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*TB 9-6625-082-50

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR OSCILLOSCOPE, HEWLETT-PACKARD MODELS 120A, 120AR, 120B. AND 120BR

Headquarters, Department of the Army, Washington, DC
14 January 1974

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**SECTION I
IDENTIFICATION AND DESCRIPTION**

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Oscilloscope, Hewlett-Packard Models 120A, 120AR, 120B, and 120BR. The manufacturer's instruction manuals were used as the prime data source in compiling these instructions. The oscilloscope will be referred to as the "TI" (test instrument) throughout this bulletin.

a. Model Variations. Variations among models are described in text.

b. Time and Technique. The time required for this calibration is approximately 4 hours using the dc and low frequency technique.

2. Calibration Data Card, DA Form 2416

a. Forms, records, and reports required for calibration personnel at all levels are prescribed by TM 38-750. DA Form 2416 must be annotated in accordance with TM 38-750 for each calibration performed.

b. Adjustments to be reported on DA Form 2416 are designated (R) at the end of the sentence in which they appear. When adjustments are in tables, the (R) will follow the designated adjustment. Report only those adjustments made and designated with (R).

3. Calibration Description. TI parameters and performance specifications which pertain to this calibration are listed in table 1.

Table 1. Calibration Description

Test instrument parameters	Performance specifications
Power input requirements ¹	115 or 230 vac $\pm 10\%$, 50 to 1000 Hz, 130 w
Vertical and horizontal amplifier bandwidth (models 120 and 120AR): Dc coupled Ac coupled	Dc to 200 kHz 2 Hz to 200 kHz
Vertical amplifier bandwidth (models 120B and 120BR): Dc coupled Ac coupled	Dc to 450 kHz 2 Hz to 450 kHz
Horizontal amplifier bandwidth (models 120B and 120BR): Dc coupled Ac coupled	Dc to 300 kHz 2 Hz to 300 kHz
Horizontal sensitivity: Range Vernier Accuracy	0.1 to 100 v/cm in 3 calibrated steps; .1, 1, and 10 v/cm Continuously variable between steps and extends 10 v/cm step to at least 100 v/cm $\pm 5\%$
Vertical sensitivity: Range Vernier Accuracy (models 120A and 120AR) Accuracy (models 120B and 120BR)	10 mv/cm to 100 v/cm in 4 calibrated steps; 10 mv, 100 mv, 1 v, and 10 v/cm Continuously variable between steps and extends 10 v/cm step to at least 100 v/cm $\pm 5\%$ $\pm 3\%$
Internal calibrator	Calibrator signal automatically connected to vertical amplifier; accuracy $\pm 2\%$
Common-mode rejection ¹	At least 40 db. Common mode signal must not exceed ± 3 v peak
Phase shift	Vertical and horizontal amplifiers have same phase characteristics within $\pm 2^\circ$ to 100 kHz when verniers are in CAL

See footnote at end of table.

Table 1. Cable Description - Continued.

Test Instrument Parameters	Performance Specifications
Sweep: Sweep range Vernier Accuracy Sweep expand	1 μ sec to 0.5 sec/cm in 15 calibrated steps 1, 2, 5, 10, etc., sequence, 5 μ sec/cm to 200 ms/cm Continuously variable between ranges and extends 200 ms/cm step to at least 0.5 sec/cm \pm 5% X5 sweep expansion may be used on all ranges and extends fastest sweep to 1 μ sec/cm, accuracy \pm 10%
Automatic triggering (models 120A and 120AR): Internal External Trigger point	From signals 50 Hz to 250 kHz causing 0.5 cm or more vertical deflection; and from line voltage At least 2.5 v p-p Zero crossing, negative slope of external sync signals; zero crossing, positive or negative slope of vertical deflection signal
Automatic triggering (models 120B and 120BR): Internal External Trigger point	From signals 50 Hz to 450 kHz causing 0.5 cm or more vertical deflection; and from line voltage At least 1.5 v p-p Zero crossing, negative slope of external sync signals; zero crossing, positive or negative slope of vertical signal
Selectable trigger level: Models 120A and 120AR ¹ Models 120B and 120BR	Screwdriver control overrides automatic triggering and permits trigger point to be set between -10 to +10 v Front-panel control overrides automatic triggering and permits trigger point to be set between -7 to +7 v

¹This specification is for information only and is not necessarily verified in this bulletin.

SECTION II EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 2 identifies the specific equipment used in this calibration procedure. This equipment is issued with secondary transfer calibration standards set 4931-621-7877 and is to be used in performing this procedure. Alternate items may be used by the calibrating activity when the equipment listed in table 2 is not available. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one accuracy ratio between the standard and TI. Where the four-to-one ratio cannot be met, the actual accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories listed in table 3 are issued with secondary transfer calibration standards set 4931-621-7877 and are to be used in this calibration procedure. When necessary, these items may be substituted by equivalent items unless specifically prohibited.

Table 2. Minimum Specifications of Equipment Required

Item	Common name	Minimum use specifications	Manufacturer and model (part number)
A1	AC/DC VOLTMETER	Range: -146 to -154 V dc; +33.58 to +37.12 V ac Accuracy: $\pm 0.75\%$	Dana, Model 5703-S-2127 (7912606)
A2	AUTOTRANSFORMER	Range: 105 to 125 V ac Accuracy: $\pm 1\%$	General Radio, Model W10MT3AS3 (7910809)
A3	DC VOLTMETER	Range: -1235 to -2363 V Accuracy: $\pm 1.66\%$	Electrical Instruments Service, Model ESV (MIS-10276)
A4	SIGNAL GENERATOR	Frequency: 100 kHz Voltage: 0.03 to 20 V rms	Hewlett-Packard, Model 202CR (8616395-2)
A5	SQUARE-WAVE GENERATOR	Frequency: 5 to 30 kHz Voltage: 0.8 to 50 V p-p	Tektronix, Type 106 (MIS-10284)
A6	VOLTAGE CALIBRATOR	Range: 34.5825 mv rms to 37.2 v rms Accuracy: $\pm 0.75\%$	Hewlett-Packard, Model 745A (MIS-10342)
A7	TEST OSCILLATOR	Frequency: 10 Hz to 500 kHz Voltage: 0.03 to 2.9 v rms Accuracy: $\pm 0.75\%$	Preston, Model 134A (MIS-10224)
A8	TIME-MARK GENERATOR	Range: 1 μ sec to 50 ms Accuracy: $\pm 0.75\%$	Tektronix, Type 184MOD146B (7912042-2)

Table 3. Accessories Required

Item	Common Name	Description and Part Number
B1	ADAPTER ¹	Single banana jack to alligator clip (black) (7907560)
B2	ADAPTER	BNC jack to double banana plug (7907592)
B3	ADAPTER	BNC T type, 2 jacks, 1 plug (MS35173-274)
B4	CABLE	30-in., RG-58/U; BNC plug terminations (7907467)
B5	CABLE ¹	30-in., RG-58/U; double banana plug terminations (7907470)
B6	CABLE ¹	36-in., RG-58/U; BNC plug and double banana plug terminations (7907471)
B7	LEAD	24-in., No. 18 AWG; single banana plug terminations (7907498)
B8	TERMINATION	50-ohm feed-through; BNC jack to BNC plug Hewlett-Packard, Model 11048B (11048B)

¹Two required.

SECTION III PRELIMINARY OPERATIONS

6. Preliminary Instructions

a. The instructions outlined in this section are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

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b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2, and for prefix B, see table 3.

WARNING

HIGH VOLTAGE is used during the performance of this calibration. DEATH ON CONTACT may result if personnel fail to observe safety precautions.

