

4776-400H  
Issue I

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CALIBRATION PROCEDURE  
HEWLETT-PACKARD MODEL 400H  
VACUUM TUBE VOLTMETER

Prepared For:  
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CALIBRATION PROCEDURE FOR NASA TEST EQUIPMENT

HEWLETT-PACKARD MODEL 400H

VACUUM TUBE VOLTMETER

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## SECTION I. GENERAL

### 1. Purpose and Scope.

1.1 This procedure provides instructions for the periodic calibration of Hewlett-Packard Model 400H Vacuum Tube Voltmeter. Inasmuch as personnel involved with the use of this procedure are trained and qualified in the usage of calibration standards equipment, detailed instructions concerning operation of the calibration standards are not contained in this procedure.

1.2 Section I includes the purpose and scope of the procedure, description of the item to be calibrated, specifications, and the difference among models. Section II provides the list of equipment required for calibration and the procedures for checking performance and making adjustment.

1.3 Integrated throughout this procedure are illustrations delineating the location of controls and components involved in this calibration procedure, as well as diagrams showing equipment setups. Equipment ground connections are not necessarily shown in the diagrams.

2. Description. The Hewlett-Packard Model 400H Vacuum Tube Voltmeter is useful primarily as a precision ac voltmeter. The 400H will also accurately measure dbm (1 mw into 600-ohm load) and serve as a broadband, high-gain amplifier. Inherent to the 400H is its high input impedance of 10 megohms, which prevents loading of the circuit being measured.

3. Specifications.

- 3.1 Power Requirements - - - - - 115/230 volts  $\pm 10\%$ ,  
50 to 1000 cps, approxi-  
mately 100 watts.
- 3.2 Voltage Range - - - - - 1 millivolt to 300 volts  
full scale in 12 ranges.
- 3.3 Decibel Range - - - - - -72 dbm to +52 dbm.
- 3.4 Accuracy - - - - -  $\pm 1\%$  of full scale, 50 cps  
to 500 kc.  
 $\pm 2\%$  of full scale, 20 cps  
to 1 mc.  
 $\pm 3\%$  of full scale, 20 cps  
to 2 mc.  
 $\pm 5\%$  of indication over the  
frequency range of 10 cps  
to 4 mc.
- 3.5 Input Impedance - - - - - 10 megohms shunted by  
15 pf on the 1- to 300-volt  
range, 25 pf on the 0.001-  
to 0.3-volt range.
- 3.6 Amplifier:
- 3.6.1 Output - - - - - 0.15 volts rms.
- 3.6.2 Output Impedance - - - - - 50 ohms.

4. Difference Among Models. This procedure is written for models with serial numbers 2838 and up. Models with lower serial numbers have differences in accuracy versus frequency range. Refer to manufacturer's manual. On all models, certain components are adjusted at the factory and will differ in value or may be omitted entirely. Some components may be added or may differ in value through modifications. *THIS PROCEDURE IS NOT APPLICABLE TO SERIAL# PREFIXES 017-, 048- and 116-.*

## SECTION II. CALIBRATION

5. Equipment Required. Equipment required for calibration is listed in Table I. If any equipment listed in Table I is not available, an equivalent item may be used.

TABLE I

EQUIPMENT REQUIRED FOR CALIBRATION OF  
HEWLETT-PACKARD MODEL 400H  
VACUUM TUBE VOLTMETER

A. AUTHORIZED STANDARDS

Nomenclature	Manufacturer	Model No.
AC Voltmeter	Hewlett-Packard	400D
Autotransformer	General Radio	W5MT3W
DC Voltmeter	John Fluke	801
VTVM Calibration System	Hewlett-Packard	738AR 739AR 200SR

Note. Standards equipment used for calibration must bear evidence that its use has not exceeded the calibration period.

