HEWLETT-PACKARD COMPANY

412A

DC VACUUM TUBE VOLTMETER

SERIALS PREFIXED: 004-

OPERATING AND SERVICING MANUAL

PRINTED 5-60

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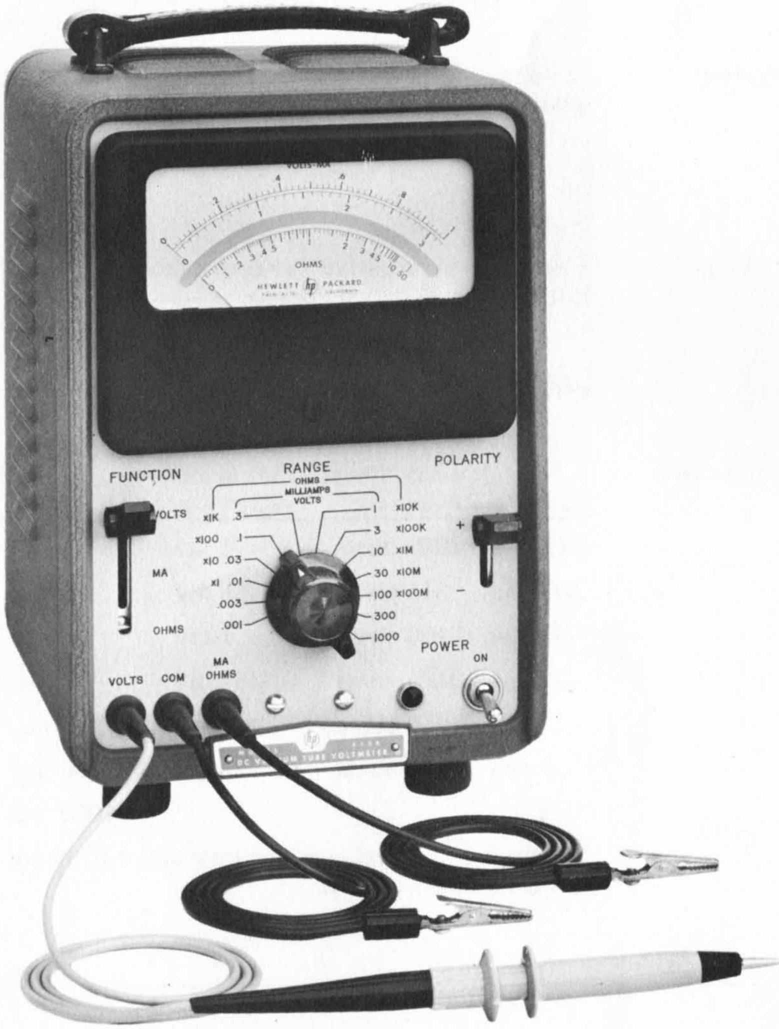


275 PAGE MILL ROAD, PALC ALTO, CALIFORNIA, U.S.A.

SPECIFICATIONS

VOLTMETER

Voltage Range: Positive and negative voltages from 1 millivolt full scale to 1000 volts full scale in thirteen ranges.

Accuracy: ±1% of full scale on any range.

Input Resistance:
10 megohms ±1% on 1 mv, 3 mv, and 10 mv ranges.
30 megohms ±1% on 30 mv range.
100 megohms ±1% on 100 mv range.
200 megohms ±1% on 300 mv range and above.

AC Rejection: A voltage at power line or twice power line frequency 40 db greater than full scale affects reading less than 1%. Peak voltage must not exceed 1500 volts.

AMMETER

Current Range: Positive and negative currents from 1 microampere full scale to 1 ampere full scale in thirteen ranges.

Accuracy: ±2% of full scale on any range.

Input Resistance:

Range	Internal Shunt Resistance*	Full Scale Voltage Drop	Range	Internal Shunt Resistance*	Full Scale Voltage Drop
.001 ma	1000 ohms	1 mv	1 ma	1 ohm	1 mv
.003 ma	316 ohms	0.9486 mv	3 ma	0.316 ohm	0.9486 mv
.01 ma	100 ohms	1 mv	10 ma	0.1 ohm	1 mv
.03 ma	31 .6 ohms	0.9486 mv	30 ma	0.1 ohm	3 mv
.1 ma	10 ohms	1 mv	100 ma	0.1 ohm	10 mv
.3 ma	3. 16 ohms	0.9486 mv	300 ma	0.1 ohm	30 mv
			1000 ma	0.1 ohm	100 mv

* For total insertion resistance add 0.07 ohms copper lead resistance at 25°C.

SPECIFICATIONS (CONT'D.)

OHMMETER

Resistance Range: Resistance from 1 ohm centerscale to 100 megohms centerscale in nine decade ranges.

Accuracy: ±5% of reading from 0.2 ohm to 500 megohms. ±10% of reading from 0.1to 0.2 ohm and from 500 megohms to 5000 megohms.

Voltages and Currents:

Range	Open Circuit Volts	Short Circuit Current	Range	Open Circuit Volts	Short Circuit Current
X1	10 mv	10 ma	X10K	1 v	100 μa
X10	100 mv	10 ma	X100K	1 v	10 μa
X100	1 v	10 ma	X1M	1 v	1 μa
X1000	1 v	1 ma	X10M	1 v	.1 μa
			X100M	1 v	.01 μa

AMPLIFIER

Voltage Gain: 1000 maximum

AC Rejection: Approximately 3 db at 1 cps, 80 db at 50 and 60 cps.

Output: Proportional to meter indication; 1 volt at full scale. (Full scale corresponds to 1.0 on upper scale.)

Output Impedance: Less than 2 ohms at 0 cps.

Noise: Less than 0.1% (rms) of full scale on any range.

Drift: Negligible.

GENERAL

Isolated Input: Input terminals are isolated from case (power line) ground by a minimum leakage resistance of 100 megohms shunted by 0.1 μf. Maximum potential difference between common lead and case ground: 500 v peak.

Power: 115/230 volts ±10%, 50-60 cps, 35 watts.

Dimensions: Cabinet Mount: 11-1/2 in. high, 7-1/2 in. wide, 10 in. deep.
Rack Mount: 5-1/4 in. high, 19 in. wide, 10 in. deep.

Weight: Cabinet Mount: Net 12 lbs., shipping 17 lbs.

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL

The Model 412A DC Vacuum Tube Voltmeter is a precision, wide range, multipurpose instrument which covers the entire range of voltage, current, and resistance measurements normally encountered in electronic equipment. It measures voltages from less than 0.1 millivolt to 1000 volts, currents from less than 0.1 microampere to 1 ampere, and resistances from 0.02 ohm to 5000 megohms.

1-2 DAMAGE IN SHIPMENT

Inspect and operate this instrument upon receipt. Section IV includes a performance check which is a good test as part of incoming quality control inspection. The check can be made with the instrument in its cabinet. If there is any damage, see the "Claim for Damage in Shipment" paragraph at the rear of this manual.

