MAINTENANCE

This section of the manual contains information for conducting preventive maintenance, troubleshooting, and corrective maintenance on the 2465 Oscilloscope.

STATIC-SENSITIVE COMPONENTS

The following precautions are applicable when performing any maintenance involving internal access to the instrument.

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. Table 6-1 lists the relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

When performing maintenance, observe the following precautions to avoid component damage:

1. Minimize handling of static-sensitive components.

2. Transport and store static-sensitive components or assemblies in their original containers or on a metal rail. Label any package that contains static-sensitive components or assemblies.

3. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these components. Servicing static-sensitive components or assemblies should be performed only at a static-free work station by qualified service personnel.

4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5. Keep the component leads shorted together whenever possible.

6. Pick up components by their bodies, never by their leads.

Table 6-1
Susceptibility to Static Discharge Damage

Semiconductor Classes	Relative Susceptibility Levels[a]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a]**Voltage equivalent for levels: (Voltage discharged from a 100 pF capacitor through a resistance of 100 Ω.)**

1 = 100 to 500 V	**4 = 500 V**	**7 = 400 to 1000 V(est.)**
2 = 200 to 500 V	**5 = 400 to 600 V**	**8 = 900 V**
3 = 250 V	**6 = 600 to 800 V**	**9 = 1200 V**

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work-surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only approved antistatic, vacuum-type desoldering tools for component removal.

PREVENTIVE MAINTENANCE

INTRODUCTION

Preventive maintenance consists of cleaning, visual inspection, and checking instrument performance. When accomplished regularly, it may prevent instrument malfunction and enhance instrument reliability. The severity of the environment in which the instrument is used determines the required frequency of maintenance. An appropriate time to accomplish preventive maintenance is just before instrument adjustment.

GENERAL CARE

The cabinet minimizes accumulation of dust inside the instrument and should normally be in place when operating the 2465. The front cover supplied with the instrument provides both dust and damage protection for the front panel and crt, and it should be on whenever the instrument is stored or is being transported.

INSPECTION AND CLEANING

The 2465 should be visually inspected and 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, prevent efficient heat dissipation. It also provides an electrical conduction path that could result in instrument failure, especially under high-humidity conditions.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use a nonresidue-type cleaner, preferably isopropyl alcohol or a solution of 1% mild detergent with 99% water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Exterior

INSPECTION. Inspect the external portions of the instrument for damage, wear, and missing parts; use Table 6-2 as a guide. Instruments that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Deficiencies found that could cause personal injury or could lead to further damage to the instrument should be repaired immediately.

Table 6-2
External Inspection Check List

Item	Inspect For	Repair Action
Cabinet, Lid, Front Panel	Cracks, scratches, deformations, damaged hardware or gaskets.	Touch up paint scratches and replace defective components.
Front-panel Controls	Missing, damaged, or loose knobs, buttons, and controls.	Repair or replace missing or defective items.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.	Replace defective parts. Clear or wash out dirt.
Carrying Handle	Correct operation.	Replace defective parts.
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors.	Replace damaged or missing items, frayed cables, and defective parts.

CAUTION

To prevent getting moisture inside the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

CLEANING. Loose dust on the outside of the instrument can be removed with a soft cloth or small soft-bristle brush. The brush is particularly useful for dislodging dirt on and around the controls and connectors. Dirt that remains can be removed with a soft cloth dampened in a mild detergent-and-water solution. Do not use abrasive cleaners.

Two plastic light filters, one blue and one clear, are provided with the oscilloscope. Clean the light filters and the crt face with a soft lint-free cloth dampened with either isopropyl alcohol or a mild detergent-and-water solution.

Interior

To gain access to internal portions of the instrument for inspection and cleaning, refer to the "Removal and Replacement Instructions" in the "Corrective Maintenance" part of this section.

INSPECTION. Inspect the internal portions of the 2465 for damage and wear, using Table 6-3 as a guide. Deficiencies found should be repaired immediately. The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

If any electrical component is replaced, conduct a Performance Check for the affected circuit and for other closely related circuits (see Section 4). If repair or replacement work is done on any of the power supplies, conduct a complete Performance Check and, if so indicated, an instrument readjustment (see Sections 4 and 5).

Table 6-3
Internal Inspection Check List

Item	Inspect For	Repair Action
Circuit Boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Clean solder corrosion with an eraser and flush with isopropyl alcohol. Resolder defective connections. Determine cause of burned items and repair. Repair defective circuit runs.
Resistors	Burned, cracked, broken, blistered.	Replace defective resistors. Check for cause of burned component and repair as necessary.
Solder Connections	Cold solder or rosin joints.	Resolder joint and clean with isopropyl alcohol.
Capacitors	Damaged or leaking cases. Corroded solder on leads or terminals.	Replace defective capacitors. Clean solder connections and flush with isopropyl alcohol.
Semiconductors	Loosely inserted in sockets. Distorted pins.	Firmly seat loose semiconductors. Remove devices having distorted pins. Carefully straighten pins (as required to fit the socket), using long-nose pliers, and reinsert firmly. Ensure that straightening action does not crack pins, causing them to break off.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace defective wires or cables.
Chassis	Dents, deformations, and damaged hardware.	Straighten, repair, or replace defective hardware.

CAUTION

To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the instrument.

CLEANING. To clean the interior, blow off dust with dry, low-pressure air (approximately 9 psi). Remove any remaining dust with a soft brush or a cloth dampened with a solution of mild detergent and water. A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.

If these methods do not remove all the dust or dirt, the instrument may be spray washed using a solution of 5% mild detergent and 95% water as follows:

CAUTION

Exceptions to the following procedure are the Attenuator assemblies and the Front-Panel module. Clean these assemblies only with isopropyl alcohol as described in step 4.

1. Gain access to the parts to be cleaned by removing easily accessible shields and panels.

2. Spray wash dirty parts with the detergent-and-water solution; then use clean water to thoroughly rinse them.

3. Dry all parts with low-pressure air.

NOTE

Most of the switches used in the 2465 are sealed and the contacts are inaccessible. If cleaning is deemed necessary, use only isopropyl alcohol.

4. Clean switches with isopropyl alcohol and wait 60 seconds for the majority of the alcohol to evaporate. Then complete drying with low-pressure air.

5. Dry all components and assemblies in an oven or drying compartment using low-temperature (125° F to 150° F) circulating air.

LUBRICATION

There is no periodic lubrication required for this instrument.

SEMICONDUCTOR CHECKS

Periodic checks of the transistors and other semiconductors in the oscilloscope are not recommended. The best check of semiconductor performance is actual operation in the instrument.

PERIODIC READJUSTMENT

To ensure accurate measurements, check the performance of this instrument every 2000 hours of operation, or if used infrequently, once each year. In addition, replacement of components may necessitate readjustment of the affected circuits.

Complete Performance Check and Adjustment instructions are given in Sections 4 and 5. The Performance Check Procedure can also be helpful in localizing certain troubles in the instrument.

TROUBLESHOOTING

INTRODUCTION

Preventive maintenance performed on a regular basis should reveal most potential problems before an instrument malfunctions. However, should troubleshooting be required, the following information is provided to facilitate location of a fault. In addition, the material presented in the "Theory of Operation" and "Diagrams" sections of this manual may be helpful while troubleshooting.

TROUBLESHOOTING AIDS

Diagnostic Firmware

The operating firmware in this instrument contains diagnostic routines that aid in locating malfunctions. When instrument power is applied, power-up tests are performed to verify proper operation of much of the instrument's circuitry. If a failure is detected, this information is passed on to the operator in the form of either a crt readout or illuminated LED indicators. The failure information directs the operator to the failing block of circuitry. If the failure is such that the processor can still execute the diagnostic routines, the user can call up specific tests to further check the failing circuitry. The specific diagnostic routines are explained later in this section.

Schematic Diagrams

Complete schematic diagrams are located on tabbed foldout pages in the "Diagrams" section. Portions of circuitry mounted on each circuit board are enclosed by heavy black lines. The assembly number and name of the circuit are shown near either the top or the bottom edge of the diagram.

Functional blocks on schematic diagrams are outlined with a wide grey line. Components within the outlined area perform the function designated by the block label. The "Theory of Operation" uses these functional block names when describing circuit operation as an aid in cross-referencing between the theory and the schematic diagrams.

Component numbers and electrical values of components in this instrument are shown on the schematic diagrams. Refer to the first page of the "Diagrams" section for the reference designators and symbols used to identify components. Important voltages and waveform reference numbers (enclosed in hexagonal-shaped boxes) are also shown on each diagram. Waveform illustrations are located adjacent to their respective schematic diagram.

Circuit Board Illustrations

Circuit board illustrations showing the physical location of each component are provided for use in conjunction with each schematic diagram. Each board illustration is found in the "Diagrams" section on the back of a foldout page, preceding the first schematic diagram(s) to which it relates.

The locations of waveform test points are marked on the circuit board illustrations with hexagonal outlined numbers corresponding to the waveform numbers on both the schematic diagram and the waveform illustrations.

Circuit Board Locations

The placement in the instrument of each circuit board is shown in a board locator illustration. This illustration is located on the foldout page along with the circuit board illustration.

Power Distribution Diagrams

Power Distribution diagrams (diagrams 11 and 12) are provided in the "Diagrams" section to aid in troubleshooting power-supply problems.

Circuit Board Interconnection Diagram

A circuit board interconnection diagram (diagram 13) and tables listing the interconnecting pins and signals carried are provided in the "Diagram" section following the Power Distribution diagrams.

Grid Coordinate System

Each schematic diagram and circuit board illustration has a grid border along its left and top edges. A table located adjacent to each diagram lists the grid coordinates of each component shown on that diagram. To aid in physically locating components on the circuit board, this table also lists the grid coordinates of each component on the circuit board illustration.

