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including Change 1.

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DEPARTMENT OF THE ARMY TECHNICAL BULLETIN  
CALIBRATION PROCEDURE FOR  
OSCILLOSCOPES AN/USM-140 AND AN/USM-141 (HEWLETT-PACKARD  
MODELS 170 AND 170AR); AN/USM-140A (HICKOK INSTRUMENT CO.,  
MODEL 1807); AN/USM-140B AND AN/USM-141A (HEWLETT-  
PACKARD MODELS 170B AND 170BR); AN/USM-140C AND AN/USM-  
141B (HICKOK INSTRUMENT CO.); SWEEP DELAY  
GENERATOR MS-2962/USM (HEWLETT-  
PACKARD MODEL 166D) AM-3568/USM (HEWLETT-PACKARD  
MODEL K01-166F); DUAL-TRACE PREAMPLIFIER MX-2930A/USM  
(HEWLETT-PACKARD MODEL 162A); MX-2721/USM-105 (HEWLETT  
PACKARD MODEL H02-162A, AND HICKOK MODEL 1804A-2);  
MX-2930B/USM (HEWLETT PACKARD  
MODEL 162C); AND MX-2930C/USM  
(HICKOK INSTRUMENT CO.)

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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**CALIBRATION PROCEDURE FOR OSCILLOSCOPES  
AN/USM-140 AND AN/USM-141 (HEWLETT-PACKARD  
MODELS 170A AND 170AR); AN/USM-140A  
(HICKOK INSTRUMENT CO., MODEL 1807);  
AN/USM-140B AND AN/USM-141A  
(HEWLETT-PACKARD MODELS 170B AND 170BR);  
AN/USM-140C AND AN/USM-141B (HICKOK  
INSTRUMENT CO.); SWEEP DELAY GENERATOR  
MX-2962/USM (HEWLETT-PACKARD MODEL 166D);  
AM-3568/USM (HEWLETT-PACKARD MODEL K01-  
166F);  
DUAL-TRACE PREAMPLIFIER MX-2930A/USM  
(HEWLETT-PACKARD MODEL 162A); MX-2721/USM-  
105  
(HEWLETT-PACKARD MODEL H02-162A, AND  
HICKOK  
MODEL 1804A-2); MX-2930B/USM (HEWLETT-  
PACKARD  
MODEL 162C); AND MX-2930C/USM  
(HICKOK INSTRUMENT CO.).**

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**SECTION I.  
IDENTIFICATION AND DESCRIPTION**

**1. Test Instrument Identification**

This bulletin provides instructions for the A-level calibration of Oscilloscopes AN/USM-140 and AN/USM-141 (Hewlett-Packard Models 170A and 170AR); AN/USM-140A (Hickok Instrument Co., Model 1807); AN/USM-140B and AN/USM-141A (Hewlett-Packard Models 170B and 170BR); AN/USM-140C and AN/USM-141B (Hickok Instrument Co.); Sweep Delay Generator MX-2962/USM (Hewlett-Packard Model 166D); AM-3568/USM (Hewlett-Packard Model K01-166F); Dual-Trace Preamplifier MX-2930A/USM (Hewlett-Packard Model 162A); MX-2721/USM-105 (Hewlett-Packard Model H02-162A, and Hickok Model 1804A-2); and MX-2930C/USM (Hickok Instrument Co.); and A- and C-level calibration for Dual-Trace Preamplifier MX-2930B/USM (Hewlett-Packard Model 162C). The manufacturer's instruction manuals were used as the prime data source in compiling these instructions. The equipment listed above will be referred to as the "TI" (test instrument) throughout this bulletin.

a. *Model Variations.* Electrical differences among

models are listed in table 1. In addition, there are differences in adjustment components and locations. These differences are described in the text.

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

**2. Calibration Data Card (DA Form 2416)**

Maintenance forms, records, and reports which are to be used by calibration personnel at all calibration levels are listed in and prescribed by TM 38-750.

**3. Reporting of Errors**

The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028, Recommended Changes to Publications, and forwarded direct to Commander, U.S. Army Missile Command, ATTN: AMSMI-MFPA, Redstone Arsenal, AL 35809.

**4. 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  |
|--|---|
| Oscilloscopes (all)  |   |
| Power input requirements   | 115 or 230 vac, + 10%; 50 to 440 Hz 480 w   |
| Main vertical amplifier:<br>Bandwidth<br><br>Sensitivity<br>Rise time    | Dc to 30 MHz (dc to 35 MHz for AN/USM-140C and AN/USM-141B)<br>0.2 v p-p/cm, ±5%<br>11 nsec or less (12 nsec or less for AN/USM-140A) |
| Horizontal amplifier.<br>Bandwidth<br>Sensitivity<br><br>Input impedance | Dc to 1 MHz<br>0.1 to 10 v/cm in 7 ranges.<br>Vernier control extends sensitivity to 25 v/cm.<br>1 megohm shunted by 30 picofarads    |

<sup>1</sup> See footnote at end of table.

Table 1. Calibration Description - Continued

| Test Instrument Parameters  | Performance Specifications   |
|---|--|
| Sweep Generator:<br>Sweep range<br><br>Sweep magnifier<br><br>Gate output <sup>1</sup><br><br>Sweep output <sup>1</sup> | 0.1 usec/cm to 5 sec/cm,<br>±3%, in 24 ranges. Ver-<br>nier control extends slo-<br>west sweep speed to 15<br>sec/cm.<br><br>7 calibrated ranges in 1, 2, 5<br>sequence ±3% (X1, X2,<br>and X5 ranges); ±5%<br>(X10 and X20 ranges to<br>0.02 usec/cm); ± 10%<br>(X50 and X100 ranges to<br>0.02 nsec/cm).<br><br>Approx +50 V (+45 v for<br>AN/USM-140 and<br>AN/USM-141) for dura-<br>tion of sweep.<br><br>Approx -50 to ± 50 v (-40 to<br>+40 v for AN/USM-140<br>and AN/USM-141). |
| Trigger requirements:<br>Internal<br><br>External<br>Level <sup>1</sup>   | Line or vertical input sig-<br>nal producing 2 mm or<br>more of vertical de-<br>flection.<br><br>0.5 v p-p or more<br>-30 to +30v  |
| Calibrator:<br>Waveshape <sup>1</sup><br><br>Voltage<br><br>Current <sup>1</sup>  | 1000-Hz square wave, 1-<br>usec rise and decay ti-<br>mes.<br><br>0.2 mv to 100 v p-p, t3%,<br>in 18 ranges<br><br>5 ma p-p, ±3%   |
| <b>Sweep Delay Generator MX-2962/USM</b>  |  |
| Delay time  | 1 usec to 10 sec   |
| Delaying sweep  | 2sec/cm to 1 sec/cm in 18<br>ranges  |
| Delay length  | 0 to 10 cm   |
| Accuracy  | 1% for 2 usec to 0.1 sec<br>ranges; ± 3% for 0.2, 0.5,<br>and 1 sec ranges.  |

<sup>1</sup> See footnote at end of table.

Table 1. Calibration Description - Continued

| Test Instrument Parameters  | Performance Specifications   |
|---|--|
| Linearity   | ±0.2% on all but 2, 5, and 10 usec ranges;<br>± 0.5% on 2, 5, and 10 usec ranges.  |
| Jitter <sup>1</sup>   | Less than 0.01 usec, or ±0.005% of total delay.  |
| Delayed trigger output <sup>1</sup>                                 | Approx +20 v   |
| Wideband High-Gain Pre-amplifier AM3568/USM<br>Sensitivity:         |  |
| Ac and dc coupling<br>Ac X10 gain<br>Vernier<br><br>Bandwidth       | 0.05 to 20 v/cm, ±3%<br>0.005 to 2 v/cm, ± 3%<br>Extends sensitivity to 50 v/cm (ac and dc)<br>Dc to 30 MHz when installed in AN/USM-140 or AN/USM-141 series oscilloscopes. |
| Rise time:<br><br>Ac or dc coupling<br>Ac X10 gain                  | 12 nsec or less<br>15 nsec or less   |
| Input impedance <sup>1</sup>  | 1 megohm shunted by 22 picofarads  |
| Dual-Trace Pre-amplifiers MX-2930A (B and C) and<br>MX-2721/USM-105 |  |
| Sensitivity<br><br>Bandwidth:<br>Dc coupled<br>Ac coupled           | 0.02 to 20 v/cm ±5% in 10 ranges. Vernier control extends sensitivity to 50 v/cm.<br><br>Dc to 22 MHz<br>2 Hz to 22 MHz  |
| Rise time   | 16 nsec or less  |
| Input impedance <sup>1</sup>  | 1 megohm shunted by 30 picofarads  |
| Common mode rejection <sup>1</sup>                                  | At least 40 db at maximum sensitivity. At least 30 db when using input attenuators.  |

<sup>1</sup> See footnote at end of table.

Table 1. Calibration Description - Continued

| Test Instrument Parameters | Performance Specifications |
|----------------------------|----------------------------|
| Electronic switching       | Approx 1 MHz               |
| Display polarity           | Positive or negative       |

<sup>1</sup>This specification is for information only and is not necessarily verified in this bulletin.

## SECTION II. A-LEVEL EQUIPMENT REQUIREMENTS

### 5. Equipment Required

Table 2 identifies the specific equipment used in this procedure for A-level calibration. 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.

### 6. 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 procedure for A-level calibration. 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, Model, and Part Number  |
|------|---------------------------|--|---|
| A1   | AC CALIBRATOR             | Range: 6.8579 mv rms to 29.694 v rms<br>Accuracy: $\pm 0.75\%$ | Hewlett-Packard, Model 745A (MIS-10342)   |
| A2   | SQUARE-WAVE GENERATOR     | Range: 4 Hz to 1 MHz<br><br>Rise Time: Less than 11 nsec       | Tektronix, Type 106 (MIS-10284)   |
| A3   | TIME-MARK GENERATOR       | Range: 20 nsec to 5 sec<br>Accuracy: $\pm 0.75\%$              | Tektronix, Type 184MOD146B (7912042-2)  |
| A4   | TEST OSCILLOSCOPE         | Range: 0.2 ms<br><br>Accuracy: $\pm 3\%$                       | Tektronix, Type RM561A (7910655-2) w/plug-ins 3A6 (7911441-1) and 3B4 (7912040-1) |
| A5   | OSCILLOSCOPE <sup>1</sup> | ---  | AN/USM-140( ) or AN/UJSM-141( ) series  |

<sup>1</sup> See footnote at end of table.



Table 2. Minimum Specification of Equipment Required - Continued

| Item | Common Name                             | Minimum Use Specifications                                   | Manufacturer, Model, and Part Number           |
|------|---|--|--|
| A6   | DUAL-TRACE <sup>1</sup><br>PREAMPLIFIER | ---  | MX-2930( )/USM series                          |
| A7   | HORIZONTAL <sup>1</sup><br>PLUG-IN      | ---  | MX-2962( )/USM,<br>or equivalent               |
| A8   | AUXILIARY <sup>1</sup><br>PLUG-IN       | ---  | MX-3078( )/USM series                          |
| A9   | AUTOTRANS-<br>FORMER                    | Range: 105 to 125 vac<br><br>Accuracy: $\pm 0.75\%$          | General Radio, Model<br>W10Mt3as3<br>(7910809) |
| A10  | AC/DC<br>VOLTMETER                      | Range: +17.145 to<br>+18.205 vac, and<br>-1515 to +373.7 vdc | John Fluke, Model<br>887ABAN<br>(MIS-10216)    |

<sup>1</sup> Additional equipment required; must be compatible with TI.

Table 3. Accessories Required

| Item | Common Name                 | Description and Part Number  |
|------|-----------------------------|--|
| B1   | ADAPTER <sup>1</sup>        | Single banana jack to alligator clip (red) (7907556)                       |
| B2   | ADAPTER <sup>1</sup>        | Single banana jack to alligator clip (black) (7907560)                     |
| B3   | ADAPTER                     | BNC T type; two jacks, one plug (MS35173-274C)                             |
| B4   | ADAPTER                     | BNC plug to double banana jack (UG-1441U)                                  |
| B5   | TEST ADAPTER                | Special adapter for vertical and horizontal plug-in units (7920784)        |
| B6   | ADAPTER BOX                 | Spade lug terminals to banana jacks (SKD-4850-3)                           |
| B7   | CABLE                       | Double banana plug to test probe and alligator clip (7911305)              |
| B8   | CABLE <sup>1</sup>          | 30-in., RG-58( )/U; BNC plug terminations (7907467)                        |
| B9   | CABLE                       | 30-in., RG-58( )/U; double banana plug terminations (7907470)              |
| B10  | CABLE <sup>1</sup>          | 36-in., RG-58( )/U; BNC plug and double banana plug terminations (7907471) |
| B11  | EXTENDER CABLE <sup>2</sup> | Hewlett-Packard, Model 10400B  |
| B12  | LEAD                        | 8-in., No. 18; single banana plug terminations (red) (7907493)             |

See footnotes at end of table.

Table 3. Accessories Required - Continued

| Item | Common Name       | Description and Part Number   |
|------|-------------------|---|
| B13  | LEAD              | 8-in., No.18; single banana plug terminations (black) (7907494)       |
| B14  | LEAD              | 24-in., No. 18 AWG; single banana plug terminations (red) (7907497)   |
| B15  | LEAD              | 24-in., No. 18 AWG; single banana plug terminations (black) (7907498) |
| B16  | TEST PROBE        | Tektronix, Type P6006 (7911545)                                       |
| B17  | ADAPTER CONNECTOR | GR connector to BNC jack (MS57093)                                    |
| B18  | LOAD              | 50-ohm feed-thru (Hewlett-Packard, Model 11048B) (5985-563-9679)      |

<sup>1</sup> Two required

<sup>2</sup> Additional accessory required

**SECTION III.  
A-LEVEL PRELIMINARY OPERATIONS**

**7. Preliminary Instructions**

a. The instructions outlined in this section are preparatory to the calibration process. Personnel should become familiar with sections I through VII of this bulletin before beginning the calibration.