1-3 POWER CABLE

The three-conductor power cable supplied with this instrument terminates in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two-blade connector. This contact grounds the instrument when used with an appropriate receptacle. An adapter should be used to connect the NEMA plug to a standard two-contact output. When the adapter is used, the ground connection becomes a short lead from the adapter. This lead should be connected to a suitable ground for the protection of operating personnel.

1-4 230 VOLT OPERATION

The 412A is normally wired at the factory for operation from a 115 volt, 50-60 cps power source.

To convert it for use from a 230 volt, 50-60 cps power source, change the dual 115 volt primary windings of the power transformer from a parallel combination to a series combination. See schematic diagram for details. At the time of conversion, change line fuse from 1/2 ampere, slow-blow type to 1/4 ampere, slow-blow type.

SECTION II
OPERATING INSTRUCTIONS

2-1 LOW-LEVEL ELECTRICAL PHENOMENA

Stray low-level electrical phenomena are present, in one form or another, in nearly all electrical circuits. The 412A does not distinguish between stray and signal voltages; it measures net voltage. Thus, when using the lower voltage ranges, consider the possibility of low-level electrical phenomena. Thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (dielectric absorption), battery action of two terminals mounted on an imperfect insulator (galvanic action) all can produce voltages within the range of the 412A.

The 412A voltage probe, current/resistance lead, and common lead are designed to have a very low thermoelectric effect with copper, the most common electrical conductor. However, you may encounter other materials. For example, the leads of many transistors are made of a mixture of iron, nickel, and cobalt known commercially as Kovar, Fernico, etc. This material makes a very good thermocouple with copper: about 40 μv/°C with respect to a reference junction.

Whenever possible, connect the 412A leads to copper and maintain the points of connection at the same temperature, preferably ambient temperature. With the leads so connected, any voltage indicated by the 412A is developed within the circuit under test.

2-2 OPERATING INSTRUCTIONS

CAUTION

Do not overload the instrument. Amplifier input, current shunts, and internal resistance standards are not protected from extreme overload. Momentary overloads ten times full scale will not damage the instrument.

Turn the 412A on and allow a few minutes warm up.

A. VOLTAGE MEASUREMENT

1) Set FUNCTION selector to VOLTS.

2) Set POLARITY switch to desired polarity.

3) Set RANGE switch to desired range.

4) Use VOLTS and COM leads to connect instrument across circuit or component, and read voltage.

B. CURRENT MEASUREMENT

1) Set FUNCTION selector to MA.

2) Set RANGE switch to desired range.

3) De-energize circuit to be tested.

4) Use MA/OHMS and COM leads to connect instrument into circuit.

5) Energize circuit, set POLARITY switch for upscale reading, and read current.

NOTE

When measuring current, be sure there is no connection between the chassis-ground and cabinet-ground terminals of the DC AMPLIFIER OUTPUT connector.

C. RESISTANCE MEASUREMENT

1) Set FUNCTION selector to OHMS.

2) De-energize circuit to be measured.

3) Use MA/OHMS and COM leads to connect instrument across circuit or component.

4) Select range which brings meter pointer as close as possible to midscale, and read resistance.

When measuring the resistance of non-linear devices such as crystal diodes or transistors, you may want to know the voltage applied to the device and/or the current through it at the time of measurement. By using Table 2-1 and the upper voltage scale on the meter face, you can determine both. The meter reading is directly proportional to the voltage across the device being measured, and the meter reading subtracted from full scale is directly proportional to the current. For example, on the X10 range the upper voltage scale is a 0-100 mv scale and a 10-0 ma scale. If the meter indicates .25 on the resistance scale, the device being measured has an equivalent resistance of 2.5 ohms. But the meter also indicates .2 on the upper voltage scale; thus, from Table 2-1, the device has 2.5-ohms equivalent resistance with 20 mv across it and 8 ma flowing through it.

D. OPERATION WITH A RECORDER

To obtain permanent records of 412A readings, connect a recorder to the DC AMPLIFIER OUTPUT connector and operate the 412A as directed above. The output of the 412A is 1 volt at full scale; if necessary, externally attenuate the 412A output to match it with recorder sensitivity. Maximum rated load current from the 412A is 1 ma. A load resistance of less than 1000 ohms may cause the load current to exceed 1 ma and thus cause errors in meter indication and amplifier gain.

TABLE 2-1. RESISTANCE RANGE VS OPEN-CIRCUIT VOLTS/SHORT-CIRCUIT CURRENT

Range	Open Circuit Volts (1.0 on upper voltage scale)	Short Circuit Current (0 on upper voltage scale)
X1	10 mv	10 ma
X10	100 mv	10 ma
X100	1 v	10 ma
X1000	1 v	1 ma
X10K	1 v	100 μa
X100K	1 v	10 μa
X1M	1 v	1 μa
X10M	1 v	0.1 μa
X100M	1 v	0.01 μa

SECTION III
CIRCUIT OPERATION

3-1 GENERAL

The 412A is basically a 0 to 0.9 millivolt dc voltmeter. Precision voltage dividers, shunts, and reference resistors extend the range of the basic voltmeter and permit current and resistance measurements as well.

3-2 CIRCUIT OPERATION

With the FUNCTION selector and RANGE switch properly set, voltage is applied to a photoconductive modulator through a low-pass filter. See Figure 3-1. The filter attenuates ac components present on any input signal, and the modulator converts the remaining dc component to a square wave. A synchronous-motor-driven, light-beam chopper sets modulator frequency at 5/6 power-line frequency. An ac-coupled amplifier amplifies modulator output about 500,000 times. A demodulator synchronized with the modulator by the light-beam chopper, converts amplifier output to dc. The output of the demodulator is filtered and applied through a cathode follower to 1) a feedback network 2) the DC AMPLIFIER OUTPUT terminals and 3) an output indicator. The feedback network stabilizes the dc gain of the modulator-amplifier-demodulator system to a value of 1111, thereby providing an output of 1 volt for an input of 0.9 millivolt. The output indicator is a 0-1 voltmeter. The POLARITY switch permits reversal of indicator connections, if required, to obtain up-scale readings. The POLARITY switch is disabled when the FUNCTION selector is set to OHMS.

