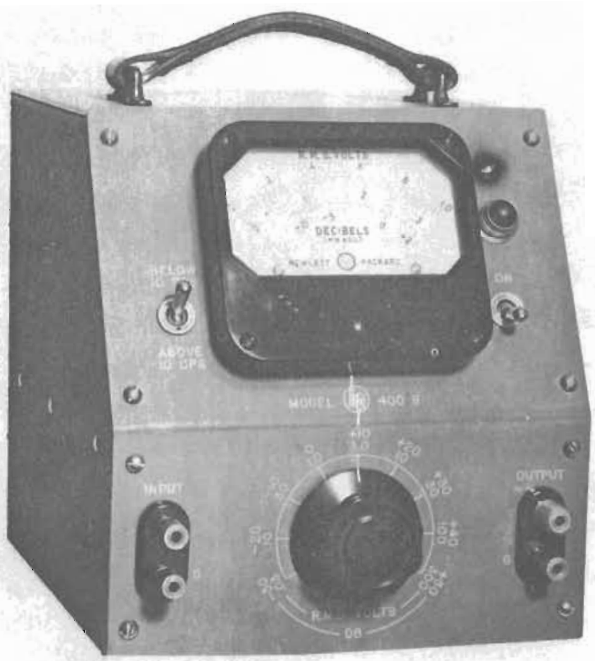
OPERATING AND SERVICING MANUAL

FOR

MODEL 400B

VACUUM TUBE VOLTMETER

Serial 8938 and Above



HEWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

400B001-1

OPERATING AND SERVICING MANUAL

FOR

MODEL 400B

VACUUM TUBE VOLTMETER

ERRATA

Delete binding post, insulator, yellow plastic cap, -hp- Stock No. M-58.

Add: binding post, red, -hp-Stock No. G-10D, Mfr. HP.

Add: binding post, insulator, -hp- Stock No. G-83F, Mfr. HP

Add: binding post, ground (left) with shorting strap, -hp- Stock No. G-76J, Mfr. HP.

Add to Serial 8938 and above

INSTRUCTION AND OPERATING MANUAL

FOR

MODEL 400B

VACUUM TUBE VOLTMETER

PRODUCTION CHANGES

Serial 8938 and above:

Change C7 to 2 μf, fixed, paper dielectric, ±20%, 400 vdcw, -hp- Stock No. 16-81, Mfr. Gudeman Co. #231E205

Add to Serial 8700 and above:

#400B001

SPECIFICATIONS

MODEL 400B

VACUUM TUBE VOLTMETER

VOLTAGE RANGES:	Volts Full Scale (RMS) - .03 .1 .3 1 3 10 30 100 300 DB - -30 -20 -10 0 +10 +20 +30 +40 +50
FREQUENCY RANGE:	2 to 100,000 cycles/sec.
ACCURACY:	±3% of full scale indication on all ranges, from 10 cycles/sec. to 100 KC. ±1/2 db 3 to 10 cycles/sec. ±1 db 2 to 3 cycles/sec.
METER CALIBRATION:	Meter calibrated to RMS value of a sine wave. Linear voltage scales 0-1V and 0-3V. Voltage ranges related by 10 db steps. Zero Level - 1 milliwatt into 600 ohms.
VOLTMETER STABILITY:	Line voltage variations from 105 to 125 volts will cause less than ±2% variation in reading on all frequencies below 100 KC.
INPUT IMPEDANCE:	Approximately 9 megohms at 100 cycles/sec. and 4 megohms at 100,000 cycles/sec.
OVERLOAD CAPACITY:	Meter will not be damaged by occasional overloads of 100 times normal.
POWER SUPPLY RATING:	Voltage - 115 volts Frequency - 50 - 1000 cycles Wattage - 50 watts
OVERALL DIMENSIONS:	Cabinet Mount - 7-3/4" wide x 9-1/4" high x 10-1/2" deep. Rack Mount - 19" wide x 8-3/4" high x 10-1/2" deep.
WEIGHT:	Cabinet Mount - 14 lbs. net; shipping 27 lbs. Rack Mount - 17 lbs. net; shipping 30 lbs.

400B001-1 8/20/56 Serial 8938 and above

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hp MODEL 400B

VACUUM TUBE VOLTMETER

SECTION I

GENERAL DESCRIPTION

1-1 GENERAL

The Model 400B Vacuum Tube Voltmeter is an accurate voltmeter with high sensitivity and high input impedance. Alternating current voltage as small as .005 volts and up to 300 volts at frequencies from 2 cycles/sec. to 100,000 cycles/sec. may be measured with the voltmeter. The input impedance is high enough so as not to disturb the majority of circuits being measured.

The Model 400B is useful for laboratory work where quick and accurate measurements of amplifier gain, network response hum level, and output level are to be made.

The higher voltage ranges are useful for measuring power circuit voltages in broadcast and television equipment.