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.**

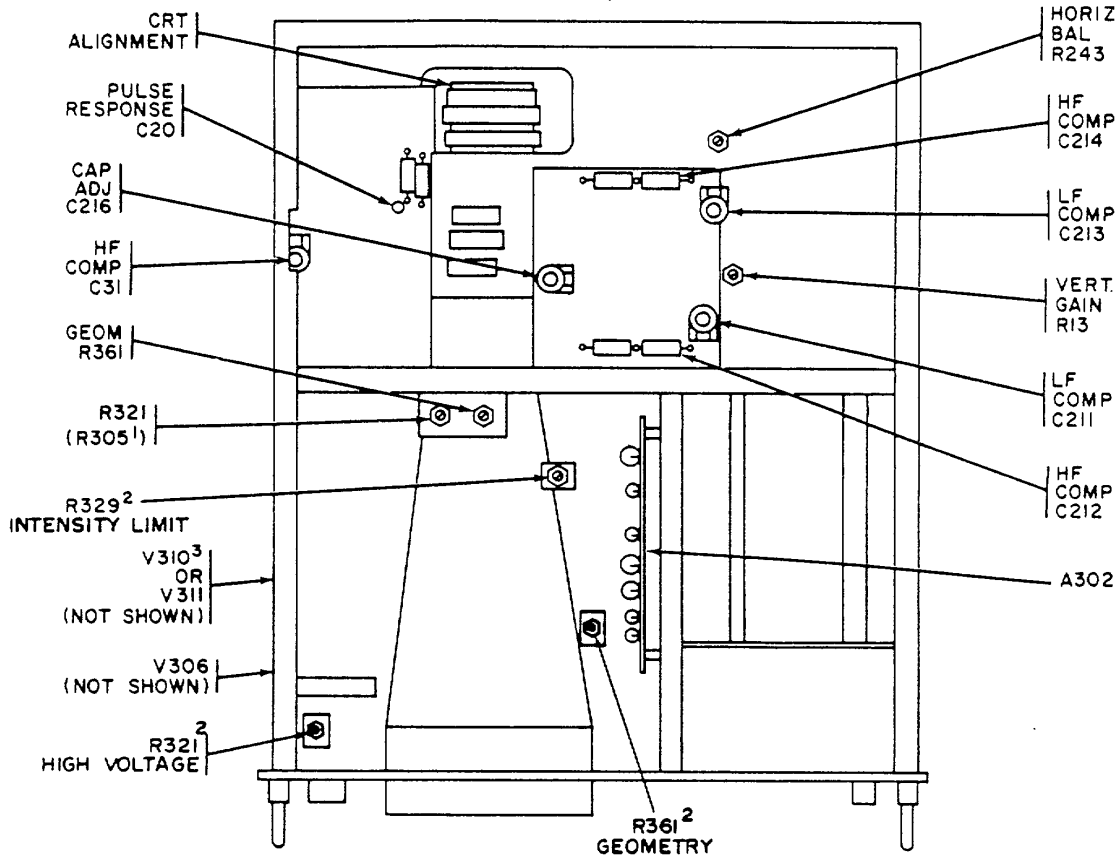
**8.**

**Equipment Setup for Oscilloscopes**

- a. Remove protective cover from TI.
- b. Connect TI to autotransformer (A9).
- c. Connect autotransformer to 115-volt ac source and adjust for 115 volts ac.
- d. Position TI controls as listed in (1) through (11) below:

- (1) INTENSITY control fully counterclockwise.
- (2) CALIBRATOR switch to 50.
- (3) HORIZONTAL DISPLAY switch to X1.
- (4) EXTERNAL VERNIER control to CAL.
- (5) SWEEP TIME switch to .5 MILLI-SECONDS/CM.
- (6) SWEEP TIME VERNIER control to CAL.

- (7) TRIGGER LEVEL control to 0 (zero).
- (8) TRIGGER SLOPE switch to +(positive).
- (9) TRIGGER SOURCE switch to INT.
- (10) SWEEP MODE control to FREE RUN.
- (11) DC-AC switch to AC.
- e. Install auxiliary plug-in (AS) in left-hand compartment of TI.
- f. Set auxiliary plug-in INTENSITY MODULATION switch to NORMAL and SWEEP OCCURRENCE switch to NORMAL.
- g. Install dual-trace preamplifier (A6) in right-hand compartment of TI.
- h. Position dual-trace preamplifier controls as listed in (1) through (5) below:
  - (1) Channel A POLARITY switch to +UP.
  - (2) Channel A SENSITIVITY switch to 5 VOLTS/CM.
  - (3) Channel A VERNIER to CALIBRATED.
  - (4) Channel A AC-DC switch to AC.
  - (5) Channel selector switch to CHANNEL A.
- i. Set TI POWER switch to ON. Allow 15 minutes for warm-up and stabilization.
- j. Adjust SCALE LIGHT control for convenient viewing.
- k. Adjust INTENSITY, VERTICAL, and HORIZONTAL POSITION controls until left edge of trace is aligned with left vertical graticule line and is positioned along center horizontal graticule line. If necessary, adjust CRT ALIGNMENT (fig. 1).



<sup>1</sup> R305 ONLY FOR AN/USM-140A.

<sup>2</sup> THESE LOCATIONS ARE ONLY IN AN/USM-140 AND AN/USM-141.

<sup>3</sup> V311 FOR AN/USM-140A; V310 FOR ALL OTHER MODELS.

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Figure 1. Oscilloscope - top interior view.

*l.* Adjust TI FOCUS and ASTIGMATISM controls until trace is sharp and well defined.

*m.* Connect TI CALIBRATOR VOLTS connector to dual-trace preamplifier channel A INPUT connector, using cable (B8).

**NOTE**

When TI is AN/USM-140A or AN/USM-141, use cable (B10).

*n.* Adjust TI HORIZONTAL POSITION control to position vertical trace alternately on left- and right-edge graticule lines, and observe trace curvature. Adjust INTENSITY control as required.

*o.* Disconnect cable from dual-trace preamplifier channel A INPUT.

*p.* Adjust dual-trace preamplifier VERTICAL POSITION control to position trace alternately on top and bottom graticule lines and observe trace curvature.

*q.* Adjust GEOM R361 (fig. 1) for minimum distortion of both vertical and horizontal traces.

**NOTE**

Step *r* below is applicable only to models ANI/USM-140 and AN/USM-141.

**NOTE**

r. Adjust INTENSITY control to approximately 9 o'clock position. Adjust R329 (fig. 1) until trace is just extinguished.

**Allow sufficient time for TI trace persistence.**  
 s. Repeat k above.

**SECTION IV.  
 A-LEVEL CALIBRATION PROCESS FOR  
 OSCILLOSCOPES AN/USM-140 (A, B, C) AND  
 AN/USM-141 (A and B).**

**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 calibration.**

**NOTE**

**When indications specified in paragraphs 9 through 20 are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs 9 through 20. Do not perform power supply check if all other parameters are within tolerance.**

**9. Calibrator**

*a. Performance Check*

(1) Remove V306 (fig. 1) from TI.

(2) Connect ac/dc voltmeter (A10) to TI CALIBRATOR VOLTS connector, using cable (B10).

**NOTE**

**When TI is AN/USM-140A or AN/USM-141, use cable (B9).**

(3) Turn TI CALIBRATOR switch to 100. Ac/dc voltmeter will indicate between 97 and 103 volts dc.

(4) Repeat technique of (3) above for TI CALIBRATOR switch settings listed in table 4. Ac/dc voltmeter will indicate within limits specified.

(5) Connect ac/dc voltmeter to TI CALIBRATOR MV connector.

(6) Turn TI CALIBRATOR switch to 100. Ac/dc voltmeter will indicate between 97 and 103 millivolts dc.

(7) Turn TI CALIBRATOR switch to OFF.

(8) Replace V306 in TI.

*b. Adjustments.* No adjustments can be made.

**10. Sweep Gain**

*a. Performance Check*

(1) Install test adapter (B5) in left-hand compartment of TI.

(2) Connect ac calibrator (A1) to test adapter J2 INPUT, using cable (B10).

*Table 4. Calibrator*

| Test Instrument<br>CALIBRATOR<br>Switch Setting | Ac/Dc Voltmeter<br>Indications (vdc) |       |
|---|--------------------------------------|-------|
|   | Min                                  | Max   |
| 50  | 48.5                                 | 51.5  |
| 20  | 19.4                                 | 20.6  |
| 10  | 9.7                                  | 10.3  |
| 5   | 4.85                                 | 5.15  |
| 2   | 1.94                                 | 2.06  |
| 1   | .097                                 | 1.03  |
| .5  | 0.485                                | 0.515 |
| .2  | 0.194                                | 0.206 |

for 5.5 centimeters of horizontal deflection on TI. If

(3) Set ac calibrator to 1 kHz and adjust output

ac calibrator does not indicate between 17.145 and 18.205 volts rms, perform b(1) and (2) below.

(4) Turn TI HORIZONTAL DISPLAY switch to X100.

(5) Repeat a(3) above. If ac calibrator does not indicate between 171.45 and 182.05 millivolts rms,

perform b(3) and (4) below.

(6) Repeat technique of (4) and (5) above for TI HORIZONTAL DISPLAY switch settings listed in table 5. Ac calibrator will indicate within limits specified.

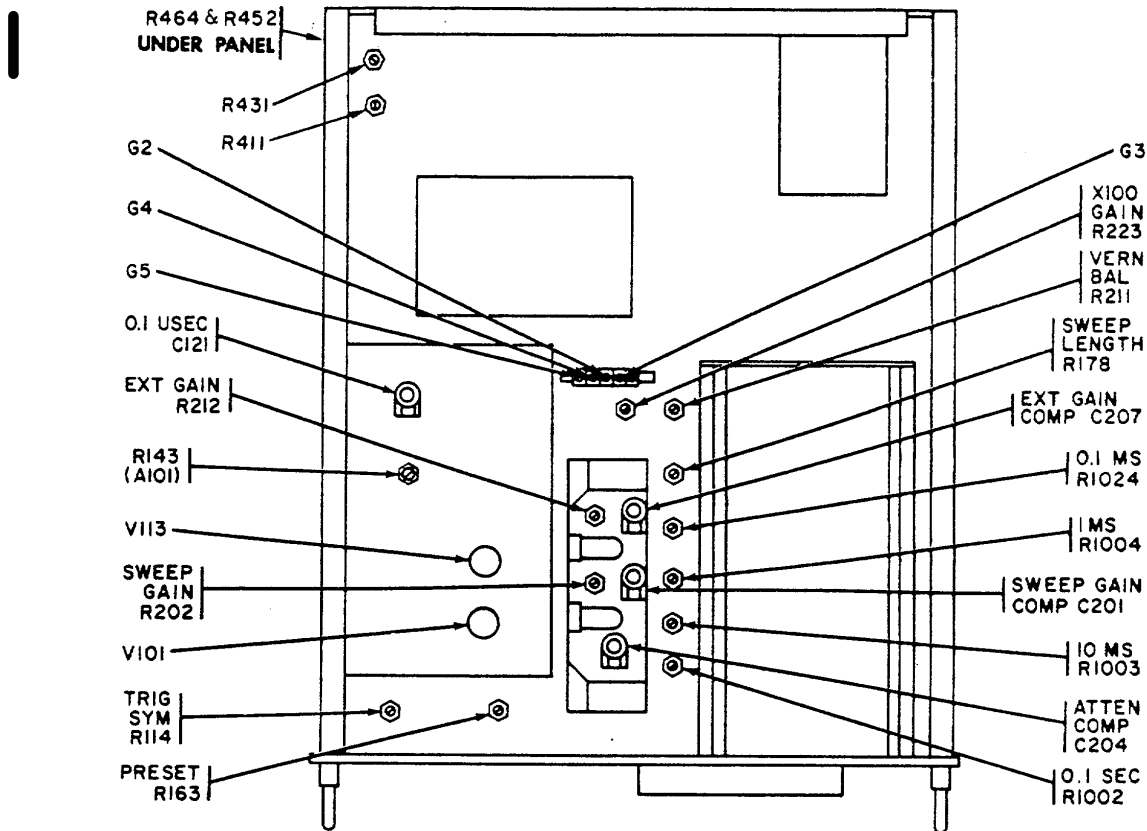
Table 5. Sweep Gain

| Test Instrument<br>HORIZONTAL DISPLAY<br>Switch Settings | Ac Calibrator<br>Indication (rms) |             |
|--|-----------------------------------|-------------|
|  | Min                               | Max         |
| X50  | 342.8950 mv                       | 364.1050 mv |
| X20  | 857.2375 mv                       | 910.2625 mv |
| X10  | 1.7144 v                          | 1.8205 v    |
| X5   | 3.429 v                           | 3.641 v     |
| X2   | 8.573 v                           | 9.103 v     |

*b. Adjustments*

(1) Adjust ac calibrator for 17.675 volts rms.

(2) Adjust SWEEP GAIN R202 (fig. 2) for 5.5 centimeters of horizontal deflection.



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Figure 2. Oscilloscope - bottom interior view.

- (3) Adjust ac calibrator output to 176.75 millivolts rms.
- (4) Adjust X100 GAIN R223 (fig. 2) for horizontal deflection of 5.5 centimeters.

### 11. Sweep Frequency Compensation

#### a. Performance Check

- (1) Connect TI SWEEP OUTPUT connector to dual-trace preamplifier (A6) channel A INPUT connector, using cable (B8).
- (2) Connect square-wave generator (A2) - (NEGATIVE) OUTPUT to test adapter (B5) J2 INPUT, using cable and 50-ohm termination supplied with square-wave generator. Connect square-wave generator TRIGGER OUTPUT to TI TRIGGERING SOURCE INPUT, USING CABLE (B8).
- (3) Position TI controls as listed in (a) through (c) below:

- (a) HORIZONTAL DISPLAY switch to X100.
- (b) SWEEP TIME switch to .1 MILLI-

SECONDS/CM.

- (c) TRIGGER SOURCE switch to EXT AC.

(4) Adjust dual-trace preamplifier SENSITIVITY switch and sensitivity. VERNIER control until TI vertical deflection is approximately 5 centimeters.

(5) Adjust square-wave generator repetition rate to 4 kHz and amplitude until TI horizontal deflection is 5 centimeters. Adjust TRIGGER LEVEL, SWEEP MODE, and HORIZONTAL POSITION controls as required. If top and bottom of square waves displayed on TI are not flat with minimum overshoot or rounding, perform b(l) below.