TABLE I (Continued)

EQUIPMENT REQUIRED FOR CALIBRATION OF  
HEWLETT-PACKARD MODEL 400H  
VACUUM TUBE VOLTMETER

B. AUTHORIZED ACCESSORIES

Nomenclature	Description	Model or Part No.
Adapter	Isolates power-line ground from chassis of test equipment	Hubbell Type 5273L
Cable Assembly	36-in., RG-58/U, double banana plug terminations	PECO 2BC-36
Cable Assembly	36-in., RG-58/U, double banana to BNC	PECO 2BC-BNC-36
Test Plug	100-k resistor across the terminals of a shielded connector	HP-125-23

6. Preliminary Procedure.

- 6.1 Remove the 400H Vacuum Tube Voltmeter from the case.
- 6.2 Connect the ground-isolation adapter between the power cord of the 400H and the output of the autotransformer.
- 6.3 Connect equipment to a 115-volt, 60-cps power source and energize. Refer to figure 1 for the location of all switches and controls on the 400H.

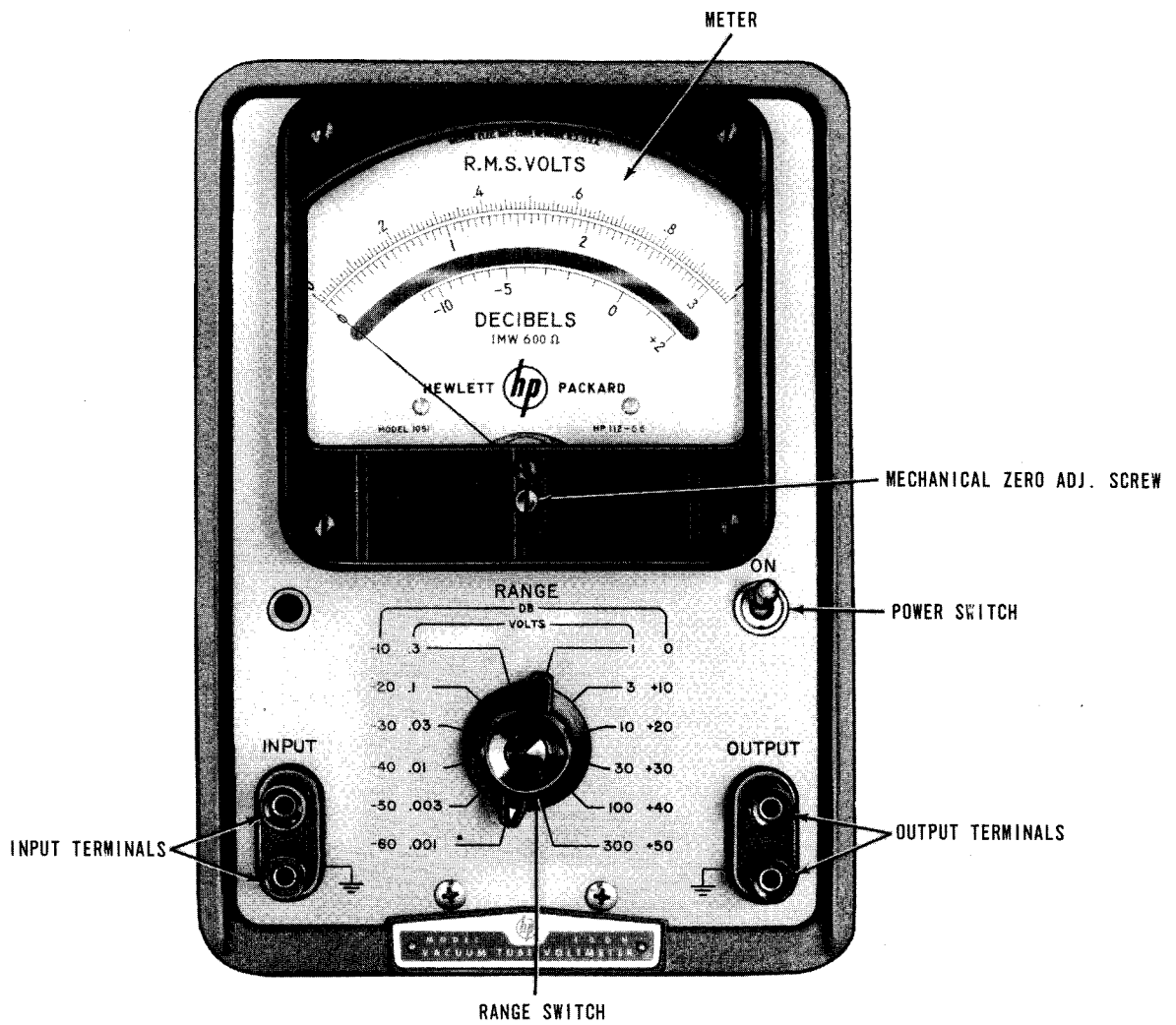


FIGURE 1. VACUUM TUBE VOLTMETER - FRONT PANEL VIEW.



6.4 Adjust the autotransformer for a 115-volt output. Allow a 10-minute warm-up period.

Note. In the following paragraphs, when the performance check is not within tolerance, perform the corresponding adjustments before continuing with the calibration procedure. When the performance check is not within tolerance and no adjustment is specified, the deficiency of the item must be corrected before continuing with the procedure.

7. Power Supply.

7.1 Connect the 801 voltmeter to pin 1 of V7 (fig. 2). The voltmeter should indicate between 245 and 255 vdc. Null the 801 voltmeter.

7.2 Vary the output of the autotransformer from 103 to 127 volts. The 801 voltmeter should not vary over 2 volts from its nulled indication. Adjust the autotransformer for a 115-volt output.

7.3 Disconnect the 801 voltmeter and connect the 400D voltmeter to pin 1 of V7. The 400D voltmeter should indicate 3 millivolts or less.

