SECTION V
MAINTENANCE INSTRUCTIONS

5-1. OPERATIONAL CHECKOUT (PERFORMANCE CHECK). The operational checkout is a performance check of the 465M using test equipment listed in Table 2-1. Satisfactory completion of the checkout procedures indicates that the instrument should perform as listed in the Performance Requirement column in Table 1-1. The Operational Checkout procedure (Performance Check) is contained in Table 5-1 and is structured as follows:

a. The STEP column lists the sequential steps of the procedure.

b. The PROCEDURE column lists the instructions and illustrations necessary to setup and perform the procedure.

c. The PERFORMANCE REQUIREMENT column lists the desired result of the test.

d. The control settings listed in step 1 are used as initial settings for each numbered procedure step. Therefore, the numbered procedure steps may be performed individually or in any order by first performing step 1, then any other desired step. This feature is useful for testing the instrument after making repairs or replacing components in individual sections of the instrument.

CAUTION

Do not connect the instrument to a power source until instructed to do so in a procedural step. This will prevent instrument damage in the event the LINE RANGE Selector switch or other controls are not properly set.

Table 5-1. Operational Checkout Procedures (Performance Check)

Step	Procedure	Performance Requirement
1.	**Preliminary Procedure**	
a.	To place the 465M into a basic operating mode: Check that the fuse value and Line Voltage Selector switch setting (on the rear panel) are set for the available power input voltage. Unless otherwise specified, the instrument is shipped from the factory with the switch set for 116 V and a fuse value of 1 A/250 V (to operate from a power input voltage source within a range of 100 to 132 volts). If the Line Selector switch setting is changed to the 232 V position (for operation from a power input voltage source within a range of 200 to 264 volts) the fuse value and type must be changed to 0.5 A, fast-blow. Then set the 465M controls as stated in the following list (set both vertical channels the same and both horizontal sweeps the same unless otherwise indicated). POSITION (vertical) — Midrange VOLTS/DIV — 5 m (1X probe window) VAR (VOLTS/DIV) — Fully clockwise (detent) AC-GND-DC — DC VERT MODE — CH 1 INVERT — Out (normal) INTEN — Midrange	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

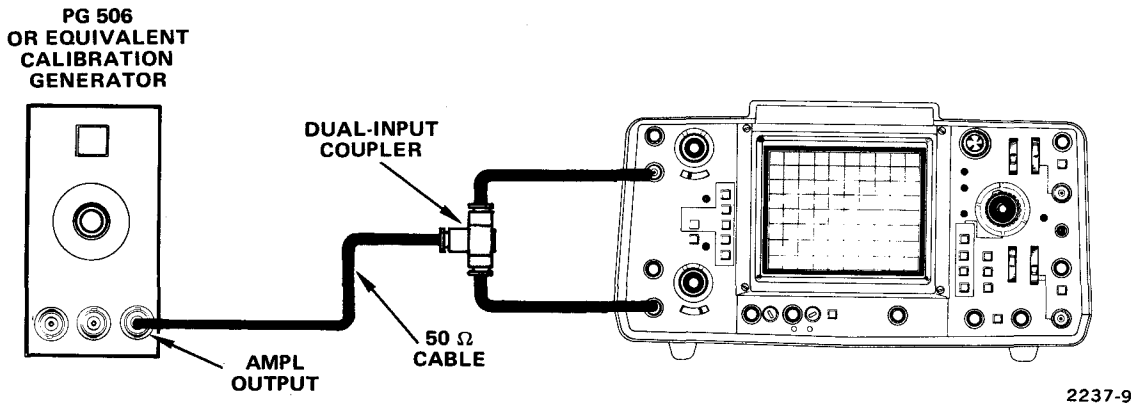
Step	Procedure	Performance Requirement
1. (continued)		
	SCALE ILLUM — Fully counterclockwise HORIZ DISPLAY — A A AND B TIME/DIV — .1 ms VAR (A AND B TIME/DIV) — Fully clockwise (detent) DELAY TIME POS — 0.0 X10 MAG — Out (off) A TRIGGER HOLDOFF — NORM (detent) LEVEL — Midrange of + side of control (adjust as necessary throughout procedure) SLOPE — Out + COUPLING — AC SOURCE — NORM TRIG MODE — AUTO POSITION (horizontal) — Midrange	
	Next, remove the 465M top cover. Connect the 465M power cord plug to the desired power input voltage source. Pull the 465M POWER switch to ON.	
	NOTE *Allow approximately 5 minutes warmup time before starting any step of the Operational Checkout procedure.*	
	Set CH 1 AC-GND-DC to GND. Adjust INTEN and FOCUS for a low-intensity well-defined trace. Position the trace to the center horizontal graticule line, and if necessary adjust TRACE ROTATION so the trace is parallel with the graticule line. Return AC-GND-DC to DC.	
2.	**Regulation**	
	NOTE *Step 2 is optional and may be partially or totally omitted unless there is an individual reason to verify the 465M operation over all power input voltage ranges. To completely check the 465M for the power input voltage ranges of 100 to 132 volts and 200 to 264 volts requires variable power input voltage sources that will cover both ranges. An alternative method is to check that the individual 465M power supplies are within limits with the 465M powered from the available power input source voltage, and then proceed to step 3.*	
a.	Set the Digital Multimeter to read 50 volts dc.	
b.	Connect the meter Low lead to ground and the Volts lead to the +32 V (regulated) test point.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
2. (continued)		
c.	Check (using the following chart) the 465M power supplies regulation over the desired power input voltage ranges (vary the power input source voltage and alter meter settings and connections as required).	
	POWER INPUT VOLTAGE / **POWER SUPPLY**	
	100 V to 132 V or 200 V to 264 V / +32 V +5 V −5 V	+31.9 V to +32.1 V +4.97 V to +5.03 V −4.97 V to −5.03 V
	(Change Line Voltage Selector switch setting and fuse as appropriate)	
d.	Set the 465M POWER switch to OFF, disconnect the meter leads from the 465M and the 465M line cord plug from the power input voltage source. Change the fuse value and Line Voltage Selector switch setting for the available source of power input voltage to be used for the rest of this procedure (116 V for a 100 V to 132 V range, or 232 V for a 200 to 264 V range). Refer to step 1, Preliminary Procedure before performing any other steps.	
3.	**Calibrator Output**	
a.	Preset the 465M per step 1, then set POWER to OFF.	
b.	Connect a Digital Multimeter (preset to read +1 V dc) to the CALIBRATOR output connector.	
c.	Connect a shorting jumper between TP376 and TP386 (a miniature alligator clip is suitable).	
d.	Turn the 465M on and allow at least 5 minutes warm-up.	
e.	Check the Digital Multimeter reading.	+0.99 V dc to +1.01 V dc
f.	Disconnect the Digital Multimeter leads, turn the 465M power off, and disconnect the shorting jumper from TP376 and TP386.	
g.	Turn the 465M power on and use a 1X probe (465M standard accessory) to connect the 465M channel 1 input to the CALIBRATOR output terminal.	
h.	Preset the 465M controls as follows: Deflection Factor .2 V Vertical Input Coupling DC Sweep Speed .1 ms	
i.	Check the calibrator waveform characteristics.	Square wave of 5 divisions peak-to-peak at 1 kHz within 0.1 kHz; risetime, less than 1 μs; symmetry, within 25%.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
4.	**Vertical Deflection Factor Accuracy.**	
a.	Connect the equipment as follows:	



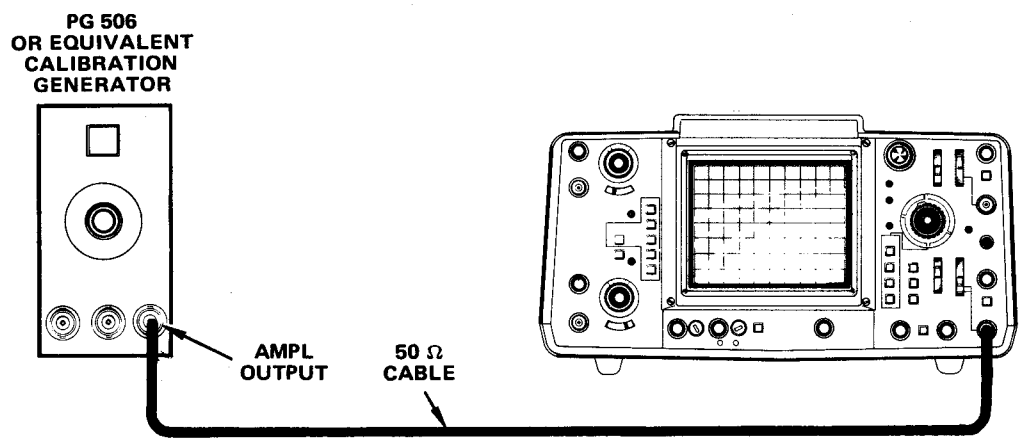
b.	Preset controls as listed in step 1.	
c.	Check CH 1 and CH 2 vertical deflection factors at the following settings (VERT MODE must be set to channel being tested):	

Calibration Generator Setting	VOLTS/DIV Setting (in X1 probe window)	Vertical Display (in divisions)
20 mV	5 mV	3.92 to 4.08
50 mV	10 mV	4.90 to 5.10
0.1 V	20 mV	4.90 to 5.10
0.2 V	50 mV	3.92 to 4.08
0.5 V	.1 V	4.90 to 5.10
1.0 V	.2 V	4.90 to 5.10
2.0 V	.5 V	3.92 to 4.08
5.0 V	1 V	4.90 to 5.10
10.0 V	2 V	4.90 to 5.10
20.0 V	5 V	3.92 to 4.08

5.	**Variable Vertical Deflection Factor Range.**	
a.	Connect the equipment as shown in step 4, part a.	
b.	Preset the 465M as listed in step 1; then reset CH 1 VOLTS/DIV to 10 m.	
c.	Set the calibration generator to 50 mV.	4.9 to 5.1 division vertical display.
d.	Rotate CH 1 VOLTS/DIV VAR fully counterclockwise.	2 division or less vertical display.
e.	Set VERT MODE to CH 2 and CH 2 VOLTS/DIV to 10 m.	4.9 to 5.1 division vertical display.
f.	Rotate CH 2 VOLTS/DIV VAR fully counterclockwise.	2 division or less vertical display.
g.	Reset CH 1 and CH 2 VOLTS/DIV VAR fully clockwise (in detent position).	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

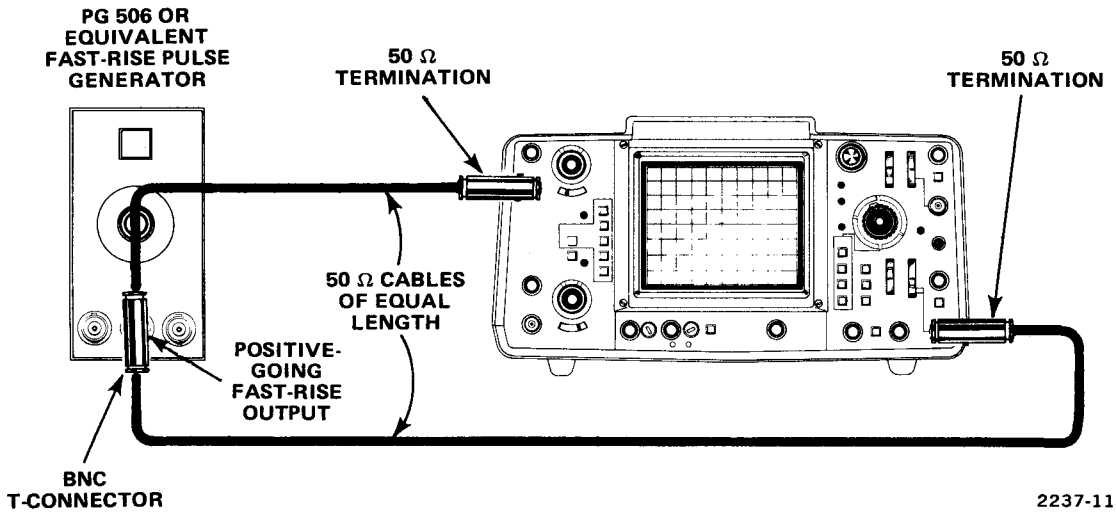
Step	Procedure	Performance Requirement
6.	**X Gain.**	
a.	Connect the equipment as shown in step 4, part a.	
b.	Preset the 465M as listed in step 1; then reset as follows: CH 2 AC-GND-DC GND VERT MODE CH 2 A AND B TIME/DIV X-Y	
c.	Set the calibration generator for 20 mV (INTEN may need to be increased).	3.88 to 4.12 division horizontal display.
d.	Set CH 1 AC-GND-DC to AC.	3.88 to 4.12 division horizontal display.
7.	**Trigger View Gain.**	
a.	Connect the equipment as follows:	



b.	Preset the 465M as listed in 1; then reset as follows: CH 1 VOLTS/DIV .1 A SOURCE EXT A LEVEL 0 A AND B TIME/DIV .2 ms	
c.	Set calibration generator for 0.2 V.	
d.	Push in and hold TRIG VIEW, observe display, then release TRIG VIEW.	1.4 to 2.6 division vertical display.
e.	Set instrument controls as follows: VOLTS/DIV 1 A SOURCE EXT ÷ 10	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
7. (continued)		
f.	Set calibration generator to 2 V.	
g.	Repeat step 7, part d.	
8.	**Channel Position Effect.**	
a.	Connect the equipment as follows:	



b.	Preset the 465M as listed in step 1; then, reset as follows: CH 1 VOLTS/DIV 20 m A AND B TIME/DIV .05 μs	
c.	Set calibration generator for a 5-division display at 100 kilohertz.	
d.	Rotate CH 1 vertical POSITION to observe the top of the waveform at the top horizontal graticule line then rotate POSITION and observe top of waveform at the bottom horizontal graticule line.	The front corner of the waveform has no more than 0.3 division peak-to-peak aberrations.
e.	Set A SLOPE to − (IN).	
f.	Change the calibration generator output to the negative-going fast rise output.	
g.	Repeat step 8, parts c and d.	
h.	Change the calibration generator output cable from CH 1 to CH 2.	
i.	Set the instrument controls as follows: CH 2 VOLTS/DIV 20 m VERT MODE CH 2	
j.	Repeat step 8, parts c and d using CH 2 vertical POSITION.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
8. (continued)		
k.	Set A SLOPE to + (OUT).	
l.	Change the calibration generator output to the positive going fast rise output.	
m.	Repeat step 8, parts c and d using CH 2 vertical position.	
9.	**Rise Time.**	
a.	Connect the equipment as shown in step 8, part a.	
b.	Preset controls as listed in step 1, then reset as follows: A AND B TIME/DIV .05 μs CH 1 VOLTS/DIV 20 m	
c.	Set calibration generator for a 5-division display at 1 megahertz.	
d.	Adjust vertical POSITION to place display between the 0 and 100% marks on the graticule.	
e.	Set X10 MAG to the In position (on).	
f.	Measure the time duration of the positive going portion of the display between 10 and 90% markers on the graticule.	3.5 nanoseconds (0.7 division) or less.
g.	Change the calibration generator output from CH 1 to CH 2.	
h.	Set controls as follows: CH 2 VOLTS/DIV 20 m VERT MODE CH 2 X10 MAG Out (off)	
i.	Repeat step 9, parts c through f.	
10.	**Cascaded Sensitivity and Bandwidth.**	
a.	Connect the equipment as follows:	

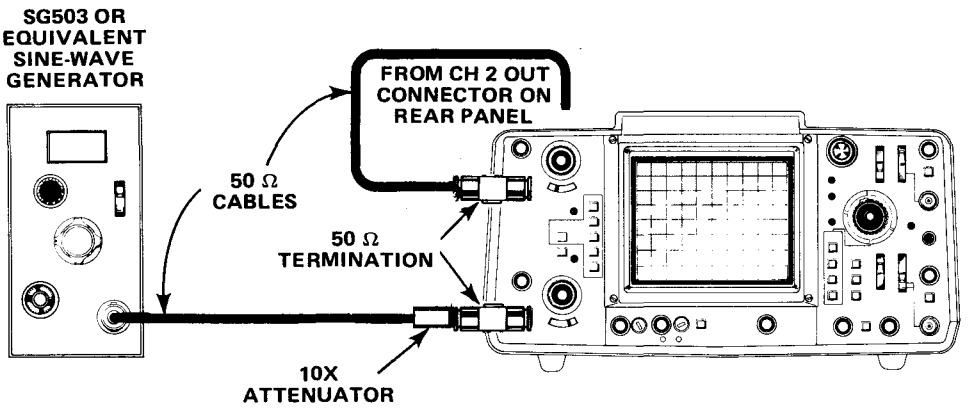


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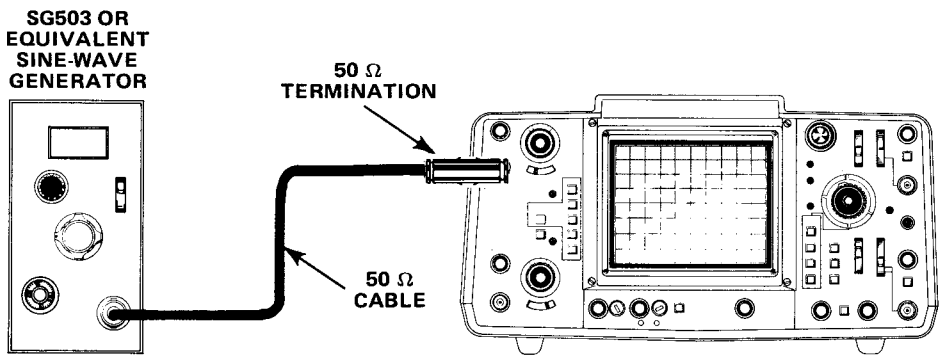
Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
10. (continued)		
b.	Preset controls as listed in step 1, then reset as follows: VERT MODE CH 2 A AND B TIME/DIV .2 ms	
c.	Set sine-wave generator for a 1-division 50 kilohertz display.	
d.	Set VERT MODE to CH 1.	3.5 to 6.5 division vertical display.
e.	Set sine-wave generator for a 5-division display (may need to insert a 10X attenuator between 50 ohm BNC cable and 50 ohm termination).	
f.	Set sine-wave generator to 40 megahertz.	3.5 division or more vertical display.
11.	**Channel 1, Channel 2, and X Bandwidth.**	
a.	Connect equipment as follows:	



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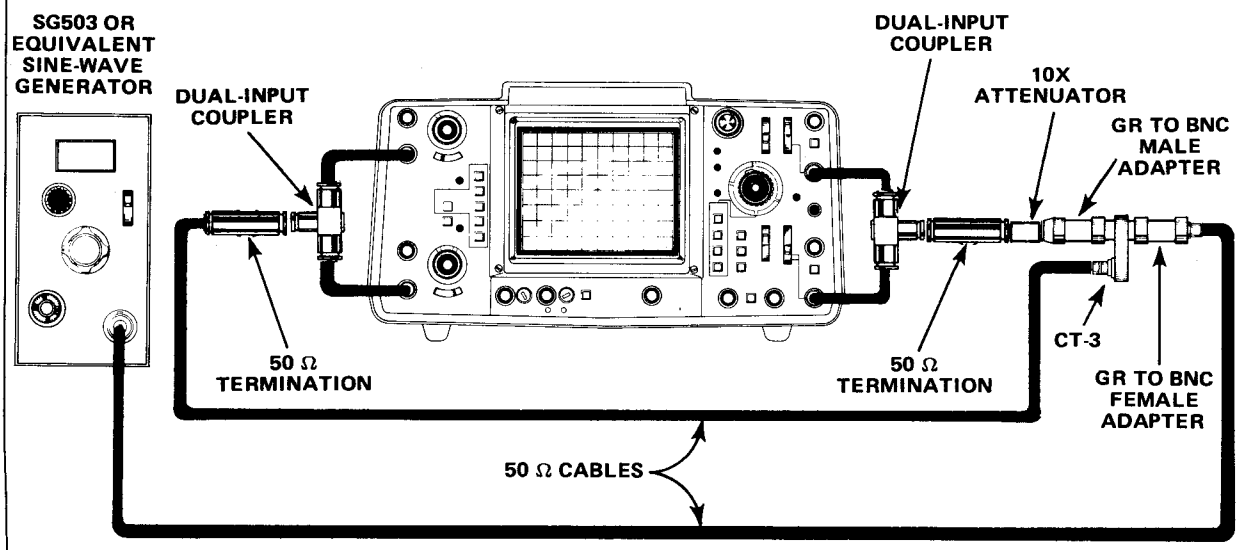
b.	Preset controls as listed in step 1, then reset A AND B TIME/DIV to 0.5 μs.	
c.	Set sine-wave generator to 3 megahertz and adjust for a 6-division display.	
d.	Set sine-wave generator to 100 megahertz.	4.2 division or more vertical display.
e.	Change the sine-wave generator output from CH 1 to CH 2.	
f.	Set VERT MODE to CH 2.	
g.	Repeat step 11, parts c through d.	
h.	Change the generator output from CH 2 to CH 1.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
11. (continued)		
i.	Set controls as follows: A AND B TIME/DIV — X-Y CH 1 POSITION — May need adjustment for an on-screen display. INTEN — May need to be increased.	
j.	Set sine-wave generator to 50 kilohertz and adjust for a 6-division horizontal display.	
k.	Set sine-wave generator to 4 megahertz.	4.2 division or more horizontal display.
12.	**Trigger Jitter.**	
a.	Connect the equipment as shown in step 11, part a.	
b.	Preset controls as listed in step 1; then reset as follows: A AND B TIME/DIV — .05 μs X10 MAG — In (on)	
c.	Set sine-wave generator to 100 megahertz and adjust for a 3-division display.	
d.	Adjust A LEVEL for a display with minimum horizontal displacement (jitter).	0.1 division or less, plus trace width, of horizontal displacement (jitter).
e.	Set controls as follows: VERT MODE — CH 2 HORIZ DISPLAY — B DLY'D	
f.	Change sine-wave generator output from CH 1 to CH 2.	
g.	Repeat step 12, parts c and d using B LEVEL control.	
13.	**Trigger Level Range.**	
a.	Connect the equipment as shown in step 11, part a.	
b.	Preset controls as listed in step 1, part a; then reset as follows: VOLTS/DIV — 1 TIME/DIV — 10 μs	
c.	Set sine-wave generator to 50 kilohertz and adjust for a 4-division display.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
13. (continued)		
d.	Rotate A LEVEL between its limits.	The display is triggered on the positive going slope of the waveform and free runs at either extreme setting of A LEVEL.
e.	Set A SLOPE to − (IN).	
f.	Rotate A LEVEL between its limits.	The display is triggered on the negative going slope of the waveform and free runs at either extreme setting of A LEVEL.
g.	Set HORIZ DISPLAY to B DLY'D.	
h.	Repeat step 13, parts d through f using B LEVEL and B SLOPE.	The display disappears when not triggered, rather than free running.
14.	**25 MHz Triggering.**	
a.	Connect the equipment as follows:	