7. Equipment Setup

- a.** Remove protective cover from TI.
- b.** Connect TI to autotransformer (A2).
- c.** Connect autotransformer to 115-volt ac source and adjust for 115 volts ac.

CAUTION

To prevent damage to crt, turn INTENSITY control fully counterclockwise during warm-up.

d. Energize equipment and allow sufficient time for equipment to warm up and stabilize.

SECTION IV

CALIBRATION PROCESS FOR MODELS 120A AND 120AR

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met before continuing with the procedure.

NOTE

When indications specified in paragraphs **8** through **17** are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs **8** through **17**. Do not perform power supply check if all other parameters are within tolerance.

8. Intensity Limit

a. Performance Check

- (1) Position TI controls as listed in (a) through (i) below:

- (a) TRIGGER LEVEL control to AUTO.
- (b) INTENSITY control fully counterclockwise.
- (c) Vertical AC-DC switch to AC.
- (d) VERT. SENSITIVITY VERNIER control to CAL.
- (e) VERT. SENSITIVITY switch to 1 VOLTS/CM.
- (f) SWEEP EXPAND switch to X1.
- (g) SWEEP TIME-HOR. SENS. switch to 1 MILLISECONDS/CM.
- (h) SYNC switch to INT + (positive).
- (i) HORIZ. POS. and VERT. POS. controls to midrange.

(2) Adjust INTENSITY and FOCUS controls for normal display. If normal display cannot be obtained, perform **b** below.

b. Adjustments

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) SWEEP TIME-HOR. SENS. switch to 10 VOLTS/CM.
 - (b) FOCUS control for best focus.
 - (c) INTENSITY control index marker to 9 o'clock position.
- (2) Adjust R316 (fig. 1) for a small round spot.
- (3) Adjust R322 (fig. 1) until spot just disappears.

9. Vertical and Horizontal Amplifier Dc Balance

a. Performance Check

- (1) Position TI controls as listed in (a) through (e) below:
 - (a) VERT SENSITIVITY switch to 10 VOLTS/CM.
 - (b) VERT SENSITIVITY VERNIER control fully counterclockwise.
 - (c) VERT POS. control to center spot on graticule.
 - (d) Vertical AC-DC switch to DC.
 - (e) SWEEP TIME-HOR SENS. switch to 10 VOLTS/CM.

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(2) Vary VERT. SENSITIVITY VERNIER control. If spot does not remain in center of graticule, perform **b(1)** through (3) below.

(3) Turn VERT SENSITIVITY VERNIER control to CAL. VERT SENSITIVITY to OFF, and SWEEP TIME HOR. SENS. switch to 10 V/CM.

(4) Repeat (1) and (2) above, using horizontal controls. If spot does not remain in center of graticule, perform **b(4)** through (8) below.

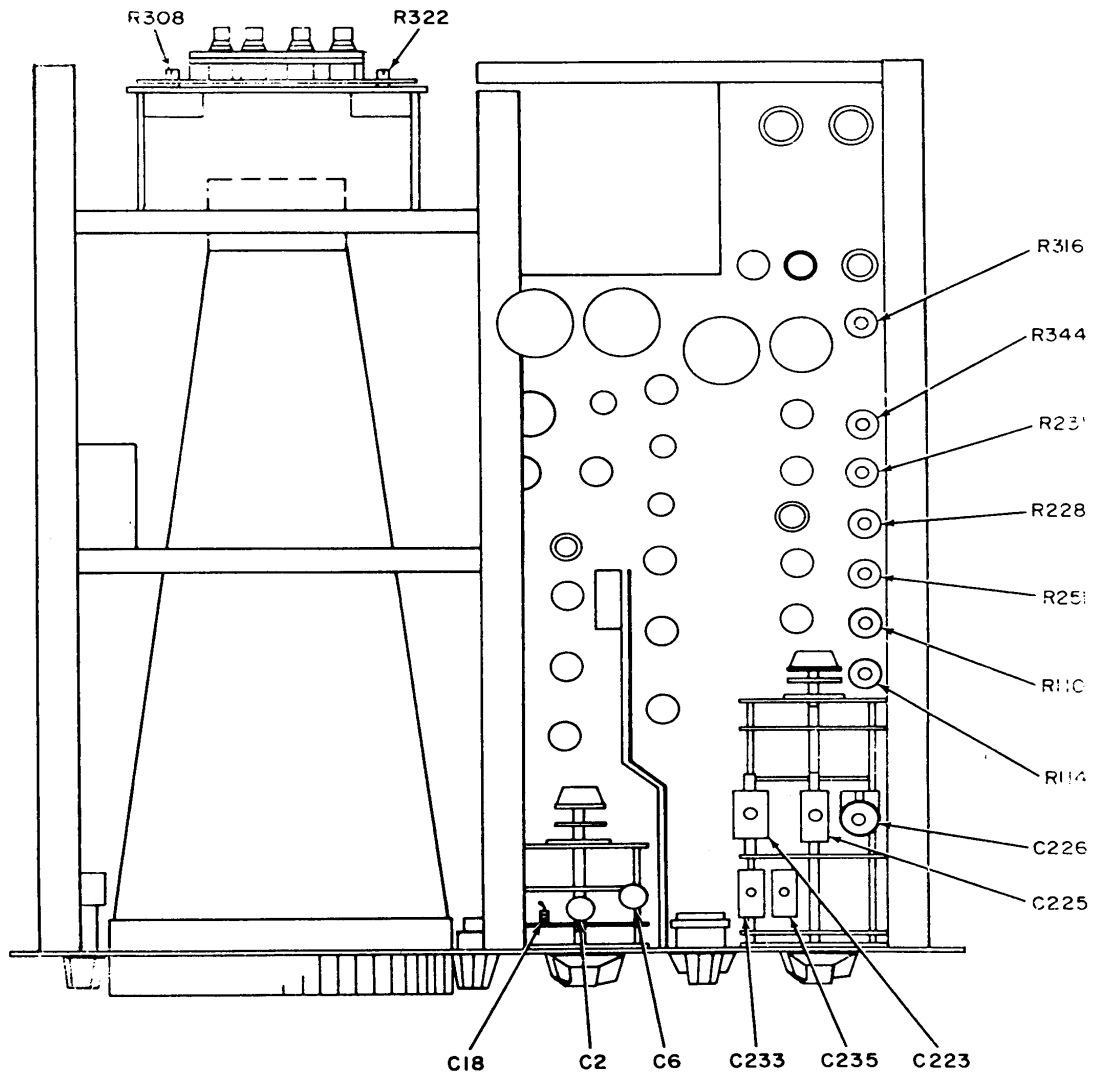


Figure 1. Oscilloscope - top view.

b. Adjustments

- (1) Turn VERT SENSITIVITY VERNIER control to midrange.
- (2) Adjust VERT. DC BAL. control (front panel) to center spot on graticule.
- (3) Vary VERT. SENSITIVITY VERNIER control and adjust VERT. DC BAL. control until no spot shift is observed.
- (4) Turn SWEEP TIME-HOR. SENS. VERNIER control fully counterclockwise.
- (5) Adjust R110 (fig. 1) to center spot on graticule.
- (6) Turn SWEEP TIME-HOR. SENS. VERNIER control to CAL.
- (7) Turn HORIZ. POS. control to center spot on graticule.
- (8) Repeat (4) through (7) above until no shift is observed when varying SWEEP TIME HOR. SENS. VERNIER control.