(6) Turn TI SWEEP TIME switch to 5 MICROSECONDS/CM.

(7) Repeat (4) above.

(8) Adjust square-wave generator repetition rate to 100 kHz and amplitude until TI horizontal deflection is 5 centimeters. If top and bottom of square

waves displayed on TI are not flat with minimum overshooting or rounding, perform b(2) and (3) below.

*b. Adjustments*

(1) Adjust SWEEP GAIN COMP C201 (fig. 2) for optimum square-wave display.

(2) Adjust LF COMP C211 and C213 (fig. 1) for optimum square-wave display.

(3) Adjust CAP ADJ C216 (fig. 1) until some overshoot appears on left side of crt display; then, adjust C216 in opposite direction until overshoot just disappears.

**12. Horizontal Balance**

*a. Performance Check*

(1) Adjust TI HORIZONTAL POSITION control to midrange.

(2) Turn HORIZONTAL DISPLAY switch midway between X1 and .1 VOLTS/CM. Adjust INTENSITY control as required. If spot displayed on TI is not centered horizontally, perform b(1) below.

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

(4) Adjust HORIZONTAL POSITION control until spot displayed on TI is centered horizontally.

(5) Rotate EXTERNAL VERNIER control

throughout its range. If spot displayed on TI does not remain centered, perform b(2) below.

(6) Turn EXTERNAL VERNIER control to CAL.

*b. Adjustments*

(1) Adjust HORIZ BAL R243 (fig. 1) until spot is centered horizontally on TI crt.

(2) Adjust VERN BAL R211 (fig. 2) until spot shows no shift as EXTERNAL VERNIER is rotated throughout its range.

**NOTE**

**Adjust HORIZONTAL POSITION control as necessary to keep spot centered horizontally on TI crt.**

**13. Horizontal Amplifier Gain**

*a. Performance Check*

(1) Connect ac calibrator (A1) to TI horizontal INPUT, using cable (B10).

(2) Adjust ac calibrator until horizontal deflection of trace displayed on TI crt is 10 centimeters. If ac calibrator does not indicate between 0.342895 and 0.364105 volt rms, perform b(1) and (2) below.

(3) Repeat technique of (2) above for TI HORIZONTAL DISPLAY switch settings listed in table 6. If ac calibrator does not indicate within limits specified, perform b(3) below.

Table 6. Horizontal Amplifier Gain

| Test Instrument                   |                            | Ac Calibrator Indication (rms) |            |
|-----------------------------------|----------------------------|--------------------------------|------------|
| HORIZONTAL DISPLAY Switch Setting | Horizontal Deflection (cm) | Min                            | Max        |
| .2 VOLTS/CM                       | 10                         | 685.790 mv                     | 728.210 mv |
| .5 VOLTS/CM                       | 10                         | 1.7144 v                       | 1.8205 v   |
| 1 VOLTS/CM                        | 10                         | 3.429 v                        | 3.641 v    |
| 2 VOLTS/CM                        | 10                         | 6.858 v                        | 7.282 v    |
| 5 VOLTS/CM                        | 5                          | 8.573 v                        | 9.103 v    |
| 10 VOLTS/CM                       | 2                          | 6.858 v                        | 7.282 v    |

*b. Adjustments*

(1) Adjust ac calibrator output for 0.3535 volt rms.

(2) Adjust EXT GAIN R212 (fig. 2) for horizontal deflection of 10 centimeters.

(3) Readjust R212 for an in-tolerance condition on all ranges.

(1) Connect TI SWEEP OUTPUT connector to dual-trace preamplifier (A6) channel A INPUT connector, using cable (B8).

(2) Connect square-wave generator (A2) HI AMPLITUDE OUTPUT to TI horizontal INPUT, using cable and 50-ohm termination supplied with square-wave generator.

(3) Connect TI test point G3 (fig. 2) to junction of violet/orange wire (white/yellow/violet wire for AN/USM-140B and AN/USM-141A) and R143 on A101

**14. Horizontal Amplifier Frequency Compensation**

*a. Performance Check*

(fig. 2), using lead and two adapters (B12 and B1).

#### NOTE

**On some models, R143 is located near V101**

**(fig. 2).**

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

(a) HORIZONTAL DISPLAY switch to .5 VOLTS/CM.

(b) SWEEP TIME switch to .1 MILLISECONDS/CM.

(c) TRIGGER SOURCE switch to INTI

(5) Adjust dual-trace preamplifier SENSITIVITY switch and sensitivity VERNIER control until TI vertical deflection is approximately 4 centimeters.

(6) Adjust square-wave generator repetition rate to 4 kHz and amplitude until TI horizontal deflection is 6 centimeters. If top and bottom of square-wave display is not flat with a minimum of overshoot or rounding, perform b(1) below.

(7) Turn TI HORIZONTAL DISPLAY to 1 VOLTS/CM.

(8) Repeat (6) above. If square waves displayed are not flat with a minimum overshoot and rounding, perform b(2) below.

(9) Remove lead and adapters installed in (3) above.

(10) Disconnect cable from TI SWEEP OUTPUT and dual-trace preamplifier channel A INPUT connectors.

#### b. Adjustments

(1) Adjust EXT GAIN COMP C207 (fig. 2) for optimum square-wave display.

(2) Adjust ATTEN COMP C204 (fig. 2) for optimum square-wave display.

#### 15. Trigger Sensitivity

##### a. Performance Check

(1) Connect ac calibrator (A1) to dual-trace preamplifier (A6) channel A INPUT connector, using cable (B10).

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

(a) HORIZONTAL DISPLAY switch to X1.

(b) SWEEP TIME switch to 1 MILLISECONDS/CM.

(c) SWEEP MODE control to PRESET.

(3) Turn dual-trace preamplifier SENSITIVITY switch to 1 VOLTS/CM and sensitivity VERNIER control to CALIBRATED.

(4) Install auxiliary plug-in (A8) in left-hand compartment of TI.

(5) Adjust ac calibrator until TI sweep triggers and remains stable. If vertical deflection does not indicate 02 centimeter or less, perform b(1) through (6) below.

(6) Connect ac calibrator to TI TRIGGER INPUT, using cable (B10).

(7) Turn TI TRIGGER SOURCE switch to EXT AC.

(8) Adjust ac calibrator until TI sweep triggers and remains stable. If ac calibrator does not indicate 176.75 millivolts rms or less, perform b(7) through (10) below.

#### b. Adjustments

(1) Adjust ac calibrator output to 0 (zero).

(2) Connect ac/dc voltmeter (A10) between pin 8 of V113 (fig. 2) and chassis ground, using cable (b7).

(3) Slowly turn SWEEP MODE control clockwise until trace appears on crt; then, turn counterclockwise until trace just disappears. Record indication on ac/dc voltmeter.

(4) Turn TI SWEEP MODE control to PRESET,

(5) Turn PRESET R163 (fig. 2) fully counterclockwise and then clockwise until ac/dc voltmeter indicates 1.5 volts less negative than indication recorded in (3) above.

(6) Disconnect ac/dc voltmeter and repeat a(5) above.

(7) Adjust ac calibrator output to 176.75 millivolts rms.

(8) Connect pin 7 of V101 (fig. 2) to chassis ground, using lead and two adapters (B13 and B2).

(9) Adjust TRIG SYM R114 (fig. 2) until sweep triggers.

(10) Remove lead from between pin 7 of V101 and chassis ground.

#### 16. Sweep Time

##### a. Performance Check

(1) Connect time-mark generator (A3) MARKER OUTPUT connector to dual-trace preamplifier (A6) channel A INPUT connector, using cable (B8).

(2) Connect time-mark generator TRIGGER OUTPUT connector to TI trigger INPUT connector, using cable (B8).

(3) Adjust time-mark generator for 10-mS markers and 10-mS trigger.

(4) Adjust dual-trace preamplifier SENSITIVITY switch and sensitivity VERNIER control for convenient display amplitude.

(5) Turn TI SWEEP TIME switch to 10 MILLISECONDS/CM and adjust TRIGGER LEVEL control for shortest possible sweep. If 11 markers are not displayed on TI and trace does not end immediately following marker 12, perform b(1) below.

(6) Turn TI SWEEP TIME switch to .1 MILLISECONDS/CM.

(7) Adjust time-mark generator for 100-uS markers and 1-mS trigger.

(8) Adjust TI HORIZONTAL POSITION control to align second marker behind second vertical graticule line. If TI does not display 1 marker per centimeter, and



10th marker is not displayed with  $\pm 1.5$  minor divisions of 10th graticule line, perform *b(2)* below.

(9) Repeat (6) through (8) above for TI SWEEP TIME switch settings and time-mark generator out-

puts listed in table 7. If either 10th (1/cm) or 19th (2/cm) marker is not displayed within  $\pm 1.5$  minor divisions of 10th graticule line at each setting, perform applicable adjustments listed in table 7.

Table 7. Sweep Time

| Time-Mark Generator |             | Test Instrument                  |   |   |
|---------------------|-------------|----------------------------------|---|---|
| Switch Settings     |             | SWEEP TIME<br>Switch<br>Settings | Number of<br>Markers<br>Displayed<br>Per cm | Adjust-<br>ments                          |
| Trigger             | Marker      |                                  |   |   |
| 1 mS                | 0.1 mS      | .2 MILLISECONDS/CM               | 2   | ---                                       |
| 1 mS                | 0.5 mS      | .5 MILLISECONDS/CM               | 1   | ---                                       |
| 1 mS                | 1 mS        | 1 MILLISECONDS/CM                | 1   | R1004<br>(fig. 2)                         |
| 1 mS                | 1 mS        | 2 MILLISECONDS/CM                | 2   | ---                                       |
| 10 mS               | 5 mS        | 5 MILLISECONDS/CM                | 1   | ---                                       |
| 10 mS               | 10 mS       | 10 MILLISECONDS/CM               | 1   | R1003<br>(fig. 2)                         |
| 10 ms               | 10 mS       | 20 MILLISECONDS/CM               | 2   | ---                                       |
| 0.1 S               | 50 mS       | 50 MILLISECONDS/CM               | 1   | ---                                       |
| 0.1 S               | 0.1 S       | .1 SECONDS/CM                    | 1   | R1002<br>(fig. 2)                         |
| 0.1 S               | 0.1 S       | .2 SECONDS/CM                    | 2   | ---                                       |
| 1 S                 | 0.5 S       | .5 SECONDS/CM                    | 1   | ---                                       |
| 1 S                 | 1 S         | 1 SECONDS/CM                     | 1   | ---                                       |
| 1 S                 | 1 S         | 2 SECONDS/CM                     | 2   | ---                                       |
| <sup>1</sup>        | 5 S         | 5 SECONDS/CM                     | 1   | ---                                       |
| 1 $\mu$ S           | 0.1 $\mu$ S | .1 MICROSECONDS/CM               | 1   | C121<br>(fig. 2)                          |
| 1 $\mu$ S           | 20 nS       | .1 MICROSECONDS/CM <sup>2</sup>  | 1   | C212 AND<br>C214 <sup>2</sup><br>(fig. 1) |
| 1 $\mu$ S           | 0.1 $\mu$ S | .2 MICROSECONDS/CM               | 2   | C1016<br>(fig. 3)                         |

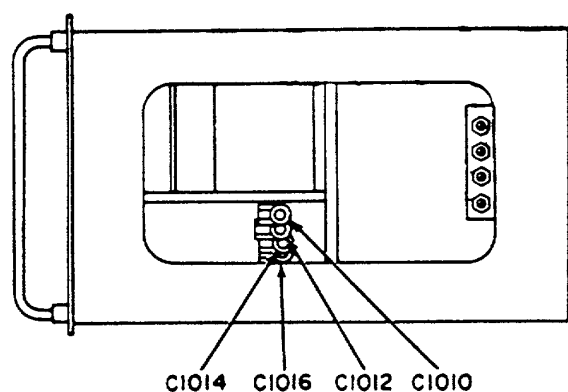
<sup>1</sup> See footnote at end of table.

Table 7. Sweep Time - Continued

| Time-Mark Generator<br>Switch Settings |             | Test Instrument                  |   |                   |
|--|-------------|----------------------------------|---|-------------------|
|  |             | SWEEP TIME<br>Switch<br>Settings | Number of<br>Markers<br>Displayed<br>Per cm | Adjust-<br>ments  |
| Trigger                                | Marker      |                                  |   |                   |
| 1 $\mu$ S                              | 0.5 $\mu$ S | .5 MICROSECONDS/CM               | 1   | C1014<br>(fig. 3) |
| 1 $\mu$ S                              | 1 $\mu$ S   | 1 MICROSECOND/CM                 | 1   | C1012<br>(fig. 3) |
| 1 $\mu$ S                              | 1 $\mu$ S   | 2 MICROSECONDS/CM                | 2   | ---               |
| 0.1 mS                                 | 5 $\mu$ S   | 5 MICROSECONDS/CM                | 1   | ---               |
| 0.1 mS                                 | 10 $\mu$ S  | 10 MICROSECONDS/CM               | 1   | C1010<br>(fig. 3) |
| 0.1 mS                                 | 10 $\mu$ S  | 20 MICROSECONDS/CM               | 2   | ---               |
| 0.1 mS                                 | 50 $\mu$ S  | 50 MICROSECONDS/CM               | 1   | ---               |

<sup>1</sup> For this check only, turn TRIGGER SOURCE switch to .INT.

<sup>2</sup> Turn TI HORIZONTAL DISPLAY switch to X5. If markers are not symmetrical about the centerline of graticule, adjust C212 and C214. Return HORIZONTAL DISPLAY switch to X1.



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Figure 3. Oscilloscope - right-side interior view.

#### b. Adjustments

(1) Adjust SWEEP LENGTH R178 (fig. 2) until end of sweep occurs just after 12th marker.

(2) Adjust R1024 (fig. 2) until 10th marker is behind 10th graticule line.

### 17. Sweep Magnification

#### a. Performance Check

(1) Turn TI SWEEP TIME switch to 1 MILLISECONDS/CM.

(2) Adjust time-mark generator (A3) for 0.5-mS markers and 1-mS trigger.

(3) Turn TI HORIZONTAL DISPLAY switch to X2 and adjust HORIZONTAL POSITION control until second marker coincides with second vertical graticule line. Observe that TI displays 1 marker per centimeter and that 10th marker coincides with 10th vertical graticule line within  $\pm 1.5$  minor divisions.