Near each circuit board illustration is an alphanumeric listing of all components mounted on that board. The second column in each listing identifies the schematic diagram on which each component can be found. These component-locator tables are especially useful when more than one schematic diagram is associated with a particular circuit board.

Troubleshooting Charts

The troubleshooting charts contained in the "Diagrams" section are to be used as an aid in locating malfunctioning circuitry. To use the charts, begin with the Preliminary Tests flowchart. This chart will help identify problem areas and will direct you to other appropriate charts for further troubleshooting.

Some malfunctions, especially those involving multiple simultaneous failures, may require more elaborate troubleshooting approaches with references to circuit descriptions in the "Theory of Operation" section of this manual.

Component Color Coding

Information regarding color codes and markings of resistors and capacitors is located on the color-coding illustration (Figure 9-1) at the beginning of the "Diagrams" section.

RESISTOR COLOR CODE. Resistors used in this instrument are carbon-film, composition, or precision metal-film types. They are usually color coded with the EIA color code; however, some metal-film type resistors may have the value printed on the body. The color code is interpreted starting with the stripe nearest to one end of the resistor. Composition resistors have four stripes; these represent two significant digits, a multiplier, and a tolerance value. Metal-film resistors have five stripes representing three significant digits, a multiplier, and a tolerance value.

CAPACITOR MARKINGS. Capacitance values of common disc capacitors and small electrolytics are marked on the side of the capacitor body. White ceramic capacitors are color coded in picofarads, using a modified EIA code.

Dipped tantalum capacitors are color coded in microfarads. The color dot indicates both the positive lead and the voltage rating. Since these capacitors are easily destroyed by reversed or excessive voltage, be careful to observe the polarity and voltage rating when replacing them.

DIODE COLOR CODE. The cathode end of each glass-encased diode is indicated by either a stripe, a series of stripes or a dot. For most diodes marked with a series of stripes, the color combination of the stripes identifies three digits of the Tektronix Part Number, using the resistor color-code system. The cathode and anode ends of a metal-encased diode may be identified by the diode symbol marked on its body.

Semiconductor Lead Configurations

Figure 9-2 in the "Diagrams" section shows the lead configurations for semiconductor devices used in the instrument. These lead configurations and case styles are typical of those used at completion of the instrument design. Vendor changes and performance improvement changes may result in changes of case styles or lead configurations. If the device in question does not appear to match the configuration shown in Figure 9-2, examine the associated circuitry or consult a manufacturer's data sheet.

Multipin Connectors

Multipin connector orientation is indexed by two triangles; one on the holder and one on the circuit board. Slot numbers are usually molded into the holder. When a connection is made to circuit board pins, ensure that the index on the holder is aligned with the index on the circuit board (see Figure 6-1).

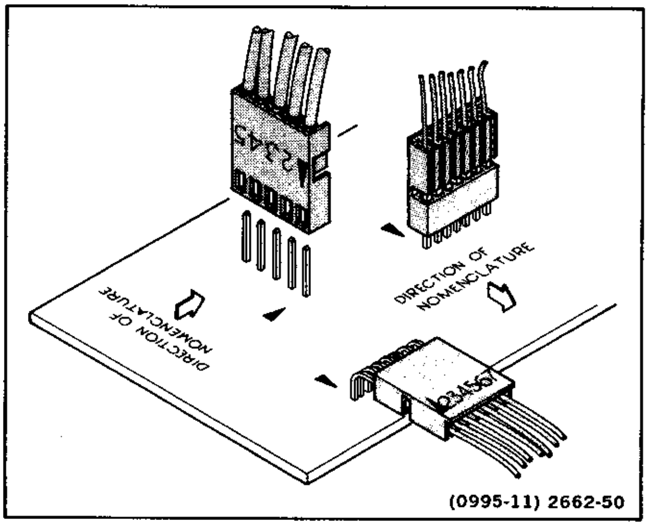

Figure 6-1. Multipin connector orientation.

TROUBLESHOOTING EQUIPMENT

The equipment listed in Table 4-1 of this manual, or equivalent equipment, may be useful when troubleshooting this instrument.

TROUBLESHOOTING TECHNIQUES

The following procedure is arranged in an order that enables checking simple trouble possibilities before requiring more extensive troubleshooting. The first two steps use diagnostic aids inherent in the instrument's operating firmware and will locate many circuit faults. The next four procedures are check steps that ensure proper control settings, connections, operation, and adjustment. If the trouble is not located by these checks, the remaining steps will aid in locating the defective component. When the defective component is located, replace it using the appropriate replacement procedure given under "Corrective Maintenance" in this section.

CAUTION

Before using any test equipment to make measurements on static-sensitive, current-sensitive, or voltage-sensitive components or assemblies, ensure that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

1. Power-up Tests

The 2465 performs automatic verification of much of the instrument's circuitry when power is first applied. The "Kernel" tests verify proper operation of the Microprocessor, the ROM, and the RAM. If all Kernel tests pass, a second level of checks, the "Confidence" tests, are performed. The Confidence tests, when passed, give the user a high degree of assurance that the instrument is functioning properly.

If a Kernel test or Confidence test fails, the area of failure is identified either by a message on the crt (if the instrument is able to produce a display) or by an error code displayed on the front-panel LED indicators. If a failure occurs, refer to the "Diagnostic Routines" discussion later in this section for definitions of error messages and LED error codes.

Once a problem area has been identified, the associated troubleshooting procedure should be performed to further isolate the problem. The troubleshooting procedures are located on tabbed-foldout pages in the "Diagrams" section at the rear of this manual.

2. Diagnostic Test and Exerciser Routines

Each of the tests automatically performed at power up, along with several other circuit exercising routines, may be individually selected by the user to further clarify the nature of a suspected failure. The desired test or exerciser is selected by "scrolling" through a menu of the available routines when under control of the "Diagnostic Monitor." Entry into the Diagnostic Monitor and its uses are explained in the "Diagnostic Routines" discussion later in this section.

3. Check Control Settings

Incorrect control settings can give a false indication of instrument malfunction. If there is any question about the correct function or operation of any control, refer to either the "Operating Information" in Section 2 of this manual or to the 2465 Operators Manual.

4. Check Associated Equipment

Before proceeding, ensure that any equipment used with the 2465 is operating correctly. Verify that input signals are properly connected and that the interconnecting cables are not defective. Check that the ac-power-source voltage to all equipment is correct.

5. Visual Check

Perform a visual inspection. This check may reveal broken connections or wires, damaged components, semiconductors not firmly mounted, damaged circuit boards, or other clues to the cause of an instrument malfunction.

6. Check Instrument Performance and Adjustment.

Check the performance of either those circuits where trouble appears to exist or the entire instrument. The apparent trouble may be the result of misadjustment. Complete performance check and adjustment instructions are given in Sections 4 and 5 of this manual.

7. Isolate Trouble to a Circuit

To isolate problems to a particular area, use any symptoms noticed to help locate the trouble. Refer to the troubleshooting charts in the "Diagrams" section as an aid in locating a faulty circuit.

When trouble symptoms appear in more that one circuit, first check the power supplies; then check the affected circuits by taking voltage and waveform readings. Check first for the correct output voltage of each individual supply. These voltages are measured between the power supply test points and ground (see schematic diagrams 8, 9, and 10, and associated circuit board illustrations in the "Diagrams" section). If the power-supply voltages and ripple are within the listed ranges, the supply can be assumed to be working correctly. If they are outside the range, the supply may be either misadjusted or operating incorrectly.

The Low Voltage Power Supply levels are interdependent. All the low voltage supplies use the +10 V reference for their reference levels. If more that one of the low voltage supplies appears defective, repair them in the following order: +10 V REF, +5 V Digital, +87 V, +42 V, +15 V, +5 V Analog, −15 V, −8 V, and −5 V.

A defective component elsewhere in the instrument can create the appearance of a power-supply problem and may also affect the operation of other circuits. Use the power supply troubleshooting charts to aid in locating the problem.

8. Check Circuit Board Interconnections

After the trouble has been isolated to a particular circuit, again check for loose or broken connections, improperly seated semiconductors, and heat-damaged components.

9. Check Voltages and Waveforms

Often the defective component can be located by checking circuit voltages or waveforms. Typical voltages are listed on the schematic diagrams. Waveforms indicated on the schematic diagrams by hexagonal-outlined numbers are shown adjacent to the diagrams. Waveform test points are shown on the circuit board illustrations.

NOTE

Voltages and waveforms indicated on the schematic diagrams are not absolute and may vary slightly between instruments. To establish operating conditions similar to those used to obtain these readings, see the voltage and waveform setup conditions preceding the waveform illustrations.

Note the recommended test equipment, front-panel control settings, voltage and waveform conditions, and cable-connection instructions. Any special control settings required to obtain a given waveform are noted under the waveform illustration. Changes to the control settings from the initial setup, other than those noted, are not required.

10. Check Individual Components

The following procedures describe methods of checking individual components. Two-lead components that are soldered in place are most accurately checked by first disconnecting one end from the circuit board. This isolates the measurement from the effects of the surrounding circuitry. See Figure 9-1 for component value identification and Figure 9-2 for semiconductor lead configurations.

WARNING

To avoid electric shock, always disconnect the instrument from the ac power source before removing or replacing components.

CAUTION

When checking semiconductors, observe the static-sensitivity precautions located at the beginning of this section.

TRANSISTORS. A good check of a transistor is actual performance under operating conditions. A transistor can most effectively be checked by substituting a known-good component. 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-type transistor checker for testing. Static-type transistor checkers are not recommended, since they do not check operation under simulated operating conditions.

