

# MAINTENANCE

This section of the manual contains information for performing preventive maintenance, troubleshooting, and corrective maintenance for the 7104 Oscilloscope mainframe.

## PREVENTIVE MAINTENANCE

Preventive maintenance, when performed on a regular basis, can prevent instrument breakdown and may improve the reliability of the instrument. The severity of the environment to which the instrument is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is preceding electrical adjustment of the instrument.

### CABINET PANEL REMOVAL

#### WARNING

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

The side, top, and bottom cabinet panels provide protection to personnel from operating potentials present within the instrument. In addition, they reduce radiation of electromagnetic interference from the instrument. The cabinet panels are held in place by slotted fasteners. To remove the panels, turn each fastener counterclockwise a quarter turn with a large screwdriver. Lift the panels away. Operate the instrument with the panels in place to protect the interior from dust.

### CLEANING

The 7104 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path which may result in instrument failure. The side panels reduce the amount of dust reaching the interior of the instrument. Operation without the panels in place necessitates more frequent cleaning.

#### CAUTION

*Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Exercise care when cleaning Hypcon connectors; see cleaning instructions under Hypcon Connectors in this section. Use a nonresidue type of cleaner, preferably isopropyl alcohol, totally denatured ethyl alcohol, or a Freon TF cleaner such as Spray-On #2002. Before using any other type of cleaner, consult your Tektronix Service Center or representative.*

### EXTERIOR

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

### CRT

Clean the plastic light filter, implosion shield, and the crt faceplate with a soft, lint-free cloth dampened with denatured alcohol.

The crt mesh filter (furnished with Option 3 only) can be cleaned as follows:

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

2. Greasy residues, or dried-on dirt, can be removed with a solution of warm water and a neutral-pH liquid detergent. Use the brush to lightly scrub the filter.
3. Rinse the filter thoroughly in clean water and allow to air dry.
4. If any lint or dirt remains, use clean low-pressure air to remove it. Do not use tweezers or other hard cleaning tools on the filter, as the special finish may be damaged.
5. When not in use, store the mesh filter in a lint-free dust-proof container, such as a plastic bag.

### INTERIOR

Cleaning the interior of the instrument should only be occasionally necessary. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air (approximately 5 lb/in<sup>2</sup>). Remove any dirt which remains with a soft brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces, or for cleaning more delicate circuit components.

**CAUTION**

*Circuit boards and components must be dry before applying power to prevent damage from electrical arcing.*

The high-voltage circuits should receive special attention. Excessive dirt in this area may cause high-voltage arcing and result in improper instrument operation.

## TROUBLESHOOTING

The following information is provided to facilitate troubleshooting of the 7104 Oscilloscope mainframe. Information contained in other sections of this manual should be used in conjunction with the following data to aid in locating a defective component. An understanding of the circuit operation is helpful in locating troubles. See Section 3, Theory of Operation, for this information.

### TROUBLESHOOTING AIDS

#### DIAGRAMS

Complete schematic diagrams are given on the pullout pages in Section 8, Diagrams and Circuit Board Illustrations. The component number and electrical value of each component in this instrument are shown on these diagrams. (See the first page of the Diagrams and Circuit Board Illustrations section for definitions of the reference designators and symbols used to identify components in this instrument.) Important voltages and numbered waveform test points are also shown on the diagrams. Important waveforms, and the numbered test

### VISUAL INSPECTION

The 7104 should be inspected occasionally for such defects as broken connections, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts. The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged parts are found. Overheating usually indicates other trouble in the instrument; therefore, correcting the cause of overheating is important to prevent recurrence of the damage.

### SEMICONDUCTOR CHECKS

Periodic checks of semiconductors are not recommended. The best check of semiconductor performance is actual operation in the instrument. More details on semiconductors are given under Troubleshooting later in this section.

### PERIODIC ELECTRICAL ADJUSTMENT

To ensure accurate measurements, check the electrical adjustment of this instrument after each 1000 hours of operation, or every six months if used infrequently. In addition, replacement of components may necessitate adjustment of the affected circuits. Complete adjustment instructions are given in Section 5, Calibration. This procedure can be helpful in localizing certain troubles in the instrument, and in some cases, may correct them.

points where they were obtained, are located adjacent to each diagram. The portions of circuits mounted on circuit boards are enclosed with heavy solid-black lines.

### CIRCUIT BOARD ILLUSTRATIONS

To aid in locating circuit boards, a circuit board location illustration appears on the back of the pullout page facing the schematic diagram. In addition, an illustration of the circuit board(s) is included here, with the physical location of the components and waveform test points that appear on the schematic diagram identified. Each circuit board illustration is arranged in a grid locator with an

index to facilitate rapid location of components contained in the schematic diagrams.

## TROUBLESHOOTING CHART

A troubleshooting chart is given in Section 8, Diagrams and Circuit Board Illustrations to aid in locating a defective circuit. The shaded blocks on the Troubleshooting Chart indicate circuit(s) that may cause the indicated malfunction. The circuits listed are discussed in detail in Section 3, Theory of Operation.

## ADJUSTMENT AND TEST POINT LOCATIONS

To aid in locating test points and adjustable components called out in the various portions of the Calibration procedure, the Adjustment and Test Point Locations pullout pages are provided in Section 8, Diagrams and Circuit Board Illustrations.

## COMPONENT COLOR CODING

The instrument contains brown composition resistors, some metal-film resistors, and some wire-wound resistors. The resistance values of wire-wound resistors are usually printed on the component body. The resistance values of composition resistors and metal-film resistors are color coded on the components using the EIA color code (some metal-film resistors may have the value printed on the body). The color code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes, which consist of two significant figures, a multiplier, and a tolerance value (see Fig. 4-1). Metal-film resistors have five stripes consisting of three significant figures, a multiplier, and a tolerance value.

The values of common disc capacitors and small electrolytics are marked on the side of the component body. The white ceramic and epoxy-coated tantalum capacitors used in the instrument are color coded using a modified EIA code (see Fig. 4-1).

The cathode end of glass-encased diodes is indicated by a stripe, a series of stripes, or a dot. The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

## SEMICONDUCTOR LEAD CONFIGURATIONS

Lead configurations for semiconductor devices used in the 7104 Oscilloscope are shown in Figure 4-2.

## MULTI-PIN CONNECTORS

Pin 1 on multi-pin connectors is designated with a triangle. A triangle, dot or square printed on circuit boards denotes pin 1. When a connection is made to a circuit board, the orientation of the triangle on the multi-pin holder is determined by the index (triangle, dot or square) printed on the circuit board (see Fig. 4-3). Some multi-pin connectors are keyed with a plastic pin that protrudes through a hole on the circuit board. Proper mating with the multi-pin connector and the pin(s) on the circuit board cannot be accomplished unless this pin is aligned with the hole on the circuit board.

Some multi-pin connectors are equipped with a locking mechanism to more readily secure the connector to the circuit board. To remove these connectors, grasp the connector body and pull perpendicular to the circuit board. They should not be removed by pulling on the wire leads; this causes the locking mechanism to clamp onto the circuit board pins.

## TROUBLESHOOTING EQUIPMENT

The following equipment is useful for troubleshooting the 7104 Oscilloscope mainframe:

### 1. Transistor Tester

**Description:** Dynamic-type tester.

**Purpose:** Test semiconductors.

**Recommended type:** TEKTRONIX 577/177 Curve Tracer, TEKTRONIX 576 Curve Tracer, 7CT1N Curve Tracer plug-in unit and a 7000-series oscilloscope system, or a 5CT1N Curve Tracer plug-in unit and a 5000-series oscilloscope system.

### 2. Digital Multimeter

**Description:** 10 megohm input impedance and 0 to 1 kilovolt range, ac and dc; ohmmeter, accuracy, within 0.1%. Test probes must be insulated to prevent accidental shorting.

**Purpose:** Check voltages and resistances.

**Recommended type:** TEKTRONIX DM 501 Digital Multimeter.

### 3. Test Oscilloscope

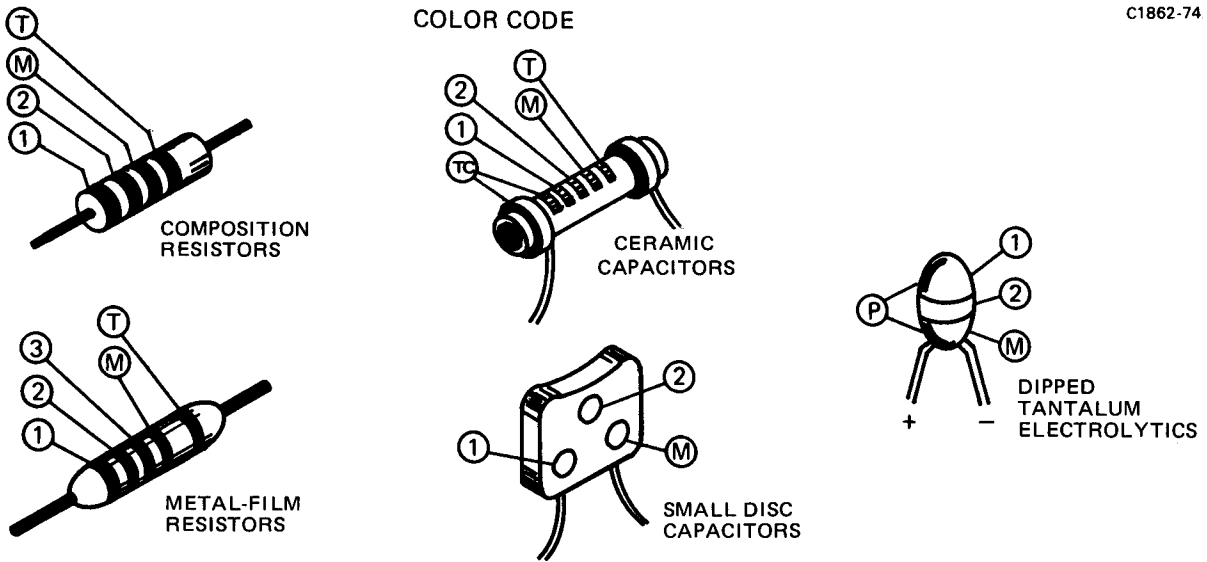
**Description:** Frequency response, dc to 100 megahertz minimum; deflection factor, 5 millivolts to 5 volts/division and 1 milliamperes to 1 ampere/division. A 10X, 10-megohm voltage probe should be used to reduce circuit loading for voltage measurements. For current waveforms, use a TEKTRONIX P6021 Current Probe with passive termination, or the equivalent.

**Purpose:** Check operating waveforms.

**Recommended type:** Refer to the Tektronix Products catalog for applicable oscilloscope system.

### 4. Variable Autotransformer

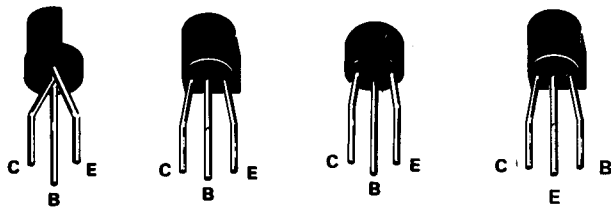
**Description:** Output variable from 0 to 140 volts, 10 amperes minimum rating. Must have three-wire power cord, plug, and receptacle.



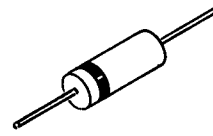
① ② and ③ - 1ST, 2ND, AND 3RD SIGNIFICANT FIGS.    T AND/OR TC COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS;  
 M - MULTIPLIER    T - TOLERANCE;  
 TC - TEMPERATURE COEFFICIENT.    P - POLARITY AND VOLTAGE RATING

COLOR	SIGNIFICANT FIGURES	RESISTORS		CAPACITORS			DIPPED TANTALUM VOLTAGE RATING
		MULTIPLIER (OHMS)	TOLERANCE	MULTIPLIER (pF)	TOLERANCE		
					OVER 10pF	UNDER 10pF	
BLACK	0	1	---	1	±20%	±2pF	4VDC
BROWN	1	10	±1%	10	±1%	±0.1pF	6VDC
RED	2	10 <sup>2</sup> or 100	±2%	10 <sup>2</sup> or 100	±2%	---	10VDC
ORANGE	3	10 <sup>3</sup> or 1 K	±3%	10 <sup>3</sup> or 1000	±3%	---	15VDC
YELLOW	4	10 <sup>4</sup> or 10K	±4%	10 <sup>4</sup> or 10,000	+100% -0%	---	20VDC
GREEN	5	10 <sup>5</sup> or 100 K	±1/2%	10 <sup>5</sup> or 100,000	±5%	±0.5pF	25VDC
BLUE	6	10 <sup>6</sup> or 1 M	±1/4%	10 <sup>6</sup> or 1,000,000	---	---	35VDC
VIOLET	7	---	±1/10%	10 <sup>7</sup> or 10,000,000	---	---	50VDC
GRAY	8	---	---	10 <sup>-2</sup> or 0.01	+80% -20%	±0.25pF	---
WHITE	9	---	---	10 <sup>-1</sup> or 0.1	±10%	±1pF	3VDC
GOLD	---	10 <sup>-1</sup> or 0.1	±5%	---	---	---	---
SILVER	---	10 <sup>-2</sup> or 0.01	±10%	---	---	---	---
NONE	---	---	±20%	---	±10%	±1pF	---

Figure 4-1. Color code for resistors and capacitors.



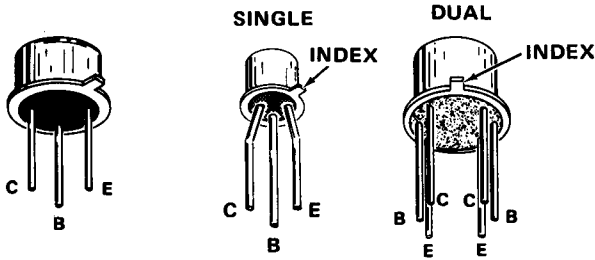
PLASTIC-CASED TRANSISTORS



SIGNAL DIODE



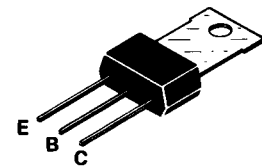
LIGHT EMITTING DIODE (L.E.D.)



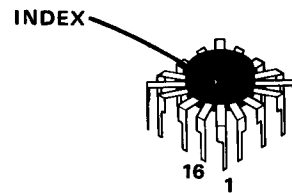
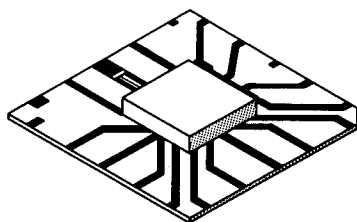
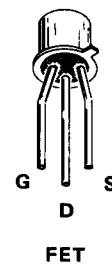
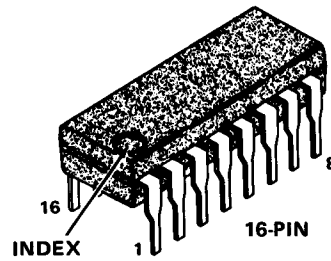
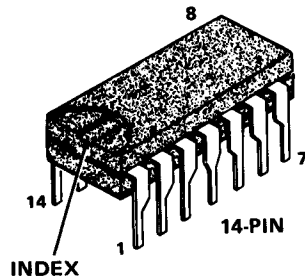
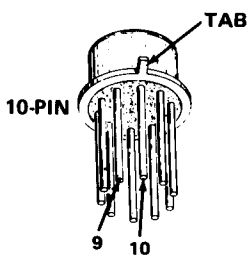
METAL-CASED TRANSISTORS



PLASTIC-POWER TRANSISTORS



DARLINGTON TRANSISTOR



INTEGRATED CIRCUITS

(1988-26) 2314-34

Figure 4-2. Semiconductor lead configurations.