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b.	Preset controls as listed in step 1; then reset as follows:	
	A AND B TIME/DIV — 10 μs COUPLING — DC SOURCE — EXT VOLTS/DIV — 10 m	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
14. (continued)		
c.	Set sine-wave generator to 50 kilohertz and adjust for a 5-division display; then set A AND B TIME/DIV to 0.5 μs and sine-wave generator to 25 megahertz.	
d.	Rotate A LEVEL for a stable display.	A stable display can be obtained.
e.	Set HORIZ DISPLAY to B DLY'D.	
f.	Rotate B LEVEL for a stable display.	A stable display can be obtained.
g.	Set controls as follows: VOLTS/DIV 5 m SOURCE NORM	
h.	Adjust sine-wave generator for a 3-division display.	
i.	Set VOLTS/DIV to 50 m.	
j.	Set each of the following conditions, then rotate B LEVEL to obtain a stable display: *NOTE* *When checking B Sweep control, the A trigger must be stable. To restabilize A Trigger, set HORIZ DISPLAY to A and readjust A LEVEL for a stable display. Then, reset HORIZ DISPLAY to B DLY'D and continue check.*	

B COUPLING	B SOURCE
DC	NORM
LF REJ	NORM
AC	NORM
DC	CH 1
DC	CH 2

k.	SET TRIG MODE to NORM.	
l.	Repeat step 14, part j.	
m.	Set B SLOPE to − (IN).	
n.	Repeat step 14, part j.	
o.	Set TRIG MODE to AUTO.	
p.	Repeat step 14, part j.	
q.	Set B COUPLING to HF REJ and rotate B LEVEL between its limits.	No stable display can be obtained.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

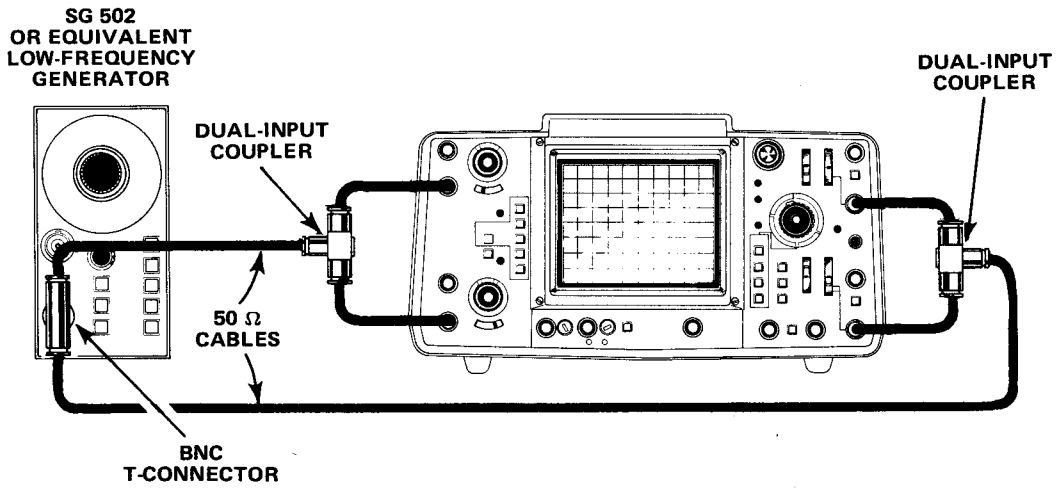
Step	Procedure	Performance Requirement
14. (continued)		
r.	Set HORIZ DISPLAY to A.	
s.	Repeat step 14, parts j through q. using A LEVEL, A COUPLING, and A SOURCE.	
15.	**100 MHz Triggering.**	
a.	Connect equipment as shown in step 14, part a.	
b.	Preset controls as listed in step 1; then reset as follows: VOLTS/DIV 50 m COUPLING DC SOURCE EXT	
c.	Set sine-wave generator to 50 kilohertz and adjust output for a 3-division display; then set generator to 100 megahertz.	
d.	Set controls as follows: A AND B TIME/DIV 0.5 μs X10 MAG In (on)	
e.	Rotate A LEVEL for a stable display.	A stable display can be obtained.
f.	Set HORIZ DISPLAY to B DLY'D.	
g.	Rotate B LEVEL for a stable display.	A stable display can be obtained.
h.	Set SOURCE to NORM.	
i.	Adjust sine-wave generator for a 1 division display.	
j.	Set each of the following conditions, then rotate B LEVEL to obtain a stable display.	A stable display can be obtained.

B COUPLING	B SOURCE
DC	NORM
LF REJ	NORM
AC	NORM
DC	CH 1
DC	CH 2

k.	Set TRIG MODE to NORM.
l.	Repeat step 15, part j.
m.	Set B SLOPE to − (IN).
n.	Repeat step 15, part j.
o.	Set TRIG MODE to AUTO.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
15. (continued)		
p.	Repeat step 15, part j.	
q.	Set HORIZ DISPLAY to A.	
r.	Repeat step 15, part j. using A LEVEL, A COUPLING, and A SOURCE.	
16.	**Low Frequency Trigger.**	
a.	Connect equipment as follows:	



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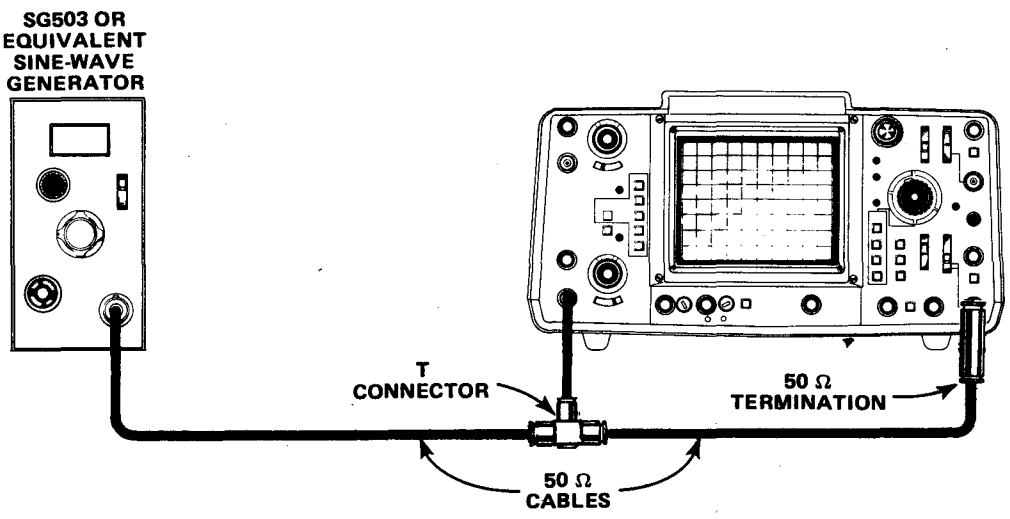
b.	Preset controls as listed in step 1; then reset as follows: A AND B TIME/DIV 10 m TRIG MODE NORM	
c.	Set low frequency sine-wave generator to 30 hertz and adjust for a 3-division display.	
d.	Set VOLTS/DIV to 50 m.	
e.	Rotate A LEVEL to obtain a stable display	A stable display can be obtained.
f.	Set A SLOPE to − (IN).	
g.	Repeat step 16, part e.	
h.	Set A COUPLING to LF REJ.	
i.	Rotate A LEVEL between its limits.	No stable display can be obtained.
j.	Set HORIZ DISPLAY to B DLY'D.	
k.	Repeat step 16, parts e through i. using B LEVEL, B SLOPE, and B COUPLING.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

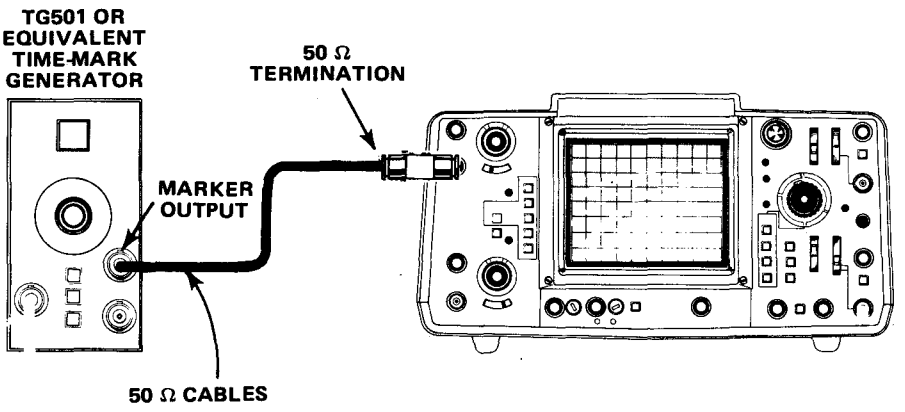
Step	Procedure	Performance Requirement
17.	**Z-Axis Input.**	
a.	Connect equipment as follows:	



b.	Preset controls as listed in step 1; then reset as follows: VERT MODE — CH 2 CH 2 VOLTS/DIV — 1 A AND B TIME/DIV — .5 ms A SOURCE — EXT	
c.	Set sine-wave generator to 50 kilohertz and adjust for a 5-division display.	
d.	Change the sine-wave generator output (T Connector) from CH 2 to Z-AXIS input on rear panel.	Trace modulation is noticeable at normal intensity.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
18.	**Sweep Rate Accuracy.**	
a.	Connect equipment as follows:	



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b.	Preset controls as listed in step 1; then reset as follows: CH 1 VOLTS/DIV .5 B SOURCE STARTS AFTER DELAY	
c.	Check A TIME/DIV accuracy at the following settings:	1 time mark per division within 0.2 division at the 11th vertical graticule line.

TIME/DIV Setting	Time-Mark Generator Output
.05 μs	50 ns
.1 μs	0.1 μs
.2 μs	0.2 μs
.5 μs	0.5 μs
1 μs	1μs
2 μs	2 μs
5 μs	5 μs
10 μs	10 μs
20 μs	20 μs

1 time mark per division within 0.2 division at the 11th vertical graticule line.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
18. (continued)	**TIME/DIV Setting** / **Time-Mark Generator Output** 50 µs / 50 µs .1 ms / 0.1 ms .2 ms / 0.1 ms .5 ms / 0.5 ms 1 ms / 1 ms 2 ms / 2 ms 5 ms / 5 ms *10 ms / 10 ms *20 ms / 20 ms *50 ms / 50 ms *.1 s, *.2 s, *.5 s (A SWEEP ONLY) / 0.1 s, 0.2 s, 0.5 s ***Set TRIG MODE switch to NORM.**	1 time mark per division within 0.2 division at the 11th vertical graticule line.
d.	Set HORIZ DISPLAY to B DLY'D.	
e.	Repeat Step 18, part c using B TIME/DIV. *NOTE* *If the 11th time marker is not visible, set A TIME/DIV one position counterclockwise from B TIME/DIV (e.g., A set to 1 ms and B to .05 ms).*	
19.	**Variable Sweep Rate Range.**	
a.	Connect equipment as shown in step 18, part a.	
b.	Preset controls as listed in step 1; then reset as follows: CH 1 VOLTS/DIV .5 A AND B TIME/DIV 2 ms VAR TIME/DIV Fully counterclockwise	
c.	Set time-mark generator for 5 millisecond time markers.	1 division or less between markers.
20.	**Magnified Sweep Accuracy.**	
a.	Connect equipment as shown in step 18, part a.	
b.	Preset controls as listed in step 1; then reset as follows: CH 1 VOLTS/DIV .5 A AND B TIME/DIV .05 µs	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

<table>
<tr><th>Step</th><th>Procedure</th><th>Performance Requirement</th></tr>
<tr><td>20. (continued)</td><td></td><td></td></tr>
<tr><td>c.</td><td>Set time-mark generator for 10 nanosecond time markers.</td><td></td></tr>
<tr><td>d.</td><td>Adjust horizontal POSITION to align first time marker with the left vertical graticule line.</td><td></td></tr>
<tr><td>e.</td><td>Set X10 MAG to In (on).</td><td></td></tr>
<tr><td>f.</td><td>Check magnified A TIME/DIV accuracy at the following settings:

NOTE

When aligning time markers with a graticule line after a new TIME/DIV selection, do not position the trace beyond alignment with the closest graticule line (see NOTE under Portion of total magnified sweep length to exclude from measurement column below).</td><td>1 time marker per division within 0.3 division at the 11th vertical graticule line; except on .05 μs setting, there is 1 time marker per two divisions.</td></tr>
<tr><td></td><td>
<table>
<tr><th>TIME/DIV Setting</th><th>Time-Mark Generator Setting</th><th>Portion of total magnified sweep length to exclude from measurement</th></tr>
<tr><td>0.5 μs</td><td>10 ns</td><td rowspan="17">First and last 50 nanoseconds

NOTE
To determine the excluded portion of the sweep at .05, .1 and .2 μs, position the beginning (or end) of the sweep at the left (or right) vertical graticule line. Then horizontally POSITION the trace to the left (or right) the following number of time markers to exclude 50 ns of the sweep (be sure X10 MAG is selected): 10 time markers at 0.5 μs; 5 at .1 μs, or 2.5 at .2 μs.</td></tr>
<tr><td>.1 μs</td><td>10 ns</td></tr>
<tr><td>.2 μs</td><td>20 ns</td></tr>
<tr><td>.5 μs</td><td>50 ns</td></tr>
<tr><td>1 μs</td><td>0.1 μs</td></tr>
<tr><td>2 μs</td><td>0.2 μs</td></tr>
<tr><td>5 μs</td><td>0.5 μs</td></tr>
<tr><td>10 μs</td><td>1 μs</td></tr>
<tr><td>20 μs</td><td>2 μs</td></tr>
<tr><td>50 μs</td><td>5 μs</td></tr>
<tr><td>.1 ms</td><td>10 μs</td></tr>
<tr><td>.2 ms</td><td>20 μs</td></tr>
<tr><td>.5 ms</td><td>50 μs</td></tr>
<tr><td>1 ms</td><td>0.1 ms</td></tr>
<tr><td>2 ms</td><td>0.2 ms</td></tr>
<tr><td>5 ms</td><td>0.5 ms</td></tr>
<tr><td>10 ms</td><td>1 ms</td></tr>
<tr><td>20 ms</td><td>2 ms</td></tr>
<tr><td>50 ms</td><td>5 ms</td></tr>
<tr><td>*.1 s A
*.2 s SWEEP
*.5 s ONLY</td><td>10 ms
20 ms
50 ms</td></tr>
<tr><td colspan="3">***Change TRIG MODE switch to NORM.**</td></tr>
</table>
</td><td>1 time marker per division within 0.3 division at the 11th vertical graticule line except on .05 μs setting, there is 1 time marker per two divisions.</td></tr>
<tr><td>g.</td><td>Set HORIZ DISPLAY to B DLY'D.</td><td></td></tr>
</table>

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

<table>
<tr><th>Step</th><th>Procedure</th><th>Performance Requirement</th></tr>
<tr><td>20. (continued)</td><td></td><td></td></tr>
<tr><td>h.</td><td>Set A AND B TIME/DIV to 0.5 μs.</td><td></td></tr>
<tr><td>i.</td><td>Repeat step 20, parts c through f.</td><td></td></tr>
<tr><td>21.</td><td>Differential Time Measurement Accuracy.</td><td></td></tr>
<tr><td>a.</td><td>Connect equipment as shown in step 18, part a.</td><td></td></tr>
<tr><td>b.</td><td>Preset controls as listed in step 1; then reset as follows:
CH 1 VOLTS/DIV .5
HORIZ DISPLAY B DLY'D
B SOURCE STARTS AFTER DELAY
DELAY TIME POS 1.00</td><td></td></tr>
<tr><td>c.</td><td>Set time-mark generator for 0.1 microsecond time markers.</td><td></td></tr>
<tr><td>d.</td><td>Check each of the following conditions by using step 21, parts e through l.
<table>
<tr><th>Time-Mark Generator Output</th><th>A TIME/DIV Setting</th><th>B TIME/DIV Setting</th></tr>
<tr><td>.1 μs</td><td>.5 μs</td><td>.05 μs</td></tr>
<tr><td>1 μs</td><td>1 μs</td><td>.1 μs</td></tr>
<tr><td>2 μs</td><td>2 μs</td><td>.2 μs</td></tr>
<tr><td>5 μs</td><td>5 μs</td><td>.5 μs</td></tr>
<tr><td>10 μs</td><td>10 μs</td><td>1 μs</td></tr>
<tr><td>20 μs</td><td>20 μs</td><td>2 μs</td></tr>
<tr><td>50 μs</td><td>50 μs</td><td>5 μs</td></tr>
<tr><td>0.1 ms</td><td>.1 ms</td><td>10 μs</td></tr>
<tr><td>0.2 ms</td><td>.2 ms</td><td>20 μs</td></tr>
<tr><td>0.5 ms</td><td>.5 ms</td><td>50 μs</td></tr>
<tr><td>1 ms</td><td>1 ms</td><td>.1 ms</td></tr>
<tr><td>2 ms</td><td>2 ms</td><td>.2 ms</td></tr>
<tr><td>5 ms</td><td>5 ms</td><td>.5 ms</td></tr>
<tr><td>10 ms</td><td>10 ms</td><td>1 ms</td></tr>
<tr><td>20 ms</td><td>20 ms</td><td>*2 ms</td></tr>
<tr><td>50 ms</td><td>50 ms</td><td>*5 ms</td></tr>
</table>
*Change TRIG MODE to NORM.</td><td></td></tr>
<tr><td>e.</td><td>Adjust horizontal POSITION to align 1st marker with the center vertical graticule line.</td><td></td></tr>
<tr><td>f.</td><td>Set DELAY TIME POS to 9.00, then adjust it to align the 1st marker with the center vertical graticule line.</td><td>8.91 to 9.09 DELAY TIME POS dial reading.</td></tr>
<tr><td>g.</td><td>Select new settings from step 21, part d.</td><td></td></tr>
<tr><td>h.</td><td>Set DELAY TIME POS to 9.00.</td><td></td></tr>
</table>

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
21. (continued)		
i.	Adjust horizontal POSITION to align 1st marker with the center vertical graticule line.	
j.	Set DELAY TIME POS to 1.00, then adjust it to align the 1st marker with the center graticule line.	0.91 to 1.09 DELAY TIME POS dial reading.
k.	Select new settings from step 21, part d.	
l.	Set DELAY TIME POS to 1.00 and return to step 21, part e.	
22.	**Delay Time Jitter.**	
a.	Connect equipment as shown in step 17, part a.	
b.	Preset controls as listed in step 1; then reset as follows: CH 1 VOLTS/DIV .5 A TIME/DIV 1 ms B TIME/DIV .5 μs DELAY TIME POS 1.00 HORIZ DISPLAY B DLY'D B SOURCE STARTS AFTER DELAY INTEN Visible display	
c.	Set time-mark generator for 1 millisecond time markers.	
d.	Very slightly adjust DELAY TIME POS until leading edge of waveform is visible.	1 division or less horizontal displacement (jitter) of waveform leading edge.
e.	Set DELAY TIME POS to 9.00.	
f.	Repeat step 22, part d.	
23.	**Mixed Sweep Accuracy.**	
a.	Connect equipment as shown in step 18, part a.	
b.	Preset controls as listed in step 1; then reset as follows: B SOURCE STARTS AFTER DELAY HORIZ DISPLAY MIXED VOLTS/DIV .5 A TIME/DIV 1 ms B TIME/DIV .1 ms DELAY TIME POS Fully Clockwise	
c.	Set time-mark generator for 1 millisecond time markers.	
d.	Adjust horizontal POSITION to align 1st time marker with the left vertical graticule line.	1 time marker per division within 0.36 division from the first to the tenth graticule line.