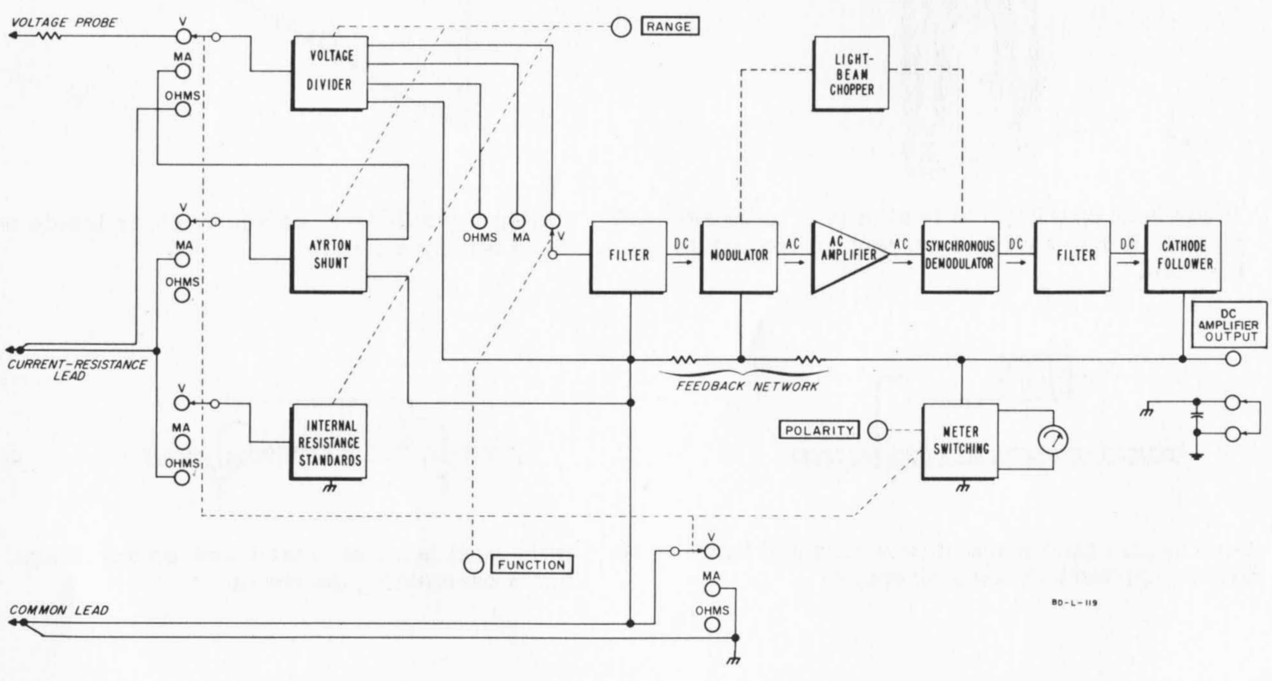


Figure 3-1. Model 412A Block Diagram

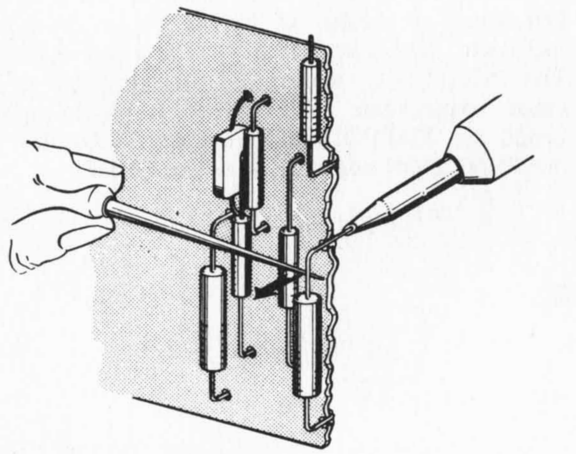
SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

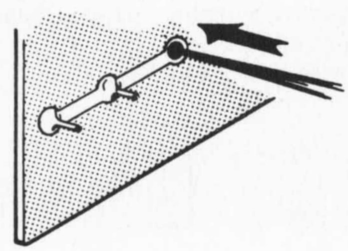
Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

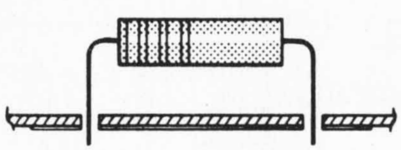
When replacing tube sockets it will be necessary to lift each pin slightly, working around the socket several times until it is free.



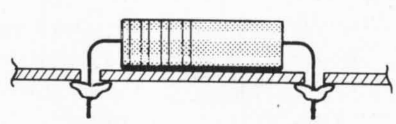
1. Apply heat sparingly to lead of part to be replaced. Remove part from card as iron heats the lead.



2. Using a small awl, carefully clean inside of hole left by old part.



3. Bend clean tinned leads on new part and carefully insert through holes on board.



4. Hold part against board and solder leads. Avoid overheating the board.

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

This section contains testing and servicing information. Included is a performance check to verify proper instrument operation. The check can be made with the instrument in its cabinet and is a good test as part of routine maintenance or incoming quality control inspection.

Standard, readily available components are used for manufacture of hp instruments whenever possible. Special components are available through your local hp Representative who maintains a parts stock for your convenience.

When ordering parts, specify instrument model and serial number plus the component description and stock number appearing in the Table of Replaceable Parts.

Your local hp Representative maintains complete facilities and specially trained personnel to assist you with any problems you may have with hp instruments.

4-2 REQUIRED TEST EQUIPMENT

To carry out the instructions in this section, you will need the following test equipment:

1) A dc voltmeter with an input resistance of at least 100 megohms to measure voltages from 1 volt to 350 volts. You can use a voltmeter with 20,000 ohms/volt sensitivity, but circuit loading will cause errors in some readings. Recommended hp equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Voltmeter.

2) A dc metering device which can resolve 10 mv. A plain meter movement is satisfactory if it can resolve 10 mv. Recommended hp equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

3) A dc voltage source to supply voltages from .001 volt to 300 volts in steps of 1, 3, 10, etc., and voltages from 0 to 1 volt in 0.1-volt steps. All voltages should be accurate within 0.1%. Recommended hp equipment: Model 738A Voltmeter Calibrator.

4) An oscilloscope with 0.01 volt/cm sensitivity for measuring 10-cps hum. Recommended hp equipment: 120A Oscilloscope.

5) Variable power transformer for varying line voltage between 103, 115 and 127 volts. The transformer should have a monitor voltmeter accurate within 1 volt and should have a capacity of at least 1 amp.

6) An ohmmeter. Recommended hp equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

4-3 PERFORMANCE CHECK

You can check instrument performance without removing the cabinet. Before starting, check the mechanical zero of the meter; if the meter requires adjustment, see Paragraph 4-5A.

A. VOLTMETER CHECK

1) Turn Voltmeter Calibration Generator on and allow 5-minute warm up.

2) Connect 412A to variable power source, set line voltage to rated value (115/230v), and turn 412A on. Allow 412A a few minutes warm up.

3) Set FUNCTION selector to VOLTS AND POLARITY switch to +.

4) Connect VOLTS and COM leads to OUTPUT connector of Voltmeter Calibration Generator.

5) Check 412A reading versus Voltmeter Calibration Generator output on each 412A range. Maximum 412A error should be no greater than 1% of full scale.