7.4 Vary the autotransformer output from 103 to 127 volts. The 400D voltmeter should indicate 3 millivolts or less.

7.5 Adjust the autotransformer for a 115-volt output. Disconnect the 400D voltmeter.

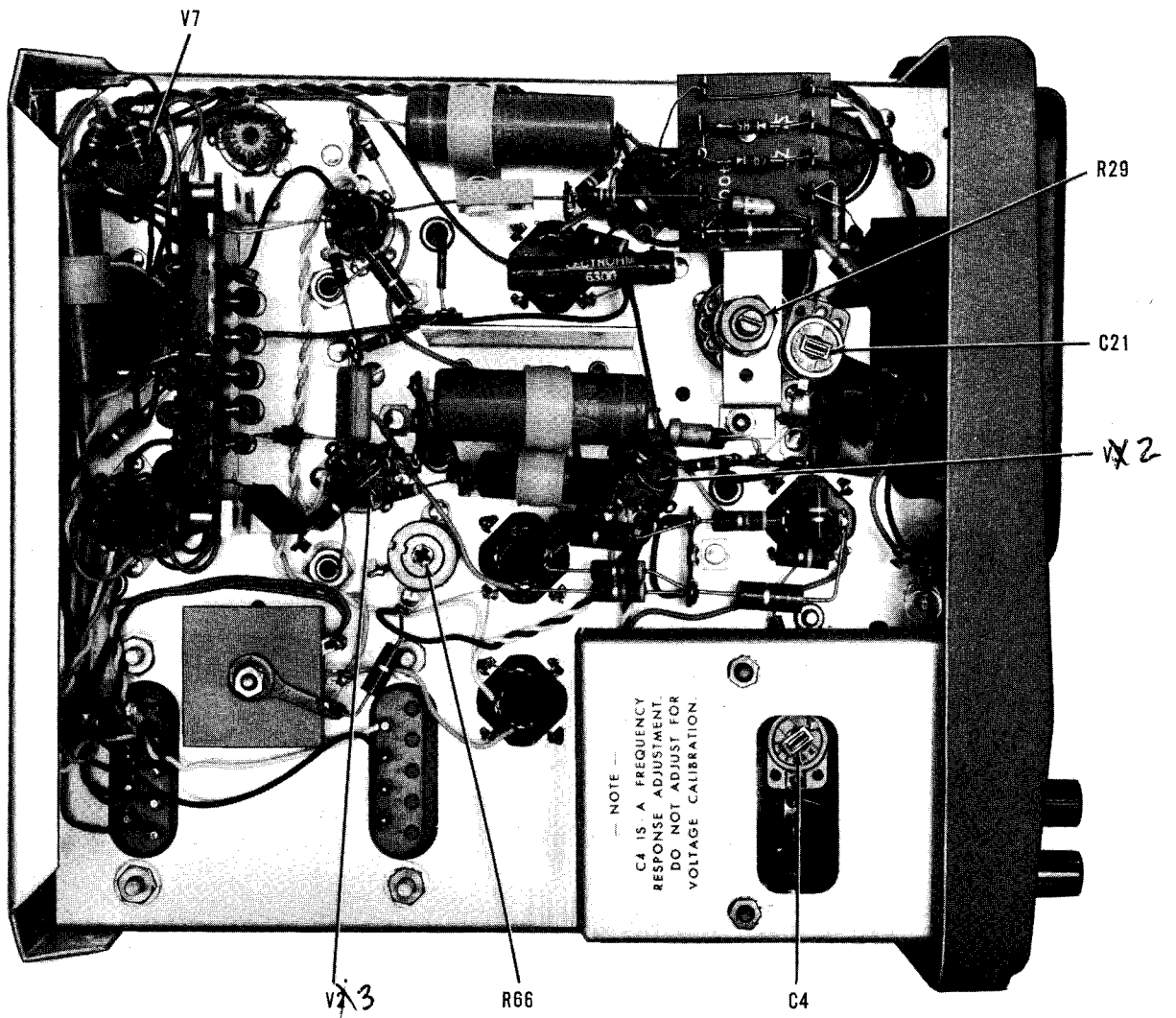


FIGURE 2. VACUUM TUBE VOLTMETER - LEFT SIDE VIEW.

7.6 Connect the 801 voltmeter to pin 3 of V3 (fig. 2). The voltmeter should indicate between 12.4 and 12.8 vdc. Adjust R66 (fig. 2) for a 12.6-volt indication on the 801 voltmeter.

7.7 Connect the 801 voltmeter to pin 4 of V2 (fig. 2). The voltmeter should indicate between 6.1 and 6.5 vdc. Disconnect the voltmeter.

#### 8. Noise and Stability.

8.1 De-energize the 400H, install in the case, and energize.

8.2 Connect the test plug (HP-125-23) to the 400H INPUT terminals.

8.3 Set the RANGE switch on the 400H to .001. The meter indication should not exceed 0.00005 volt or five minor scale divisions.

8.4 Rotate the RANGE switch through all ranges in clockwise and counterclockwise directions. The meter may momentarily indicate the switching transient, but should quickly return to zero.

#### 9. Meter Zero, Voltage Ranges, and Tracking.

9.1 De-energize the 400H. Adjust the mechanical-zero screw until the meter on the 400H indicates zero.

9.2 Remove the case from the 400H and energize.

9.3 Connect the 738AR calibrator to the INPUT connector on the 400H.

9.4 Set the RANGE switch on the 400H to .3.

9.5 Adjust the 738AR calibrator for a 0.3-volt rms output. Adjust R29 (fig. 2) for a full-scale indication of 0.3 volts.

9.6 Set the RANGE switch on the 400H to 1 and perform the operations listed in Table II.

TABLE II  
TRACKING, 1-VOLT RANGE

738AR Calibrator Output (volts rms)	400H Meter Indication (volts)	
	Minimum	Maximum
1.0	0.990	1.010
0.9	0.890	0.910
0.8	0.790	0.810
0.7	0.690	0.710
0.6	0.590	0.6010
0.5	0.490	0.5010
0.4	0.390	0.4010

