INSTRUCTION AND OPERATING MANUAL

FOR

MODEL 404A

VACUUM TUBE VOLTMETER
(PORTABLE)

Serial 462 and Above

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

General Description

The Model 404A Vacuum Tube Voltmeter is designed for general voltage measurements where alternating current power is not available. It is an easily handled portable voltmeter using self-contained standard dry batteries.

Measurements of voltages from .001 to 300 volts at frequencies from 2 to 20,000 cycles/sec. may be made with this instrument. These voltage and frequency ranges make this instrument suitable for remote broadcast line and carrier current checks, strain gauge system tests, geophysical and telemetering circuit measurements. It may also be used as a standard amplifier of 60 db gain.

CAUTION

THE MAXIMUM VOLTAGE APPLIED TO THE INPUT TERMINALS OF THE MODEL 404A 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 CAPACITOR IN THE INPUT SYSTEM OF THE INSTRUMENT.

CAUTION

IN ORDER TO OBTAIN MAXIMUM USEFUL LIFE FROM THE BATTERIES IN THIS INSTRUMENT, ALWAYS TURN OFF THE POWER SWITCH WHEN THE INSTRUMENT IS NOT IN USE.

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 the replacement of any of these parts is necessary, either the substitute value or the original value may be used.

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Specifications

Voltage Ranges --

Volts Full Scale (RMS)-

.003, .01, .03, .1, .3, 1, 3, 10, 30, 100, and 300

DB -

-50, -40, -30, -20, -10, 0, +10, +20, +30, +40, and +50

Frequency Range --

2 to 50,000 cycles/second

Accuracy --

±3% of full scale, 2 to 20,000 cycles/sec.
±7% of full scale, 2 to 50,000 cycles/sec.
Including calibration error, tube aging, and battery aging.

Meter Calibration --

Meter calibrated to RMS value of a sine wave.
Linear voltage scales 0 - 1V and 0 - 3V.
DB scale - -12 to +2 db
Voltage ranges related by 10 DB steps.
Zero level = 1 milliwatt into 600 ohms.

Input Impedance --

10 megohms shunted by approximately 20 μμf.

Amplifier --

Maximum gain - 60 db ±5 db into an open circuit
Maximum output voltage - 15 volts into an open circuit

Power Source (Self Contained) --

Filament - 5 Burgess No. 2 (or equivalent) flashlight batteries (1-1/2 volts each)

Plate - 3 Burgess #Z30NX (or equivalent) batteries (45 volts each)

Battery Life - 60 hours total when used at a rate of 4 hours daily.

Overall Dimensions --

12-1/8" high x 9-7/8" wide x 10-3/8" deep

Weight --

Approximately 17 lbs. including batteries

Operating Instructions

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.

Controls and Terminals --

BELOW 10 CPS - ABOVE 10 CPS - In the BELOW 10 CPS switch position, additional capacity is connected across the meter to prevent the meter pointer from oscillating when measuring voltages at frequencies below 10 cycles/sec. This switch does not function when the VOLTMETER-AMPLIFIER switch is set to AMPLIFIER.

OFF-ON - This rotary switch controls the power supplied to the instrument from the batteries. When the switch is in the OFF position, the four filament circuits and the two high voltage wires from the batteries are opened. When the instrument is turned on, the neon lamp on the control panel will flash periodically.

VOLTMETER - AMPLIFIER - In the VOLTMETER position the instrument functions as a voltmeter. When the toggle switch is changed to the AMPLIFIER position, the meter M1 and the two crystal rectifiers are switched out of the circuit and the instrument functions as an amplifier with 60 db gain. This switch also connects the output of the amplifier to the OUTPUT terminals and inserts the necessary compensating resistors in the amplifier output circuit.

