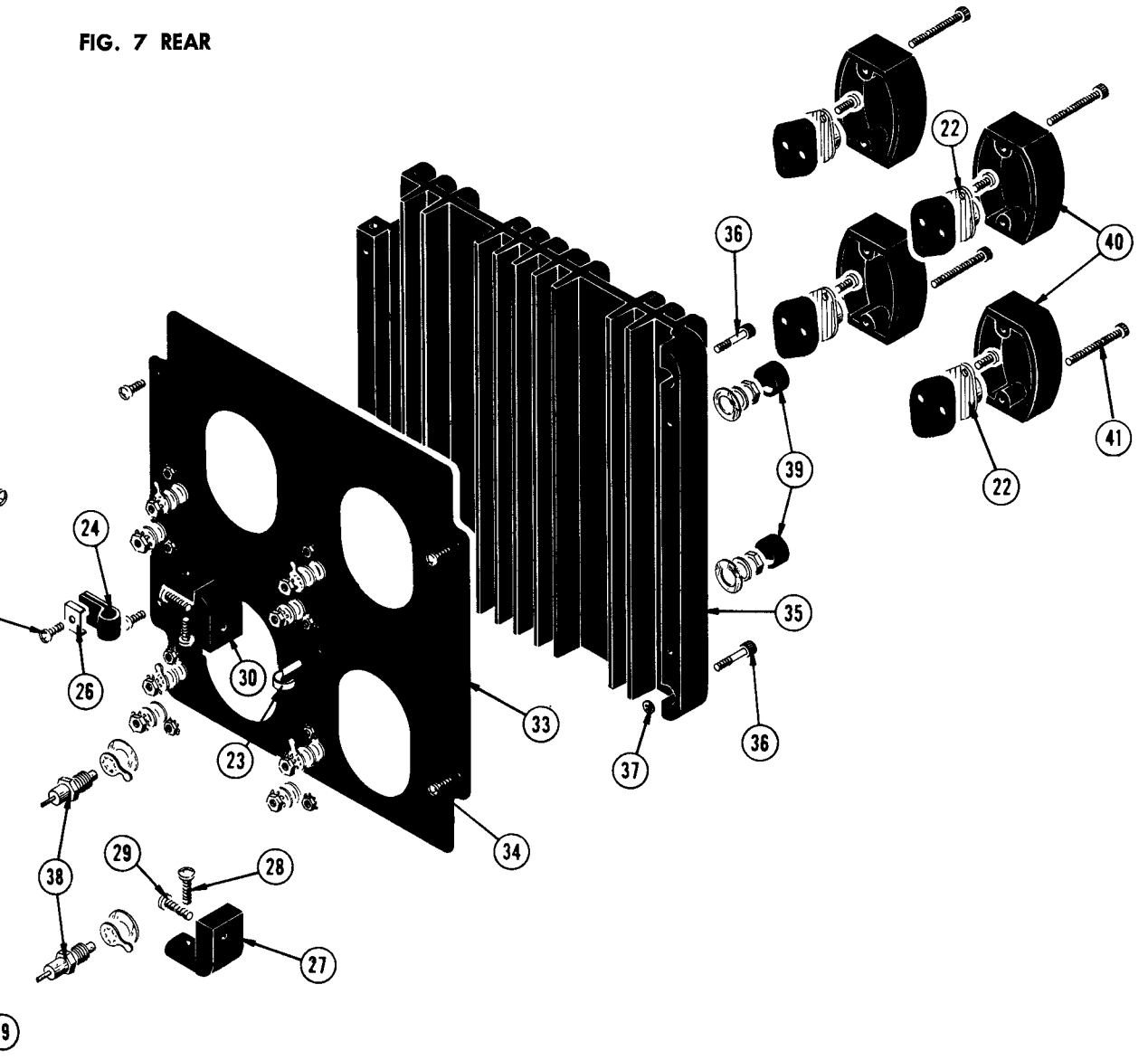
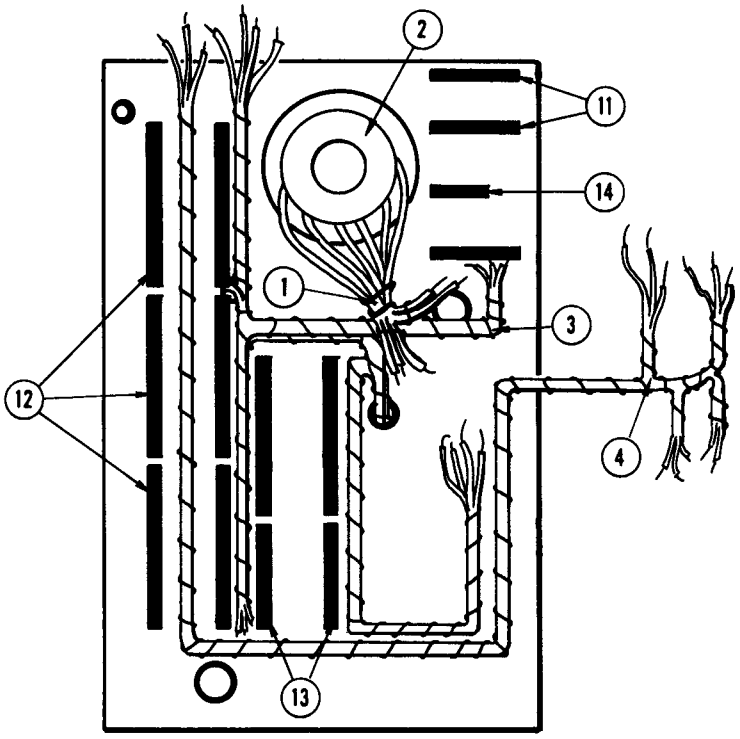
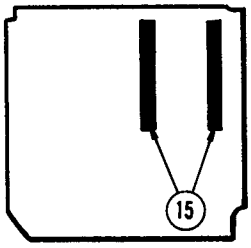


