

***TB 9-4931-700-50**

CHANGE 6

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR AC VOLTAGE STANDARD, HEWLETT-PACKARD MODEL 745A AND HIGH VOLTAGE AMPLIFIER, HEWLETT-PACKARD MODEL 746A INCLUDING OPTIONS C90, C91, AND C93

Headquarters, Department of the Army, Washington, DC
11 September 2001

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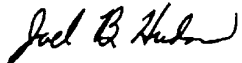
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JOEL B. HUDSON
*Administrative Assistant to the
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Change 5

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CALIBRATION PROCEDURE FOR AC VOLTAGE STANDARD, HEWLETT-PACKARD MODEL 745A AND HIGH VOLTAGE AMPLIFIER, HEWLETT-PACKARD MODEL 746A INCLUDING OPTIONS C90, C91, AND C93

Headquarters, Department of the Army, Washington, DC
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DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

**CALIBRATION PROCEDURE FOR
AC VOLTAGE STANDARD,
HEWLETT-PACKARD MODEL 745A
AND HIGH VOLTAGE AMPLIFIER,
HEWLETT-PACKARD MODEL 746A
INCLUDING OPTIONS C90, C91, AND C93**

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DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR AC VOLTAGE STANDARD, HEWLETT-PACKARD MODEL 745A AND HIGH VOLTAGE AMPLIFIER, HEWLETT-PACKARD MODEL 746A INCLUDING OPTIONS C90, C91, AND C93

Headquarters, Department of the Army, Washington, DC
9 December 1977

REPORTING OF ERRORS

You can help improve this publication. If you find any mistakes or if you know of a way to improve the procedure, please let us know. Mail your letter or DA Form 2028 to: Commander, U. S. Army Aviation and Missile Command, ATTN: AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5230. A reply will be furnished to you. You may also send in your comments electronically to our e-mail address: lp@redstone.army.mil or FAX 256-842-6546/DSN 788-6546.

SECTION		Paragraph	Page
I.	IDENTIFICATION AND DESCRIPTION		
	Test instrument identification.....	1	2
	Calibration data card, DA Form 2416.....	2	2
	Calibration description.....	3	2
II.	EQUIPMENT REQUIREMENTS		
	Equipment required.....	4	3
	Accessories required.....	5	3
III.	PRELIMINARY OPERATIONS		
	Preliminary instructions.....	6	6
	Equipment Setup.....	7	7
IV.	CALIBRATION PROCESS		
	Frequency accuracy.....	8	7
	Error measurement.....	9	12
	Voltage accuracy, regulation, and frequency response (Model 745A).....	10	14

*This bulletin supersedes TB 9-4931-700-60, 6 October 1976.

	Paragraph	Page
Voltage accuracy, regulation, and frequency response (Model 746A).....	11	20
Distortion	12	26
Power supply (Model 745A).....	13	28
Power supply (Model 746A).....	14	30
Final procedure.....	15	31

**SECTION I
IDENTIFICATION AND DESCRIPTION**

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Ac Voltage Standard, Hewlett-Packard Model 745A and High Voltage Amplifier, Hewlett-Packard Model 746A including Options C90, C91, and C93. The manufacturer's instruction manuals were used as the prime data source in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. There are no variations among models which affect the calibration of the TI. The C90 option adds slides to the instrument. The C91 option adds a blower to the instrument. The C93 option adds slides and a blower to the instrument.

b. Time and Technique. The time required for this calibration is approximately 8 hours, using the dc (direct current) and low frequency technique.

2. Calibration Data Card, DA Form 2416

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

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

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

Table 1. Calibration Description

Test instrument parameters	Performance specifications
Output frequency range	Continuously adjustable from 10 Hz to 110 kHz in 4 decade ranges with 10% overlap
Frequency accuracy	±2% of setting
Error measurement range	±0.3% and ±0.3% with zero center dial
Error measurement accuracy	±0.51% of FS
Distortion and noise	(0.05% of setting + 10 μ V)

See footnote at end of table.

Table 1. Calibration Description - Continued.

Test Instrument Parameters		Performance Specifications	
Line regulation		±0.001% of setting change in output voltage for a 10% change in line voltage (included in accuracy specifications)	
Voltage stability		1 mV to 100 V: short term; ±0.002% of setting for 24 hrs. 1000 V: short term; ±0.005% of setting for 24 hrs	
	1 -mV 10-mV, and 100-mV ranges	50 Hz to 20 kHz 20 to 50 Hz and 20 to 110 kHz 10 to 20 Hz	±(0.04% of setting +0.002% of range + 10µ V) ¹ ±(0.07% of setting +0.005% of range +50µ V) ±(0.22% of setting +0.005% of range +50µ V)
Output voltage	1-V, 10-V, and 100-V ranges	50 Hz to 20 kHz 20 to 50 Hz and 20 to 110 kHz 10 to 20 Hz	±(0.032% of setting +0.002% of range +10µ V) ±(0.062% of setting +0.005% of range +50µ V) ±(0.212% of setting +0.005% of range +50µ V)
	1000-V range	50 Hz to 20 kHz 20 to 50 Hz and 20 to 50 kHz 10 to 20 Hz 50 to 110 kHz	±0.04% of setting ±0.08% of setting ±(0.2% of setting +0.005% of range) ±0.15% of setting

¹Combined accuracy and load regulation.

**SECTION II
EQUIPMENT REQUIREMENTS**

4. Equipment Required. Table 2 identifies the specific equipment used in this calibration procedure. This equipment is issued with Secondary Reference Standards Calibration Set NSN 4931-00-621-7878 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 ratio between the standard and TI

5. Accessories Required. The accessories listed in table 3 are issued as indicated in paragraph 4 above and are to be used in this calibration procedure. When necessary, these items may be substituted by equivalent items unless specifically prohibited.

TB 9-4931-700-50

Table 2. Minimum Specifications of Equipment Required

Item	Common Name	Minimum Use Specifications	Manufacturer and Model (Part Number)
A1	AC/DC VOLTMETER (DIFFERENTIAL VOLTMETER)	Range: 0.002 to 1850 V dc Accuracy: ¹ Capability: Use as null detector	John Fluke, Models 887ABAN (887 ABAN) and 80E10 (80E10)
A2	AUTOTRANSFORMER (VARIABLE POWER TRANSFORMER)	Range: 105 to 125 V ac Accuracy: ±1%	General Radio, Model W10MT3AS3 (7910809)
A3	DECADE RESISTOR	Range: 22 to 3010 ohms	Biddle Gray, Model 601147-1 (7910328)
A4	DISTORTION ANALYZER (SPECTRUM ANALYZER)	Range: 10 Hz to 100 kHz Accuracy: Measure less than .06% (Must have amplifier capability)	Hewlett-Packard, Model 334A (7911957)
A5	FREQUENCY COUNTER (ELECTRONIC DIGITAL COUNTER)	Range: 9.8 Hz to 119 kHz Accuracy: ±0.5%	Systron-Donner, Model 1037M (7910823) w/Timer Interval Unit, Model 1926A (7910824)
A6	LOAD (CALIBRATOR LOAD)	Range: 2200 ohms Accuracy: ±5%	MIRCOM, Model SKA-4850-101
A7	OSCILLOSCOPE	Sensitivity: 0.01 to 20 V/cm Sweeptime: 2 ms to 10 ms/cm	Tektronix, Model RM561A (7910655-2) w/3A6 plug-in (7911441-1) and 3B4 (7912040-1)
A8	RATION TRANSFORMER (AC RATIO STANDARD)	Capability: Divide to 7 places Accuracy: ±0.0085%	Gertsch, Model 1000 (7907060-1)
A9	THERMAL TRANSFER STANDARD	Range: 1 to 100 V dc 1 to 100 V ac Accuracy: ¹	Ballantine Laboratories, Model 1600A (MIS-10554-2)
A10	VARIABLE CAPACITOR (VARIABLE CAPACITANCE STANDARD)	Range: 100 and 200 pF	General Radio, Model 1422D (8579475)

¹Combined accuracy of A1 and A9: ±0.0087%.

Table 3. Accessories Required

Item	Common Name (Official Nomenclature)	Description (Part Number)
B1	ADAPTER (POWER ADAPTER)	2 to 2-wire isolation plug (7912356)
B2	ADAPTER (ELECTRICAL PLUG CONNECTOR)	Double banana plug to BNC jack terminations (7907592)
B3	ADAPTER (CONNECTOR ADAPTER)	Double banana jack to phone plug adapter (7907566)
B4	ADAPTER (TIP JACK ASSEMBLY)	GR plug to binding posts 874Q2 (874Q2)
B5	CABLE (RF CABLE ASSEMBLY)	30-in., RG-58()/U with BNC plug terminations (7907467)
B6	CABLE (RF CABLE ASSEMBLY)	36-in., RG-58()/U with BNC plug to alligator clips (7909410)

B7	CABLE ¹ (RF CABLE ASSEMBLY)	30-in., RG-58()/U with double banana plug terminations (7907470)
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Table 3. Accessories Required - Continued.