9.7 Set the RANGE switch on the 400H to 3 and perform the operations listed in Table III.

TABLE III  
TRACKING, 3-VOLT RANGE

738AR Calibration Output (volts rms)	400H Meter Indication (volts)	
	Minimum	Maximum
3.0	2.970	3.030
2.5	2.47	2.53
2.0	1.97	2.03
1.5	1.47	1.53
1.0	0.97	1.03
0.5	0.47	0.53

9.8 Perform operations listed in Table IV.

TABLE IV  
VOLTAGE RANGE CHECKS

400H RANGE Switch Setting	738AR Calibrator Output (volts rms)	400H Meter Indication (volts)	
		Minimum	Maximum
.001	0.001	0.00099	0.00101
.003	0.003	0.00297	0.00303
.01	0.01	0.0099	0.0101
.03	0.03	0.0297	0.0303
.1	0.10	0.099	0.101
.3	0.3	0.297	0.303
3	3.0	2.97	3.03
10	10.0	9.9	10.1
30	30.0	29.7	30.3
100	100.0	99.0	101.0
300	300.0	297.0	303.0

10. Frequency Response.

10.1 Connect the 400H to the output of the 739AR test set.

10.2 Set the RANGE switch on the 400H to .1.

10.3 Adjust the 739AR test set output for a 0.098-volt rms, 400-cps reference on the 400H, and establish a set level indication on the 739AR test set.

10.4 Adjust the output frequency of the 739AR test set to 4 mc. Adjust C21 (fig. 2) for a 0.098-volt indication on the 400H

10.5 Increase the output frequency of the 739AR test set to 6.4 mc and re-establish the set level indication. The indication on the 400H may decrease, but should not exceed 0.1 volt. If necessary, readjust C21 for a 0.098-volt indication on the 400H.

10.6 Repeat steps 10.3 and 10.4 if C21 was adjusted in step 10.5. The 400H should indicate no less than 0.096 volt at 4 mc.

10.7 Set the RANGE switch on the 400H to 3.

10.8 Adjust the 739AR test set output for a 2.8-volt rms, 400-cps reference on the 400H, and establish a set level indication on the 739AR test set.

10.9 Adjust the output frequency of the 739AR test set to 4 mc. Adjust C14 (fig. 3) until the 400H indicates 2.8 volts.

10.10 Adjust the 739AR test set output for a 0.0098-volt rms, 400-cps reference on the 400H, and establish a set level indication on the 739AR test set.