When troubleshooting transistors in the circuit with a voltmeter, measure both the emitter-to-base and emitter-to-collector voltages to determine whether they are consistent with normal circuit voltages. Voltages across a transistor may vary with the type of device and its circuit function.

Some of these voltages are predictable. The emitter-to-base voltage for a conducting silicon transistor will normally range from 0.6 V to 0.8 V. The emitter-to-collector voltage for a saturated transistor is about 0.2 V. Because these values are small, the best way to check them is by connecting a sensitive voltmeter across the junction rather than comparing two voltages taken with respect to ground. If the former method is used, both leads of the voltmeter must be isolated from ground.

If voltage values measured are less that those just given, either the device is shorted or no current is flowing in the external circuit. If values exceed the emitter-to-base values given, either the junction reverse biased or the device is defective. Voltages exceeding those given for typical emitter-to-collector values could indicate either a nonsaturated device operating normally or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across the resistors in series with it; if open, no voltage will be developed across the resistors unless current is being supplied by a parallel path.

CAUTION

When checking emitter-to-base junctions, do not use an ohmmeter range that has a high internal current. High current may damage the transistor. Reverse biasing the emitter-to-base junction with a high current may degrade the current-transfer ratio (Beta) of the transistor.

A transistor emitter-to-base junction also can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter set to a range having a low internal source current, such as the R X 1 kΩ range. The junction resistance should be very high in one direction and much lower when the meter leads are reversed.

When troubleshooting a field-effect transistor (FET), the voltage across its elements can be checked in the same manner as previously described for other transistors. However, remember that in the normal depletion mode of operation, the gate-to-source junction is reverse biased; in the enhanced mode, the junction is forward biased.

INTEGRATED CIRCUITS. An integrated circuit (IC) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential when troubleshooting a circuit having IC components. Use care when checking voltages and waveforms around the IC so that adjacent leads are not shorted together. An IC test clip provides a convenient means of clipping a test probe to an IC.

HYBRIDS. Hybrid components can best be checked by observing voltages and waveforms on the circuit board. Measurements should not be made on any hybrid component while out of the circuit as they may easily be damaged. Direct substitution is the best troubleshooting method when a hybrid failure is suspected.

CAUTION

When checking a diode, do not use an ohmmeter scale that has a high internal current. High current may damage a diode. Checks on diodes can be performed in much the same manner as those on transistor emitter-to-base junctions. Do not check tunnel diodes or back diodes with an ohmmeter; use a dynamic tester, such as the TEKTRONIX 576 Curve Tracer.

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

Silicon diodes should have 0.6 to 0.8 V across their junctions when conducting. Higher readings indicate that they are either reverse biased or defective, depending on polarity.

RESISTORS. Check resistors with an ohmmeter. Refer to the "Replaceable Electrical Parts" list for the tolerances of resistors used in this instrument. A resistor normally does not require replacement unless its measured value varies widely from its specified value and tolerance.

INDUCTORS. Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by check the waveform response when high-frequency signals are passed through the circuit.

CAPACITORS. A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter set to one of the highest ranges. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after the capacitor is charged to the output voltage of the ohmmeter. An open capacitor can be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

ATTENUATORS. The Attenuators are built as complete assemblies and should not be taken apart. If an Attenuator is suspected as having failed, direct substitution is the recommended troubleshooting method.

11. Repair and Adjust the Circuit.

If any defective parts are located, follow the replacement procedures given under "Corrective Maintenance" in this section. After any electrical component has been replaced, the performance of that circuit and any other closely related circuit should be checked. Since the power supplies affect all circuits, performance of the entire instrument should be checked if work has been done on the power supplies or if the power transformer has been replaced. Readjustment of the affected circuitry may be necessary . Refer to the "Performance Check" and "Adjustment Procedure", Sections 4 and 5 of this manual.

DIAGNOSTIC ROUTINES

The diagnostic routines contained in the 2465 operating firmware consist of the various power-up tests that are automatically performed when power is first applied and several circuit exerciser routines. The test or exerciser routines are selected by "scrolling" through a menu of available routines when the firmware is under control of the Diagnostic Monitor. Monitor control is indicated by the message "DIAGNSTIC. PUSH A/B TRIG TO EXIT" displayed in the top crt graticule division.

Entry into the monitor is automatic if a power-up test fails. The user may also force entry into the Diagnostic Monitor from the normal operating mode by holding in the front-panel ΔV and Δt push buttons and then pressing the front-panel SLOPE push button. Exiting the monitor is accomplished by pressing in the A/B TRIG push button, as instructed by the crt readout display.

Depending on how the Diagnostic Monitor was entered (from normal mode or as a result of a power-up test failure), the first menu item displayed may vary; entry into the monitor from the normal mode begins at ALL TESTS while entry from power up starts at the first failed test. Since, in a failure mode, the crt readout may not be able to display the selected menu item, the VERT TRIGGER SOURCE indicator illuminates as a reference when ALL TESTS is selected. With the VERT TRIGGER SOURCE indicator illuminated, the user may scroll to the desired test or exerciser routine using the test order called out in Table 6-4. Whether the menu is displayed or not, scrolling is accomplished by pressing the front-panel TRIGGER MODE switch either up to increment or down to decrement the menu position by one.

Table 6-4

Sequence of Diagnostic Tests and Exerciser Routines

Routine Type	Type Number	Routine Name	Error Code	Error Code Meaning
All Tests[a]	00	All	ZZ	The left digit is the option number and the right digit is the test number of the first failing test of the last ALL TESTS run. When looping, it shows the last failing test.
Test	01	Interrupt Request	01	Interrupt request is missing or has wrong period.
Test	02	Switch Stuck	01 02 08 10 28 30 44 48 50 61 62 64 68 70[b]	Trigger COUPLING down. Trigger COUPLING up. CH 1 Coupling down. CH 1 Coupling up. CH 2 Coupling down. CH 2 Coupling up. Δ t (delta time). Δ V (delta volts). Trigger SLOPE Trigger SOURCE down. Trigger SOURCE up. Trigger MODE down. Trigger MODE up. A/B TRIG select.
Test	03	Readout Board	01 02	Shift register failure. Readout RAM failure.
Test	04	EAROM	X1 X8 1X	Parity error on read (bit 0 set). Bad read after write (bit 3 set). Bad checksum (bit 4 set).
Test	05	Main Board	01 X2 X4 2X 4X	AUTO LVL failed to trigger. Negative level not negative enough. Negative level too negative. Positive level not positive enough. Positive level too positive.
Exerciser	01	Pots and Switches	None	
Exerciser	02	EAROM Examine	None	
Exerciser	03	Cycle Error Clear	None	
Exerciser	04	Display ROM Headers	None	

[a]VERT TRIG SOURCE indicator lights when in ALL TESTS as a visual reference in the event a crt display can not be produced.

[b]If the A/B TRIG switch is stuck on power up, the oscilloscope will branch to "normal" operation after a short delay. The associated error message will only be visible momentarily if the crt is warmed-up.

Routine Control

When the desired Test or Exerciser has been selected, the operator has two types of control that may be exercised over the routine: START/STOP and LOOP.

Starting or stopping the execution of the selected routine is controlled by the front-panel TRIGGER COUPLING switch. Pressing the switch up starts the routine; pressing it down stops it.

All of the test routines, except EAROM—TEST 04, may be set to LOOP mode (continuously repeated) by pressing the front-panel TRIGGER SOURCE switch up while the routine is selected but not executing. The LOOP feature will cause the routine to be continuously repeated once started until stopped when the operator presses the COUPLING switch down. Once the routine is stopped, the LOOP feature may be disabled by pressing the SOURCE switch down.

While a Test or Exerciser routine is executing, the Diagnostic Monitor Control message on the top line of the crt display will be cleared as an indication that a routine is running. When test routines are looping, the message "LOOP" is displayed in the bottom division of the crt graticule.

Display Format

The Tests and Exercisers routines display information about the routine type and number, as well as any test results, at the bottom of the crt display. The readout line is formatted as follows:

OD TYPE XY STATUS ZZ LOOP OD<ABCC>

The information is defined as follows:

"OD" is a two-character option designator identifying the option that this particular line of diagnostic information refers to (see Options manual for details). For the basic instrument, the OD location is blank.

"TYPE" refers to routine type: All Tests (ALL), Test (TEST), Exerciser (EXER), or Calibration (CAL).

"X" indicates which bit of the "Option Select Register" is set to turn on the option called out by "OD" (see Options manual for description of Options Select Register). This bit is zero for the basic instrument.

"Y" is the TYPE number of the routine (see the "Type Number" column of Table 6-4).

"STATUS" shows the results of the last time a selected test routine ran: either PASS or FAIL. This space is blank for exerciser and calibration routines. When the diagnostics are called up from normal operating mode, the space will be blank until the selected test is executed.

"ZZ" is a two-digit error code identifying the nature of the failure in a failed test (see the "Error Code" column of Table 6-4).

"LOOP" indicates when a selected test is set to the LOOP mode.

"OD<ABCC>" is the CYCLE mode failure indicator. When the CYCLE mode is activated (see CYCLE ERROR CLEAR description), data will be written to the EAROM about the first test failure that occurs. This information will be displayed until the operator performs the CYCLE ERROR CLEAR routine (Exerciser 03). The information displayed is an abbreviated version of the previous items:

"OD" is a two-character option designator showing which option failed first while in the CYCLE mode (the same codes as for "OD" at the start of the readout line).

"A" identifies the option-select bit for the failing option (the same code as for "X").

"B" is the test Type Number where the failure occurred (the same codes as for "Y").

"CC" is the error code for the test (the same codes as for "ZZ").