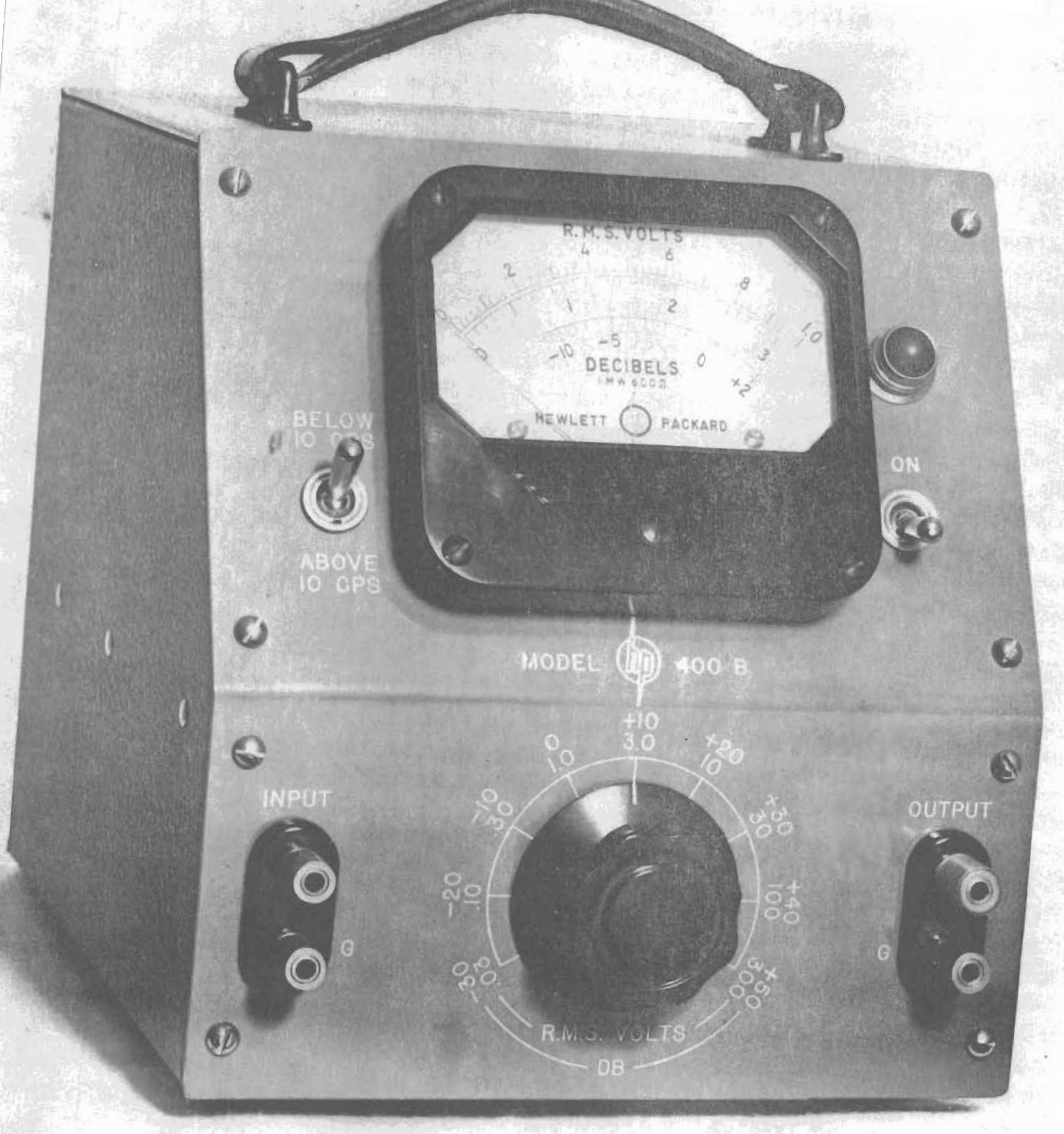
1-2 PARTS SUBSTITUTIONS

Difficulties in procuring some of the parts used in this instrument may cause the electrical or physical values to deviate from those shown in this instruction manual. These substitutions have been made so as not to impair the performance of this instrument. Whenever replacement of any of these parts is necessary, either the substitute value or the original value may be used.

CAUTION

The maximum voltage applied to the input terminals of the Model 400B Vacuum Tube Voltmeter must not exceed 600 volts, the sum of the dc voltage and the ac peak voltage. Higher voltages will break down the capacitors in the input system of the instrument.

Electrolytic capacitor C9 abcd is a very high quality capacitor which has a useful life of from five to ten years. Do not replace this capacitor unless it is proven defective by accurate tests.



Front View of Model 400B

400B001-1 8/20/56 Serial 8938 and above

SECTION II

OPERATING INSTRUCTIONS

2-1 INSPECTION

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received.

After the instrument is unpacked, it should be carefully inspected for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this instruction book.

2-2 CONTROLS AND TERMINALS

ON

This toggle switch controls the power supplied to the instrument from the power line. When the switch is in the ON position the red indicator will glow.

DB - RMS VOLTS

This rotary switch connects the proper multiplier resistors into the circuit for the desired voltage range. The position of the switch indicates the meter scale and the full scale voltage of the range in use. The switch position also indicates the DB level when the meter pointer indicates zero on the DB scale.

INPUT

The two binding posts, located in the lower left hand corner of the control panel, are connected to the input circuit of the instrument. The binding post marked G is connected to the chassis.

OUTPUT

The two binding posts, located in the lower right hand corner of the control panel, are connected to the output of the amplifier. The amplifier has a high impedance output circuit. The output voltage available at these terminals is from 17.5 to 24 volts with full scale meter deflection.

CAUTION

The maximum voltage applied to the input terminals of the Model 400B Vacuum Tube Voltmeter <u>must not exceed 600 volts</u>, the sum of the dc voltage and the ac peak voltage. Higher voltages will break down the capacitors in the input system of the instrument.

FUSE

The fuseholder, located on the back of the chassis, contains a .6 ampere slo-blo cartridge fuse. To replace the fuse, unscrew the fuseholder cap and remove the blown fuse. Insert a new fuse of the same type and replace the fuseholder cap.