10.11 Set the RANGE switch on the 400H to .01.

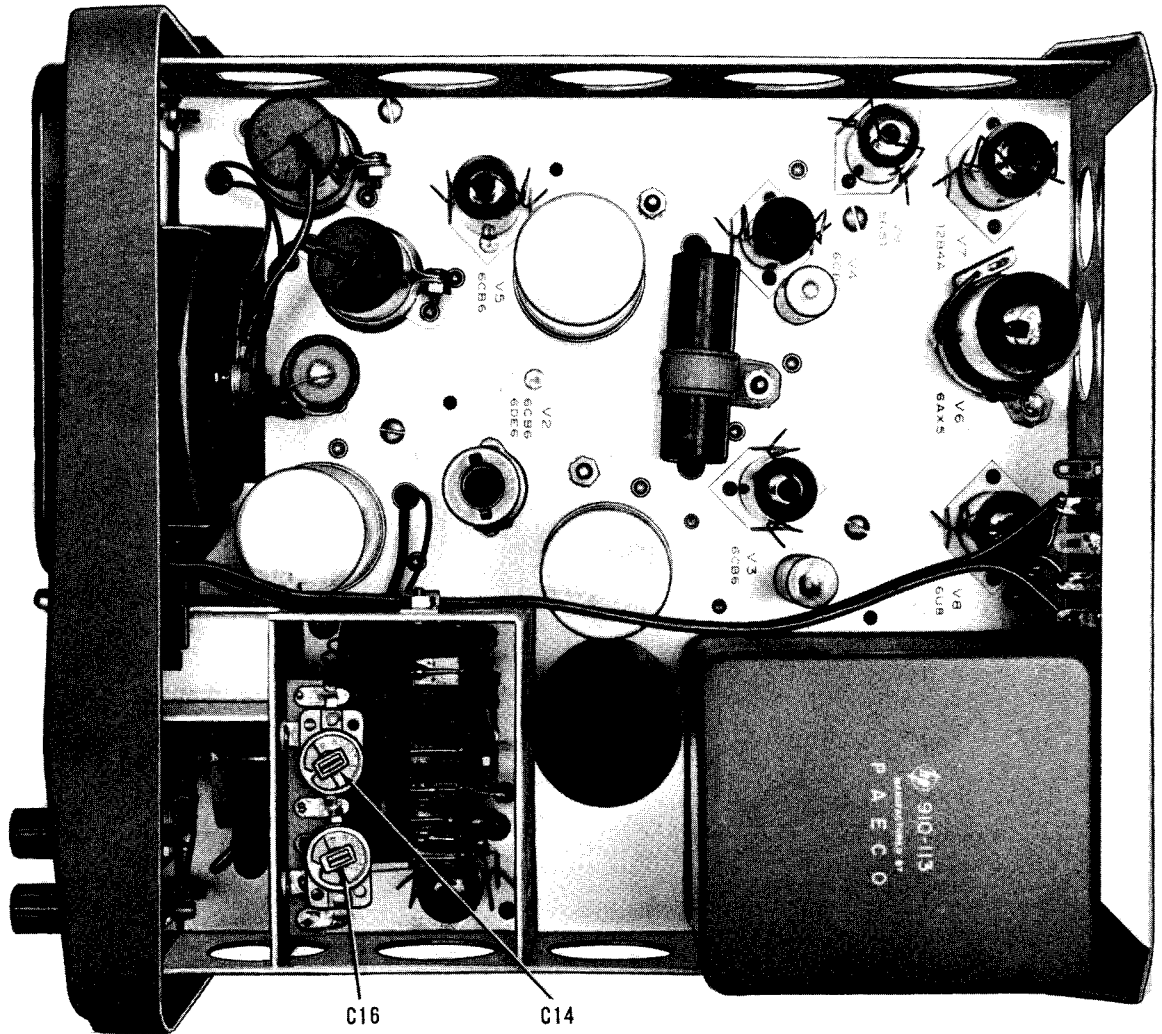


FIGURE 3. VACUUM TUBE VOLTMETER - RIGHT SIDE VIEW.



10.12 Adjust the output frequency of the 739AR test set to 4 mc.  
Adjust C16 (fig. 3) until the 400H indicates 0.0098 volt.

10.13 Set the RANGE switch on the 400H to 1.

10.14 Adjust the 739AR test set output for a 0.98-volt rms,  
400-cps reference on the 400H, and establish a set level indication on the  
739AR test set.

10.15 Adjust the output frequency of the 739AR test set to 4 mc.  
Adjust C4 (fig. 2) until the 400H indicates 0.98 volt.

10.16 Adjust the 739AR test set output for a 0.95-volt rms,  
400-cps reference on the 400H, and establish a set level indication on the  
739AR test set.

10.17 Perform the operations listed in Table V. Maintain a set  
level indication on the 739AR test set before each operation. The indica-  
tion on the 400H should be within the limits specified.