NOTE

When checking 412A on its .003 and .001 volt ranges, set the selector switch of Voltmeter Calibration Generator to OFF and note any 412A zero offset due to thermoelectric voltage. Add or subtract, as appropriate, any offset from the 412A reading when Voltmeter Calibration Generator selector switch is set to DC + . ---------------

6) Check 412A meter tracking on + and - 1 volt ranges. Maximum error should be no greater than 0.01 volt.

7) Repeat step 5 (on one range only) at line voltage of 103 and 127 volts.

B. MILLIAMMETER CHECK

1) Set line voltage to 115 volts.

2) Set FUNCTION selector to MA and POLARITY switch to + .

3) Connect 412A to Voltmeter Calibration Generator as shown in Figure 4-1.

4) Check 412A as shown in Table 4-1.

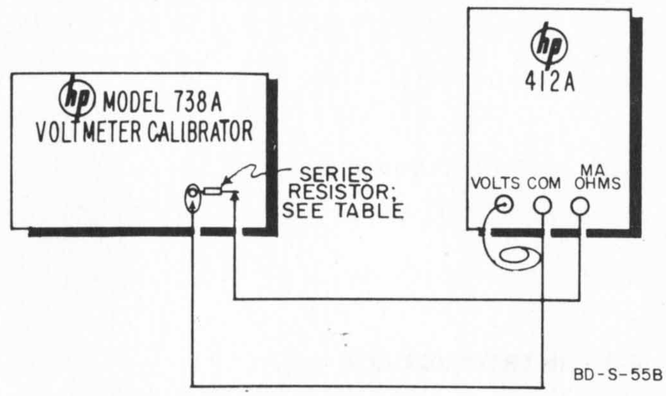


Figure 4-1. Equipment Setup for Current Check

NOTE

Switching through the current ranges from 10 to 1000 does not change the current shunt. Only the voltage attenuator, checked in part A above, changes. (See Figures 4-5, 4-6 and 4-7 for simplified switching details.)

C. OHMMETER CHECK

1) Set FUNCTION selector to OHMS.

2) Connect 1% resistor of 1, 10, 100, 1000, 10K, 100K, 1M, 10M and 100M ohms between MA/OHMS

TABLE 4-1. AMMETER CHECK

Output of Voltmeter Calibration Generator	Series Resistance	Model 412A Range	Model 412A Reading (±2% of full scale)
1 volt	1.00M ±0.1%	.001	1.0
3 volts	1.00M ±0.1%	.003	3.0
10 volts	1.00M ±0.1%	.01	1.0
30 volts	1.00M ±0.1%	.03	3.0
100 volts	1.00M ±0.1%	.1	1.0
300 volts	1.00M ±0.1%	.3	3.0
300 volts	300K ±0.1%	1	1.0
300 volts	100K ±0.1%	3	3.0
300 volts	30K ±0.1% (5 watts)	10	1.0
300 volts	30K ±0.1% (5 watts)	30	1.0 (on 0-3 scale)

and COM leads. With appropriate range selected, meter should indicate between 0.95 and 1.05 in each case.

4-4 CABINET REMOVAL

1) Unplug power cord from power source.

2) Remove two retaining screws from instrument rear.

3) Slide instrument chassis forward out of cabinet. Bezel ring remains attached to front panel.

NOTE

Avoid touching the RANGE switch wafers. A dirty switch can degrade instrument performance.

4-5 ADJUSTMENTS

A. MECHANICAL ZERO ADJUSTMENT

1) Turn instrument off. Allow several minutes for power-supply capacitors to discharge.

2) Rotate meter adjustment screw, located directly below meter face, clockwise until pointer is upscale.

3) Continue rotating adjustment screw clockwise until meter pointer indicates zero exactly. If pointer overshoots zero, repeat steps 2 and 3.

B. HUM BALANCE ADJUSTMENT

1) Turn instrument on and allow a few minutes warm up.

2) Set FUNCTION selector to VOLTS.

3) Connect oscilloscope to DC AMPLIFIER OUTPUT connector.

4) Adjust Hum Bal. (R126), for minimum 10-cps signal on oscilloscope. (If power-line frequency is 50 cps, adjust for minimum 8-1/3 cps signal.) See Figure 4-10 for location of R126.

C. CATHODE FOLLOWER BIAS ADJUSTMENT

1) Set RANGE switch full clockwise - one step beyond 1000.

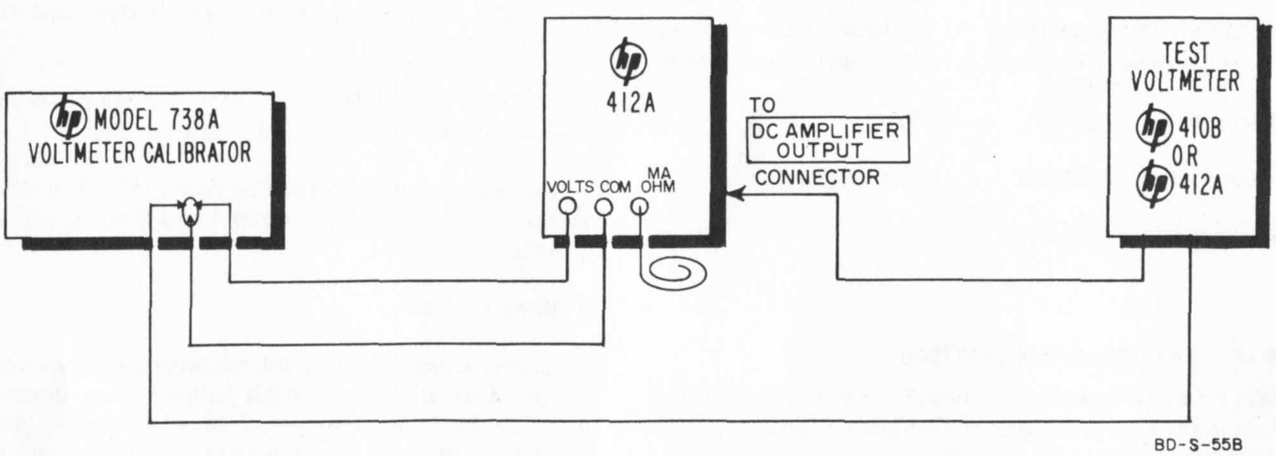
2) Adjust BIAS ADJ. (R116), to set meter pointer approximately on zero. R116 is located on instrument rear. This adjustment is not critical, since any deviation from zero is reduced more than 100 times when the RANGE switch is on any operating position.

D. AMPLIFIER GAIN CALIBRATION AND METER CALIBRATION

1) Connect equipment as shown in Figure 4-2. You may replace the test voltmeter with any high resistance meter device which can resolve 10 mv.

2) Set Voltmeter Calibration Generator output to +1 volt.

3) On 412A under test, set FUNCTION selector to VOLTS, POLARITY switch to +, RANGE switch to 1.