Power Cable

The power cable consists of three conductors. Two of these conductors carry power to the instrument while the third conductor (green wire) is connected to the instrument chassis. The third wire projects from the cable near the plug end of the cable and may be connected to a ground when it is desirable to have a grounded chassis.

BELOW 10 CPS, ABOVE 10 CPS

This toggle switch is used to add capacity across the meter when the instrument is operated on frequencies below 10 cycles/sec. The added capacity (2000 µf) bypasses the very low frequencies around the meter so that the meter pointer will not vibrate.

2-3 OPERATION

Voltage Measurements - Plug the power cable into a 115 volt power line and turn the toggle switch to ON. Allow the instrument about five minutes to reach a state of stable operation. Set the DB-RMS VOLTS range switch to the desired voltage range and connect the input terminals to the voltage being measured. The BELOW 10 CPS, ABOVE 10 CPS switch should be set to agree with the frequency of the voltage being measured. The meter scale multiplying factor (DB-RMS VOLTS switch position divided by the full scale value of the meter scale in use) times the meter indication equals the voltage being measured.

Examples:

A. 100 (DB-RMS VOLTS switch position) ÷ 1 (full scale value of meter scale in use) = 100 (Meter scale multiplying factor).

100 (meter scale multiplying factor) x .83 (meter scale indication) = 83 volts (measured voltage).

B. 30 (DB-RMS VOLTS switch position) ÷ 3 (full scale value of meter scale in use) = 10 (meter scale multiplying factor).

10 (meter scale multiplying factor) x 2.3 (meter scale indication) = 23 volts (measured voltage).

Whenever it is necessary to view the wave shape of the measured voltage, an oscilloscope may be connected to the OUTPUT terminals of the instrument.

As a precaution in maintaining accuracy of measurement, it must be kept in mind that the instrument is an average reading-device. Although the calibration on the face of the instrument is marked "RMS Volts", this simply means that the meter will read the rms value of a true sine wave. If the wave form of the voltage being measured contains appreciable harmonic voltages or other spurious voltages, errors in measurement will be encountered of a magnitude indicated by the following table.

EFFECT OF HARMONICS ON MODEL 400B VOLTAGE MEASUREMENTS		
Input Voltage Characteristics	True RMS Value	Value Indicated by Model 400B
Fundamental - 100	100	100
Fundamental + 10% 2nd harmonic	100.5	100
Fundamental + 20% 2nd harmonic	102	100 - 102
Fundamental + 50% 2nd harmonic	112	100 - 110
Fundamental + 10% 3rd harmonic	100.5	96 - 104
Fundamental + 20% 3rd harmonic	102	94 - 108
Fundamental + 50% 3rd harmonic	112	90 - 116

DB Measurement - Decibel measurements are made in the same way as voltage measurements except that the DB scale is used and the measurements must be made across 600 ohms, if the 1 milliwatt across 600 ohms reference level is to be used. The difference between two or more voltages, measured in decibels, may be read directly from the Model 400B provided each measurement is made across the same value of impedance. The decibel level being measured is determined by sum difference of the meter scale indication and the range switch indication. The plus or minus signs before the meter scale figures, determine whether the meter scale indication is to be added or subtracted from the decibel level shown by the range switch.

Examples:

C. Interpreting the range switch position and meter scale indication for a level of +12 db. Measured across 600 ohms with one milliwatt across 600 ohms as the reference level.

+10 db (DB-RMS VOLTS switch position) plus +2 db (db meter scale indication) = +12 db or +20 db (DB-RMS VOLTS switch position) plus -8 db (db meter scale indication) = +12 db.

D. Interpreting the range switch position and meter scale indication for the difference between two voltages, measured in decibels, across the same value of impedance.

Voltages equal -37 db and +12 db.
-30 db (DB-RMS VOLTS switch position) plus -7 db (db meter scale indication) = -37 db
+10 db plus +2 db (from Example C) = (-) +12 db
49 db

(total decibel difference between the two voltages)

Characteristics of the Amplifier Function of the Model 400B - The output circuit of the amplifier (OUTPUT terminals) is designed to work into a load of 100,000 or more ohms.

At full scale meter indication, the output voltage will be approximately 17.5 to 24 volts on any range. The approximate gain between the INPUT and OUTPUT terminals, with full scale meter indication, is shown by the following table.

Gain	Range
+56 db	.03V full scale
+46 db	.1 V " "
+36 db	.3 V " "
+26 db	1.0 V " "
+16 db	3.0 V " "
+ 6 db	10.0 V " "
- 4 db	30.0 V " "
-14 db	100.0 V " "
-24 db	300.0 V " "

Zero Meter Indication - The meter pointer may not coincide with the zero scale mark when the instrument is turned off. This condition is normal.

SECTION III

THEORY OF OPERATION

3-1 INTRODUCTORY

The circuit of the Model 400B Vacuum Tube Voltmeter consists of a cathode follower input stage, a stablized amplifier, a rectifier and meter section, and a regulated power supply.

The voltage applied to the input terminals is passed through a blocking capacitor to the grid of the 6J5 cathode-follower input stage. The cathode resistor is a tapped precision wirewound resistor which serves as the voltmeter multiplier on all but the two highest ranges. On the higher ranges a high-resistance frequency-compensated voltage divider is switched across the input terminals and ahead of the grid of the first tube.

The cathode follower feeds into a broad-band resistance-coupled amplifier using 6AC7 tubes. Negative feedback is used in this amplifier in order to obtain high stability and uniform response over a wide frequency range, and to make the amplifier more independent of variations in tube characteristics.