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
23. (continued)		
e.	Set DELAY TIME POS fully counterclockwise.	
f.	Set time-mark generator for 0.1 millisecond time markers.	
g.	Adjust horizontal POSITION to align the first time marker with the left vertical graticule line.	1 time marker per division within 0.18 division from the second to the eleventh graticule line.
h.	Set controls as follows: A TIME/DIV .5 μs B TIME/DIV .05 μs	
i.	Set time-mark generator for 50 nanosecond time markers.	
j.	Adjust horizontal POSITION to align the first time marker with the left vertical graticule line.	1 time marker per division within 0.18 division from the second to the eleventh graticule line.
k.	Set DELAY TIME POS fully clockwise.	
l.	Set time-mark generator for 0.5 microsecond time markers.	
m.	Adjust horizontal POSITION to align the first time marker with the left vertical graticule line.	1 time marker per division within 0.36 division from the first to the tenth graticule line.
24.	**+Gate Outputs and A Trigger Holdoff.**	
a.	Preset controls as listed in step 1; then reset A AND B TIME/DIV to 2 μs.	
b.	Connect a monitor oscilloscope to the +A GATE output on the rear panel with a 50 ohm BNC cable and set its TIME/DIV to 5 μs.	5 volt positive pulse within 0.5 volt.
c.	Set oscilloscope under Test A AND B TIME/DIV to 5 μs.	
d.	Set monitor oscilloscope TIME/DIV to 20 μs.	
e.	Adjust monitor oscilloscope VAR TIME/DIV so the negative portion of the pulse is 1-division wide.	
f.	Rotate oscilloscope under test A TRIGGER HOLDOFF fully clockwise.	Negative portion of pulse width expands to 3 divisions or more.
g.	Rotate oscilloscope under test A TRIGGER HOLDOFF fully counterclockwise into the NORM detent.	
h.	Set monitor oscilloscope VAR TIME/DIV to its calibrated detent.	

Table 5-1. Operational Checkout Procedures (Performance Check)—Continued

Step	Procedure	Performance Requirement
24. (continued)		
i.	Set controls as follows: HORIZ DISPLAY — B DLY'D B SOURCE — STARTS AFTER DELAY A AND B TIME/DIV — 2 μs	
j.	Change monitor oscilloscope input from +A GATE to +B GATE on oscilloscope under test.	5 volt positive pulse within 0.5 volt.
25.	**Chopped Mode Repetition Rate.**	
a.	Preset controls as listed in step 1; then reset as follows: A AND B TIME/DIV — 1 μs VERT MODE — CHOP A LEVEL — Stable display	33.3 to 5 divisions between the start of each complete wave cycle of the display.

5-2. PREVENTIVE MAINTENANCE. Operator preventive maintenance consists of external inspection and cleaning. Instrument repair agency preventive maintenance consists of external and internal inspection, cleaning, and lubrication. When performed regularly, preventive maintenance can prevent instrument breakdown and improve reliability.

a. Preventive Maintenance Schedule. Preventive maintenance schedules are usually established by a combination of user policies, equipment uses, and equipment environmental conditions. Lacking this guidance, Table 5-2 is a recommended preventive maintenance schedule for instruments in continuous use.

Table 5-2. Preventive Maintenance Schedule

	As required	Monthly	Semiannual or 1000 instrument hours
External cleaning	X		
External inspection		X	
Internal cleaning			X
Internal inspection			X
Calibration			X

b. External Preventive Maintenance. The following instructions are intended for use by either operators or the instrument repair agency.

(1) External Inspection. Table 5-3 is a list of external items to be inspected for damage or wear. Coordinate with the repair agency for repair of items that would cause serious or further damage to the instrument if not repaired immediately.

CAUTION

Instruments that appear to have been dropped, or otherwise abused, should be checked by qualified instrument repair technicians to verify correct operation and calibration.

(2) External Cleaning, Except Crt Faceplate and Filter. Dust the exterior surfaces with a dry, lint-free cloth or a soft bristle brush. If hard dirt remains, use a cloth or swab dampened with warm water and a mild detergent. A small swab is useful for cleaning in narrow spaces and around controls.

CAUTION

To prevent getting water inside the instrument during external cleaning use only enough water to dampen the cloth or swab.

Do not use chemical cleaning agents as they may damage the plastics used in the instrument. Use only approved cleaning agents.

(3) Cleaning the Crt Faceplate and Filter. To clean the crt faceplate and light filter, remove the filter as shown in Figure 3-1. Clean the faceplate and filter with a soft, lint-free cloth dampened with isopropyl alcohol.

Table 5-3. External Inspection Checklist

Item	Inspect for	Repair action (by repair agency unless otherwise noted)
Cabinet, front panel cover, front panel, and rear panel	Cracks, scratches deformations, and damaged hardware or gaskets.	Touch-up paint scratches (user), Replace cracked, deformed, or damaged parts.
Carrying handle	Correct operation.	Replace damaged parts.
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, damaged connectors.	Repair frayed cables (user). Replace damaged or missing items (user). Repair damaged parts.
Front panel controls	Missing, damaged, or loose knobs or push buttons, Binding controls.	Tighten loose knobs (user). Repair or replace missing or damaged controls. Determine cause of binding controls, and repair.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connector.	Replace damaged parts. Clean or wash out dirt (user).

c. Internal Preventive Maintenance. The following instructions are intended for use by instrument repair agencies only. When this maintenance is performed, the maintenance under External Preventive Maintenance above should also be performed.

WARNING

Electric shock hazards inside the instrument are exposed when the cabinet is removed. Disconnect the instrument from any power source before removing the covers.

(1) Cabinet Removal. Refer to Component Removal and Replacement for instructions on cabinet removal.

(2) Internal Cleaning. Internal cleaning should be done with a dry, low velocity stream of air. A soft bristle brush or swab is useful for cleaning in narrow spaces or around components. If these methods do not remove all the dust or dirt, the instrument may need to be disassembled and washed. Components may be spray washed using a 5% solution of water and mild detergent as follows:

CAUTION

Do not disassemble or wash the TIME/DIV switch and its associated circuit boards. Also, do not wash the vertical attenuators and their circuit boards. Washing may leave a residue on the switch contacts causing intermittent electrical problems.

When washing near unsealed electromechanical components, such as push-button switches use as little washing action as possible. This is to prevent washing all of the lubricant out of the part.

Do not use fluorocarbon base spray cleaners or silicone spray lubricants on cam switches or push-button switches. These sprays may damage the circuit board material or plastic parts and leave a dust collecting residue.

(a) Remove easily accessible shields and covers.

(b) Spray wash and thoroughly rinse the component.

(c) Blow-dry the component with low velocity air.

(d) Spray all switch contacts with isopropyl alcohol, wait for 60 seconds, and blow dry with low velocity air.

(e) Heat dry all components in an oven or compartment using low temperature (125° to 150°F) circulating air.

(3) TIME/DIV Switch Cleaning. This switch should not need cleaning unless it is intermittent. If so, rotate the switch between its limits a few times to see if it will self-clean. If this doesn't work, spray the contact area with

isopropyl alcohol, wait for 60 seconds, and blow dry with low velocity air. If these two methods do not solve the problem, remove the A AND B Timing Switch Board Assembly and disassemble it. Cleaning instructions are contained in the disassembly instructions.

(4) Attenuator Cleaning. The attenuator cam switches should be cleaned like the TIME/DIV switch above. If this doesn't work, disassemble the attenuator and clean the switch pads with an eraser (soft type on a pencil). See Component Removal, Replacement, and Disassembly instructions.

(5) Internal Inspection. Inspect the instrument for internal damage or wear using Table 5-4. Also, inspect externally using Table 5-3.

(6) Lubrication. Components are factory lubricated, which should be adequate for the life of the instrument. Occassionally, a replacement part in an assembly, such as a cam switch, may need lubricating. Where necessary, lubrication instructions are included in the Component Removal and Replacement instructions.

5-3. TROUBLESHOOTING. The following information is provided for troubleshooting the instrument. An understanding of the Theory of Operation in Section IV may be helpful in location of troubles.

Table 5-4. Internal Inspection Checklist

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 connections. Determine cause of burned items, and repair. Repair damaged circuit runs.
Chassis	Detents, deformation, and damaged hardware.	Straighten, repair, or replace damaged hardware.
Resistors	Burned, cracked, broken, or blistered.	Replace damaged resistors.
Solder Connections	Cold solder or rosin joints.	Resolder and clean joint with isopropyl alcohol.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed.	Firmly seat connectors. Repair or replace damaged wire or cables.
Capacitors	Damaged or leaking cases. Corroded solder on terminals or leads.	Replace capacitors with damaged or leaking cases. Clean solder connections and flush with isopropyl alcohol.
Semiconductors	Loosely inserted in sockets. Bent pins.	Remove items with bent pins, carefully straighten the pins with long-nose pliers, and reinsert firmly (be sure that the straightening action hasn't cracked the pin such that it will break easily). Firmly seat all loose semiconductors.
Push-button controls	Binding controls. Missing push buttons.	Determine cause of binding control, and repair. Replace push buttons.

a. Troubleshooting Aids.

(1) Diagrams. Complete circuit diagrams are contained on foldout pages in Section VI, Diagrams. The portions of the circuit mounted on circuit boards are enclosed with heavy lines. The component number and electrical value of each component in this instrument are shown on the diagrams (see the Diagrams section for symbols used on diagrams). Each main circuit is assigned a series of component numbers to assist in identifying their circuit location. Important voltages and waveforms are also shown on the diagrams. The physical locations of the waveform test points are shown on the circuit board illustrations.

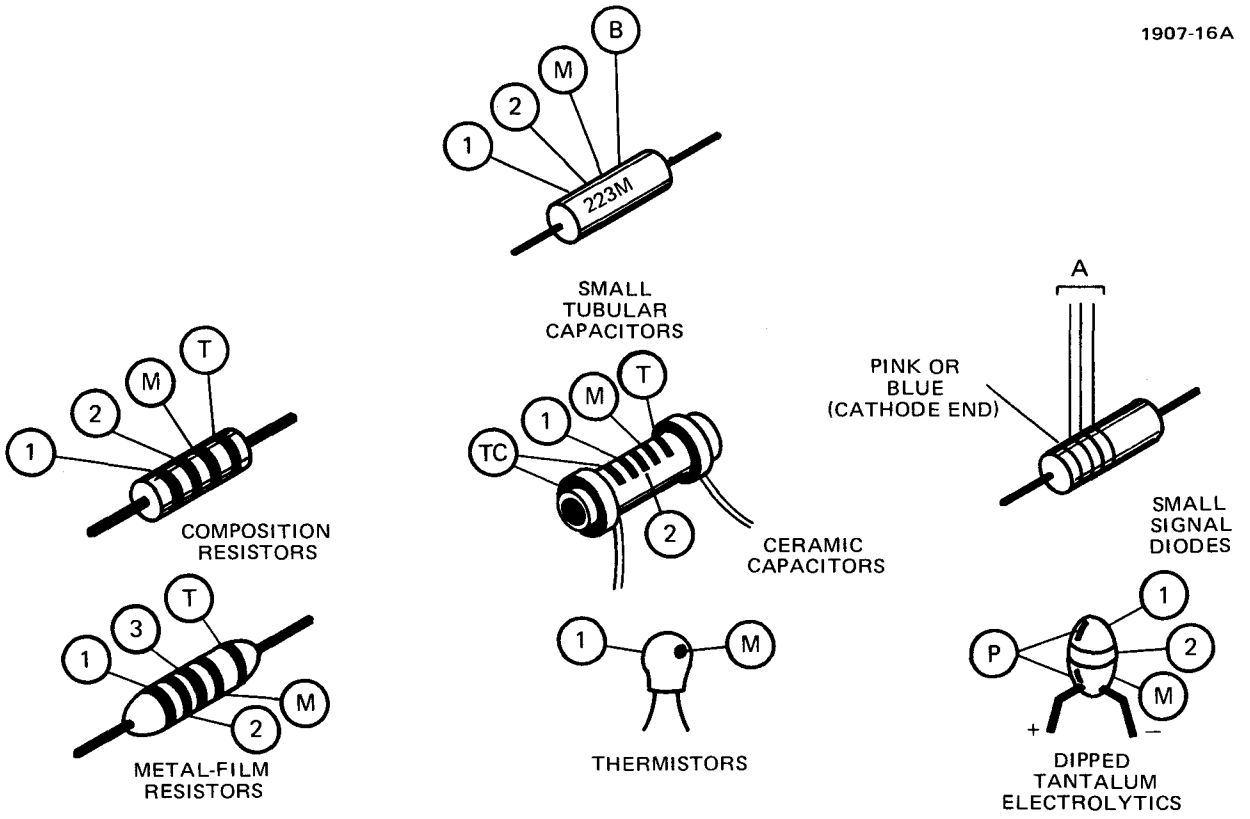
(2) Circuit Board Illustrations. An illustration showing the location of each circuit board precedes each applicable schematic diagram. Portions of a circuit board may apply to more than one schematic diagram. A circuit board illustration showing all of the components on a board is located on the back of a foldout page preceding the first schematic diagram the board components apply to. Each circuit board illustration is provided with a grid and a grid index to facilitate rapid location of components contained on the circuit board.

(3) Component Value Identification. Values of capacitors, diodes and resistors used in this instrument are identified by direct numerical values or by a color code scheme. Figure 5-1 shows the color code and numerical value schemes used.

(4) Troubleshooting Chart. A troubleshooting chart Figure 5-2, is provided to aid in locating problem areas.

(5) Semiconductor Lead Configurations. Typical semiconductor lead configurations are shown in Figure 5-3.

1907-16A



(A) COLORS IDENTIFY SIGNIFICANT DIGITS IN TEKTRONIX PART NUMBER (E.G. BROWN, GRAY, GREEN STRIPES INDICATE PART NUMBER 152-0185-00)

(B) TOLERANCE; F=±1%, J=5%, K=10%, M=20%

(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 (Ω)		CAPACITORS (pF)			DIPPED TANTALUM VOLTAGE RATING
		MULTIPLIER	TOLERANCE	MULTIPLIER	TOLERANCE		
					over 10 pF	under 10 pF	
BLACK	0	1	–––	1	±20%	±2 pF	4 VDC
BROWN	1	10	±1%	10	±1%	±0.1 pF	6 VDC
RED	2	10^2 or 100	±2%	10^2 or 100	±2%	–––	10 VDC
ORANGE	3	10^3 or 1 K	±3%	10^3 or 1000	±3%	–––	15 VDC
YELLOW	4	10^4 or 10 K	±4%	10^4 or 10,000	+100% –9%	–––	20 VDC
GREEN	5	10^5 or 100 K	±½%	10^5 or 100,000	±5%	±0.5 pF	25 VDC
BLUE	6	10^6 or 1 M	±¼%	10^6 or 1,000,000	–––	–––	35 VDC
VIOLET	7	–––	±1/10%	–––	–––	–––	50 VDC
GRAY	8	–––	–––	10^{-2} or 0.01	+80% –20%	±0.25 pF	–––
WHITE	9	–––	–––	10^{-1} or 0.1	±10%	±1 pF	3 VDC
GOLD	–	10^{-1} or 0.1	±5%	–––	–––	–––	–––
SILVER	–	10^{-2} or 0.01	±10%	–––	–––	–––	–––
NONE	–	–––	±20%	–––	±10%	±1 pF	–––

Figure 5-1. Component value identification.

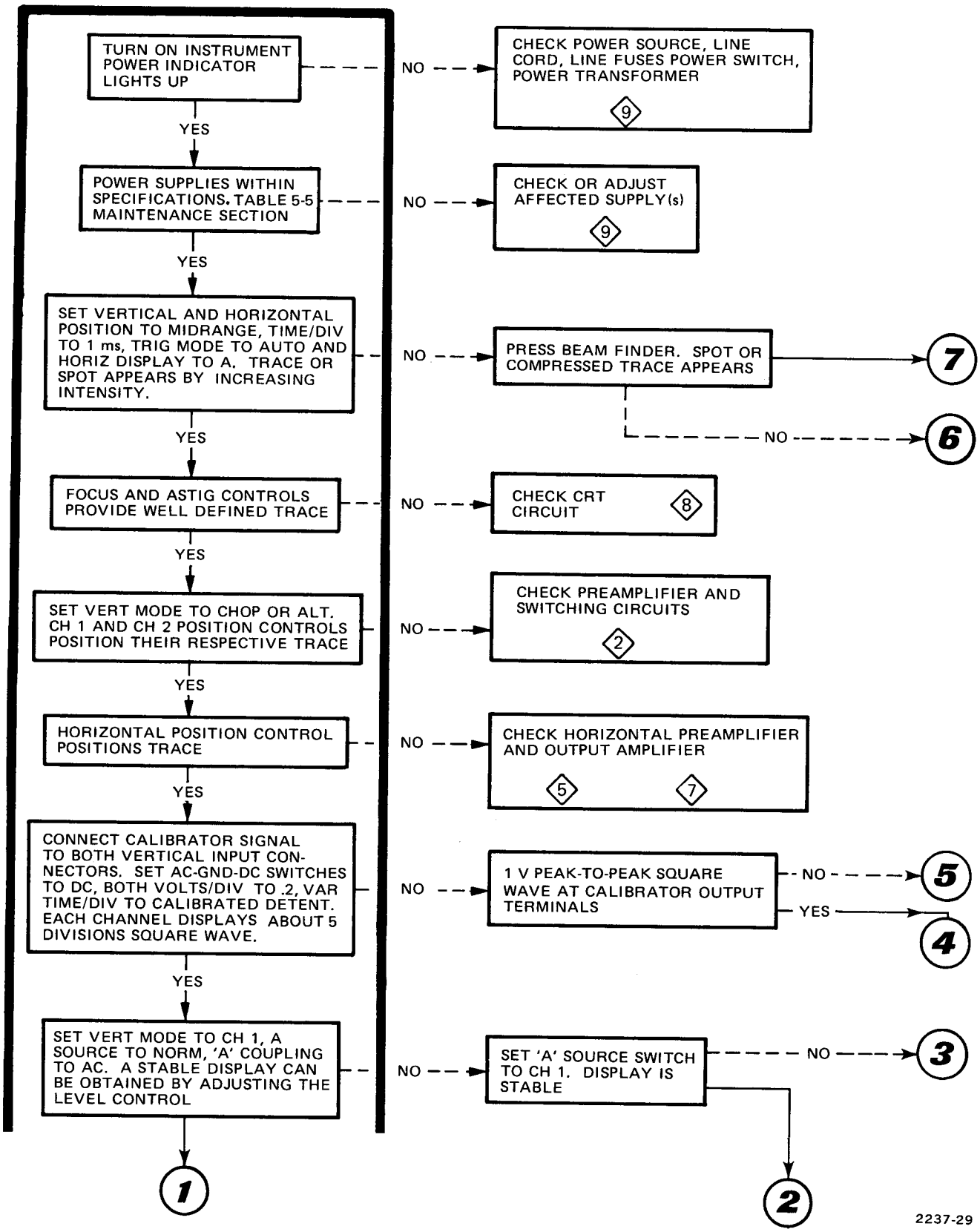
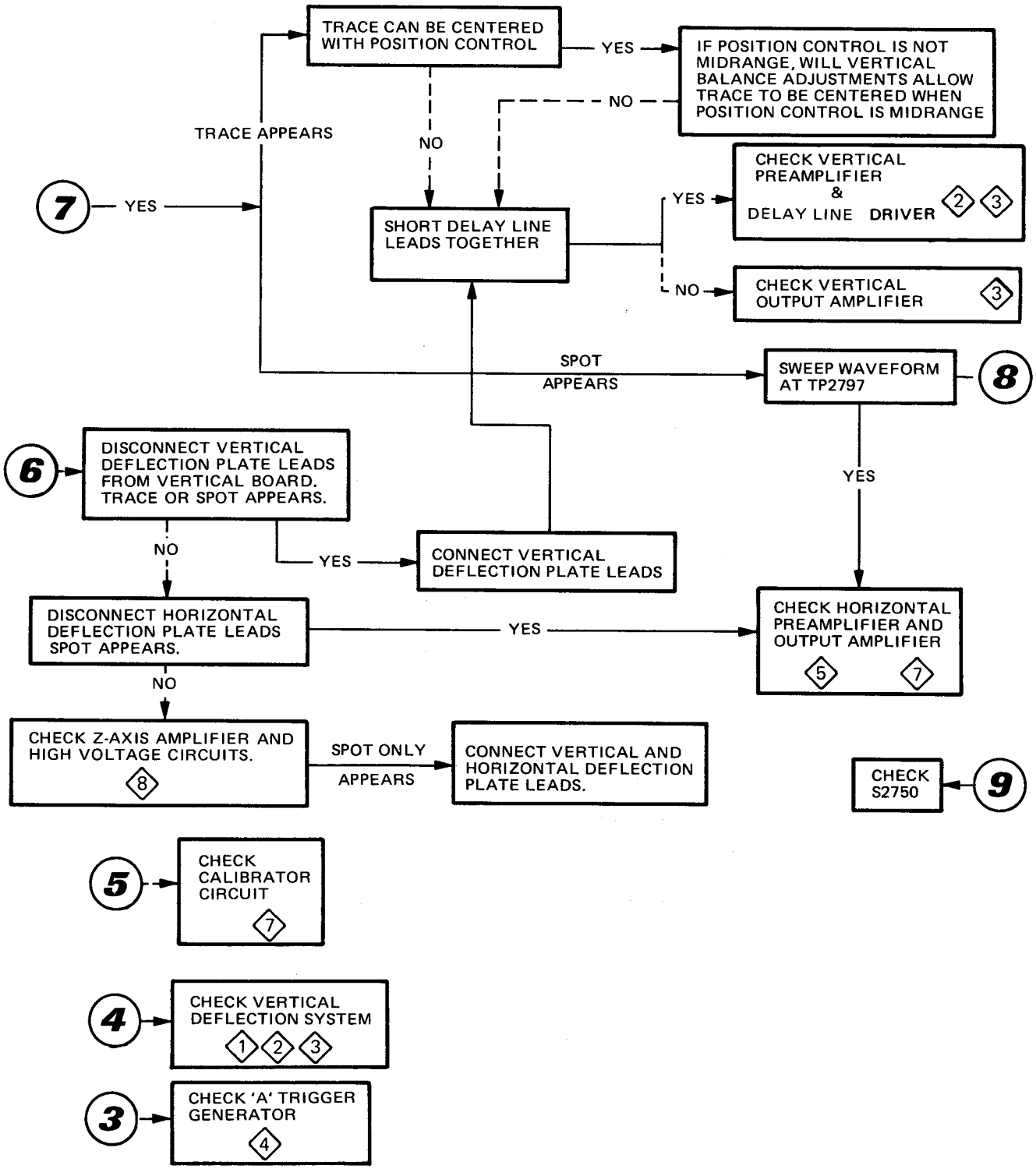
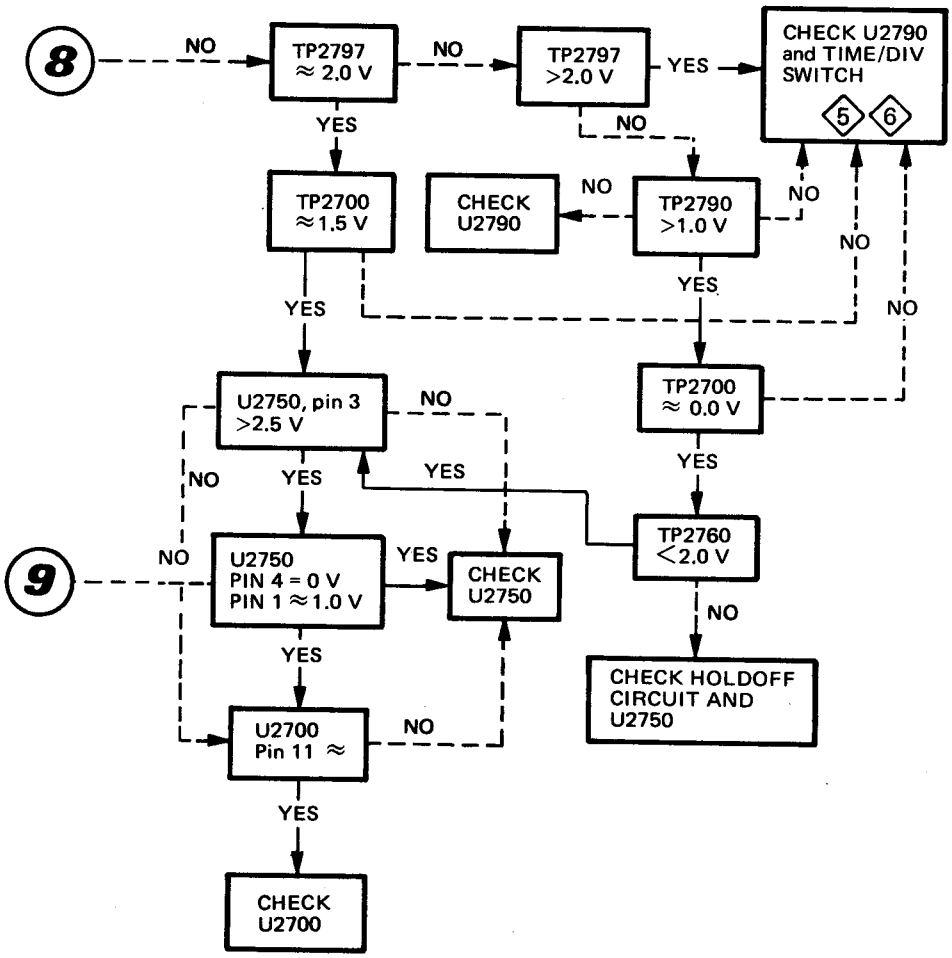