10. Triggering Range and Level

a. Performance Check

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) VERT SENSITIVITY switch to 1 VOLTS/CM.
 - (b) SWEEP TIME-HOR. SENS. switch to 5 MICROSECONDS/CM.
 - (c) SYNC switch to EXT.
- (2) Observe that baseline is displayed on TI crt.
- (3) Connect test oscillator (A7) to TI horizontal input connector, using cable and termination (B6 and B8).
- (4) Connect TI horizontal input connector to TI vertical input connector, using cable (B5).
- (5) Adjust test oscillator frequency to 250 kHz and amplitude for stable display on TI.
- (6) Slowly reduce test oscillator amplitude until TI display becomes unstable. If test oscillator amplitude is not .70 volt rms or less, perform **b**(1) and (2) below.
- (7) Turn SWEEP TIME-HOR. SENS. switch to 10 MILLISECONDS/CM.

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- (8) Adjust test oscillator frequency to 50 Hz and amplitude for display on TI.
- (9) Repeat (6) above.

NOTE

Some adjustment of TI TRIGGER LEVEL control may be necessary at high frequencies.

(10) Turn SYNC switch to INT + (positive) and SWEEP TIME-HOR. SENS. switch to 50 MICROSECONDS/CM.

(11) Adjust test oscillator to 10 kHz and .8 centimeters of display on TI crt. If sweep does not trigger on positive-going portion of display waveform, perform **b**(3) through (11) below.

(12) Turn SYNC switch to INT-(negative). Observe that sweep triggers on negative going part of waveform.

b. Adjustments

- (1) Adjust test oscillator amplitude for stable display on TI.
- (2) Adjust R247 (fig. 2) while reducing test oscillator amplitude until triggering becomes stable at minimum test oscillator amplitude (less than .70 volt rms).
- (3) Turn TI VERT. SENSITIVITY VERNIER control to CAL.
- (4) Connect ac/dc voltmeter (A1) between pin 8 of V203 (fig. 2) and chassis ground.
- (5) If no trace is present on TI, perform adjustments (a) and (b) below:
 - (a) Adjust R228 (fig. 1) counterclockwise until trace appears.
 - (b) Turn R228 clockwise until trace just disappears.
- (6) If trace is present, adjust R228 clockwise until trace just disappears.
- (7) Record ac/dc voltmeter indication.
- (8) Connect lead (B7) with two adapters (B1), between pin 1 of V201 (fig. 2) and chassis ground.
- (9) Slowly turn R228 counterclockwise until trace appears and then clockwise until trace just disappears. Record ac/dc voltmeter indication.
- (10) Adjust R228 for indication of 2 volts more positive than value recorded in (9) above.

(11) Remove lead connected in (8) above.

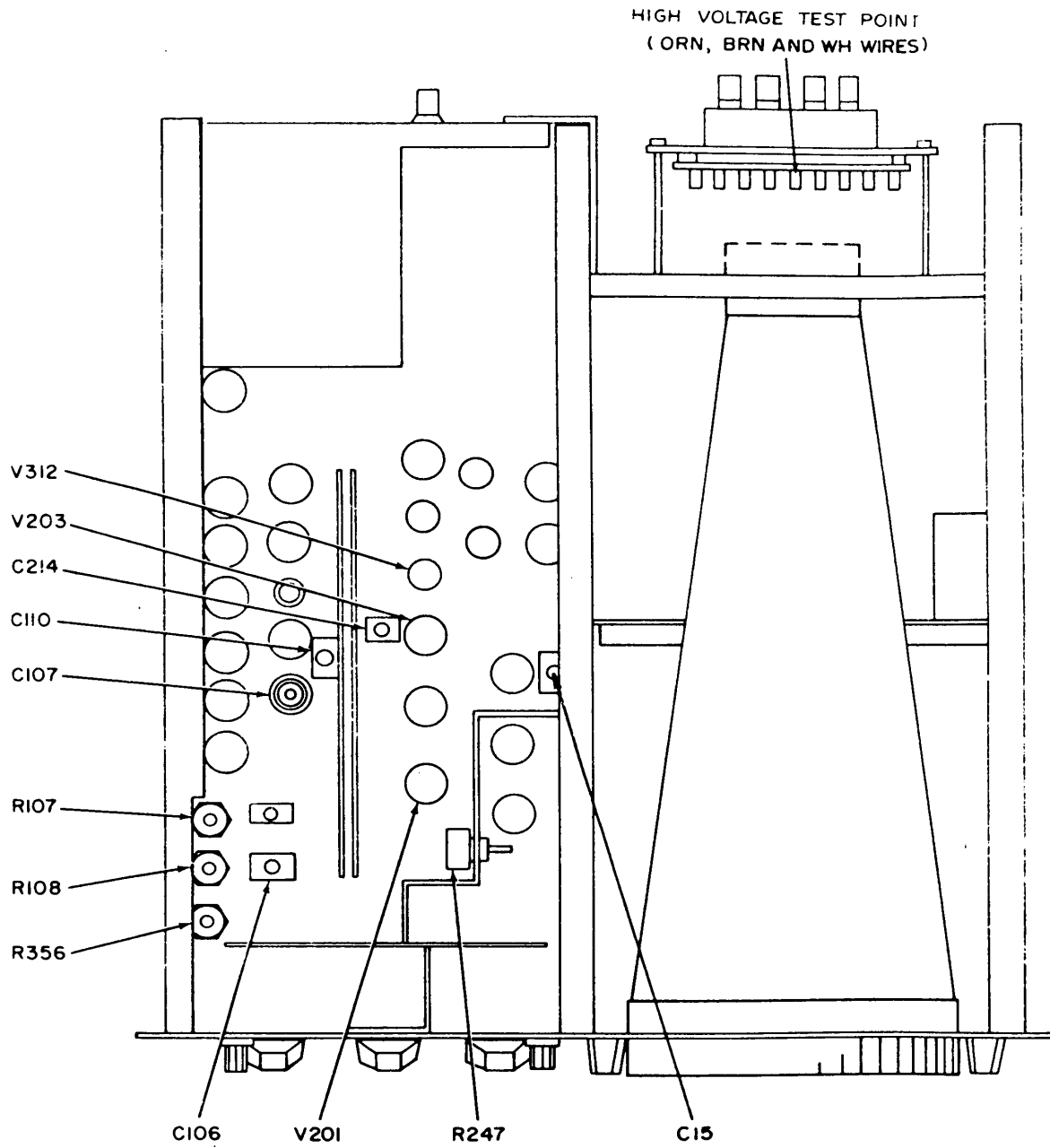


Figure 2. Oscilloscope - bottom view.

11. Vertical and Horizontal Sensitivity and Range

a. Performance Check

(1) Position TI controls as listed in (a) through (d) below:

- (a) SYNC switch to INT + (positive).
- (b) SWEEP TIME-HOR. SENS. switch to 1 MILLISECOND/CM.
- (c) VERT. SENSITIVITY switch to 100 MILLIVOLTS/CM.
- (d) VERT. AC-DC switch to AC.

(2) Connect voltage calibrator (A6) to TI vertical input connector, using cable (B5). Connect negative and ground vertical input connector together with ground strap.

(3) Adjust voltage calibrator for a 10-centimeter display amplitude on TI crt. If voltage calibrator does not indicate between 335.825 and 371.175 millivolts rms, perform **b(1)** and (2) below.

(4) Repeat (3) above, using settings listed in table 4. If voltage calibrator does not indicate within limits specified, perform **b(1)** and (2) below to obtain best in-tolerance compromise for all VERT. SENSITIVITY switch positions.

Table 4. Vertical and Horizontal Sensitivity and Range

Test instrument VERT. SENSITIVITY switch settings	Voltage calibrator indication (rms)	
	Min	Max
10 mV/cm	33.5825 mV	37.1175 mV
1 V/cm	3.358 V	3.712 V
10 V/cm	33.58 V	37.12 V

(5) Connect voltage calibrator (A6) to horizontal input connectors of TI.