From the amplifier the voltage is passed to a full wave rectifier using a 6H6 duo-diode tube. The indicating meter is connected from one plate to the opposite cathode of the tube and therefore is actuated by a portion of the plate current of the two diodes.

Direct current for the plate supply of the tubes in the instrument is obtained from a conventional full-wave rectifier feeding into a resistance-capacity filter. A voltage-regulating circuit across the output of the rectifier keeps the plate supply voltage constant over a wide range of line voltages.

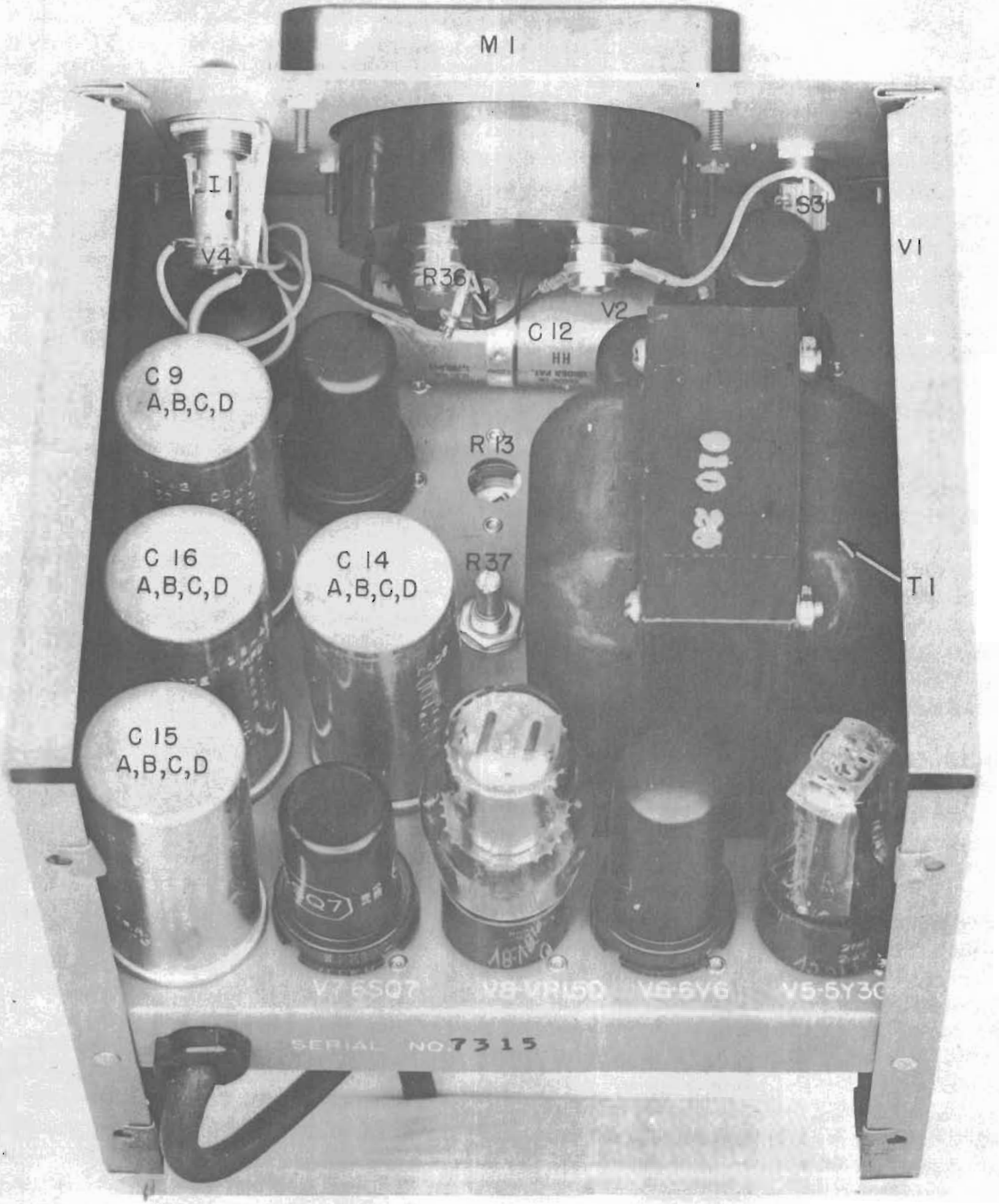


Fig. 1. Top View of Model 400B Cover Removed

SECTION IV

MAINTENANCE

4-1 COVER AND BOTTOM PLATE REMOVAL

The cover is removed by unscrewing the four screws which fasten the cover to the back of the instrument, and sliding the cover away from the panel.

The bottom plate is fastened to the instrument with four screws, one in each corner of the plate.

4-2 TUBE REPLACEMENT

The replacement of tubes will have a slight effect upon the calibration of this instrument. Now and then, when replacing 6AC7 tubes, a permanent deflection of the meter pointer will be observed with the input terminals shorted and when the new tube has heated. This condition is usually caused by a cathode-heater leakage and the tube should be rejected in favor of another.

When replacing 6H6 and/or 6AC7 tubes, it is desirable to check the voltage response of the new tube if the voltmeter is being operated from an unregulated line voltage. This check can be made by applying a constant voltage to the input terminals and varying the line voltage ±10 volts from 115 volts. The voltmeter reading should not change by more than 2% at frequencies below 100 KC. Try another tube if necessary.

4-3 CHECKING CALIBRATION

Probably the most accurate method which can be used in the field to check the calibration of the Model 400B is a test using a cathode-ray oscilloscope and a freshly calibrated dynamometer type voltmeter.