FIG. 8 CABLE HARNESS & CERAMIC

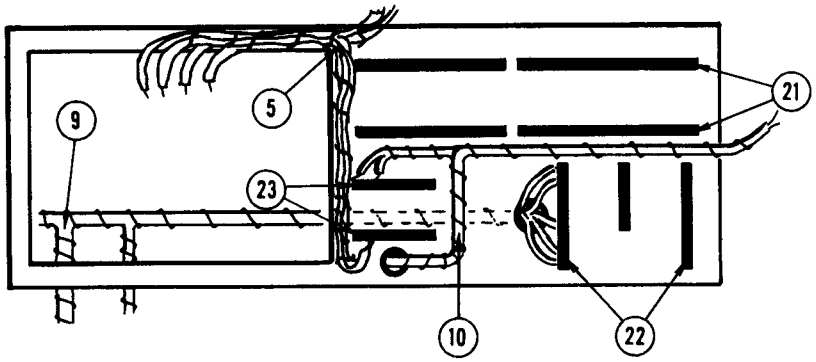
POWER CHASSIS



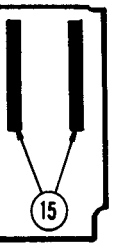
CAPACITOR CHASSIS



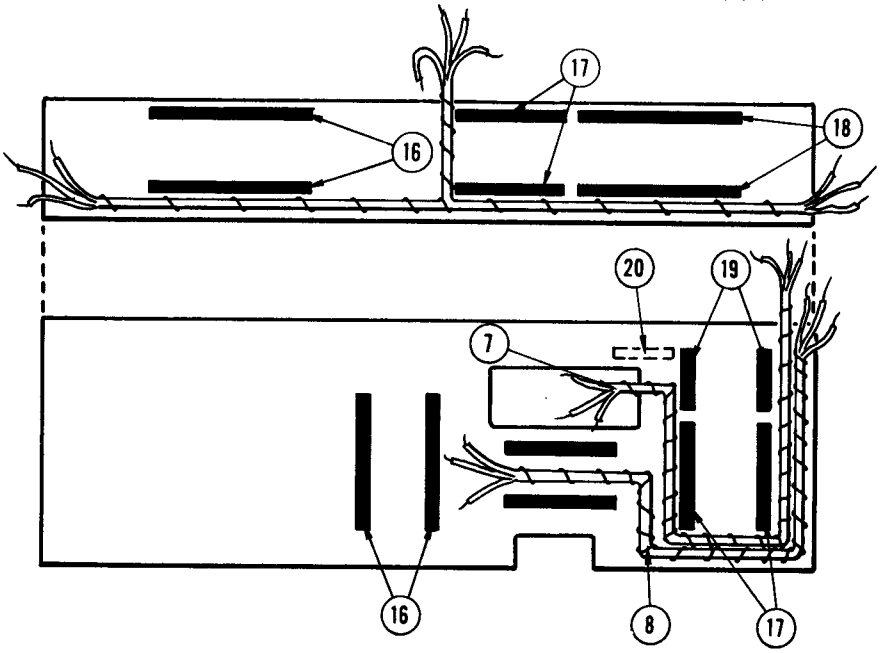
CALIBRATOR / FOCUS & INTENSITY CHASSIS



OR CHASSIS



HORIZONTAL AMPLIFIER CHASSIS



PLUGIN HOUSING

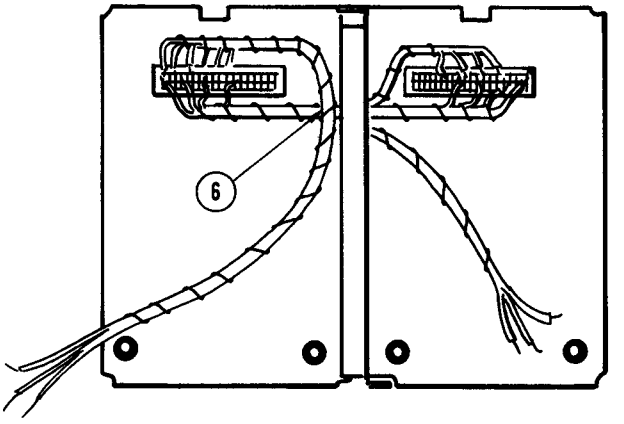


FIG. 9 STANDARD ACCESSORIES

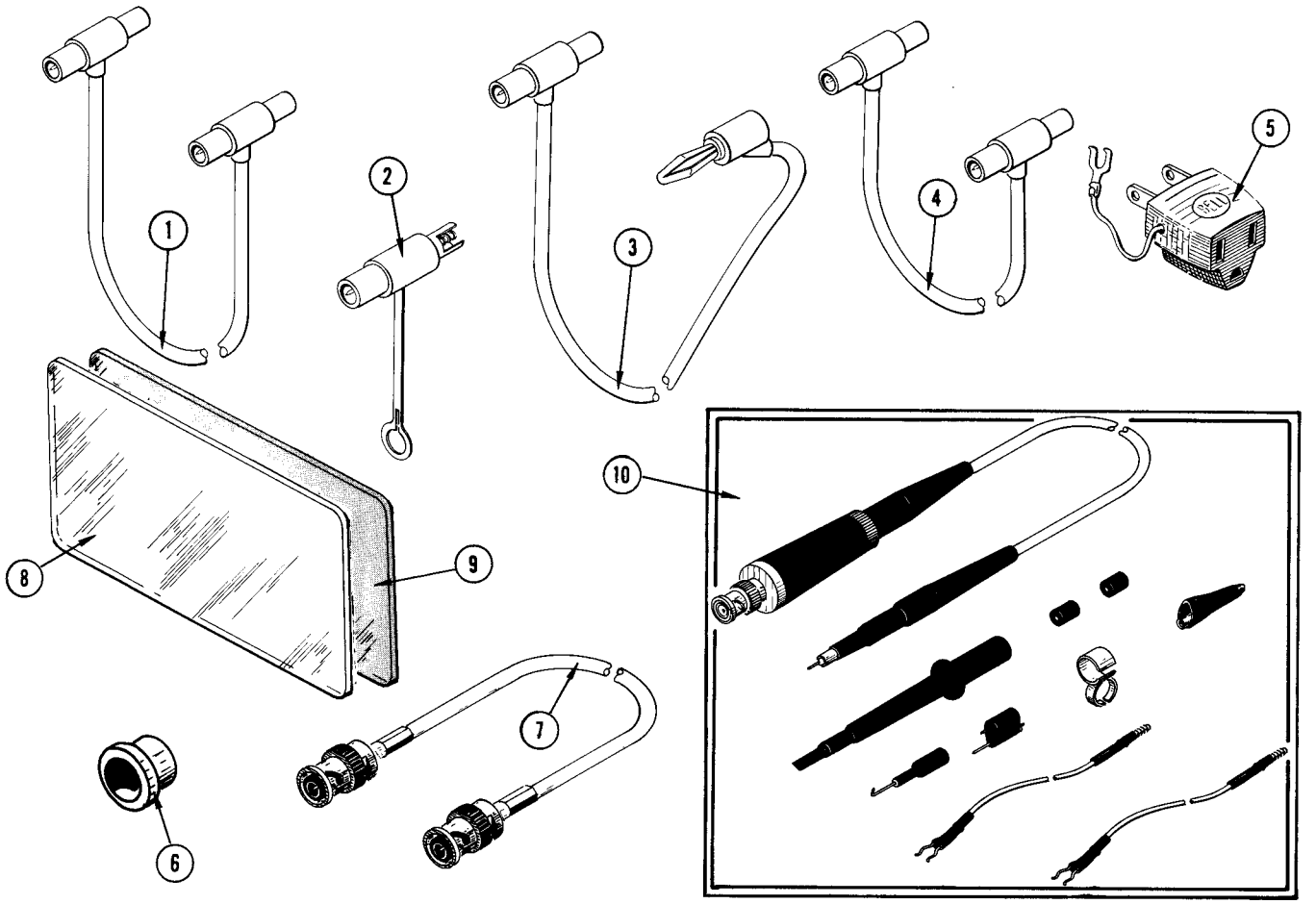


Fig & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
9-1	012-0087-00			1	PATCH CORD, BNC to BNC, red 18 inches long
-2	012-0092-00			1	JACK BNC—post
-3	012-0091-00			1	PATCH CORD, BNC to banana, red 18 inches long
-4	012-0085-00			1	PATCH CORD, BNC to BNC, red, 6 inches long