(6) Turn HORIZONTAL AC-DC switch to AC and SWEEP TIME-HOR. SENS. switch to .1 VOLTS/CM.

(7) Adjust voltage calibrator for a 10-centimeter horizontal deflection on TI crt. If voltage calibrator does not indicate between 335.825 and 371.175 millivolts rms, perform **b(3)** and (4) below.

(8) Repeat technique of (6) above, 1 VOLT/CM and 10 VOLTS/CM settings listed in table 4, and substituting HOR. SENS. switch for VERT SENSITIVITY switch. If voltage calibrator does not indicate within specified limits, perform **b(3)** and (4) below to obtain best in-tolerance compromise of error.

b. Adjustments

- (1) Adjust voltage calibrator for a .3535-volt rms output.
 - (2) Adjust VERT. GAIN control for 10 centimeters of display amplitude on TI crt.
 - (3) Adjust voltage calibrator output to .3535 volt rms.
 - (4) Adjust R114 (fig. 1) for 10 centimeters of horizontal display amplitude on TI crt.
- (R)

12. Calibrator

a. Performance Check. Turn VERT. SENSITIVITY switch to CAL 6 CM and SWEEP TIME-HOR. SENS. switch to 2 MILLISECONDS/CM. If display amplitude does not indicate 6 centimeters, perform **b** below.

b. Adjustments. Adjust R356 (fig. 2) for display amplitude of 6 centimeters on crt.(R)

13. Vertical Amplifier Frequency Response and Attenuator Compensation

a. Performance Check

(1) Turn VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM and SWEEP TIME-HOR. SENS. switch to 100 MILLISECONDS/CM.

(2) Connect test oscillator (A7) to TI vertical input connectors; using cable and termination (B6 and B8).

(3) Adjust test oscillator for 10 Hz and for a display amplitude of 10 centimeters. Note indication of test oscillator output meter.

(4) Maintain constant test oscillator output amplitude noted in (3) above, and increase test oscillator frequency until display amplitude is 8 centimeters. Test oscillator frequency will be at least 200 kHz.

(5) Disconnect test oscillator and connect output of square-wave generator (A5) to TI vertical input terminals, using cable and termination supplied with square-wave generator, and adapter (B2).

(6) Turn SWEEP TIME-HOR. SENS. switch to 5 MICROSECONDS/CM.

(7) Adjust square-wave generator to 50 kHz and 8 centimeters of display amplitude on TI crt. If square wave with maximum of 2 percent overshoot is not displayed; perform **b(1)** below.

(8) Turn SWEEP TIME-HOR. SENS. switch to 200 MICROSECONDS/CM and VERT. SENSITIVITY switch to 100 MILLIVOLTS.

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(9) Adjust square-wave generator to 5 kHz and 8 centimeters of amplitude display. If flat-top square wave is not displayed, perform **b(2)** below.

(10) Turn VERT. SENSITIVITY switch to 1 VOLTS/CM and adjust square-wave generator for 8 centimeters of display. If flat-top is not displayed, perform **b(3)** below.

b. Adjustments

(1) Adjust C15 (fig. 2) for best square-wave response.

(2) Adjust C6 (fig. 1) for flat-top square wave.

(3) Adjust C2 (fig. 1) for flat-top square wave.

14. Horizontal Amplifier Frequency Response and Attenuator Compensation

a. Performance Check

(1) Position TI controls as listed in (a) through (c) below:

(a) SWEEP TIME-HOR. SENS. switch to .1 VOLTS/CM.

(b) Horizontal AC-DC switch to DC.

(c) VERT. POS. control to center display.

(2) Connect test oscillator (A7) to TI horizontal input connectors, using cable and termination (B6 and B8).

(3) Adjust test oscillator to 10 Hz and a 10-centimeter trace length. Note indication of test oscillator level meter.

(4) Maintain constant test oscillator output amplitude of (3) above, and increase test oscillator frequency until trace length is 8 centimeters. Test oscillator frequency will be at least 200 kHz.

(5) Connect equipment as shown in figure 3.

(6) Adjust square-wave generator (A5) to 50 kHz and 8 centimeters of display amplitude.

(7) Adjust test oscillator for approximately 5 kHz and stable display of 10 centimeters. Readjust test oscillator frequency for best display of square wave. If square wave with flat top and maximum of 2 percent overshoot is not displayed; perform **b(1)** below.

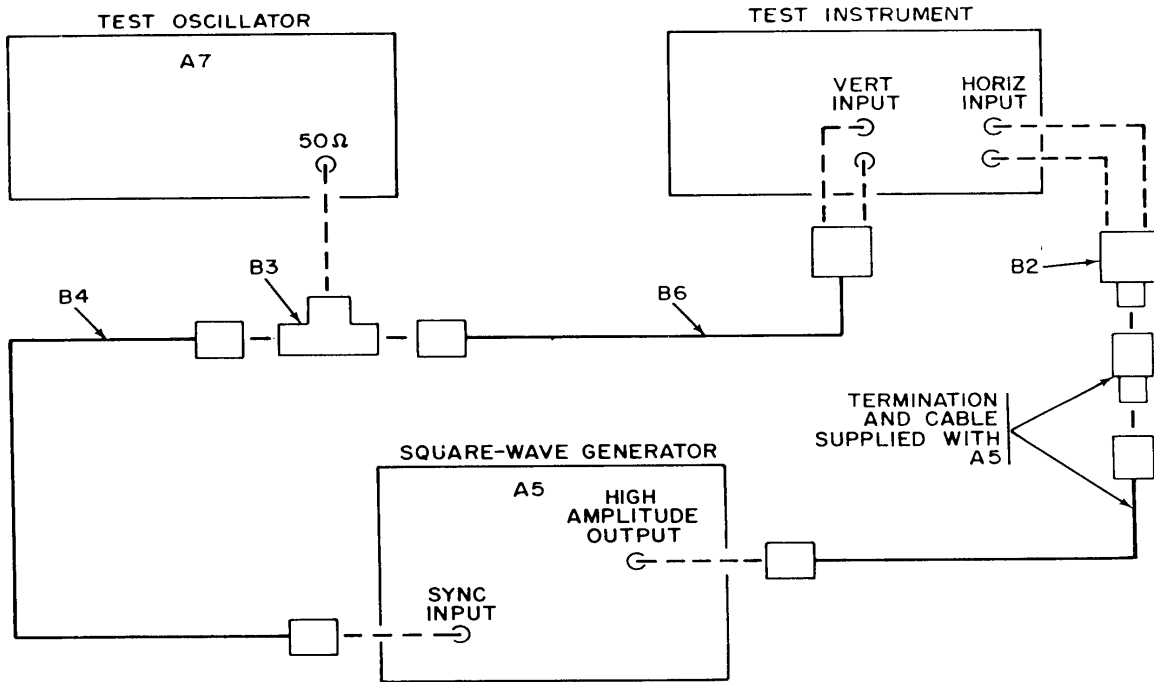


Figure 3. Horizontal amplifier compensation - equipment setup.

(8) Turn SWEEP TIME-HOR. SENS. switch to 1 VOLTS/CM.

(9) Adjust square-wave generator to 5 kHz and 8 centimeters of display. Adjust test oscillator to approximately 500 Hz and stable display of 8 centimeters. If flat-top square wave is not displayed, perform **b(2)** below.