4-2. Equipment Setup for Amplifier Gain Calibration

4) Adjust Gain Cal. (R119), for zero on test voltmeter. For location of R119 see Figure 4-10. A 10-mv reading on test voltmeter indicates 1% error in gain calibration.

5) Adjust Meter Cal. (R46), to set meter pointer on 1.0.

6) Disconnect test voltmeter.

7) Check 412A reading versus Voltmeter Calibration Generator output on each range. See note in step 5 of paragraph 4-3A. If any reading is in error more than 1% of full scale, readjust Gain Cal. (R119), to bring all readings within 1%.

E. OHMMETER ADJUSTMENT

1) Set FUNCTION selector to OHMS and RANGE switch to X1K. Be sure MA/OHMS and COM leads are not connected through some external resistance.

2) Adjust OHMS ADJ. (R36), to set meter pointer on ∞, which corresponds to 1.0 on upper voltage scale. R36 is located on instrument rear.

4-6 TUBE REPLACEMENT

Tubes will sometimes cause trouble; check them by substitution and replace only those which are defective. Following the replacement of a particular tube, make the adjustment indicated:

Tube Replaced	Adjustment
V101 (12AX7) Amplifier	Hum balance; check gain calibration
V102 (6AU8) Amplifier/ Cathode Follower	Cathode follower bias; check gain calibration
V103 (6X4) Rectifier	None
V104 (OA2) Regulator	Ohmmeter
V105 (OB2) Regulator	None

4-7 TROUBLE SHOOTING

When isolating trouble, consider the 412A as having two sections: switching and amplifier/power supply sections. Front-panel indications should indicate the section in which a trouble is located and, in the case of switching-section trouble, should isolate the trouble to a few components. For example, if the instrument operates properly on all voltage ranges but .003, only R1, R9, or associated switch contacts and wiring can be faulty. For a simplified breakdown of the switching sequence, see Figures 4-5, 4-6 and 4-7. Figures 4-11 and 4-12 identify parts mounted on the RANGE, FUNCTION and POLARITY switches.

NOTE

BE CAREFUL when working with the RANGE switch. Avoid touching the switch wafers. A dirty switch can degrade instrument performance. When soldering to the switch, use a minimum of heat. Excessive heat will melt the wafer material.

Should trouble occur in the amplifier/power supply section, it will be common to all ranges and all functions. Voltages are indicated at various points on the schematic diagram; these are typical voltages and may vary somewhat from instrument to instrument.

The 412A is a sensitive instrument. If it has an offset from zero or gives unexpected readings on its lowest voltage ranges, it may be measuring thermoelectric voltages, etc., in addition to the expected voltage (see paragraph 2-1). When in doubt, check instrument performance (paragraph 4-3) before trouble shooting.

If the instrument fails to operate at all, be sure power is supplied to it, the POWER switch is on, and fuse F101 is good before checking inside.

4-8 MODULATOR CHECK

1) Unplug instrument from power source and remove cabinet.

2) Remove shield from left side of chassis to expose terminals of C103 (see Figure 4-10).

3) Connect 1.5 volt battery across C103. Any other source of dc voltage between 1 and 5 volts will do as well.

4) Remove V101.

5) Connect one lead of 22M resistor to signal connector of oscilloscope. With jumper wire, connect other resistor lead to pin 2 of V101 socket (grid connector of V101A). Connect common lead of oscilloscope to 412A COM lead. The 22M resistor reduces circuit loading by oscilloscope.

6) Turn 412A ON and compare waveform on oscilloscope with that shown in Figure 4-3. Peak-to-peak amplitude of signal at pin 2 of V101 should approximately equal the applied dc voltage. Signal frequency should be 5/6 power-line frequency.

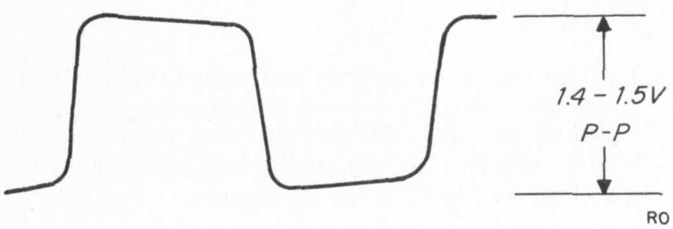


Figure 4-3. Modulator Waveform

4-9 MODULATOR REPLACEMENT

Should it become necessary to replace the modulator, we recommend that you send your instrument to your ⓗⓟ Representative for repair. If you repair the instrument, check with your ⓗⓟ Representative about a replacement modulator. The procedure for replacement is as follows:

1) Unplug 412A from power source.

2) Unlace harness containing two black leads from amplifier input assembly. Disconnect the black leads at COM cable terminal (point A of Figure 4-9) and at RANGE switch (point B of Figure 4-9).

NOTE

Lead placement is important on the COM cable terminal. See Figure 4-4 when replacing assembly. BE CAREFUL when connecting and disconnecting leads from RANGE switch. Keep switch clean and apply minimum heat with soldering iron. A dirty switch will degrade instrument performance, and too much heat will melt wafer material.

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3) Disconnect white-orange lead at C115 (point C of Figure 4-10).

4) Disconnect white lead at Gain Cal potentiometer R119 (point D of Figure 4-9).

5) Disconnect cable to amplifier at amplifier (point E of Figure 4-9).

6) Remove four machine screws and nuts holding light beam chopper (Figure 4-8) and let it hang by its leads.

7) Spread collars on modulator light rods (Figure 4-9) and slide rods out of modulator assembly.

8) Remove four screws holding modulator/amplifier input assembly to main chassis. Each screw has an insulating shoulder washer, for the modulator/amplifier input assembly is insulated from the chassis. Be sure to seat the washers in the chassis holes when replacing the screws.

9) Lift out modulator/amplifier input assembly and disconnect green lead at amplifier input assembly (point F of Figure 4-10).

10) Reverse above procedure to install replacement assembly.

4-10 DEMODULATOR CHECK

The demodulator assembly is located between the main chassis and power transformer. See Figure 4-10. Proceed as follows:

1) Unplug instrument from power source and remove cabinet.

2) Remove V102.

3) On light-beam chopper assembly, remove upper lamp nearest front of instrument. This lamp illuminates the forward section of demodulator.

4) Connect 1 μf capacitor across input terminals of ohmmeter.

5) Connect ohmmeter common lead to demodulator terminal which has the pink-orange lead connected to it.

6) Connect other ohmmeter lead to the terminal which has the white-orange lead connected to it.

7) Plug instrument into power source and turn it ON.

8) Note resistance indicated by ohmmeter. Typical resistance is between 1m. and 2m.

9) Turn instrument off and unplug it from power source.

10) Replace lamp in light-beam chopper and remove upper lamp nearest rear of instrument. This lamp illuminates rear section of demodulator.