-5	103-0013-00			1	ADAPTER, power cord, 3 wire to 2 wire
-6	377-0105-00			2	INSERT, graticule light, red plastic
-7	012-0118-00	B010100	B049999	1	CABLE, coaxial, 50 Ω, BNC male to BNC male, 8 inches long
	012-0123-00	B050000		1	CABLE, coaxial, 93 Ω, BNC male to BNC male, 8 inches long
-8	337-0573-00			1	SHIELD, implosion plastic (installed)
-9	378-0548-00			1	FILTER, light, smokey gray (installed)
-10	010-0211-00			2	PROBE, P6047, BNC 42 inches
	070-0614-00			2	MANUAL, instruction (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. If it does not, your manual is correct as printed.

TYPE 647A TENT SN B080720

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D361	152-0141-02	Silicon	1N4152
D362	152-0141-02	Silicon	1N4152
D363	152-0141-02	Silicon	1N4152
D650	152-0141-02	Silicon	1N4152
D948	152-0141-02	Silicon	1N4152

M13,721/1168

TYPE 647A TENT SN B070700

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R948Y	323-0638-06	50 kΩ	1/2 W	Prec	1/4%
R948Z	323-0637-06	50 Ω	1/2 W	Prec	1/4%

M12,856/968

STANDARD ACCESSORIES CORRECTION

Fig. 9 Accessories

CHANGE: 9-7 to read as follows:

012-0123-00	1	CABLE, coaxial, 93 Ω, BNC male to BNC male

TYPE 647A TENT SN B060620

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R425	315-0510-00	51 Ω	1/4 W	5%
R426	315-0470-00	47 Ω	1/4 W	5%
R435	315-0510-00	51 Ω	1/4 W	5%
R436	315-0470-00	47 Ω	1/4 W	5%
R850	315-0623-00	62 kΩ	1/4 W	5%
R851	315-0393-00	39 kΩ	1/4 W	5%