Figure 5-2. Troubleshooting chart (sheet 1 of 5).



2237-109

Figure 5-2. Troubleshooting chart (sheet 2 of 5).



2237-110

Figure 5-2. Troubleshooting chart (sheet 3 of 5).

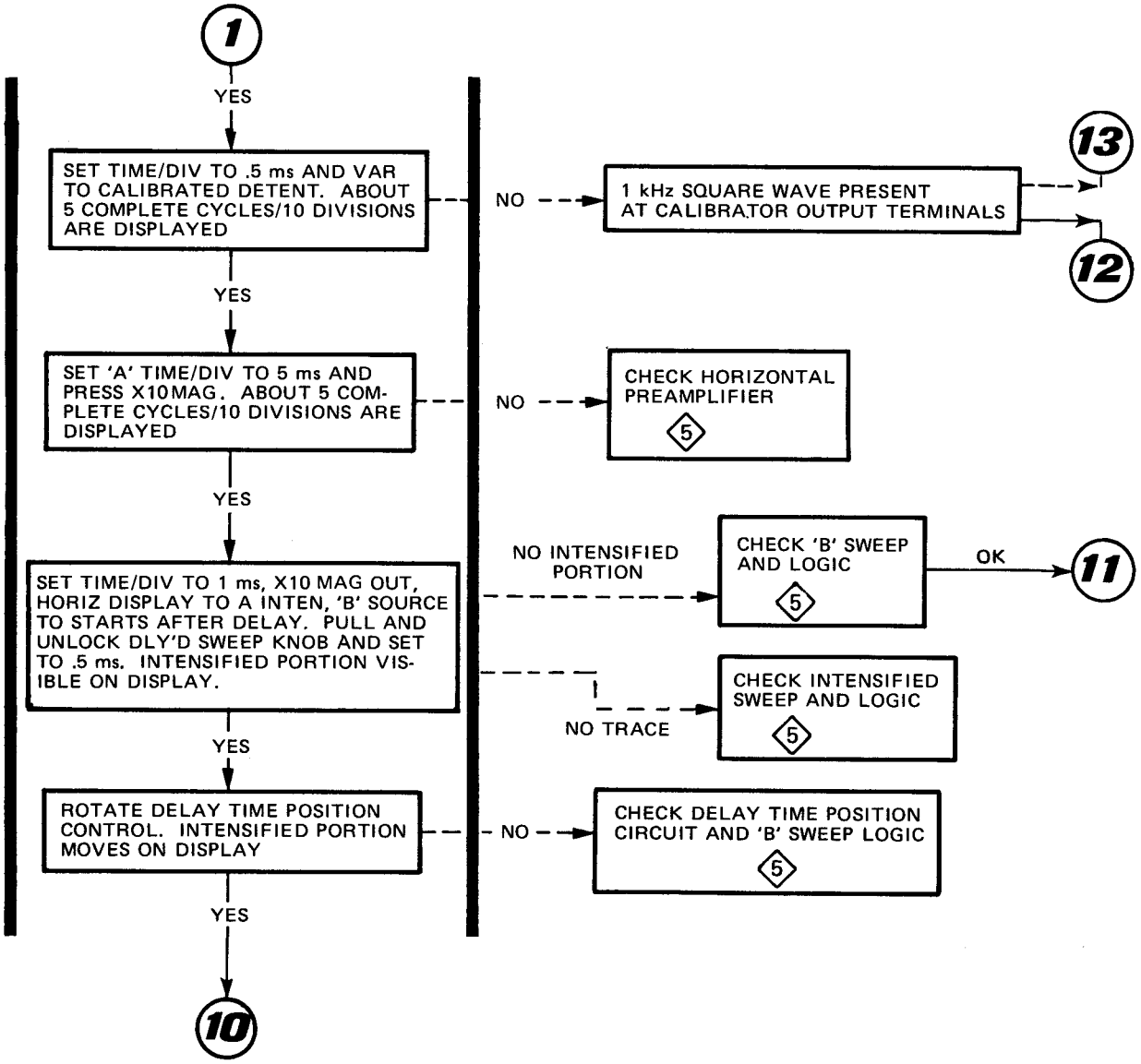


Figure 5-2. Troubleshooting chart (sheet 4 of 5).

2237-30

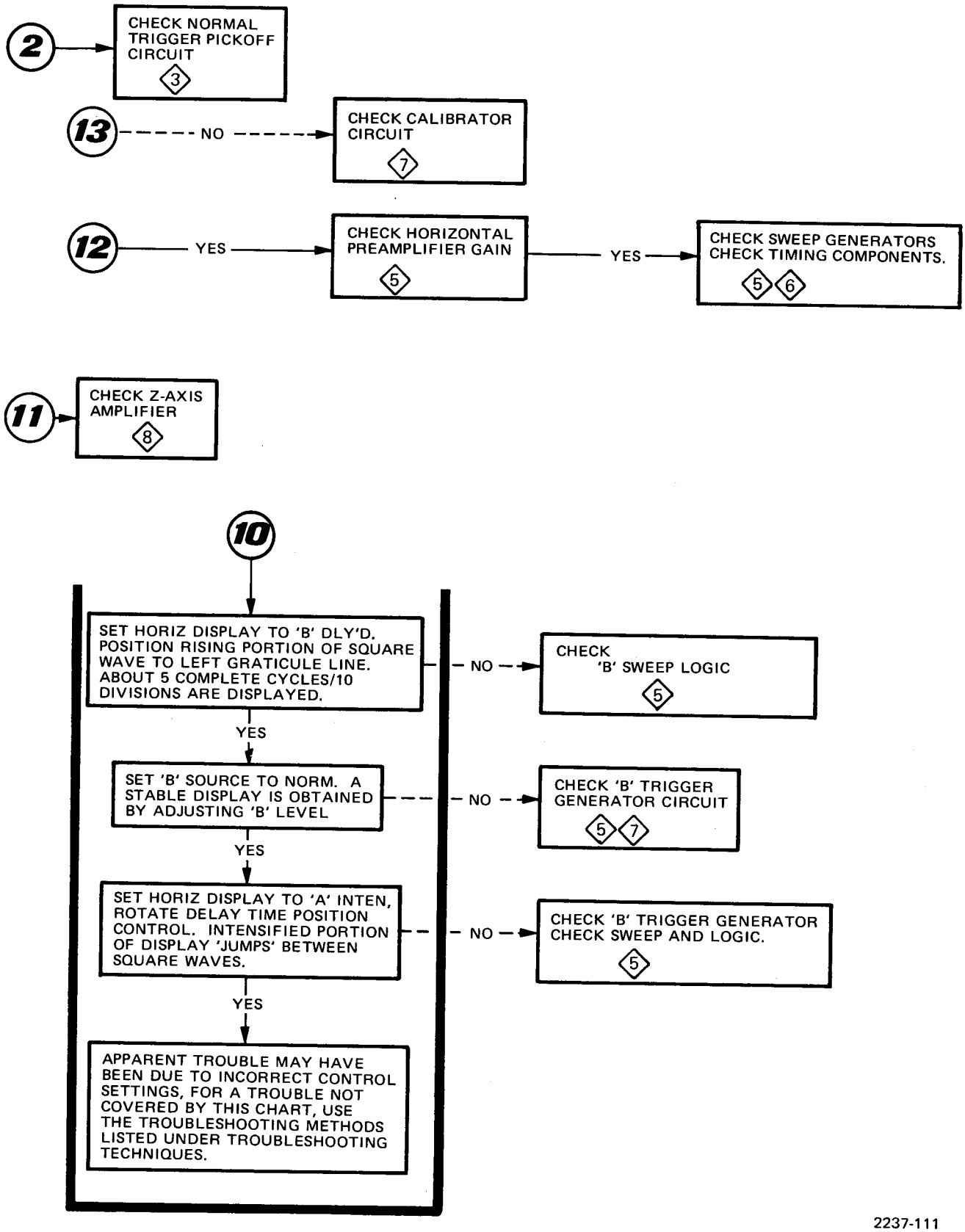


Figure 5-2. Troubleshooting chart (sheet 5 of 5).

NOTE
LEAD CONFIGURATIONS AND CASE STYLES ARE TYPICAL, BUT MAY VARY DUE TO VENDOR CHANGES OR INSTRUMENT MODIFICATIONS.

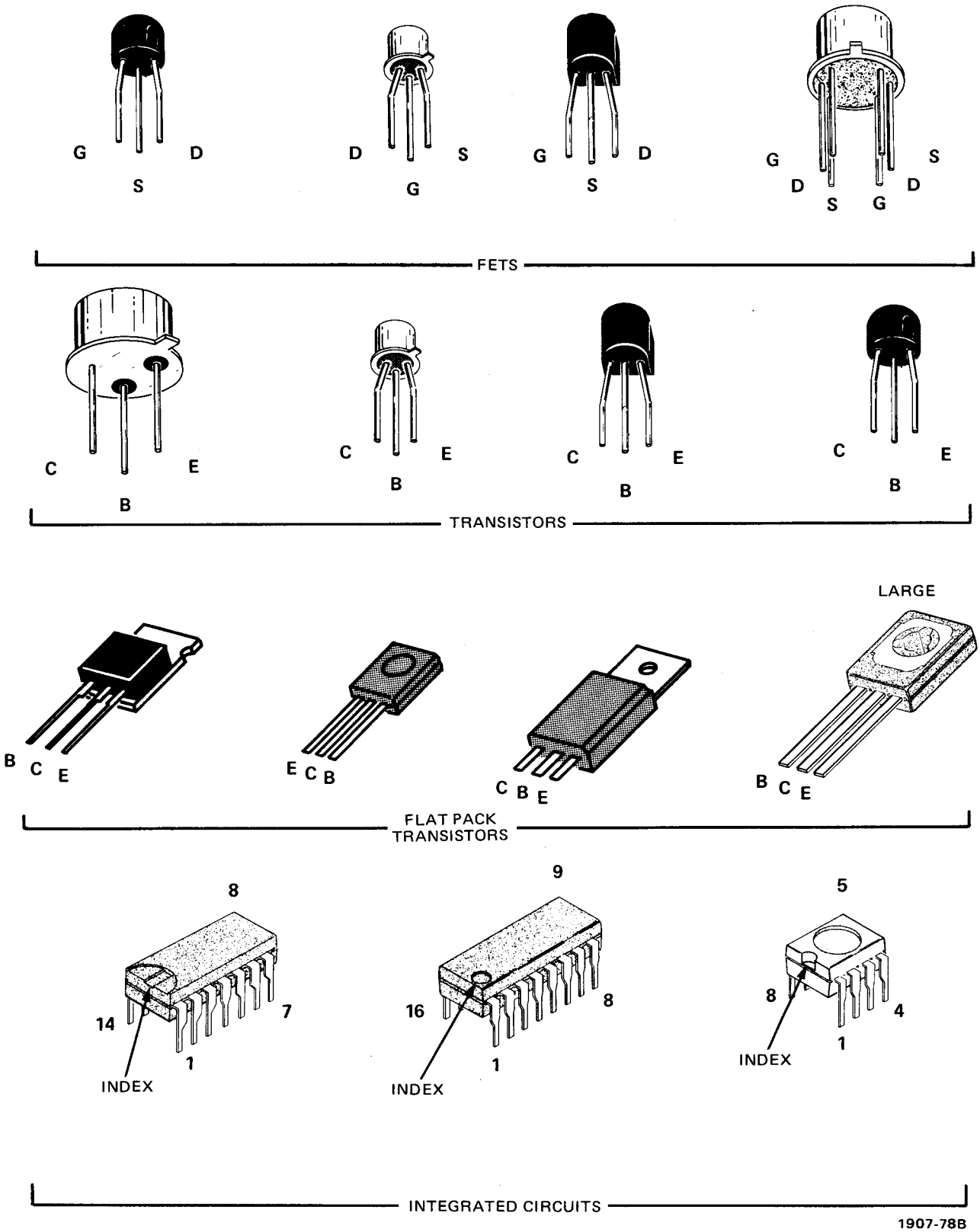


Figure 5-3. Semiconductor lead configurations.

b. Troubleshooting Techniques. The following procedures are arranged in an order that checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining checks should aid in locating the defective component.

(1) Check Control Settings. Incorrect control settings can give a false indication of an instrument malfunction. If there is any question about the correct function or operation of any control, see the Operation Instructions section.

(2) Check Associated Equipment. Before proceeding with troubleshooting, check that the quipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

(3) Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble exists in one circuit. The apparent trouble may only be misadjustment that can be corrected by calibration.

(4) Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visible indications such as unsoldered connections, broken wires, damaged circuit boards, and damaged components.

(5) Isolate Trouble to a Circuit. Using the troubleshooting chart Figure 5-2, isolate trouble to a particular circuit. The symptom often identifies the defective circuit. Trouble appearing in more than one circuit can indicate possible power supply problems. Power supply tolerance and ripple limits can be checked using Table 5-5. Power supply disconnect jumpers are provided for each of the supplies. Refer to the schematics and circuit board illustrations for their location. These jumpers can be unsoldered to disconnect the circuit load from most of the supplies. Each unregulated supply contains a fuse for circuit protection.

(6) Check Circuit Board Interconnections. After the trouble has been isolated to a particular circuit, check for loose or broken connections, improperly seated transistors and heat damaged components.

(7) Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages are given on the diagrams. Waveforms are shown on the circuit diagram apron.

NOTE

Voltages and waveforms given on the diagrams are not absolute and therefore may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the voltage and waveform set up procedures in the Diagrams section. Individual deviations should be noted on the schematics for future reference.

Table 5-5. Power Supply Tolerance and Ripple.

Supply	Tolerance	Maximum Ripple (peak-to-peak)
−5 V	±1.1% (5.5 mV)	1 mV
+5 V	±1.1% (5.5 mV)	1 mV
+32 V	±0.6% (192 mV)	1 mV
+95 V	±2.0 V	1 V
−2 kV	±1.25% (25 V)	200 mV

(8) Check Individual Components. The following procedures described methods of checking individual components. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

WARNING

The Power switch must be turned off before removing or replacing components to prevent electrical shock or circuit damage.

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

1 When troubleshooting transistors in the circuit with a voltmeter, measure the emitter to base and emitter to collector voltages to determine if the voltages are consistent with normal circuit voltages. Voltages across a transistor vary with the type of device and its circuit function. Some of these voltages are predictable. The emitter to base voltage of a conducting silicon transistor will normally be 0.6 to 0.8 volts. The emitter to collector voltages of a saturated transistor is about 0.2 volts. Because these values are small, the best way to check them is by

connecting the voltmeter across the junction and using a sensitive voltmeter setting, rather than by comparing 2 voltages taken with respect to ground (both leads of the voltmeter must be isolated from ground if this method is used). If values less than these are obtained, either the device is short-circuited or no current is flowing in the circuit. If values are in excess of the base emitter values given, the junction is back biased or the device is defective. Values in excess of those given for emitter collector could indicate either a nonsatured device operating normally, or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across resistances in series with it; if it is open, no voltage will be developed across resistances in series with it unless current is being supplies by a parallel path.

2 When troubleshooting a field effect transistor, the voltages across its elements can be checked in the same manner as for transistors. However, it should be remembered that normal depletion mode operation has the gate to source junction reverse biased, while the enhanced mode has the junction forward biased.

3 Integrated circuits (IC's) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential to troubleshooting circuits using IC's. Use care when checking voltages and waveforms around the IC's so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin IC's is with an IC test clip. This device also doubles as an extraction tool.

(b) Diodes. A diode can be checked for an open or for a short circuit by measuring the resistance between terminals with an ohmmeter set to the R X 1 kilohm scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents can damage diodes. Check diodes in the same manner as transistor emitter to base junctions. Silicon diodes should have 0.6 to 0.8 volts across the junction when conducting. Higher readings indicate that they are either back biased or defective, depending on polarity.

(c) Resistors. Check the resistors with an ohmmeter. Check the parts list for tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies considerably from the specified value.

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

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

(f) Attenuators. The thick film attenuators are best checked by substitution. If only one channel is not operating properly, and there is reason to believe an attenuator is defective, replace the suspected attenuator with the same attenuator from the other channel and check instrument operation. If proper operation results, replace or repair the defective attenuator.

5-4. CALIBRATION AND CHECKOUT AFTER REPAIR.

Whenever repairs involve the power supplies or instrument disassembly, Calibration and an Operational Checkout should be performed.

5-5. COMPONENT REMOVAL, REPLACEMENT, AND DISASSEMBLY.

WARNING

To prevent electrical shock or damage to the instrument, always disconnect the instrument from the power source before removing or replacing components. Also, review the Safety Summary page in the front of this manual.

a. Cabinet Top and EMI Shield Removal and Replacement.

(1) Using a coin or large bladed screwdriver, rotate the three circular locks on each side of the cabinet (see Figure 5-5) counterclockwise until the slots are vertical.

(2) Lift the cabinet top straight up.

(3) Remove the nine screws holding the EMI Shield (6 on left side near the front, 2 on the top at the rear, and 1 on the top right at the front).

(4) Lift the EMI Shield straight up.

(5) Replace the EMI Shield and cabinet top in reverse order.

b. Interconnecting Cables and Connectors (Figure 5-4). The interconnecting cable assemblies are factory assembled. They consist of machine installed pin connectors mounted in plastic holders. The plastic holders are easily replaced as individual items, but if the connectors are faulty, the entire cable should be replaced. It is possible for the pin connectors to become dislodged from the plastic holders. If this happens, the connector can be reinstalled as follows:

(1) Bend grooved portion of holder away from cable as shown.

(2) Reinsert connector into its hole in the plug-in portion of holder. Wires are positioned in holder according to color code system (see note below).

NOTE

Holder positions are numbered (number one is identified with a triangle).