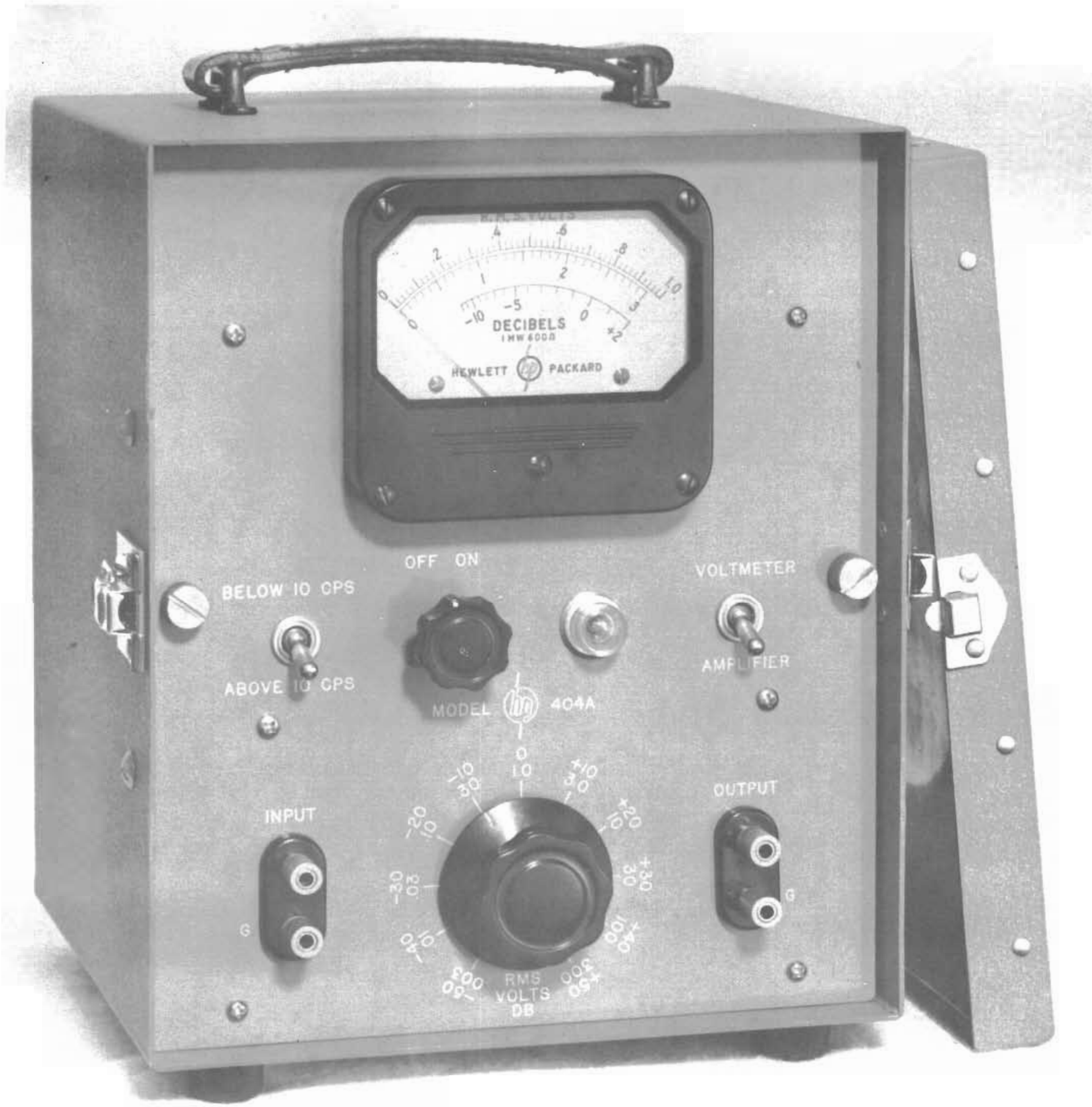

Fig. 1 Model 404A Vacuum Tube Voltmeter

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

OUTPUT - The two binding posts, located in the lower right corner of the control panel, are the output terminals of the amplifier. The lower binding post marked G is connected to the chassis.

RMS VOLTS - DB - 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 full scale voltage of the range in use. The switch position also indicates the DB level (instrument connected across 600 ohms) when the meter pointer indicates zero on the DB scale.

Operation --

CAUTION

THE MAXIMUM VOLTAGE APPLIED TO THE INPUT TERMINALS OF THE MODEL 404A 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 CAPACITOR IN THE INPUT SYSTEM OF THE INSTRUMENT.

Voltage Measurements - Set the DB-RMS VOLTS range switch to the desired voltage range, the VOLTMETER - AMPLIFIER switch to VOLTMETER and the BELOW 10 CPS - ABOVE 10 CPS switch to the correct position for the frequency of the voltage to be measured. Turn the OFF - ON switch to ON and connect the INPUT terminals to 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) $\div$ 1 (full scale value of meter scale in use) = 100 (Meter scale multiplying factor)

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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)

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.

% Harmonic	True RMS Value	Model 404A Indication	Peak Meter Indication
0	100	100	100
10% 2nd	100.5	100	90 to 100
20% 2nd	102	100-102	80 to 120
50% 2nd	112	100-110	75 to 150
10% 3rd	100.5	96-104	90 to 110
20% 3rd	102	94-108	80 to 120
50% 3rd	112	90-116	108 to 150

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 404A provided each measurement is made across the same value of impedance. The decibel level being measured is determined by sum or 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.

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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)

An oscilloscope may be connected to the OUTPUT terminals of the instrument for observing the wave shape of the voltage being measured.

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

The zero adjustment screw is set for optimum meter tracking accuracy and then the screw is sealed.

Amplifier Operation - To change the instrument to operate as an amplifier, set the VOLTMETER-AMPLIFIER switch to AMPLIFIER. Connect the INPUT terminals to the voltage to be amplified and the OUTPUT terminals to a high impedance load (100,000 ohms or more) such as an oscilloscope. Set the RMS-DB (range switch) so that the input voltage does not exceed the values given in the following table.

Range Switch Position	Maximum Input	Overall Gain
.003 V	.015 V	60 db
.01 V	.045 V	50 db
.03 V	.15 V	40 db
.1 V	.45 V	30 db
.3 V	1.5 V	20 db
1.0 V	4.5 V	10 db
3.0 V	15.0 V	0 db

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The maximum gain obtainable from this amplifier is 60 db, over the frequency range 2 to 20,000 cycles/sec., when the range switch is in the .003 volt position. The maximum output voltage obtainable with negligible distortion is 15 volts into an open circuit at the range switch positions .003, .01, .1, .3, 3 volts. The output voltage at the .03 and 1 volt range switch positions is limited to 7 volts. Range switch positions above the 3 volt range provide less than unity amplifier gain.

Circuit Description

The Model 404A Vacuum Tube Voltmeter consists of frequency compensated attenuator, amplifier, meter rectifier circuit, and dry batteries to supply the filament and plate voltages.

The unknown voltage is applied to the input terminals of the instrument which are connected through C1 to the first section of the frequency compensated attenuator. This section of the attenuator consists of C2-C5, R1-R6, and S1A-S1C, S1H. The manner in which the various elements of the attenuator are connected for each voltage range is shown in Fig. 2.

After the unknown voltage has been attenuated sufficiently it is applied to the grid of tube V1. Tubes V1 and V2 form a two stage resistance coupled amplifier which is stabilized by negative feedback. The output of this amplifier is fed to the second section of the frequency compensated attenuator through capacitor C10.

The amplified unknown voltage is reduced in this section of the attenuator in the same way as in the first section but in a different amount. The second section consists of C11-C14, R16-R20, S1D, S1G, S1I, S1J. The connections of the various elements of the attenuator for each voltage range are shown below.

Tubes V3 and V4 are connected as a two stage amplifier with negative feedback. This amplifier amplifies the unknown voltage from the second section of the attenuator and feeds it to the meter rectifier circuit. The two crystal rectifiers CR1 and CR2 provide full-wave rectification of the unknown voltage and produce a direct current which causes the meter to indicate the RMS value of the original unknown voltage. The meter circuit is returned to ground through resistors R30, R31. Voltage from this circuit is also applied to the grid circuit of V3 to provide negative feedback around tubes V3 and V4.