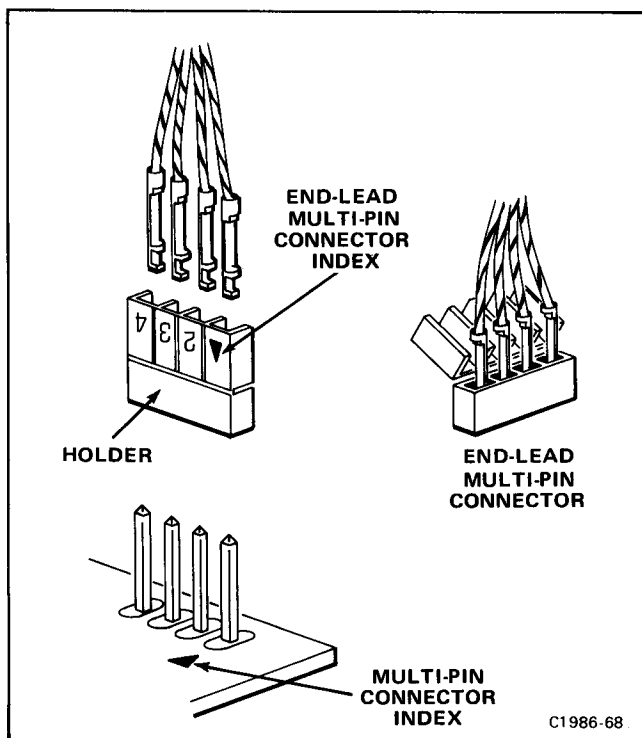


Figure 4-3. Orientation of multi-pin connectors.

**Purpose:** Vary input line voltage when troubleshooting in the power-supply unit.

**Recommended type:** General Radio W10MT3W Variac Autotransformer.

#### 5. Isolation Transformer

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

**Purpose:** To isolate 7104 from line potential when troubleshooting power supply.

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

## TROUBLESHOOTING TECHNIQUES

This troubleshooting procedure is arranged to check the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation, and adjustment. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, replace it 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 on the 7104, refer to Section 2, Operating Instructions.

### 2. CHECK ASSOCIATED EQUIPMENT

Before proceeding with troubleshooting, check that the equipment used with this instrument is operating correctly. Also, check that the input signals are properly connected and that the interconnecting cables are not defective. Check the line-voltage source.

### 3. VISUAL CHECK

Visually check that portion of the instrument in which the trouble is located. Many troubles can be found by visible indications, such as unsoldered connections, loose cable connections, broken wires, damaged circuit boards, and damaged components.

### 4. CHECK INSTRUMENT ADJUSTMENT

Check the electrical adjustment of this instrument, or of the affected circuit if the trouble appears in one circuit. The apparent trouble may only be a result of misadjustment. Complete adjustment instructions are given in Section 5, Calibration.

### 5. ISOLATE TROUBLE TO A CIRCUIT

To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check the affected circuits by taking voltage and waveform measurements. Also check for the correct output signals at the front- and rear-panel output connectors with a test oscilloscope. If the signal is correct, the circuit is working correctly up to that point. For example, correct sawtooth output indicates that the time-base unit and sawtooth output portion of the Output Signals circuit is operating correctly. If a malfunction in the Readout System is suspected of causing trouble to appear in the Z-Axis Amplifier, Vertical Amplifier, or Horizontal Amplifier circuits, the trouble can be localized by removing the Readout System circuit board. This board can be removed without significantly affecting the operation of other circuits in the instrument.

Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. If incorrect operation of the power supplies is suspected, refer to Troubleshooting the High-Efficiency Power-Supply Unit given later in this section.

The 7104 Troubleshooting Chart in the Diagrams and Circuit Board Illustrations, Section 8, provides a guide for locating defective circuits. Start at the top of the chart and perform the checks given on the left side of the page until a step is found that does not produce the indicated

results. Further checks, or the circuit in which the trouble is probably located, are listed to the right of the step. This chart does not include checks for all possible defects; use steps 6 and 7 in such cases.

After the defective circuit has been located, proceed with steps 6 and 7 to locate the defective component(s).

## 6. CHECK VOLTAGES AND WAVEFORMS

Often the defective component can be located by checking for the correct voltages or waveforms in the circuit. Typical voltages and waveforms are given in Section 8, Diagrams and Circuit Board Illustrations.

### NOTE

*Voltages and waveforms given in Section 8, Diagrams and Circuit Board Illustrations, are not absolute and may vary slightly between 7104 Oscilloscope mainframes. To obtain operating conditions similar to those used to take these readings, see the appropriate schematic.*

## 7. CHECK INDIVIDUAL COMPONENTS

The following procedures describe methods of checking individual components in the 7104. Components which are soldered in place are best checked by first disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

### WARNING

*To avoid electric-shock hazard, always disconnect the 7104 from the power source before removing or replacing components.*

### Fuses

Check for open fuses by checking continuity with an ohmmeter.

### Transistors

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

### Integrated Circuits

Integrated circuits can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of the circuit operation is essential to troubleshooting circuits using integrated circuits. In addition, operating waveforms, logic levels, and other

operating information for the integrated circuits are given in Section 3, Theory of Operation and Section 8, Diagrams and Circuit Board Illustrations. Use care when checking voltages and waveforms around the integrated circuits so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the in-line, multi-pin integrated circuits is with an integrated-circuit test clip. This device also doubles as an integrated-circuit extraction tool.

### Diodes

A diode can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter on a scale having a low internal source current, such as the R X 1k scale. The resistance should be very high in one direction and very low when the meter leads are reversed.

### CAUTION

*When checking diodes, do not use an ohmmeter scale that has a high internal current, since high currents may damage the diodes under test.*

### Resistors

Check the resistors with an ohmmeter. Resistor tolerances are given in Section 7, Replaceable Electrical Parts. Normally, resistors do not need to be replaced unless the measured value varies widely from the specified value.

### Capacitors

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

## 8. REPAIR AND ADJUST THE CIRCUIT

If any defective parts are located, follow the replacement procedures given under Component Replacement in this section. Check the performance of any circuit that has been repaired or that has had any electrical components replaced. Adjustment of the circuit may be necessary.

## TROUBLESHOOTING THE HIGH-EFFICIENCY POWER-SUPPLY UNIT

### GENERAL

The following information is provided to facilitate troubleshooting the high-efficiency power-supply unit. Information contained in other sections of this manual should be used in conjunction with this procedure to aid in locating a defective component. An understanding of the circuit operation is valuable in locating troubles. See

Section 3, Theory of Operation, for this information. Specifications for the troubleshooting equipment referred to in this procedure are given earlier in this section under Troubleshooting Equipment.

**WARNING**

*Extreme caution must be used when troubleshooting in the power-supply unit due to the line voltage and the high-voltage/high-current potentials present in the unit.*

When a fault condition occurs which is not of sufficient magnitude to open the line fuse, power-supply protection circuitry will cause the inverter to operate in a pulse mode. In this mode the inverter will turn on for a short period of time, and then turn off for a longer period of time. This cycle repeats until the malfunction is corrected. This pulse mode causes either a "ticking" or a "chirping" sound. Whenever either of these sounds is heard, turn off the 7104 and proceed with the Preliminary Procedure given below.

**PRELIMINARY PROCEDURE**

**WARNING**

*To avoid electric shock, always disconnect the instrument from the power source before removing or replacing components or plug-in units.*

1. Remove all plug-in units from the mainframe.
2. Set the CONTROL ILLUMINATION switch on the rear panel to the OFF position, and the GRAT ILLUM switch on the front panel to the fully clockwise position.
3. Remove the power-supply unit from the mainframe following the procedure given later in this section under Component Removal and Replacement.
4. Connect the power-cord plug of the 7104 to the output of a variable autotransformer which is set for 115 volts. Connect the autotransformer to an isolation transformer and plug the isolation transformer into a 115-volt power source.
5. Push the 7104 POWER button in (to turn the instrument on) and note the trouble symptoms.
6. Turn the 7104 off and proceed to the appropriate step in the Troubleshooting Procedure as indicated by the Trouble Symptoms column in Table 4-1.

**TROUBLESHOOTING PROCEDURE**

**Step A: Check Line Fuse**

To check the line fuse, perform the following procedure:

1. Check the line fuse (F1200), located on the rear panel of the power-supply unit, for continuity and proper rating as given in Section 7, Replaceable Electrical Parts.

**TABLE 4-1**  
**Recommended Power Supply Troubleshooting Sequence**

Trouble Symptom	Procedure	Proceed to Troubleshooting Step:
7104 inoperative; no pulse mode.	1. Check line fuse.	A
7104 inoperative; no pulse mode; line fuse open.	1. Check line input circuit.	D
	2. Check LV rectifier circuit.	H
	3. Check inverter circuit.	G
7104 inoperative; no pulse mode; line fuse normal.	1. Check inverter circuit.	G
7104 operating in the pulse mode.	1. Isolate malfunction from the mainframe circuitry.	B
	2. Check pre-regulated power supplies.	C
	3. Check crt and high-voltage circuits.	E
	4. Check inverter control circuit.	F
	5. Check inverter circuit.	G



2. If the line fuse is open, replace with a new one of proper rating.

### Step B: Isolate Malfunction from the Mainframe Circuitry

To isolate the malfunction perform the following procedure:

#### WARNING

*Use extreme caution when troubleshooting in the power-supply unit, to avoid electric shock. Stored dc potentials on the A23-Inverter circuit board remain long after the instrument is disconnected from the power source. Verify that the power-cord plug is disconnected and that the line storage capacitors (C1216 and C1217) are completely discharged before attempting any repairs or ohmic measurements. (A warning-indicator neon bulb, located on the A23-Inverter board, flashes when this stored voltage exceeds about 80 volts. However, simply because the neon bulb is not flashing does not mean that the capacitors are fully discharged.)*

1. Remove the 7104 power-cord plug from the power source.
2. Remove the protective cover from the power-supply unit following the procedure under Access to Components in the Power-Supply Unit.
3. Manually discharge the line-storage capacitors using the procedure given, later in this section, under Access to Components in the Power-Supply Unit.
4. Check the resistance of the power supplies at the test points given in Table 4-2.

#### NOTE

*Place the common lead of the ohmmeter to ground when measuring power-supply resistance.*

5. If any of the resistance readings are significantly lower than that listed, remove the electrical connections between the mainframe and the power-supply unit. Disconnect P1417, P1482, P1483 on the A25-Low-Voltage Regulator board. This isolates the circuitry in the mainframe from the power-supply unit. Recheck the resistance. If the readings remain low, the malfunction is located within the mainframe circuits. If the readings increase to normal or above, the malfunction is in the power supplies.

6. Replace all electrical connections which were disconnected in part 5.

**TABLE 4-2**  
Typical Power-Supply Resistance

Power Supply	Test Point	Ohmmeter Scale	Typical Resistance Reading
+50 V	TP891	2k	≥ 1.05 kΩ
+15 V	TP893	2k	≈ 0.115 kΩ
+5 V	TP895	2k	≈ 0.005 kΩ
-15 V	TP897	2k	≈ 0.19 kΩ
-50 V	TP899	2k	≥ 0.59 kΩ

### Step C: Check the Pre-Regulated Power Supplies

To check the pre-regulated power supplies, perform the following procedure:

1. Connect a 10X voltage probe from the test oscilloscope to resistor R1284 on the A24-Rectifier board. Set the test oscilloscope vertical deflection factor as necessary for an on-screen display; set the horizontal sweep rate for 2 milliseconds/division.
2. Set the variable autotransformer for 115 volts. Connect the 7104 power-cord plug to the variable autotransformer; turn on the 7104.
3. Compare the waveform on the test oscilloscope to those shown in Figure 4-4. If the waveform resembles that of Figure 4-4A, proceed to Step E of this procedure. If it resembles that of Figure 4-4B, proceed with part 4 of this step.
4. Remove the 10X voltage probe from R1284. Set the test oscilloscope vertical coupling to dc and the horizontal sweep rate to 10 milliseconds/division.
5. Connect the 10X probe to each power supply at the test points given in Table 4-3. Note the polarity, amplitude, and shape of the waveform present at each test point. (Adjust the vertical deflection factor of the test oscilloscope as necessary to maintain an on-screen display.)

#### NOTE

*Look for a power supply where the burst voltage is very low in relation to the specified supply voltage.*

6. When a low supply voltage is found, disconnect the 7104 from the power source and discharge the line-storage capacitors following the procedure given under Access to Components in the Power-Supply Unit. Check for shorted components in the suspected power supply; also check the filter capacitors for leakage.

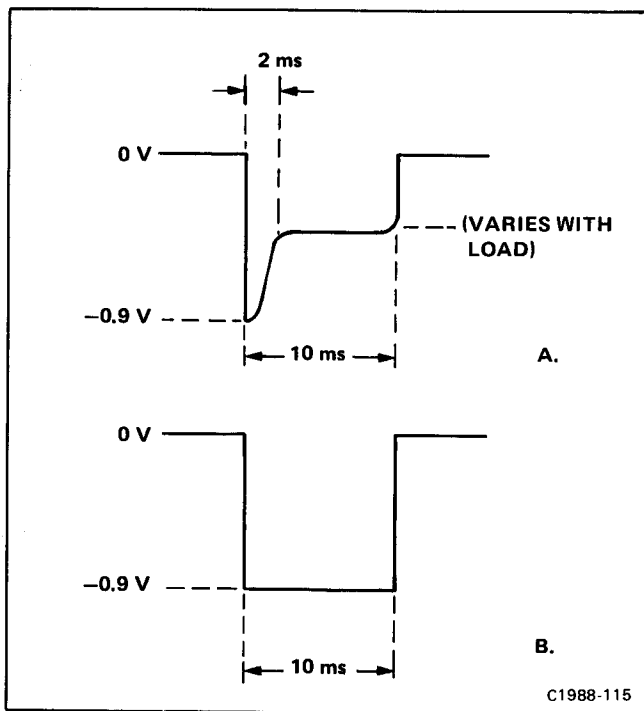


Figure 4-4. Current sensing waveform at R1284 showing:  
 A. Power supplies not in current limit operation.  
 B. Power supplies in current limit operation.

TABLE 4-3  
 Burst Voltage Test Points

Pre-Regulated Power Supply	Test Point Located on Rectifier Board
+108 V	TP1326
+54 V	Pin 4 of P1452
+17 V	Pin 6 of P1452
-17 V	Pin 2 of P1452
+8 V	Pin 7 of P1450
-54 V	Pin 3 of P1452
+5 V Lights	Pin 6 of P1450

**Step D: Check Line Input Circuit**

To check the input circuit, perform the following procedure:

1. Disconnect the 7104 from the variable auto-transformer and discharge the line-storage capacitors following the procedure given under Access to Components in the Power-Supply Unit.

2. Replace the line fuse.

3. Check diode bridge CR1215 on the A23-Inverter board and the associated line input circuit for a shorted component. If the circuit appears normal, connect the power-cord to the variable autotransformer.

4. Attach a 10X voltage probe from the test oscilloscope to one of the screws used to discharge C1216 and C1217 (see Fig. 4-5). Set the variable autotransformer for 20 volts and turn the 7104 on. Set the test oscilloscope for line triggering.

5. Check for an ac waveform on the test oscilloscope (see Fig. 4-6). Note the amount of dc the waveform is offset. Move the probe tip to the other capacitor screw. Check for an ac waveform which is both offset an equal amount of dc, and is opposite in polarity, from the previous waveform. (This checks the condition of the line-storage capacitors.)

**Step E: Check Crt and High-Voltage Circuit**

To check the crt circuitry, perform the following procedure:

1. Disconnect the 7104 from the power source and discharge the line-storage capacitors following the procedure given under Access to Components in the Power-Supply Unit.

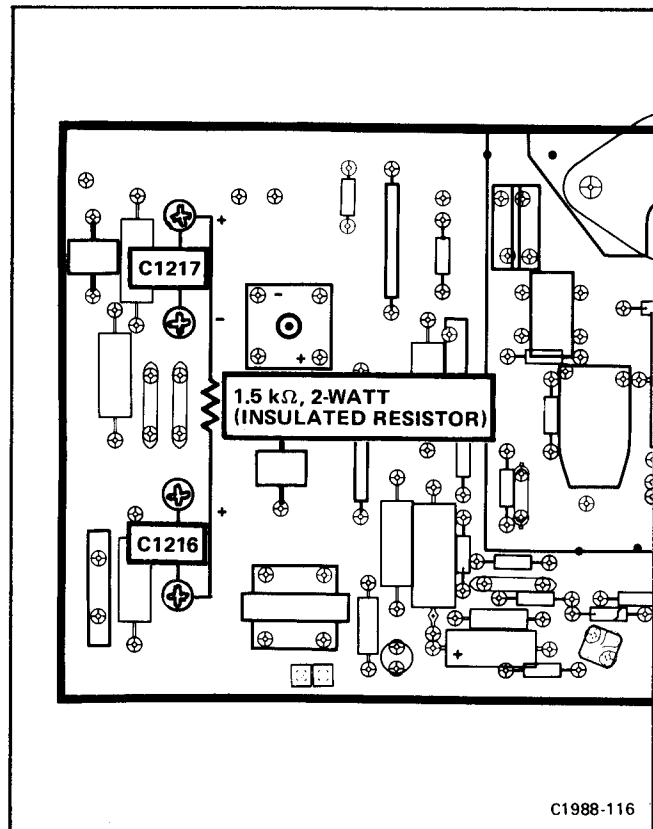


Figure 4-5. Location of line storage capacitor screws used for manually discharging C1216 and C1217.