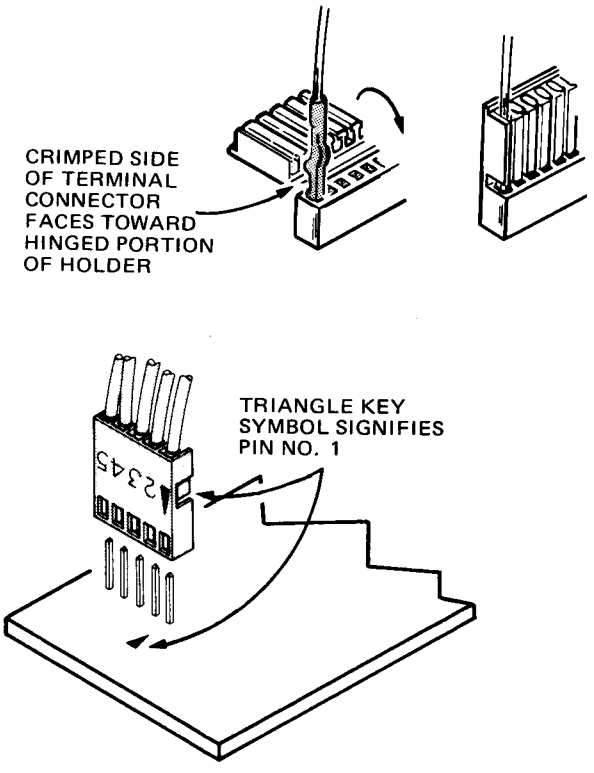


Figure 5-4. Multiconductor connector identification.

(3) Bend grooved part of holder so that connector is inserted into groove.

(4) When plugging connector holders on to board pins, be sure to match triangle mark on holder with triangle mark on circuit board.

c. Rear Panel Assembly Removal and Replacement (Figure 5-5).

(1) Remove the cabinet top.

(2) Unplug the power cord.

(3) Unplug the coaxial connector end at the +A GATE OUT (white wire with yellow trace) and CH 2 OUT (white wire with brown trace) connectors located on the A8 Sweep and A5 Vertical boards, respectively.

(4) Remove the four screws on the inside corners of the rear subpanel.

CAUTION

When removing the rear panel in the next step, be careful not to break or damage the attached wiring or cables.

(5) While carefully pulling the top of the rear panel away from the mounting brackets lift the bottom up and out of the groove in the cabinet bottom. Then lay the rear panel on its back and disconnect the attached wires and cables.

(6) Replace the rear panel in the reverse order. Reconnect the wires and cables. Then hold the panel vertical and set it into the groove in the cabinet bottom. Align the screw holes and install the four corner screws. If the rear panel wires and cables were not tagged when removed, the following may be useful.

(a) The input power wires and power transformer leads are color coded as shown on the schematic diagrams. Also, the circuit board lead mounting holes for the rectifiers are color code numbered for the transformer leads (e.g., 2 is red, 6 is blue, etc).

(b) The clear plastic connectors for the transistors on the rear panel can be installed only with the mounting holes closest to the panel. These transistors are numbered Q736, Q746, and Q768 starting at the power transformer and moving away from it. They connect to number matching

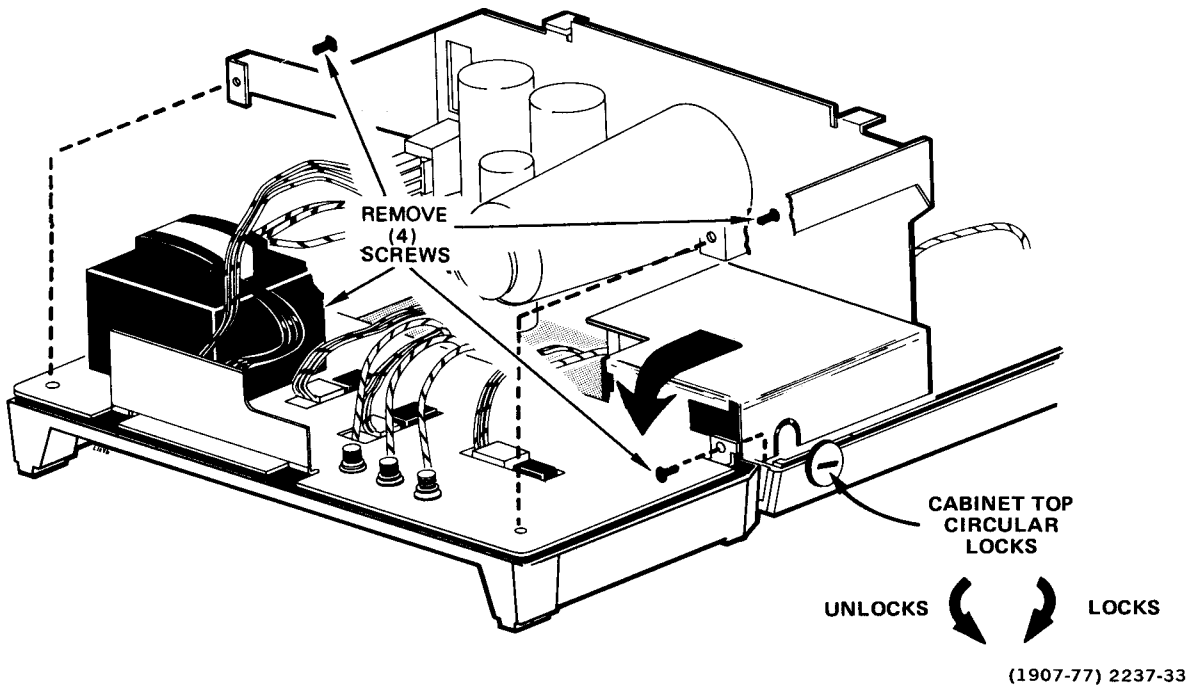


Figure 5-5. Rear panel removal.

plugs (e.g., Q736 to J736, etc.) on the A11 board. Be sure multiconductor holders are installed with proper triangle key orientation (see Figure 5-4).

d. Cabinet Bottom Removal and Replacement (Figure 5-6).

(1) Remove the cabinet top.

(2) Raise the front of the instrument and remove the four external screws from the cabinet bottom.

(3) Remove the rear panel assembly.

(4) Remove the remaining seven internal screws from the cabinet bottom.

(5) Lift the instrument off the cabinet bottom.

(6) Replace the bottom in the reverse order of removal. When installing the four external screws in the front part of the cabinet bottom, the floating nuts inside the instrument along side the front part of the crt, may need to be aligned.

e. Vertical Module Removal (Figure 5-7).

(1) Remove the remaining screw holding the module.

(2) Unplug CH 2 OUT cable, vertical deflection plate leads, and multiconductor connector to the horizontal module.

(3) Pull plug in module straight up and away from interface connector.

(4) Reinstall the module in reverse order. Be sure CH 2 OUT cable is routed through cutout at bottom of module.

f. Horizontal Module Removal (Figure 5-8).

(1) Remove the remaining screw holding the module.

(2) Unplug multiconductor connector to vertical module and +A GATE OUT cable.

(3) Unsnap the POWER switch extension rod from yokes on POWER switch shaft.

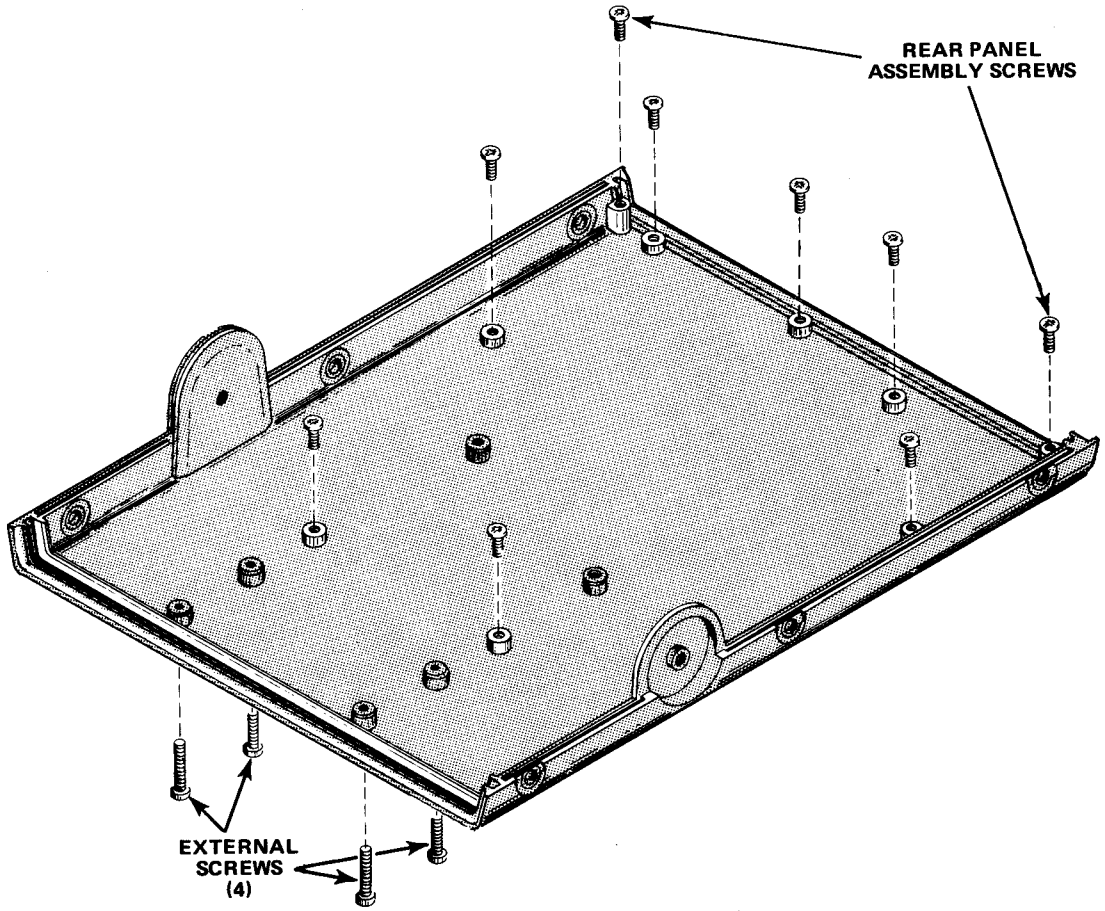


Figure 5-6. Cabinet bottom removal.

(4) Pull plug in module straight up and away from interface connector.

(5) Reinstall the module in reverse order. Be sure plastic yokes on POWER switch are aligned before reinstalling the extension rod.

g. Cathode Ray Tube (Crt) Removal.

WARNING

Handle crt carefully. Rought handling or scratching may cause crt to implode.

(1) Remove vertical module.

(2) Remove plastic bezel and filter on front of crt.

(3) Unplug crt anode lead and discharge to chassis.

(4) Unplug crt base socket.

NOTE

When removing leads in the next two steps make a note of the lead color, or tag the leads.

(5) Disconnect two vertical deflection plate leads from left side of crt neck.

(6) Disconnect two horizontal deflection plate leads from the circuit board.

(7) Hold crt face in one hand and slowly push crt base with other hand.

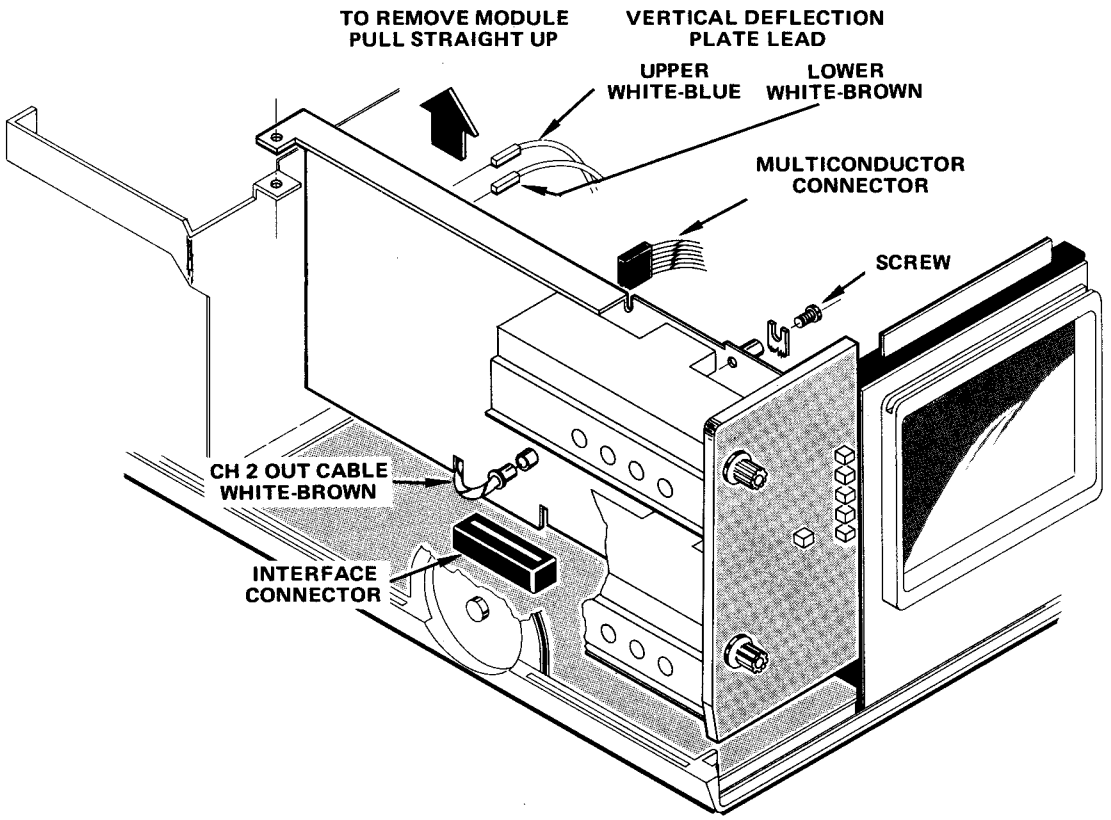


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Figure 5-7. Vertical module removal.

(8) Carefully pull crt out of shield (watch horizontal deflection leads).

(9) Reinstall the crt in reverse order.

h. Shaft-Knob Removal (Figure 5-9).

(1) Grip knob end with one hand and shaft with other hand.

(2) Pull on knob, while pushing on shaft, to free recessed portion of shaft from retainer bushing. Some shaft-knobs may require considerable force to remove.

(3) Replace the shaft-knob in reverse order.

i. Interface Board Removal.

(1) Remove the vertical and horizontal modules.

(2) Lift up the front of the instrument and remove the four external cabinet bottom screws.

(3) Unplug the crt socket.

(4) Remove the high voltage shield.

(5) Remove the shaft-knob from INTEN, ASTIG, FOCUS, TRACE ROTATION, and SCALE ILLUM controls (see h. above).

(6) Unplug the crt anode lead and discharge it to the chassis.

(7) Unplug the crt vertical deflection plate leads from crt (left side) and horizontal deflection plate leads from the Interface circuit board.

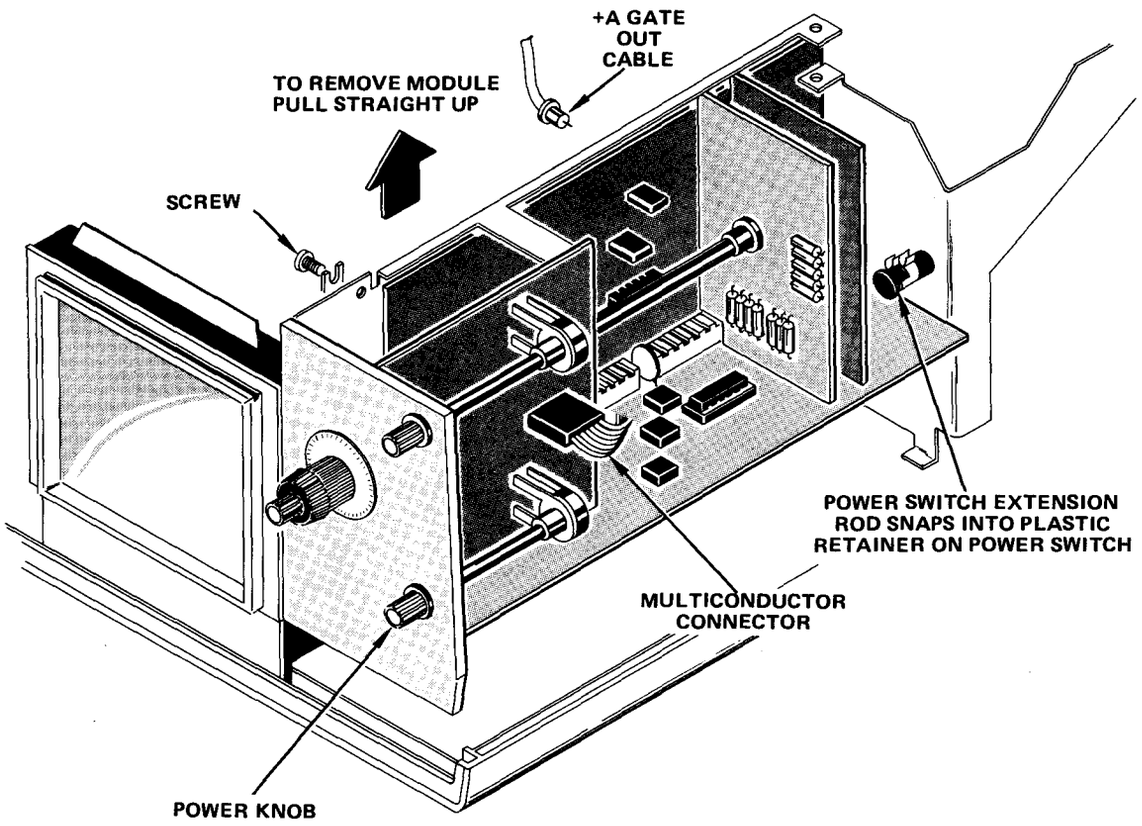


Figure 5-8. Horizontal module removal.

(8) Unplug the crt trace rotation and Y-Axis leads coming from the top of the crt.

(9) Remove the ground post and bracket at the top rear of the crt shield.

(10) Carefully lift the crt assembly (crt, shield, and center front section) forward and up away from the chassis.

The BEAM FINDER push button should slip out of the assembly.

(11) Remove the two screws and two nuts holding the power supply chassis divider. Loosen the small screw in the front lower right corner of this chassis (there is a heat sink on the other side). Carefully remove the chassis.

(12) Remove the rear panel and disconnect the wires and cables to the Interface Board.

(13) Remove the remaining screws holding the Interface Board to the cabinet bottom.

(14) Reinstall the board in reverse order. Be sure to properly install the heat sink when replacing the divider chassis in step (11).

j. A and B Timing Switch Board Assembly Removal and Replacement (Figure 5-10).

(1) Remove the horizontal module.

(2) Remove the VAR (1 hex screw) and the TIME/DIV knobs by loosening their set screws with a 1/16 inch hex wrench.

(3) Remove the two screws and hex nuts holding the switch board assembly.

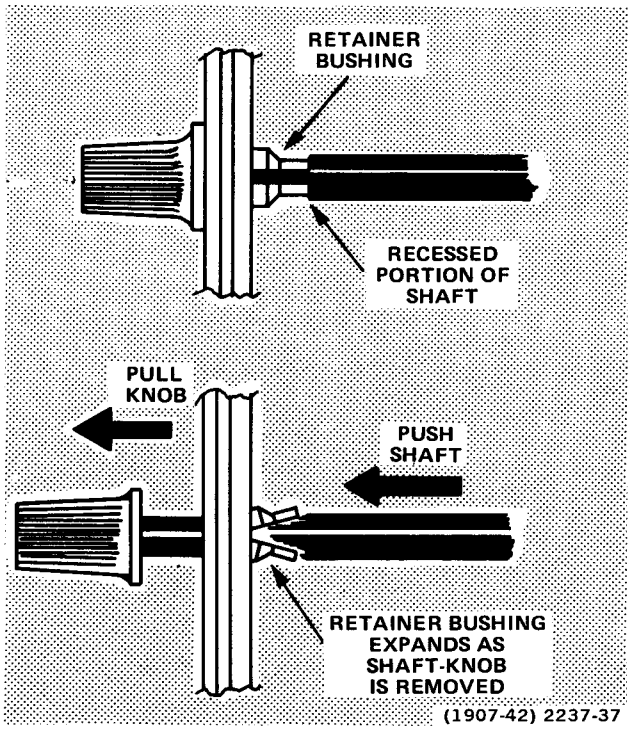


Figure 5-9. Shaft-knob removal.

(4) Remove the TIME/DIV knob skirt by loosening its set screw with a 5/64 inch hex wrench.

CAUTION

When removing the assembly in the next step, be careful not to bend the connector pins on the A8 Sweep Board.

(5) Carefully pull the board assembly away from the Sweep Board until it just unplugs. Then pull the board assembly toward the rear of the module until the switch shaft exits the front panel.

(6) Reinstall the assembly as follows:

(a) Guide the switch shaft through the front panel opening and carefully plug the board into the Sweep board.

(b) Grip the bushing at the switch end of the A TIME/DIV shaft and rotate the shaft fully counterclockwise, then two positions clockwise (.2 ms). Install the plastic knob skirt so the window in the skirt aligns with the .2 ms panel marking and tighten the knob skirt set screw.

(c) Grip the bushing at the switch and rotate the A TIME/DIV shaft fully counterclockwise. Temporarily install the B TIME/DIV knob, pull to unlock and rotate the B TIME/DIV shaft fully counterclockwise.

(d) Loosen set screw and install the B TIME/DIV knob so that the white line points to the same setting as the black bordered window on the knob skirt (pointing at X-Y). Tighten the set screws.

(e) Grip the VAR potentiometer shaft coupling and rotate the VAR shaft fully clockwise into the detent. Install the VAR knob with the word VAR horizontal and tighten the set screw.

(f) Set TIME/DIV to X-Y. Pull the B TIME/DIV knob to unlock and rotate fully clockwise. When properly installed, B TIME/DIV should set to 0.5 μs and cause A TIME/DIV to set to .2 s.

k. A and B Timing Switch Disassembly (Figures 5-10 and 5-11).

(1) Remove the VAR shaft by loosening its set screw at the VAR potentiometer coupling with a 0.05 inch hex wrench.