When the instrument is used as an amplifier, the meter rectifier circuit is removed from the circuit and compensating resistors are inserted to maintain the correct negative feedback.

Maintenance

Battery Replacement --

Measurement of Battery Voltage - The most convenient method of measuring the battery voltage is to unscrew the clear plastic cover and remove the neon glow lamp I1. Connect the negative terminal of a high resistance voltmeter to the chassis. Turn on the instrument and connect the positive terminal of the voltmeter to the shell or center contact (the contact producing the highest voltmeter indication) of the neon lamp socket. For satisfactory operation of the instrument this voltage should be 100 volts (filament voltage 1,1 volts) or more with the instrument in operation.

When the battery voltage drops below 100 volts, both the filament and plate supply batteries must be replaced. If the batteries are used after the voltage has fallen below 100 volts inaccurate voltage measurements will result.

The instrument is designed so that the plate and filament batteries will deteriorate at approximately the same rate. Therefore, the two sets of batteries must be replaced at the same time.

Battery Replacement Procedure - The procedure for replacing the batteries is as follows:

1. Remove the case cover and unscrew the two captive screws. Slide the instrument out of the case.

2. Face the back of the instrument. Remove the four screws which hold the back plate in place and remove. Loosen the battery terminals and remove all the wires from the batteries.

3. Lift out the batteries and replace with a set of fresh batteries. Connect the wires to the proper terminals. (See Fig. 5) Replace the back plate.

4. Replace the filament supply batteries with fresh batteries.

5. Turn on the instrument and measure the battery voltages as described in the Measurement of Battery Voltage section. The plate batteries should be at least 130 volts under load and filament batteries at least 1-1/2 volts when loaded. If the battery voltages are normal, then replace the instrument in the case.

Tube Replacement --

If the tubes used for replacement in this instrument have average characteristics, there will be little or no change in the calibration. However, if there is reason to suspect the calibration accuracy, the instrument should be checked against a known sine wave voltage or compared with another meter that is known to be accurate. The procedures described below may be used to restore the calibration to approximately its specified accuracy or the instrument may be returned

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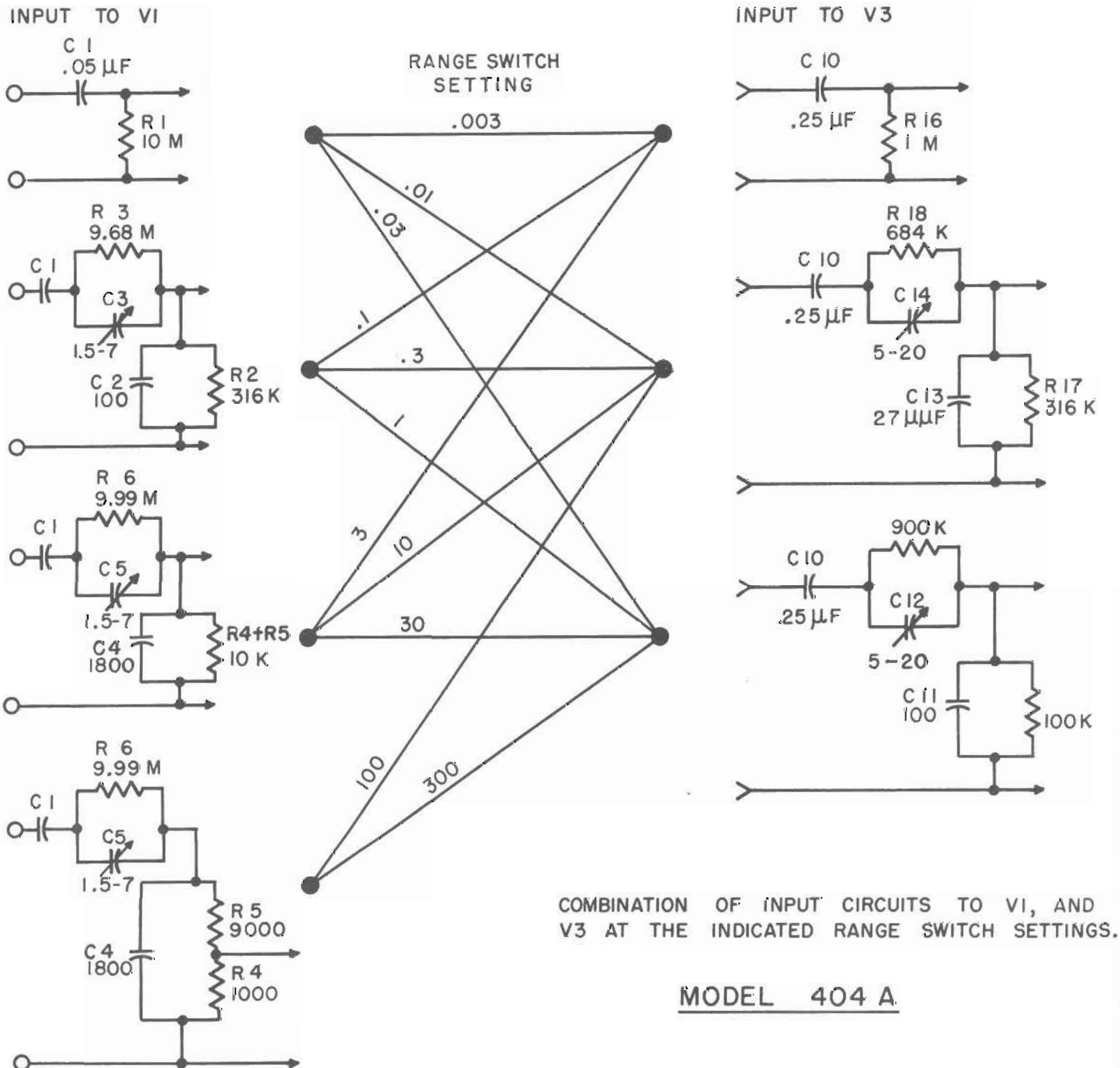

COMBINATION OF INPUT CIRCUITS TO V1, AND V3 AT THE INDICATED RANGE SWITCH SETTINGS.