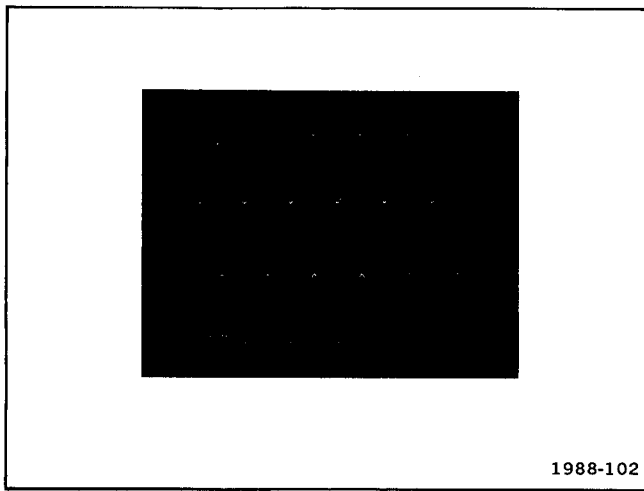


Figure 4-6. Typical waveforms on C1216 and C1217 with the line voltage set to about 20 volts.

2. Remove multi-lead cable P1440 from the A24-Rectifier board.
3. Set the variable autotransformer for 115 volts. Connect the 7104 power-cord plug to the variable autotransformer; turn the 7104 on.
4. Check for stable operation (no pulse mode) of the power supplies. If the power supplies operate properly, a crt failure or malfunction in the high-voltage circuitry is indicated.

#### Step F: Check the Inverter Control Circuit

To check the inverter control circuit, perform the following procedure:

1. Disconnect the 7104 from the power source and discharge the line-storage capacitors following the procedure given under Access to Components in the Power-Supply Unit.
2. Remove Q1254 from the A24-Rectifier board.
3. Connect the 7104 power-cord plug to the variable autotransformer. Turn the 7104 on and apply 115 volts from the variable autotransformer. If the power supplies stabilize, check the inverter control circuit for a malfunction. If the 7104 continues in pulse mode, proceed to part 4 of this step.
4. Repeat part 1 of this step. Then remove Q1252 from the A24-Rectifier board.
5. Set the variable autotransformer to 0 volts. Connect the 7104 power-cord plug to the variable autotransformer. Turn the 7104 on. While monitoring the +108 V test point on the A25-Low-Voltage Regulator

board with a voltmeter, slowly increase the output of the variable autotransformer until the voltmeter just reads +108 volts.

#### NOTE

*If the variable autotransformer's output is increased past the point where the voltmeter just reaches a reading of +108 volts, the 7104 will switch to pulse mode.*

6. If the power supplies stabilize, check U1275 and the inverter control circuit for a malfunction. If the 7104 continues in the pulse mode, proceed to Step G of this procedure.

#### Step G: Check Inverter Circuit

To check the inverter circuit, perform the following procedure:

1. Disconnect the 7104 power-cord plug from the power source and discharge the line-storage capacitors following the procedure given under Access to Components in the Power-Supply Unit.
2. Remove Q1234, Q1240, CR1234, and CR1241 on the A23-Inverter board and check the characteristics of each with a curve tracer. Install the checked or replaced components in the A23-Inverter board. Replace the line fuse, if it is open.
3. If the faulty component was not found, check Q2143, Q2145, and VR1245 with a curve tracer.

#### NOTE

*A shift in the zener voltage of VR1245 can cause erratic operation of the inverter circuit.*

4. If the 7104 continues in the pulse mode or continues to open the line fuse, check the current waveform through T1230. To do this, first repeat part 1 of this step. Then connect a current probe from the test oscilloscope to the gray lead that passes through toroid transformer T1230. Set the test oscilloscope for a vertical deflection factor of about 1 volt/division and a horizontal sweep rate of 2 milliseconds/division. Connect the 7104 power-cord plug to the variable auto transformer which is set for 0 volt. Turn the 7104 on and slowly increase the variable autotransformer's output to about 60 volts. Check for a burst waveform on the test oscilloscope (similar to that shown in Fig. 4-7).

#### NOTE

*The burst waveform indicates that the inverter circuit is attempting to start. If no burst waveform occurs, proceed to part 6; if a burst waveform is obtained, proceed to part 5.*

5. If a burst waveform was obtained in part 4 above, check for stable inverter operation when the line input voltage is increased to about 85 volts. Figure 4-8 shows

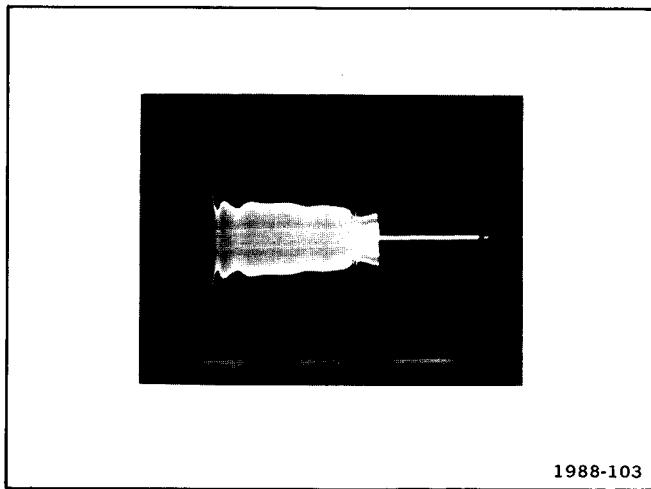


Figure 4-7. Current waveforms of T1230 showing burst operation at line voltage of about 60 volts.

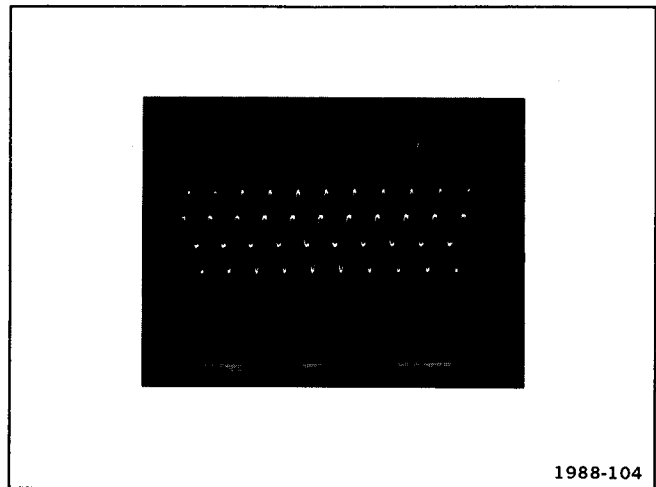


Figure 4-8. Current waveform at T1230 for normal inverter operation at line voltage of 115 volts.

the current waveform at T1230 for normal inverter operation at a line source of 115 volts. (NOTE: The test oscilloscope horizontal sweep rate has been changed to about 50 microseconds/division for Fig. 4-8.)

6. If no burst waveform occurred in part 4, repeat part 1 of this step. Then remove the current probe from the 7104 and the test oscilloscope. Connect a 10X voltage probe from the test oscilloscope to TP1234 on the A23-Inverter board. Set the variable autotransformer for 20 volts and check for a line-ripple waveform which is about dc centered (see Fig. 4-9). If the waveform is not centered check Q1246, CR1232, CR1240, CR1249, and CR1245 for shorts or leakage.

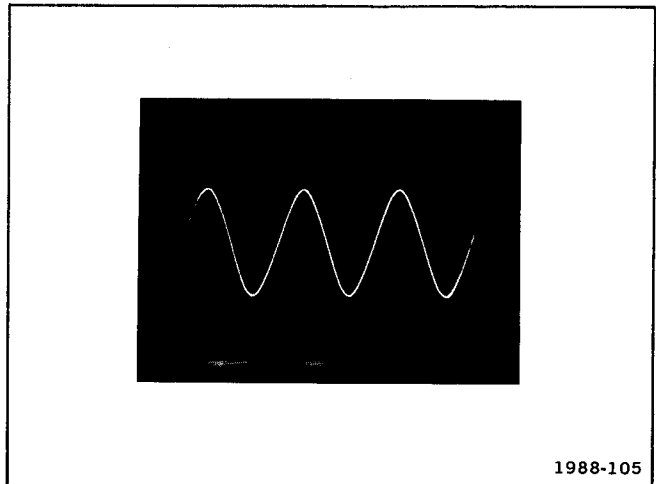


Figure 4-9. Waveform at TP 1234 on the power-supply inverter board with the line voltage at about 20 volts.

### Step H: Check LV Rectifier Circuit

1. Disconnect the 7104 power-cord plug from the power source and discharge the line-storage capacitors in the power-supply unit, following the procedure given under Access to Components in the Power-Supply Unit. Inspect the A24-Rectifier board and connecting cables for shorts and damaged components.

2. Remove dual diode CR1351 from the A24-Rectifier board and check with a curve tracer. Reinstall tested or replaced parts, making certain that the case is not shorted to the heat sink.

3. Lift one leg each of CR1340, CR1341, CR1342, and CR1343 and check with a curve tracer. Reconnect tested or replaced parts.

4. Lift one leg each of CR1330, CR1331, CR1332, CR1333, CR1350, and CR1353 and check with a curve tracer. Reconnect tested or replaced parts.

5. Check the electrolytic capacitors which filter the supplies, including C1354 (under the board) for shorts.

## TROUBLESHOOTING THE CRT AND ASSOCIATED CIRCUITRY

The following information is provided to facilitate troubleshooting the crt connections and associated circuitry, and is designed to eliminate unnecessary crt replacement. Information contained in other sections of this manual should be used in conjunction with this procedure to aid in locating troubles. See Section 3, Theory of Operation, for this information.

**WARNING**

*Extreme caution must be used when troubleshooting the crt and associated circuitry due to the high voltage present in this area of the instrument.*

**CRT DISPLAY SYMPTOM CHECKOUT PROCEDURE**

Perform the following procedure to determine the display symptoms associated with a crt circuit failure. Then proceed to the appropriate step in the CRT Circuit Troubleshooting Procedure as indicated by the Trouble Symptom column of Table 4-4.

## Preliminary Setup:

1. Set the 7104 front-panel controls as follows:

POWER ..... OFF  
 A INTENSITY ..... Counterclockwise  
 FOCUS ..... Midrange  
 B INTENSITY ..... Counterclockwise  
 READOUT ..... OFF  
 VERTICAL MODE ..... RIGHT  
 HORIZONTAL MODE ..... A  
 BEAMFINDER ..... Pushbutton in

2. Connect the 7104 to a power source that meets the voltage and frequency requirements of the instrument.

3. Install a Tektronix 7A-series amplifier unit in the RIGHT VERT compartment.

4. Install a Tektronix 7B-series time-base unit in the A HORIZ compartment and set it to 1 ms/div. Set triggering controls for a free-running sweep.

5. Press the POWER switch to the ON (locked in) position. If a trace appears on the crt, turn the POWER switch OFF and disconnect P1702 (crt heater). See Trouble Symptom #1 in Table 4-4.

6. Rotate the A INTENSITY and READOUT INTENSITY controls clockwise to about midrange.

a. If no display appears on the crt, turn the POWER switch OFF and disconnect P1702 (crt heater). Refer to Trouble Symptom #2 in Table 4-4.

b. If only the readout portion of the display appears on the crt, refer to Trouble Symptom #3 in Table 4-4.

c. If the intensity of the displayed trace appears to change during warmup, refer to Trouble Symptom #6 in Table 4-4.

d. If the displayed trace appears dim with the A INTENSITY control set fully clockwise, refer to Trouble Symptom #5 in Table 4-4.

7. Set the time-base unit to 5  $\mu$ s/div. Adjust the A INTENSITY control for a visible display. Set the time-base to 2 ns/div. If the display disappears and cannot be obtained with the A INTENSITY control, refer to Trouble Symptom #4 in Table 4-4.

8. Rotate the A INTENSITY control. If a charging phenomena appears on the display, refer to Trouble Symptom #8 in Table 4-4.

9. Perform the Geometry procedure in Section 5, Calibration. If the crt geometry or linearity is unsatisfactory, refer to Trouble Symptom #7 in Table 4-4.

10. Perform the Photographic Writing-Rate procedure in Section 5, Calibration.

a. If the waveform and readout display focuses at different positions of the FOCUS control, refer to Trouble Symptom #9 in Table 4-4.

b. If the photographic writing rate is unsatisfactory, refer to Trouble Symptom #10 in Table 4-4.

c. If the photograph indicates background scintillation, refer to Trouble Symptom #11 in Table 4-4.

**CRT CIRCUIT TROUBLESHOOTING PROCEDURE****Step A: Check Anode Voltage Multiplier**

1. Check that the anode lead is properly installed.

2. Turn all INTENSITY controls counterclockwise.

3. Turn the instrument off, disconnect the anode lead. Watch for an arc while you short the anode lead to the chassis. An arc indicates that the Anode Voltage Multiplier is at least partially working.

**NOTE**

*If the crt anode is open, the screen capacitance will not be charged and an arc will not be drawn when the anode is discharged to ground.*

4. Turn the instrument on and measure the anode voltage. The voltage should measure approximately 12.5 kV.

**TABLE 4-4**  
**Recommended CRT Circuitry Troubleshooting Sequence**

Trouble Symptom	Recommended Procedure	Proceed to Step:
1. Bright display; no response with INTENSITY controls.	1. Check CRT Grid; pin 3.	R
	2. Check Grid Bias Supply circuit.	E
	3. Check Control Grid DC Restorer circuit.	G
	4. Check Z-Axis Amplifier circuit.	I
2. No waveform or readout display.	1. Check Anode Voltage Multiplier output.	A
	2. Check CRT Heater supply.	B, T
	3. Check Microchannel Plate Supply circuit.	C
	4. Check -2400 Volt Supply circuit.	D
	5. Check Grid Bias Supply circuit.	E
	6. Check Z-Axis Amplifier circuit.	I
	7. Check Intensity Limiter circuit.	J
	8. Check Grid Crowbar circuit.	F
	9. Check Control Grid DC Restorer circuit.	G
	10. Check CRT First Anode, Second Section.	P
3. No waveform display; readout display only.	1. Check Intensity Limiter circuit.	J
4. Display only at sweep speeds below 5 $\mu$ s/div.	1. Check CRT Grid, pin 3.	R
5. Dim display.	1. Check Microchannel Plate Supply circuit.	C
	2. Check Grid Crowbar circuit.	F
	3. Check Z-Axis Amplifier circuit.	I
	4. Check Intensity Limiter circuit.	J
	5. Check Grid Bias Supply circuit.	E
	6. Check Anode Voltage Multiplier output.	A
	7. Check First Anode, First Section.	U
6. Display intensity varies during warmup.	1. Check Grid Bias circuit.	L
7. Geometry or linearity unsatisfactory.	1. Check CRT Scan Expansion Lens.	O
	1. Check Focus Grid DC Restorer circuit.	H
8. Focusing problems; charging phenomena may be observed.	2. Check following CRT pin connections:	
	a. Astigmatism, pin 10.	X
	b. Stigmator, pin 11.	V
	c. First Anode, First Section, pin 7.	U
	d. D1-D2 Shield, P1813-pin 5.	W
	e. Focus Electrode, pin 4.	Q

**TABLE 4-4 (CONT.)**  
**Recommended CRT Circuitry Troubleshooting Sequence**

Trouble Symptom	Recommended Procedure	Proceed to Step:
8. Focusing problems; charging phenomena may be observed (cont.).	2. Check following CRT pin connections (cont.):  f. Spot Demagnification Lens, pin 5. g. Cathode, pin 2. h. Isolation Shield, P1813-pin 6.	Y S N
9. Waveform and readout displays do not focus simultaneously.	1. Check Auto Focus circuit.	K
10. Low writing rate.	1. Check Microchannel Plate Supply circuit. 2. Check Grid Bias Supply circuit. 3. Check Anode Multiplier circuit.	C E A
11. Unacceptable background scintillation appears in photographs.	1. Check Microchannel Plate Supply circuit.	C
12. Display present with background glow.	1. Check CRT Exit Electrode.	M

**NOTE**

*The output impedance of the anode supply is 100 M $\Omega$ . When measuring the anode voltage the loading of the voltmeter should be taken into account. Due to the 100 M $\Omega$  output impedance, the Anode Voltage Multiplier is short-proof.*

5. Check the input voltage to the Anode Voltage Multiplier at R1750. This should be a square-wave signal roughly centered about ground with an amplitude of 2500 volts peak-to-peak and a frequency of approximately 25 kHz. If this voltage is correct, turn the instrument off and remove the High Voltage board (see Fig. 8-1 for the board location). Check to see if the input and ground leads of the Anode Voltage Multiplier are connected.