TABLE V

739AR Test Set Frequency Output	400H Meter Indication (volts)	
	Minimum	Maximum
10 cps	0.9025	0.9975
20 cps	0.9310	0.9690
50 cps	0.9405	0.9595
100 cps	0.9405	0.9595
500 cps	0.9405	0.9595
1 kc	0.9405	0.9595
5 kc	0.9405	0.9595
10 kc	0.9405	0.9595
50 kc	0.9405	0.9595
100 kc	0.9405	0.9595
500 kc	0.9405	0.9595
1 mc	0.9310	0.9690
2 mc	0.9215	0.9785
4 mc	0.9025	0.9975

10.18 Repeat steps 10.16 and 10.17 (making decimal corrections) for the .001, .01, and .1-volt ranges of the 400H. The indications on the 400H should be within the limits specified in Table V.

10.19 Set the RANGE switch on the 400H to 3.

10.20 Adjust the 739AR test set output for a 2.85-volt rms, 400-cps reference on the 400H, and establish a set level indication on the 739AR test set.

10.21 Perform the operations listed in Table VI. Maintain a set level indication on the 739AR test set before each operation. The indications on the 400H should be within the limits specified.

TABLE VI

739AR Test Set Frequency Output	400H Meter Indication (volts)	
	Minimum	Maximum
10 cps	2.7075	2.9925
20 cps	2.7930	2.9070
50 cps	2.8215	2.8785
100 cps	2.8215	2.8785
500 cps	2.8215	2.8785
1 kc	2.8215	2.8785
5 kc	2.8215	2.8785
10 kc	2.8215	2.8785
50 kc	2.8215	2.8785
100 kc	2.8215	2.8785
500 kc	2.8215	2.8785
1 mc	2.7930	2.9070
2 mc	2.7645	2.9355
4 mc	2.7075	2.9925

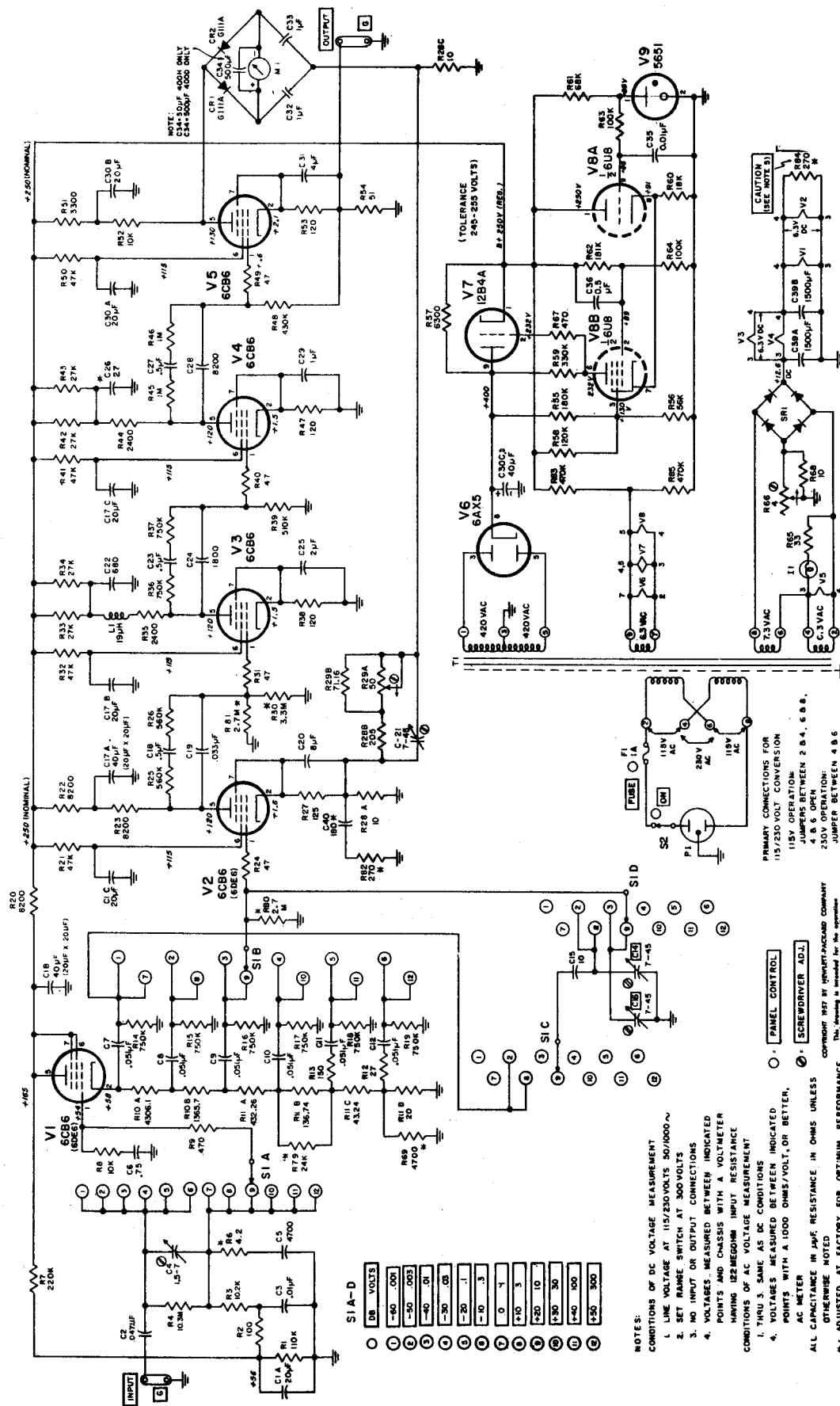
10.22 Repeat steps 10.20 and 10.21 (making decimal corrections) for the .003, .03, and .3-volt ranges of the 400H. The indications on the 400H should be within the limits specified in Table VI.