Item	Common Name (Official Nomenclature)	Description (Part Number)
B8	CABLE (TEST LEAD)	36-in., RG-58()/U with BNC plug and double banana plug terminations (7907471)
B9	HOOK-UP WIRE (ELECTRICAL POWER CABLE)	Shielded pair No. 18 AWG, solid copper (MIS-10312)
B10	ISOLATION BOX (ADAPTER BOX)	Double banana jack terminals (SKD4850-3)
B11	PROBE	Tektronix, Type 010-0128-00 (010-0128-00)

¹Three required.

SECTION III PRELIMINARY OPERATIONS

6. Preliminary Instructions

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

NOTE

Unless otherwise specified, verify the results of each test and, whenever the test requirement is not met, take corrective action before continuing with the calibration. Adjustments required to calibrate the TI are included in this procedure. Additional maintenance information is contained in the manufacturer's manual, TM 9-4931-700-14/1, and TM 9-4931-700-14-2 for this TI.

NOTE

Unless otherwise specified, all controls and control settings refer to the TI.

7. Equipment Setup

- a.** Connect TI to autotransformer (A2).
- b.** Connect autotransformer to 115-volt ac (alternating current) and adjust its output control to obtain a 115-volt output.
- c.** Set LINE switches to ON and allow 1 hour for equipment to warm-up and stabilize.

**SECTION III
CALIBRATION PROCESS**

NOTE

When indications specified in paragraphs 8, 9, 10, or 12 are not within tolerance, perform the power supply check in paragraph 13 prior to making adjustments. After adjustments are made, repeat paragraphs 8, 9, 10, and 12. If indications specified in paragraph 11 are not within tolerance, the power supply check in paragraph 14 prior to making adjustments. Do not perform power supply checks if all other parameters are within tolerance.

8. Frequency Accuracy

a. Performance Check

- (1) Connect TI front panel output to input of frequency counter (A5), using cable (B8).
- (2) Position TI controls as listed in (a) through (d) below:
 - (a) Press FREQUENCY RANGE X10 pushbutton.
 - (b) Adjust FREQUENCY control to obtain FREQ scale indication of 1.
 - (c) Press VOLTAGE RANGE 1V pushbutton.
 - (d) Set voltage controls to obtain indication of 1.000000 V.
- (3) If frequency counter does not indicate between 98.0392 and 102.041 ins (milliseconds), perform **b** below.
- (4) Repeat technique of (2) and (3) above, using settings and indications listed in table 4

Table 4. Frequency Accuracy

Test Instrument		Frequency Counter Indications	
Frequency Settings	FREQUENCY RANGE Switch Setting	Minimum	Maximum
2	X10	49.0196 ms	51.0204 ms
3		32.6797 ms	34.0136 ms
5		19.6078 ms	20.4082 ms
7		14.0056 ms	14.5773 ms
10		9.8039 ms	10.2041 ms
1	X100	9.80392 ms	10.2041 ms
2		4.90196 ms	5.10204 ms
3		3.26797 ms	3.40136 ms
5		1.96078 ms	2.04082 ms
7		1.40056 ms	1.45773 ms
10		980 Hz	1020 Hz
1	X1K	980 Hz	1020 Hz
2		1960 Hz	2040 Hz
3		2940 Hz	3060 Hz
5		4900 Hz	5100 Hz
7		6860 Hz	7140 Hz
10		9.8 kHz	10.2 kHz
1	X10K	9.8 kHz	10.2 kHz
2		19.6 kHz	20.4 kHz
3		29.4 kHz	30.6 kHz
5		49.0 kHz	51.0 kHz
7		68.6 kHz	71.4 kHz
10		98.0 kHz	102.0 kHz

b. Adjustments

(1) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control for FREQ scale indication of 1.0.

(2) Adjust A12C2 (fig. 1) to obtain indication of 10.000 kHz (kilohertz) on frequency counter (R).

(3) Adjust FREQUENCY control slowly clockwise while observing frequency counter indication. If frequency increases, proceed to **b(6)** below. If frequency decreases, proceed to **b(4)** below.

(4) Repeat (1) above.

(5) While observing frequency counter indication, adjust A12C2 (fig. 1) to obtain a second 10 kHz output frequency (R). If a second 10 kHz cannot be obtained by adjusting A12C2, readjust A12C2 to obtain original 10 kHz frequency. While observing frequency counter indication, adjust A12L1 (fig. 1) in direction that causes output to decrease and pass through 0 (zero) Hz (hertz) and increase to 10 kHz. Adjust A12L1 to obtain indication of 10.000 kHz on frequency counter (R).

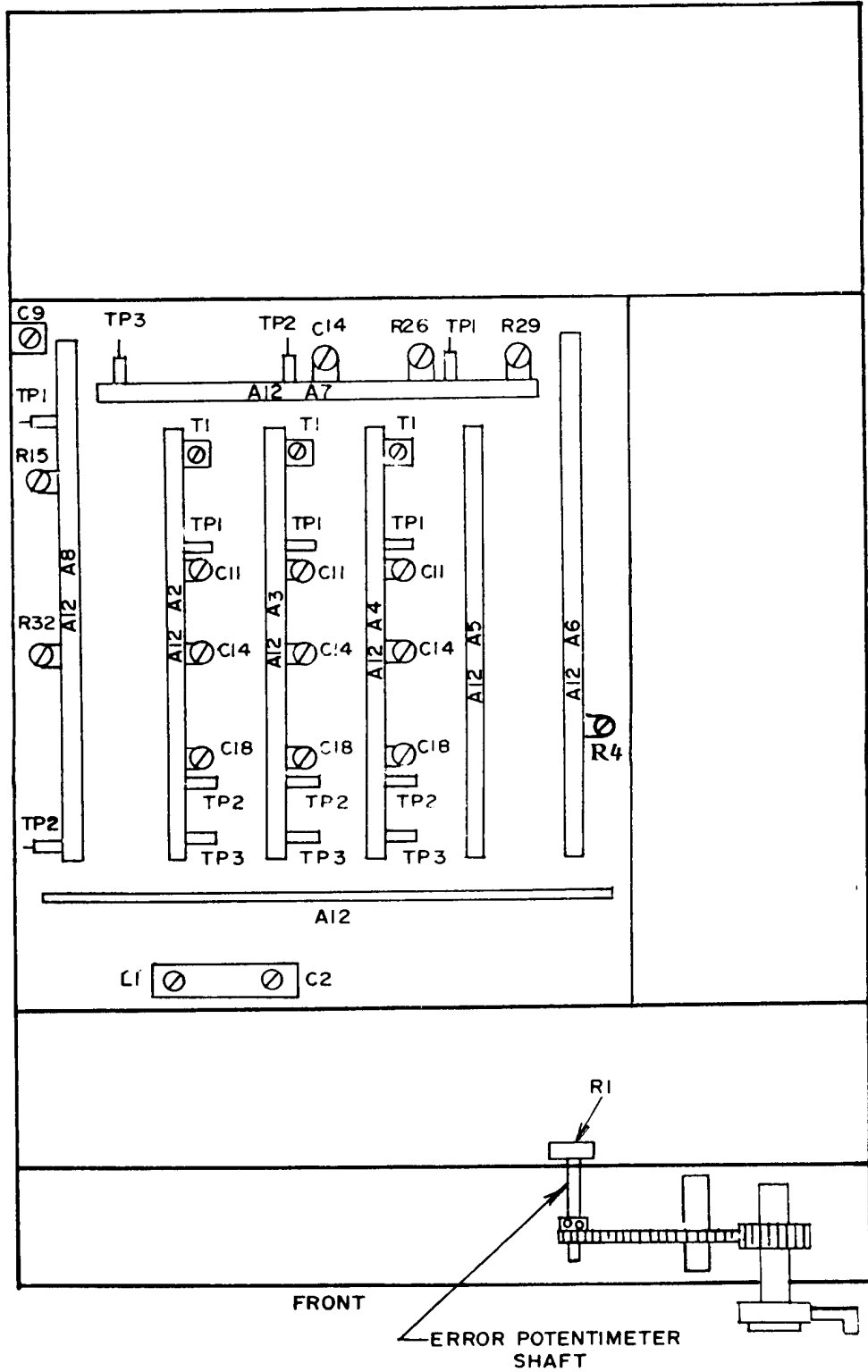


Figure 1. Model 745A bottom view - adjustment location.

TB 9-4931-700-50

(6) Adjust FREQUENCY control to obtain FREQ scale indication of 10.0. Record frequency counter indication.

(7) Refer to table 5 frequency counter indication column and locate frequency nearest to one recorded in (6) above. Record corresponding frequency in the adjoining column.

Table 5. FREQUENCY Scale Tracking

Frequency Counter Indication (kHz)	Set A1211 (fig. 1) to Obtain (kHz)
80	150
81	147
82	144
83	142
84	139
85	137
86	134
87	131
88	129
89	126
90	124
91	121
92	119
93	117
94	114
95	112
96	109
97	107
98	104.6
99	102.3
100	100
101	97.69
102	95.41
103	93.2
104	90.9
105	88.7
106	86.4
107	84.1
108	82.1
109	79.9
110	77.8
111	75.6
112	73.5
113	71.4
114	69.3
115	67.2
116	65.1
117	63.1
118	61.0
119	59.0

(8) Adjust A12L1 (fig. 1) to obtain frequency recorded in (7) above.