(10) Turn SWEEP TIME-HOR. SENS. switch to 10 VOLTS/CM. If flat-top square wave is not displayed, perform **b(3)** below.

b. Adjustments

(1) Adjust C110 (fig. 2) for best square wave response. (R)

(2) Adjust C235 (fig. 1) for flat-top square wave. (R)

(3) Adjust C233 (fig. 1) for flat-top square wave. (R)

15. Amplifier Phase Shift

a. Performance Check

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) SWEEP TIME-HOR. SENS. switch to .1 VOLTS/CM.
 - (b) VERT SENSITIVITY switch to 100 MILLIVOLTS/CM.
 - (c) Horizontal AC-DC switch to AC.
- (2) Connect signal generator (A4) to TI vertical input connectors, using cable (B5).
- (3) Connect TI vertical input connectors to horizontal input connectors, using cable (B5).
- (4) Adjust signal generator to 100 kHz and approximately 6 centimeters deflection on TI crt. If pattern opening on crt is more than 0.2 centimeter, perform **b(1)** below.
- (5) Turn SWEEP TIME-HOR. SENS. and VERT. SENSITIVITY switches to 10 VOLTS/CM.
- (6) Increase signal generator output to obtain approximately same pattern as before. If pattern opening on crt is more than 0.2 centimeter, perform **b(2)** below.

b. Adjustments

- (1) Adjust C107 (fig. 2) for closed pattern on crt. (R)
- (2) Adjust C18 (fig. 1) for closed pattern on crt. (R)

16. Sweep Timing

a. Performance Check

- (1) Connect MARKER OUTPUT jack of time-mark generator (A8) to TI vertical input connectors, using cable (B6).
- (2) Turn SWEEP TIME-HOR. SENS. switch to 10 MILLISECONDS/CM and VERT. SENSITIVITY switch to 1 VOLT.
- (3) Set time-mark generator to 5 mS.
- (4) Adjust HORIZ. POS. control to align third time marker with second vertical graticule line. If nineteenth marker is not displayed within ± 0.5 centimeter of tenth graticule line, and sweep length is not 10.5 centimeters; perform **b** below.

(5) Turn SWEEP TIME-HOR. SENS. switch to 5 MICROSECONDS/CM. Adjust time-mark generator for 5 μ S output.

(6) Adjust HORIZ. POS. control to align second marker with second vertical graticule line. Tenth time marker will be within 0.5 centimeter of tenth vertical graticule line.

(7) Repeat technique of (5) and (6) above, using values listed in table 5. Perform adjustments listed in the table as necessary for out-of-tolerance sweep timing.

Table 5. Sweep Timing

Test instrument SWEEP TIME-HOR. SENS. switch	Time-mark generator output	Time mark/ cm	Adjustments
10 MICROSECONDS/CM	10 μ s	1	C226 ¹ (fig. 1) (R) C214 ² (fig. 2) (R)
20 MICROSECONDS/CM	10 μ s	2	---
50 MICROSECONDS/CM	50 μ s	1	C225 (fig. 1) (R)
100 MICROSECONDS/CM	0.1 ms	1	---
200 MICROSECONDS/CM	0.1 ms	2	---
.5 MILLISECONDS/CM	0.5 ms	1	C223 (fig. 1) (R)
1 MILLISECONDS/CM	1 ms	1	---
2 MILLISECONDS/CM	1 ms	2	---
5 MILLISECONDS/CM	5 ms	1	---
20 MILLISECONDS/CM	10 ms	2	---
50 MILLISECONDS/CM	50 ms	1	R251 (fig. 1) (R)

¹Adjust C226 until last five markers coincide with last five major graticule divisions (one marker per cm). (R)

²Adjust C214 until first five markers coincide with first five major graticule divisions (one marker per cm). (R)

b. Adjustments. Adjust R107 (R) (fig. 2) for one marker per centimeter and R231 (R) (fig. 1) for sweep length of 10.5 centimeters.

17. Sweep Magnifier

a. Performance Check

(1) Turn SWEEP TIME-HOR. SENS. switch to 10 MILLISECONDS/CM and SWEEP EXPAND switch to X5.

(2) Set time-mark generator (A8) to 10 mS.

NOTE

Adjust TI TRIGGER LEVEL control for stable display, if necessary.

(3) Adjust HORIZ. POS. control to align first time marker with left-hand graticule edge. If one marker per 5 centimeters is not displayed, perform **b(1)** below.

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(4) Turn SWEEP TIME-HOR. SENS. switch to 20 MICROSECONDS/CM.

(5) Set time-mark generator to 1 μ S.

(6) Adjust HORIZ. POS. control to align fifth time marker with second vertical graticule line. If thirty-seventh time marker is not within 1 centimeter of 10th vertical graticule line, perform **b(2)** below.

b. Adjustments

(1) Adjust R108 (fig. 2) for one marker per five centimeters. (R)

(2) Adjust C106 (fig. 2) for equal spacing of markers on first portion of sweep (four markers per centimeter).(R)

18. Power Supply

NOTE

Do not perform power supply check if all other parameters are within tolerance.

a. Performance Check

(1) Connect ac/dc voltmeter (A1) between pin 2 of V312 (fig. 2) and chassis ground. If ac/dc voltmeter does not indicate between -146 and -154 volts dc, perform **b(1)** below. Record ac/dc voltmeter indication.

(2) Adjust autotransformer (A2) from 105 to 125 volts and back to 115 volts. Ac/dc voltmeter will indicate within ± 1 percent of indication recorded in (1) above.

(3) Connect positive lead of dc voltmeter (A3) to chassis ground and negative lead to HIGH VOLTAGE TEST POINT (fig. 2). If dc voltmeter does not indicate between -2137 and -2363 volts, perform **b(2)** below.

b. Adjustments

(1) Adjust R344 (fig. 1) for indication of -150 volts dc on ac/dc voltmeter. (R)

(2) Adjust R308 (fig. 1) for indication of -2250 volts dc on dc voltmeter. (R)

19. Final Procedure

a. Deenergize and disconnect all equipment and reinstall protective covers on TI.

b. In accordance with TM 38-750, annotate and affix DA Label 80 (U.S. Army Calibration System). When the TI cannot be adjusted within tolerance, annotate, and affix DA Form 2417 (Unserviceable or Limited Use tag).

**SECTION V
CALIBRATION PROCESS FOR MODELS 120B AND 120BR**

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met before continuing with the procedure.

NOTE

When indications specified in paragraphs **21** through **30** are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs **21** through **30**. Do not perform power supply check if all other parameters are within tolerance.

20. Equipment Setup

- a.** Remove protective cover from TI.
- b.** Connect TI to autotransformer (A2) and connect autotransformer to 115-volt ac source, and adjust for 115 volts ac.
- c.** Energize TI by turning INTENSITY and POWER control to ON and allow 20 minutes for equipment to warm up and stabilize.

21. Intensity Limit

a. Performance Check

- (1) Position TI controls as listed in (a) through (i) below:
 - (a) TRIGGER SOURCE switch to INT + (Positive).
 - (b) TRIGGER SOURCE/LEVEL control to AUTO
 - (c) INTENSITY control fully counter. clockwise, but not to OFF.
 - (d) Vertical AC/DC switch to AC.
 - (e) VERTICAL SENSITIVITY/VERNIER control to CAL.
 - (f) VERTICAL SENSITIVITY switch to 1 VOLTS/CM.
 - (g) SWEEP MAGNIFIER switch to X1.
 - (h) HORIZONTAL DISPLAY switch to 1 MILLISECONDS/CM.

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- (i) Horizontal POSITION and vertical POSITION controls to midrange.

CAUTION

To prevent damage to the crt, turn INTENSITY control of TI back to position of normal viewing brightness immediately after performing (2) below.