After the new tube has heated in the Model 400B, apply a low-frequency (50-60 cps) voltage simultaneously to both the Model 400B and the dynamometer type voltmeters. Readings of the two instruments should agree closely. Try another tube if necessary.

Next, calibrate the cathode-ray tube of the oscilloscope by applying a low-frequency sinusoidal voltage simultaneously to the dynamometer voltmeter and to the vertical-deflecting electrodes of the c-r tube. No horizontal sweep voltage should be used. Directions for connecting to the deflecting electrodes of the tube are usually given by the manufacturer of the oscilloscope. By measuring the peak-to-peak deflection of the c-r tube trace with a graph screen and by noting the reading of the voltmeter, the deflection voltage of the c-r tube can be quickly determined. It is important that the voltage used to calibrate the c-r tube be essentially sinusoidal and free from harmonics.

Now connect the Model 400B in parallel with the vertical-deflecting plates of the c-r tube and apply sinusoidal voltages of frequencies up to 100 KC to the combination of the two instruments. The voltage shown by the Model 400B should agree closely with that indicated by the magnitude of deflection of the c-r tube trace. If such is not the case, try another tube in the Model 400B and repeat the process.

The above procedure will give a reasonable check at all frequencies within the range of the Model 400B, although a check cannot be made of small voltages. Low voltage ranges can be checked by starting with a voltage within one of the ranges checked on the oscilloscope and working downward. For example, if the accuracy and frequency response of the 100-volt range of the Model 400B have been checked on the oscilloscope, apply a 25-volt wave to the Model 400B and note the reading on the 100-volt range. Then switch to the 30-volt range and note that the reading is correct. By extending this procedure, all ranges of the instrument can be checked.

Although the above methods will not give precision results, they will often prove helpful in determining whether or not old tubes have exceeded their service life or new tubes are satisfactory to use.

Beyond changing tubes, it is not recommended that repair or calibration of this instrument be attempted in the field, because of the elaborate equipment required. Either the ⓗⓟ factory or any ⓗⓟ authorized field Repair Station will recalibrate the instrument quickly and at a nominal charge; contact your ⓗⓟ field engineer for further information. Use of this service will usually save a great deal of time.

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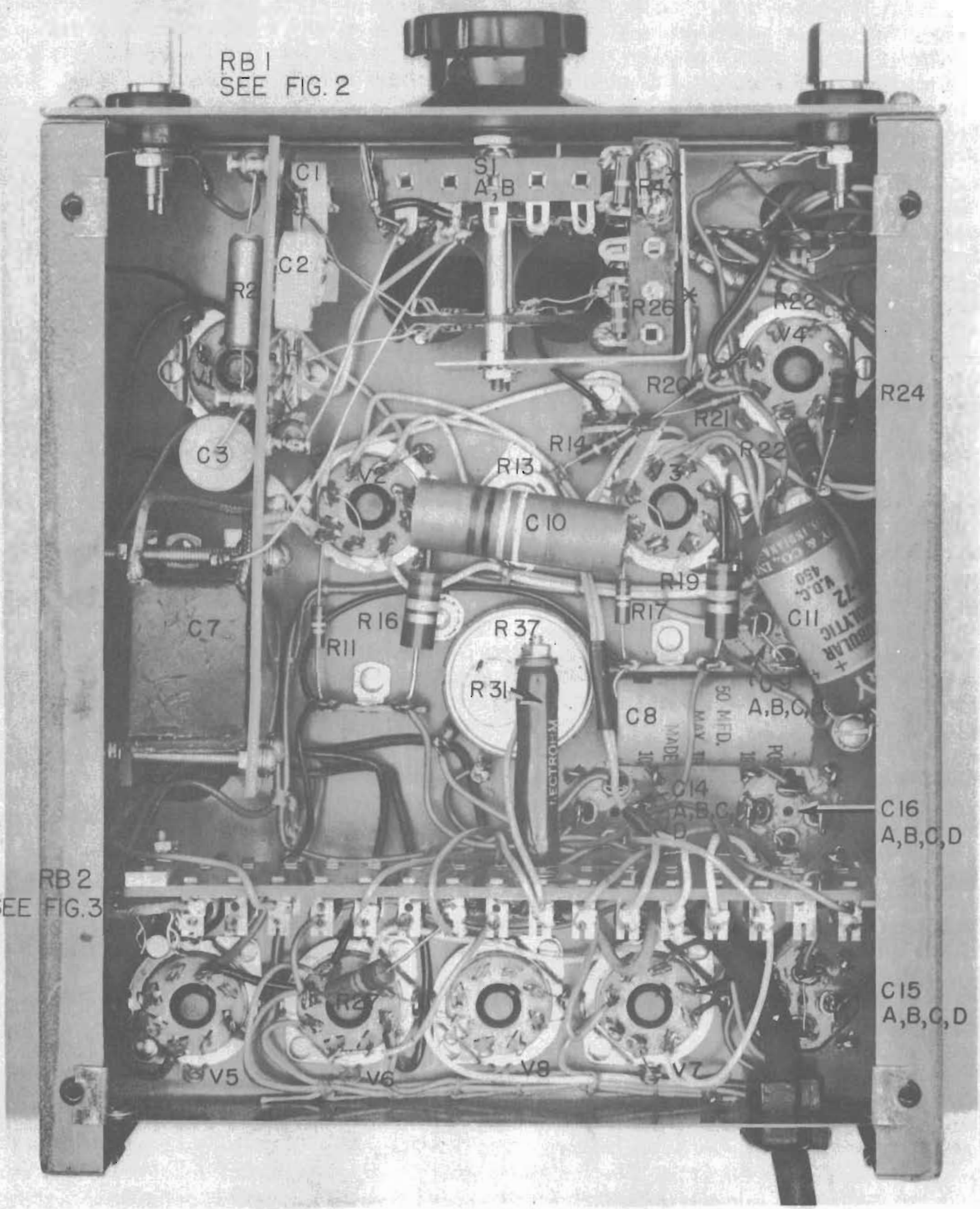