M13,727/768

TYPE 647A TENT SN 570

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

C675	285-0622-00	.1 μF	PTM	100 V	20%

M13,944/568

TYPE 647A TEKT SN B080720

ELECTRICAL PARTS LIST CORRECTION

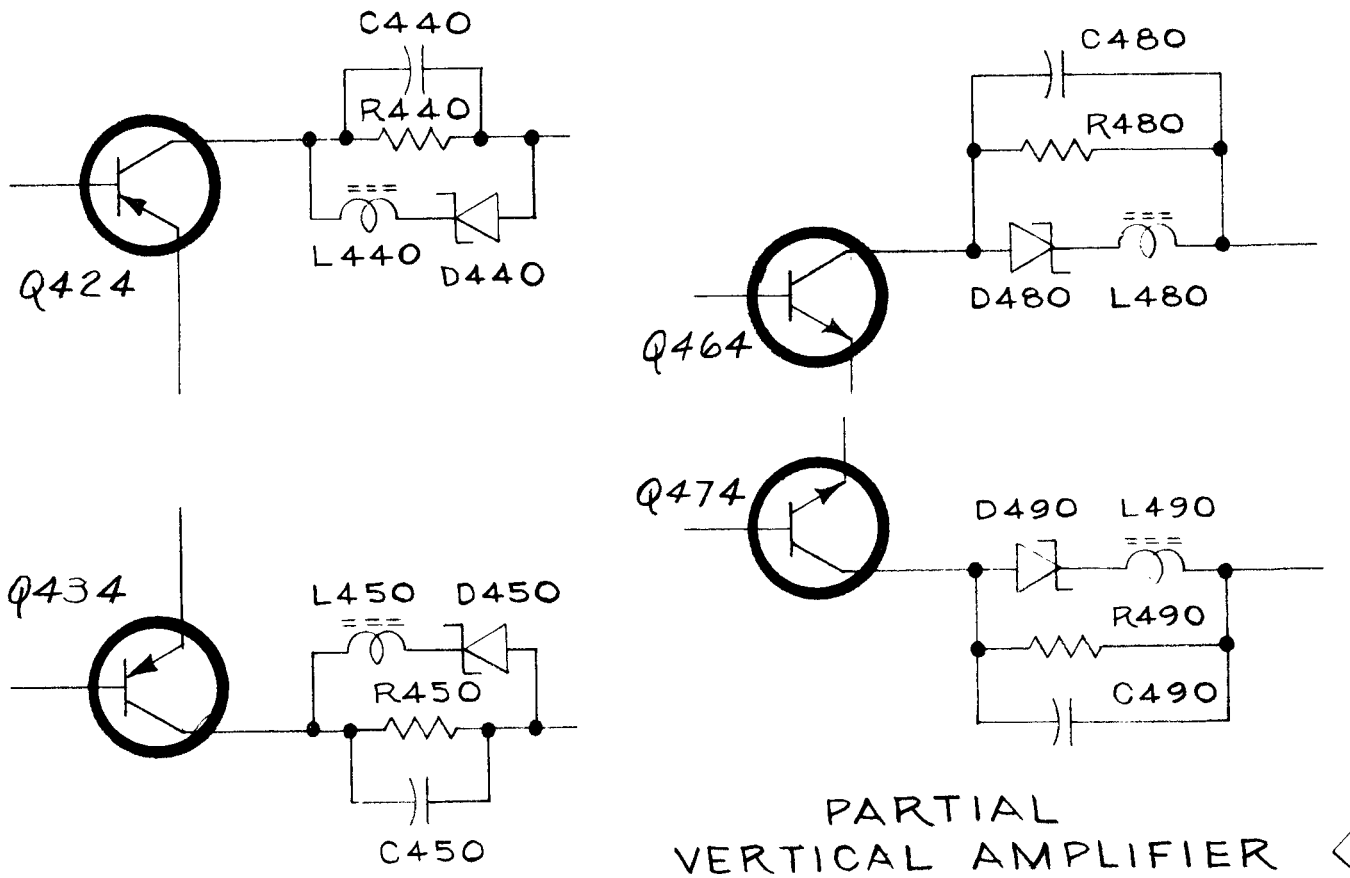
CHANGE TO:

C439	281-0604-00	2.2 pF	Cer	500 V
C466	281-0574-00	82 pF	Cer	500 V
Q614	151-0232-00	Silicon	Dual	

ADD:

L440	276-0528-00	Core, Ferramic Suppressor
L450	276-0528-00	Core, Ferramic Suppressor
L480	276-0528-00	Core, Ferramic Suppressor
L490	276-0528-00	Core, Ferramic Suppressor

SCHEMATIC CORRECTION



PARTIAL
VERTICAL AMPLIFIER (2)

M14,619/1168

TYPE 647A TENT SN B080720

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D374	152-0024-00	1N3024B	1 W, 15 V, ±5%
D397	152-0291-00	1N3027B	1 W, 20 V, ±5%
D714	152-0295-00	1N3042B	1 W, 82 V, ±5%

M11,191/1068