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Fig. 2

to the Hewlett-Packard Co. where this service will be performed for a nominal charge.

Calibration Procedure --

Screen Voltage Adjustment - This adjustment is necessary when tube V1 or V2 has been replaced. When the screen resistor R9 has been set to the optimum value, the accuracy of the instrument is practically independent of the decrease in voltage of the plate supply batteries over the normal life of the batteries.

The procedure for this adjustment is as follows:

1. Remove the instrument from the case and remove the back plate so that the battery connections are accessible.

2. Operate the instrument as a voltmeter and apply a voltage of 1 volt RMS at 100 cycles/sec. to the INPUT terminals. Record the exact meter indication.

3. Turn off the instrument. Re-connect the high voltage wires to the batteries (BT6, BT7, BT8) as follows: (See Fig. 5)

+135V (red wire) to the 112-1/2 V. battery terminal
+112-1/2 (orange wire) to the +90 V. battery terminal
+135 V battery terminal vacant

4. Turn on the instrument. Apply exactly the same voltage, as in step 2, to the INPUT terminals. If the meter indication is the same as before, no adjustment is necessary.

5. If the adjustment is correct, then return the battery wires to their original terminals.

6. If adjustment is necessary, adjust R9 (see Fig. 3) so that the meter indication is the same as was recorded for step 2. Input voltage same as in step 2.

7. Return battery wires to their original terminals. Repeat step 2. If the original meter indication and the meter indication obtained in this step are the same, the adjustment is complete. If the meter indications are not the same, repeat all the above adjustments. Another new tube may be necessary if the correct adjustment cannot be obtained after several tries.

Calibration Adjustment -- Adjustment of the .003 volt range may be performed in the field and usually this adjustment will provide satisfactory calibration accuracy. The adjustment of the frequency response and other voltage ranges should not be attempted in the field.

The procedure for adjusting the calibration of the .003 volt range is as follows:

1. Set the range switch to .003 VOLTS and apply .003 volts at approximately 100 cycles/sec. to the INPUT terminals of the instrument. Adjust R30 (see Fig. ~~8~~ 4) so that the meter indicates exactly .003 volts.

Amplifier Gain Adjustment -

The procedure for adjusting the gain of the amplifier is as follows:

1. Set the VOLTMETER-AMPLIFIER switch to the AMPLIFIER position and the range switch to the .003 VOLTS position.

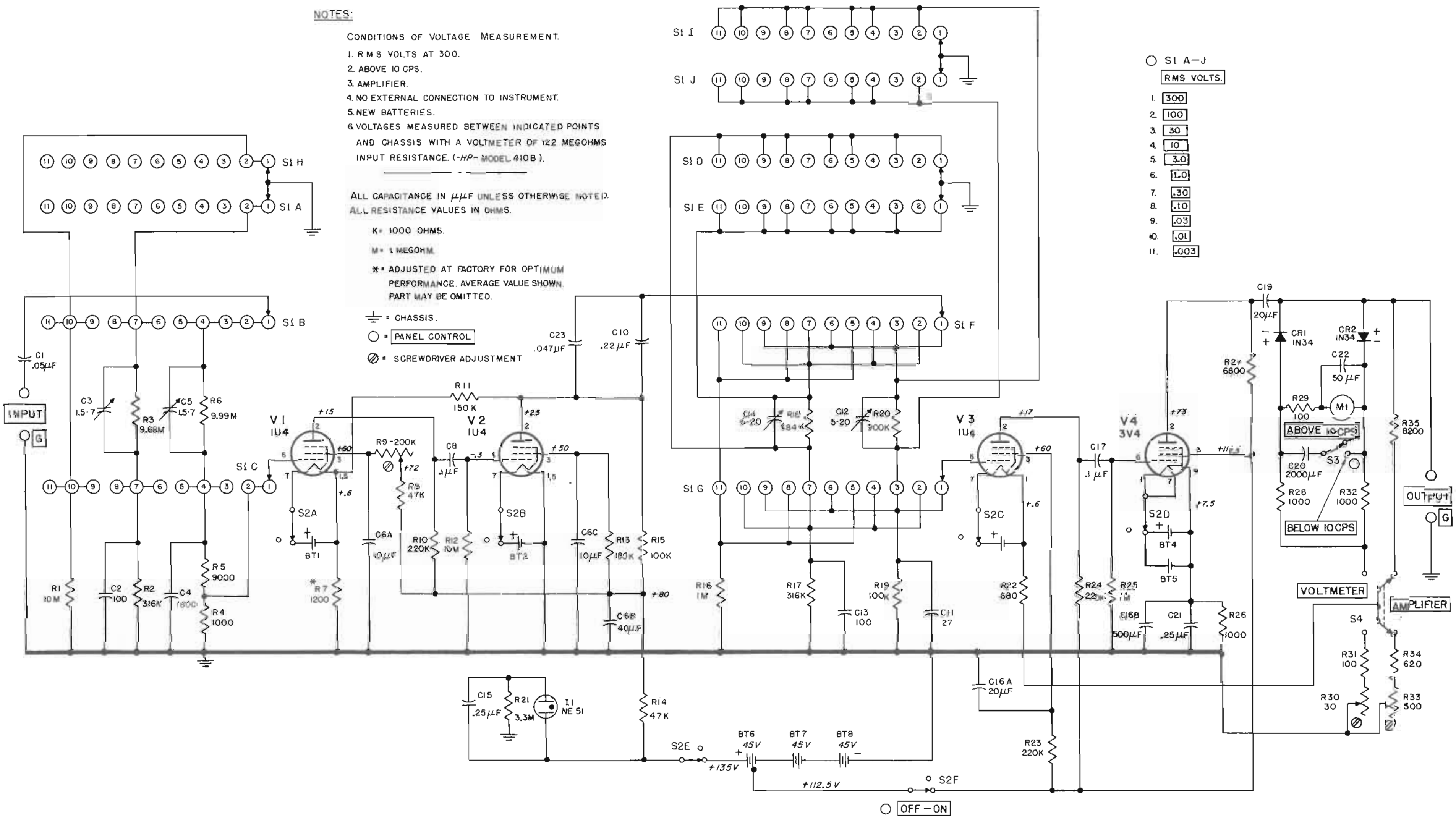
Connect a high impedance alternating current voltmeter to the OUTPUT terminals of the instrument.