Kernel Tests

The Kernel tests are those tests which, when failed, are considered "fatal" to the operation of the Microprocessor. Failure of a Kernel test will cause the front-panel TRIG'D indicator to flash, and certain of the other front-panel indicators will be illuminated with an error code. The code points to the area of failure as indicated in Table 6-5. Tables 6-6 and 6-7 are used to determine the option and device numbers used in Table 6-5. Only the basic instrument codes are given in Table 6-5. Option codes are defined in the "Options Service Manual."

Table 6-5
Kernel Test Failure Codes

Failure Codes		
Option	Device	Failing Device
0	0	Control Board RAM
0	1	ROM at E000 (hex)
0	2	ROM at C000 (hex)
0	3	ROM at A000 (hex)
0	4	ROM at 9000 (hex)

Table 6-6
Front-Panel LED Option Codes

Option Code					
CH 1 LED (bit 3)	CH 2 LED (bit 2)	CH 3 LED (bit 1)	CH 4 LED (bit 0)	Option Number (in hex)	Option Name
OFF	OFF	OFF	OFF	0	Basic Instrument
ON	ON	ON	ON	F	Options Buffer Board

Table 6-7
Front-Panel LED Device Codes

	Device Code		
READY LED (bit 2)	+ LED (bit 1)	− LED (bit 0)	Device Number
OFF	OFF	OFF	0
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6
ON	ON	ON	7

Even if a Kernel test fails, the operator may try to go to normal oscilloscope operation by pressing the A/B TRIG select push button. Depending on the exact nature of the failure, the instrument may or may not be functional.

Kernel tests are automatically executed at power up. The Kernel tests are divided into RAM tests and ROM tests as follows:

RAM TEST. This test is a complete march test. The RAM is first filled with zeros. The first location is then read, checking that only zeros are present. (In later cycles this ensures that a previous write hasn't written to the location.) A "1" is walked through each bit of the addressed location and read back after each write to ensure only one bit at a time changes. Each of the succeeding address locations is read, then written to in the same way until the RAM is filled with ones. After the RAM is filled, a "0" is walked through each bit location in a similar manner.

Test checks: RAM address decoding, RAM address lines, RAM data lines, and Data Bus Buffers.

ROM TEST. The ROM test performs three checks on each of the system read-only memories.

Data Bus Drive—Two locations containing complementary data patterns are read.

Test checks: Data bus lines and the Data Bus Driver.

Correct Part—A byte in the ROM being checked is compared to the most-significant byte of the addressed ROM block (starting address of where the ROM should be installed).

Test checks: ROM address decoding and proper installation of ROM components.

Checksum—A sixteen bit, spiral-add checksum is calculated and compared to a two-byte value stored in ROM being checked.

Test checks: ROM contents, ROM addressing, ROM data lines, and the Data Bus Driver.

Confidence Tests

The Confidence tests provide checks for much of the remaining circuitry to ensure that instrument operation is correct. Confidence tests are performed automatically at power up after the Kernel is determined to be functional or initiated by the operator from the Diagnostic Monitor.

A failure of any Confidence test during power up will pass control to the Diagnostic Monitor; this permits the test results to be examined. Descriptions of the Confidence tests follow.

INTERRUPT REQUEST (Test 01). Ten consecutive interrupt cycles are checked to ensure that succeeding interrupts occur not more than 4.5 ms apart (5600 "E" cycles).

Test checks: Interrupt Timer circuitry.

SWITCH STUCK (Test 02). The front-panel, momentary-contact switches are scanned, checking for a closed switch. At power up, the test runs immediately.

By holding one of the momentary switches in a closed position when power is first applied, this test will fail, and the Diagnostic Monitor will be entered. When the test is started from the Diagnostic Monitor, a one-half second delay is incorporated to allow the COUPLING (test start) switch to return to its normal (open) position. Table 6-4 defines the error codes that may be encountered when a switch is detected as closed.

NOTE

When the user presses the COUPLING switch to stop this test, an error code may be generated. This is normal and does not indicate an actual failure.

Test checks: Momentary switches, row scanning circuitry, and column scanning circuitry.

READOUT BOARD (Test 03). This two-part test checks the interface to the Readout Board from the Microprocessor and the character RAM circuits.

Processor Interface Test—The Microprocessor loads the three, eight-bit shift registers with an alternating bit pattern that is then shifted back to the processor for comparison.

Test checks: Data Registers, data strobes (clocks), and the data input and output lines.

RAM Test—A "1" is rotated through each byte of the Readout RAM, one bit at a time. Each time an additional bit is rotated into the byte, the byte is loaded into the processor interface and clocked back to the processor for comparison. The byte is then restored to its original content, and each successive byte is tested in the same manner.

Test checks: Readout RAM addressing, Readout RAM data lines, and RAM read/write capability.

EAROM (Test 04). Three checks are performed on the EAROM to verify its contents and the interface circuitry.

Read/Write Test—The contents of one location are read, modified, and then reread to verify functioning of the device interface.

Test checks: EAROM input and output lines, EAROM mode control, EAROM reading and writing, and the EAROM clock.

Checksum Test—The contents of locations containing calibration constants are checksummed using a sprial-add technique. The result is compared to the contents of location 0 (the checksum generated at the time of calibration).

Test checks: EAROM addressing and EAROM contents.

Parity Test—As each of the calibration constants is read for the Checksum test above, the parity of each 14-bit word is checked.

Test checks: EAROM data retention and EAROM reading.

MAIN BOARD (Test 05). The AUTO LVL triggering feature (a routine stored in firmware) is operated to detect the peaks of a Line Trigger signal. Detected peaks are compared to expected values to verify operation (and calibration) of interrelated signal processing circuits.

Test checks: Line Trigger source, the A Trigger generation circuitry, and Control DAC U2234 (located on the Control board).

Exerciser Routines

The Exerciser routines allow the operator to set and examine various bytes of control data used in determining instrument function.

POTS AND SWITCHES (Exerciser 01). This routine displays the values that the Microprocessor detects as the various digitized pots and switches are activated. The top line of the crt display has the following format:

AA BB CC DEEE FF GG HI JJ KL

The format is defined as follows:

"AA" is the code of the most-recently-activated potentiometer (see Table 6-8 for definition of pot codes).

"BB" is the current value (in hexadecimal) of pot AA.

"CC" is the previous value (in hexadecimal) of pot AA.

"D" is the DAC Multiplexer code used to select pot AA (see Table 6-9).

"EEE" is the DAC value (in hexadecimal) associated with pot AA.

"FF" is the code of the previously-activated potentiometer (see Table 6-8).

"GG" is the row code of the most-recently-activated switch (see Table 6-10 for definition of row codes).

"H" is the switch-position code: 0 for open; C for closed.

"I" is the column code of the most-recently-activated switch (see Table 6-10).

"JJ" is the row for for the previously-activated switch.

"K" is the switch-position code: 0 for open; C for closed.

"L" is the column code for the previously-activated switch.

NOTE

For all momentary switches (except A/B TRIG) only the closed position will be shown in the switch-position code locations (H and K). The A/B TRIG switch has both the open and the closed positions shown.

Table 6-8

Potentiometer Code Numbers

Code Number	Potentiometer
01	HOLDOFF
02	Trigger LEVEL
03	SEC/DIV VAR
04	Horizontal POSITION
05	Δ (A section)
06	Δ (B section)
07	Δ REF OR DLY POS (A section)
08	Δ REF OR DLY POS (B section)
09	CH 1 VOLTS/DIV VAR
0A	CH 2 VOLTS/DIV VAR

Table 6-9

DAC Multiplexer "D" Codes

D Code	Control Indicated
0	CH 1 VOLTS/DIV VAR
1	A SEC/DIV VAR
2	CH 2 VOLTS/DIV VAR
3	A Trigger LEVEL
5	Horizontal POSITION
6	HOLDOFF

NOTE

In the case of the Δ REF OR DLY POS and Δ controls, the D code position shows the two most-significant bits of the 14-bit DAC output (in hexadecimal).

Table 6-10

Pots and Switches Column and Row Code Definitions

Row Code	Column Code	Definition	Row Code	Column Code	Definition
0	0	Trig COUPLING Down	5	0	B SEC/DIV LSB
0	1	Trig COUPLING Up	5	1	B SEC/DIV Bit 2
0	2	Unused	5	2	B SEC/DIV Bit 3
0	3	CH 1 Coupling Down	5	3	B SEC/DIV Bit 4
0	4	CH 1 Coupling Up	5	4	B SEC/DIV MSB
1	0	CH 4 VOLTS/DIV	6	0	CH 1 VERT MODE
1	1	CH 3 VOLTS/DIV	6	1	CH 2 VERT MODE
1	2	Unused	6	2	ADD VERT MODE
1	3	CH 2 Coupling Down	6	3	CH 3 VERT MODE
1	4	CH 2 Coupling Up	6	4	CH 4 VERT MODE
2	0	CH 1 VOLTS/DIV LSB	7	0	Unused
2	1	CH 1 VOLTS/DIV Bit 2	7	1	B ENDS A
2	2	CH 1 VOLTS/DIV Bit 3	7	2	Unused
2	3	CH 1 VOLTS DIV MSB	7	3	CHOP/ALT
2	4	CH 2 INVERT	7	4	BW LIMIT
3	0	CH 2 VOLTS/DIV LSB	8	0	X10 MAG
3	1	CH 2 VOLTS/DIV Bit 2	8	1	TRACKING/INDEP
3	2	CH 2 VOLTS/DIV Bit 3	8	2	Δ t
3	3	CH 2 VOLTS/DIV MSB	8	3	ΔV
3	4	Horiz Display Select	8	4	Trig SLOPE
4	0	A SEC/DIV LSB	9	0	Trig SOURCE Down
4	1	A SEC/DIV Bit 2	9	1	Trig SOURCE Up
4	2	A SEC/DIV Bit 3	9	2	Trig MODE Down
4	3	A SEC/DIV Bit 4	9	3	Trig MODE Up
4	4	A SEC/DIV MSB	9	4	A/B TRIG Select

EAROM EXAMINE (Exerciser 02). This routine allows the operator to examine the contents of any or all EAROM locations. The EAROM has 100 (decimal) locations (63 hexadecimal). Addresses above 63 (hex) are not defined. When entered, the Exerciser displays the contents of EAROM location 00 (hex) on the top line of the crt display. Calibration constants reside between addresses 01 (hex) and 4C (hex) and each should have odd parity as explained below. The remaining locations may be of either parity. The readout display line has the following format:

AA DDDD P

The format is defined as follows:

"AA" is the eight-bit address in hexadecimal notation.