11) Connect common ohmmeter lead to demodulator terminal which has the brown-orange lead connected to it.

12) Connect other lead from ohmmeter , the terminal which has the white-orange lead connected to it.

13) Plug instrument into power source, turn it ON, and note resistance indicated on ohmmeter. Typical resistance is between 1 meg and 2 megs.

14) Turn instrument off; replace lamp and V102.

4-11 DEMODULATOR REPLACEMENT

Check with your ⓗⓟ Representative about a replacement demodulator.

1) Turn instrument off.

2) Remove three leads connected to demodulator.

3) Remove nuts from demodulator mounting screws and remove demodulator from instrument. If you must get at screw heads to remove nuts, remove four mounting screws from light-beam chopper assembly (Figure 4-8) and let assembly hang by its leads.

Reverse the above procedure to install replacement assembly. Be sure to connect pink-orange lead to terminal nearest instrument rear, white-orange lead to center terminal, and brown-orange lead to terminal nearest front of instrument.

4-12 CABLE REPLACEMENT

Figure 4-4 is a connection diagram for the VOLTS, MA/OHMS, and COM cables. Replacement of the VOLTS and MA/OHMS cables is straightforward: connect the new ones as indicated in the figure. However, be careful when replacing the COM cable. The position of the leads on terminal post #3 is critical. Connect the leads as shown in detail.

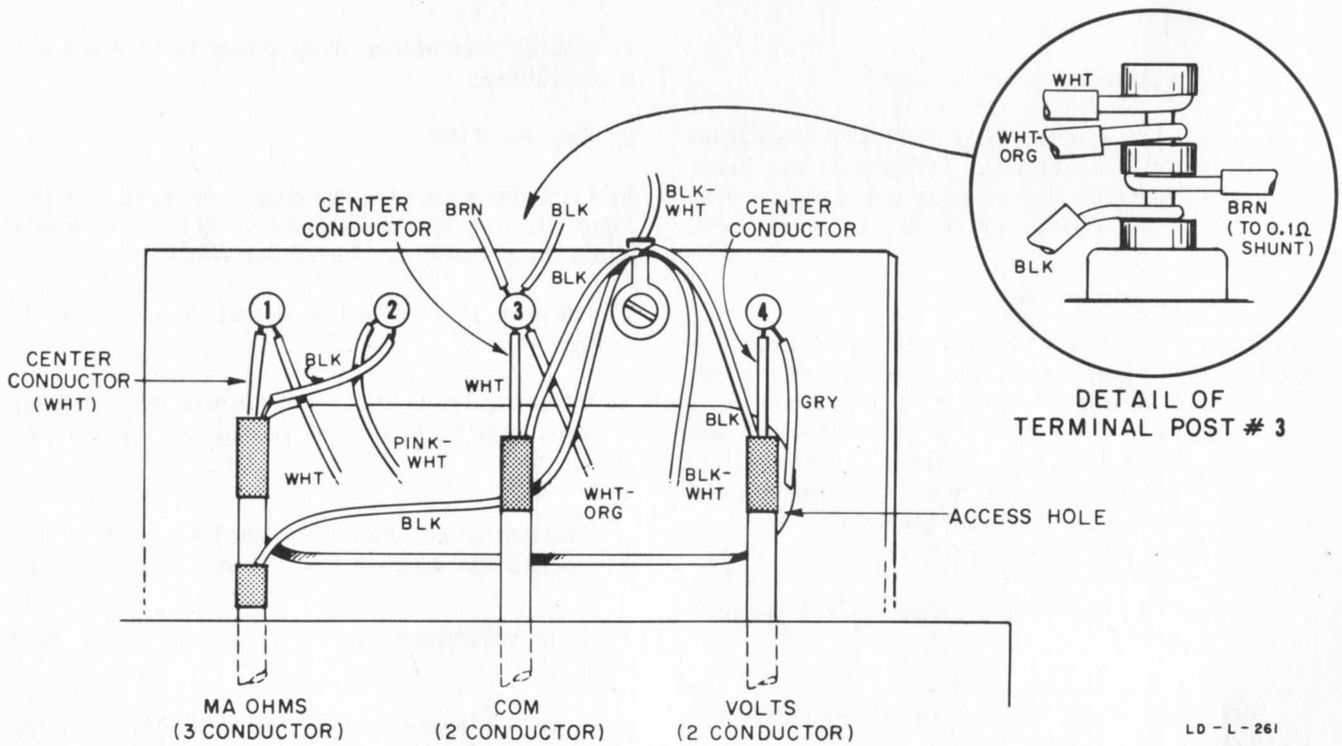
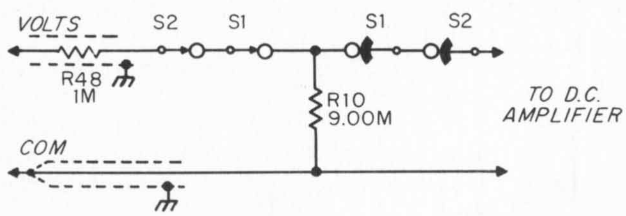
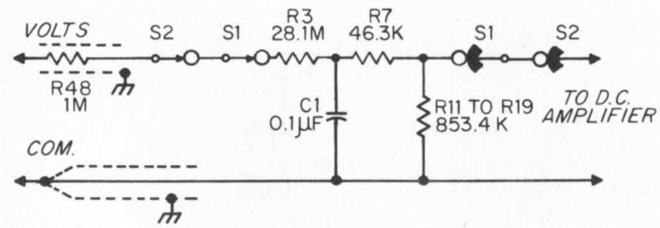


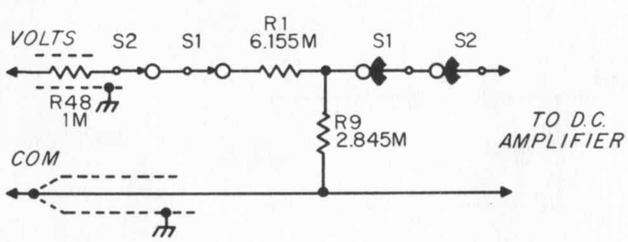
Figure 4-4. Connection Diagram for Volts, MA/OHMS and COM Cables