(4) Repeat (1) through (3) above at control settings listed in table 8. At each setting, 10th marker will be displayed within  $\pm 1.5$  minor divisions of 10th vertical graticule line.

Table 8. Sweep Magnification

| Time-Mark Generator<br>Switch Settings |        | Test Instrument                                    |   |
|--|--------|--|---|
|  |        | SWEEP TIME<br>Switch Settings<br>(MILLISECONDS/CM) | HORIZONTAL<br>DISPLAY<br>SWITCH<br>Settings |
| Trigger                                | Marker |  |   |
| 1 mS                                   | 0.1 mS | .5   | X5  |
| 1 mS                                   | 0.1 mS | 1  | X10   |
| 1 mS                                   | 50 μS  | 1  | X20   |
| 1 mS                                   | 10 μS  | .5   | X50   |
| 1 mS                                   | 10 μS  | 1  | X100  |

b. *Adjustments.* No adjustments can be made.

**18. Main Vertical Amplifier Gain**

a. *Performance Check*

(1) Remove dual-trace preamplifier (A6) and install test adapter (B5) in right-hand compartment of TI.

(2) Connect ac calibrator (A1) to test adapter J3 INPUT connector, using cable (B10).

(3) Position TI controls as listed in (a) through (c) below.

(a) HORIZONTAL DISPLAY switch to X1.

(b) TRIGGER SOURCE switch to INT.

(c) TRIGGER LEVEL control to 0 (zero).

**NOTE**

**Adjust test adapter vertical position control as required during following steps.**

(4) Adjust ac calibrator until TI vertical deflection is 4 centimeters. If ac calibrator does not indicate between 268.660 and 296.940 millivolts rms, perform b below.

(5) Adjust ac calibrator TI vertical deflection is 2 centimeters. Ac calibrator will indicate between 134.28 and 148.47 millivolts rms.

b. *Adjustments*

(1) Adjust ac calibrator output to 282.80 millivolts rms.

(2) Adjust VERT GAIN R13 (fig. 1) for vertical deflection of 4 centimeters.

**19. Main Vertical Amplifier Rise Time**

a. *Performance Check*

(1) Connect square-wave generator (A2) +(positive) OUTPUT to test adapter (B5) J1 INPUT connector and -(negative) OUTPUT to J3 using cable and termination supplied with square-wave generator, and adapter connector and load (B17 and B18).

(2) Turn TI SWEEP TIME switch to .1 MICROSECONDS/CM and HORIZONTAL DISPLAY

switch to X5.

(3) Adjust square-wave generator repetition rate for 1MHz and maximum output amplitude.

(4) Adjust TI INTENSITY and test adapter BALANCE controls as necessary to center display on crt.

(5) Adjust TI TRIGGER LEVEL control to shift displayed square wave as far to right as possible. Adjust HORIZONTAL POSITION control as required.

(6) Measure rise time, using standard rise-time technique. If rise time is not 11 nanoseconds or less (12 nanoseconds or less for AN/U SM-140A), perform b below.

b. *Adjustments*

(1) Turn TI SWEEP TIME switch to .5 MICROSECONDS/CM and HORIZONTAL DISPLAY switch to X1.

(2) Adjust square-wave generator repetition rate to 500 kHz.

**NOTE**

**Disregard any high-frequency ringing that may occur on displayed square wave during the following step.**

(3) Adjust HF COMP C31 (fig. 1) for flat-topped square wave as displayed on TI crt.

(4) Adjust test adapter BALANCE control until square wave is centered vertically.

(5) Adjust PULSE RESPONSE C20 (fig. 1) for optimum square wave with minimum overshoot or rounding.

(6) Repeat a(2) through (6) above.

**20. Regulated Power Supplies**

**NOTE**

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

a. *Performance Check*

(1) Connect ac/dc voltmeter (A10) between test point G3 (fig. 2) and chassis ground, using cable (B7). If ac/dc voltmeter does not indicate between -99.6 and -100.4 volts dc, perform b(1) below.

(2) Adjust autotransformer (A9) for output from 105 to 125 volts. Ac/dc voltmeter will indicate between -99.6 and -100.4 volts dc.

(3) Adjust output of autotransformer to 115 volts ac.

(4) Connect ac/dc voltmeter between test point G2 (fig. 2) and chassis ground. If ac/dc voltmeter does not indicate between + 6.2 and + 6.4 volts dc, perform b(2) below.

(5) Repeat (2) and (3) above. Ac/dc voltmeter will indicate between +6.2 and +6.4 volts dc.

(6) Connect ac/dc voltmeter between test point G4 (fig. 2) and chassis ground. If ac/dc voltmeter does not indicate between + 109.56 and + 110.44 volts dc, perform b(3) below.

(7) Repeat (2) and (3) above. Ac/dc voltmeter will indicate between +109.56 and +110.44 volts dc.

(8) Connect ac/dc voltmeter between test point G5 (fig. 2) and chassis ground. If ac/dc voltmeter does not indicate between +366.3 and +373.7 volts dc, perform b(4) below.

(9) Repeat (2) and (3) above. Ac/dc voltmeter will indicate between +366.3 and +373.7 volts dc.

*b. Adjustments*

(1) Adjust R452 (fig. 2) until ac/dc voltmeter indicates -100.0 volts dc.

(2) Adjust R464 (fig. 2) until ac/dc voltmeter indicates +6.3 volts dc.

(3) Adjust R431 (fig. 2) until ac/dc voltmeter

indicates +110.0 volts dc.

(4) Adjust R411 (fig. 2) until ac/dc voltmeter indicates +370.0 volts dc.

## 21. High-Voltage Power Supply

### NOTE

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

*a. Performance Check*

(1) Connect ac/dc voltmeter (A10) to adapter box (B6), using cable supplied with ac/dc voltmeter.

(2) Connect adapter box between V310 cap (V311 AN/USM-140A) (fig. 1) and chassis ground, using leads and adapters (B14, B15, B1, and B2). If ac/dc voltmeter does not indicate between -1485 and -1515 volts dc (-1435.5 and -1464.5 volts dc for AN/USM-140A), perform b below.

(3) Adjust autotransformer (A9) for output from 105 to 125 volts ac. Ac/dc voltmeter will indicate between -1485 and -1515 volts dc (-1435.5 and -1464.5 volts dc for AN/USM-140A).

(4) Adjust autotransformer for 115 volts ac.

*b. Adjustments.* Adjust R321 (R305 for AN/USM-140A) (fig. 1) until ac/dc voltmeter indicates -1500 volts dc (-1450 volts dc for AN/USM-140A).

## 22. Final Procedure

*a.* Deenergize and disconnect all equipment and reinstall protective covers.

*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.

### A-LEVEL CALIBRATION PROCESS FOR SWEEP DELAY GENERATOR MX-2962/USM.

#### 23. Equipment Setup

*a.* Remove protective cover from oscilloscope (A5). Install dual-trace preamplifier (A6) in right-hand compartment of oscilloscope.

*b.* Install TI in left-hand compartment of oscilloscope.

*c.* Position TI controls as listed in (1) through (8) below:

(1) SWEEP. SELECTOR switch to MAIN SWEEP.

(2) DELAY LENGTH CM control to 0 (zero).

(3) DELAY FUNCTION switch to TRIGGER MAIN SWEEP.

(4) DELAYING SWEEP TIME/CM switch to .5 MILLISECONDS.

(5) SWEEP MODE control to PRESET.

(6) TRIGGER SOURCE switch to INT.

(7) TRIGGER SLOPE control to + (positive).

(8) TRIGGER LEVEL control to 0 (zero).

*d.* Position oscilloscope controls as listed in (1) through (14) below:

(1) INTENSITY control fully counterclockwise.

(2) HORIZONTAL DISPLAY switch to X1.

(3) EXTERNAL VERNIER control to CAL.

(4) SWEEP TIME switch to 1 MILLISECONDS/CM.

(5) SWEEP TIME VERNIER control to CAL.

(6) TRIGGER LEVEL control to 0 (zero).

(7) TRIGGER SLOPE control to + (positive).

(8) TRIGGER SOURCE switch to INT.

(9) SWEEP MODE control to FREE RUN.

(10) Dual-trace preamplifier channel selector switch to CHANNEL A.

(11) Channel A SENSITIVITY switch to 1

VOLTS/CM.

(12) Channel A VERNIER control to CALIBRATED.

(13) Channel A POLARITY switch to +UP.

(14) Channel A AC-DC switch to AC.

e. Set oscilloscope POWER switch to ON. Allow 15 minutes for equipment to warm up and stabilize.

f. Adjust oscilloscope INTENSITY, FOCUS, and ASTIGMIATISMI controls for optimum viewing.

**NOTE**

**Adjust oscilloscope HORIZONTAL POSITION and dual-trace preamplifier VERTICAL POSITION controls as required**

g. Turn oscilloscope SWEEP MODE control to PRE-SET.

**24. Trigger Sensitivity**

*a. Performance Check*

(1) Connect ac calibrator (A1) to dual-trace preamplifier (A6) channel A INPUT, using cable (B 10).

(2) Adjust ac calibrator until oscilloscope (A5) sweep triggers and remains stable. If oscilloscope vertical deflection is not 0.2 centimeter or less, perform b(1) through (11) below.

(3) Connect ac calibrator to plug-in (A6) A INPUT and TI trigger INPUT, using two cables (B10) and adapter (B3).

(4) Turn TI TRIGGER SOURCE switch to EXT AC and SWEEP SELECTOR switch to DELAYING SWEEP.

(5) Adjust ac calibrator until sweep triggers and remains stable. Adjust TI TRIGGER LEVEL as required. Ac calibrator will indicate 176.75 millivolts rms or less.

(6) Turn TI TRIGGER SOURCE switch to INT.

*b. Adjustments*

(1) Adjust ac calibrator output to 0 (zero).

(2) Connect ac/dc voltmeter (A1) between pin 3 of V2513 (fig. 4) and chassis ground, using cable (B7)

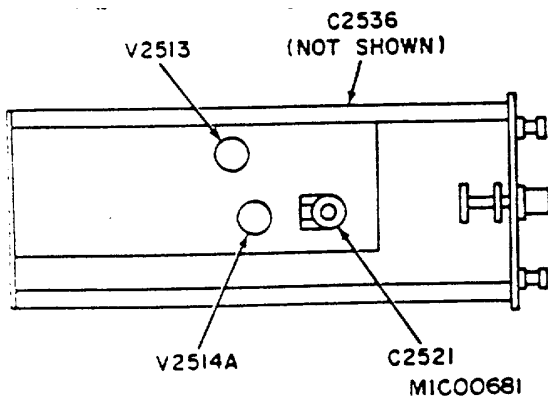


Figure 4. Sweep delay generator - left-side view.

(3) Turn TI SWEEP MODE control to FREE RUN position and then turn toward PRESET position until sweep just stops. Record ac/dc voltmeter indication.

(4) Turn TI SWEEP MODE control to PRESET.

(5) Adjust R2560 (fig. 5) until ac/dc voltmeter indication is 1.5 volts less negative than indication recorded in (3) above.

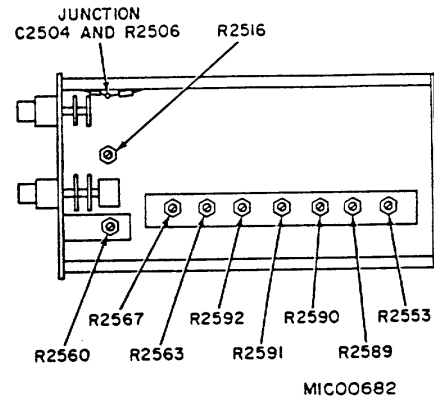


Figure 5. Sweep Delay generator - bottom view.

(6) Disconnect ac/dc voltmeter from XV2513.

(7) Connect junction of C2504 and R2506 (fig. 5) to chassis ground, using lead and two adapters (B13 and B2).

(8) Adjust ac calibrator output and R2516 (fig. 5) to produce a triggered sweep with a vertical deflection of 0.2 centimeter

(9) Disconnect lead from junction of C2504 and R2506 to chassis ground.

(10) Turn TI TRIGGER SLOPE control to - (negative) and observe that sweep remains triggered.

(11) Turn TI TRIGGER SLOPE control to + (positive).

**25. Sweep Length**

*a. Performance Check*

(1) Connect time-mark generator (A3) MARKER OUTPUT connector to dual-trace preamplifier (A6) channel A INPUT, using cable (B8).

(2) Set time-mark generator to 5  $\mu$ S markers.

(3) Adjust dual-trace preamplifier SENSITIVITY switch and sensitivity VERNIER control for 4 centimeters of vertical deflection as displayed on oscilloscope (AS) crt.

(4) Adjust TI TRIGGER LEVEL control for shortest possible sweep. If sweep length is not at least 10.2 centimeters, perform b below.

b. *Adjustments.* Adjust R2553 (fig. 5) for sweep length of 10.2 centimeters.

**26. Delaying Sweep**

a. *Performance Check*

(1) Turn oscilloscope (A5) SWEEP TIME switch to .1 MICROSECONDS/CM.

(2) Turn TI DELAYING SWEEP TIME/CM switch to 5 MICROSECONDS.

(3) Adjust time-mark generator (A3) for 5μS markers.

(4) Adjust TI HORIZONTAL POSITION

control to aline second marker behind second vertical graticule line. If oscilloscope crt does not display 1 marker per centimeter and 10th marker is not displayed within ±0.5 minor division of 10th graticule line, perform b below.

(5) Repeat (2) through (4) above for TI DELAYING SWEEP TIME/CM switch settings and time-mark generator outputs listed in table 7. If either 10th (1/cm) or 19th (2/cm) marker is not displayed within ±0.5 minor division of 10th graticule line at each setting, perform b below.