"DDDD" is the 14-bit word stored at that location (13 bits of data and one parity bit).

"P" is a parity indicator for the data word: X indicates even parity; blank is odd parity.

Pushing the MODE switch up or down will increment or decrement the EAROM address by 16 (10 hex) respectively. Similarly, pushing the SOURCE switch up or down will increment or decrement the address by 1 respectively.

CYCLE ERROR CLEAR (Exerciser 03). This routine provides a way for the operator to clear the cycle-failure data written to the EAROM when a CYCLE mode failure occurs. Until the data is cleared, each time the instrument is powered up, the Diagnostic Monitor is entered and a diagonal line is display across the crt.

CYCLE mode, when entered by removing the CAL/NO CAL jumper (P501), causes the instrument to continuously

LOOP through the Power Up Diagnostic Tests (except for EAROM—Test 04). If a failure occurs, the cycle-failure data, identifying the first failure encountered, is written to a specific location in the EAROM. Thereafter, at each power up, the Diagnostic Monitor is automatically entered, and the failure data is displayed even when the instrument is returned to the normal operating configuration (CAL/NO CAL jumper in the NO CAL position). Intepretation of the cycle failure data is explained in the "Display Format" description provided earlier in this section. The error data must be cleared from the EAROM location to eliminate the CYCLE mode error display.

Clearing the EAROM location is done by scrolling to the EAROM CLEAR exerciser and pressing the following switches in sequence:

COUPLING up (starts exerciser),
SOURCE down,
MODE down, then
COUPLING down.

When the EAROM CLEAR routine is successfully executed, the cycle failure data and the diagonal line will disappear from the display.

DISPLAY ROM HEADERS (Exerciser 04). This routine displays the Standard Tektronix ROM Header of each system ROM on the top line of the crt display. The readout line has the following format:

CCCC PPPP SS AAAA

The definition of the format is as follows:

"CCCC" is a two-byte hexadecimal checksum.

"PPPP" is the four middle digits of the ROM part number.

"SS" is the suffix of the ROM part number (version number).

"AAAA" is the starting address of the ROM (address where the ROM should be installed).

Pressing the COUPLING switch up increments the routine to the next ROM Header; pressing it down exits the routine.

CONTROLLER LATCHES EXERCISER. This routine is not user selectable, but it runs automatically when the Diagnostic Monitor is waiting for a key activation.

The routine first sets latches U2034 and U2134 (diagram 2). It then pulses the BSWPCLK line (pin 13 of U2596, diagram 1), as a scope trigger, and rotates a "0" through 15 of the 16 latched bits. Bit 16 is not set since it would reset Interrupt Timer U2268 (diagram 1) and upset processor interrupt timing. By externally triggering a test oscilloscope on the BSWPCLK signal line and observing the shifted timing relationships of the latched signals, proper operation of the DAC latches may be verified.

NOP KERNEL EXERCISER. This exerciser is not a firmware routine, but rather a forced hardware condition. It is best suited for troubleshooting an inoperative Control Board, as it exercises only the Microprocessor address bus and the associated Address Decode circuitry. By moving Jumper P503 (diagram 1) to the Diagnostic position, Data Bus Buffers U2194 and U2294 are disabled, and the Microprocessor is forced into a NOP (no operation) loop. This causes the address on the address bus to be continuously incremented for exercising the Address Decode circuitry. Troubleshooting of kernel addressing with an oscilloscope or logic analyzer is then possible.

CORRECTIVE MAINTENANCE

INTRODUCTION

Corrective maintenance consists of component replacement and instrument repair. This part of the manual describes special techniques and procedures required to replace components in this instrument. If it is necessary to ship your instrument to a Tektronix Service Center for repair or service, refer to the "Instrument Repackaging Instructions" in Section 2.

MAINTENANCE PRECAUTIONS

To reduce the possibility of personal injury or instrument damage, observe the following precautions.

1. Disconnect the instrument from the ac power source before removing or installing components.

2. Verify that the line-rectifier filter capacitors are discharged prior to performing any servicing.

3. Use care not to interconnect instrument grounds which may be at different potentials (cross grounding).

4. When soldering on circuit boards or small insulated wires, use only a 15-watt, pencil-type soldering iron.

OBTAINING REPLACEMENT PARTS

Most electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can usually be obtained from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., please check the "Replaceable Electrical Parts" list for the proper value, rating, tolerance, and description.

NOTE

Physical size and shape of a component may affect instrument performance, particularly at high frequencies. Always use direct-replacement components, unless it is known that a substitute will not degrade instrument performance.

Special Parts

In addition to the standard electronic components, some special parts are used in the 2465. These components are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. The various manufactures can be identified by referring to the "Cross Index-Manufacturer's Code number to Manufacturer" at the beginning of the "Replaceable Electrical Parts" list. Many of the mechanical parts used in this instrument were manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts

When ordering replacement parts from Tektronix, Inc., be sure to include all of the following information:

1. Instrument type (include modification or option numbers).

2. Instrument serial number.

3. A description of the part (if electrical, include its full circuit component number)

4. Tektronix part number.

MAINTENANCE AIDS

The maintenance aids listed in Table 6-11 include items required for performing most of the maintenance procedures in this instrument. Equivalent products may be substituted for the examples given, provided their characteristics are similar.

Table 6-11

Maintenance Aids

Description	Specification	Usage	Example
1. Soldering Iron	15 to 25 W.	General soldering and unsoldering.	Antex Precision Model C.
2. Flat-bit Screwdriver	3-inch shaft, 3/32-inch bit.	Assembly and disassembly.	Xcelite Model R3323.
3. Torx Screwdriver	Tip sizes: #T9, #T10, #T15, #T20.	Assembly and disassembly.	Tektronix Part Numbers #T9 003-0965-00 #T10 003-0815-00 #T15 003-0966-00 #T20 003-0866-00
4. Nutdrivers	3/16 inch, 1/4 inch.	Assembly and disassembly	Xcelite #6 and #8.
5. Open-end Wrenches	1/4 inch, 5/16 inch, 7/16 inch	Assembly and disassembly.	
6. Allen Wrenches	0.050 inch, 1/16 inch	Assembly and disassembly.	
7. Long-nose Pliers		Component removal and replacement.	Diamolloy Model LN55-3.
8. Diagonal Cutters		Component removal and replacement.	Diamalloy Model M554-3.
9. Vacuum Solder Extractor	No static charge retention.	Unsoldering static sensitive devices and components on multilayer boards.	Pace Model PC-10.
10. Spray Cleaner	No-Noise	Switch and Pot cleaning.	Tektronix Part Number 006-0442-02.
11. Pin-replacement Kit		Replace circuit board connector pins	Tektronix Part Number 040-0542-00.
12. IC-Removal Tool		Removing DIP IC packages.	Augat T114-1.
13. Isopropyl Alcohol	Reagent grade.	Cleaning attenuator and front panel assemblies.	2-Isopropanol.

INTERCONNECTIONS

Interconnection in this instrument are made with pins soldered onto the circuit boards. Several types of mating connectors are used for the interconnecting pins. The following information provides the replacement procedures for the various type connectors.

End-Lead Pin Connectors

Pin connectors used to connect the wires to the interconnect pins are factory assembled. They consist of machine-inserted pin connectors mounted in plastic holders. If the connectors are faulty, the entire wire assembly should be replaced.

Multipin Connectors

When pin connectors are grouped together and mounted in a plastic holder, they are removed, reinstalled, or replaced as a unit. If any individual wire or connector in the assembly is faulty, the entire cable assembly should be replaced. To provide correct orientation of a multipin connector, an index arrow is stamped on the circuit board, and either a matching arrow is molded into or the numeral 1 is marked on the plastic housing as a matching index. Be sure these index marks are aligned with each other when the multipin connector is reinstalled.

TRANSISTORS, INTEGRATED CIRCUITS, AND HYBRID CIRCUITS

Transistors, integrated circuits, and hybrid circuits should not be replaced unless they are actually defective. If removed from their sockets or unsoldered from the circuit board during routine maintenance, return them to their original board locations. Unnecessary replacement or transposing of semiconductor devices may affect the adjustment of the instrument. When a semiconductor is replaced, check the performance of any circuit that may be affected.

Any replacement component should be of the original type or a direct replacement. Bend transistor leads to fit their circuit board holes, and cut the leads to the same length as the original component. See Figure 9-2 in the "Diagrams" section for lead-configuration illustrations.

The heat-sink-mounted power supply transistors are insulated from the heat sink with a heat-transferring insulator pad. Reinstall the insulator pads and bushings when replacing these transistors. Do not use any type of heat-transferring compound on the insulator pads.

NOTE

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

To remove socketed dual-in-line packaged (DIP) integrated circuits, pull slowly and evenly on both ends of the device. Avoid disengaging one end of the integrated circuit from the socket before the other, since this may damage the pins.