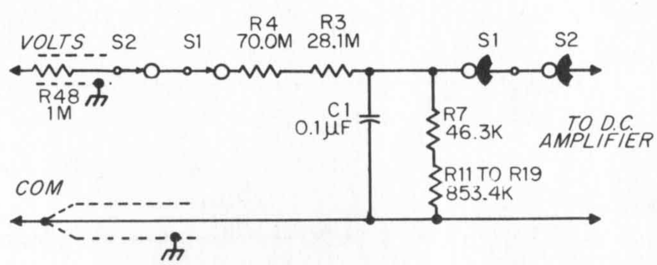
.001-volt range



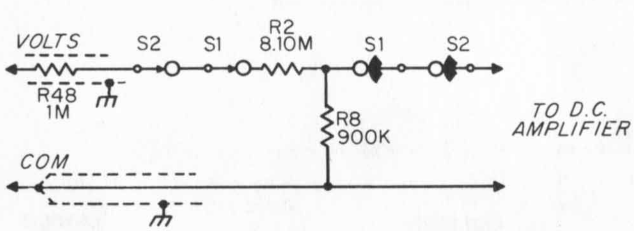
.03-volt range



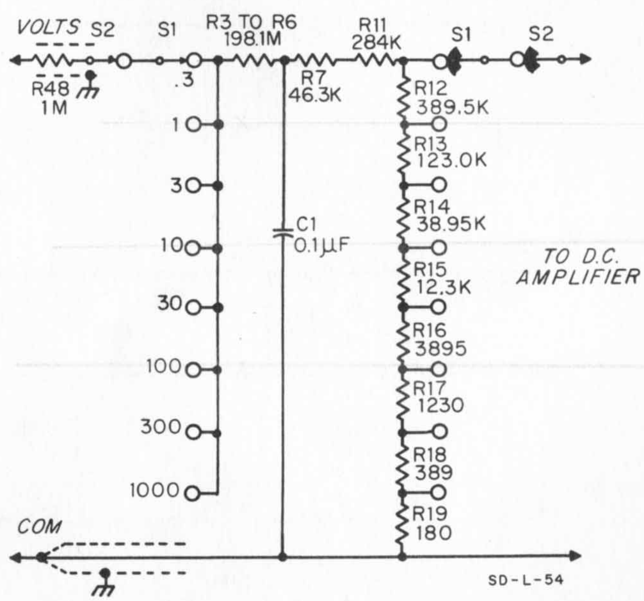
.003-volt range



.1-volt range



.01-volt range



.3 to 1000-volt ranges

Figure 4-5. Simplified Diagram of Voltmeter Switching