6. Replace the High Voltage board.

**Step B: Check CRT Heater Supply**

1. Visually check for loose connections to the crt. Then check to see if the heater glows.

**WARNING**

*Potential shock hazard exists when measuring the heater supply. The heater supply is elevated to -2565 volts.*

2. Disconnect harmonica P1702 and measure the heater voltage with a true rms voltmeter. The voltage should be

6.3 volts rms; frequency about 25 kHz. If a low reading of the supply is obtained, the high voltage transformer may be defective.

3. Turn the instrument off. Check for continuity between pins 1 and 2 of P1702, and between pins 1 and 14 of the crt.

**Step C: Check Microchannel Plate (MCP) Supply****WARNING**

*Potential shock hazard exists: the MCP voltage can be as high as +1200 volts.*

1. Visually check for loose connections on the High Voltage board. (See Fig. 8-1 for board location.)

2. Turn all INTENSITY controls counterclockwise. Measure the MCP output voltage at TP1775 and note the reading.

3. Turn R1720 (MCP Gain) clockwise. The voltage reading should be about 860 volts. Turn R1720 counterclockwise. The voltage reading should be about 460 volts. Reset R1720 to the voltage reading noted in part 2.

a. If the MCP voltage at TP1775 is low, ground TP1707 and again note the MCP voltage reading. If the voltage now reads about 1250 volts; check components Q1708, U1714A, CR1707, CR1708, C1707 and C1708. If the voltage is still low, check components CR1710, CR1711, C1710, and C1711.

**NOTE**

*With TP1707 grounded, the voltage at the secondary of the MCP transformer should be a square wave of about 625 volts peak.*

Remove the ground from TP1707.

4. Remove the plug-ins from the horizontal compartments. Set the HORIZONTAL MODE switch to A and turn the A INTENSITY control fully clockwise. The MCP output voltage (at TP1775) should increase by about 350 volts. With the HORIZONTAL MODE switch in CHOP, ALT, or B, turn the B INTENSITY control fully clockwise. The MCP output voltage should increase by about 350 volts. If the MCP output voltage does not increase, check for continuity of the Intensity Sense line to the Logic board (P1785 pin 7), and check U1714.

5. If the MCP voltage measurements are correct, check for a loose connection to the microchannel plate at the crt (P1819, pins 3 and 7). This can be done without removing the crt by connecting a DVM across resistors R1725 and R1726 to check for about 10 volts. Typically, the voltage reading is around 10 volts, corresponding to a current of 50  $\mu$ A. If no current flows, remove the crt and check for open connections.

**Step D: Check -2400 Volt Supply**

**WARNING**

*To avoid electric shock, use extreme caution when troubleshooting the -2400 Volt Supply.*

1. Check the voltage at TP1844 on the High Voltage board.

a. If the reading is -2400 volts, within 5 volts, the supply is operating properly.

b. If the reading is more than 5 volts from -2400 volts, check the cathode supply at TP1846 for -2265 volts. If necessary, adjust R1805 (-2265 V Adjust) to -2265 volts. If the adjustment has no effect, check the high-voltage regulator Q1784 (see below). If the adjustment has some effect but fails to obtain -2265 volts at TP1846, the Grid Bias Supply may not be functioning properly. (See Step E: Check Grid Bias Supply.)

c. If the reading is near ground, check:

(1) For a 2500 volt (p-p) square-wave signal at the junction of R1750 and pin 9 of T1770 with the other end of the winding (pin 7) held near ground. If the appropriate signal is not obtained, check diodes CR1776, CR1778, and CR1784.

(2) Check the voltage doubler by removing regulator transistor Q1784. The dc voltage at TP1844 should be approximately -2300 volts. If not,

check diodes CR1762, CR1763 and capacitors C1750 and C1764.

(3) Check the regulator transistor Q1784 and zener diode VR1784. With transistor Q1784 removed, the voltage at TP1784 should be 200 volts dc.

(4) Check operational amplifier U1802.

(5) Check the -2265 Adjust, R1805. Remove the regulator transistor Q1784 and connect a DVM to TP1806. Moving R1805 throughout its range should cause a dc voltage change of about 200 mV at TP1806. If not, lift diodes CR1803 and CR1804 and repeat the measurement. Check for shorted or opened resistors if the 200 mV change is not obtained.

(6) Check the thick-film high-voltage resistor R1802.

**Step E: Check Grid Bias Supply**

**WARNING**

*Potential shock hazard exists when measuring the Grid Bias Supply; the DVM is elevated to -2400 volts.*

1. Place a voltmeter between TP1846 (-2265 volts) and TP1844 (-2400 volts). Check for a reading of 137 volts, within 5 volts.

a. If the voltage is low (approximately 60 to 70 volts), check Q1838, Q1842, and C1846 for a shorted condition. Then check Q1835 for an open junction.

b. If the voltage is high (approximately 200 volts), check Q1842 and Q1838 for an open junction.

c. If the voltage is more than 5 volts from 175 volts, check transistors Q1835, Q1838, and Q1842 on a curve tracer. Check capacitor C1846 for leakage by lifting one end of the capacitor from the circuit board and remeasuring the Grid Bias Supply voltage.

**Step F: Check Grid Crowbar Circuit**

**WARNING**

*Potential shock hazard exists when working on the Grid Crowbar circuit since it is elevated to -2400 volts.*

1. Remove transistor Q1687 and check for a display. If a display is obtained, check Q1687 on a curve tracer. If a display is not obtained, check C1687 for leakage.



**CAUTION**

To ensure crt cathode protection, check the Grid Crowbar circuit for proper operation.

**Step G: Check Control Grid DC Restorer****WARNING**

To prevent shock hazard, turn instrument power off before working on high-voltage circuits.

1. Set the time-base unit for a  $20 \mu\text{s}/\text{div}$ , free-running mode.
2. Check that the waveform at the junction of R1811 and CR1747 is similar to that shown in Figure 4-10.

**NOTE**

A typical waveform at this junction is a square wave with a frequency of about 25 kHz. The positive level should not exceed +50 volts and the negative level should be more positive than -50 volts.

If the waveform is not like that of Figure 4-10, check the Z-Axis Amplifier by increasing the A INTENSITY setting; the positive level of the square wave should also increase until the Intensity Limiter limits the Z-Axis drive. Then check the Grid Bias circuit by changing the setting of CRT Grid Bias adjustment R1746; the negative level of the square wave should also change.

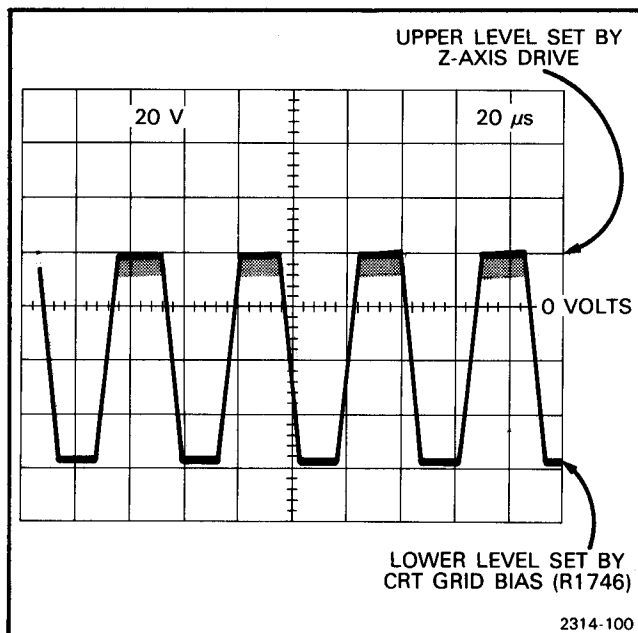


Figure 4-10. Typical waveform at junction of R1811 and CR1747 on the High Voltage circuit board.

a. If the square wave appears normal, but the display is bright and not controllable with the INTENSITY controls, check for an open crt grid.

b. If the positive level of the square wave exceeds +50 volts and the display is bright regardless of the INTENSITY controls, the low-frequency signal from the Z-Axis Amplifier is disconnected from the Control Grid DC Restorer. Check diode CR1749 for an open, then check for loose connections.

c. If the negative level of the square wave is more negative than -50 volts and the display is bright regardless of the INTENSITY control, the Grid Bias circuit is disconnected from the Control Grid DC Restorer. Check CR1447 for an open.

d. If the square wave appears normal, but no display can be obtained, check CR1792, CR1794, and C1793 for an open.

e. If the waveform is only a dc level which varies as the Z-Axis Amplifier output varies and no display can be obtained, check CR1794 for a short.

f. If the square wave amplitude is only about 10 to 20 volts and can be positioned with the CRT Grid Bias adjustment, R1746, but no display can be obtained, check CR1747 for a short.

g. If the square-wave amplitude is only about 10 to 20 volts, and cannot be positioned with CRT Grid Bias adjustment or the INTENSITY controls, and no display can be obtained, check CR1792 and CR1794 for a short.

h. If the square wave appears normal but the INTENSITY controls have no effect on its positive level, check the Z-Axis Amplifier circuit.

i. If the square wave appears normal but a display can only be obtained with the INTENSITY controls fully clockwise, the Grid Bias circuit is not functioning. Check transistors Q1748 and Q1742.

j. If the waveform is not normal and no display can be obtained, the high-voltage transformer is not driving the Control Grid DC Restorer. Check the resistor string of R1811, R1812, R1788, and R1789.

**Step H: Check Focus Grid DC Restorer****WARNING**

To prevent shock hazard, turn instrument power off before working on high-voltage circuits.

1. Check that the waveform at the junction of R1814 and CR1816 is similar to that shown in Figure 4-11.

**NOTE**

*A typical waveform is a square wave of about 25 kHz. The negative level should be -0.7 volt. The positive level is determined by the setting of the front-panel FOCUS control and varies between +0.7 volt and +50 volts.*

- a. If the negative level of the waveform is more negative than -50 volts, check diode CR1816 for an open.
- b. If the positive level of the waveform exceeds +50 volts, check diode CR1820 for an open.
- c. If the amplitude of the waveform is small and the FOCUS control has no effect on the positive level of the waveform, check diode CR1816 for a short.
- d. If the amplitude of the waveform is small but the FOCUS control varies the positive level from 0 to +50 volts, check diode CR1820 for a short.
- e. If the waveform is not as shown in Figure 4-11 and the dc level is above ground with the FOCUS control at midrange, check diode CR1818 or CR1819 for a short.
- f. If the waveform does not appear as shown in Figure 4-11, the Focus Grid DC Restorer may not be receiving drive signal from the high voltage transformer. Check resistors R1788, R1789, R1813, and R1814.
- g. If the waveform appears normal but the display has focusing problems, check for an open crt focus

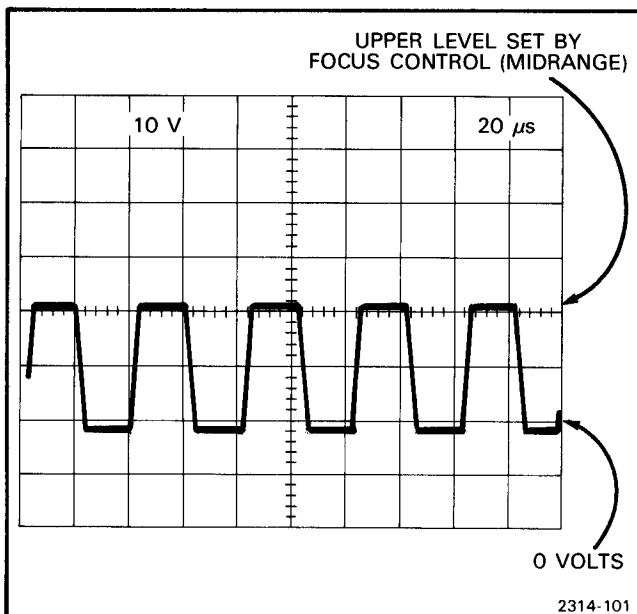


Figure 4-11. Typical waveform at junction of R1814 and CR1816 on the High Voltage circuit board.

electrode. Then check for proper adjustment of the Focus Preset and for defective resistors in the focus string. Check CR1819, CR1818, and C1819 for an open.

**NOTE**

*The focus-preset voltage, across C1820, ranges from about -1385 volts to -1560 volts as determined by R1825.*

**Step I: Check Z-Axis Amplifier**

1. Check TP1678, on the Z-Axis board, for a waveform with a baseline at +8 volts, within 1 volt, and an amplitude of at least 55 volts above the baseline.

**NOTE**

*To obtain maximum Z-Axis drive without engaging the Intensity Limiter, set the time-base time/division switch fully clockwise and position the trace off the crt screen. Refer to Z-Axis and Display in Section 5, Calibration, to properly adjust the Z-Axis Amplifier.*

2. Check the dc voltage at TP1672. The voltage should be +75 volts, within 5%. If it is not, check transistor Q1672 and zener diode VR1671.

3. If the voltage at TP1672 is about +60 volts and the display intensity is high, check the voltage at the collector of Q1608: the baseline should be at +1.6 volts, and the signal amplitude should be about 700 mV.

a. If the conditions in part 3 are met, check transistors Q1648, Q1668, and Q1676.

b. If the conditions in part 3 are not met, check transistors Q1608 and Q1618 for a short.

4. If the voltage at TP1678 is at ground and no display can be obtained, the Intensity Limiter may be inhibiting the Z-Axis Amplifier by saturating Q1644, or Q1644 may be shorted.

a. If the baseline voltage at the collector of Q1608 is not at +1.6 volts and the signal amplitude is not about 700 mV, check Q1626, Q1608, Q1632, and Q1203.

b. If the signal is correct, check transistors Q1668 and Q1644 for a short.

**Step J: Check Intensity Limiter**

**CAUTION**

*To prevent damage to the MCP when troubleshooting the Intensity Limiter circuit, flood the crt display with many cycles of a large amplitude sine wave.*

1. If the Intensity Limiter is inhibiting the Z-Axis Amplifier, check the Z-Axis Off signal at TP1992. On a

properly operating instrument the signal level at TP1992 is +120 mV; on an instrument which is shutdown the signal level is +3.4 volts.

a. If the signal at TP1992 is +120 mV, the fault is in the Z-Axis Amplifier. (Refer to Step 1: Check Z-Axis Amplifier.)

b. If the reading is +3.4 volts, check pin 2 of U1992 (the flip-flop may not be receiving a reset). Check U1992 by replacement.

2. Check that operational amplifier U1952 converts the average screen current to a dc voltage at a rate of 1  $\mu\text{A}/\text{volt}$ . With all INTENSITY controls turned fully counterclockwise, the voltage at TP1952 should be zero volts and should increase as the INTENSITY controls are advanced. If this does not occur, check the Screen I Sense connection to the Anode Voltage Multiplier. (When the INTENSITY control is advanced, a negative voltage should be measured at pin 8 of P1904. If zero volts is measured here, either the connection is open or the Anode Voltage Multiplier is defective.) Also check U1952.