To remove a soldered DIP IC when it is going to be replaced, clip all the leads of the device and remove the leads from the circuit board one at a time. If the device must be removed intact for possible reinstallation, do not heat adjacent conductors consecutively. Apply heat to pins at alternate sides and ends of the IC as solder is removed. Allow a moment for the circuit board to cool before proceeding to the next pin.

Hybrid circuits and heatsinks are removed as a unit by removing the mounting nuts at the four corners of the heatsink/housing. A firm downward pressure at the center of the housing will aid in removal of the nuts. The hybrid circuit substrate is bonded to the heatsink/housing casting. Attempting to separate the hybrid device from its housing will damage the device.

SOLDERING TECHNIQUES

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used to remove or replace parts. General soldering techniques, which apply to maintenance of any precision electronic equipment, should be used when working on this instrument.

WARNING

To avoid an electric-shock hazard, observe the following precautions before attempting any soldering: turn the instrument off, disconnect it from the ac power source, and verify that the line-rectifier filter capacitors have discharged. (See label on the primary power shield.) If, due to a component failure, the capacitors are not discharging, it may be necessary to discharge them. Use a 1 kΩ, 5-watt resistor and discharge the capacitors from point to point through the access holes in the primary power shield.

Use rosin-core wire solder containing 63% tin and 37% lead. Contact your local Tektronix Field Office or representative to obtain the names of approved solder types.

When soldering on circuits boards or small insulated wires, use only a 15-watt, pencil-type soldering iron. A higher wattage soldering iron may cause etched circuit conductors to separate from the board base material and melt the insulation on small wires. Always keep the soldering-iron tip properly tinned to ensure best heat transfer from the iron tip to the solder joint. Apply only enough solder to make a firm joint. After soldering, clean the area around the solder connection with an approved flux-removing solvent (such as isopropyl alcohol) and allow it to air dry.

Circuit boards in this instrument may have as many as four conductive layers. Conductive paths between the top and bottom board layers may connect to one or more inner layers. If any inner-layer conductive path becomes broken due to poor soldering practices, the board becomes unusable and must be replaced. Damage of this nature can void the instrument warranty.

CAUTION

Only an experienced maintenance person, proficient in the use of vacuum-type desoldering equipment should attempt repair of any circuit board in this instrument.

Desoldering parts from multilayer circuit boards is especially critical. Many integrated circuits are static sensitive and may be damaged by solder extractors that generate static charges. Perform work involving static-sensitive devices only at a static-free work station while wearing a grounded antistatic wrist strap. Use only an antistatic vacuum-type solder extractor approved by a Tektronix Service Center.

CAUTION

Attempts to unsolder, remove, and resolder leads from the component side of a circuit board may cause damage to the reverse side of the circuit board.

The following techniques should be used to replace a component on a circuit board:

1. Touch the vacuum desoldering tool to the lead at the solder connection. Never place the iron directly on the board; doing so may damage the board.

NOTE

Some components are difficult to remove from the circuit board due to a bend placed in the component leads during machine insertion. To make removal of machine-inserted components easier, straighten the component leads on the reverse side of the circuit board.

2. When removing a multipin component, especially an IC, do not heat adjacent pins consecutively. Apply heat to the pins at alternate sides and ends of the IC as solder is removed. Allow a moment for the circuit board to cool before proceeding to the next pin.

CAUTION

Excessive heat can cause the etched circuit conductors to separate from the circuit board. Never allow the solder extractor tip to remain at one place on the board for more than three seconds. Solder wick, spring-actuated or squeeze-bulb solder suckers, and heat blocks (for desoldering multipin components) must not be used. Damage caused by poor soldering techniques can void the instrument warranty.

3. Bend the leads of the replacement component to fit the holes in the circuit board. If the component is replaced while the board is installed in the instrument, cut the leads so they protrude only a small amount through the reverse side of the circuit board. Excess lead length may cause shorting to other conductive parts.

4. Insert the leads into the holes of the board so that the replacement component is positioned the same as the original component. Most components should be firmly seated against the circuit board.

5. Touch the soldering iron to the connection and apply enough solder to make a firm solder joint. Do not move the component while the solder hardens.

6. Cut off any excess lead protruding through the circuit board (if not clipped to the correct length in step 3).

7. Clean the area around the solder connection with an approved flux-removing solvent. Be careful not to remove any of the printed information from the circuit board.

8. When soldering to the ceramic crt-termination network, a slightly larger soldering iron can be used. It is recommended that a solder containing about 3% silver be used when soldering to the ceramic material to avoid destroying the the bond. The bond can be broken by repeated use of ordinary tin-lead solder or by the application of too much heat; however, occasional use of ordinary solder will not break the bond, provided excessive heat is not applied when making the connection.

REMOVAL AND REPLACEMENT INSTRUCTIONS

WARNING

To avoid electric shock, disconnect the instrument from the ac power source before removing or replacing any component or assembly.

The exploded view drawing in the "Replaceable Mechanical Parts" list at the rear of this manual may be helpful during the removal and reinstallation of individual components or subassemblies. Circuit board and component locations are illustrated in the "Diagrams" section of this manual.

Cabinet Removal

Removal of the instrument wrap-around cabinet is accomplished by the following steps:

1. Unplug the power cord from the ac power source.

2. Unplug the power cord from the rear-panel connector.

3. Install the front-panel cover, place the cabinet handle against the bottom of the cabinet, and set the instrument face down on a flat surface.

4. Unwrap the power cord from the instrument feet.

5. Remove the four screws in the rear-panel feet (see Figure 6-2).

6. Remove the two screws from the top-center and bottom-center of the rear panel (see Figure 6-2).

7. Lift the rear panel and power cord away from the instrument, leaving the rear-panel feet attached.

WARNING

Dangerous potentials exist at several points throughout this instrument. If it is operated with the cabinet removed, do not touch exposed connections or components. Some transistors may have elevated case voltages. Disconnect the ac power source from the instrument and verify that the line-rectifier filter capacitors have discharged before cleaning the instrument or replacing parts (see label on the primary power shield).

8. Slide the cabinet off of the instrument.

To reinstall the wrap-around cabinet, perform the reverse of the preceding instructions. Ensure that the cabinet fits properly into the emi gasket grooves in the front frame and rear panel.

WARNING

The line-rectifier filter capacitors normally retain a charge for a short period (approximately 15 to 20 seconds) after the instrument is turned off and can remain charged for a longer period if a bleeder-resistor or power-supply problem occurs. Before beginning any cleaning or work on the internal circuitry of the oscilloscope, disconnect the ac power source from the instrument and verify that the capacitors have discharged to 24 V or less. Measurement is made at the three points indicated on the plastic primary input shield at the rear of the instrument (after the Top-Cover Plate is removed). If the capacitors retain charges of greater than 24 V for more than 20 seconds, discharge them using a 1 kΩ, 5-watt resistor connected point-to-point across the capacitors (through the access holes). Ensure that the capacitors are discharged before commencing troubleshooting.

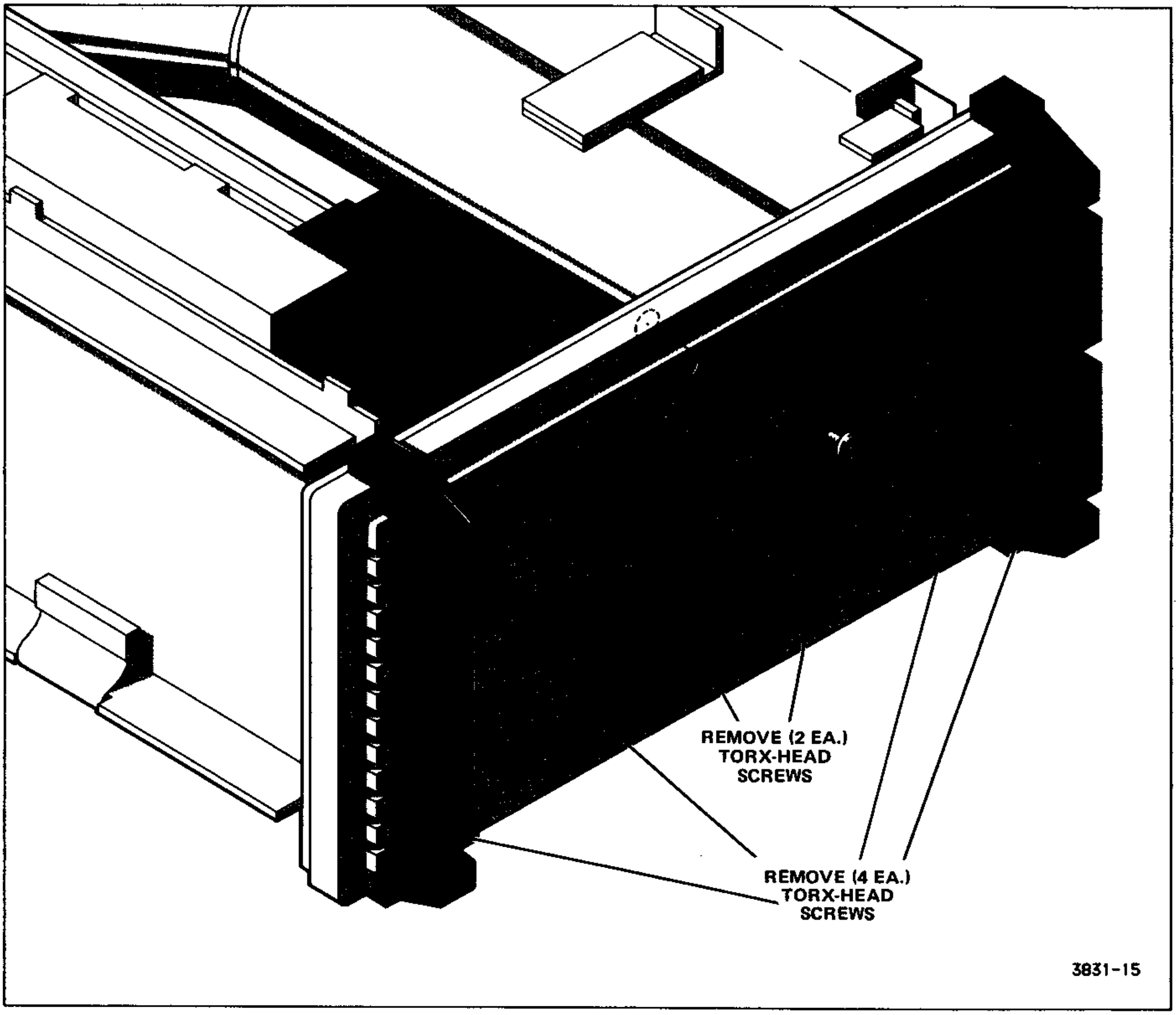

Figure 6-2. Rear panel removal.