Table 9. Sweep Time

| Time-Mark Generator Settings (Marker) | Test Instrument                        |                                    |                |
|---------------------------------------|--|------------------------------------|----------------|
|                                       | DELAYING SWEEP TIME/CM Switch Settings | Number of Markers Displayed Per cm | Adjustments    |
| 5 μS                                  | 5 MICROSECONDS                         | 1                                  | C2536 (fig. 4) |
| 10 μS                                 | 10 MICROSECONDS                        | 1                                  | ---            |
| 1 μS                                  | 2 MICROSECONDS                         | 2                                  | ---            |
| 50 μS                                 | 50 MICROSECONDS                        | 1                                  | R2592 (fig. 5) |
| 0.1 mS                                | .1 MILLISECONDS                        | 1                                  | ---            |
| 10 μS                                 | 20 MICROSECONDS                        | 2                                  | ---            |
| 0.5 mS                                | .5 MILLISECONDS                        | 1                                  | R2591 (fig. 5) |
| 1 mS                                  | 1 MILLISECONDS                         | 1                                  | ---            |
| 0.1 mS                                | .2 MILLISECONDS                        | 2                                  | ---            |
| 5 mS                                  | 5 MILLISECONDS                         | 1                                  | R2590 (fig. 5) |
| 10 mS                                 | 10 MILLISECONDS                        | 1                                  | ---            |
| 1 mS                                  | 2 MILLISECONDS                         | 2                                  | ---            |
| 0.1 S                                 | .1 SECONDS                             | 1                                  | R2589 (fig. 5) |
| 50 mS                                 | 50 MILLISECONDS                        | 1                                  | ---            |
| 1- mS                                 | 20 MILLISECONDS                        | 2                                  | ---            |
| 0.1 S <sup>1</sup>                    | .2 SECONDS                             | 2                                  | ---            |
| 0.5 S <sup>1</sup>                    | .5 SECONDS                             | 1                                  | ---            |
| 1 S <sup>1</sup>                      | 1 SECONDS                              | 1                                  | ---            |

<sup>1</sup> Marker displayed will be within ±1.5 minor divisions.

b. *Adjustments.* Perform applicable adjustments as listed in table 9. Where one adjustment applies to more than one DELAYING SWEEP TIME/CM switch position, adjust for best in-tolerance condition.

**27. Delaying Sweep Linearity**

a. *Performance Check*

(1) Turn oscilloscope (AS5) SWEEP TIME switch to 10 MICROSECONDS/CM.

(2) Turn TI DELAYING SWEEP TIME/CM switch to 1 MILLISECONDS.

(3) Adjust time-mark generator (A3) for 1-mS markers.

(4) Adjust oscilloscope HORIZONTAL POSITION control until leading edge of second marker, as displayed on oscilloscope, coincides with second graticule.

(5) Adjust TI DELAY LENGTH CM control until intensified part of trace is under second marker.

(6) Turn SWEEP SELECTOR switch to MAIN SWEEP DELAYED.

(7) Adjust DELAY LENGTH CM control until leading edge of marker coincides with left edge of graticule. Record DELAY LENGTH CM control indication on prepared table, as shown in sample table 10.

(8) Repeat (7) above for marker displays listed in table 10 and record DELAY LENGTH CM control indication in respective column.

**NOTE**

**TI SWEEP SELECTOR switch may be turned to DELAYING SWEEP to determine which marker is being displayed Return SWEEP SELECTOR switch to MAIN SWEEP DELAYED before proceeding.**

*Table 10. 1-Ms Sweep Linearity (Sample Table)*

| Marker Number | DELAY LENGTH CM control Indication (sample) | Deviations in Minor Divisions |
|---------------|---|-------------------------------|
| 2             | 0.842                                       | -15.8                         |
| 3             | 1.850                                       | -15                           |
| 4             | 2.858                                       | -14.2                         |
| 5             | 3.86  | -14                           |
| 6             | 4.865                                       | -13.5                         |
| 7             | 5.868                                       | -13.2                         |
| 8             | 6.869                                       | -13.4                         |
| 9             | 7.865                                       | -13.5                         |
| 10            | 8.86  | -14                           |
| 11            | 9.85  | -15                           |

(9) In table prepared as per sample, record in "Deviations in Minor Divisions" column the deviation from Example:

Normal DELAY LENGTH CM control indication for third marker  
 Actual DELAY LENGTH CM control indication  
 Deviation from normal indication

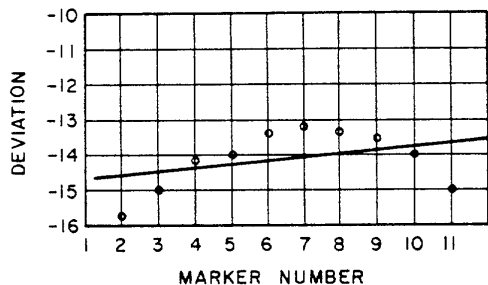
DELAY LENGTH CM control normal indication for each marker being checked.

=2.00 cm  
 =1.85 cm  
 =-15 cm = -15 minor divisions on dial

**NOTE**

**Normal indication will always be one less than marker number being checked.**

(10) Prepare graph as per sample shown in figure 6, using values recorded in (9) above.



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Figure 6. Sample deviation graph.

(11) Draw straight line through points on graph so that all points will be as close as possible to straight line. If any point deviated vertically from straight line by more than two minor divisions, perform b(1) through (12) below.

(12) Turn oscilloscope SWEEP TIME switch to .1 MICROSECONDS/CM.

(13) Turn TI DELAYING SWEEP TIME/CM switch to 5 MICROSECONDS and TI SWEEP SELECTOR switch to DELAYING SWEEP.

(14) Adjust time-mark generator for 5- $\mu$ S markers.

(15) Repeat (4) through (11) above. If any point deviates vertically from the line by more than five minor dial divisions, perform b(13) through (22) below.

**NOTE**

**Turn TI SWEEP SELECTOR switch as required to determine marker being displayed**

*b. Adjustments*

(1) Connect test oscilloscope (A4) vertical input between pin 8 of V2514A (fig. 4) and chassis ground, using test probe (B16).

(2) Turn oscilloscope SWEEP TIME switch to 1 MILLISECONDS/CM.

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

(a) DELAYING SWEEP TIME/CM switch to .2 MILLISECONDS.

(b) SWEEP MODE control to FREE RUN.

(c) DELAY LENGTH CM control to greater than 1.00 division.

(4) Adjust C2521 (fig. 4) until bottom of sawtooth waveform displayed on test oscilloscope is flat.

(5) Disconnect test oscilloscope from V2514A of TI.

(6) Turn TI SWEEP MODE control to PRESET.

(7) Repeat a(1) and (2) above.

(8) Adjust DELAY LENGTH CM control to 1.00 division.

(9) Adjust R2563 (fig. 5) until 2nd marker coincides with left graticule.

**NOTE**

**If necessary, turn TI SWEEP SELECTOR switch to DELAYING SWEEP to determine marker. Then, return SWEEP SELECTOR switch to MAIN SWEEP DELAYED to make adjustment.**

(10) Adjust DELAY LENGTH CM control to 10.00 divisions.

(11) Adjust R2567 (fig. 5) until 11th marker coincides with left edge of graticule.

(12) Repeat (8) through (11) above until no further adjustments are required.

(13) Turn TI DELAYING SWEEP TIME/CM switch to 50 MICROSECONDS.

(14) Adjust time-mark generator for 50- $\mu$ S markers.

(15) Adjust TI DELAY LENGTH CM control until leading edge of second marker occurs at start of trace. Note DELAY LENGTH CM control indication.

(16) Increase DELAY LENGTH CM control setting by 9.00 divisions above that noted in (15) above.

(17) Adjust R2592 (fig. 5) until leading edge of 11th marker occurs at start of trace.

(18) Turn TI DELAYING SWEEP TIME/CM switch to 5 MICROSECONDS.

(19) Adjust time-mark generator for 5  $\mu$ S markers.

(20) Repeat (15) and (16) above.

(21) Adjust C2536 (fig. 4) until leading edge of 11th marker occurs at start of trace.

(22) Repeat paragraph 26a above.

**28. Final Procedure**

*a.* Deenergize and disconnect all equipment and reinstall protective covers of 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 VI.**

**A-LEVEL CALIBRATION PROCESS FOR WIDEBAND HIGH-GAIN PREAMPLIFIER AM-3568/USM.**

**29. Equipment Setup**

*a.* Remove protective cover from oscilloscope

(A5) and install auxiliary plug-in (A8) in left-hand compartment of oscilloscope.



b. Install TI in right-hand compartment of oscilloscope.

c. Position TI controls as listed in (1) through (3) below:

(1) SENSITIVITY switch to .05 - .005 VOLTS/CM.

(2) Sensitivity VERNIER control to CALIBRATED.

(3) INPUT SELECTOR switch to AC.

d. Position oscilloscope controls as listed in (1) through (9) below:

(1) INTENSITY control fully counterclockwise.

(2) HORIZONTAL DISPLAY switch to X1.

(3) EXTERNAL VERNIER control to CAL.

(4) SWEEP TIME switch to 1 MILLISECONDS/CM.

(5) SWEEP TIME VERNIER control to CAL.

(6) TRIGGER LEVEL control to 0 (zero).

(7) TRIGGER SLOPE control to +(positive).

(8) TRIGGER SOURCE switch to INT.

(9) SWEEP MODE control to FREE RUN.

e. Set oscilloscope POWER switch to ON. Allow 15 minutes for warmup and stabilization.

f. Adjust oscilloscope INTENSITY, FOCUS, and ASTIGMATISM controls for optimum trace and SCALE LIGHT control for convenient viewing.

**Note**

**Adjust oscilloscope HORIZONTAL POSITION and TI VERTICAL controls as required throughout entire procedure.**

**30. Balance**

a. *Performance Check*

(1) Adjust TI VERTICAL POSITION control

until trace displayed on oscilloscope (A5) coincides with center graticule line.

(2) Turn TI sensitivity VERNIER control fully counterclockwise, then clockwise (CALIBRATED position). If trace shows a vertical shift, perform b(1) below.

(3) Turn TI INPUT SELECTOR switch to AC X10 GAIN.

(4) Repeat (2) above. If trace shows a vertical shift, perform b(2) below.

(5) Turn TI INPUT SELECTOR switch to AC.

b. *Adjustments*

(1) Adjust BAL. control (located on TI front panel) until trace shows no vertical shift.

(2) Adjust X10 BAL. control (located on TI front panel) until trace shows no vertical shift.

**31. Sensitivity**

a. *Performance Check*

(1) Connect ac calibrator (A1) to TI INPUT, using cable (B10).

(2) Turn Oscilloscope (A5) SWEEP MODE control to PRESET.

(3) Set SENSITIVITY switch to .05 - .005 VOLTS/CM.

(4) Adjust ac calibrator for vertical deflection of 4 centimeters. If ac calibrator does not indicate between 68.579 and 72.821 millivolts rms, perform b below.

(5) Repeat (4) above for TI SENSITIVITY switch settings listed in table 11. Ac calibrator will indicate within limits specified.

Table 11. Sensitivity

| Test Instrument<br>SENSITIVITY Switch<br>Settings (VOLTS/CM) | Ac Calibrator Indication (rms) |            |
|--|--------------------------------|------------|
|  | Min                            | Max        |
| .1 - .01   | 137.158 mv                     | 145.642 mv |
| .2 - .02   | 274.316 mv                     | 291.284 mv |
| .5   | 685.79 mv                      | 728.21 mv  |
| 1  | 1.37158 v                      | 1.45642 v  |
| 2  | 2.74316 v                      | 2.91284 v  |
| 5  | 6.858 v                        | 7.282 v    |
| 10   | 13.716 v                       | 14.564     |
| 20   | 27.432 v                       | 29.128 v   |

- b. *Adjustments*  
 (1) Adjust ac calibrator to 70.700 millivolts rms.  
 (2) Adjust GAIN control (located on TI front panel) for vertical deflection of 4 centimeters.

**32. Ac X10 GAIN Sensitivity**

- a. *Performance Check*  
 (1) Connect ac calibrator (A1) to TI INPUT, using cable (B10).  
 (2) Turn TI INPUT SELECTOR switch to AC

X10 GAIN and SENSITIVITY switch to .05 - .005 VOLTS/CM.

(3) Adjust ac calibrator for 4 centimeters vertical deflection on oscilloscope (A5) crt. If ac calibrator does not indicate between 6.8579 and 7.2821 millivolts rms, perform b below.

(4) Repeat (3) above for TI SENSITIVITY switch settings listed in table 12. Ac calibrator will indicate within limits specified.

Table 12. AC X10 GAIN Sensitivity

| Test Instrument<br>SENSITIVITY Switch<br>Settings (VOLTS/CM) | Ac Calibrator Indications (rms) |            |
|--|---------------------------------|------------|
|  | Min                             | Max        |
| .1 - .01   | 13.7158 mv                      | 14.5642 mv |
| .2 - .02   | 27.4316 mv                      | 29.1284 mv |
| .5   | 68.579 mv                       | 72.821 mv  |
| 1  | 137.158 mv                      | 145.642 mv |
| 2  | 274.316 mv                      | 291.284 mv |
| 5  | 685.79 mv                       | 728.21 mv  |
| 10   | 1.37158 v                       | 1.45642 v  |
| 20   | 2.74316 v                       | 2.91284 v  |

- b. *Adjustments*  
 (1) Adjust ac calibrator to 7.0700 millivolts rms.  
 (2) Adjust X10 GAIN control (located on TI front panel) for vertical deflection of 4 centimeters.

**33. Attenuator Frequency Compensation**

- a. *Performance Check*  
 (1) Set oscilloscope (A5) POWER switch to OFF.  
 (2) Remove TI from oscilloscope and reconnect, using extender cable (B11).  
 (3) Set oscilloscope POWER switch to ON and SWEEP TIME switch to .2 MILLISECONDS.

**NOTE**

**Wait 2 minutes before proceeding.**

- (4) Connect square-wave generator (A2) +OUTPUT to TI INPUT, using cable and 50-ohm termination supplied with square-wave generator.  
 (5) Turn TI INPUT SELECTOR switch to AC and SENSITIVITY switch to .1 - .01 VOLTS/CM.  
 (6) Adjust square-wave generator repetition

rate to 1kHz and amplitude for appropriate vertical deflection on oscilloscope. If leading edge of square waves displayed on oscilloscope does not have minimum overshoot or rounding, perform b(1) below.

(7) Repeat technique of (5) and (6) above for remaining SENSITIVITY switch positions listed in table 13. Use square-wave generator HI AMPLITUDE output as required. If square waves displayed are not as specified, perform applicable adjustments listed in table 13.

(8) Connect square-wave generator +OUTPUT to TI INPUT, using test probe (B16).