3. Increase the INTENSITY controls until the LIMITED VIEWING TIME indicator turns steadily on, and observe that this occurs when the voltage at TP1952 is approximately +0.2 volt dc (0.2  $\mu\text{A}$  of average screen current).

a. If the condition in part 3 is not met, check that the voltage at pin 6 of U1958B is +0.2 volt dc. Measure the voltage at TP1962; with zero screen current the reading should be about -12 volts. When the INTENSITY control is advanced and the average screen current exceeds 0.2  $\mu\text{A}$ , the reading should be about +12 volts. If the readings are much different, check operational amplifier U1958 by replacement.

b. If the condition in part 3 is not met, check for a loose connection to LED DS1970. Check LED DS1970.

c. If the LIMITED VIEWING TIME indicator is on continuously (at zero screen current) and starts flashing at an average screen current above 0.2  $\mu\text{A}$ , transistor Q1970 is shorted.

4. Increase the INTENSITY setting until the LIMITED VIEWING TIME indicator starts flashing, and observe that this occurs when the voltage at TP1952 is approximately +2.0 volts dc, or 2  $\mu\text{A}$  average screen current. If this does not occur, check the following:

a. Check the 3 Hz Oscillator U1968; at zero screen current the voltage at TP1968 is about +12 volts, but will oscillate between ground and +12 volts when the INTENSITY control is advanced to the limited-viewing condition (LIMITED VIEWING TIME indicator is on steadily). If no oscillation occurs, check U1968 by replacement.

b. The voltage at pin 2 of U1958A should be +2.0 volts dc.

c. Measure the voltage at TP1958, with zero screen current the reading should be about -12 volts. When the INTENSITY control is advanced and the average screen current is 2  $\mu\text{A}$ , the voltage reading should have increased to at least -8.0 volts dc. If the readings are much different, check operational amplifier U1958 by replacement.

d. Check transistor Q1970 for conduction.

5. Increase the INTENSITY setting until the LIMITED VIEWING TIME indicator just starts to flash. Observe that further advance of the INTENSITY control does not increase the display intensity and that limiting is taking place. (With proper limiting, the voltage at TP1956 is -10.6 volts and increases towards ground when limiting occurs.) If this does not occur, check the following:

a. Check transistor Q1956 for a short.

b. Check for proper connection of the Intensity Reference Line (pin 4 of P1904) to diodes CR2009 and CR2019 on the Display Control board. (See Fig 8-1 for location of the Display Control board.)

c. Check diodes CR2009 and CR2019 for opens.

6. Increase the INTENSITY setting until the LIMITED VIEWING TIME indicator flashes. Check that after approximately two minutes the SHUTDOWN indicator starts to flash. If this does not occur:

a. Check integrator U1970. With zero screen current, the voltage at TP1970 should be at ground or is moving toward ground. Observe that when the INTENSITY setting is increased until the LIMITED VIEWING TIME indicator is steadily on, the voltage starts moving toward -10 volts. If the INTENSITY is further increased, the slew rate of the voltage should increase. The slew rate is maximum when limiting occurs (LIMITED VIEWING TIME indicator is flashing) and should be about 5 volts/minute. If this does not occur, one of the following failures may have occurred:

(1) The base of Q1980 is held at ground by either a shorted RESET button or by a shorted or saturated Q1999.

(2) Transistor Q1982 is not conducting.

(3) Transistor Q1978 is shorted.

(4) Operational amplifier U1970 is defective.

(5) Field-effect transistor Q1974 is not conducting. This causes the voltage at TP1970 to stop at about -2.0 or -3.0 volts instead of -10 volts.

(6) Capacitor C1971 is leaking. The symptoms are similar to those for an open field-effect transistor. Press the RESET button, then increase the INTENSITY setting until limiting occurs. After approximately two minutes, the voltage at TP1970 should be -10 volts. If this differs significantly, replace C1971.

(7) Check the 10-second delay timer. The voltage at TP1986 should measure zero volts at zero screen current. When the INTENSITY setting is increased and the output of the integrator has reached about -10 volts, the voltage at TP1986 should jump to about +3.6 volts. After approximately 10 seconds, the voltage should drop back to ground level. If this does not occur, check U1986 by replacement.

(8) Check SHUTDOWN LED DS1994 for loose connections or failure.

7. Increase the INTENSITY setting until limiting occurs, and wait approximately two minutes until the SHUTDOWN indicator starts flashing. After approximately 10 seconds, the indicator should be on steadily and the display should shut down. If this does not occur:

a. Check transistor Q1995. This transistor should momentarily go out of saturation when timer U1986 has timed out.

b. Check the flip-flop U1992. The voltage at TP1992 should increase from 0.1 volt to about +3.4 volts when timer U1986 has timed out.

c. Check transistor Q1994.

d. Check for a loose connection of the Z-Axis Off line (pin 1 of P1904) to the Z-Axis Amplifier.

e. Check transistor Q1644.

8. When the instrument is shut down, the voltage at TP1992 is about +3.4 volts dc. If pressing the RESET button at this time does not restore the display, check the following:

a. Check the RESET switch. The voltage at the base of Q1980 should be +2.3 volts and should drop to +0.2 volt when the RESET button is pressed.

b. Check flip-flop U1992 by replacement.

9. With the SHUTDOWN indicator flashing, shutdown can be prevented by reducing the average screen current to below 0.2  $\mu$ A (LIMITED VIEWING TIME indicator off). If this does not occur, check the following:

a. Transistors Q1998 and Q1999.

b. 10-second delay timer U1986 if it does not reset.

### Step K: Check Auto Focus Amplifier

1. Check the dc voltage at the emitter of Q1607. The voltage should be about -8.5 volts. If the voltage reading differs by more than 0.2 volt, check transistor Q1607 and diode CR1607.

2. Obtain a full-drive crt display that is not intensity limited. The front-panel LIMITED VIEWING TIME indicator should not flash.

3. Check the auto-focus signals at the collector of Q1603. With the INTENSITY control fully counterclockwise, the signal is clamped by diode CR1609 to a voltage of -7.9 volts. At about midrange of the INTENSITY control, diode CR1609 ceases to conduct. With the INTENSITY control fully clockwise, the waveform at the collector of Q1603 should have an amplitude of 0.9 volt. If not, check transistor Q1603 and diode CR1609.

4. Check the auto-focus signal at TP1628. With the INTENSITY control fully clockwise, the amplitude of the signal should be about 7 volts (depending upon the focus gain adjustment). If not, check transistors Q1629, Q1620, and Q1617.

5. Check the connection to the crt focus electrode.

### Step L: Check Grid Bias Compensation

1. Turn the instrument off and discharge capacitor C1753.

2. Connect a DVM to TP1736 and turn the instrument on. The voltage should be approximately +7.1 volts and should increase to +12.5 volts in 10 minutes. If the voltage is different, check the following:

a. Check operational amplifier U1736 by replacement.

b. Check CR1736.

c. Check C1736 for leakage.

d. Check Q1742.

### Step M: Check CRT Exit Electrode

1. The best way to detect an open exit electrode is with a magnified sweep and maximum Z-Axis drive. The duty cycle should be such that the LIMITED VIEWING TIME indicator stays lit.

2. Position the trace vertically and horizontally and look for a background glow. This glow indicates an open exit electrode.

### Step N: Check CRT Isolation Shield (P1813, Pin 6)

1. Obtain a focused display, then turn the instrument off and disconnect pin 6 of P1813.

2. Turn the instrument back on. If the CRT heater (Pins 1 and 14, CRT Socket) is open, the display will now be out of focus.

**Step H: Check First Anode (Pin 7, CRT Socket)**  
 If the first anode is open, the display is very badly defocused and is dim. Charging can be observed when the Z-Axis drive is open. If the anode is not open, a defocused display can be observed at the junction of R1895 and R1897 which is related to the Z-Axis drive. The front-waveform is useful for establishing a time relationship to the Z-Axis drive.

**Step I: Check CRT Stigmator (Pin 11, CRT Socket)**  
 If the stigmator is open, the display cannot be focused. If the instrument has been off for a few minutes and is turned on with the INTENSITY control at display at first is severely defocused and changes to a defocused display. The effect can be corrected by adjusting R1894 on the High Voltage board. The effect on the display.

**Step J: Check CRT D1-D2 Shield (Pin 5, P1813)**  
 If the D1-D2 shield is open, the display cannot be focused and charging effects are not noticeable. The D1-D2 shield is open if adjusting R1892 on the High Voltage board has no effect on the display.

**Step K: Check CRT Astigmatism (Pin 10, CRT Socket)**  
 If the astigmatism element is open, the display cannot be focused. Charging may be observed. The front-screwdriver adjustment has no effect. Turn the FOCUS control to midrange, slowly turn the INTENSITY control to about midrange. The trace initially goes into focus and defocuses again. If the instrument has been off for some time, turn the INTENSITY controls to midrange, and turn on the FOCUS control. Initially the display is very badly defocused and slowly drifts into focus and finally defocuses again.

**Step L: Check Spot Demagnification Lens (Pin 5, CRT Socket)**  
 If the spot demagnification lens is open, the display is very dim and the FOCUS control has no effect.

**Step O: Check CRT Scan Expansion Lens (P1810, P1819 Pin 10)**

**WARNING**

*To prevent electric shock, turn the instrument off before attempting to work on the High-Voltage board.*

**NOTE**

*The scan-expansion lens is connected to seven different high potentials. Six are negative, one is positive. If any of these elements are floating, obtaining a focused display is still possible. In addition to a focused trace, the display can show geometry problems, linearity problems, and low vertical or horizontal gain.*

*Since the lens does not draw any current, detecting an open element is difficult. To detect an open connection to the Horizontal Bowing element, adjust Horizontal Bowing and observe that the display is not affected. This is the only case where the voltage varies on only one element; the other elements are adjusted in pairs.*

1. To detect an open scan-expansion lens, lift the 160-ohm series resistors on the High Voltage board one at a time and look for a change in the display. No change in the display indicates an open connection.

**Step P: Check CRT First Anode, Second Section (Pin 8, CRT Socket)**

An open first anode, second section, will result in no display. Some display flashing may be observed as the INTENSITY control is advanced.

**Step Q: Check CRT Focus Electrode (Pin 4, CRT Socket)**

When the crt focus electrode is open, the display is very badly defocused and the FOCUS control has no effect.

**Step R: Check CRT Grid (Pin 3, CRT Socket)**

The display is always bright and the Z-Axis has no control when the crt grid is open. Check the connection to pin 3 of the crt.

**Step S: Check CRT Cathode (Pin 2, CRT Socket)**

With an open crt cathode, the display defocuses when the Z-Axis drive is changed.

**Step T: Check CRT Cathode (Pin 2, CRT Socket)**

If the crt cathode is open, the display is very dim and the FOCUS control has no effect.

**Step U: Check CRT Cathode (Pin 2, CRT Socket)**

If the crt cathode is open, the display is very dim and the FOCUS control has no effect.

**Step V: Check CRT Cathode (Pin 2, CRT Socket)**

If the crt cathode is open, the display is very dim and the FOCUS control has no effect.

**Step W: Check CRT Cathode (Pin 2, CRT Socket)**

If the crt cathode is open, the display is very dim and the FOCUS control has no effect.

**Step X: Check CRT Cathode (Pin 2, CRT Socket)**

With an open crt cathode, the display defocuses when the Z-Axis drive is changed.

**Step Y: Check CRT Cathode (Pin 2, CRT Socket)**

If the crt cathode is open, the display is very dim and the FOCUS control has no effect.

# CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in the 7104 Oscilloscope mainframe are given here.

## OBTAINING REPLACEMENT PARTS

Most electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, you should be able to obtain many of the standard electronic components from a local commercial source in your area. Before you purchase or order a part from a source other than Tektronix, Inc., please check the electrical parts list for the proper value, rating, tolerance and description.

### NOTE

*When selecting replacement parts, remember that the physical size and shape of a component may affect its performance in the instrument. All replacement parts should be direct replacements unless you know that a different component will not adversely affect instrument performance.*

Some parts are manufactured or selected by Tektronix, Inc. to satisfy particular requirements, or are manufactured for Tektronix, Inc. to our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine manufacturer of parts, refer to Parts List, Cross Index Mfr. Code Number to Manufacturer.

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

*To avoid electric-shock hazard, disconnect the instrument from the power source before soldering.*

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used

when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core, electronic-grade solder. The choice of soldering iron is determined by the repair to be made.

### CAUTION

*Several of the circuit boards in the 7104 are multi-layer type boards with a conductive path laminated between the top and bottom board layers. All soldering on these boards should be done with extreme care to prevent breaking the connections to this center conductor. Only experienced maintenance personnel should attempt repair of these boards: A6-Main Interface, A13-Logic, A14-Trigger Selector, and A21-Z-Axis.*

*Do not allow solder or solder flux to flow under printed circuit board switches. The printed circuit board is part of the switch contacts, intermittent switch operation can occur if contaminated.*

*Soldering in the area of HYPCON connectors requires special precautions, see the discussion of HYPCON Connectors under Semiconductors in this section.*

When soldering on circuit boards or small wiring, use only a 15-watt, pencil-type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering-iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat-sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder-removing wick to remove excess solder from connections or to clean circuit board pads.

The following technique should be used to replace a component on any of the circuit boards not mentioned in the preceding Caution. Most components can be replaced without removing the board(s) from the instrument.

1. Touch the soldering iron to the lead at the solder connection. Never place the iron directly on the board, as this may damage the board.
2. Melt a small amount of solder onto the component lead connection. This replaces the flux, which may have been removed during instrument cleaning, and facilitates removal of the component.
3. Grip the component lead with a pair of long-nose pliers. When the solder begins to flow, gently pull the component lead from the board. If unable to separate the lead from the board, try removing the other end of the component.

#### NOTE

*Some components are difficult to remove from the circuit boards due to a bend placed in each lead during machine insertion of the component. The purpose of the bent leads is to hold the component in position during a flow-solder manufacturing process which solders all components at once. To make removal of machine inserted components easier, straighten the leads of the component on the back of the circuit board, using a small screwdriver or pliers, while heating the soldered connection.*

4. Bend the leads of the replacement component to fit the holes in the circuit 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 that the component is firmly seated against the board, or as originally positioned.
5. Touch the iron to the connection and apply enough solder to make a firm solder joint.
6. Cut off any excess lead protruding through the board (if not clipped in step 4).
7. Clean the area around the solder connection with a flux-removing solvent. Be careful not to remove information printed on the circuit board.

## COMPONENT REMOVAL AND REPLACEMENT

### WARNING

*To avoid electric-shock hazard, always disconnect the instrument from the power source before removing or replacing components or plug-in units.*

The exploded-view drawings associated with the Replaceable Mechanical Parts list (located at the rear of this manual) may be helpful in the removal or disassembly of individual components or sub-assemblies.

### DISPLAY UNIT KICKSTAND

The Display unit of the 7104 Oscilloscope mainframe is equipped with a kickstand for easier access to interior components of the instrument. To use the kickstand feature, disconnect the power-cord plug from the power source. Then remove the side and top panels as described under Cabinet Panel Removal. Remove the two screws on each side of the 7104 which connect the two units. The two units can now be separated at the front of the instrument (the kickstand will hold the units apart). To assemble the units, disengage the kickstand and reverse the disassembly procedure.