(9) Adjust FREQUENCY control counterclockwise to obtain FREQ scale indication of 10 kHz while observing frequency counter to insure that indication does not pass through 0 (zero) Hz. If output frequency passes through 0 (zero) Hz, repeat (2) through (8) above.

(10) Adjust FREQUENCY control to obtain scale indication of 1.0. Adjust A12C2 to obtain indication of 10.00 kHz on frequency counter.

(11) Repeat (6) through (10) above until frequency counter indications are within tolerance at frequency settings of 10 and 100 kHz.

(12) Repeat **a**(2) through (4) above and if lower frequency ranges (X10) through X1K) are still out of tolerance, perform **(a)** through **(t)** below.

(a) Extend circuit board A12A2 (fig. 1), using extender board furnished with TI.

(b) Connect oscilloscope (A7) to A12A2TP1 (fig. 1), using probe (B11).

(c) Adjust A12A2T1 (fig. 1) to obtain maximum amplitude of ac signal displayed on oscilloscope (R).

(d) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 1.0.

(e) Connect oscilloscope to A12A2TP2 (fig. 1), using probe.

(f) Adjust A12A2C11 and A12A2C18 (fig. 1) to obtain maximum amplitude of ac signal displayed on oscilloscope (R).

(g) Adjust FREQUENCY control to obtain FREQ scale indication of 11.0.

(h) Adjust A12A2C14 (fig. 1) to obtain maximum signal amplitude (R).

(i) Adjust FREQUENCY FREQ scale indication of 1.0.

(j) Adjust A12A2C11 (fig. 1) to obtain maximum signal amplitude.

(k) Adjust FREQUENCY FREQ scale indications of from 1.0 to 11.0. Signal amplitude will be approximately same at both ends. Adjust A12A2C18 (fig. 1) to obtain same amplitude at both ends.

(l) Signal at A12A2TP2 will be 0.7 volt p-p or greater at frequencies from 10 to 110 kHz.

(m) Replace circuit board A12A2 in the TI and extend circuit board A12A3 (fig. 1), using extender board.

(n) Connect oscilloscope to A12A3TP1 (fig. 1), using probe.

(o) Adjust A12A3T1 (fig. 1) to obtain maximum signal amplitude as indicated on oscilloscope (R).

(p) Adjust FREQUENCY control to obtain FREQ scale indication of 5.5.

(q) Connect oscilloscope to A12A3TP2 (fig. 1), using probe.

(r) Adjust A12A3C11 A12A3C14, and AJ2A3C18 (fig. 1) to obtain maximum signal amplitude indication on oscilloscope (R).

(s) Replace circuit board A12A3 in TI and extend circuit board A12A4 fig. 1 using extender board.

TB 9-4931-700-50

(t) Repeat technique of (n) through (r) above for A12A4. Replace A12A4 in TI.

(13) Repeat **a**(1) through (4) above.

9. Error Measurement

a. Performance Check

(1) Insert adapter (B1) between TI and autotransformer (A2) and connect OUTPUT and SENSE terminals to ratio transformer (A8), using hook-up wire (B9). Monitor output of ratio transformer, using ac/dc voltmeter (A1) and hook-up wire.

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

- (a) Press VOLTAGE RANGE 1V pushbutton.
- (b) Set voltage controls to obtain indication of 1.000000 v
- (c) Adjust FREQUENCY control to obtain FREQ scale indication of 1.
- (d) Press FREQUENCY RANGE X1K pushbutton.
- (e) Press ERROR RANGE 0 pushbutton.
- (f) Press SENSE REMOTE pushbutton.

(3) Set ratio transformer dials to 1.000000 and record ac/dc voltmeter indication.

(4) Press ERROR RANGE X1 pushbutton and adjust ERROR MEASUREMENT control to obtain an indication of 0 (zero) on % ERROR scale. If ac/dc voltmeter does not indicate within ± 0.00017 V of value recorded in (3) above, perform **b** below.

(5) Repeat technique of (3) and (4) above, using setting and indications listed in table 6.

Table 6. Error Measurement

Test Instrument		Ration Transformer Setting	Ac/dc Voltmeter Indication (V)
ERROR RANGE Setting	% ERROR Scale Setting		
X1	-3	.970874	Value of 9a(3) above ± 0.00017
X1	-2	.980392	Value of 9a(3) above ± 0.00017
X1	-1	.990099	Value of 9a(3) above ± 0.00017
X1	0 ¹	1.000000	Value of 9a(3) above ± 0.00017
X1	+3	1.030929	Value of 9a(3) above ± 0.00017
X1	+2	1.020408	Value of 9a(3) above ± 0.00017
X1	+1	1.010101	Value of 9a(3) above ± 0.00017
X.1	0 ¹	1.000000	Value of 9a(3) above ± 0.000035
X.1	-3	.997009	Value of 9a(3) above ± 0.000035
X.1	+3	1.003009	Value of 9a(3) above ± 0.000035

¹Establish a new 1-volt reference as in 9a(3) above.

b. Adjustments

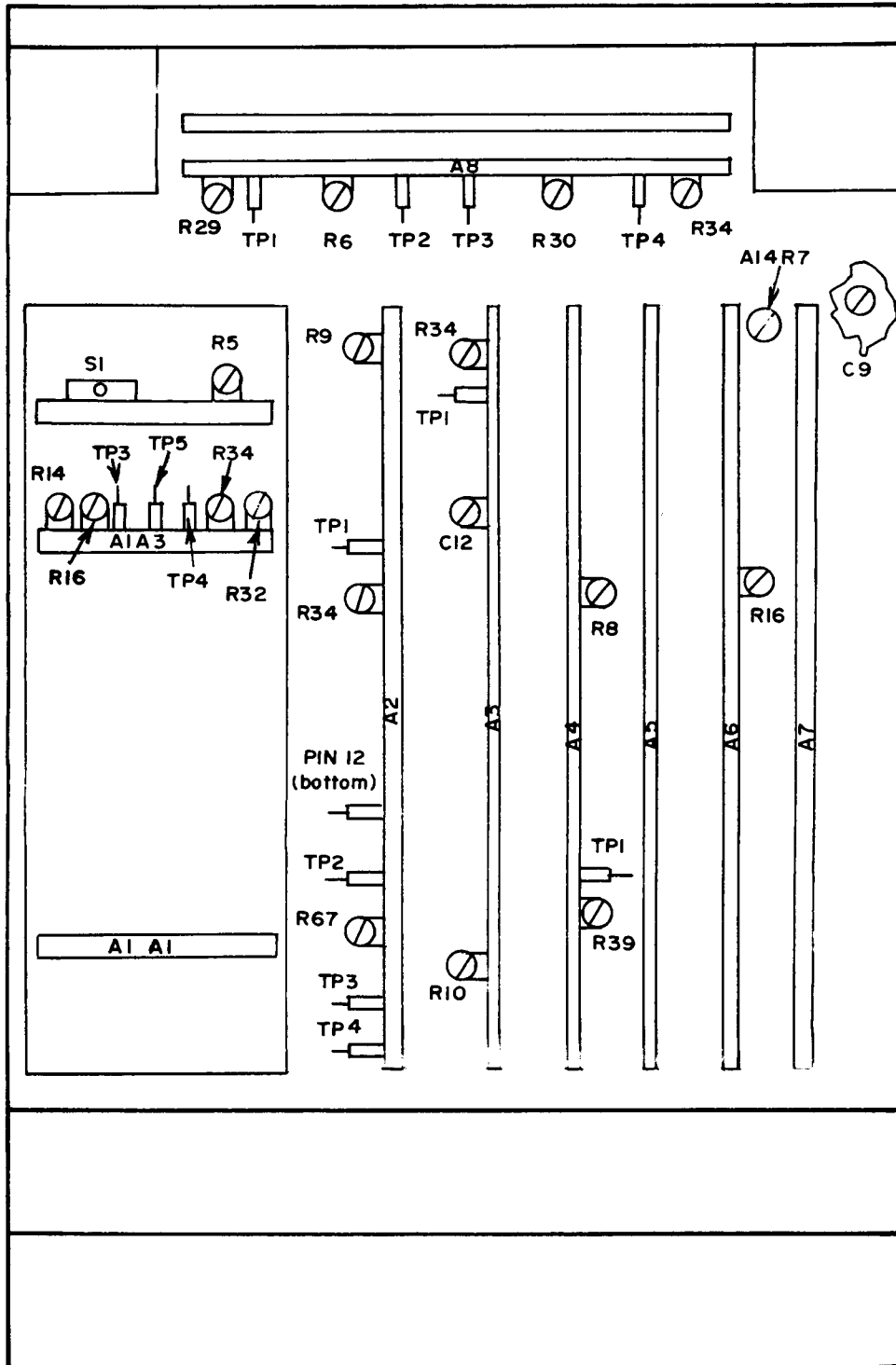
(1) Set A1A4S1 (fig. 2) to +9.9 V position.

NOTE

Overload lamp illuminates.