(2) Remove the four screws holding the switch and boards together. Separate the boards, being careful that the switch doesn't fall out. Also, do not lose the two plastic nut retainers.

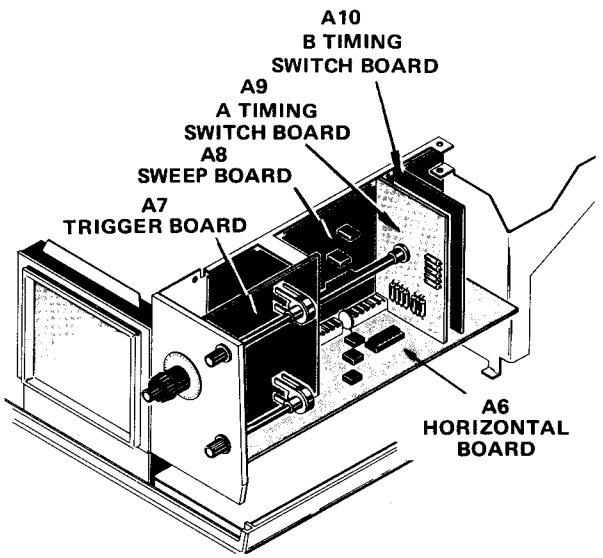


Figure 5-10. Horizontal module board locator.

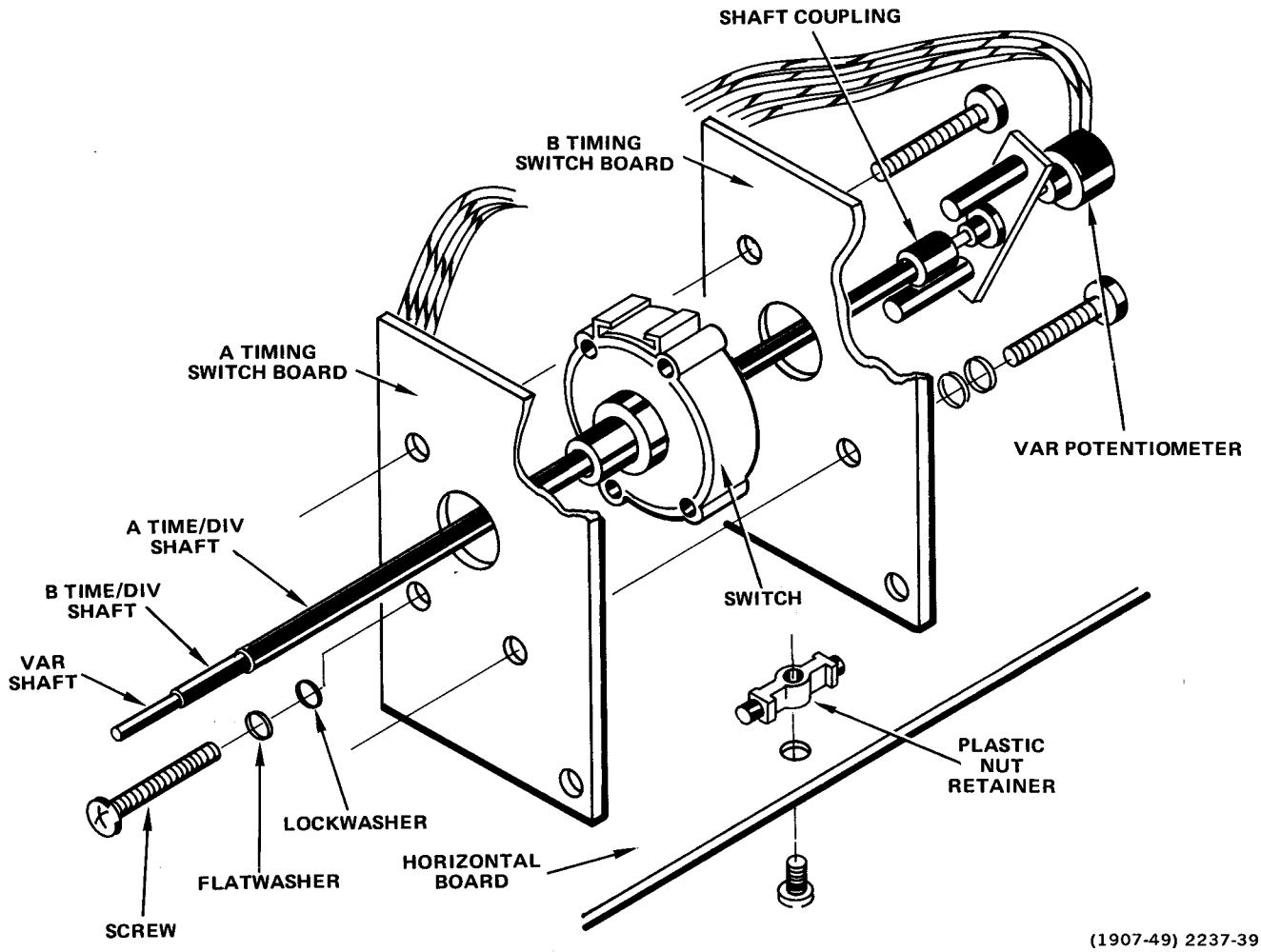


Figure 5-11. TIME/DIV switch disassembly.

CAUTION

Do not touch the switch contact wipers as they are easily damaged or contaminated. Do not use a brush or swab to clean the wipers. Whenever the switch is separated from the boards, it should be placed in some type of container for protection from damage or contamination.

(3) Clean the switch contact pads with a soft eraser (pencil type).

(4) Clean the boards with isopropyl alcohol.

(5) Reassemble the switch as follows:

(a) Insert the switch shaft through the A Timing Switch Board from the control side of the board and position the switch on the board.

NOTE

There are two small tabs on the switch—one round and one oval. These fit into properly sized holes for switch positioning.

(b) Set the remaining switch board on the switch. Be sure the two plastic nut retainers are in place. Install the

two screws and nuts that hold the boards together (insert from the B Timing Switch board side in the unplated holes), but do not tighten them.

(c) Install the VAR potentiometer using the remaining two screws, but do not tighten them.

(d) Install the VAR shaft (untapered end) in the VAR potentiometer and tighten the set screw with a 0.050 inch hex wrench.

(e) Tighten the four screws holding the assembly together.

l. Trigger Board Removal and Replacement (Figure 5-10).

(1) Remove the horizontal module.

(2) Unplug the three multiconductor connectors.

(3) Unsolder the B Trigger external input and its ground at the rear of the BNC connector.

(4) Remove one screw at top rear of board.

(5) Carefully pull the bottom of the board toward the right until it just unplugs. Then pull the board out away from the module.

(6) Replace the board in reverse order.

m. Source and Coupling Switch Disassembly. These switches are disassembled by removing the one screw holding each set to the board. Once disassembled, the switch contact pads can be cleaned with an eraser (pencil type) and isopropyl alcohol. Reassemble the switches in reverse order.

CAUTION

Do not touch or clean the switch contact wipers as they are easily damaged or contaminated. Whenever the switches are disassembled, place the switches in a container to protect the wipers.

n. Horizontal Board Removal and Replacement (Figure 5-10).

(1) Remove the horizontal module.

(2) Remove the Trigger Board.

(3) Remove both screws holding the A and B Timing Switch Board Assembly. Unplug the assembly and move it far enough toward the top of the module to uncover the Horizontal Board plugs to the Sweep Board.

(4) Remove the horizontal POSITION and A TRIGGER HOLDOFF shaft knobs (see h. above).

(5) Remove the two screws holding the board (left rear corner and right front corner).

(6) Unsolder the A Trigger external input at the BNC connector and remove the board.

(7) Replace the board in reverse order.

o. Sweep Board Removal and Replacement (Figure 5-10).

(1) Remove the horizontal module.

(2) Remove the A and B Timing Switch Board Assembly.

(3) Remove the Trigger Board.

(4) Remove the Horizontal Board.

(5) Unplug the three multiconductor connectors going to front panel controls.

(6) Remove the four screws holding the board to the chassis and remove the board.

(7) Replace the board in reverse order.

p. Graticule Illumination Board Removal and Replacement.

(1) Remove the horizontal module.

(2) Remove the crt.

(3) Unplug the Graticule Illumination Board connector (beside the Graticule illumination potentiometer), and remove the board.

(4) Reinstall the board in reverse order.

q. Hybrid IC Removal and Replacement (Figure 5-12).

CAUTION

When removing the hybrid IC, handle it with care as the ceramic material may break or crack if dropped or hit sharply.

(1) Remove the vertical module.

(2) Release the TRIG VIEW/20 MHz BW switch shaft from the switch using a 0.050 inch hex wrench. Move it away from the hybrid IC.

(3) Release the INVERT switch shaft by holding the shaft and pulling off the gray push button. Rotate the shaft away from the hybrid IC.

(4) Insert a narrow blade screwdriver between the socket (near the lip) and the mounting clip. Carefully twist the screwdriver until the mounting clamp unlatches from the lip. While holding a finger on the mounting clamp to keep it from springing into the air, unlatch the other lip on the same side. Remove the mounting clamp.

(5) Lift out the hybrid IC.

(6) Replace the hybrid IC as follows:

(a) Note the index key on the hybrid IC and the socket, then set the IC into the socket.

(b) Hook one end of the mounting clamp over two of the lips on one end of the socket; hold this end of the clamp so it doesn't spring off the socket. Push the other end of the clamp down until it hooks over the other two lips.

(c) Return to step (3) above and continue the replacement in reverse order of removal.

r. VOLTS/DIV Attenuator Disassembly (Figure 5-13).

(1) Remove the vertical module.

(2) Remove the VAR knob and shaft by loosening the shaft coupling set screw at the VAR potentiometer with a 0.050 inch hex wrench.

(3) Remove the VOLTS/DIV knob with skirt and shaft by pulling it away from the module.

(4) Remove the vertical POSITION knob with shaft (see h. above).

(5) Remove the attenuator shield by removing its four holding screws and the ground braid screw from the module chassis (on channel 2, unsolder the ground braid from the lug on the shield).

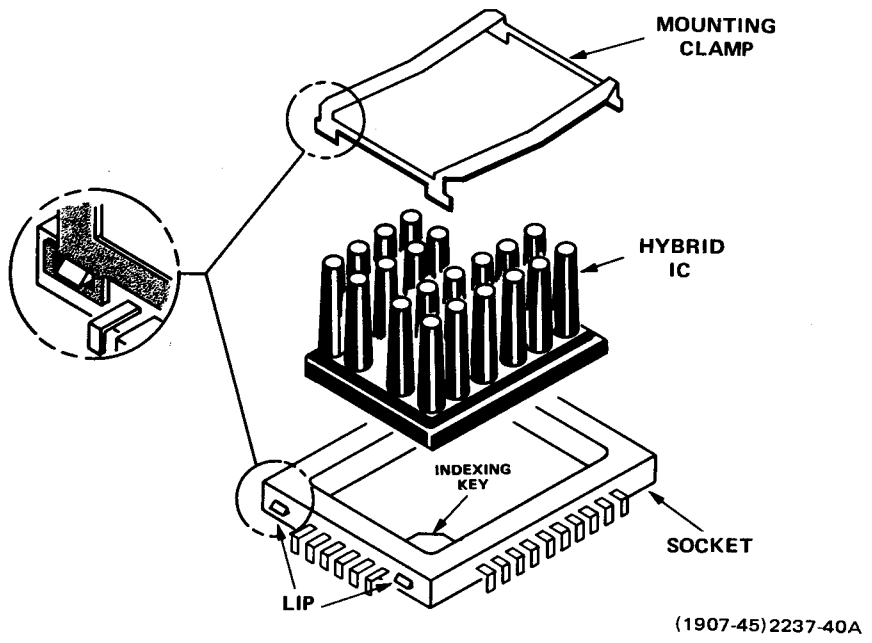


Figure 5-12. Hybrid IC removal.

(6) Remove the small grounding bracket at the front right part of the attenuator assembly by removing the nut just above the BNC connector and the screw under the front right corner of the assembly.

(7) Unsolder the resistor and adjustable capacitor tab from the BNC center conductor.

(8) Remove the BNC connector by unscrewing the large nut and pulling the connector out through the front panel.

NOTE

On some early instruments, the vertical input BNC connector lock washers are secured with Loctite. Later instruments use Loctite without lock washers. Once the Loctite seal on a lock washer is broken, it is recommended that the washer be removed and the nut secured with a drop of Loctite. Hardened Loctite can be softened with low temperature heat between 80° — 100°F.

(9) Unplug the multiconductor connector from the Vertical Board (located near the rear of the attenuator).

(9.1) Remove large shield on soldered side of board (be careful not to lose the two washers under the shield in the holes near the front of the module. They must be installed under the shield in the holes).

(10) Remove the long, narrow shield on the soldered side of the Vertical Board.

(11) Unsolder the one pin connection under the shield removed in (10) above.

(12) Remove the remaining three screws holding the attenuator assembly to the chassis (one located on the soldered side of the Vertical Board near the top front corner; the other two are located on the chassis under the attenuator).

(13) Carefully remove the attenuator assembly. Ensure that the 4 pins near the pin unsoldered in (11) above are disconnected without damage and note their orientation for reassembly reference.

(14) Pull off the AC-GND-DC lever (may need to be very carefully pried away from the cam assembly with a small, thin blade screwdriver).

(15) Remove the three screws holding the cam bearing sections to the circuit board. Then lift the cam out of the assembly.

(16) Remove the three screws holding the contact retainer to the circuit board. Being careful that the two switch contact assemblies (wipers) do not fall out, or otherwise get damaged, lift the retainer out of the assembly. If the contact assemblies stay in the switch, lift them out. If they stick to the retainer, carefully pull them off.

CAUTION

If the contact assemblies are not to be immediately reinstalled, put them in a protective container to prevent damage or contamination.

(17) The switch contact pads on the circuit board can be cleaned with an eraser (pencil type) and isopropyl alcohol.

(18) The cam can be removed from the end bearing section by pulling the cam rotor out of the end bearing section with a twisting motion.

(19) Reassemble the switch as follows:

(a) Install the contact assemblies on the contact retainer as shown in Figure 5-13B. Install these parts in the attenuator assembly. Be sure the plastic alignment posts on the contact retainer are properly inserted in the circuit board. Install the three contact retainer screws, but don't fully tighten them. Very carefully push the end contact assembly down to its pad and check the alignment. Move the contact retainer to align the contact assembly and pad, then tighten the three contact retainer screws.

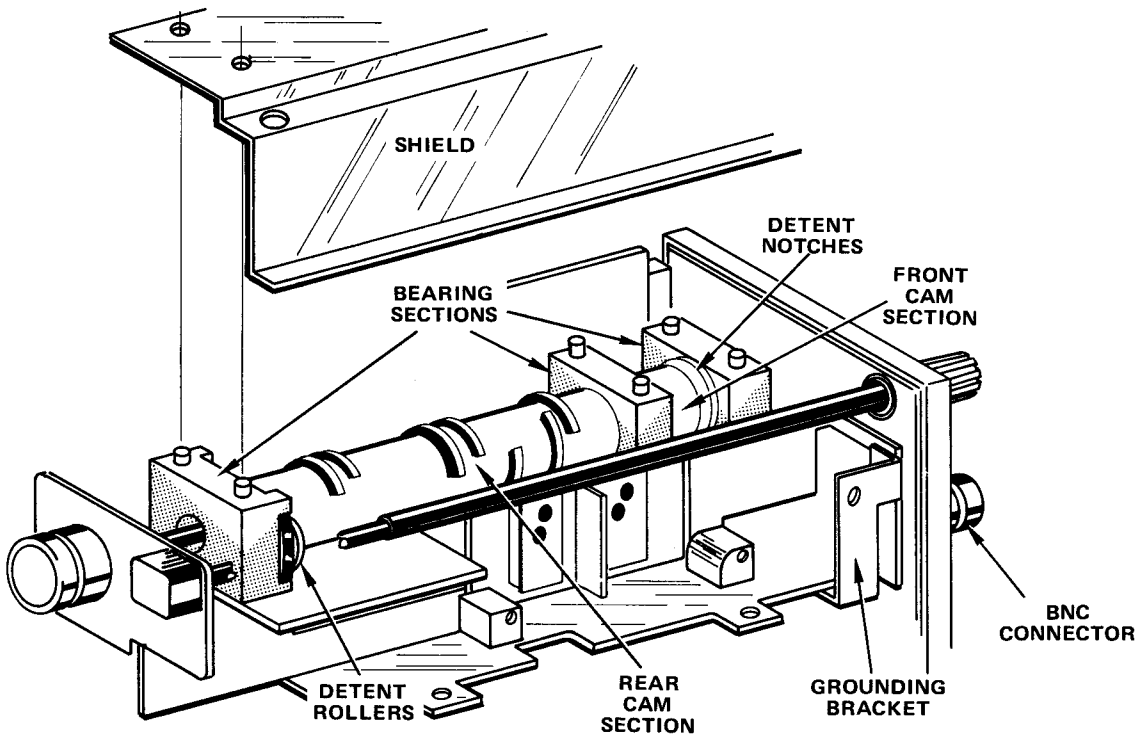
(b) Install each of the two cams in an end bearing section. Set the notched detent end of the cam on the section, then push it into the bearing until it seats (the cam may need to be rotated to get the detent notches past the detent rollers).

NOTE

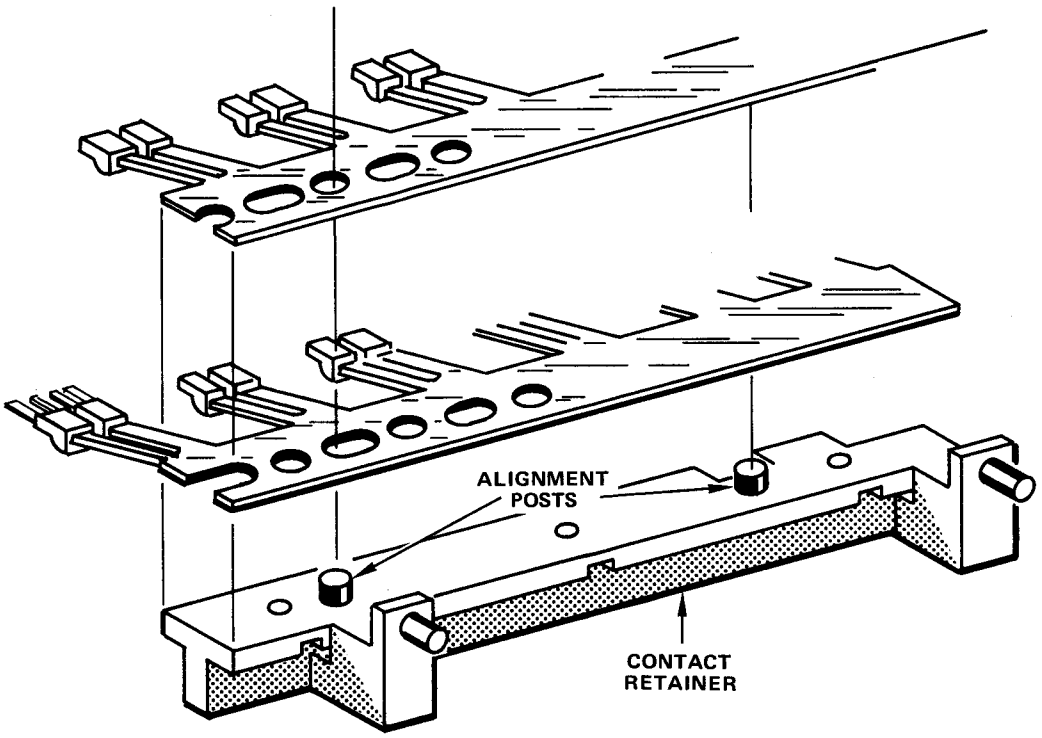
If new cam parts are being installed or the cam has been washed, very lightly lubricate the detent notches and cam ends with silicone grease.

WARNING

Handle silicone grease with care as it can cause skin or eye irritation. Wash hands throughly after use.



A. ATTENUATOR CAM AND BEARING SECTIONS



B. ATTENUATOR CONTACT ASSEMBLIES

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Figure 5-13. VOLTS/DIV attenuator dissassembly.

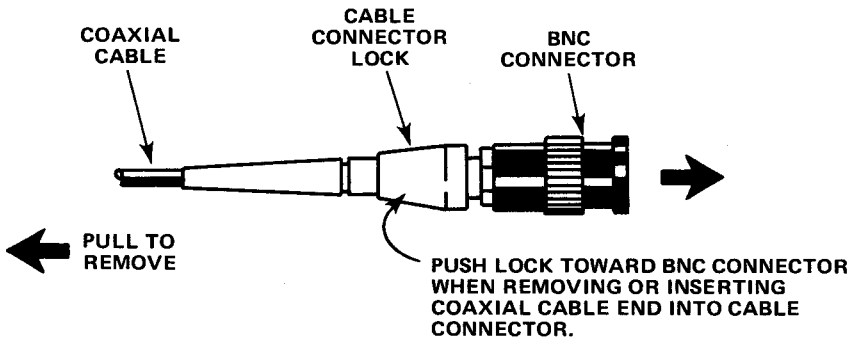

Figure 5-14. Probe BNC connector removal and replacement.

(c) Assemble the cam and three bearing sections so the attaching nuts are facing downward. Hold these parts together and set them into the attenuator assembly with the attaching nuts toward the circuit board. Install the three cam bearing section screws.

(d) Return to step (14) above and continue the reassembly in reverse order of disassembly.

s. Probe Disassembly and Repair.

(1) BNC Connector. The BNC connector on the P6101 probe is removed and replaced as shown in Figure 5-14.