### POWER-SUPPLY UNIT REMOVAL

The power-supply unit can be slid out of the rear of the 7104 to gain better access to the A13-Logic board, A14-Trigger Selector board, A25-Low-Voltage Regulator board, or for power-supply maintenance and troubleshooting. To remove the power-supply unit from the mainframe, first remove the four screws which hold the power-supply unit to the rear frame of the instrument (see Fig. 4-12). Slide the power-supply unit out of the mainframe until it can be set down on the work surface (be sure to guide the interconnecting cables so they do not catch on other parts of the instrument). The power-supply unit remains electrically connected to the rest of the instrument in this position, allowing for troubleshooting. If it is necessary to operate this instrument with the power-supply unit removed for a

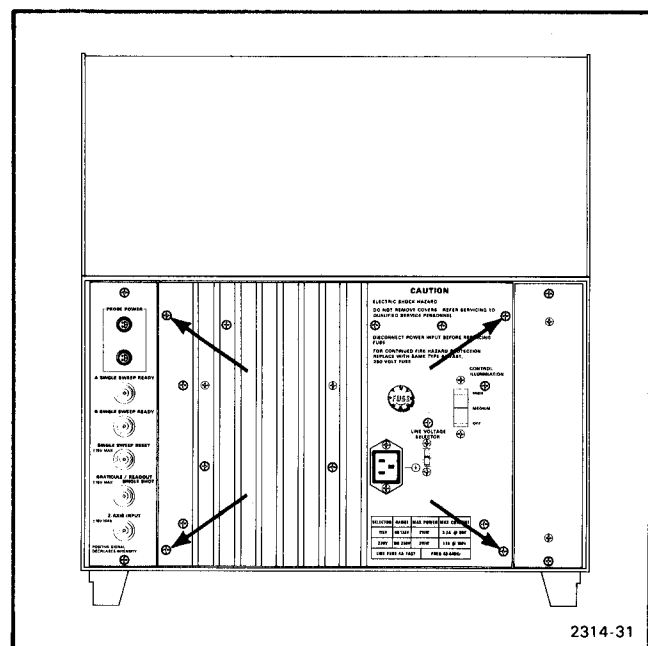


Figure 4-12. Power supply unit securing screws.

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period of time, we recommend that the power-supply unit be secured to the instrument with spacers between the rear frame and the power-supply unit.

Reverse the above procedure when placing the power-supply unit into the mainframe of the instrument; be careful not to pinch the interconnecting cables when replacing the unit. Be sure that all the securing screws are tight enough to hold the power-supply unit properly in place.

### Access to Components in the Power-Supply Unit

To reach the components located inside the power-supply unit for maintenance or repair, use the following procedure:

#### WARNING

*Disconnect the instrument from the power source and allow the line-storage capacitors to discharge, before removing the power-supply unit cover. The line-storage capacitors remain charged with high voltage dc for several minutes after the line power is disconnected unless they are manually discharged. A warning-indicator (neon bulb) located on the A23-Inverter board, flashes when this stored voltage exceeds about 80 volts. Do not remove the power-unit cover while this light is flashing.*

1. Slide out the power unit as previously described.
2. Remove the four small screws that secure the cover to the rear heatsink.
3. Remove the 9 screws that attach the sides of the cover to the power unit chassis.
4. Disconnect the two coaxial connectors from P1440 on A24-Rectifier board.
5. Remove the cover from the power-supply unit.
6. The power-supply unit is now open for maintenance or repair. If the 7104 is to be operated with the cover removed, first reconnect the coaxial cables to the A24-Rectifier board.
7. Reverse the order of removal to replace the power-unit cover.

Before performing maintenance or taking ohmic measurements in the power-supply unit, manually discharge the line-storage capacitors (C1216 and C1217) as follows:

1. Remove the protective cover from the power-supply unit following the preceding procedure.

2. Apply a 1.5-kilohm, 2-watt, insulated resistor across the capacitor screws as indicated in Figure 4-5.

## CATHODE-RAY TUBE REMOVAL

### NOTE

*Before removing the crt be certain that removal is necessary, see troubleshooting the CRT and Associated Circuitry.*

Remove the cathode-ray tube (crt) as follows:

#### WARNING

*The crt may retain a dangerous electrical charge. Before removing the crt, the anode must be fully discharged by shorting the anode lead from the crt to the chassis. Wait approximately ten minutes and again firmly short this lead to the chassis. Then remove the crt.*

*Use care when handling a crt. Breakage of the crt causes a high-velocity scattering of glass fragments (implosion). Protective clothing and safety glasses should be worn. Avoid striking the crt on any object which might cause it to crack or implode. When storing a crt, place it in a protective carton or set it face down in a protected location on a smooth surface with a soft mat under the faceplate.*

1. Remove the rear panel and the A21-Z-Axis board, directly behind the crt base.
2. Remove the crt base-pin socket from the rear of the crt.
3. Loosen the two screws located above and below the crt base pins until the tension of the springs on these screws is released. Then, press in upon the screws to be certain that the crt clamp inside the crt shield is loose.
4. Disconnect the two vertical deflection-plate connectors from the left side of the crt.
5. Disconnect the two horizontal deflection-plate connectors from the top of the crt.
6. Disconnect the crt anode lead from the jack located at the high-voltage on the right of the instrument (on Option 2 instruments remove the X-Y delay line to gain access to crt anode lead). Ground this lead to the chassis to dissipate any stored charge remaining in the crt.
7. Remove the plastic A22-High Voltage board shield on the right side of the instrument.



8. Disconnect P1811, P1810, and P1813 from the A22-High Voltage board.

9. Remove the plastic mask which covers the crt bezel.

10. Remove the four screws securing the crt bezel to the front panel. Remove the bezel while disconnecting the three-pin connector from the left rear of the bezel.

11. Remove the plastic faceplate protector, the graticule light assembly, and the gray crt faceplate mask. (The graticule light assembly need not be unsoldered from its leads.)

12. Hold one hand on the crt faceplate and gently push forward on the crt base with the other. Slowly pull the crt out from the front of the instrument while guiding the cable connected to P1811, P1810, and P1813, and the crt anode lead, through the holes in the crt shield.

### CATHODE-RAY TUBE REPLACEMENT

Replace the cathode-ray tube (crt) as follows:

1. Insert the crt into the shield, guiding the crt anode plug and the cables connected to P1811, P1810, and P1813 through the holes in the crt shield and vertical delay line assembly. Set the crt firmly against the front-panel casting.

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

3. Place the gray crt mask over the faceplate. Reconnect the multi-pin connector to the crt bezel (align the arrow on the connector with the arrow on the bezel).

4. Hold the faceplate protector in position and replace the crt bezel, graticule light assembly, light filter frame, and light filter. Firmly tighten the four screws making sure that the light filter is properly aligned.

5. Gently push forward on the crt base to ascertain that the crt is as far forward as possible. Then tighten the two screws beside the crt base until the springs on the screws are fully compressed.

6. Place the crt base-pin socket on the crt base pins.

7. Reconnect the crt anode plug.

8. Carefully reconnect all cables and crt neck-pin connectors.

9. Replace the plastic crt bezel mask.

10. Replace the A21-Z-Axis board and rear panel.

### NOTE

*The replacement of the crt will require that the instrument be re-adjusted. Refer to Section 5, Calibration.*

### CIRCUIT BOARDS

If a circuit board is damaged beyond repair, replace the entire board assembly. Part numbers are given in Section 7, Replaceable Electrical Parts, for completely wired boards.

The pin connectors, except for coaxial-type connectors, used for interconnection between circuit boards are color-coded to aid in identification and circuit tracing. The color of the connector body matches the resistor color-code for the last digit of the connector circuit number; e.g., P602 is red, P603 is orange, etc.

Most of the circuit boards in this instrument are mounted on the chassis; pin connectors are used for electrical interconnection with chassis mounted components and other circuit boards. Several boards plug onto the rear of the A6-Main Interface board; feed-thru connectors connect the plug-on board to the A6-Main Interface board.

### Chassis-Mounted Boards

Remove and replace all chassis-mounted circuit boards as follows:

1. Disconnect all pin connectors attached to the board, or which connect the board to other parts of the instrument.

2. Remove the securing screws.

3. Remove the chassis-mounted board.

4. Replace chassis-mounted boards in the reverse order of removal. Match the index arrow on the multi-pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown on the circuit board illustration in Section 8, Diagrams and Circuit Board Illustrations.

### Plug-On Boards

Remove and replace the plug-on boards as follows:

1. Remove the power-supply unit (see Power-Supply Unit Removal) as necessary to gain access to the boards mounted on the rear of the A6-Main Interface board.

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

3. Loosen all of the board's securing screws.

4. Keeping the board parallel to the A6-Main Interface board, gently pull out on the edges of the board until the feed-thru terminals are cleared.
5. To replace a plug-on circuit board, position the board parallel to the A6-Main Interface board so that all feed-thru pins are properly aligned with their sockets.
6. Gently press the circuit board against the mounting surface. Be sure that all feed-thru pins and sockets mate properly.
7. Uniformly tighten the securing screws (recommended torque: four to six inch-pounds).

### A5-Mode Switch Circuit Board

Remove or replace the A5-Mode Switch circuit board as follows:

**CAUTION**

*Do not allow solder or solder flux to flow under printed circuit board switches. The printed circuit board is part of the switch contacts, and intermittent switch operation can occur if contaminated.*

1. Separate the Display Unit from the Acquisition Unit as previously described under Display Unit Kickstand.
2. Remove the VERT TRACE SEPARATION (B) knob.
3. Disconnect the pin connectors and remove the 5 screws holding the board to the chassis.

**NOTE**

*When removing wires from a circuit board, always tag the wire and the corresponding connection point on the circuit board.*

4. Slide the board toward the rear of the instrument until the front-panel pushbuttons clear the chassis.
5. Lift the board from the instrument.
6. Replace the board by reversing the order of removal. Match the index arrow on the pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown on the circuit board illustration in Section 8, Diagrams and Circuit Board Illustrations.

### A6-Main Interface Circuit Board

Remove and replace the A6-Main Interface circuit board as follows:

1. Remove the plug-in units and the power-supply unit (see Power-Supply Unit Removal).

2. Disconnect all connectors from the A6-Main Interface board. Note the location of the connectors so they can be correctly replaced.

3. Remove the screws from inside each plug-in compartment which hold the plug-in interface connectors to the chassis (see Fig. 4-13). Also remove the screws which hold the ground straps to the chassis.

4. Slide the Main Interface board assembly to the rear of the instrument and remove it.

5. Replace the A6-Main Interface circuit board in the reverse order of removal. Match the index arrow on the pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown in the circuit board illustrations in Section 8, Diagrams and Circuit Board Illustrations.

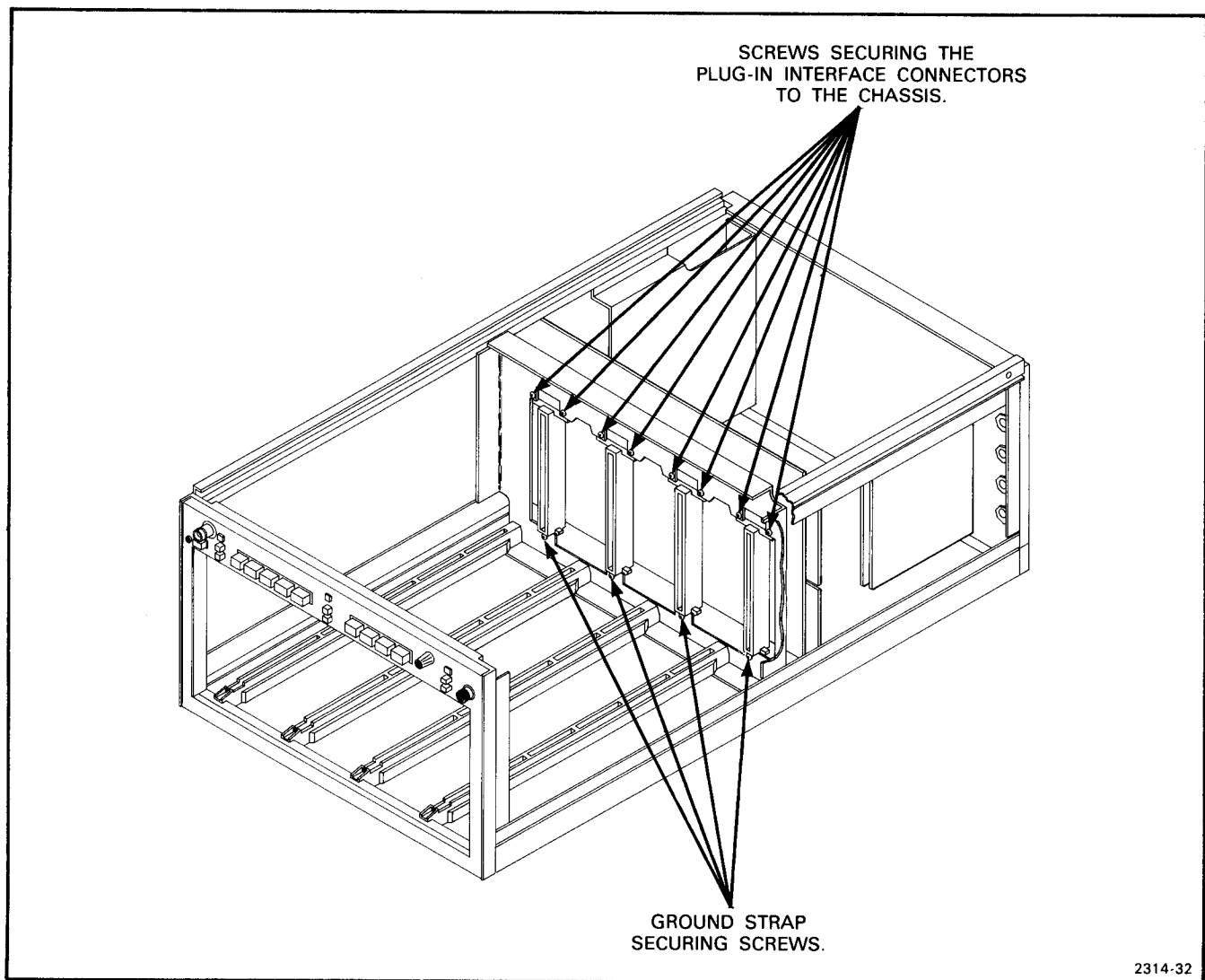
### A7/A8/A9/A10/A11/A12-Follower Circuit Boards

Follower circuit boards with four or six interface contacts are used in the plug-in interface connectors to provide optimum signal connections between the plug-in units and the 7104. Each Follower board is held in place by a spring so that the board can move back and forth within the interface connector to compensate for length differences between plug-in units. If a contact on a Follower board is damaged, the entire board with contacts and interconnecting cables is replaced as a unit.

Remove a Follower circuit board as follows:

1. Disconnect the instrument from the power source and remove any plug-in units.
2. Remove the power-supply unit (see Power-Supply Unit Removal).
3. Remove the metal shields in front of the A6-Main Interface board.
4. Disconnect the coaxial leads of the Follower board from the A16-Vertical Channel Switch board, A19-Horizontal Amplifier or A14-Trigger Selector board. Note the location of the connectors so they may be correctly replaced.
5. Using long-nose pliers, disengage the spring from the Follower board (spring is in front of A6-Main Interface board).
6. Remove the Follower board with interconnecting cables from the rear of the interface connector, through the hole in the A6-Main Interface board.

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



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Figure 4-13. Location of securing screws for the A6-Main Interface board.

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

2. Insert the folded end of the shim stock (with the Follower board) into the rear of the interface connector through the hole in the A6-Main Interface board. When the Follower board contacts are almost fully inserted into the connector, hold the board in place and remove the shim stock through the front of the interface connector while fully inserting the Follower board.

3. Secure the Follower board with the spring.

4. Reconnect the Follower board coaxial leads to the A16-Vertical Channel Switch or A19-Horizontal Amplifier board and the A14-Trigger Selector board.

5. Replace the power supply unit.

6. Replace the metal shields.

#### A26-Fan Motor Circuit Board

The exhaust fan and A26-Fan Motor circuit board are removed as a unit. Remove and replace the Fan assembly as follows:

1. Remove the A22-High Voltage board.

2. Remove the two screws which mount the fan housing assembly to the 7104 chassis.

3. Disconnect the pin connector from the board.

4. Remove the Fan assembly from the instrument.

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5. To replace the Fan assembly, first place the two screws through the holes in the chassis and secure the fan housing assembly to the chassis.
6. Replace the pin connector matching the index arrow with the arrow on the circuit board.
7. Replace the A22-High Voltage board.

### A25-Low-Voltage Regulator Circuit Board

Remove and replace the A25-Low-Voltage Regulator circuit board as follows:

1. Slide the power-supply unit out of the instrument (see Power-Supply Unit Removal).
2. Disconnect the multi-pin connectors from the board (two of the multi-pin connectors are self-locking; see the discussion on Multi-Pin Connectors in this section). Note the location of the pin connectors so they may be correctly replaced.