TB 9-4931-700-50

- (2) Connect ac/dc voltmeter to A1A3TP5 (fig. 2), using cable (B6) and adapter (B2).
- (3) Press ERROR RANGE 0 pushbutton and adjust ERROR MEASUREMENT control to obtain indication of 0 (zero) on % ERROR scale. Record ac/dc voltmeter indication.
- (4) Press ERROR RANGE X1 pushbutton. Loosen two setscrews that fasten the drive sprocket to shaft of error potentiometer (fig. 1).
- (5) Using a pair of long-nose pliers, rotate shaft of error potentiometer until ac/dc voltmeter indicates exact value recorded in (3) above.
- (6) While holding shaft of the error potentiometer in place, adjust ERROR MEASUREMENT control to obtain exact 0 (zero) on % ERROR scale and tighten two setscrews.
- (7) Repeat adjustments as necessary to obtain optimum operation.
- (8) Set A1A4S1 (fig. 2) to center position.



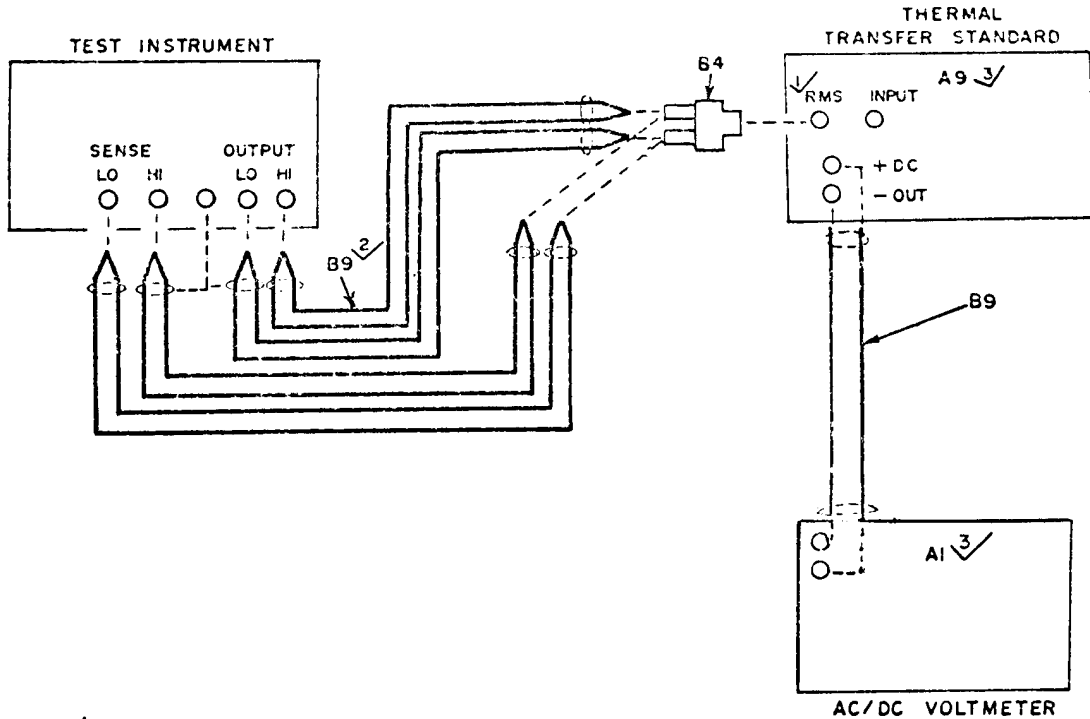
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Figure 2. Model 745A top view - adjustment location.

10. Voltage Accuracy, Regulation, and Frequency Response (Model 745A)

a. Performance Check

(1) Connect equipment as shown in figure 3. Remove isolation (B1) from between TI and autotransformer.



- ✓ 1 CONNECT AS APPROPRIATE FOR INPUT LEVEL.
- ✓ 2 USE BOTH CONDUCTORS OF A PAIR FOR EACH CONNECTION, GROUND SHIELDS AT TEST INSTRUMENT ONLY.
- ✓ 3 ISOLATE.

Figure 3. Output voltage - equipment setup.

- (2) Position TI controls as listed in (a) through (f) below:
- (a) Press VOLTAGE RANGE 1V pushbutton..
 - (b) Set voltage controls to obtain an indication of 1.000000 V.
 - (c) Press FREQUENCY RANGE X1K pushbutton.
 - (d) Adjust FREQUENCY control to obtain FREQ scale indication of 1.0.
 - (e) Press ERROR RANGE 0 pushbutton.
 - (f) Press SENSE REMOTE pushbutton.

NOTE

Each time measurement of TI output is directed, a minimum of four readings should be taken. The first reading should be disregarded and the other three readings averaged. The average reading is the indication to be recorded for future use. The ac/dc voltmeter (A1) indication should be read between 15 and 20 seconds after thermal transfer standard (A9) transfers to the dc output.

(3) Measure TI output, using thermal transfer standard in auto mode. Record ac/dc Voltmeter indication.

(4) Compute and record difference between the indication recorded in (3) above and TI voltage controls setting. If indication in (3) is large a + (plus) sign is assigned to difference. If it is smaller, a - (minus) sign is assigned to difference. Convert difference to percentage retaining assigned sign.

(5) Refer to test report for thermal transfer standard to obtain percentage of ac/dc difference for 1 V at appropriate frequency.

(6) Add algebraically two percentages obtained in (4) and (5) above. The result is percentage of TI output error. If TI output error is ± 0.035 percent or more, perform **b(1)** through (3) below.

(7) Repeat technique of (1) through (6) above with autotransformer (A2) set at 105 and 125 V ac. If error does not remain within ± 0.035 percent and adjustments were not performed in (6) above, perform **b(1)** through (3) below and repeat (2) through (6) above. Return autotransformer setting to 115 V ac.

(8) With decade resistor (A3) set to 22 ohms, connect at input to thermal transfer standard, using cable (B7).

(9) Repeat technique of (1) through (6) above. The TI output will remain within specified limits.

(10) Perform technique of (1) through (6), (8), and (9) above, using settings and indications listed in table 7.

(11) Disconnect decade resistor.

(12) Set TI frequency to 1 kHz and voltage range to 1 V.

(13) With thermal transfer standard in manual balance mode and dc output state, adjust its manual balance controls to obtain an ac/dc voltmeter indication of 1.000000 V dc.

TB 9-4931-700-50

Table 7. Frequency Response

Test Instrument			Decade resistor Setting (Ohms) (Step a(8))	Adjustments
Frequency	Voltage Output (V)	Acceptable Error (Percent) (Step a(6))		
10 Hz	1	±0.22%	22	If an out-of-tolerance condition is indicated for any frequency on the 1 V range, perform 10b(1) through (3) below and repeat all checks on 1 V range.
100 Hz	1	±0.035%	22	
10 kHz	1	±0.035%	22	
20 kHz	1	±0.035%	22	
50 kHz	1	±0.072%	22	
100 kHz	1	±0.072%	22	
10 Hz	10 ¹	±0.22%	221	If an out-of-tolerance condition is indicated for any frequency on the 10 V range, perform 10b(1), (2), and (4) below and repeat all checks on 10 V range.
100 Hz	10	±0.034%	221	
1 kHz	10	±0.034%	221	
10 kHz	10	±0.034%	221	
20 kHz	10	±0.034%	221	
50 kHz	10	±0.068%	221	
100 kHz	10	±0.068%	221	If an out-of-tolerance condition is indicated for 10 Hz, or 1 kHz on the 100 V range, perform 10b(2), (5), and (6) below and repeat all previous checks on 100 V range.
10 Hz	100 ¹	±0.22%	2200 ²	
100 Hz	100	±0.034%	2200	
1 kHz	100	±0.034%	2200	
10 kHz	100	±0.034%	2200	
20 kHz	100	±0.034%	2200	
50 kHz	100	±0.067%	2200	If an out-of-tolerance condition is indicated for 10, 20, 50, or 100 kHz on the 100 V range, perform 10b(2), (5), and (7) below, and repeat all checks on 100 V range.
100 kHz	100	±0.067%	2200	

¹Repeat technique of (7) above.

²Replace decade resistor (A3) with load (A6) for remaining checks.

(14) Set thermal transfer standard to ac balancing state. Adjust TI voltage controls to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed.. Record TI voltage control indication.

(15) Repeat (13) and (14) above twice. Average the three voltage control indications. If average indication is 1.0 or more, subtract 1.0 from it and assign a - (minus) sign. If it is less than 1.0, subtract it from 1.0 and assign a + (plus) sign. Record value.

(16) Refer to test report for thermal transfer standard to obtain percentage of ac/dc difference for 1 V at 1 kHz. Convert percentage to voltage error, retaining sign. Record value.

(17) Add algebraically values recorded in (15) and (16) above. Reverse sign and add to 1.0. Record this value. This is the correct TI voltage control setting to obtain 1 V output.

(18) Connect equipment as shown in figure 4.