Top-Cover Plate Removal

Removal of the Top-Cover Plate is accomplished by the following steps:

1. Remove the instrument cabinet as described in that procedure.

2. Set the instrument, bottom down, on a flat surface.

3. Remove the two securing screws from the top edge of the rear-panel chassis.

4. Remove the securing screw from the left side of the chassis.

5. Remove the two top securing screws at the front edge of the cover plate.

6. Remove the top securing nut at the rear of the cover plate.

7. Lift the Top-Cover Plate up and away from the instrument.

To reinstall the Top-Cover Plate, perform the reverse of the preceding instructions.

A5—Control Board Removal

Removal of the Control Board is accomplished by the following steps:

1. Remove the instrument wrap-around cabinet as described in that procedure.

2. Place the instrument on its left side on a flat surface.

3. Disconnect the three ribbon-cable connectors from the Control board (P251, P651, and P652) (see Figure 6-3).

4. Disconnect the two ribbon-cable connectors from the Main board (P511 and P512).

5. Remove the five mounting screws securing the board to the chassis, one at each corner of the board and one at the center.

6. Lift the Control board away from the chassis.

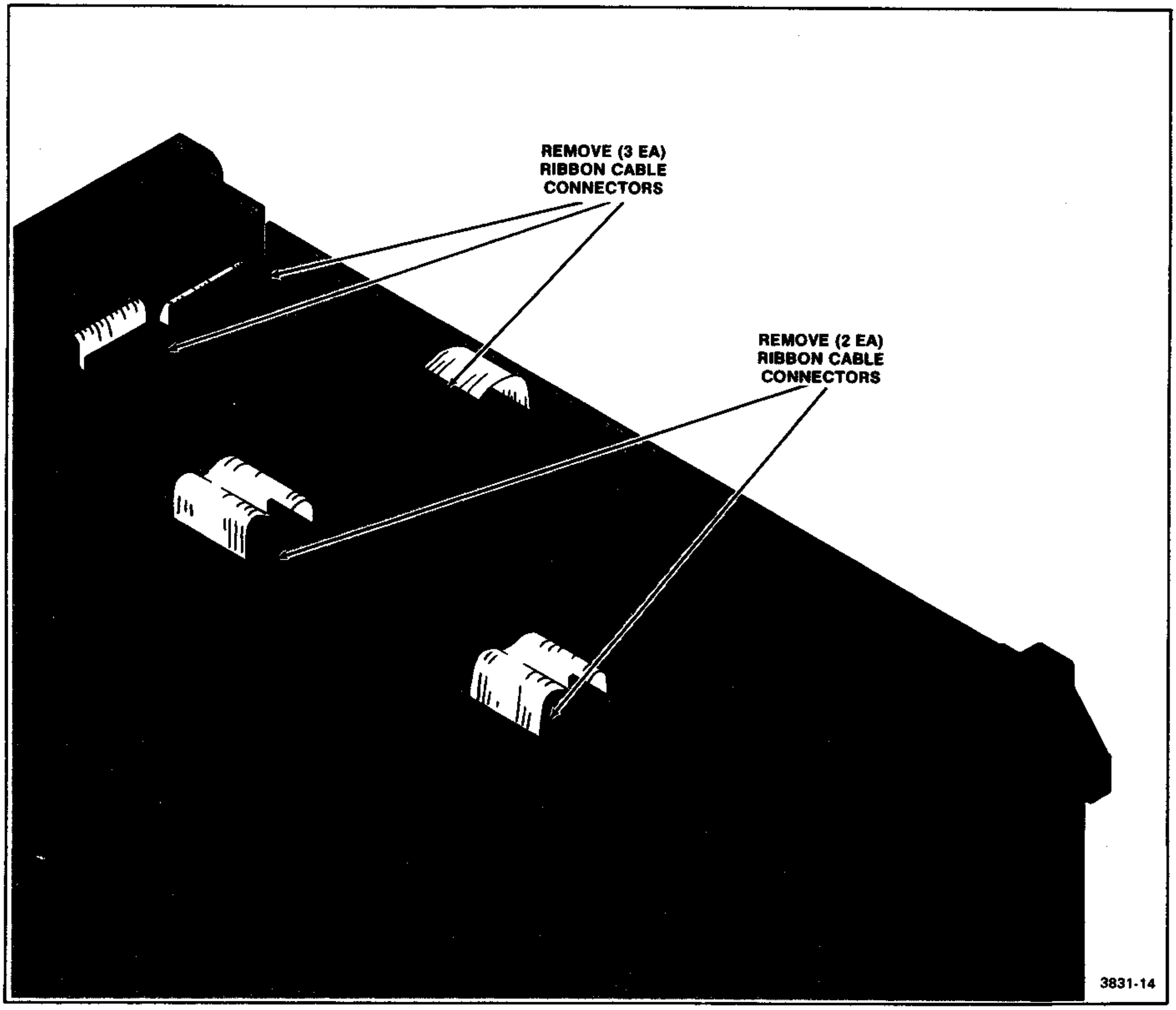

Figure 6-3. Ribbon cable removal.

To reinstall the Control board, perform the reverse of the preceding instructions.

A2, A3, and A12—Power Supply Assembly Removal

Removal of the Power Supply assembly is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Top-Cover Plate as described in that procedure.

3. Loosen, but do not remove, the nut securing the fan blade to the fan motor shaft (a 1/4-inch nut driver is required).

4. Grasp the fan blade and, using firm pressure, pull the fan blade and mounting collar from the motor shaft.

5. Remove the two rear-panel screws holding the plastic primary circuit shield and remove the shield.

6. Remove the two screws holding the rear of the Power Supply assembly to the rear panel.

7. Remove the three screws securing the power-transistor heatsink to the chassis.

8. Disconnect the power supply ribbon-cable connector from the Control board (P251) and feed the cable through the slot in the Control board.

9. Disconnect the two power supply multipin connectors from the Power Supply assembly to the Main board (P121 and P122).

10. Disconnect the four primary power connections at the rear of the supply assembly (P204, P205, P206, and P207). Note their orientation for reinstallation.

11. If the Probe Power option is installed, disconnect the Probe Power connectors from the Power Supply assembly (P201 and P202).

12. Lift the Power Supply assembly from the instrument.

To reinstall the Power Supply assembly, perform the reverse of the preceding instructions.

The following procedures describe the further disassembly of the Power Supply circuit boards once the assembly is removed from the instrument.

FAN REMOVAL. To remove the Fan board and motor from the Power Supply assembly, perform the following steps:

1. Loosen the four screws on the plastic motor mount.

2. Disconnect the multipin connector from the Fan board (P301). Note the connector orientation for reinstallation.

3. Slide the Fan board and motor from the motor mount.

To reinstall the Fan board and motor, perform the reverse of the preceding steps.

INVERTER BOARD AND REGULATOR BOARD SEPARATION. To separate the Inverter and Regulator boards, perform the following steps:

1. Remove the rear-corner securing screw from the Regulator board.

2. Unplug the four thru-pin connectors (J231, J232, J233, and J234).

3. Separate the two circuit boards by unclipping the plastic edge connectors.

To rejoin the Inverter and Regulator boards, perform the reverse of the preceding steps.

A9—High-Voltage Board Removal

Removal of the High-Voltage board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Top-Cover Plate as described in that procedure.

WARNING

The crt anode lead may retain a high-voltage charge after the instrument is turned off. To avoid electrical shock, ground the crt anode lead to the chassis after disconnecting the plug. Reconnect and disconnect the anode-lead plug several time, grounding the anode lead to chassis ground each time it is disconnected to fully dissipate the charge.

3. Unplug the CRT anode lead and discharge it to chassis ground.

4. Unplug the two leads from the ceramic termination strip to the crt. Use long-nose pliers to pull the connectors straight away from the crt neck pins. Avoid putting excessive pressure on the metal-to-glass seal. Raise the connectors high enough to allow clearance for the crt anode lead (in step 7).

5. Disconnect the single conductor connector from the ceramic termination strip.

6. Remove the screw retaining the high-voltage lead clamp.

7. Slide the high-voltage lead sideways under the termination strip.

8. Loosen the two screws on the left side of the crt socket cover and remove the one on the right side. Remove the cover.

9. Remove the five screws securing the High-Voltage board shield to remove the shield.

10. Remove the four mounting posts securing the High-Voltage board to the chassis.

11. Unplug the crt socket by gently prying evenly on both sides of the socket until the socket can be disengaged from the crt pins. Do not apply excessive side pressure on the socket.