11. Final Procedure.

11.1 De-energize and disconnect equipment.

11.2 Replace the 400H in the case.

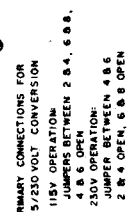
12. Certification. Date and attach the appropriate decal to the 400H Vacuum Tube Voltmeter.



SIA-D

0	0.01
1	0.02
2	0.05
3	0.1
4	0.2
5	0.5
6	1
7	2
8	5
9	10
0	20
1	50
2	100
3	200
4	500
5	1000

- NOTES:
- CONDITIONS OF DC VOLTAGE MEASUREMENT
1. LINE VOLTAGE AT 115/230 VOLTS, 50/1000~
  2. SET RANGE SWITCH AT 500 VOLTS
  3. NO INPUT OR OUTPUT CONNECTIONS
  4. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH A VOLTMETER HAVING 20 MEGOHM INPUT RESISTANCE
- CONDITIONS OF AC VOLTAGE MEASUREMENT
1. THRU 3. SAME AS DC CONDITIONS
  4. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT, OR BETTER, AC METER
- ALL CAPACITANCE IN JMW RESISTANCE IN OHMS UNLESS OTHERWISE NOTED
- \*\* ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE. AVERAGE VALUE SHOWN. PART MAY BE OMITTED.
- 1K = 1000 OHMS IM = (M/1000) CHASSIS
3. R84 MUST BE USED IF V1 & V2 ARE 6CB6'S
- R84 MUST BE REMOVED IF V1 & V2 ARE 6CB6'S



PRIMARY CONNECTIONS FOR 115/230 VOLT CONVERSION

115V OPERATION: JUMPER BETWEEN 2 & 4, 6 & 8, 4 & 6 OPEN

230V OPERATION: JUMPER BETWEEN 4 & 6, 2 & 4 OPEN, 6 & 8 OPEN

SCHEMATIC DIAGRAM