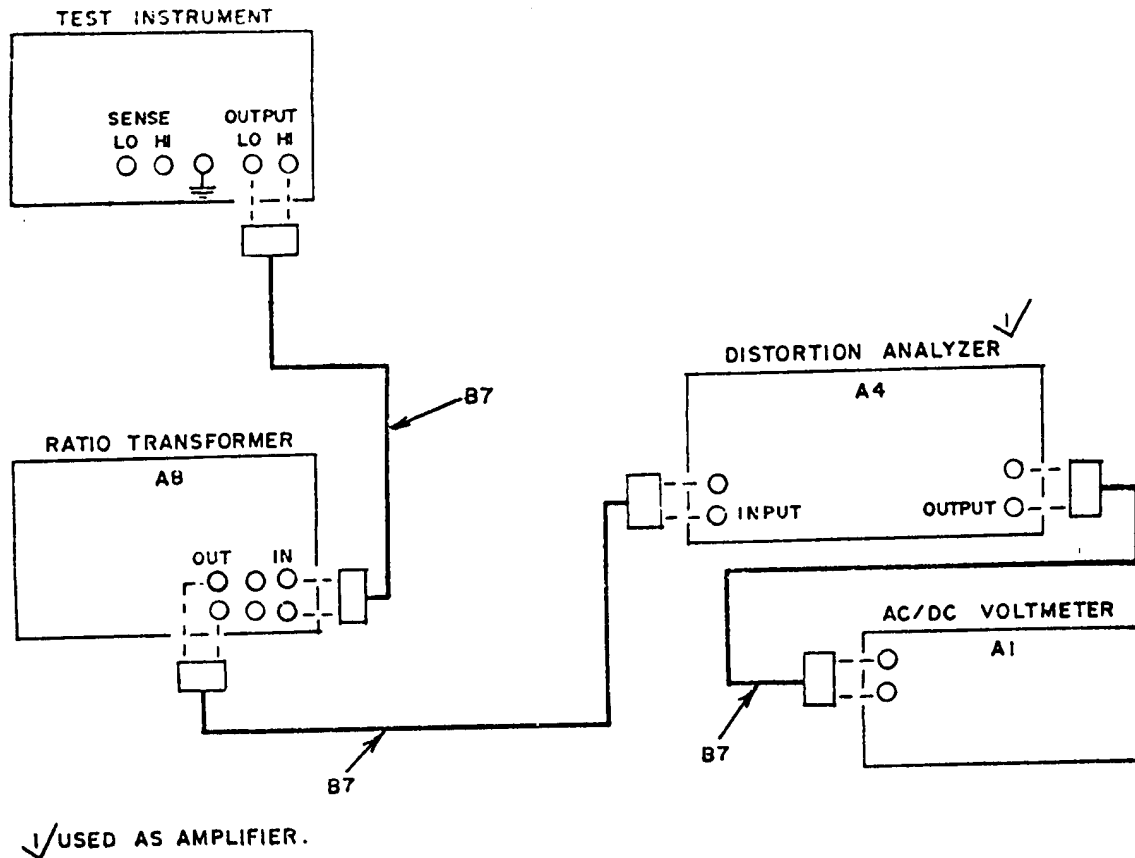


Figure 4. Low voltage - equipment setup.

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

- (a) Press VOLTAGE RANGE 1 mV pushbutton.
- (b) Set voltage controls to obtain indication of 1.000000 mv.
- (c) Press FREQUENCY RANGE X1 K pushbutton.

(20) Set ratio transformer (A8) dials to 1.000000.

NOTE

In following checks, distortion analyzer (A4) is utilized as an amplifier only.

(21) Set distortion analyzer to voltmeter function and 1 mV (millivolt) range.

(22) Adjust ac/dc voltmeter (A1) dials to obtain null indication. Leave voltage readout dials set.

TB 9-4931-700-50

- (23) Set ratio transformer dials to .001000.
- (24) Position TI controls as listed in (a) through (c) below:
 - (a) Press VOLTAGE RANGE 1V pushbutton.
 - (b) Set voltage controls to obtain same indication recorded in (17) above.
 - (c) Press ERROR RANGE X1 pushbutton.
- (25) Adjust ERROR MEASUREMENT control to obtain a null indication on ac/dc voltmeter. % ERROR scale will indicate within ± 1.04 percent.
- (26) Position TI controls as listed in (a) through (c) below:
 - (a) Press VOLTAGE RANGE 10 mV pushbutton.
 - (b) Set voltage controls to obtain indication of 10.00000 mv.
 - (c) Press ERROR RANGE 0 pushbutton.
- (27) Set distortion analyzer range to 10 mV.
- (28) Set ratio transformer dials to 1.000000.
- (29) Adjust ac/dc voltmeter dials to obtain null indication. Leave voltage readout dials set.
- (30) Set ratio transformer dials to .010000.
- (31) Position TI controls as listed in (a) through (c) below:
 - (a) Press VOLTAGE RANGE 1V pushbutton.
 - (b) Set voltage controls to obtain same indication recorded in (17) above.
 - (c) Press ERROR RANGE X.1 pushbutton.
- (32) Adjust ERROR MEASUREMENT control to obtain a null indication on ac/dc voltmeter. The % ERROR scale will indicate within ± 0.142 percent.

- (33) Position TI controls as listed in (a) through (c) below:
 - (a) Press VOLTAGE RANGE 100mV pushbutton.
 - (b) Set voltage controls to obtain indication of 100.0000 mv.
 - (c) Press ERROR RANGE 0 pushbutton.
- (34) Set distortion analyzer range to 100 mV.
- (35) Set ratio transformer dials to 1.000000.
- (36) Adjust ac/dc voltmeter dials to obtain a null indication. Leave voltage readout dials set.
- (37) Set ratio transformer dials to .100000.
- (38) Position TI controls as listed in (a) through (c) below:
 - (a) Press VOLTAGE RANGE 1V pushbutton.
 - (b) Set voltage controls to obtain same indication recorded in (17) above.
 - (c) Press ERROR RANGE X.1 pushbutton.
- (39) Adjust ERROR MEASUREMENT control to obtain null indication on ac/dc voltmeter. The % ERROR scale will indicate within ± 0.052 percent.
- (40) Set decade resistor dials to 3010 ohms and connect across TI OUTPUT terminals, using cable (B7).
- (41) Repeat (33) through (39) above.

b. Adjustments

NOTE

Perform power supply check in paragraph 13 prior to making adjustments.

- (1) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 10.
- (2) With thermal transfer standard in manual balance mode and dc output state, adjust its manual balance controls to obtain ac/dc voltmeter indication equal to the value of TI voltage controls setting.
- (3) Set thermal transfer standard to ac balancing state. Adjust TI A3C12 (fig. 2) to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed (R).
- (4) Set thermal transfer standard to ac balancing state. Adjust TI A6R16 (fig. 2) to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed (R).
- (5) Press FREQUENCY RANGE X1K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 10.
- (6) Set thermal transfer standard to ac balancing state. Adjust TI A14R7 (fig. 2) to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed (R).

TB 9-4931-700-50

(7) Set thermal transfer standard to ac balancing state. Adjust TI C9 (fig. 2) to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed (R).

11. Voltage Accuracy, Regulation, and Frequency Response (Model 746A)

a. Performance Check

(1) Connect equipment as shown in figure 5.

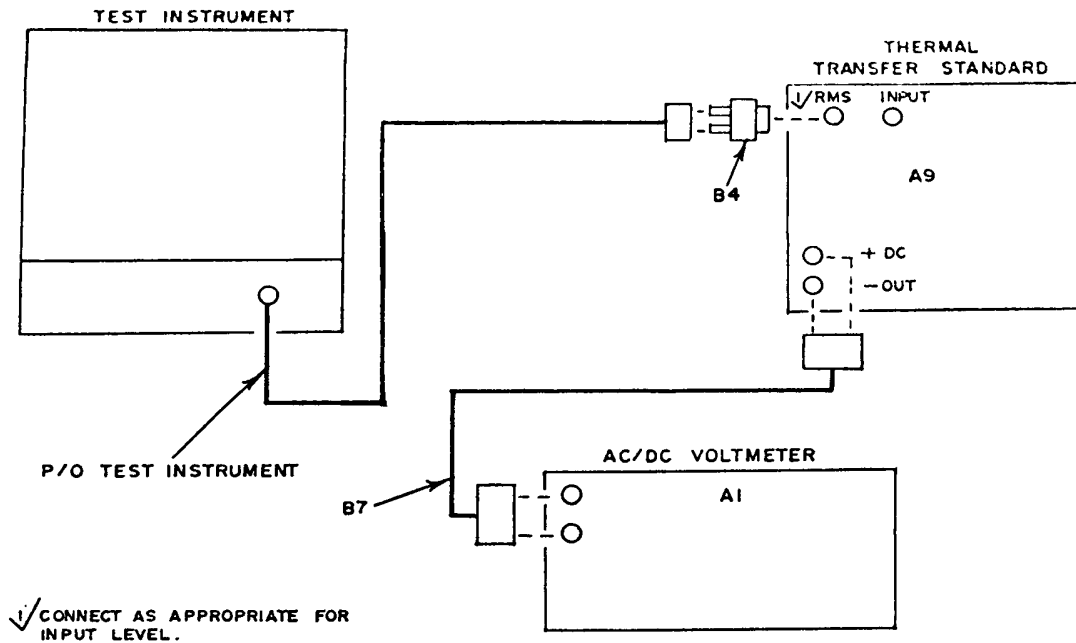


Figure 5. High - equipment setup.