(9) Turn SENSITIVITY switch to .05 - .005 VOLTS/CM and INPUT SELECTOR switch to DC.

(10) Adjust square-wave generator rate to 1kHz and amplitude for appropriate vertical deflection on oscilloscope.

(11) Standardize probe.

(12) Turn SENSITIVITY switch to .1 - .01 VOLTS/CM. If square waves displayed on oscilloscope does not have flat tops, perform b(2) below.

(13) Repeat technique of (12) above for remaining TI SENSITIVITY switch positions listed in table 14. Use square-wave generator HI AMPLITUDE OUTPUT when required. If square waves displayed are not as specified, perform applicable adjustments listed in table 14.

(14) Set oscilloscope POWER switch to OFF.

(15) Disconnect extender cable from oscilloscope and reinstall TI in oscilloscope right-hand compartment.

(16) Set oscilloscope POWER switch to ON.

**NOTE**

**Wait 2 minutes before proceeding.**

*b. Adjustments*

(1) Adjust C1805 (fig. 7) for minimum overshoot or rounding of leading edge.

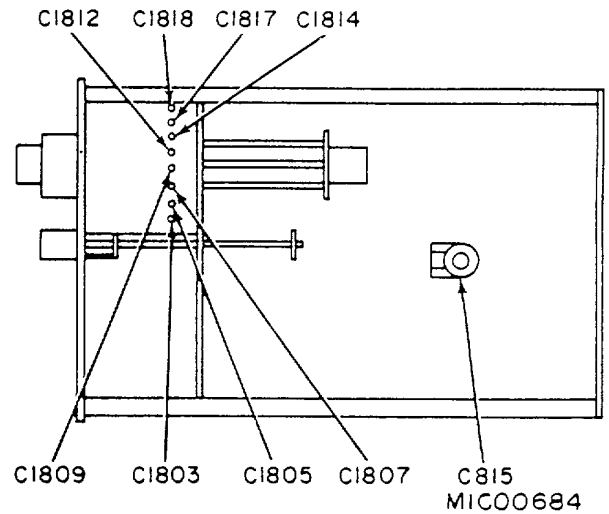


Figure 7. Wideband high-gain preamplifier - right-side view.

Table 13. Compensation Adjustment

| Test Instrument SENSITIVITY Switch Settings (VOLTS/CM) | Adjustments    |
|--|----------------|
| .2   | C1809 (fig. 7) |
| .5   | C1814 (fig. 7) |
| 1  | C1818 (fig. 7) |
| 2  | C1826 (fig. 8) |
| 5  | C1830 (fig. 8) |
| 10   | C1834 (fig. 8) |
| 20   | C1838 (fig. 8) |

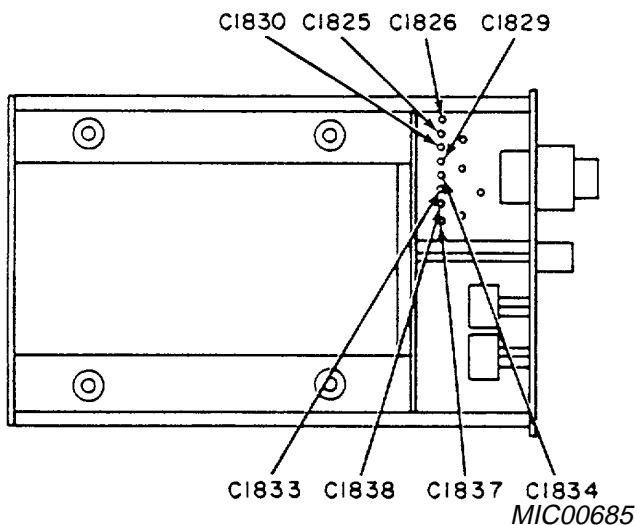


Figure 8. Wideband high-gain preamplifier - left-side view.

(2) Adjust C1803 (fig. 7) for flat tops

Table 14. Compensation Adjustment

| Test Instrument<br>SENSITIVITY Switch<br>Settings (VOLTS/CM) | Adjustments    |
|--|----------------|
| .2   | C1807 (fig. 7) |
| .5   | C1812 (fig. 7) |
| 1  | C1817 (fig. 7) |
| 2  | C1825 (fig. 8) |
| 5  | C1829 (fig. 8) |
| 10   | C1833 (fig. 8) |
| 20   | C1837 (fig. 8) |

**34. Rise Time***a. Performance Check*

(1) Replace auxiliary plug-in (A5) with horizontal plug-in (A7).

(2) Turn horizontal plug-in SWEEP SELECTOR switch to MAIN SWEEP.

(3) Connect square-wave generator (A2) +OUTPUT to TI INPUT, using cable and termination supplied with square-wave generator.

(4) Turn oscilloscope (A5) SWEEP TIME switch to .1 MICROSECONDS/CM and HORIZONTAL DISPLAY switch to X5.

(5) Turn TI SENSITIVITY switch to .05 - .005 VOLTS/CM and INPUT SELECTOR switch to AC.

(6) Adjust square-wave generator repetition rate to 1MHz and amplitude for 4 centimeters of vertical

deflection.

(7) Measure rise time, using standard rise-time technique. Rise time will be 12 nanoseconds or less.

(8) Turn TI INPUT SELECTOR switch to AC X10 GAIN.

(9) Repeat (6) and (7) above. Rise time will be 15 nanoseconds or less.

*b. Adjustments.* No adjustments can be made.

**35. Final Procedure**

*a.* Deenergize and disconnect all equipment and reinstall protective covers of oscilloscope.

*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 VII.**

**A-LEVEL CALIBRATION PROCESS FOR  
DUAL-TRACE PREAMPLIFIERS MX-2930A (B and C)  
USM AND MX-2721/USM-105**

**36. Equipment Setup**

*a.* Remove protective cover from oscilloscope (A5) and install auxiliary plug-in (A8) in left-hand compartment of oscilloscope.

*b.* Install TI in right-hand compartment of oscilloscope.

*c.* Position TI controls as listed in (1) through (5) below:

(1) Channel selector switch to CHANNEL A.

(2) Channel A and B POLARITY switches to + UP.

(3) Channel A and B SENSITIVITY switches to .02 VOLTS/CM.

(4) Channel A and B sensitivity VERNIER controls to CALIBRATED.

(5) Channel A and B AC-DC switches to AC.

*d.* Position oscilloscope controls as listed in (1) through (9) below:

(1) HORIZONTAL DISPLAY switch to X1.

(2) INTENSITY control fully counterclockwise.

(3) EXTERNAL VERNIER control to CAL.

(4) SWEEP TIME switch to 1 MILLISECONDS/CM.

(5) SWEEP TIME VERNIER control to CAL.

(6) TRIGGER LEVEL control to 0 (zero).

(7) TRIGGER SLOPE control to + (plus).

- (8) TRIGGER SOURCE switch to INT.
- (9) SWEEP MODE control to FREE RUN.
- e. Set oscilloscope POWER switch to ON. Allow 15 minutes for warmup and stabilization.
- f. Adjust oscilloscope INTENSITY, FOCUS, and ASTIGMATISM controls for optimum trace, and adjust SCALE LIGHT control for convenient viewing.

**37. Balance**

- a. *Performance Check*
  - (1) Adjust TI channel A VERTICAL POSITION control until trace displayed on oscilloscope (A5) coincides with center graticule line.
  - (2) Turn TI channel A POLARITY switch alternately to -Up and +UP. If trace shows a vertical shift, perform b below.
  - (3) Turn TI channel selector switch to CHANNEL B.
  - (4) Repeat (1) and (2) above, using TI channel B controls. If trace shows a vertical shift, perform b below.
- b. *Adjustments.* Adjust channel A (channel B)

BAL control (located on TI front panel) as necessary until trace does not shift vertically.

**38. Sensitivity**

- a. *Performance Check*
  - (1) Connect ac calibrator (A1) to TI channel B INPUT, using cable (B10).
  - (2) Turn oscilloscope (A5) SWEEP MODE control to PRESET.
  - (3) Adjust ac calibrator output for vertical deflection of 4 centimeters on oscilloscope crt. If ac calibrator does not indicate between 26.866 and 29.694 millivolts rms, perform b below.

**NOTE**

**Adjust TI channel B VERTICAL POSITION controls as necessary.**

- (4) Repeat (3) above for TI channel B (A) SENSITIVITY switch settings listed in table 15. Ac calibrator will indicate within limits specified.

Table 15. Sensitivity

| Test Instrument<br>SENSITIVITY Switch<br>Settings (VOLTS/CM) | Ac Calibrator<br>Indication (rms) |            |
|--|-----------------------------------|------------|
|  | Min                               | Max        |
| .05  | 67.165 mv                         | 74.235 mv  |
| .1   | 134.330 mv                        | 148.470 mv |
| .2   | 268.660 mv                        | 296.940 mv |
| .5   | 671.650 mv                        | 742.350 mv |
| 1  | 1.3433 v                          | 1.4847 v   |
| 2  | 2.6866 v                          | 2.9694v    |
| 5  | 6.716 v                           | 7.424 v    |
| 10   | 13.433 v                          | 14.847 v   |
| 20   | 26.766 v                          | 29.694 v   |

- (5) Connect ac calibrator to TI channel A INPUT.
- (6) Turn TI channel selector switch to CHANNEL A.
- (7) Repeat (3) and (4) above.
- b. *Adjustments*
  - (1) Adjust ac calibrator to 28.28 millivolts rms.
  - (2) Adjust channel B (A) SENS. CAL control (TI front panel) for 4 centimeters of vertical deflection.

**39. Attenuator Frequency Compensation**

- a. *Performance Check*
  - (1) Connect square-wave generator (A2) +OUTPUT to TI channel A INPUT, using cable and termination supplied with square-wave generator.
  - (2) Turn oscilloscope (A5) SWEEP TIME switch to .1 MILLISECONDS/CM.
  - (3) Turn TI channel A SENSITIVITY switch to .05 VOLTS/CM.

(4) Adjust square-wave generator repetition rate to 5 kHz and amplitude for two convenient vertical deflections. If tops of square waves displayed on oscilloscope crt are not flat with minimum overshoot or rounding, perform b(1) below.

(5) Repeat (3) and (4) above for TI channel A SENSITIVITY switch positions listed in table 16. Use square-wave generator HI AMPLITUDE OUTPUT when

required. If square waves are not as specified, perform adjustments listed in table 16.

(6) Turn TI channel selector switch to CHANNEL B.

(7) Connect square-wave generator +OUTPUT to TI channel B INPUT, using cable and termination supplied with square-wave generator.

*Table 16. Compensation Adjustment*

| Test Instrument<br>SENSITIVITY<br>Switch Settings<br>(VOLTS/CM) | Adjustments (fig. 9) |           |
|---|----------------------|-----------|
|   | Channel A            | Channel B |
| .1  | C1551                | C1508     |
| .2  | C1555                | C1512     |
| .5  | C1559                | C1516     |
| 1   | C1563                | C1520     |
| 2   | C1569                | C1526     |
| 5   | C1573                | C1530     |
| 10  | C1577                | C1534     |
| 20  | C1581                | C1538     |

(8) Repeat (3) through (5) above, using channel B controls.

(9) Connect square-wave generator +OUTPUT to TI channel A INPUT, using test probe (B16).

(10) Turn TI channel selector switch to CHANNEL A and channel A SENSITIVITY switch to .02 VOLTS/CM.

(11) Adjust square-wave generator repetition rate to 5 kHz and amplitude for appropriate vertical deflection on oscilloscope.

(12) Standardize probe.

(13) Turn channel A SENSITIVITY switch to .05 VOLTS/CM. Square waves displayed on oscilloscope will have flat tops. If not, perform b(2) below.

(14) Repeat technique of (11) and (13) above for remaining channel A SENSITIVITY switch positions listed in table 17.

Use square-wave generator HI AMPLITUDE OUTPUT when required. If square waves are not as specified, perform the adjustments listed in table 17.

(15) Disconnect probe from channel A INPUT and connect to channel B INPUT.

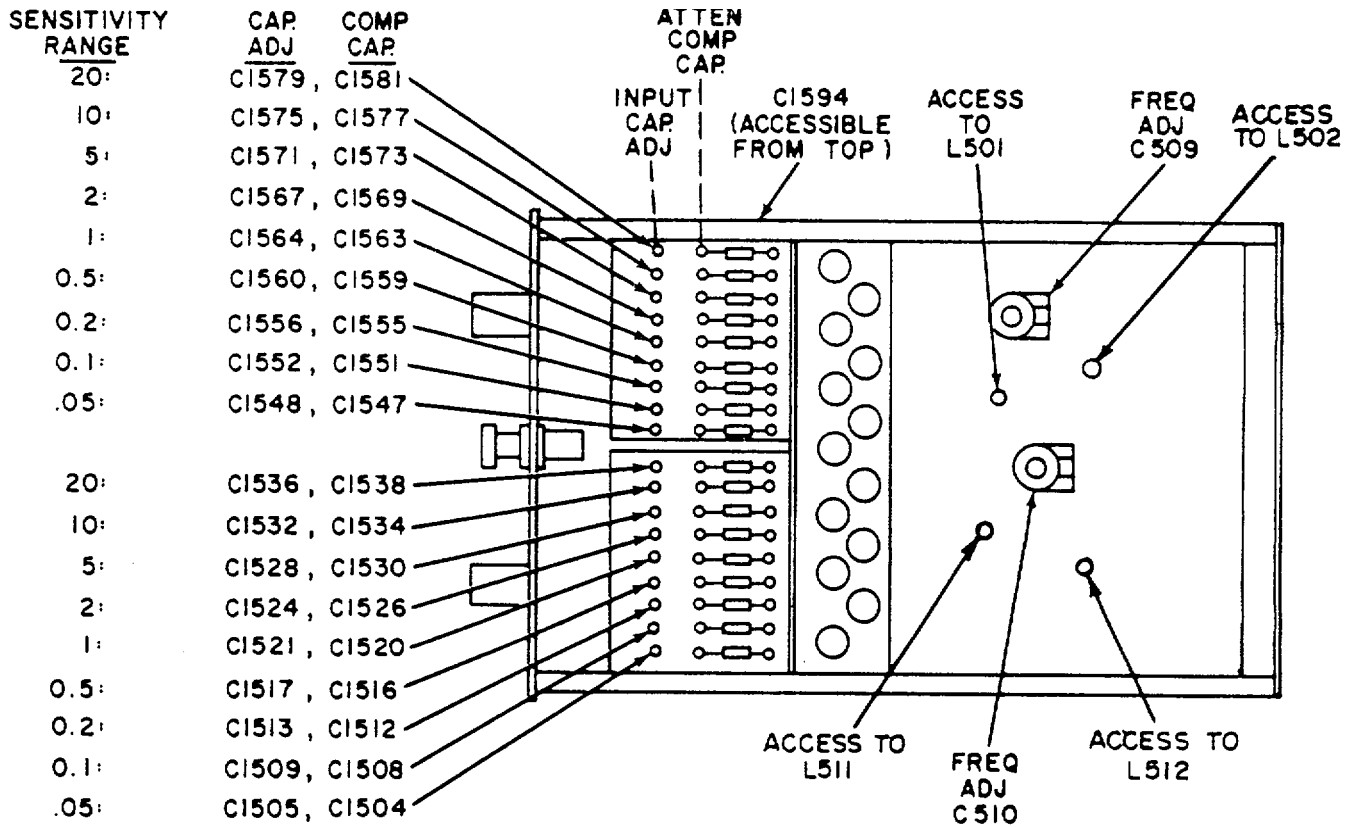
(16) Turn TI channel selector switch to CHANNEL B and channel B SENSITIVITY switch to .02 VOLTS/CM.