2. Apply .003 volts at 100 cycles/sec. to the INPUT terminals of the instrument. Adjust R33 (see Fig. ~~2~~ 4) so that the external voltmeter indicates 3 volts.

Trouble Shooting --

The following information is designed to aid in trouble shooting a defective instrument:

Symptoms	Possible Cause	Test Procedure	Remedies
Instrument inoperative, indicator lamp not flashing	Exhausted plate supply batteries	Measure battery voltage at indicator lamp socket	Replace all dry batteries
Instrument inoperative, indicator lamp flashing	Defective tube	Substitute good tubes until defective tube is found.	Replace defective tube
	Exhausted filament supply battery.	Measure voltage of each battery BT1-BT5.	Replace exhausted battery
Instrument microphonic	Tube V1 microphonic		Replace tube V1
Instrument "Motorboats"	Open capacitor (C6ABC) in screen circuit	Temporarily shunt each section of capacitor C6ABC "Motorboating" should stop.	Replace capacitor C6ABC



SCHEMATIC DIAGRAM OF MODEL 404 A
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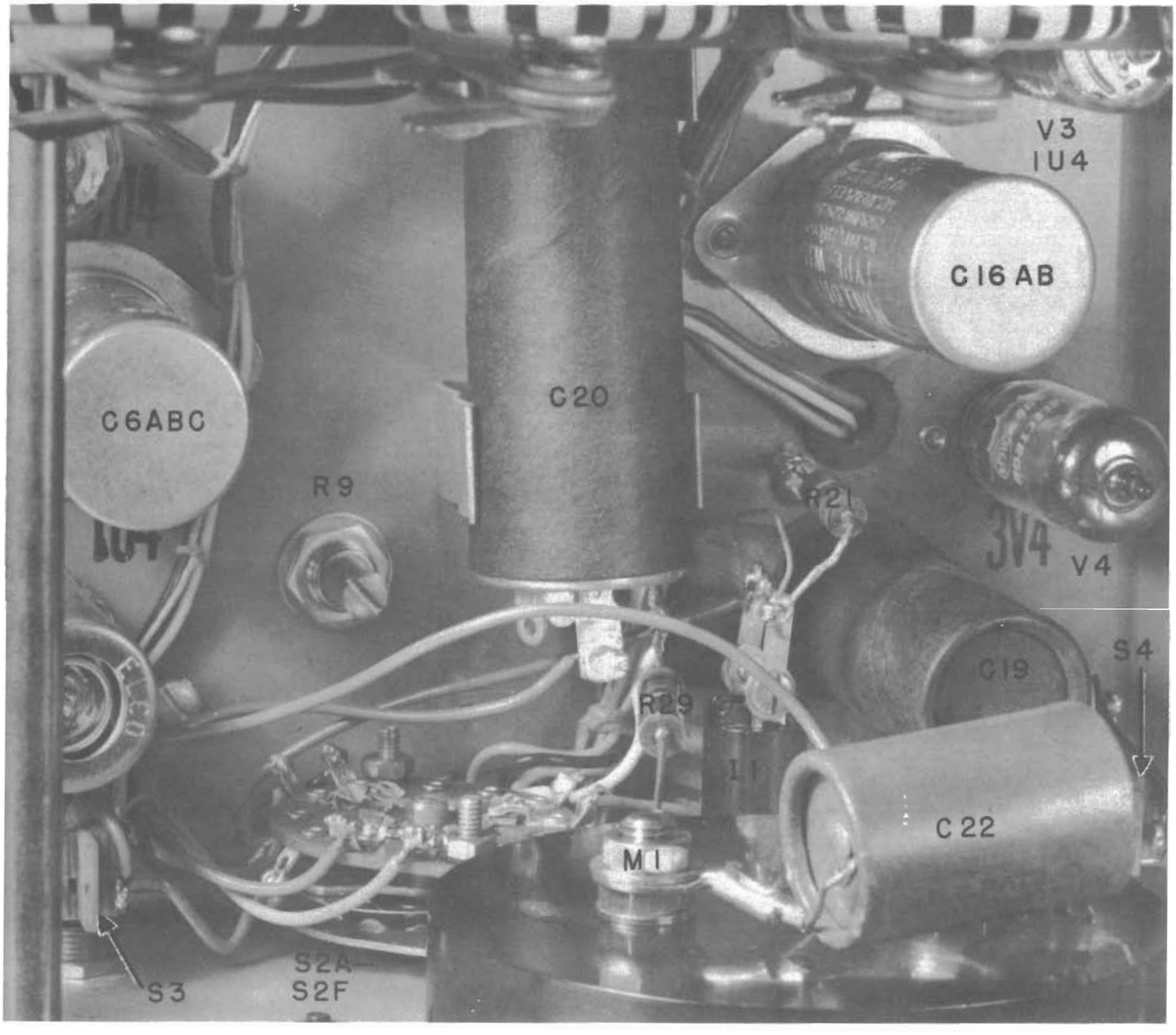