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

- Press VOLTAGE RANGE 1000 V ext. pushbutton.
- Set voltage controls to obtain an indication of 100.000 V.
- Press FREQUENCY RANGE X1K pushbutton.
- Adjust FREQUENCY control to obtain FREQ scale indication of 1.0
- Press ERROR RANGE 0 pushbutton.
- Press OUTPUT ON pushbutton.

NOTE

Each time measurement of TI output is directed, a minimum of four readings should be taken. The first reading should be disregarded and the other three readings averaged. The average reading is the indication to be recorded for future use. The ac/dc voltmeter (A1) indication should be read between 15 and 20 seconds after thermal transfer standard (A9) transfers to the dc output state.

(3) Measure TI output, using thermal transfer standard in auto mode. Wait approximately 2 minutes after applying ac voltage before transferring to the dc output state. Record ac/dc voltmeter indication. -

(4) Compute and record difference between indication recorded in (3) above and TI voltage controls setting. If indication in (3) is larger, a + (plus) sign is to difference. If it is smaller, a - (minus) sign is assigned to difference. Convert difference to percentage retaining assigned sign.

(5) Refer to test report for thermal transfer standard to obtain percentage of ac/dc difference for 100 V at appropriate frequency.

(6) Add algebraically two percentages obtained in (4) and (5) above. The result is percentage of TI output error. If TI output error is more than ± 0.04 percent, perform b below.

(7) Repeat technique of (2) through (6) above with autotransformer set at 105 and 125 V ac. If error does not remain within ± 0.04 percent and adjustments were not performed in (6) above, perform **b** below and repeat (2) through (6) above. Return autotransformer setting to 115 V ac.

(8) Repeat technique of (7) above with voltage controls set to obtain an indication of 1000.000 V.

(9) Perform technique of (3) through (6) above, using frequencies and acceptable errors listed in table 8.

Table 8. Accuracy and Frequency Response

Test Instrument Frequency	Acceptable Error (Percent)
50 Hz	± 0.04
100 Hz	± 0.04
10 kHz	± 0.04
20 kHz	± 0.04
50 kHz	± 0.08
100 kHz	± 0.15

(10) Press OUTPUT OFF pushbutton.

(11) Connect variable capacitor (A10) across TI output (connect to adapter B4 using both conductors of a pair for each connection, hook-up wire B9). Set variable capacitor dial to 125 pF (picofarad).

(12) Set voltage controls to obtain an indication of 700.000 V and press OUTPUT ON pushbutton.

(13) Repeat (9) above.

(14) Press OUTPUT OFF pushbutton.

(15) Replace variable capacitor with decade resistor (A3). Set variable resistor dials to 16000 ohms.

(16) Set voltage controls to obtain an indication of 100.000 V.

(17) Press FREQUENCY(RANGE)(10 pushbutton and adjust FREQUENCY control to obtain FREQ SCALE indication of 1.0.

TB 9-4931-700-50

(18) Press OUTPUT ON pushbutton.

(19) Repeat technique of (3) through (6) above. The TI output error will not be more than ± 0.25 percent.

(20) Press OUTPUT OFF pushbutton.

b. Adjustments

NOTE

Perform power supply check in paragraph 14 below prior to making adjustments.

NOTE

Perform (1) through (6) below and repeat **a** above. If still out-of-tolerance, perform (7) through (26) below.

(1) With thermal transfer standard in manual balance mode and dc output state, adjust its manual balance controls to obtain ac/dc voltmeter indication equal to value of TI voltage control setting.

WARNING

Do not adjust R5 or L3 with instruments floating above earth ground. Mounting hardware for R5 and L3 is at circuit ground.

(2) Set thermal transfer standard to ac balancing state. Adjust R5 (fig. 6) to obtain null indication on thermal transfer standard meter X pushbutton pressed (R).

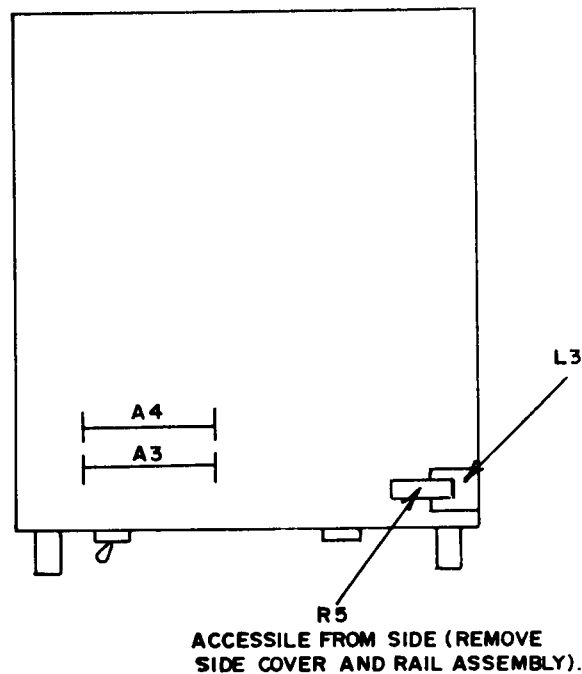


Figure 6. Model 746A top view - Adjustment locations.

(3) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 10.0.

(4) Repeat (1) above.

(5) Set thermal transfer standard to ac balancing state. Adjust L3 (fig. 6) to obtain null indication on thermal transfer standard meter with its null X5 pushbutton pressed (R).

(6) Press OUTPUT OFF pushbutton.

TB 9-4931-700-50

(7) Remove bottom cover from TI (model 746A only). Remove plastic cover from A6 amplifier assembly (fig. 7).

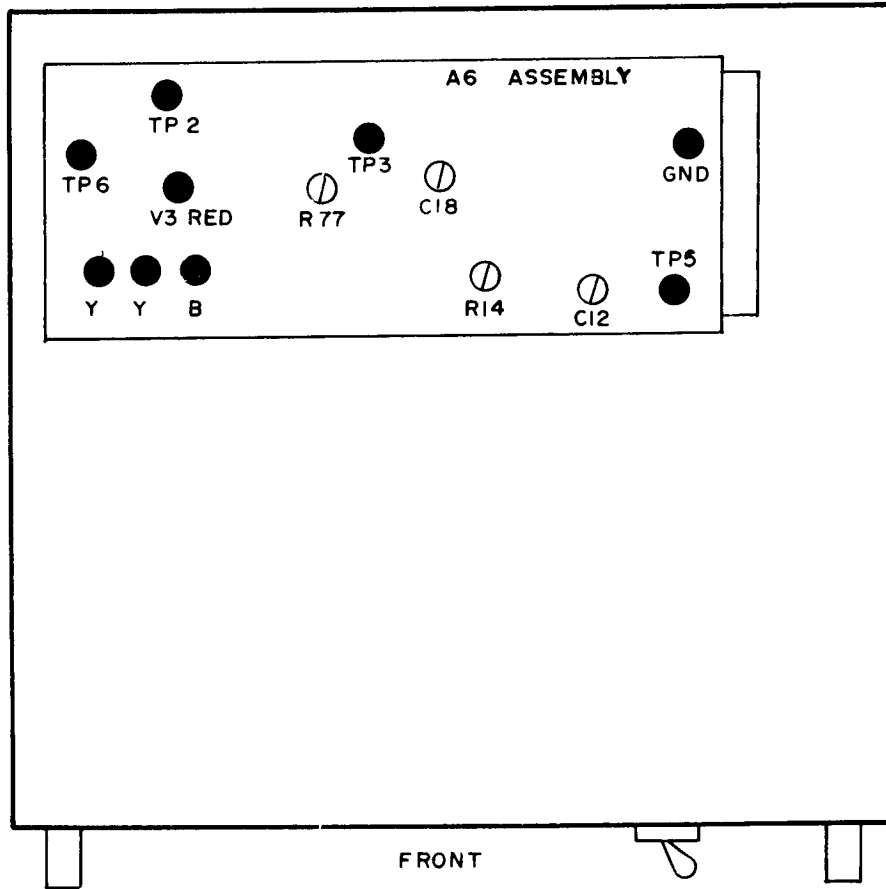


Figure 7. Model 746A bottom view - adjustment location.

(8) Connect ac/dc voltmeter high voltage leads between test point B (fig. 7) and GND (circuit ground).

(9) Press OUTPUT ON pushbutton.

NOTE

The voltages in (10) and (12) below do not have to be exact. They may vary as much as ± 50 V. The important point is that voltage difference between them is 30 ± 2 V.

(10) Adjust A6R14 (fig. 7) to obtain indication of 1850 V dc on ac/dc voltmeter (R).

(11) Move ac/dc voltmeter leads to test point A6TP6 (fig. 7) and GND (circuit ground).

(12) Adjust A6R77 (fig. 7) to obtain indication of 1820 V dc on ac/dc voltmeter (R).