(2) Compensation Box. To remove the compensation box and BNC connector section of the P6104 probe, grasp the retainer cover next to the compensation box with one hand. Then grasp the probe connector adjacent to the retainer cover with the other hand and pull the pieces apart. To reinstall the two parts, just push them together.

(3) Probe Head. The probe head on either the P6101 or P6104 probes can be removed by holding the probe head and the cable connector and pulling them apart.

(4) Probe Cable. By performing step (3) and either (1) or (2) above, the probe cable can be separated into one piece.

t. Light-Emitting Diode (LED) Replacement (Figure 5-15).

NOTE

When unplugging the LED connectors, note which wire color is connected to the LED cathode. The LED shouldn't be damaged if reverse connected, but it won't light.

(1) Remove the LED from the front panel by pushing it out of the panel from the front.

(2) Unplug the LED connector.

(3) Reinstall the LED in reverse order.

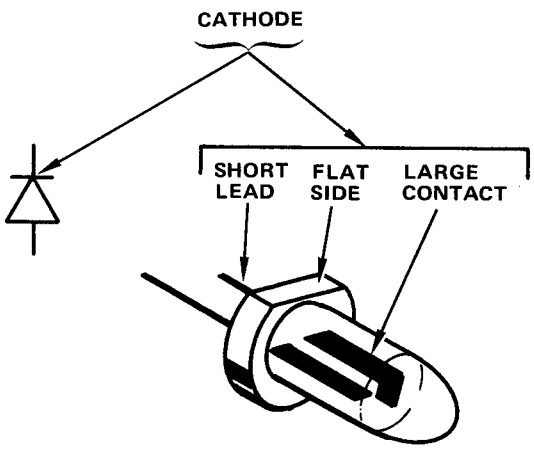

Figure 5-15. Light-emitting diode (LED) lead identification.

u. Push Button, Shaft Extension, and Shaft Extension Adapter Removal and Replacement.

(1) To remove the small gray buttons on push button switches, hold the switch shaft and pull the button off. To replace them, hold the shaft and push the button on.

(2) To remove a shaft extension or its adapter, very carefully pry the connecting joint apart and pull the extension or adapters away from its connecting part.

5-6. CALIBRATION. The following instructions contain complete adjustment procedures for the instrument. When completed, the instrument should meet its original performance characteristics. The procedures are intended to be done in the sequence listed. Test equipment needed for the procedures is listed in Table 2-1. Whenever one procedural step interacts with another, an Interaction Note is provided.

a. Preliminary Calibration Set-Up Procedure:

(1) Remove the top cabinet.

WARNING

To prevent electrical shock with the cabinet removed, do not touch exposed connections or components when the instrument is turned on, or connected to a power source.

(2) Turn on the instrument and allow at least five minutes warm-up.

NOTE

Instrument must be calibrated in an ambient temperature between +20° and +30°C (+68° to +86°F) to meet performance characteristics.

(3) Preset front panel controls as follows (set both vertical channels and horizontal sweeps the same unless otherwise indicated):

VOLTS/DIV	.5 (1X window)
VAR	Fully clockwise (in detent)
AC-GND-DC	DC
POSITION (Vertical)	Midrange
VERT MODE	CH 1
20 MHz BW	In (off)
INVERT	Out (off)
SCALE ILLUM	Fully counterclockwise
HORIZ DISPLAY	A
TRIG MODE	AUTO
COUPLING	AC
SOURCE	NORM
SLOPE	+ (out)
A AND B TIME/DIV	.5 μs
VAR	Fully clockwise (in detent)
DELAY TIME POS	0.0
POSITION (Horizontal)	Midrange
A TRIGGER HOLDOFF	NORM (in detent)
X10 MAG	Out (off)

(4) Do not preset ASTIG and TRACE ROTATION. They will be adjusted later.

(5) Throughout the procedure INTEN, FOCUS, and LEVEL may be adjusted as necessary to obtain a visible, well defined, and stable display. Occasionally, these controls may be set by a procedural step.

b. +32 Volt Power Supply (Figure 5-16).

(1) Connect a digital voltmeter between +32 Volt test point and GND.

(2) Adjust +32 V ADJ, R736 for a +32.0 voltage reading.

(3) Disconnect the voltmeter.

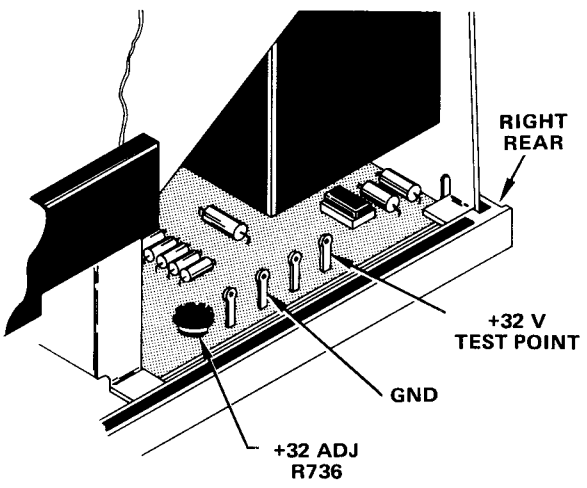

Figure 5-16. +32 volt test point and adjustment location.

c. Crt Bias (Figures 5-17 and 5-18).

(1) Set A AND B TIME/DIV to X-Y.

(2) Connect a digital voltmeter between TP526 and GND.

(3) Set INTEN for about +20 volts (within 0.5 volt) voltage reading.

(4) Disconnect the voltmeter.

(5) Adjust FOCUS and ASTIG for a well defined spot (if spot is not visible, adjust CRT BIAS, R532 until it is; then adjust FOCUS and ASTIG).

(6) Adjust CRT BIAS, R532 until the spot is just visible.

d. Z-Axis Compensation (Figure 5-17).

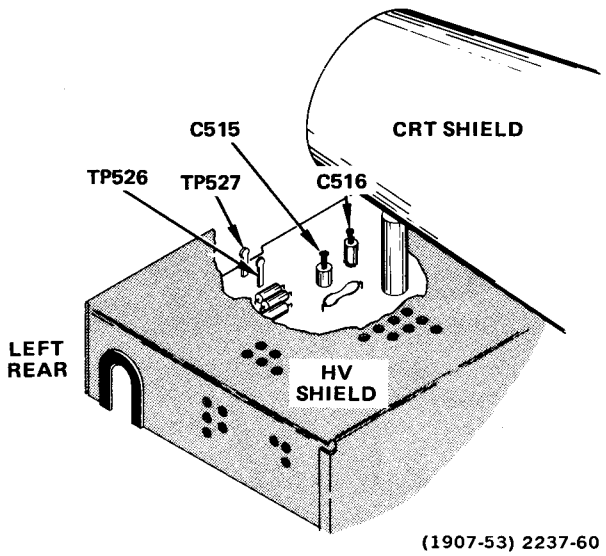

Figure 5-17. Crt and Z-Axis test point and adjustment locations.

(1) Set A TIME/DIV to .5 μs.

(2) Set INTEN for a low intensity display.

(3) Connect a test oscilloscope between TP527 and GND with a 10X probe. Set test oscilloscope TIME/DIV for 2 μs, adjust for a four division, positive going pulse display, and reset test oscilloscope TIME/DIV to 1 μs.

NOTE

A high voltage oscillator signal will be visible, but should be ignored when making the adjustment in the next step.

(4) Adjust C515 and C516 for the squarest front corner on the displayed pulse.

(5) Disconnect the test oscilloscope.

e. Y-Axis Alignment (Figure 5-18).

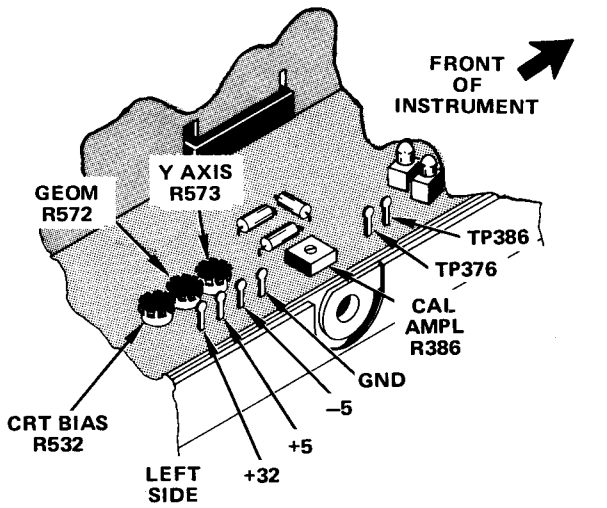

Figure 5-18. Crt and Calibration test point and adjustment locations.

(1) Set A AND B TIME/DIV to 1 ms and CH 1 AC-GND-DC to GND.

(2) Vertically position the display to the center horizontal graticule line.

(3) Adjust TRACE ROTATION to align the trace with the center horizontal graticule line.

(4) Set CH 1 AC-GND-DC to DC.

(5) Connect a time mark generator to CH 1 input through a 50 ohm BNC cable and 50 ohm termination. Set the generator for one millisecond time marks.

(6) Set CH 1 VOLTS/DIV for a dipslay of greater than 8 divisions. Adjust vertical POSITION to place baseline of display below the bottom graticule line.

(7) Set A AND B TIME/DIV, its associated VAR control, and horizontal POSITION for exactly one time marker per division.

(8) Adjust Y AXIS, R573 to align the center time marker with the center vertical graticule line.

INTERACTION NOTE

This adjustment may affect the TRACE ROTATION adjustment. Position the display baseline to the center horizontal graticule line and recheck display alignment. If TRACE ROTATION needs readjustment, alternate between it and the Y-AXIS adjustment until no further adjustment is needed.

(9) Continue to the next procedure.

f. Geometry (Figure 5-18).

(1) Readjust TIME/DIV VAR and horizontal POSITION for one time marker per division.

(2) Adjust GEOM, R572 for minimum bowing of time markers.

INTERACTION NOTE

This adjustment may affect Y-Axis Alignment and TRACE ROTATION. Repeat Y-Axis Alignment, TRACE ROTATION, and Geometry adjustments for optimum overall alignment.

(3) Reset TIME/DIV VAR fully clockwise in its detent.

(4) Disconnect the time mark generator.

g. Calibrator (Figure 5-18).

(1) Connect a digital voltmeter to the CALIBRATOR output.

(2) Connect a shorting jumper between TP376 and TP386 (a small alligator clip works nicely).

(3) Adjust CAL AMPL, R386 for a 1.00 volt dc reading.

(4) Disconnect the voltmeter.

(5) Remove the shorting jumper from TP376 and TP386.

h. Dc Balance (Figure 5-19).

(1) Set CH 1 and CH 2 VOLTS/DIV to 5 m (1X window) and A AND B TIME/DIV to .2 ms.

(2) Adjust CH 1 vertical POSITION to vertically center the trace.

(3) Adjust R4134 for no trace shift when switching CH 1 VOLTS/DIV between 5 m and 10 m.

(4) Set VERT MODE to CH 2.

(5) Adjust CH 2 vertical POSITION to vertically center the trace.

(6) Adjust R4234 for no trace shift when switching CH 2 VOLTS/DIV between 5 m and 10 m.

i. Vertical Gain (Figure 5-19).

(1) Set CH 1 and CH 2 VOLTS/DIV to 5 m (1X window) and VERT MODE to CH 1.

(2) Connect a calibration generator (select STD OUTPUT) to CH 1 input through an unterminated 50 ohm BNC cable. Set the generator for a 20 millivolt output.

(3) Adjust R4443 for a 4-division display.

(4) Set VERT MODE to CH 2.

(5) Move the calibration generator output from CH 1 input to CH 2 input.

(6) Adjust R4272 for a 4-division display.

(7) Continue to the next procedure.

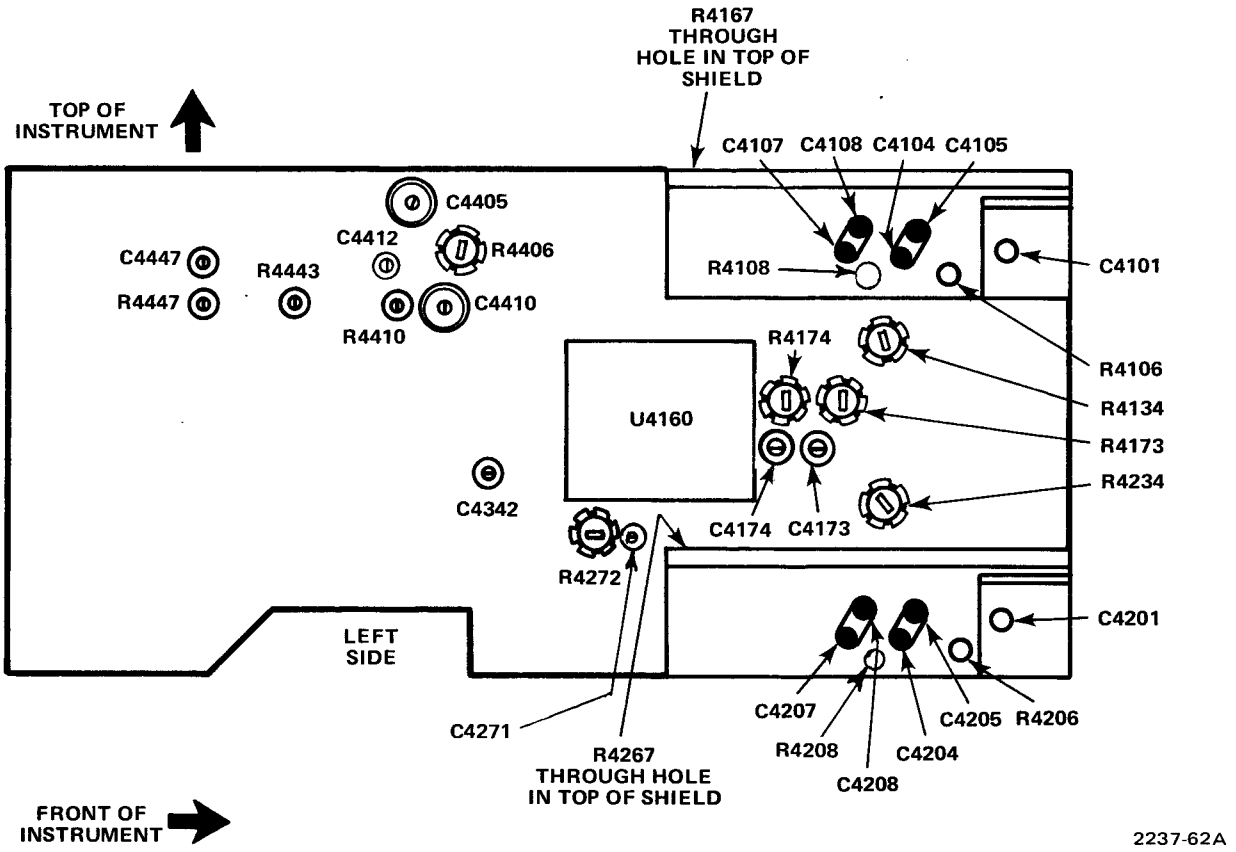

Figure 5-19. Vertical adjustment locations.

j. Channel 2 Low Frequency Compensation (Figure 5-19).

(1) Set square wave generator (same as calibration generator, if using PG 506) for a 1 kilohertz, HIGH AMPL OUTPUT.

(2) Disconnect the square wave generator output from CH 2 and reconnect it to CH 2 through a 10X attenuator, 50 ohm termination, and an input RC normalizer. Set the generator for a 5-division display. During adjustment, set the generator output as necessary to maintain a 5-division display.

NOTE

Use a low capacitance tuning tool when making compensation adjustments.

(3) Adjust C4201 for the best flat top waveform.

(4) Set CH 2 VOLTS/DIV to 50 m and reset the generator output level for a 5-division display.

(5) Adjust C4208 for the best flat top, and C4207 for the best front corner on the waveform. Alternately readjust both capacitors for the best overall waveform response.

(6) Set CH 2 VOLTS/DIV to .5, remove the 10X attenuator, and reset the generator output level for a 5-division display.

(7) Adjust C4205 for the best flat top, and C4204 for the best front corner on the waveform. Alternately readjust both capacitors for the best overall waveform response.

(8) Continue to the next procedure.

k. Channel 1 Low Frequency Compensation (Figure 5-19).

(1) Set VERT MODE to CH 1.

(2) Remove the square wave generator output from CH 2 input and reconnect it to CH 1 through a 50 ohm BNC cable, 10X attenuator, 50 ohm termination, and an input RC normalizer.

(3) Set the generator output level for a 5-division display. During adjustments, reset the generator output as necessary to maintain a 5-division display.

NOTE

Use a low capacitance tuning tool when making compensation adjustments.

(4) Adjust C4101 for the best flat top waveform.

(5) Set CH 1 VOLTS/DIV to 50 m and readjust the generator for a 5-division display.

(6) Adjust C4108 for the best flat top, and C4107 for the best front corner on the waveform. Alternately readjust both capacitors for the best overall waveform response.

(7) Set CH 1 VOLTS/DIV to .5, remove the 10X attenuator, and readjust the generator for a 5-division display.

(8) Adjust C4105 for the best flat top, and C4104 for the best front corner on the waveform. Alternately readjust both capacitors for the best overall waveform response.

(9) Continue to the next procedure.

I. High-Frequency Conpensation (Figure 5-19).

(1) Move the output of the square wave generator to its positive going, FAST RISE OUTPUT.

(2) Set CH 2 VOLTS/DIV to 5 m and VERT MODE to CH 2.

(3) Disconnect the square wave generator output from the CH 1 input, remove the input RC normalizer, install the 10X attenuator between the BNC cable and termination, and connect the generator output to CH 2. Set the generator output to 1 kilohertz and adjust for a 5-division display. During adjustments, maintain a 5-division display.

(4) Adjust R4406 for the best flat top on the waveform.

(5) Set TIME/DIV to 20 μs.

(6) Set generator to 10 kilohertz and adjust for a 5-division display.

(7) Adjust C4405 for the best flat top on the waveform.

(8) Set TIME/DIV to .1 μs.

(9) Set generator for 100 kilohertz and adjust for a 5-division display.

(10) Push in X10 MAG (on).

(11) Adjust CH 2 vertical POSITION so top of waveform is on the center horizontal graticule line.

(12) Adjust C4271, R4410, C4410, C4342, C4412, C4447, and R4447 for the best front corner of the waveform. Total aberrations should not exceed ±3% or 3% peak-to-peak (+0.15 division, −0.15 division, or 0.15 division peak-to-peak).

(13) Set CH 2 VOLTS/DIV to 20 m.

(14) Adjust generator for a 5-division display.

(15) Adjust R4267 for the best front corner of the waveform.

(15.1) Set CH 2 VOLTS/DIV to 50 m.

(15.2) Adjust generator for a 5-division display.

(15.3) Adjust R4208 for the best flat top on the front corner of the waveform.

(16) Set CH 2 VOLTS/DIV to .5.

(17) Remove the 10X attenautor from the generator input to CH 2.

(18) Adjust R4206 for the best front corner of the waveform.

(19) Reinstall the 10X attenuator in the CH 2 input. Set VOLTS/DIV to 5 m and TIME/DIV to 0.5 μs. Adjust for a 5-division display. Check rise time. If it is greater than 3.5 nanoseconds repeat steps (2) through (18).

(20) Move the generator output from CH 2 input to CH 1 input.

(21) Set CH 1 VOLTS/DIV to 5 m and VERT MODE to CH 1.

(22) Adjust CH 1 vertical POSITION so top of waveform is on the center horizontal graticule line.

(23) Adjust C4173, R4173, C4174, and R4174 for the best transient response of the waveform. Total aberrations should not exceed ±3% or 3% peak-to-peak (+0.15 division, −0.15 division, or 0.15 division peak-to-peak).

INTERACTION NOTE

If CH 1 response cannot be adjusted within requirements, very slightly touch up the adjustment in step (12) above. Then recheck the CH 2 response and rise time of both channels.

(24) Set CH 1 VOLTS/DIV to 20 m and TIME/DIV to .1 μs.

(25) Adjust R4167 for the best front corner of the waveform.

(25.1) Set CH 1 VOLTS/DIV to 50 m.

(25.2) Adjust generator for a 5-division display.

(25.3) Adjust R4108 for the best flat top on the front corner of the waveform.

(26) Set CH 1 VOLTS/DIV to .5.

(27) Remove the 10X attenuator from the CH 1 input.

(28) Adjust R4106 for the best front corner of the waveform.

(29) Disconnect the generator.

m. Trigger Hysteresis and Slope Centering (Figure 5-20).

(1) Set controls as follows:

VOLTS/DIV	5 m
A AND B TIME/DIV	5 μs
X10 MAG	Out (off)
VERT MODE	CH 2
A LEVEL	0
A SOURCE	CH 2

(2) Connect a sine wave generator to CH 1 and CH 2 through a 50 ohm BNC cable, 50 ohm termination, and dual input coupler. Set the output for 50 kilohertz and adjust for a 4-division display.

(3) Set R2245 at midrange.

(4) Adjust R2249 so trace starts at the same point when switching A SLOPE between − (in) and + (out).

(5) Set CH 2 VOLTS/DIV to .1, A AND B TIME/DIV to 50 μs, and A SLOPE to + (out).