(17) Repeat (11) above. If square waves displayed on oscilloscope do not have flat tops, perform b(3) below.

(18) Turn channel B SENSITIVITY switch to remaining positions listed in table 17. For each position, if square waves displayed on oscilloscope do not have flat tops, perform the adjustments listed in table 17.

**b. Adjustments**

(1) Adjust C1547 (fig. 9) for channel A (C1504 (fig. 9) for channel B) to obtain an optimum square wave display.



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Figure 9. Dual-trace preamplifier - right-side view.

(2) Adjust C1548 (fig. 9) for channel A (C1505 (fig. 9) for channel B) for optimum square-wave display.

(3) Adjust C1594 (fig. 9) for optimum square-wave display.

Table 17. Input Capacitance Adjustment

| Test Instrument<br>SENSITIVITY<br>Switch Settings<br>(VOLTS/CM) | Adjustments (fig. 9) |           |
|---|----------------------|-----------|
|   | Channel A            | Channel B |
| .05   | ---                  | C1505     |
| .1  | C1552                | C1509     |
| .2  | C1556                | C1513     |
| .5  | C1560                | C1517     |
| 1   | C1564                | C1521     |
| 2   | C1567                | C1524     |
| 5   | C1571                | C1528     |
| 10  | C1575                | C1532     |
| 20  | C1579                | C1536     |

**40. Rise Time**

*a. Performance Check*

(1) Replace auxiliary plug-in (A8) with horizontal plug-in (A7).

(2) Turn horizontal plug-in SWEEP SELECTOR switch to MAIN SWEEP.

(3) Connect square-wave generator (A2) +OUTPUT to TI channel B INPUT connector, using cable and termination supplied with square-wave generator.

(4) Turn oscilloscope (A5) SWEEP TIME switch to .1 MICROSECONDS/CM and HORIZONTAL DISPLAY switch to X5.

(5) Turn TI channel B SENSITIVITY switch to .02 VOLTS/CM.

(6) Adjust square-wave generator repetition rate to 1 MHz and amplitude for 4 centimeters of vertical deflection.

(7) Measure rise time, using standard rise-time technique. Rise time will be 16 nanoseconds or less.

(8) Turn TI channel selector switch to CHANNEL A and channel A SENSITIVITY switch to .02 VOLTS/CM.

(9) Repeat (3), (6), and (7) above for channel A.

*b. Adjustments.* No adjustments can be made.

**41. Electronic Switching Symmetry**

*a. Performance*

*Check*

(1) Position oscilloscope (A5) controls as listed in (a) through (c) below:

(a) SWEEP TIME switch to .2 MICROSECONDS/CM.

(b) HORIZONTAL DISPLAY switch to X1.

(c) SWEEP MODE control to FREE RUN.

(2) Turn TI channel selector to ALTERNATE and adjust channel A and B VERTICAL POSITION controls until oscilloscope displays two traces spaced 4 centimeters apart.

(3) Turn oscilloscope SWEEP MODE control to PRESET.

(4) Turn TI channel selector switch to CHOPPED. Adjust oscilloscope TRIGGER LEVEL control if required. If oscilloscope does not display two symmetrical square waves, perform b below.

*b. Adjustments.* Adjust FREQ. ADJ. C509 and C510 (fig. 9) until square waves displayed on oscilloscope are symmetrical.

**42. Final Procedure**

*a.* Deenergize and disconnect all equipment and reinstall protective covers of oscilloscope.

*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 VIII.**

**C-LEVEL EQUIPMENT REQUIREMENTS**

**43. Equipment Required**

*a.* Minimum use specifications are the principal parameters required for performance of the calibration, and are included to assist in the selection of alternate equipment. Satisfactory performance of alternate items must be verified prior to use. All applicable equipment must bear evidence of current calibration.

*b.* The instruments used in this procedure were selected from those known to be available in AN/TSM-55(V)2 and TOE 29-134. The listing by make or model number carries no implication of preference, recommendation, or approval by the Department of

Defense for use by other agencies. It is recognized that equivalent equipment produced by other manufacturers may be capable of equally satisfactory performance in the procedure.

*c.* Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 18 and 19. For the identification of equipment referenced by item numbers prefixed with A, see table 18, and for prefix B, see table 19.

*Table 18. Minimum Specifications of Equipment Required*

| Item | Common Name            | Minimum Use Specifications | Manufacturer and Model Number   |
|------|------------------------|----------------------------|---|
| A1   | AUTOTRANSFORMER<br>+3% | 105 to 125 vac,            | Variable Power Transformer TF-510/U<br>(General Radio, Model W10MT3A) |



Table 18. Minimum Specifications of Equipment Required - Continued

| Item | Common Name           | Minimum Use Specifications                       | Manufacturer and Model Number  |
|------|-----------------------|--|--|
| A2   | AUXILIARY PLUG-IN     | Intensity modulation                             | Auxiliary Plug-In MX-3078A/USM (Hewlett-Packard, Model 166F) (must be supplied).   |
| A3   | METER CALIBRATOR      | 0.36 to 36 vac, 400 Hz $\pm$ 0.5%                | Meter Calibrator TS-2734/U (John Fluke, Model 760A).   |
| A4   | OSCILLOSCOPE          | Indicator, power supplies, sweeps and triggering | Oscilloscope OS-121B/USM-140 (Hewlett-Packard, Model 170B) with 10X Probe (must be supplied).  |
| A5   | SIGNAL GENERATOR      | 50 kHz to 22 MHz<br>4 volts p-p $\pm$ 3%         | Signal Generator AN/USM-Z72 (Tektronix, Type 191) with Electrical Dummy Load DA464/U (Tektronix, Type 017-0083-00) and RF Cable Assembly CG-3364/U (Tektronix, Type 017-050500). |
| A6   | SQUARE-WAVE GENERATOR | Square wave, 5 kHz to 1 MHz, 10 nsec rise time   | Signal Generator AN/USM-256 (Fairchild, Model 791A) with Electrical Dummy Load DA454/U.  |
| A7   | RATIO TRANSFORMER     | Ratio: .0776 to .824:1400 Hz $\pm$ 0.5%          | Decade Ratio Transformer TF-515/U (Gertsch, Model RT-60).  |

Table 19. Accessories Required

| Item | Common Name      | Description and Model Number  |
|------|------------------|---|
| B1   | ADAPTER 1        | BNC jack to double banana plug, Connector Adapter UG-1887/U (Pomona Electronics, Model 1269).           |
| B2   | ADAPTER          | Binding posts to BNC plug, Connector Adapter UG-1888/U (Pomona Electronics, Model 1296).                |
| B3   | CABLE ASSEMBLY 2 | 36-in., RG48C/U; BNC plug to BNC plug; (Pomona Electronics, Model BNC-C-36).                            |
| B4   | PLUG-IN EXTENDER | Extension cable; Electronic Special Purpose Cable Assembly CX-11894/U (Hewlett-Packard, Model 10400-B). |

1 Three required  
2 Two required

**SECTION IX.**  
**C-LEVEL CALIBRATION PROCESS FOR DUAL-TRACE**  
**PREAMPLIFIER MX-2903B/USM (HEWLETT-PACKARD,**  
**MODEL 162C)**

**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 calibration.**

**44. Preliminary Instructions**

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

**WARNING**

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

45. Equipment Setup a. Install auxiliary plug-in (A2) into horizontal input compartment of oscilloscope (A4).

b. Install TI into vertical input compartment of oscilloscope, using plug-in extender (B4).

c. Adjust autotransformer (A1) output voltage control to minimum.

d. Connect oscilloscope power cord to autotransformer.

e. Energize equipment, adjust autotransformer output voltage control for a meter indication of 156 volts ac, and allow sufficient time for equipment to warm up and stabilize.

f. Position oscilloscope controls as follows:

- (1) SWEEP TIME VERNIER control to CAL.
- (2) HORIZONTAL DISPLAY switch to X1.
- (3) TRIGGER SOURCE switch to INT.
- (4) SWEEP MODE control to FREE RUN.
- (5) TRIGGER SLOPE switch to + (positive).
- (6) TRIGGER LEVEL control to - (negative).
- (7) HORIZONTAL DISPLAY EXTERNAL

VERNIER control to CAL.

g. Set auxiliary plug-in INTENSITY MODULATION switch to NORMAL and SWEEP OCCURRENCE switch to NORMAL.

h. Position TI controls as follows:

- (1) Function selector switch to CHANNEL A.
- (2) CHANNEL A and B controls:

(a) POLARITY switches to - UP.

(b) SENSITIVITY (VOLTS/CM) switches to .02.

(c) VERNIER controls to CALIBRATED.

(d) AC/DC switches to DC.

(e) VERTICAL POSITION controls to midrange.

**46. Dc Balance**

a. *Performance Check*

(1) Adjust TI CHANNEL A VERTICAL POSITION control for oscilloscope to display trace on center graticule line.

(2) Set TI CHANNEL A POLARITY switch to + UP. Oscilloscope will display trace with no vertical shift as TI CHANNEL A POLARITY switch is set from + UP to - UP.

(3) Set TI function selector switch to CHANNEL B.

(4) Adjust TI CHANNEL B VERTICAL POSITION control for oscilloscope to display trace on center graticule line.

(5) Set TI CHANNEL B POLARITY switch to + UP. Oscilloscope will display trace with no vertical shift as TI CHANNEL B POLARITY switch is set from + UP to - UP.

b. *Adjustments*

(1) Set TI function selector switch to CHANNEL A.

(2) Repeat a(1) and (2) above.

(3) Adjust CHANNEL A BAL (front panel) for oscilloscope display of trace with no vertical shift as TI CHANNEL A POLARITY switch is set from - UP to + UP.

(4) Repeat a(4) and (5) above.

(5) Adjust CHANNEL B BAL (front panel) for oscilloscope display of trace with no vertical shift as TI CHANNEL B POLARITY switch is set from - UP to + UP.

**47. Gain and Sensitivity**

a. *Performance Check*

(1) Set TI function selector switch to CHANNEL A.

(2) Set oscilloscope (A4) SWEEP TIME switch to 1 MILLISECOND/CM.

(3) Connect equipment as shown in figure 10, connection A.

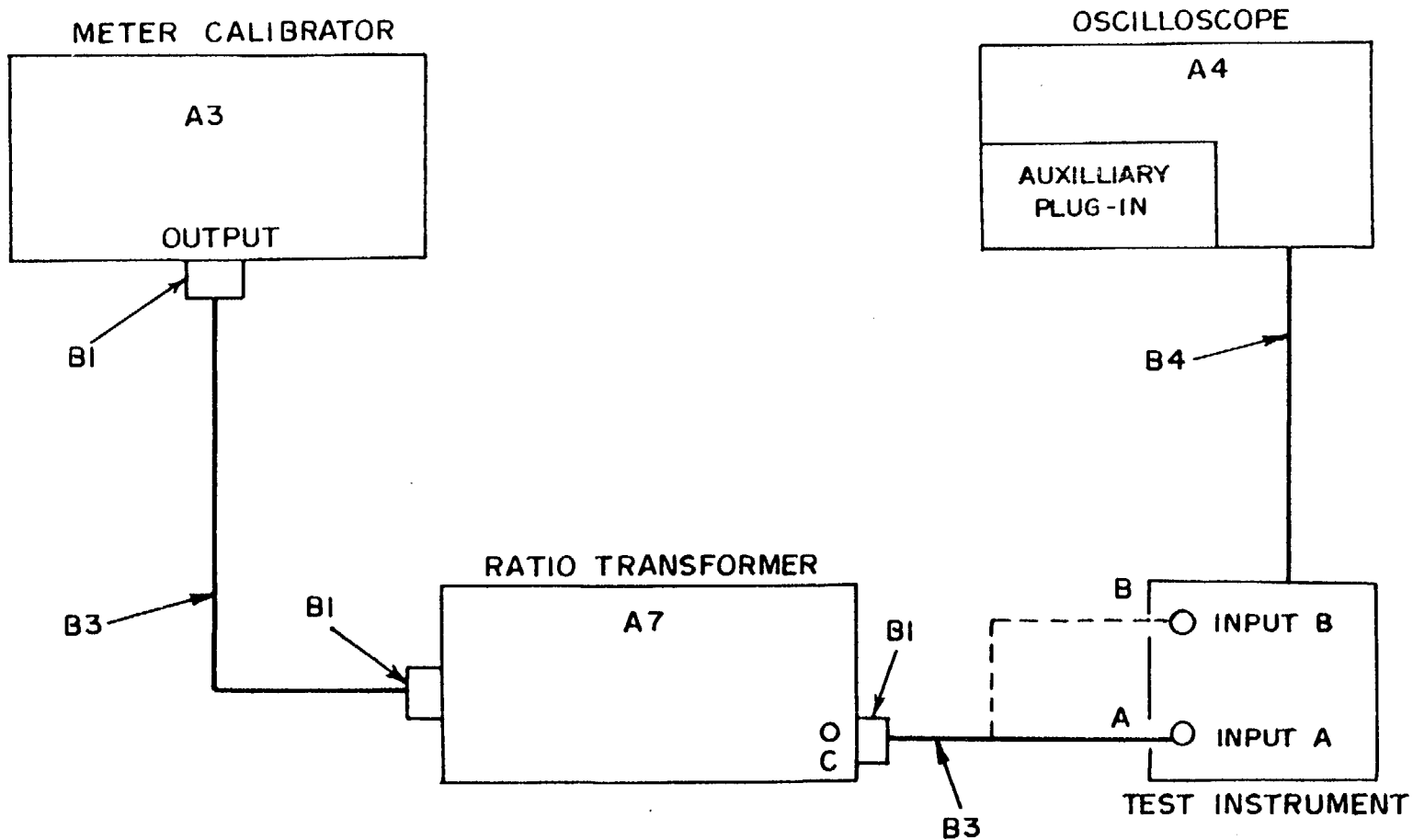


Figure 10. Gain and sensitivity - equipment setup.