Fig. 3 Model 404A Top View Case Removed

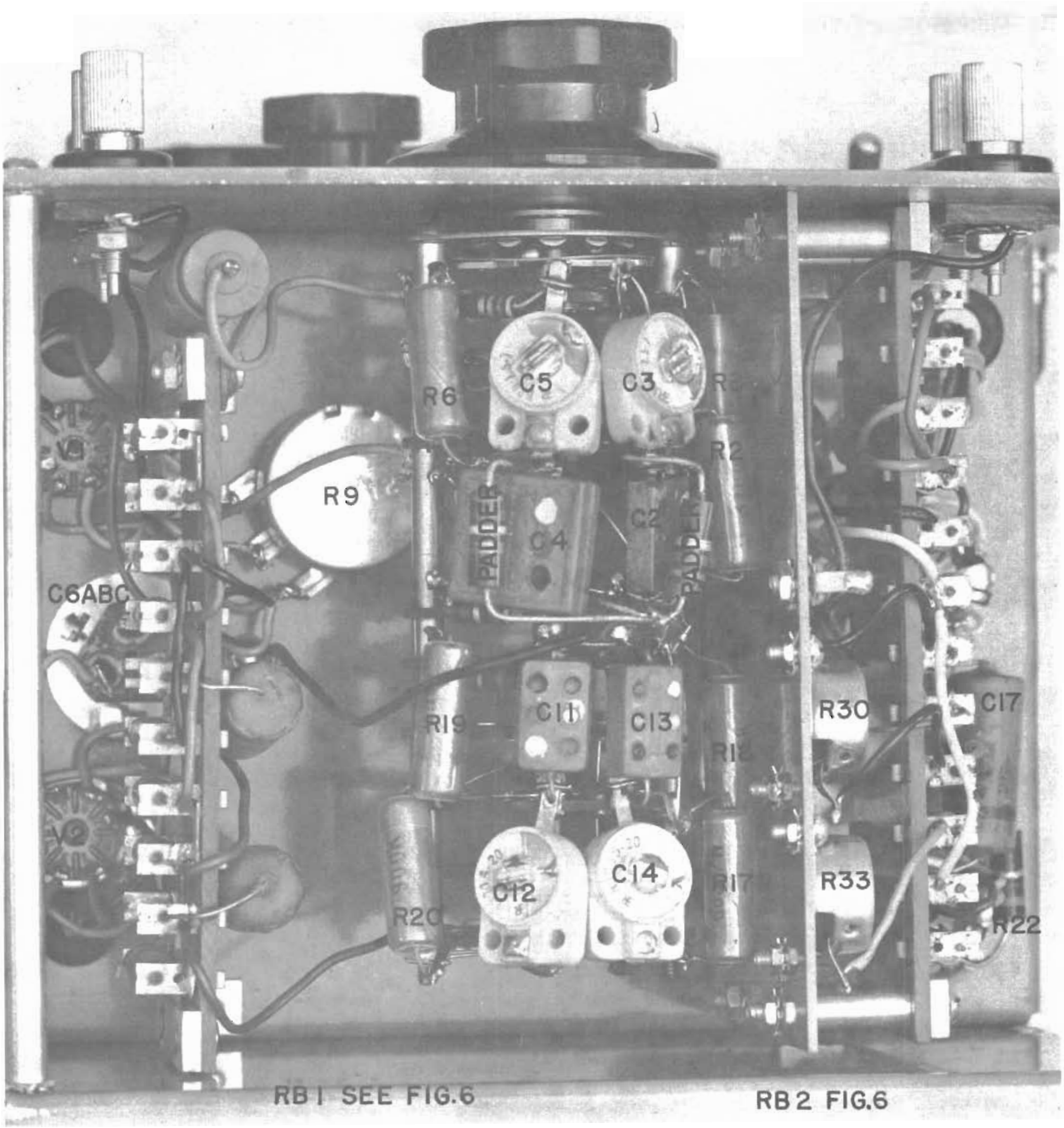

Fig. 4 Model 404A Bottom View Case Removed

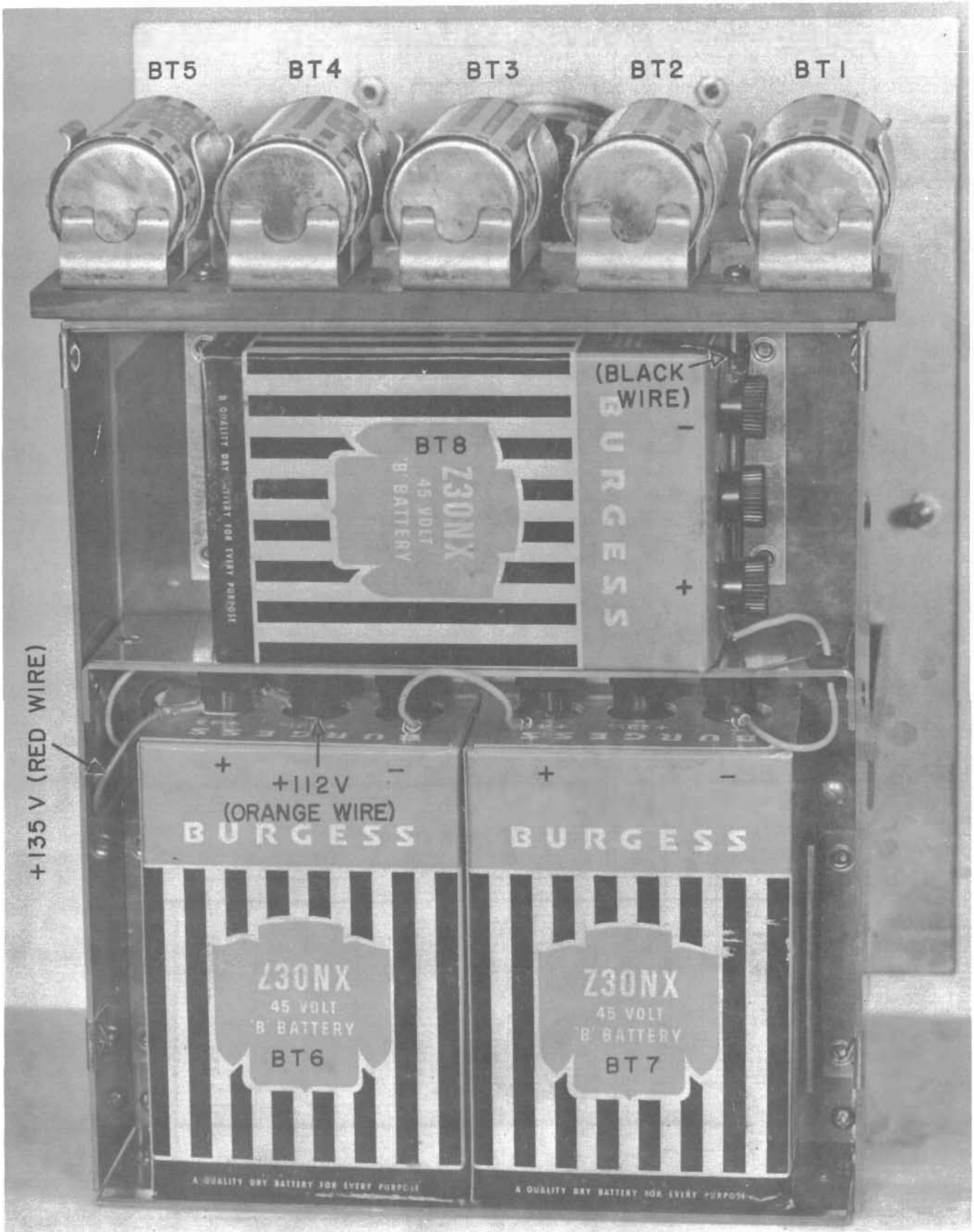

Fig. 5 Model 404A Rear View Case Removed

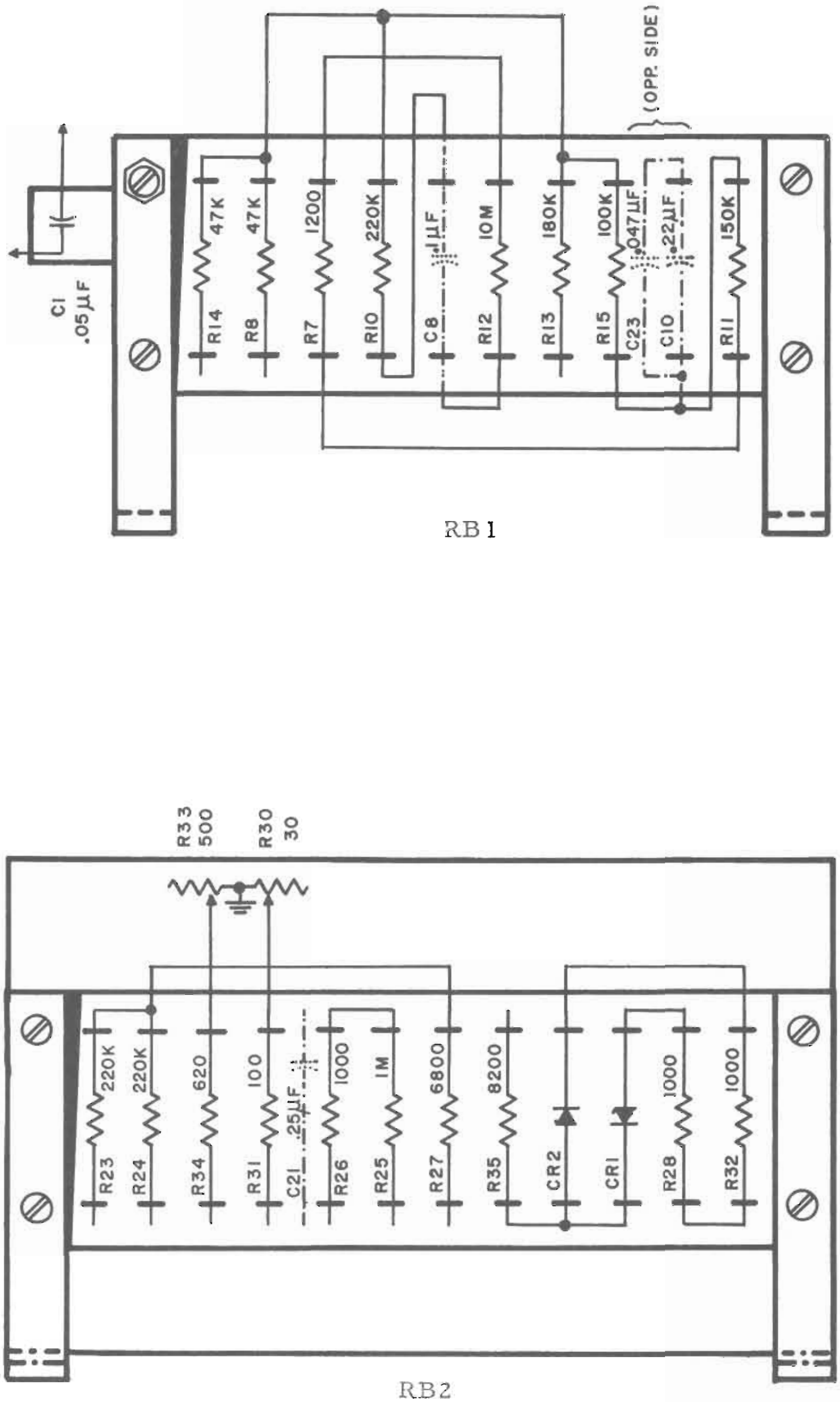

Fig. 6. Model 404A Resistor Board Detail

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C1	Capacitor: fixed, paper, .05 µf, ±10%, 600 vdcw	16-15	CC 73P47396
C2	Capacitor: Part of Range Switch Assembly		
C3	Capacitor: Part of Range Switch Assembly		
C4	Capacitor: Part of Range Switch Assembly		
C5	Capacitor: Part of Range Switch Assembly		
C6 ABC	Capacitor: fixed, electrolytic, 40, 10, 10 µf, 150 vdcw	18-8	X #203208
C7	This circuit reference not assigned		
C8	Capacitor: fixed, paper, .1 µf, ±10%, 400 vdcw	16-35	CC 67P10494
C9	This circuit reference not assigned		
C10	Capacitor: fixed, paper, .25 µf, ±20%, 600 vdcw	16-42	CC #68P37
C11	Capacitor: Part of Range Switch Assembly		
C12	Capacitor: Part of Range Switch Assembly		
C13	Capacitor: Part of Range Switch Assembly		
C14	Capacitor: Part of Range Switch Assembly		
C15	Capacitor: fixed, paper, .25 µf, ±20%, 600 vdcw	16-42	CC #68P37
C16 AB	Capacitor: fixed, electrolytic, 20 µf, 150 vdcw 500 µf, 60 vdcw	18-7	X
C17	Capacitor: fixed, paper, .1 µf, ±10%, 400 vdcw	16-35	CC 67P10494
C18	This circuit reference not assigned		

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

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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C19	Capacitor: fixed, electrolytic, 20 µf, 150 vdcw	18-9	X
C20	Capacitor: fixed, electrolytic, 2000 µf, 6 vdcw	18-11	X
C21	Capacitor: fixed, paper, .25 µf, ±20%, 600 vdcw	16-42	CC #68P37
C22	Capacitor: fixed, electrolytic, 50 µf, +200%, -10%, 50 vdcw	18-50	X TC-39
C23	Capacitor: fixed, paper, .047 µf, ±10%, 600 vdcw	16-15	CC, 73P47396
R1-R6	Part of Range Switch Assembly		
R7	Resistor: fixed, composition, 1200 ohms, ±10%, 1 W Electrical value adjusted at factory	24-1200	B GB 1221