(13) Press OUTPUT OFF pushbutton.

- (14) Connect variable capacitor across TI output (connect at isolation box, using cable). Set variable capacitor dial to 50 pF.
- (15) Connect oscilloscope (A7) to A6TP2 (fig. 7), using probe (B11).
- (16) Position TI controls as listed in (a) through (d) below:
 - (a) FREQUENCY RANGE X10K pushbutton pressed.
 - (b) FREQUENCY control to obtain FREQ scale indication of 101.
 - (c) Voltage controls to obtain indication of 100.000 V.
 - (d) OUTPUT ON pushbutton pressed.
- (17) Adjust (increase) TI output in 100 V steps to 700 V or until a glitch appears on waveform as shown in figure 8.

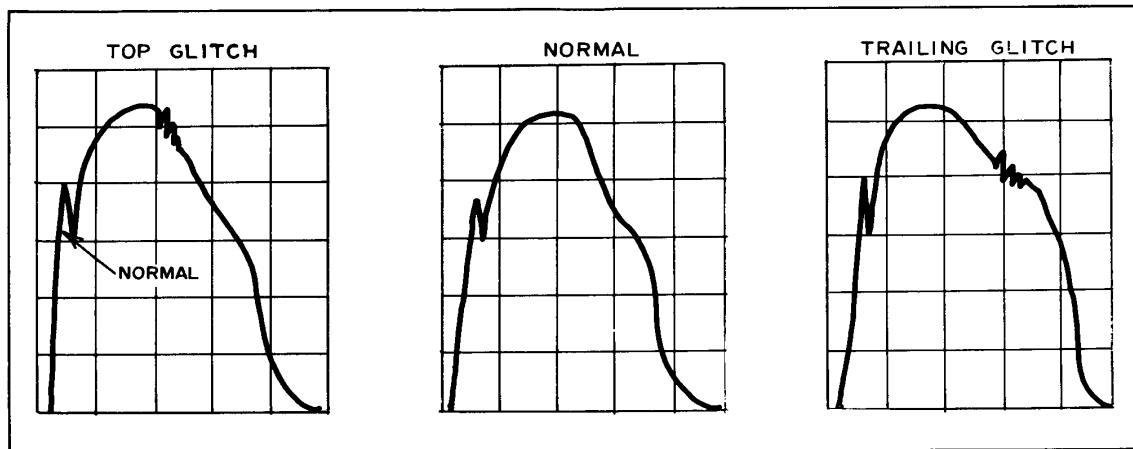


Figure 8. Waveform at A6TP2.

- (18) If no glitch appears, adjust (increase) capacitance of variable capacitor until it does appear. After glitch appears, adjust A6C18 (fig. 7) until waveform becomes clear and then another glitch appears. Note range of A6C18 between points where glitches appear.
- (19) Adjust (increase) capacitance of variable capacitor and adjust A6C18 until range as noted in (15) above is minimum (R).
- (20) Connect ac/dc voltmeter to A6TP6 (fig. 7) (same as V3 RED) and circuit ground, using leads supplied with ac/dc voltmeter.
- (21) Adjust A6R77 (fig. 7) to obtain indication of 1800 V dc on ac/dc voltmeter (R).
- (22) Adjust variable capacitor for 100 pF.
- (23) Adjust TI output from 700 V to 100 V. The oscilloscope will not show signs of oscillations.
- (24) Set voltage controls to obtain indication 700.000 V and adjust frequency from 110 to 10 kHz. If oscilloscope indication is not smooth with no oscillations, repeat (7) through (20) above.

TB 9-4931-700-50

(25) Set voltage controls to obtain indications of 100.000 V. Press FREQUENCY RANGE X1K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 1.0.

(26) Connect ac/dc voltmeter between A6TP5 (fig. 7) and circuit ground, using cable and adapter (B6 and B2). If ac/dc voltmeter does not indicate 10 V ac, use ERROR RANGE pushbuttons and ERROR MEASUREMENT control to obtain 10 V ac indication.

(27) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 10.0.

(28) If ac/dc voltmeter does not indicate between 10.3 and 10.7 V ac, adjust A6C12 (fig. 7) to obtain indication of between 10.3 and 10.7 V ac.

12. Distortion

a. Performance Check

- (1) Connect equipment as shown in figure 9.
- (2) Position TI controls as listed in (a) through (f) below:
 - (a) Press VOLTAGE RANGE 1V pushbutton.
 - (b) Set voltage set controls to obtain indication of 1.000000 V.
 - (c) Press FREQUENCY RANGE X10 pushbutton.
 - (d) Adjust FREQUENCY control to obtain FREQ scale indication of 1.0.
 - (e) Press ERROR RANGE 0 pushbutton.
 - (f) Press SENSE LOCAL pushbutton.
- (3) Adjust decade resistor (A3) dials to 22 ohms.

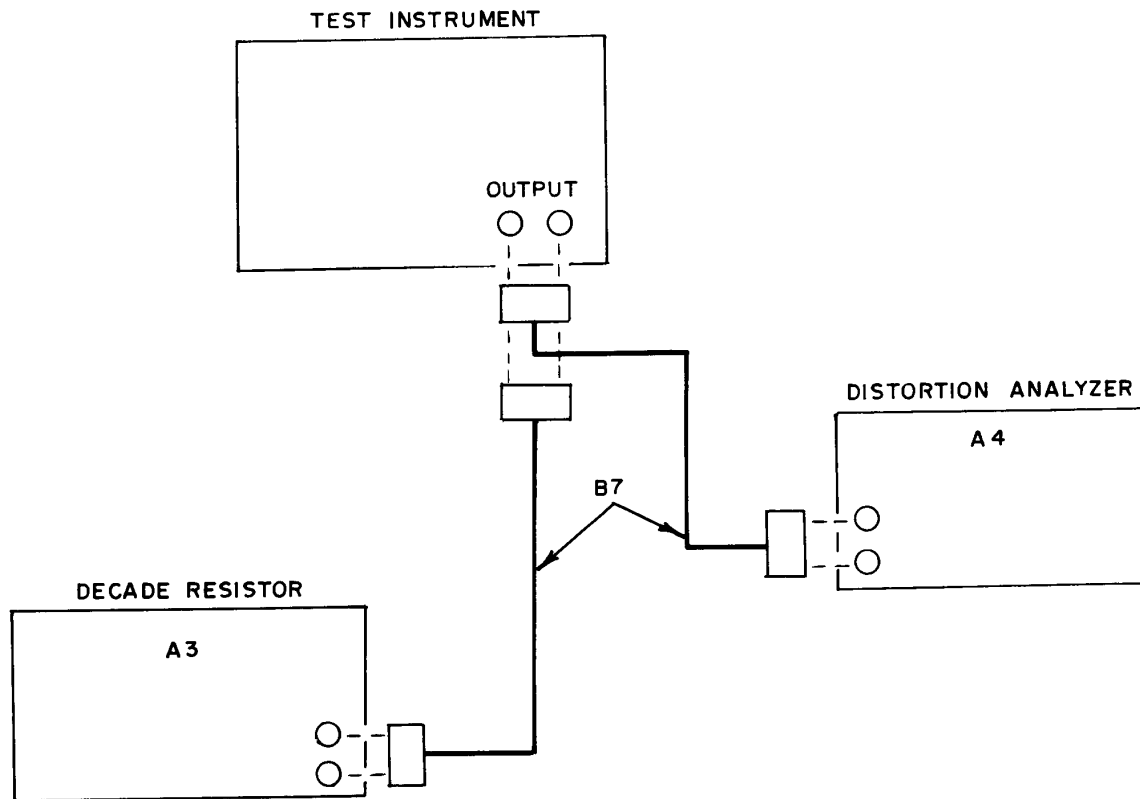


Figure 9. Distortion check - equipment setup.

- (4) Measure distortion. If distortion is not .06 percent or less, perform **b** below.
- (5) Repeat (4) above for frequencies of 50 and 100 Hz, and 1, 10, 50, and 100 kHz. If distortion is not .06 percent or less, perform **b** below.
- (6) Repeat technique of (2) through (5) above, using settings and indications listed in table 9.

Table 9. Distortion

Test Instrument VOLTAGE RANGE Switch Settings (V)	Resistance Value (Ohms)	Maximum Distortion Allowed (Percent)
10	221	.060
100	2200 ¹	.060

¹Replace decade resistor (A3) with load (A6).

- (7) Connect output of the TI (Model 746A) to input of distortion analyzer (A1).
- (8) Position TI (Model 745A) controls as listed in (a) through (d) below:
 - (a) Press FREQUENCY RANGE X10 pushbutton.
 - (b) Adjust FREQUENCY control to obtain FREQ scale indication of 1.0.
 - (c) Press VOLTAGE RANGE 1000V ext. pushbutton.
 - (d) Set voltage controls to obtain 100.000 V.
- (9) Press OUTPUT ON pushbutton (Model 746A).
- (10) Measure distortion. Distortion will be .06 percent or less.

TB 9-4931-700-50

(11) Repeat technique of (8), (9), and (10) above for frequencies of 50 Hz, and 1, 10, 50, and 100 kHz. Distortion will be .06 percent or less.