12. Disconnect the two multipin connectors and one single-conductor connector from the front of the High-Voltage board (P902, P903, and P904). Note orientation for reinstallation.

13. Tilt the top of the board out to clear the left-side frame and pull the board up to disengage the High-Voltage board pin connectors from the Main board.

14. Lift the board from the chassis while carefully feeding the crt socket, cabling, and high-voltage lead through the chassis slot.

To reinstall the High-Voltage board, perform the reverse of the preceding instructions.

A4—Readout Board Removal

Removal of the Readout board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Top-Cover Plate as described in that procedure.

3. Place the instrument, left side down, on a flat surface.

4. Disconnect the Readout Board ribbon-cable connector from the Main board (P411).

5. With the instrument still on its side, pull the circuit board out of its plastic board mounts. Remove the board from the instrument while guiding the ribbon cable and connector through the slots in the Main board and chassis.

To reinstall the Readout board, perform the reverse of the preceding steps.

A6 and A7—Front-Panel and Variable Board Assembly Removal

Removal of the Front-Panel and Variable board assembly is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Using a small-bladed screwdriver, pry the trim strip from the top edge of the front-panel trim ring. Gently pry up on the back edge to release it, then pry gently at each of the front edge retaining clips to remove the strip.

3. Remove the five screws from the top edge of the front-panel trim ring.

4. Remove the four screws and the two plastic feet from the bottom edge of the front-panel trim ring.

5. Remove the screw from either side of the front-panel trim ring (screws are recessed in the front-cover catches).

6. Using firm pressure, pull the knobs from the four controls directly below the crt (INTENSITY, FOCUS, READOUT INTENSITY, and SCALE ILLUM).

7. Slide off the front-panel trim ring and outer crt bezel.

8. Disconnect the two ribbon-cable connectors from the front edge of the Control board (P651 and P652).

9. Pull out the Front-Panel and Variable board assembly.

The following steps describe the further disassembly of the Front-Panel and Variable boards once the assembly is removed from the instrument.

ASSEMBLY SEPARATION. Separation of the Variable board from the Front-Panel board is accomplished by the following steps:

1. Using a 1/16-inch Allen wrench, loosen the set screws in the CH 1 VOLTS/DIV VAR, CH 2 VOLTS/DIV VAR, and A and B SEC/DIV VAR knobs and remove the knobs from their control shafts.

2. Disconnect the multipin connector from the Variable board (P671).

3. Remove the two screws securing the Variable board to the mounting posts.

4. Slide the Variable board and the variable-control shafts away from the Front-Panel board.

FRONT-PANEL COVER PLATE REMOVAL. Use the following procedure to remove the front-panel cover plate from the Front-Panel board.

1. Separate the Front-Panel and Variable boards as described above (if not already done).

2. Using a 1/16-inch Allen wrench, loosen the set screws in the CH 1 and CH 2 VOLTS/DIV knobs. Remove the knobs from their control shafts (if not previously removed).

3. Pull the B SEC/DIV knob to the out position to gain access to the two recessed setscrews.

4. Use a 1/16-inch Allen wrench to loosen the two setscrews and remove the B SEC/DIV knob.

5. Loosen the setscrews in the A SEC/DIV collar and remove the collar.

6. Using firm outward pressure, pull the knobs off of the Vertical and Horizontal POSITION controls, the Trigger HOLDOFF and LEVEL controls, the Delta controls, and the TRACE SEP control (ten knobs). Note the differences in the knobs for reinstallation.

7. Remove the three securing screws and two securing studs from the rear of Front-Panel board.

8. Partially separate the board from the front-panel cover plate to expose the B SEC/DIV knob microswitch and multipin connector.

9. Unplug the connector (P601) from the Front-Panel board and separate the board from the cover plate.

To reinstall the Front-Panel and Variable board assembly, perform the reverse of the preceding instructions.

A10 and A11—Channel 1 and Channel 2 Attenuator Assembly Removal

Removal of either the Channel 1 or Channel 2 Attenuator assembly is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Front-Panel and Variable board assembly as described in that procedure.

3. Remove the two screws holding the small mounting bracket under the Attenuator assemblies and remove the bracket.

4. Remove the two screws that hold the Attenuator being removed to the front-panel frame.

5. Remove the two mounting screws holding the Attenuator being removed to the Main board (through access holes in the front-panel compartment).

6. Disconnect the associated multipin connector from the Main board (either P10 for Channel 1 or P11 for Channel 2).

7. Remove the two screws holding the rear attenuator shield and remove the shield.

8. Unsolder the two Attenuator output leads and the compensation capacitor lead.

9. Unplug the Attenuator by gently pulling the assembly straight up and away from the Main board.

To reinstall a removed Attenuator assembly, perform the reverse of the preceding steps.

A1—Main Board Removal

Removal of the Main board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Top-Cover Plate as described in that procedure.

3. Remove the Front-Panel and Variable board assembly as described in that procedure.

4. Disconnect the two power-supply multipin connectors from the power supply Regulator board (P121 and P122).

5. Disconnect the three ribbon-cable connections from the bottom of the Main board (P411, P511, and P512).

6. Disconnect the vertical and horizontal deflection leads from the crt neck pins. Access is via holes in the Main board. Use long-nose pliers to disconnect the pins by gently pulling straight up on the connectors. Avoid putting excessive side pressure on the metal-to-glass seal of the crt neck pins.

7. Disconnect the rear-panel BNC connector leads from the rear of the Main Board (P106, P107, and P108).

8. Disconnect the CH 2 OUT connector from near the center of the Main board (P105)

9. Disconnect the six multipin connectors for the controls beneath the crt (P111, P112, P113, P114, P115, and P116).

10. Disconnect the two-conductor connector for the Scale Illumination board from between the ASTIG and the SCALE ILLUM control connections (P181).

11. Unsnap the Power-switch rod from the switch hinge at the rear of the instrument by applying counterclockwise torque to the shaft and sliding it out of the hinge.

12. Remove the Power-switch push-button mounting screw from the front of the instrument (on the bottom of the front frame) and extract the Power-switch rod.

13. Remove the two screws holding the small bracket under the Attenuator assemblies and remove the bracket.

14. Remove the six screws holding the Attenuator assemblies and the CH 3 and CH 4 input connectors to the front frame.

15. Remove the Main board mounting screws (eleven screws total securing the Main board to the frame).

16. Raise the rear of the Main board to unplug J191 and separate the Main board from the HV board. When the plug pins are completely disengaged and the rear of the board clears the rear frame, slide the Main board rearward out of the front-panel frame.

17. Lift the Main board and Delay Line clear of the instrument while working the power supply cables through the slot in the frame.

To reinstall the Main board, perform the reverse of the preceding instructions.

A8—Scale Illumination Board Removal

Removal of the Scale-Illumination board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the front-panel trim and outer crt bezel as described in the Front-Panel and Variable board assembly removal instructions.

3. Remove the eight screws holding the crt mounting bezel in place and remove the bezel and plastic gasket. Note the length difference in the screws for reinstallation.

4. Remove the plastic lens from the Scale-Illumination board.

5. Disconnect the scale-illumination multipin connector from the Main board (P181).

6. Remove the Scale-Illumination board by lifting it away from the front frame while working the wires and connector through the slot in the frame.

To reinstall the Scale-Illumination board, perform the reverse of the preceding instructions.

CRT Removal

WARNING

Use care when handling a crt. Breakage of the crt may cause high-velocity scattering of glass fragments (implosion). Protective clothing and safety glasses (preferably a full-face shield) should be worn. Avoid striking the crt on any object which may cause it to crack or implode. When storing a crt, place it in a protective carton or set it face down on a smooth surface in a protected location. When stored face down, it should be placed on a soft, nonabrasive surface to prevent the crt face plate from being scratched.

1. Remove the instrument Cabinet as described in that procedure.

2. Remove the Top-Cover Plate as described in that procedure.

3. Loosen the two screws on the left side of the crt socket cover and remove the one on the right side. Remove the cover.

4. Unplug the crt socket by gently prying the socket evenly on both sides until the pins can be disengaged. Do not apply excessive side pressure on the socket as it is being removed.

WARNING

The crt anode lead and the output terminal of the High-Voltage Multiplier can retain a high-voltage charge after the instrument is turned off. To avoid electrical shock, ground both the crt anode lead and the high-voltage lead to the main instrument chassis. Repeat the grounding process several times to fully dissipate the charge.

5. Disconnect the crt anode lead connector and discharge it to chassis ground.

6. Using long-nosed pliers, disconnect the horizontal and vertical deflection leads from the bottom of the crt. Pull straight out on these connectors to prevent excessive strain on the metal-to-glass seal. (Access to the connectors is through holes in the Main board).

7. Using long-nosed pliers, disconnect the vertical termination leads from the top of the crt.

8. Using long-nosed pliers, disconnect the crt shield resistor from the top of the crt.

9. Disconnect the Y-Axis Alignment coil connector from the front of the High-Voltage board (P903).

10. Remove the front-panel trim ring and outer crt bezel as described in the Front-Panel and Variable board assembly removal instructions.

11. Remove the eight retaining screws from the crt-mounting bezel at the front of the crt. Note the difference in length of the screws for reinstallation.

12. Remove the crt mounting bezel and plastic gasket from the crt.

13. Slide the crt forward slightly by gently pushing on the rear of the crt neck until the front of the crt can be grasped.

14. Slide the crt out of the instrument while feeding the anode lead and Y-Axis Alignment coil leads through their respective holes.

NOTE

Once the crt is removed, it should be stored in such a manner as to protect it from impact. If stored face down, it should be placed on a soft, nonabrasive surface to prevent the crt face plate from being scratched. To reinstall the crt, perform the reverse of the preceding instructions.