R8	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	24-47K	B GB 4731
R9	Resistor: variable, composition, 200,000 ohms, ±20%, 1/4 W	210-19	I Type 37
R10	Resistor: fixed, composition, 220,000 ohms, ±10%, 1 W	24-220K	B GB 2241
R11	Resistor: fixed, composition, 150,000 ohms, ±10%, 1 W	24-150K	B GB 1541
R12	Resistor: fixed, composition, 10 megohms, ±10%, 1 W	24-10M	B GB 1061
R13	Resistor: fixed, composition, 180,000 ohms, ±10%, 1 W	24-180K	B GB 1841
R14	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	24-47K	B GB 4731
R15	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R16 - R20	Part of Range Switch Assembly		
R21	Resistor: fixed, composition, 3.3 megohms, ±10%, 1 W	24-3.3M	B GB 3351
R22	Resistor: fixed, composition, 680 ohms, ±10%, 1 W	24-680	B GB 6811

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

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R23	Resistor: fixed, composition, 220,000 ohms, ±10%, 1 W	24-220K	B GB 2241
R24	Resistor: fixed, composition, 220,000 ohms, ±10%, 1 W	24-220K	B GB 2241
R25	Resistor: fixed, composition, 1 megohm, ±10%, 1 W	24-1M	B GB 1051
R26	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W	24-1000	B GB 1021
R27	Resistor: fixed, composition, 6800 ohms, ±10%, 1 W	24-6800	B GB 6821
R28	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W	24-1000	B GB 1021
R29	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100	B GB 1011
R30	Resistor: variable, wirewound, 30 ohms, linear taper	210-42	Muter Co. #10517
R31	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100	B GB 1011
R32	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W	24-1000	B GB 1021
R33	Resistor: variable, wirewound, 500 ohms, linear taper	210-29	Muter Co.
R34	Resistor: fixed, composition, 620 ohms, ±5%, 1 W	24-84	B GB 6215
R35	Resistor: fixed, composition, 8200 ohms, ±10%, 1 W	24-8200	B GB 8221
	Dry Battery: 45 V	312-105	Burgess Battery Co. Z30NX
	Dry Battery: 1.5 V	312-112	Burgess Battery Co. #2
	Binding Post:	312-3	HP