- (2) Adjust INTENSITY and FOCUS controls for normal display. If normal display cannot be obtained, perform **b** below.

b. Adjustments

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) HORIZONTAL DISPLAY switch to 10 VOLTS/CM.
 - (b) FOCUS control for best focus.
 - (c) INTENSITY control index marker to 9 o'clock position.
- (2) Adjust R316 (fig. 4) for a small round spot.
- (3) Adjust R320 (fig. 4) until spot disappears.

22. Vertical Amplifier Dc Balance

a. Performance Check

- (1) Position TI controls as listed in (a) through (e) below:
 - (a) HORIZONTAL DISPLAY switch to 10 VOLTS/CM.
 - (b) VERTICAL SENSITIVITY switch to 10 VOLTS/CM.
 - (c) VERTICAL SENSITIVITY/VERNIER control fully counterclockwise.
 - (d) VERTICAL POSITION control to center spot on graticule.
 - (e) Vertical AC-DC switch to DC.
- (2) Vary VERTICAL SENSITIVITY/VERNIER control and observe that spot remains in center of graticule. If spot moves, perform **b** below.

b. Adjustments

- (1) Turn VERTICAL SENSITIVITY/VERNIER control fully counterclockwise.

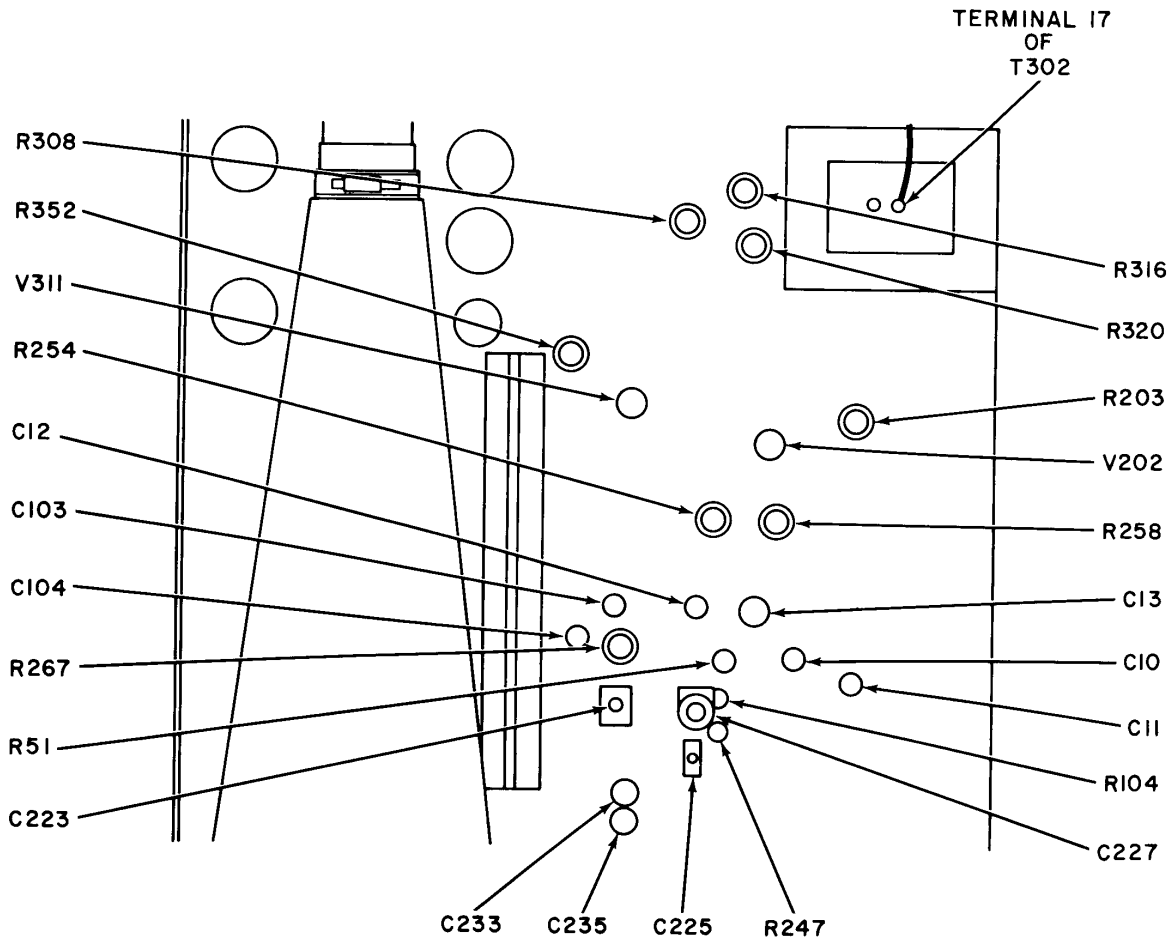


Figure 4. Oscilloscope - top view.

(2) Adjust BAL control (front panel) to center spot on TI crt graticule.

(3) Vary VERT. SENSITIVITY VERNIER control and adjust BAL control until no spot shift is observed.

23. Triggering Range and Level

a. Performance Check

(1) Position TI controls as listed in (a) through (d) below:

(a) VERTICAL SENSITIVITY VERNIER control to CAL.

(b) VERTICAL SENSITIVITY switch to 1 VOLTS/CM.

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- (c) HORIZONTAL DISPLAY switch to 5 μ SEC/CM.
- (d) TRIGGER SOURCE switch to EXT.
- (2) Observe that baseline is displayed on TI crt.
- (3) Connect test oscillator (A7) to TI horizontal input connector, using cable and termination (B6 and B8).
- (4) Connect TI horizontal input connector to TI vertical input connector, using cable (B6).
- (5) Adjust test oscillator frequency to 450 kHz and output amplitude for a stable display on TI crt.
- (6) Slowly reduce test oscillator amplitude until TI display becomes unstable. If test oscillator amplitude does not indicate 0.5 volt rms or less, perform **b**(1) and (2) below.
- (7) Turn HORIZONTAL DISPLAY switch to 10 MILLISECONDS/CM.
- (8) Adjust test oscillator frequency to 50 Hz and amplitude output for a stable display on TI crt.
- (9) Repeat (6) above.

NOTE

Some adjustment of TI TRIGGER SOURCE/ LEVEL control may be necessary at high frequency.

- (10) Turn TRIGGER SOURCE switch to INT + (positive) and HORIZONTAL DISPLAY switch to 50 μ SEC/CM.
- (11) Adjust test oscillator to 10 kHz and an 8-centimeter display on TI crt.
- (12) Adjust HORIZONTAL DISPLAY switch for several cycles of display. If sweep does not trigger on positive-going portion of displayed waveform, perform **b**(3) through (6) below.
- (13) Turn TI TRIGGER SOURCE switch to INT - (negative). Observe that sweep triggers on negative-going part of display.

b. Adjustments

- (1) Adjust test oscillator amplitude output to 0.53 volt rms.
- (2) Adjust R203 (fig. 4) until triggering becomes stable.

- (3) Position TI controls as listed in (a) through (d) below:
 - (a) VERTICAL SENSITIVITY switch to CAL.
 - (b) HORIZONTAL DISPLAY switch to .5 MILLISECONDS/CM.
 - (c) TRIGGER SOURCE switch to INT + (positive).
 - (d) TRIGGER SOURCE/LEVEL control just out of AUTO.
- (4) Connect ac/dc voltmeter (A1) between pin 2 of V202 (fig. 4) and chassis ground.
- (5) Adjust R258 (fig. 4) clockwise until sweep free-runs and then counterclockwise until sweep trace just disappears. Record ac/dc voltmeter indication.
- (6) Adjust R258 (fig. 4) for indication of 3 volts more positive than the value recorded in (5) above.