(12) Press OUTPUT OFF pushbutton.

b. Adjustments

NOTE

Deenergize TI when removing or installing circuit boards.

(1) Remove circuit board A12A5 (fig. 1) from TI and extend -circuit board A12A7 (fig. 1) using extender board supplied with TI.

(2) Press FREQUENCY RANGE X10K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 5.

(3) Connect oscilloscope (A7) to A12A7TP2 (fig. 1), using probe (B11) and connect ac/dc voltmeter (A1) to A12A8TP1 (fig. 1).

(4) Center adjustments A12A7R26 and A12A7R29 (fig. 1).

(5) Adjust 112A7C14 (fig. 1) to obtain minimum amplitude of the ac signal displayed on oscilloscope (R).

(6) Alternately adjust A12A7R26 and A12A7R29 (fig. 1) to obtain minimum amplitude of ac signal displayed on oscilloscope.

(7) Repeat (5) and (6) above to obtain optimum indication. The amplitude of ac signal should be less than 0.05 V p-p.

(8) Ac/dc voltmeter will indicate 0 ± 2 mV dc.

(9) Adjust A12A7R26 and A12A7R29 (slightly) to obtain an ac/dc voltmeter indication of 0 ± 2 mV dc.

(10) Repeat (5) through (9) as necessary until ac signal is less than 0.05 V P-P and dc voltage is 0 ± 2 mV dc.

(11) Replace circuit boards in TI.

(12) Press FREQUENCY RANGE X1K pushbutton and adjust FREQUENCY control to obtain FREQ scale indication of 1.

(13) Extend circuit board A12A8 (fig. 1), using extender board furnished with TI.

(14) Connect ac/dc voltmeter to A12A8TP1 (fig. 1) and adjust A12A8R32 to obtain indication of 0.1 V ac (R).

(15) Connect ac/dc voltmeter to A2TP4 (fig. 2) and adjust A12A6R4 (fig. 1) to obtain indication of between -.99 and 1.1 V dc (R).

(16) Connect ac/dc voltmeter to A12A8TP2 (fig. 1) and adjust A12A8R15 (fig. 1) to obtain indication of between 0.25 and 0.35 V dc (R).

(17) Replace circuit board in TI.

13. Power Supply (Model 745A)

NOTE

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

NOTE

In the following procedure all voltages are measured with respect to circuit common (1). Circuit common is available at any point on inner chassis.

a. Performance Check

- (1) Set TI for output of 1.000000 mV at 1 kHz.
- (2) Connect ac/dc voltmeter (A1) between A8TP3 (fig. 2) and circuit common, using cable and adapter (B6 and B2). If ac/dc voltmeter does not indicate between -69.5 and -70.5 V dc, perform **b** below.
- (3) Repeat technique of (1) and (2) above for settings and indications listed in table 10. If an out-of-tolerance condition is indicated, perform specified adjustment.

b. Adjustments. Adjust A8R30 (fig. 2) to obtain an ac/dc voltmeter indication of -70.00 V dc (R).

TB 9-4931-700-50

Table 10. Power Supply and Bias

Test Instrument Connection Points (fig. 2)	Ac/dc Voltmeter, Frequency Counter, or Oscilloscope Indications	Adjustments (fig. 2)
A8TP4	+69.50 to +70.50 V dc	A8434 (R)
A8TP1	-24.80 to -25.20 V dc	A8429 (R)
A8TP2	+5.10 to +5.30 V dc	A8R6 (R)
A4TP1	-0.0030 to +0.0030 V dc	A4R8 (R)
A3TP1 ¹	-0.0010 to +0.0010 V dc	A3R34 (R)
A2 PIN 12 ²	450 to 550 ms sample gate	A3410 (R)
A2501 ³	-0.0010 to +0.0010 V dc	A2R9 (4)
A2TP2 ⁴	+0.550 to +0.650 V dc	A2R34 (R)
A2TP3	-0.0001 to +0.0001 V dc	A2R67 (R)
A2TP4 ⁵	-0.90 to -1.10 V dc	---
A2TP4 ⁶	Indication equal to that recorded in footnote 5 below	A4439 (R)
A1A3TP5 ⁷	499 to 501 Hz	A1A4R5 (R)
A1A3TP5 ⁸	-9.89999 to -9.90001 V dc	A1A3R32 (coarse), R34 (fine) (R)
A1A3TP5 ⁹	+9.89999 to +9.90001 V dc ¹⁰	A1A3R14 (coarse), R16 (fine) (R)

¹Adjust frequency to 50 kHz and set A1A4S1 (fig. 2) to +9.9 V position. Overload lamp may illuminate, this may be expected when A1A4S1 is switched from 19.8 V position.

²Set A1A4S1 to 19.8 V position; connect oscilloscope (A7), using cable (B4).

³Remove PC board A3.

⁴Reinstall PC board A3 and reset frequency to 50 kHz.

⁵Press FREQUENCY RANGE X1K pushbutton. Record voltage level indication.

⁶Press FREQUENCY RANGE X100 pushbutton

⁷Connect frequency counter (A5).

⁸Set A1A4S1 to -9.9 V position.

⁹Set A1A4S1 to +9.9 V position.

¹⁰After completing check, set A1A4S1 to 19.8 V position.

14. Power Supply (Model 746A)

NOTE

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

a. Performance Check

(1) Connect ac/dc voltmeter (A1) between -30 V test point (TP3) of A4 assembly (fig. 6 and 10) and circuit ground. Ac/dc voltmeter will indicate between -29.7 and -30.3 V dc.

(2) Connect ac/dc voltmeter between +6 V test point (TP1) of A4 assembly (fig. 10) and circuit ground. Ac/dc voltmeter will indicate between 5.94 and 6.06 V dc.

(3) Connect ac/dc voltmeter between +150 V test point (TP2) of A4 assembly (fig. 10) and circuit ground. AC/dc voltmeter will indicate between 145.5 and 154.5 V dc.

b. Adjustments. No adjustments can be made.

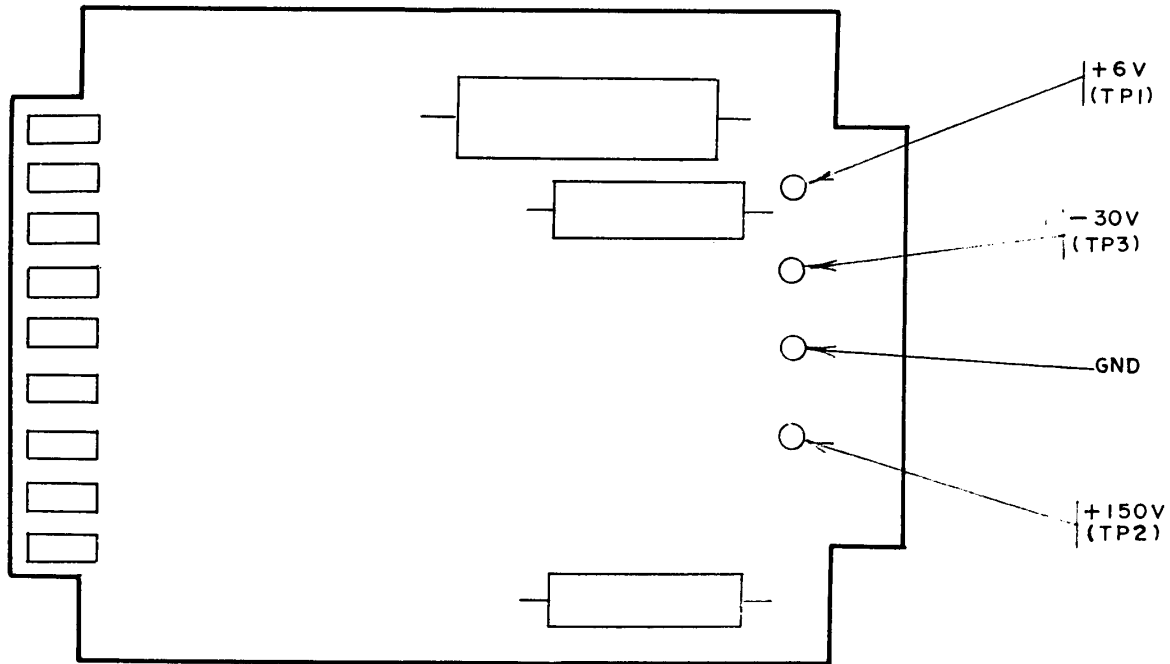


Figure 10. A4 Assembly - test point locations.

15. Flow Procedure

a. Deenergize and disconnect all equipment and reinstall TI protective cover.

b. In accordance with TM 38-750, annotate and affix DA Label 80 (US Army Calibrated Instrument). When the TI receives limited or special calibration, annotate and affix DA Label 163 (US Army Limited or Special Calibration). When the TI cannot be adjusted within tolerance, annotate and affix DA Form 2417 (US Army Calibration System Rejected Instrument).

TB 9-4931-700-50

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief Of Staff

Official:

J. C. PENNINGTON
Brigadier General, United States Army
The Adjutant General

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