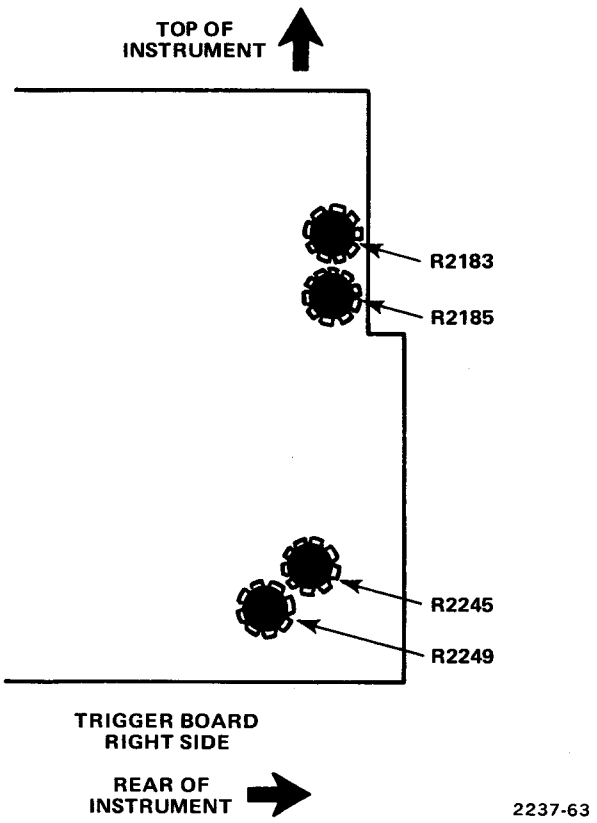

Figure 5-20. Trigger hysteresis and slope centering adjustment locations.

NOTE

When making the next adjustment, set CH 2 VOLTS/DIV to .1 for a 0.2 division signal and .2 for a 0.1 division signal.

(6) Adjust R2245 and A LEVEL so a stable display is obtained with a 0.2-division display, but not with a 0.1-division display.

NOTE

If R2245 is set too sensitive, double triggering may occur at low frequencies. To desensitize R2245, adjust A LEVEL until the display just double triggers. Then slightly readjust R2245 until the double triggering disappears.

(7) Set CH 2 VOLTS/DIV to 5 m and A AND B TIME/DIV to 5 μs.

(8) Repeat step (4) above.

(9) Set CH 2 VOLTS/DIV to 20 m and adjust A LEVEL for a stable display.

(10) Set controls as follows:

VERT MODE	CH 1
HORIZ MODE	B DLY'D
B SOURCE	CH 1
B LEVEL	0
A AND B TIME/DIV	5 μs

(11) Set R2185 to midrange.

(12) Adjust R2183 so trace starts at the same point when switching B SLOPE between − (in) and + (out).

(13) Set CH 1 VOLTS/DIV to .1, A AND B TIME/DIV to 50 μs, and B SLOPE to + (out).

NOTE

When making the next adjustment, set CH 1 VOLTS/DIV to .1 for a 0.2-division display and .2 for a 0.1-division display.

(14) Adjust R2185 and B LEVEL so a stable display is obtained with a 0.2-division display, but not with a 0.1-division display.

NOTE

If R2185 is set too sensitive, double triggering may occur at low frequencies. To desensitize R2185, adjust B LEVEL until the display just double triggers, then slightly readjust R2185 until the double triggering disappears.

(15) Set CH 1 VOLTS/DIV to 5 m and A AND B TIME/DIV to 5 μs.

(16) Repeat step (12) above.

(17) Disconnect the generator.

n. External Trigger Centering (Figures 5-21 and 5-22).

(1) Set controls as follows:

CH 2 VOLTS/DIV	5 m
VERT MODE	CH 2
HORIZ DISPLAY	A
A AND B TIME/DIV	5 μs
A SOURCE	EXT
B SOURCE	EXT

(2) Set A COUPLING to AC.

(3) Adjust A LEVEL for a stable display.

(4) Set A COUPLING to DC.

(5) Adjust A TRIGGER LEVEL CENTERING, R2715 for a stable display.

INTERACTION NOTE

A LEVEL and R2715 may interact with each other; therefore, repeat steps (2) through (5) until no further adjustment of R2715 is needed.

(6) Set HORIZ DISPLAY to B DLY'D

(7) Set B COUPLING to AC.

(8) Adjust B LEVEL for a stable display.

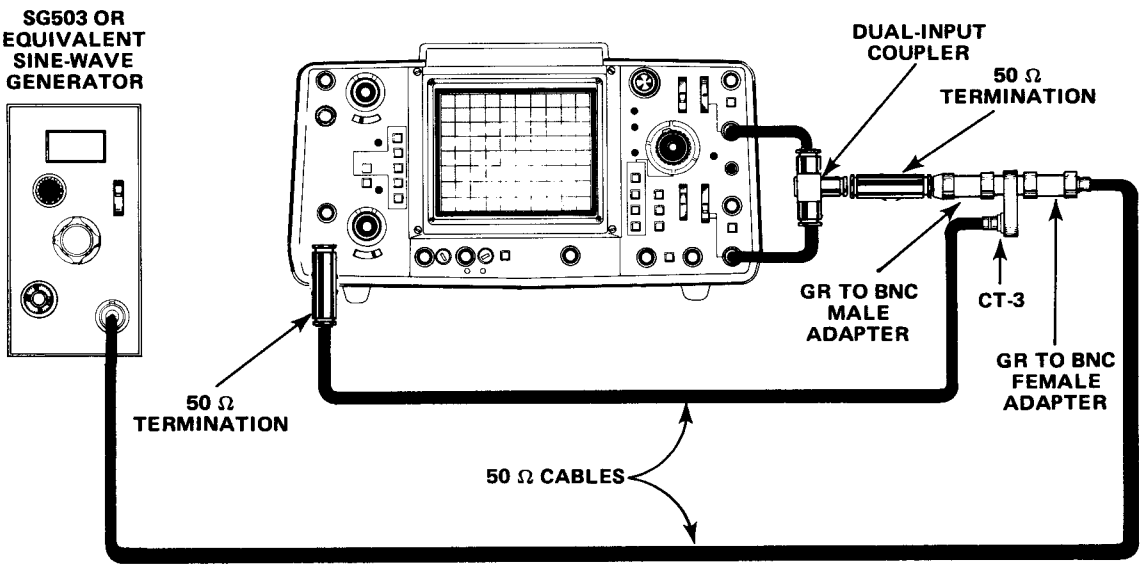

Figure 5-21. External trigger centering setup.

(9) Set B COUPLING to DC.

(10) Adjust B TRIGGER LEVEL CENTERING, R2615 for a stable display.

INTERACTION NOTE

B LEVEL and R2615 may interact with each other; therefore, repeat steps (2) through (5) until no further adjustment of R2615 is needed.

(11) Disconnect the sine wave generator.

o. Sweep Start-Stop (Figure 5-23).

(1) Set controls as follows:

VERT MODE	CH 1
CH 1 VOLTS/DIV	.5
A TIME/DIV	1 ms
B TIME/DIV	5 μs
HORIZ DISPLAY	A INTEN
A SOURCE	NORM
B SOURCE	STARTS AFTER DELAY
COUPLING	AC

(2) Connect a time mark generator to the CH 1 input through a 50 ohm BNC cable and 50 ohm termination. Set the generator for 1 millisecond time markers.

(3) Set DELAY TIME POS to 1.00.

(4) Adjust R2782 so the second time marker is intensified.

(5) Set DELAY TIME POS to 9.00.

(6) Adjust R2748 so the tenth time marker is intensified.

INTERACTION NOTE

R2782 and R2748 may interact with each other; therefore, repeat steps (3) through (6) until no further adjustment is needed.

(7) Set HORIZ DISPLAY to B DLY'D and horizontally position the start of sweep within the graticule area.

(8) Set DELAY TIME POS to 1.00.

(9) Very slightly adjust R2782 until the time marker starts at the beginning of the sweep.

(10) Set DELAY TIME POS to 9.00.

(11) Very slightly adjust R2748 until the time marker starts at the beginning of the sweep.

INTERACTION NOTE

R2782 and R2748 may interact with each other; therefore, repeat steps (8) through (11) until no further adjustment is needed.

(12) Set DELAY TIME POS to 0.0.

(13) Continue to the next procedure.

p. Horizontal Gain (Figure 5-22).

(1) Set HORIZ DISPLAY to A.

(2) Adjust X1 GAIN, R2923 until the 1st and 11th time markers are exactly aligned with a graticule line. There should be one time marker per division within 0.25 minor divisions.

(3) Set X10 Mag to In (on).

(4) Set time mark generator for .1 ms time markers.

(5) Adjust X10 GAIN, R2925 for one time marker per division.

(6) Continue to the next procedure.

q. Magnifier Registration (Figure 5-22).

(1) Set X10 MAG to In (on).

(2) Adjust horizontal POSITION until the sweep starts at the center vertical graticule line.

(3) Set X10 MAG to Out (off).

(4) Adjust MAG REG, R2932 until the sweep starts at the center vertical graticule line.

INTERACTION NOTE

R2932 and horizontal POSITION may interact; therefore, repeat steps (1) through (4) until no further adjustment of R2932 is needed.

(5) Continue to the next procedure.

r. B Sweep Timing (Figure 5-23).

(1) Set controls as follows:

X10 MAG	Out (off)
A AND B TIME/DIV	1 ms
HORIZ DISPLAY	B DLY'D

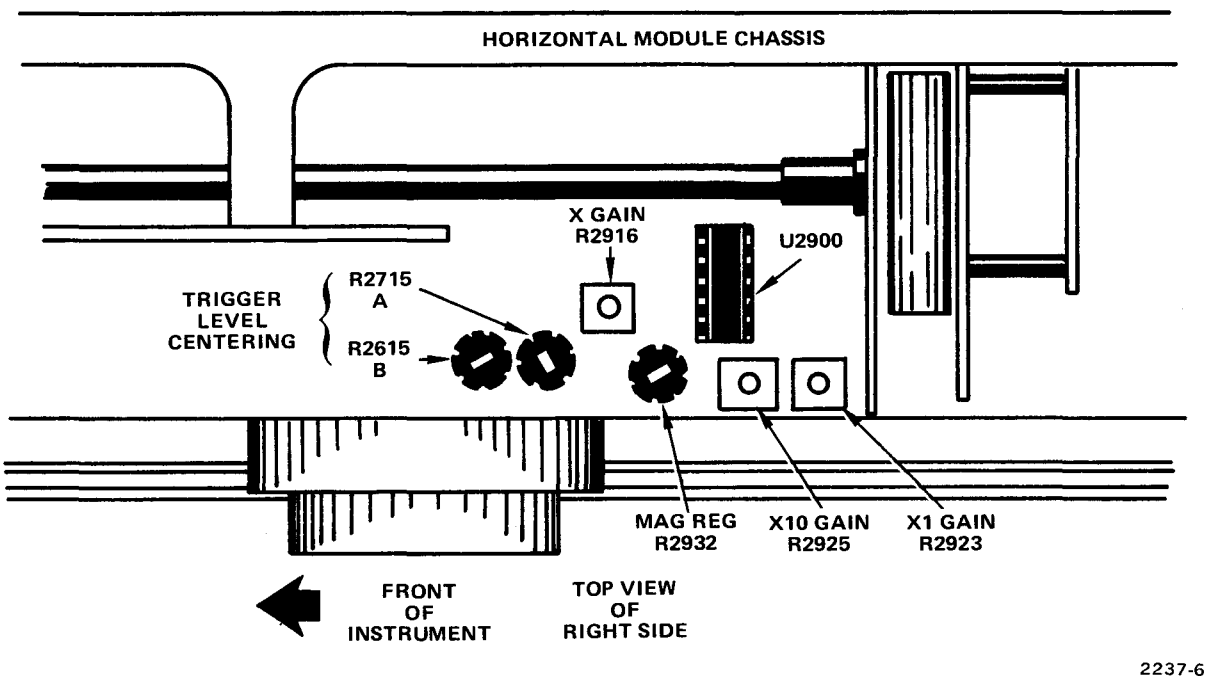

Figure 5-22. Trigger and horizontal adjustment locations.

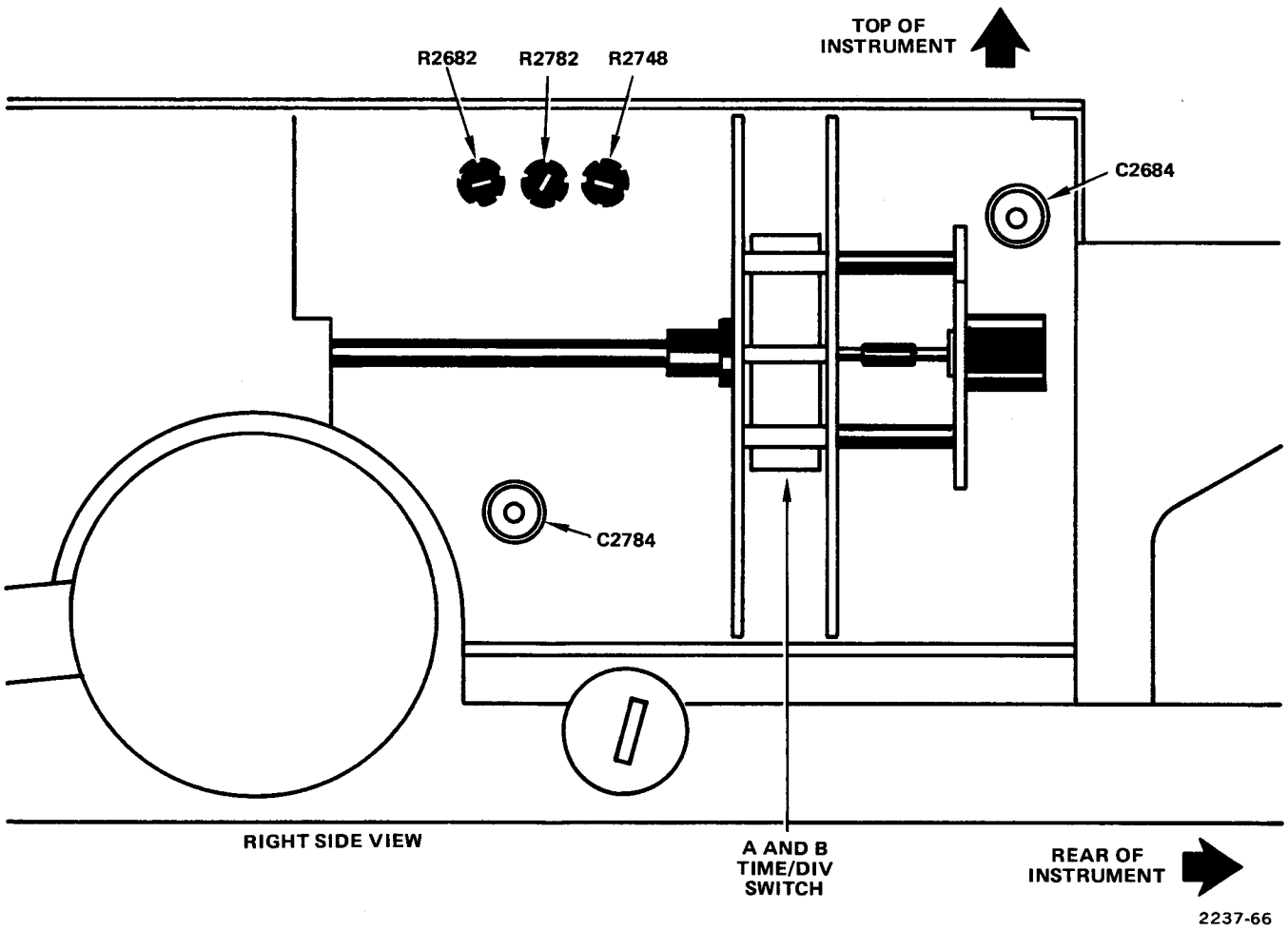

Figure 5-23. Sweep adjustment locations.

(2) Set time mark generator for one millisecond time markers.

(3) Set horizontal POSITION to align the first time marker with the left graticule line.

(4) Adjust R2782 for one time marker per division.

(5) Continue to the next procedure.

s. .5 μs Timing (Figure 5-23).

(1) Set A TIME/DIV to .5 μs and HORIZ DISPLAY to A.

(2) Set time mark generator for 0.5 microsecond time markers.

(3) Adjust C2784 for one time marker per division.

(4) Set HORIZ DISPLAY to B DLY'D.

(5) Set DELAY TIME POS to 1.00, then rotate it toward 0.0 until there is one time marker per division and a time marker is aligned with the left vertical graticule line.

(6) Adjust C2684 for one time marker per division.

(7) Set B TIME/DIV to .05 μs and DELAY TIME POS to 1.00.

(8) Adjust horizontal POSITION and align the time marker with the center vertical graticule line.

(9) Set DELAY TIME POS to 9.00.

(10) Very slightly adjust C2784 so the time marker aligns with the center vertical graticule line.

INTERACTION NOTE

C2784 and C2684 may interact; therefore, repeat this procedure until no further adjustment is needed.

(11) Set DELAY TIME POS to 0.0.

(12) Continue to the next procedure.

t. 5 ns Timing (Figure 5-24).

(1) Set controls as follows:

HORIZ DISPLAY	A
A AND B TIME/DIV	.05 μs
X10 MAG	In (on)

(2) Set time mark generator for 10 nanosecond time markers.

(3) Adjust C232 and C272 for one time marker per two divisions.

INTERACTION NOTE

The adjustment screws for C232 and C272 should be adjusted to about the same height; otherwise horizontal linearity may be degraded.

(4) Check the beginning and end of the .05 microsecond sweep using step 19 in Table 5-1 and excluding the first and last 40 nanoseconds of the sweep. If necessary, slightly readjust C232 and C272 for one time marker per two divisions.

(5) Disconnect the generator.

u. X Gain (Figure 5-22).

(1) Set controls as follows:

CH 1 VOLTS/DIV	5 m
VERT MODE	CH 2
A AND B TIME/DIV	X-Y
X10 MAG	Out (off)

(2) Connect a calibration generator STD AMPL OUTPUT to the CH 1 input through a 50 ohm BNC cable. Set the generator for a 50 millivolt output.

(3) Adjust X GAIN, R2916 for a 10-division (horizontal) display.

(4) Disconnect the generator.

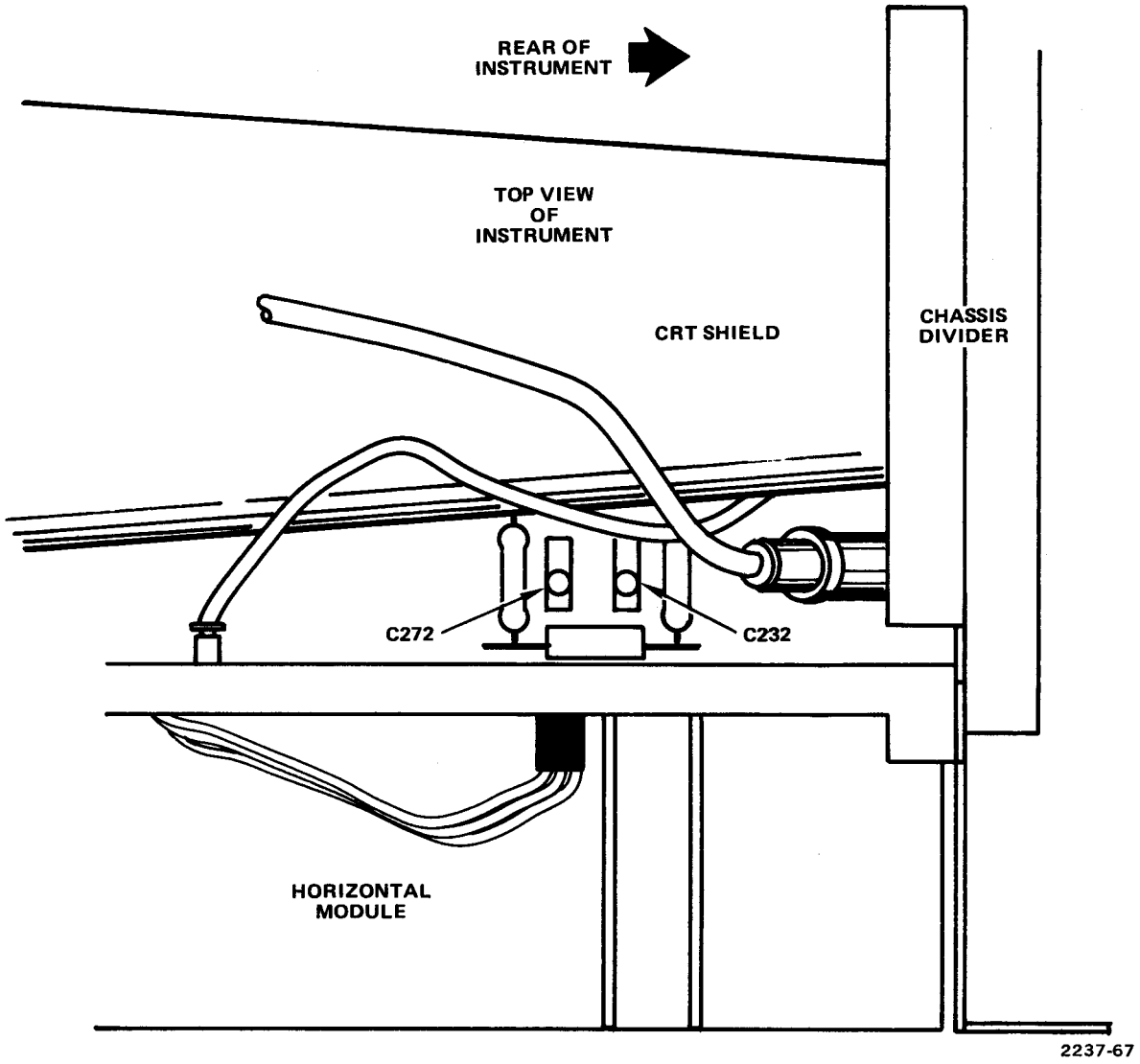

Figure 5-24. 5 nanosecond timing adjustment locations.