Fig. 2 Bottom View of Model 400B Bottom Plate Removed

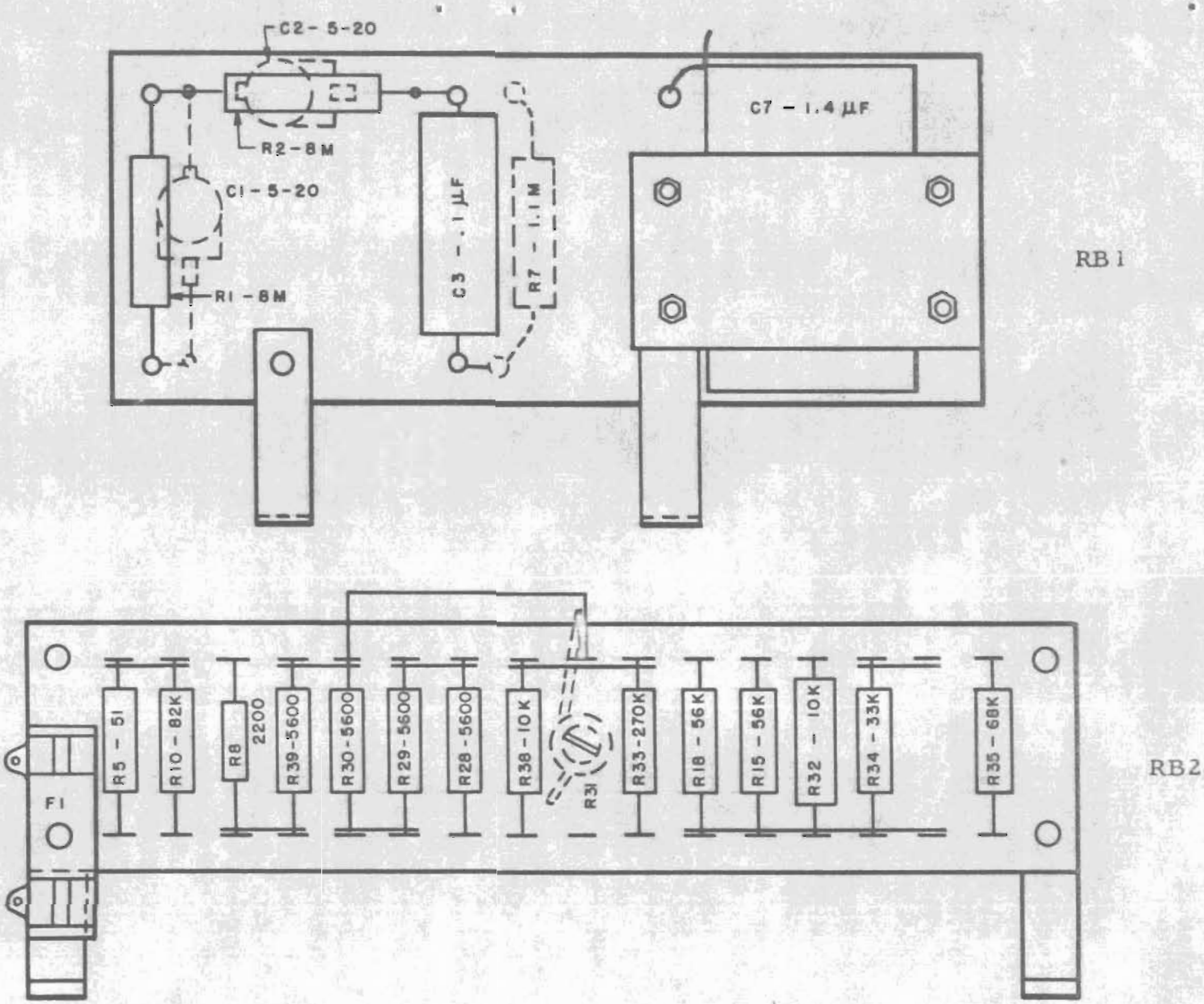
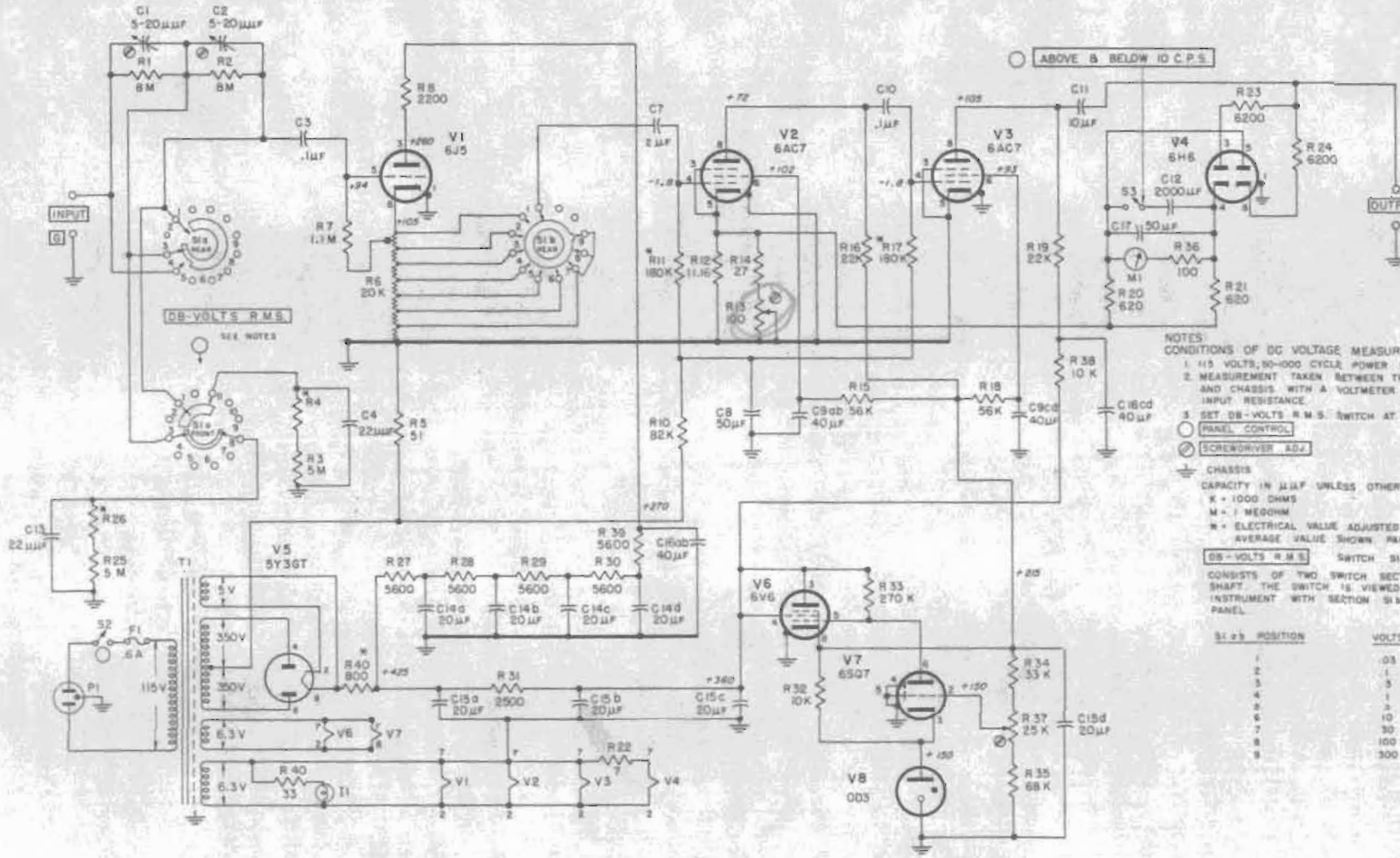