#### NOTE

*If the A25-Low-Voltage Regulator board is to be removed to allow access to other parts of the power-supply unit, proceed with steps 3 and 4 only. If the board is to be removed from the instrument, proceed with the remaining steps of the procedure.*

3. Remove the 2 screws located in the access holes under the A25-Low-Voltage Regulator board. These screws secure the chassis.
4. Remove the 3 screws securing the Low-Voltage Regulator chassis to the rear heatsink. Remove the board with attached chassis.
5. Remove the mounting hardware securing the plastic-cased power transistors to the rear heatsink (see Fig. 4-14). Note the position of the lockwashers so they can be correctly replaced.
6. Remove the 5 securing screws and lift the board with attached power transistors from the chassis.
7. To replace the A25-Low-Voltage Regulator board, first apply a thin coat of silicone grease to the back (mounting surface) of each power transistor.

#### WARNING

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

8. Place the A25-Low-Voltage Regulator board on the chassis. Replace, but do not tighten, the securing screws.

9. Check that the power transistors are aligned with their mounting screws and that the insulating washers are in place between the transistor cases and the rear heatsink.

10. Secure the transistors with the mounting hardware. Do not over-tighten the nuts; recommended torque is four to six inch-pounds.

11. Tighten the screws holding the A25-Low-Voltage Regulator board to the chassis.

12. Install the chassis on the power-supply unit.

13. Connect the multi-pin connectors to the board. Match the index arrow on the pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown in the circuit board illustration in Section 8, Diagrams and Circuit Board Illustrations.

14. Replace the power-supply unit in the instrument.

### A24-Rectifier Circuit Board

An exploded-view drawing of the power-supply unit is given in Section 9, Replaceable Mechanical Parts, at the rear of this manual. To remove the A24-Rectifier board, use the following procedure:

1. Slide the power-supply unit out of the instrument (see Power-Supply Unit Removal).
2. Remove the A25-Low-Voltage Regulator board with attached chassis as described under the A25-Low-Voltage Regulator Circuit Board.
3. Remove the 4 screws securing the power transformer to the bracket.
4. Remove the protective cover from the power-supply unit (see Access to Components in the Power-Supply Unit).
5. Disconnect the multi-pin connectors from the A24-Rectifier board. Note the location of the pin connectors so they can be correctly replaced.
6. Remove the 2 plastic screws which hold the circuit-board shield to power-supply A23-Inverter board.
7. Unsolder the 3 power-transformer leads from the power-supply A23-Inverter board. Remove the excess solder from the board pads with a vacuum-type desoldering tool.
8. Remove the 5 securing screws from the A24-Rectifier board.
9. Lift the circuit board and attached power transformer from the instrument.

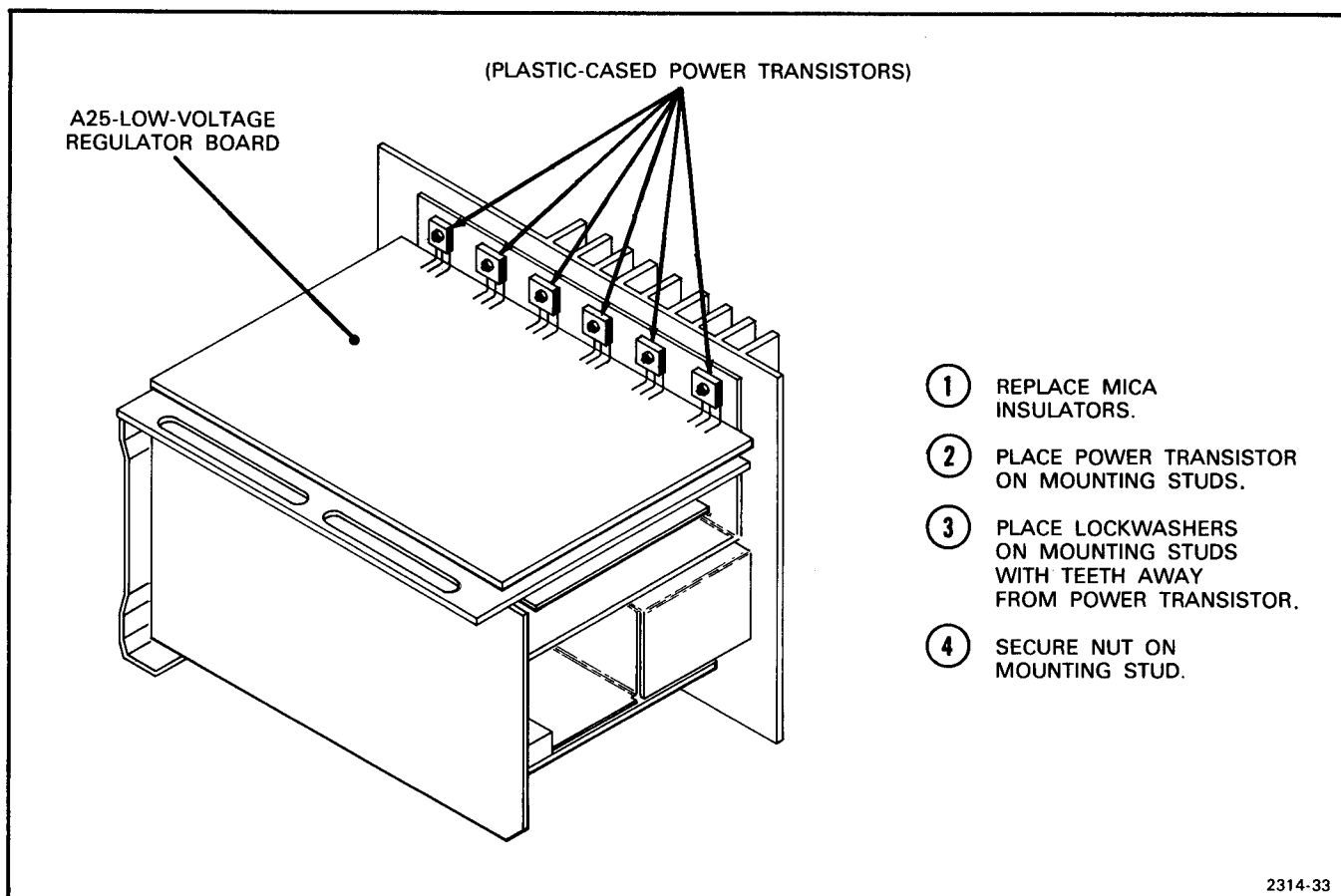


Figure 4-14. Correct placement of power transistor and mounting hardware on rear heatsink.

10. To replace the A24-Rectifier board, reverse the order of removal. Match the index arrow on the pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown on the circuit board illustration in Section 8, Diagrams and Circuit Board Illustrations.

### A23-Inverter Circuit Board

An exploded-view drawing of the power-supply unit is given in Section 9, Replaceable Mechanical Parts, at the rear of this manual. Remove and replace the power-supply A23-Inverter board as follows:

#### WARNING

*The power-supply unit has been tested at the factory to ensure safe operation. Improper repair of this unit can result in hazardous potentials on the instrument chassis. Do not remove the plate insulator, block insulator, or transistor shield from the heatsink. (See the exploded-view drawing of the power-supply unit for the location of the components.)*

1. Slide the power-supply unit out of the instrument (see Power-Supply Unit Removal).

2. Remove the protective cover from the power-supply unit (see Access to Components in Power-Supply Unit).

3. Remove A24-Rectifier board using the previous procedure.

4. Remove the 3 securing screws from A23-Inverter board.

5. Unsolder the line-input leads from the circuit board. Remove the excess solder from these circuit board pads with a vacuum-type desoldering tool.

6. Remove the two metal-cased power transistors by removing the securing nuts and pulling the transistors from their sockets.

7. Move the A23-Inverter board away from the heatsink shield until the transistor mounting studs clear the heatsink shield. Remove the board from the power-supply unit.

8. To replace the A23-Inverter board, reverse the order of removal. Match the index arrow on the pin connectors to the corresponding arrow on the board. Correct location of the pin connectors is shown on the circuit board illustration in Section 8, Diagrams and Circuit Board Illustrations.

### PLUG-IN INTERFACE CONNECTORS

The individual contacts of the plug-in interface connectors can be replaced. However, we recommend replacing the entire A6-Main Interface board if a large number of the contacts are damaged. An alternative solution is to refer the maintenance of the damaged A6-Main Interface board to your local Tektronix Field Office. Use the following procedure to remove and replace an individual contact of the plug-in interface connectors:

#### NOTE

*The plug-in interface contacts which are mounted on the Follower circuit boards cannot be replaced. A Follower board with contacts and interconnecting cables is replaced as a unit. See Circuit Boards.*

1. Remove the A6-Main Interface circuit board from the instrument as previously described.
2. Snap the white plastic connector cover off the side of the damaged plug-in interface connector.
3. Unsolder and remove the damaged contact.
4. Install the replacement contact. Carefully position it to fit against the connector body.
5. Snap the white plastic connector cover back onto the plug-in interface connector. Check that the replaced contact is aligned with the other contacts.
6. Replace the A6-Main Interface board.

### DELAY LINE REMOVAL

The vertical delay line is carefully matched at the factory. Therefore, it is not recommended that repair be attempted in the field. Instead, contact your local Tektronix Field Office.

The horizontal delay line (Option 2) is carefully matched electrically from side to side and to the electrical length of the vertical delay line. Therefore, it is not recommended that repair be attempted in the field. Instead, contact your local Tektronix Field Office.

### SEMICONDUCTORS

Semiconductors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of semiconductors may affect

the adjustment of the instrument. When semiconductors are replaced, check the operation of circuits which may be affected.

#### WARNING

*To avoid electric shock hazard, always disconnect the 7104 from the power source before removing or replacing components.*

Replacement semiconductors should be of the original type or a direct replacement. Lead configurations of the semiconductors used in this instrument are shown in Figure 4-2. Some plastic case transistors have lead configurations which do not agree with those shown. If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for standard basing as used for metal-cased transistors. When removing soldered-on transistors, use a solder-removing wick to remove the solder from the circuit board pads. Transistors which have heat radiators or are mounted on the chassis use silicone grease to increase heat transfer. Replace the silicone grease on both sides of the insulating washer when replacing these transistors.

#### WARNING

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

To replace one of the power transistors mounted on the heatsink at the rear of the power-supply unit, first remove the mounting hardware. Then, unsolder and remove the defective transistor. When replacing the transistor, be sure to install the insulating washer between the transistor and the heatsink (use silicone grease as previously described). Tighten the mounting nut just tight enough to hold the transistor in place. Then solder the replacement transistor to the A25-Low-Voltage Regulator board.

An extracting tool should be used to remove the in-line integrated circuits to prevent damaging the pins. This tool is available from Tektronix, Inc.; order Tektronix Part 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid one end disengaging from the socket before the other end.

### HYPCON Connectors

The HYPCON (hybrid-printed connector) connector is a precision-made connector designed to provide low loss electrical and/or thermally efficient connection between the printed circuit board and hybrid integrated circuit. An exploded view of the HYPCON connector is shown in

Figure 4-15. Care must be taken when replacing the hybrid IC's not to touch the elastomer gold-plated contacts with the fingers or to use a cleaner which will degrade contact reliability. The HYPCON connector and hybrid IC should be removed if it becomes necessary to use a cleaning solvent near the connector when replacing adjacent (within 1/2") circuit board components. **IMPORTANT:** Remove all traces of solder flux or foreign material contamination from the circuit board contact area before replacing the connector. Contamination usually takes place during the soldering and cleaning process. Even when the soldering is done carefully, flux, oil, or other contaminants can be carried under the connector during the cleaning operation. When the solvent evaporates, nonconductive contaminants may remain on or near the contact interfaces.

The cleaning process (either hand cleaning with a solvent or machine cleaning in an automatic detergent wash) is not recommended for boards containing HYPCON connectors.

If a component adjacent to a HYPCON connector must be replaced, the following steps are recommended:

1. Remove the hybrid IC and HYPCON connector (see Disassembly and Removal instructions) before any soldering or cleaning and store in a dirt-free covered container. When several hybrids and HYPCON connectors are to be removed, keep parts together and replace as sets; do not interchange parts.

2. Hand soldering:

- a. Use small diameter solder (0.030"-0.040").
- b. Use low wattage soldering irons (15-20 watts).
- c. Use care with solder amount and placement.

3. Remove solder flux and contact contamination with isopropyl alcohol, denatured ethyl alcohol, or a Freon TF cleaner such as Spray-On #2002.

4. Flush the hybrid and HYPCON connector mounting area with isopropyl alcohol. Do not scrub with a cotton-tipped applicator, as cotton fibers will adhere to edges and surfaces of contact areas and cause open or intermittent connections. The elastomer should be examined under light for dust, hair, etc., before it is re-installed. If the etched circuit board surfaces require more cleaning, scrub with a soft rubber eraser and blow or vacuum clean while dusting surface with a small clean brush.

5. If the hybrid IC and elastomer contact holder are contaminated, clean the contact holder and hybrid by flushing or spraying with alcohol and oven dry at 50° C. Do not scrub with a cotton-tipped applicator or similar device. If the contact holder is excessively contaminated, replace it with a new one.

Two inch-pounds of torque should be applied to the mounting screws to secure the HYPCON to the circuit board.

Make sure that the elastomer is properly seated in the contact holder before remounting the assembly to circuit board. Exercise care when mounting the frame-elastomer connector holder-hybrid IC assembly to the circuit board to prevent misalignment between the connector and board.

**CAUTION**

*Because of close tolerances involved, special care must be taken to assure correct index alignment of each HYPCON part during reassembly. Failure to do so can result in a cracked hybrid substrate. See Figure 4-15A for the index locations.*

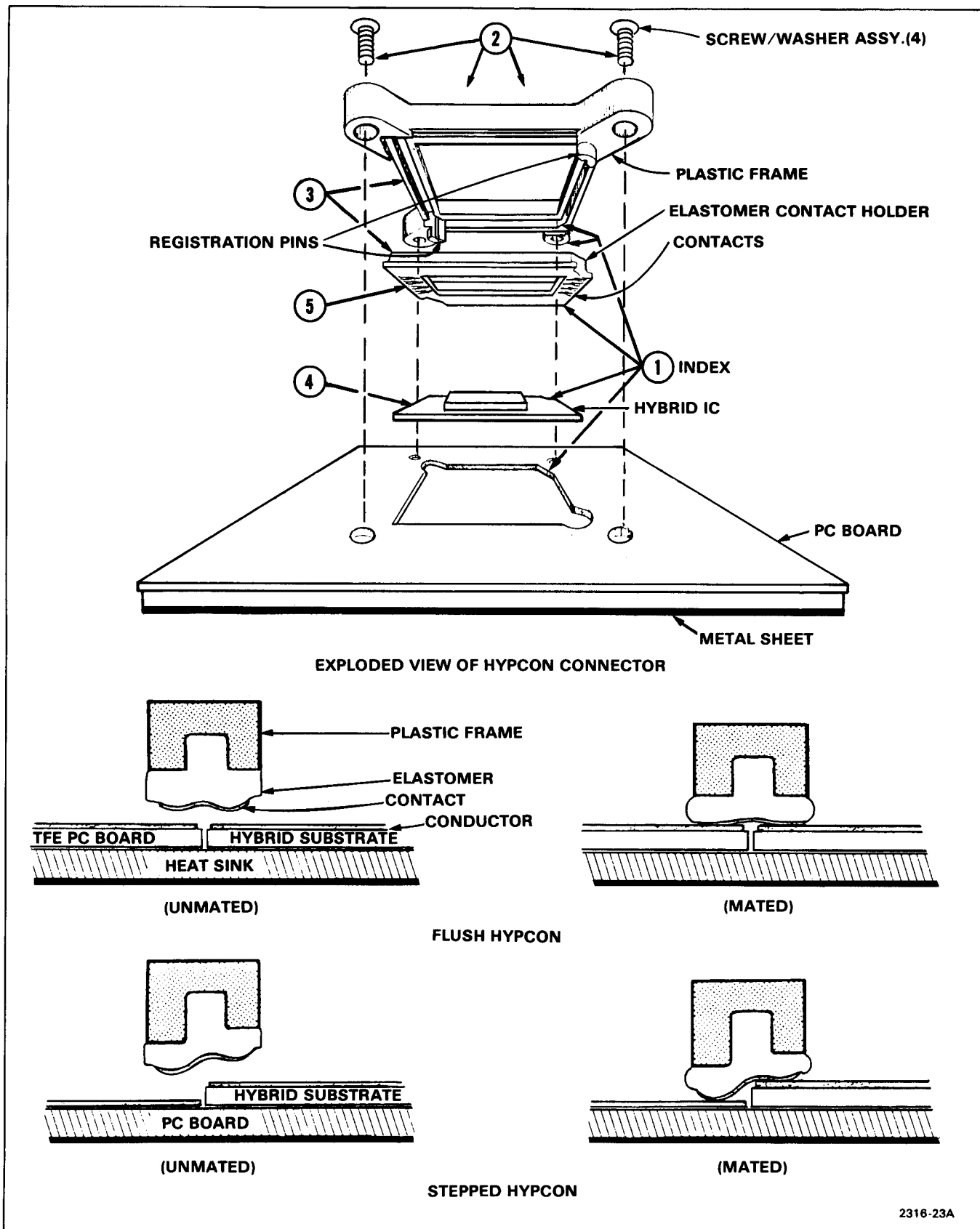
If your instrument contains both the flush and stepped type of HYPCON connectors be careful not to mix the elastomer contact holders during reassembly. The flush HYPCON connectors have green elastomer contact holders and the plastic frame is marked FLUSH. The stepped HYPCONS have neutral-colored elastomer contact holders with a slight ridge or step on the contact surface; the large frames are marked STEPPED. The registration pins on the stepped plastic frame are slightly longer than those on the flush frame. The elastomer contact holder in the small stepped connectors is indexed differently than the large connectors. Look for a small gold arrow in one corner of the holder instead of a flat corner. Match this corner arrow with the pointed corner of the plastic frame. Give close attention to this indexing, as it is easy to insert the elastomer contact holder incorrectly.