(4) Set TI CHANNEL A SENSITIVITY (VOLTS/CM) switch to settings listed in table 20 and perform the following:

(a) Set meter calibrator (A3) decade dials to settings listed.

(b) Adjust meter calibrator output controls for 400 Hz and null indication on output meter.

(c) Adjust ratio transformer (A7) decade dials for oscilloscope display of 4 centimeters peak-to-peak. Ratio transformer will indicate within limits specified.

(d) Adjust meter calibrator output controls to zero.

(5) Set TI function selector switch to CHANNEL B.

(6) Connect equipment as shown in figure 10, TB 9-6625-798-35 connection

(7) Set TI CHANNEL B SENSITIVITY (VOLTS/CM) switch to settings listed in table 20 and perform the following:

(a) Set meter calibrator decade dials to settings listed.

(b) Adjust meter calibrator output controls for 400 Hz and null indication on output meter.

(c) Adjust ratio transformer decade dials for oscilloscope display of 4 centimeters peak-to-peak. Ratio transformer will indicate within limits specified.

(d) Adjust meter calibrator output controls to zero.

(8) Disconnect equipment.

Table 20. Gain and Sensitivity

| Test Instrument<br>SENSITIVITY (VOLTS/CM)<br>Switch Setting | Meter Calibrator<br>Decade Dials<br>Setting | Ratio Transformer<br>Decade Dials<br>Setting |        |
|---|---|--|--------|
|   |   | Min  | Max    |
| .02   | 000.3535                                    | .07760                                       | .08240 |
| .05   | 000.3535                                    | .19400                                       | .20600 |
| .1  | 000.3535                                    | .38800                                       | .41200 |
| .2  | 000.3535                                    | .77600                                       | .82400 |
| .5  | 003.5350                                    | .19400                                       | .20600 |
| 1   | 003.5350                                    | .38800                                       | .41200 |
| 2   | 003.5350                                    | .77600                                       | .82400 |
| 5   | 035.3500                                    | .19400                                       | .20600 |
| 10  | 035.3500                                    | .38800                                       | .41200 |
| 20  | 035.3500                                    | .77600                                       | .82400 |

*b. Adjustments*

(1) Position TI controls as follows:

(a) Function selector switch to CHANNEL A.

(b) CHANNEL A SENSITIVITY (VOLTS/CM) switch to .02.

(2) Connect equipment as shown in figure 10, connection A.

(3) Set meter calibrator decade dials to 000.3535.

(4) Set ratio transformer decade dials to .08000.

(5) Adjust meter calibrator output controls for

400 Hz and null indication on output meter.

(6) Adjust oscilloscope controls for a stable display.

(7) Adjust CHANNEL A SENS. CAL (front panel) for oscilloscope display of 4 centimeters peak-to-peak.

(8) Position TI controls as follows:

(a) Function selector switch to CHANNEL B.

(b) CHANNEL B SENSITIVITY (VOLTS/CM) switch to .02.

(9) Connect equipment as shown in figure 10 connection B.

- (10) Repeat (3) through (6) above.
- (11) Adjust CHANNEL B SENS. CAL (front panel) for an oscilloscope display of 4 centimeters peak-to-peak.

(12) Repeat performance check

**48. Attenuator Compensation**

*a. Performance Check*

- (1) Connect square-wave generator (A6) to TI CHANNEL B INPUT connector with cable assembly (B3) and electrical dummy load (p/o A6).

- (2) Set oscilloscope SWEEP TIME switch to .2 MILLISECONDS/CM and HORIZONTAL DISPLAY switch to X1.

- (3) Set TI SENSITIVITY (VOLTS/CM) switch to settings listed in table 21. At each setting, set square-wave generator SOURCE IMPEDANCE switch to position listed and adjust OUTPUT AMPLITUDE control for oscilloscope display amplitude listed. Oscilloscope displays square wave with optimum flat top.

Table 21. Attenuator Compensation

| Test Instrument SENSITIVITY (VOLTS/CM) Switch Settings | Square-Wave Generator SOURCE IMPEDANCE Switch Settings | Oscilloscope Display Amplitude (cm) |
|--|--|-------------------------------------|
| .02  | INTERNAL 50 Ω TERMINATION                              | 4                                   |
| .05  | INTERNAL 50 Ω TERMINATION                              | 4                                   |
| .1   | INTERNAL 50Ω TERMINATION                               | 4                                   |
| .2   | INTERNAL 50Ω TERMINATION                               | 4                                   |
| .5   | NORMAL <sup>1</sup>                                    | 4                                   |
| 1  | NORMAL <sup>1</sup>                                    | 4                                   |
| 2  | NORMAL <sup>1</sup>                                    | 4                                   |
| 5  | NORMAL <sup>1</sup>                                    | 4                                   |
| 10   | NORMAL <sup>1</sup>                                    | 3                                   |
| 20   | NORMAL <sup>1</sup>                                    | 1                                   |

<sup>1</sup> Remove electrical dummy load (p/o A6) from between TI INPUT connector and cable assembly (B3) and connect cable assembly TI INPUT connector.

- (4) Disconnect cable assembly (B3) and electrical dummy load (p/o A6) from TI CHANNEL B INPUT connector and connect to CHANNEL A INPUT connector.

- (5) Set TI function switch to CHANNEL A and repeat (3) above.

*b. Adjustments*

- (1) Repeat a(1) and (2) above.
- (2) Set TI function switch to CHANNEL B.

- (3) Set TI SENSITIVITY (VOLTS/CM) switch to settings listed in table 22. Set square-wave generator SOURCE IMPEDANCE switch to settings listed in table 22 and adjust OUTPUT AMPLITUDE control for oscilloscope display of 4 centimeters peak-to-peak and 5 kHz. Adjust TI adjustments listed for oscilloscope display of square waves with optimum flat top and square corner.

Table 22. Attenuator Compensation Adjustments

| Test Instrument                        |                                |                                |  |
|--|--------------------------------|--------------------------------|--|
| SENSITIVITY (VOLTS/CM) Switch Settings | CHANNEL A Adjustments (fig. 9) | CHANNEL B Adjustments (fig. 9) | Square-Wave Generator SOURCE IMPEDANCE Switch Settings |
| .02                                    | NONE                           | NONE                           | INTERNAL 50Ω TERMINATION                               |
| .05                                    | C1547                          | C1504                          | INTERNAL 50Ω TERMINATION                               |
| .1                                     | C1551                          | C1508                          | INTERNAL 50Ω TERMINATION                               |
| .2                                     | C1555                          | C1512                          | INTERNAL 50Ω TERMINATION                               |
| .5                                     | C1559                          | C1516                          | NORMAL <sup>1</sup>                                    |
| 1                                      | C1563                          | C1520                          | NORMAL <sup>1</sup>                                    |
| 2                                      | C1569                          | C1526                          | NORMAL <sup>1</sup>                                    |
| 5                                      | C1573                          | C1530                          | NORMAL <sup>1</sup>                                    |
| 10                                     | C1577                          | C1534                          | NORMAL <sup>1</sup>                                    |
| 20                                     | C1581                          | C1538                          | NORMAL <sup>1</sup>                                    |

<sup>1</sup> Remove electrical dummy load (p/o A6) from between cable assembly (B3) and TI INPUT connector and connect cable assembly to TI INPUT connector.

(4) Disconnect cable assembly (B3) and electrical dummy load (p/o A6) from TI CHANNEL B INPUT connector and connect to CHANNEL A INPUT connector. Repeat (3) above.

(5) Repeat performance check.

**49. Input Compensation**

*a. Performance Check*

(1) Disconnect cable assembly (B3) and electrical dummy load (p/o A6).

(2) Connect 10X probe (p/o A4) to TI CHANNEL A INPUT connector. Connect probe tip to square-wave generator (A6) output connector, using adapter (B2).

(3) Set TI function switch to CHANNEL A.

(4) Set TI SENSITIVITY (VOLTS/CM) switch to settings listed in table 23. At each setting, adjust square-wave generator controls for 5 kHz and oscilloscope display of 2 centimeters peak-to-peak. Oscilloscope will display square waves with optimum square corner.

Table 23. Input Compensation

| Test Instrument                        |                                |                                |
|--|--------------------------------|--------------------------------|
| SENSITIVITY (VOLTS/CM) Switch Settings | CHANNEL A Adjustments (fig. 9) | CHANNEL B Adjustments (fig. 9) |
| .02                                    | Compensate 10X Probe           | Compensate 10X Probe           |
| .05                                    | C1548                          | C1505                          |

Table 23. Input Compensation - Continued

| SENSITIVITY<br>(VOLTS/CM)<br>Switch Settings | Test Instrument                      |                                      |
|--|--------------------------------------|--------------------------------------|
|  | CHANNEL A<br>Adjustments<br>(fig. 9) | CHANNEL B<br>Adjustments<br>(fig. 9) |
| .1   | C1552                                | C1509                                |
| .2   | C1556                                | C1513                                |
| .5   | C1560                                | C1517                                |
| 1  | C1564                                | C1521                                |
| 2  | C1567                                | C1524                                |
| 5  | C1571                                | C1528                                |
| 10   | C1575                                | C1532                                |
| 20   | C1579                                | C1536                                |

- (5) Set TI function switch to CHANNEL B.
- (6) Disconnect 10X probe from TI CHANNEL A INPUT connector and connect CHANNEL B INPUT connector. Repeat (4) above.
- (7) Disconnect equipment.
- b. Adjustments*
- (1) Repeat a(2) and (3) above.
- (2) Set TI function switch to CHANNEL A.
- (3) Set TI SENSITIVITY (VOLTS/CM) switch to settings listed in table 23. At each setting, adjust square-wave generator for 5 kHz and oscilloscope display of 2 centimeters peak-to-peak. Adjust TI adjustment (fig. 9) listed for oscilloscope display of square wave with optimum square corner.
- (4) Disconnect 10X probe from TI CHANNEL A INPUT connector and connect to CHANNEL B INPUT connector.
- (5) Set TI function selector switch to CHANNEL B and repeat (3) above.
- (6) Disconnect equipment.

**50. High-Frequency Response**

- a. Performance Check* (1) Connect square-wave generator (A6) to TI CHANNEL A INPUT connector, using cable assembly (B3).
- (2) Set square-wave generator SOURCE IMPEDANCE switch to INTERNAL 50Ω TERMINATION and adjust frequency to 1 .MHz.
- (3) Position TI controls as follows: (a) Function selector switch to CHANNEL A.
- (b) CHANNEL A and B SENSITIVITY (VOLTS/CM) switches to .02 VOLTS/CM.

- (4) Set oscilloscope SWEEP TIME switch to .5 MICROSECONDS/CM.
- (5) Adjust square-wave generator controls for oscilloscope display of 4 centimeters peak-to-peak vertical deflection.
- (6) Adjust oscilloscope TRIGGER LEVEL and TRIGGER SLOPE controls for a stable oscilloscope display. Oscilloscope will display square waves with optimum flat top and square corners.
- (7) Disconnect cable assembly (B3) from TI CHANNEL A INPUT connector and connect to CHANNEL B INPUT connector.
- (8) Set TI function selector switch to CHANNEL B and repeat (5) and (6) above.
- (9) Disconnect equipment.
- b. Adjustments*
- (1) Repeat a(1) through (6) above.
- (2) Adjust L501 and L502 (fig. 9) for oscilloscope display of square waves with optimum flat top and square corner.
- (3) Repeat a(8) above.
- (4) Adjust L511 and L512 (fig. 9) for oscilloscope display of square waves with optimum flat top and square corner.
- (5) Repeat performance check.

**51. Multivibrator Switching**

- a. Performance Check*
- (1) Set auxiliary plug-in (A2) INTENSITY MODULATION switch to EXTERNAL.
- (2) Set oscilloscope SWEEP MODE switch to

FREE RUN and SWEEP TIME switch to .1 MICROSECONDS/CM.

(3) Set TI function selector switch to ALTERNATE.

(4) Adjust TI CHANNEL A and B VERTICAL POSITION controls for oscilloscope display of two traces 4 centimeters apart.

(5) Set TI function selector switch to CHOPPED and SWEEP MODE switch to PRESET. Oscilloscope will display symmetrical square wave, 10 centimeters in length.

*b. Adjustments.* Adjust TI C509 and C510 (fig. 9) for oscilloscope displays of symmetrical square wave, 10 centimeters in length.

**52. Bandwidth**

*a. Performance Check*

(1) Connect signal generator (A5) to TI CHANNEL A INPUT connector with cable assembly (p/o A5) and electrical dummy load (p/o A5).

(2) Set TI function selector switch to

CHANNEL TB 9-6625-798-35 A and CHANNEL A SENSITIVITY (VOLTS/CM) switch to 1.

(3) Set oscilloscope (A4) SWEEP TIME switch to .5 MILLISECONDS/CM.

(4) Adjust signal generator controls for 50 kHz and oscilloscope display of 4 centimeters peak-to-peak.

(5) Increase signal generator frequency controls for oscilloscope display of 2.8 centimeters peak-to-peak. Signal generator will indicate 22 MHz or greater.

*b. Adjustments.* No adjustments can be made.

**53. Final Procedure.**

*a.* Deenergize and disconnect all equipment.

*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).



By Order of the Secretary of the Army:

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