Fig. 3. Model 400B Resistor Board Detail



NOTES
CONDITIONS OF DC VOLTAGE MEASUREMENT
1. 115 VOLTS, 50-1000 CYCLE POWER SUPPLY.
2. MEASUREMENT TAKEN BETWEEN THE INDICATED POINTS AND CHASSIS WITH A VOLTMETER OF 100 MEGOHMS INPUT RESISTANCE.
3. SET DB-VOLTS R.M.S. SWITCH AT 300 V, S3 ON ABOVE 10 C.P.S.

○ PANEL CONTROL

⊘ SCREWDRIVER ADJ.

⏚ CHASSIS

CAPACITY IN µµF UNLESS OTHERWISE NOTED

K = 1000 OHMS

M = 1 MEGOHM

* = ELECTRICAL VALUE ADJUSTED AT THE FACTORY. AVERAGE VALUE SHOWN. PART MAY BE OMITTED

DB-VOLTS R.M.S. SWITCH S1 ab

CONSISTS OF TWO SWITCH SECTIONS (a b) ON A COMMON SHAFT. THE SWITCH IS VIEWED FROM THE REAR OF THE INSTRUMENT WITH SECTION S1 b NEXT TO THE CONTROL PANEL

S1 a b POSITION	VOLTS
1	.03
2	1
3	3
4	1
5	3
6	10
7	30
8	100
9	300

hp MODEL 400B

LOW FREQUENCY VACUUM TUBE VOLTMETER

SERIAL 8938 & ABOVE

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C1	Capacitor: variable, ceramic, 5-20 μμf, 500 vdcw	13-20	L TS2A-N300
C2	Capacitor: variable, ceramic, 5-20 μμf, 500 vdcw	13-20	L TS2A-N300
C3	Capacitor: fixed, paper, .1 μf, ±10%, 600 vdcw	1601	A Type P688
C4	Capacitor: fixed, mica, 22 μμf, ±10%, 500 vdcw	14-61	V Type OXM
C5, C6	These circuit references not assigned		
C7	Capacitor: fixed, paper, dielectric, 2 μf, ±20%, 400 vdcw	16-81	Gudeman Co. # 231E205
C8	Capacitor: fixed, electrolytic, 50 μf, -10%, +200%, 50 vdcw	18-50	X TC-39
C9 abcd	Capacitor: fixed, electrolytic, 20, 20, 40 μf, 450 vdcw	18-42S	HP
C10	Capacitor: fixed, paper, .1 μf, ±10%, 600 vdcw	16-1	A Type P688
C11	Capacitor: fixed, electrolytic 10 μf, 450 vdcw	18-10	X WB 72
C12	Capacitor: fixed, electrolytic, 2000 μf, 6 vdcw	18-6	J BRH-620
C13	Capacitor: fixed, mica, 22 μ μ f, ±10%, 500 vdcw	14-61	V Type OXM
C14 abcd C15 abcd C16 abcd	Capacitor: fixed, electrolytic, 20, 20, 20, 20 μf, 450 vdcw	18-42	X FPQ-444
C17	Capacitor: fixed, electrolytic, 50 μf, -10%, +200%, 50 vdcw	18-50	X TC-39
R1, R2	Resistor: fixed, composition, 8 megohms, ±1%, 1 W	31-8M	HP
R3	Resistor: fixed, composition, 9.55 megohms, ±1%, 1W Five megohms made up of two 9.55 megohm resistors in parallel.	31-9.55M	HP
R4	Electrical value adjusted at factory		
R5	Resistor: fixed, composition, 51 ohms, ±5%, 1 W	24-51-5	B GB 5105