24. Vertical and Horizontal Sensitivity and Range

a. Performance Check

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) HORIZONTAL DISPLAY switch to 1 MILLISECONDS/CM
 - (b) VERTICAL AC-DC switch to AC.
 - (c) VERTICAL SENSITIVITY switch to 100 MILLIVOLTS/CM.
- (2) Connect voltage calibrator (A6) to TI vertical input connector, using cable (B5). Connect negative and ground vertical input connector together using ground strap.
- (3) Adjust voltage calibrator for a 10-centimeter amplitude display on TI crt. If voltage calibrator does not indicate between 335.825 and 371.175 millivolts rms, perform **b(1)** and (2) below.
- (4) Repeat (3) above, using settings listed in table 6. Voltage calibrator will indicate within limits specified.

Table 6. Vertical and Horizontal Sensitivity

Test instrument VERTICAL SENSITIVITY switch settings	Voltage calibrator or Ac/dc voltmeter indication (rms)			
	Min		Max	
	Vert	Horiz	Vert	Horiz
10 MV/CM	33.5825 mv	---	37.1175 mv	---
1 VOLTS/CM	3.429 v	3.358 v	3.641 v	3.712 v
10 VOLTS/CM	34.29 v	33.58 v	36.41 v	37.12 v

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(5) Connect voltage calibrator (A6) to horizontal input of TI, using cable (B6).

(6) Turn HORIZONTAL DISPLAY switch to .1 VOLTS/CM.

(7) Adjust voltage calibrator for a 10 centimeter horizontal deflection on crt. If voltage calibrator does not indicate between 335.825 and 371.175 millivolts rms, perform **b**(3) and (4) below.

(8) Repeat technique of (7) above at 1 VOLT/CM and 10 VOLTS/CM settings listed in table 6 for HORIZONTAL DISPLAY. Indications will be within limits specified.

b. Adjustments

(1) Adjust voltage calibrator for a 353.5 millivolt rms output.

(2) Adjust CAL control for a 10-centimeter display amplitude on TI crt.

(3) Adjust voltage calibrator output for a 353.5-millivolt rms output.

(4) Adjust R104 (fig. 4) for a 10-centimeter horizontal display amplitude on TI crt.
(R)

25. Calibrator

a. Performance Check. Turn VERT. SENSITIVITY switch to CAL (6 CM) and HORIZONTAL DISPLAY switch to 1 MILLISECONDS/CM. If display amplitude is not 6 centimeters, perform **b** below.

b. Adjustments. Adjust R51 (fig. 4) for display amplitude of 6 centimeters on TI crt.
(R)

26. Vertical Amplifier Frequency Response and Attenuator Compensation

a. Performance Check

(1) Turn VERTICAL SENSITIVITY switch to 10 MILLIVOLTS/CM and HORIZONTAL DISPLAY switch to 100 MILLISECONDS/CM.

(2) Connect test oscillator (A7) to TI vertical input, using cable and termination (B6 and B8).

(3) Adjust test oscillator for a 10-Hz output and for display height of 10 centimeters. Note indication of test oscillator level meter.

(4) Maintain constant test oscillator output amplitude of (3) above, and increase test oscillator frequency until display amplitude is 7 centimeters. Test oscillator frequency will be at least 450 kHz.

(5) Disconnect test oscillator and connect output of square-wave generator (A5) to TI vertical input terminals, using cable and termination supplied with square-wave generator, and adapter (B2).

(6) Position TI controls as listed in (a) through (c) below:

(a) VERTICAL SENSITIVITY switch to 100 MILLIVOLTS/CM.

(b) VERTICAL SENSITIVITY/VERNIER control fully counterclockwise.

(c) HORIZONTAL DISPLAY switch to 0.5 MILLISECONDS/CM.

(7) Adjust square-wave generator to 1 kHz and an 8-centimeter amplitude display on TI crt. If an optimum square wave is not displayed, perform **b(1)** below.

(8) Turn VERTICAL SENSITIVITY/VERNIER control to CAL and adjust square-wave generator for an 8-centimeter amplitude display. If an optimum square wave is not displayed, perform **b(2)** and (3) below.

(9) Turn VERTICAL SENSITIVITY switch to 1 VOLTS/CM. Adjust square-wave generator for an 8-centimeter amplitude display. If an optimum square wave is not displayed, perform **b(4)** below.

(10) Turn VERTICAL SENSITIVITY switch to 10 VOLTS/CM and adjust square-wave generator for maximum output. If an optimum square wave is not displayed, perform **b(5)** below.

(11) Position TI controls as listed in (a) through (c) below:

(a) VERTICAL SENSITIVITY switch to 10 MILLIVOLTS/CM.

(b) VERTICAL SENSITIVITY/VERNIER control fully counterclockwise.

(c) HORIZONTAL DISPLAY switch to 5 μ SEC/CM.

(12) Adjust square-wave generator to 100 kHz and 8 centimeters of display amplitude. If an optimum square wave is not displayed on TI crt, perform **b(6)** below.

(13) Disconnect cable from square-wave generator OUTPUT, and connect to square-wave generator +OUTPUT.

(14) Turn VERTICAL SENSITIVITY/VERNIER control to CAL and adjust square-wave generator for an 8-centimeter amplitude display. If an optimum square wave is not displayed on TI crt, perform **b(7)** below.

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b. Adjustments

- (1) Adjust C6 (fig. 5) for best square-wave pattern on TI crt.(R)

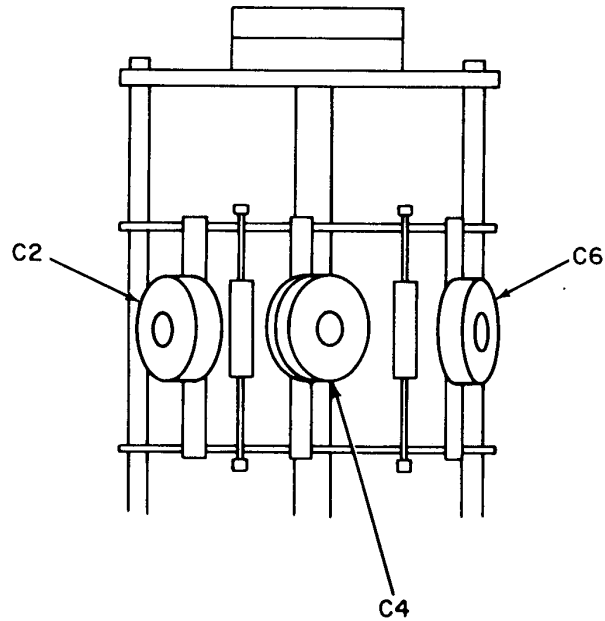


Figure 5. Vertical sensitivity switch - location of adjustments.

- (2) Adjust C9 (fig. 6) for best square-wave pattern on TI crt. (R)

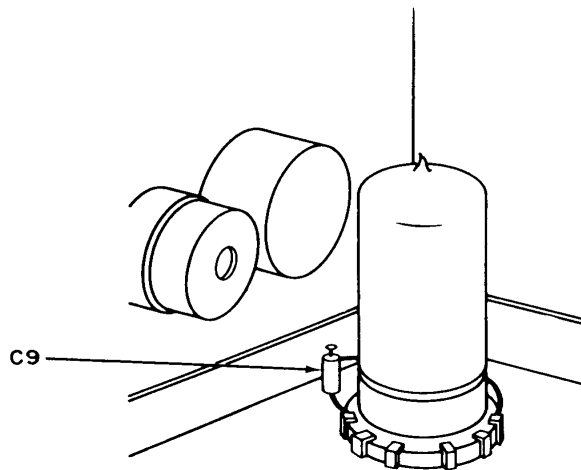


Figure 6. Oscillator - right-side view (panel removed).