	Knob: 1-1/8" diam. Knob: 2" diam.	37-9 37-13	HP HP

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

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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
I1	Lamp: neon glow	211-27	O, NE-51
	Lampholder:	312-95	II, #911308-937
M1	Meter:	112-6	HP
S1A-G, C2-C5, C11-C14, R1-R6, R16-R20	Range Switch Assembly	44A-19W	HP
S2 ABCD	Rotary Switch:	310-55	HP
S3	Toggle Switch: SPST	310-11	R. H. Fisher Co.
S4	Toggle Switch: DPDT	310-41	R. H. Fisher Co.
V1	Tube: 1U4	212-1U4	ZZ
V2	Tube: 1U4	212-1U4	ZZ
V3	Tube: 1U4	212-1U4	ZZ
V4	Tube: 3V4	212-3V4	ZZ

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

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LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

Code Letter	Manufacturer
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Electrical Reactance Co.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
HP	Hewlett-Packard
Q	Industrial Products Co.
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
U	Maguire Industries, Inc.
V	Micamold Radio Corp.
W	Oak Mfg. Co.
X	P.R. Mallory Co., Inc.
Y	Radio Corp. of America
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
BB	Signal Indicator Co.
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
GG	Wilkor Products, Inc.
HH	Amphenol
II	Dial Light Co. of America
JJ	Leecraft Manufacturing Co.
ZZ	Any tube having RMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof (except tubes, fuses and batteries). This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number, type number and serial number. On receipt of this information, we will give you service instruction or shipping data.

2. On receipt of shipping instruction, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett - Packard instruments should be made via Railway Express. The instruments should be packed in a wooden box and surrounded by two to three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

395 PAGE MILL ROAD PALO ALTO, CALIFORNIA