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R6	Resistor: Part of Range Switch Assy.		
R7	Resistor: fixed, composition, 1.1 megohms, -0% +1%, 1 W	31-1.04M	HP
R8	Resistor: fixed, composition, 2200 ohms, ±10%, 1/2 W	23-2200	B EB 2221
R9	This circuit reference not assigned		
R10	Resistor: fixed, composition, 82, 000 ohms, ±10%, 1W	24-82K	B GB 8231
R11	Resistor: fixed, composition, 180, 000 ohms, ±10%, 1/2 W Electrical value adjusted at factory	23-180K	B EB 1841
R12	Resistor: fixed, wirewound, 11.16 ohms	4B-90	HP
R13	Resistor: variable, wirewound, 100 ohms, linear taper	210-28	Muter Co. #10516
R14	Resistor: fixed, composition 27 ohms, ±10%, 1/2 W	23-27	B EB 2701
R15	Resistor: fixed, composition, 56, 000 ohms, ±10%, 1 W	24-56K	B GB 5631
R16	Resistor: fixed, composition, 22, 000 ohms, ±10%, 2 W	25-22K	B HB 2231
R17	Resistor: fixed, composition, 1800, 000 ohms, ±10%, 1/2 W electrical value adjusted at factory	23-180K	B EB 1841
R18	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R19	Resistor: fixed, composition 22, 000 ohms, ±10%, 2 W	25-22K	B HB 2231
R20	Resistor: fixed, composition, 620 ohms, ±5%, 1/2 W	23-77	B EB 6215
R21	Resistor: fixed, composition, 620 ohms, ±5%, 1/2 W	23-77	B EB 6215
R22	Resistor: fixed, wirewound, 7 ohms, ±10%, 2 W	26-18	I CM 8027
R23	Resistor: fixed, composition, 6200 ohms, ±5%, 1 W	24-86	B GB 622 5

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R24	Resistor: fixed, composition, 6200 ohms, ±5%, 1W	24-86	B GB 6225
R25**	Resistor: fixed, composition, 9.55 megohms, ±1%, 1 W Five megohms made up of two 9.55 megohm resistors in parallel.	31-9.55M	HP
R26	Resistor: electrical value adjusted at factory		
R27-R30	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W	24-5600	B GB 5621
R31	Resistor: fixed, wirewound, 2500 ohms, ±10%, 10 W	26-7	S Type 1-3/4E
R32	Resistor: fixed, composition, 10,000 ohms, ±10%, 2 W	25-10K	B HB 1031
R33	Resistor: fixed, composition, 270,000 ohms, ±10%, 1 W	24-270K	B GB 2741
R34	Resistor: fixed, composition, 33,000 ohms, ±10%, 1 W	24-33K	B GB 3331
R35	Resistor: fixed, composition, 68,000 ohms, ±10%, 1 W	24-68K	B GB 6831
R36	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100	B GB 1011
R37	Resistor: variable, composition, 25,000 ohms, linear taper	210-11	G BAI-010-1990
R38	Resistor: fixed, composition, 10,000 ohms, ±10%, 1 W	24-10K	B GB 1031
R39	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W	24-5600	B GB 5621
R40	Resistor: fixed, wirewound, 800 ohms, ±10%, 10 W Electrical value adjusted at factory	26-6	S Type 1-3/4E
	Binding Post	312-3	HP
	Binding Post Insulator	G-83A	HP
	Binding Post Insulator: yellow plastic cap	M-58	HP

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
F1	Fuse: .6A (opens in 5 sec. minimum to 60 sec. maximum at 200% overload)	211-49	T 313600
	Fuseholder:	312-8	T342001
	Indicator Lamp Assembly:	312-10	BB, 807BS
	Knob: 2" diam.	37-13	HP
I1	Lamp	211-47	O, Mazda #47
M1	Meter:	112-6	HP
P1	Power Cable:	812-56	HP
S1 ab, R3** R4, R25** R26	Range Switch Assembly: **R3 and R25 are part of Range Switch Assembly	4B-19W	HP
S2	Toggle Switch: SPST	310-11	D, 20994-HW
S3	Toggle Switch: SPST	310-11	D, 20993-HW
T1	Power Transformer:	910-20	HP
V1	Tube: 6J5	212-6J5	ZZ
V2	Tube: 6AC7	212-6AC7	ZZ
V3	Tube: 6AC7	212-6AC7	ZZ
V4	Tube: 6H6	212-6H6	ZZ
V5	Tube: 5Y3GT	212-5Y3GT	ZZ
V6	Tube: 6V6	212-6V6	ZZ
V7	Tube: 6SQ7	212-6SQ7	ZZ
V8	Tube: OD3	212-OD3	ZZ

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

400B001-1 8/20/56 Serial 8938 and above

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.