- (3) Repeat (1) and (2) above for best results.
- (4) Adjust C4 (fig. 5) for best square-wave pattern on TI crt. (R)
- (5) Adjust C2 (fig. 5) for best square-wave pattern on TI crt. (R)
- (6) Adjust C12 (R) and C13 (R) (fig. 4) for best square-wave pattern on TI crt.
- (7) Adjust C10 (R) and C11 (R) (fig. 4) for best square wave on TI crt.

27. Horizontal Amplifier Frequency Response and Attenuator Compensation

a. Performance Check

- (1) Position TI controls as listed in (a) and (b) below:
 - (a) VERTICAL SENSITIVITY switch to 1 VOLTS/CM.
 - (b) HORIZONTAL DISPLAY switch to .1 VOLTS/CM.
- (2) Connect test oscillator (A7) to TI horizontal input connectors, using cable and termination (B6 and B8).
- (3) Adjust test oscillator frequency to 10 Hz and a 10-centimeter trace length. Note test oscillator output level.
- (4) Maintain constant test oscillator output amplitude of (3) above, and increase test oscillator frequency until display amplitude is 7 centimeters. Test oscillator frequency will be at least 300 kHz.
- (5) Connect equipment as shown in figure 3.
- (6) Adjust square-wave generator (A5) to 100 kHz and 8 centimeters of amplitude display.
- (7) Adjust test oscillator to approximately 8 kHz and stable display of 10 centimeters. If an optimum square wave is not displayed, perform **b(1)** below.
- (8) Turn HORIZONTAL DISPLAY switch to 1 VOLTS/CM.
- (9) Adjust square-wave generator to 1 kHz and an 8-centimeter display. Adjust HORIZONTAL POSITION control as required.
- (10) Adjust test oscillator to approximately 800 Hz and stable display of 8 centimeters. If flat-top square wave is not displayed, perform **b(2)** below.
- (11) Turn HORIZONTAL DISPLAY switch to 10 VOLTS/CM. If flat-top square wave is not displayed, perform **b(3)** below.

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b. Adjustments

- (1) Adjust C103 and C104 (fig. 4) for flat-top square wave.(R)
- (2) Adjust C235 (fig. 4) for a flat-top square wave. (R)
- (3) Adjust C233 (fig. 4) for a flat-top square wave.(R)

28. Amplifier Phase Shift

a. Performance Check

- (1) Position TI controls as listed in (a) through (c) below:
 - (a) HORIZONTAL DISPLAY switch to .1 VOLTS/CM.
 - (b) VERTICAL SENSITIVITY switch to 100 MILLIVOLTS/CM.
 - (c) Horizontal AC-DC switch to AC.
- (2) Connect signal generator (A4) to TI vertical input connector, using cable. (B5).
- (3) Connect TI vertical input to horizontal input, using cable (B5).
- (4) Adjust signal generator to 100 kHz and approximately 6 centimeters of deflection on TI crt. Pattern opening on crt will be less than 0.2 centimeter.
- (5) Turn HORIZONTAL DISPLAY switch to 1 VOLTS/CM and VERTICAL SENSITIVITY switches to 1 VOLTS/CM.
- (6) Increase signal generator output to obtain approximately same pattern as before. Pattern opening will be less than 0.2 centimeter.

b. Adjustments. Adjustments in paragraph **27b** above interact with pattern openings checked above. If necessary, repeat paragraph **27a**(1) through (7) and **b**(1) above.

29. Sweep Timing

a. Performance Check

- (1) Connect time-mark generator (A8) MARKER OUTPUT to TI vertical input, using cable (B6).
- (2) Turn HORIZONTAL DISPLAY switch to 20 MILLISECONDS/CM.
- (3) Set time-mark generator to 10 mS.

(4) Adjust horizontal POSITION control to align third marker behind second vertical graticule line. If nineteenth marker is not displayed within ± 0.5 centimeter of 10th vertical graticule line and sweep length is not 10.75 centimeters, perform **b(1)** below.

(5) Turn HORIZONTAL DISPLAY switch to 5 $\mu\text{SEC}/\text{CM}$ and set time-mark generator to 5 μS .

(6) Adjust HORIZ. POS. control to align second time marker with second vertical graticule line. If 10th time marker is not within ± 0.5 centimeter of 10th vertical graticule line, perform **b(2)** below.

(7) Repeat technique of (5) and (6) above, using values listed in table 7. Perform adjustments (**b(3)** below) as necessary for out-of-tolerance sweep timing.

Table 7. Sweep Timing

Test instrument HORIZONTAL DISPLAY switch	Time-mark generator output	Time mark/cm	Adjustments (fig. 4)
10 $\mu\text{SEC}/\text{CM}$	10 μS	1	---
20 $\mu\text{SEC}/\text{CM}$	10 μS	2	---
50 $\mu\text{SEC}/\text{CM}$	50 μS	1	C225 (R)
100 $\mu\text{SEC}/\text{CM}$.1 ms	1	---
200 $\mu\text{SEC}/\text{CM}$.1 ms	2	---
.5 MILLISECONDS/CM	.5 ms	1	C223 (R)
1 MILLISECONDS/CM	1 ms	1	---
2 MILLISECONDS/CM	1 ms	2	C233 (R)
10 MILLISECONDS/CM	10 ms	1	---
20 MILLISECONDS/CM	10 ms	2	---
50 MILLISECONDS/CM	50 ms	1	R247 (R)
100 MILLISECONDS/CM	50 ms	2	---
200 MILLISECONDS/CM	.1 s	2	---

b. Adjustments

(1) Adjust R267 (R) (fig. 4) for 2 markers per centimeter and adjust R254 (R) (fig. 4) for sweep length of 10.75 centimeters.

(2) Adjust C227 (fig. 4) for 1 marker per centimeter.(R)

(3) Perform appropriate adjustments in table 7.

30. Sweep Magnifier

a. Performance Check

(1) Turn HORIZONTAL DISPLAY switch to 5 MILLISECONDS/CM and SWEEP MAGNIFIER switch to X5.

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(2) Set time-mark generator (A8) to 5 mS.

(3) Adjust HORIZONTAL POSITION control to align first time marker with first vertical graticule line. One marker per 5 centimeters will be displayed ± 0.5 centimeter.

b. Adjustments. No adjustments can be made.

31. Power Supply

NOTE

Do not perform power supply check if all other parameters are within tolerance.

a. Performance Check

(1) Connect ac/dc voltmeter (A1) between pin 2 of V311 (fig. 4) and chassis ground. If ac/dc voltmeter does not indicate between -145.5 and -154.5 volts dc, perform **b(1)** below.

(2) Connect positive lead of dc voltmeter (A3) to chassis ground and negative lead to terminal 17 of T302 (fig. 4). If dc voltmeter does not indicate between -2375 and -2625 volts, perform **b(2)** below.

b. Adjustments

(1) Adjust R352 (fig. 4) for indication of -150 volts dc on ac/dc voltmeter. (R)

(2) Adjust R308 (fig. 4) for indication of -2500 volts on dc voltmeter.(R)

32. Final Procedure

a. Deenergize and disconnect all equipment and replace TI within protective cover.

b. In accordance with TM 38-750, annotate and affix DA Label 80 (U.S. Army Calibration System). When the TI cannot be adjusted within tolerance, annotate and affix DA Form 2417 (Unserviceable or Limited Use tag).

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US GOVERNMENT PRINTING OFFICE: 1981 - 740-031/2007

PIN: 010316-000