Differences also exist between the large flush and large stepped HYPCON circuit board receptacles. Figure 4-15A shows the cross-sectional differences which must be observed when working with an instrument that contains both types of HYPCON connectors.

**CAUTION**

*Damage to the elastomer contact holder can result if the connectors are not mated properly with the board receptacle.*

*When replacing the hybrid, insert it into the board opening and then position the HYPCON connector in the board registration holes for perfect alignment. The outer portion of the HYPCON frame should be flush with the circuit board before the four mounting screws are tightened. Avoid touching the hybrid and elastomer contact holder with your fingers; finger oils can degrade reliability.*



2316-23A

Figure 4-15. HYPCON assembly removal and replacement.



### DISASSEMBLY AND REMOVAL

- ① Note index on circuit board (arrow, triangle, or dot) and HYPCON plastic frame (pointed mounting ear).
- ② Unscrew and remove the 4 screw/washer assemblies. Where the HYPCON connector serves to heatsink the hybrid to the chassis, 2 of the 4 screws are longer. Note the location of the yellow tinted screws for proper replacement.
- ③ Lift HYPCON connector from board.
- ④ Note index location of hybrid and remove from board with tweezers.
- ⑤ Note index location of elastomer contact holder and remove by grasping a corner of the contact holder with tweezers and lifting up. Do not touch the gold-plated contacts with your fingers.

### REASSEMBLY AND REPLACEMENT

Grasp corner of elastomer contact holder with tweezers and place in plastic frame slot being careful to match the flat contact holder with the flat frame corner. Place a clean plastic envelope over finger and press with finger to seat contact holder into the frame. The contact holder must be evenly seated on all four sides.

**Flush HYPCON:** Match hybrid flat corner with board receptable flat corner and place hybrid in receptable. Match pointed mounting ear of HYPCON connector with flat corner of receptacle and guide registration pins into the board hold.

**Stepped HYPCON:** Using tweezers, match the hybrid corner index with the elastomer contact holder index and insert between the registration pins. Turn the assembly over, grasp the hybrid "hat" with the tweezers, and guide the registration pins into the board holes. Match the plastic frame pointed mounting ear with the circuit board arrow.

Insert mounting hardware and apply 2 inch-pounds of torque to secure the connector assembly.

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Figure 4-15. HYPCON assembly removal and replacement (continued).

A procedure for removal and replacement is included in Figure 4-15.

Hybrid substrate contact numbers 1 and 20 are printed on the substrate at the index corner. See Figure 4-2, Semiconductor Lead Configurations.

### INTERCONNECTING PINS

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

#### Coaxial-Type End-Lead Connectors

Replacement of the coaxial-type end-lead connectors requires special tools and techniques; only experienced maintenance personnel should attempt to remove or replace these connectors. We recommend that the damaged cable or wiring harness be replaced as a unit. For cable or wiring harness part numbers, see Section 9, Replaceable Mechanical Parts. An alternative solution is to refer the replacement of the defective connector to your local Tektronix Field Office or representative. Figure 4-16 gives an exploded view of a coaxial end-lead connector assembly.

#### Circuit-Board Pins

A circuit-board pin replacement kit (including necessary tools, instructions, and replacement pins with attached ferrules) is available from Tektronix, Inc. Order Tektronix Part 040-0542-00. Replacing circuit-board pins on multi-layer boards is not recommended. (The multi-layer boards in this instrument are listed under Soldering Techniques in this section.)

To replace a damaged pin, first disconnect any pin connectors. Then unsolder the damaged pin and pull it from the board with a pair of pliers, leaving the ferrule (see Fig. 4-17) in the circuit board if possible. If the ferrule remains in the circuit board, remove the spare ferrule from the replacement pin and press the new pin into the hole in the circuit board. If the ferrule is removed with the damaged pin, clean out the hole using a solder-removing wick and a scribe. Then press the replacement pin, with attached spare ferrule, into the circuit board. Position the replacement pin in the same manner as the original. Solder the pin to the circuit board on each side of the board. If the original pin was bent at an angle to mate with a connector, carefully bend the new pin to the same angle. Replace the pin connector.

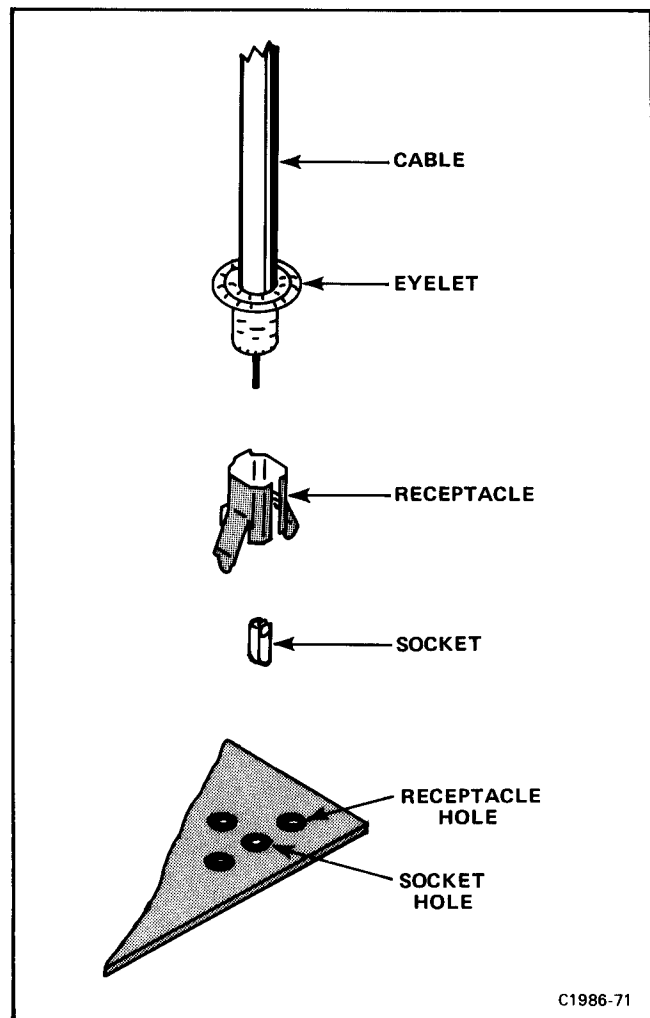


Figure 4-16. Coaxial end-lead connector assembly.

#### Circuit-Board Pin Sockets

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

#### NOTE

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

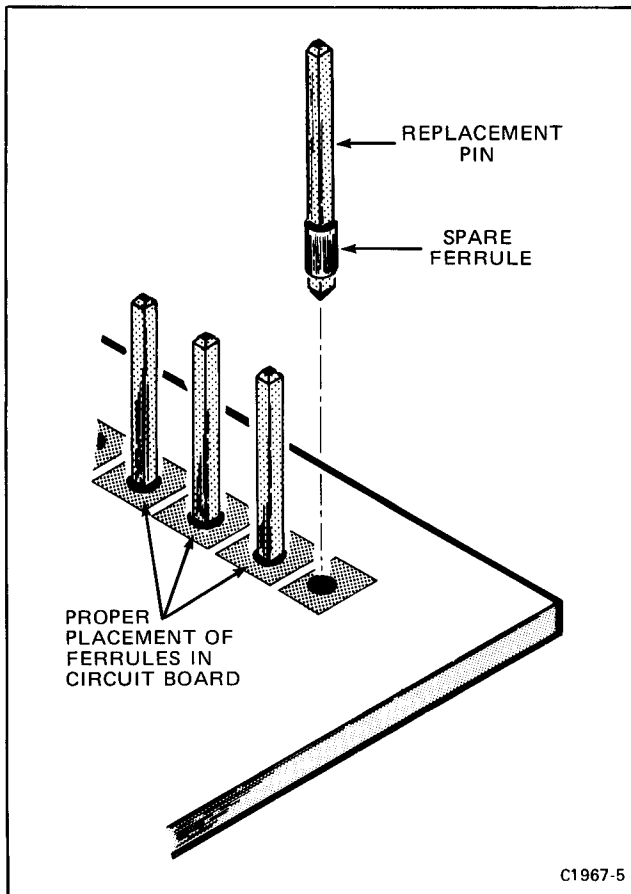


Figure 4-17. Exploded view of circuit-board pin and ferrule.

### Multi-Pin Connectors

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

#### NOTE

*Some multi-pin connectors are equipped with a special locking mechanism. These connectors cannot be removed by pulling on the wire(s). To remove the connectors from the pin(s) grasp the plastic holder and pull.*

*To remove an individual wire from the holder insert a scribe in the hole on the side of the holder and slide the extended portion under the holder. This will allow the wire to be removed from the holder.*

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that

these connectors are removed and installed as a multi-pin connector (see Troubleshooting Aids). If the individual end-lead pin connectors are removed from the plastic holder, note the order of the individual wires for correct replacement in the holder.

### PUSHBUTTON SWITCHES

The pushbutton switches used on the 7104 Oscilloscope mainframe are circuit board mounted. First remove the associated circuit board following the procedure given under Circuit Boards in this section. Figure 4-18 gives removal and replacement instructions for the pushbutton switches.

### GRATICULE LIGHT BULBS

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

### POWER TRANSFORMER

Replace the power transformer only with a direct replacement Tektronix transformer. Remove and replace the power transformer as follows:

1. Remove the A24-Rectifier board as described under Circuit Boards in this section.
2. Remove the bracket which holds the transformer to the rear heatsink.
3. Unsolder the transformer leads from the circuit boards. Remove the excess solder from the circuit-board pads (see Soldering Techniques). Note the position of the transformer leads so they may be correctly replaced.
4. Place the new transformer in position but do not yet solder the leads to the circuit-board pads.
5. Secure the bracket to the A24-Rectifier board and attach the transformer to the bracket with the 4 securing screws.
6. Reposition the A24-Rectifier board and secure with 3 screws. Attach the bracket securely to the rear heatsink.
7. Solder the transformer leads to the circuit-board pads.
8. Continue replacing the A24-Rectifier board.

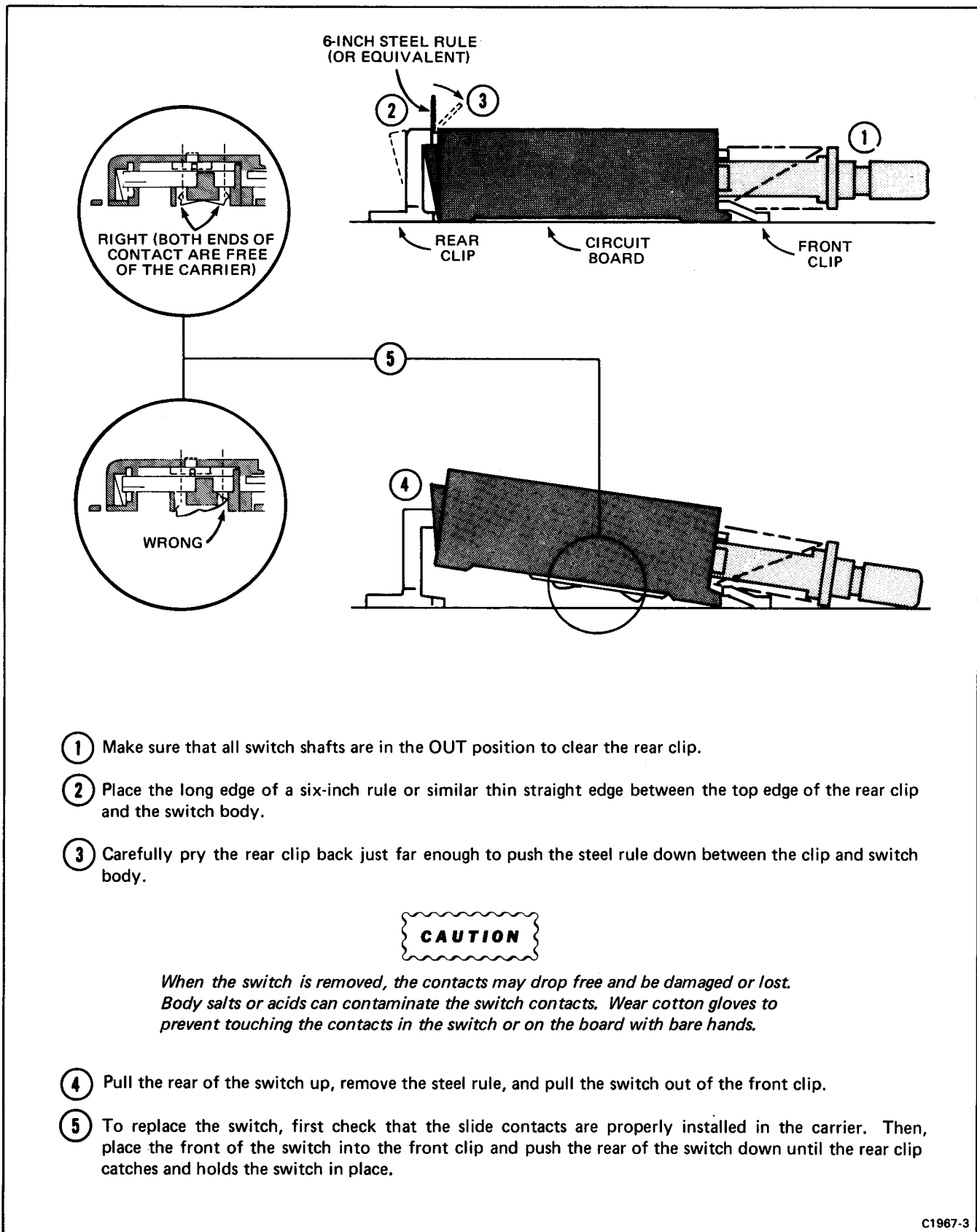


Figure 4-18. Removal procedure for pushbutton switches.

## LINE FUSE

The line fuse used in this instrument is located on the rear panel of the power-supply unit. Replace the line fuse (F1200) only with one of proper type and rating.

### NOTE

*The line voltage fuse F1200 is used for both 110 volt and 220 volt operation. No change in the fuse is necessary when switching the LINE VOLTAGE SELECTOR switch between 110 volts and 220 volts.*

## ADJUSTMENT AFTER REPAIR

After any electrical component has been replaced, the adjustment of that particular circuit should be checked, as well as the adjustment of any closely related circuits. Since the low-voltage supplies affect all circuits, adjustment of the entire instrument should be checked if component replacements have been made in these supplies or if the power transformer has been replaced. See section 5 for a complete adjustment procedure.