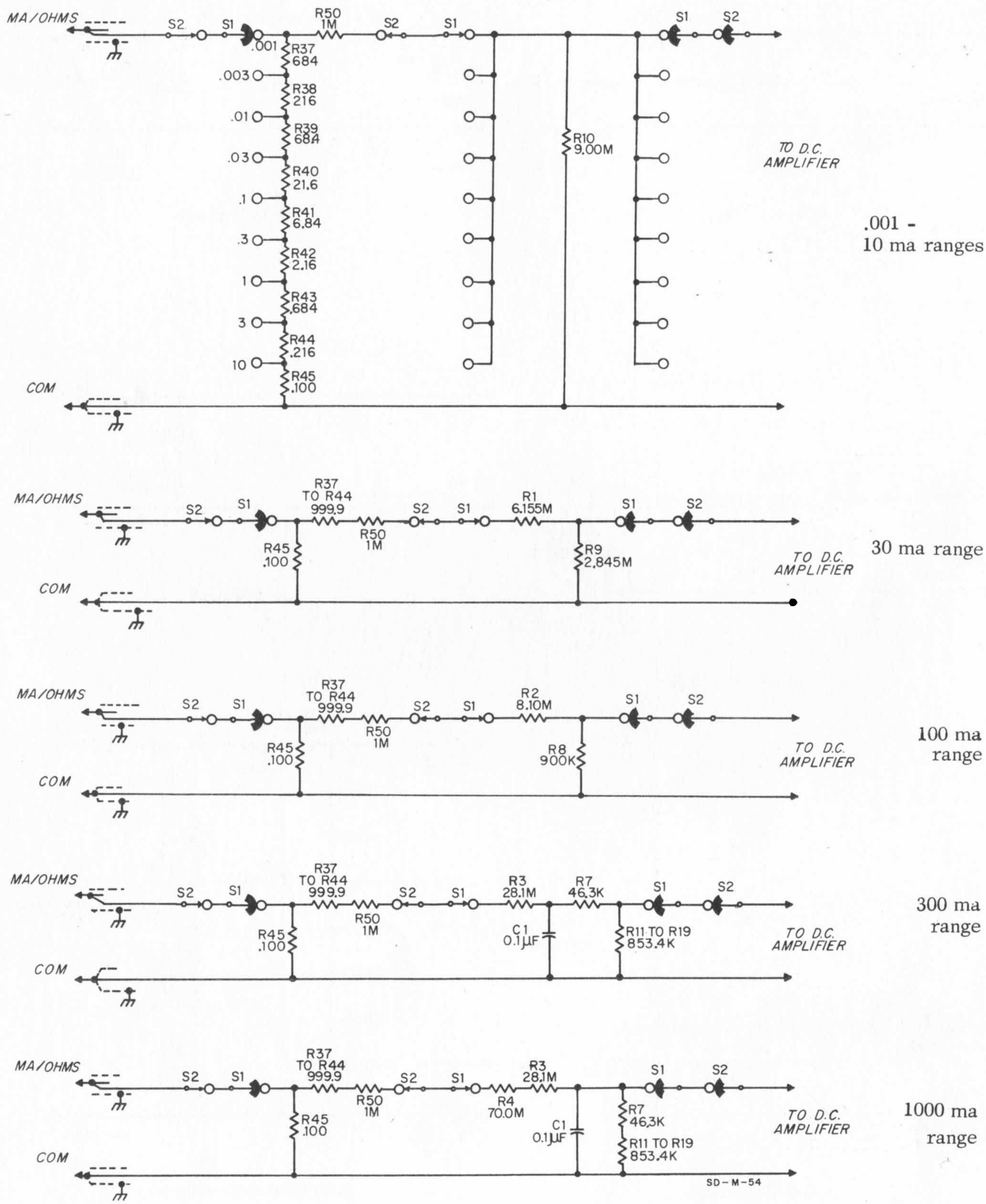


Figure 4-6. Simplified Diagram of Ammeter Switching

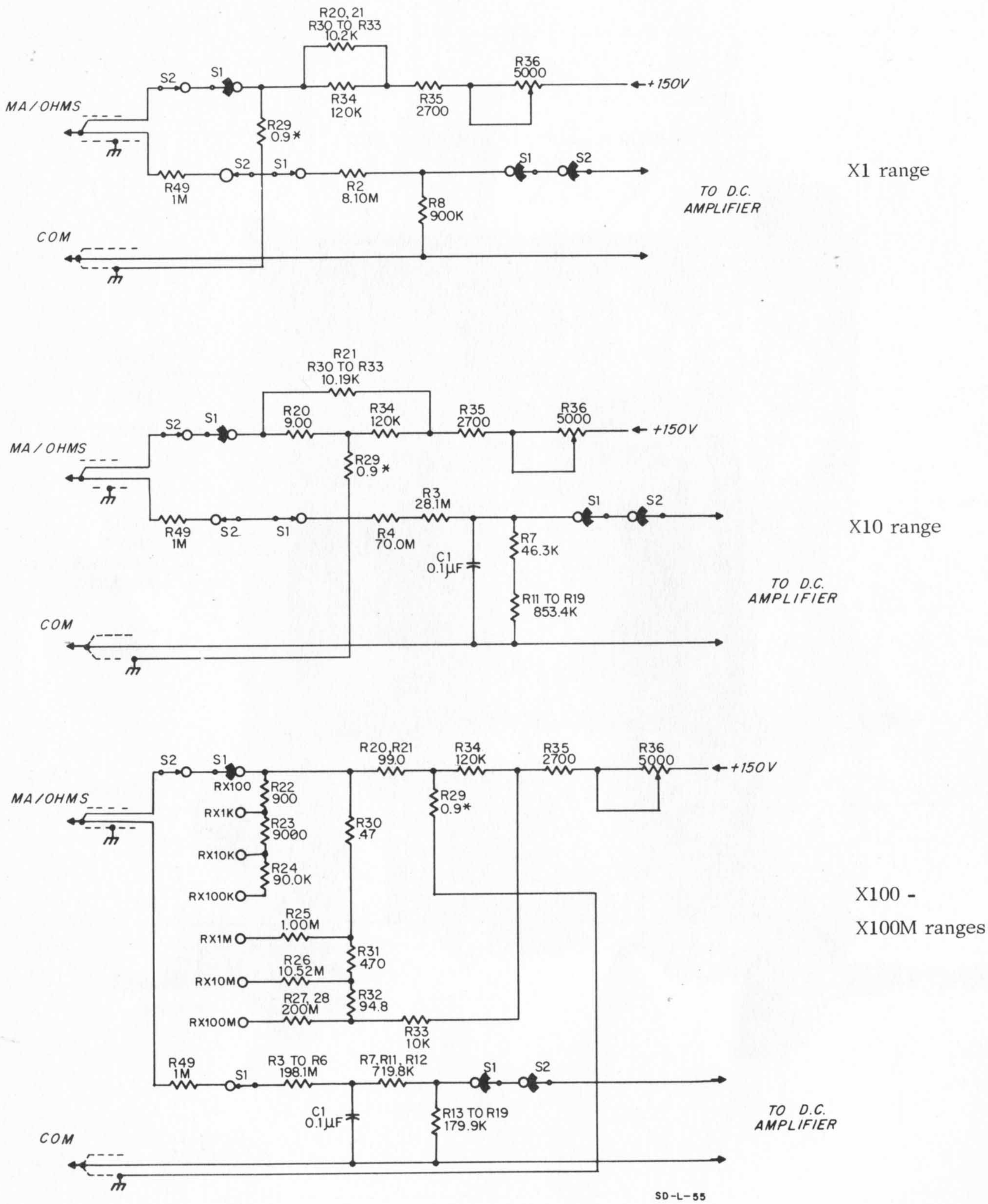


Figure 4-7. Simplified Diagram of Ohmmeter Switching Figure

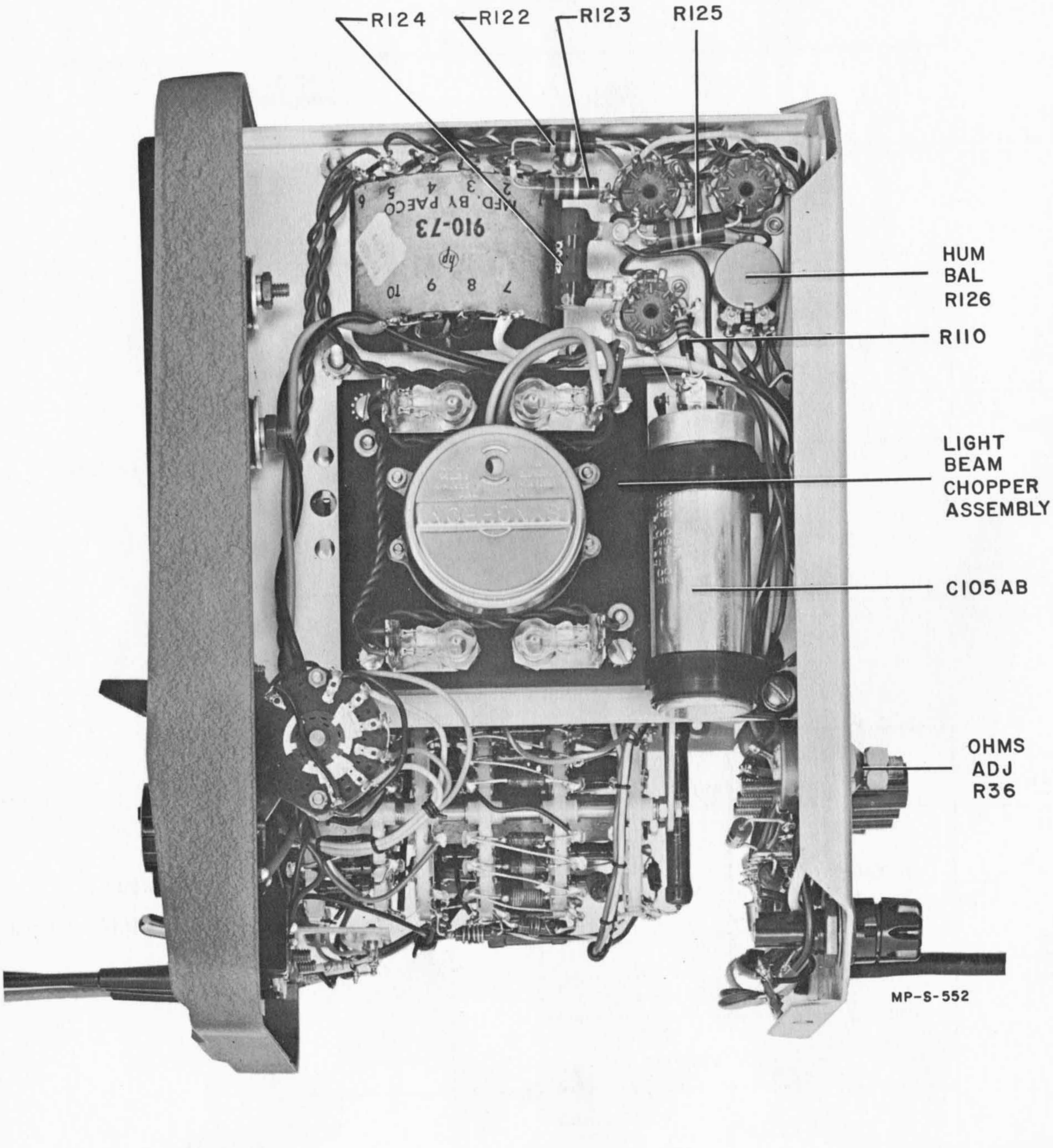


Figure 4-8. Right Side View Model 412A

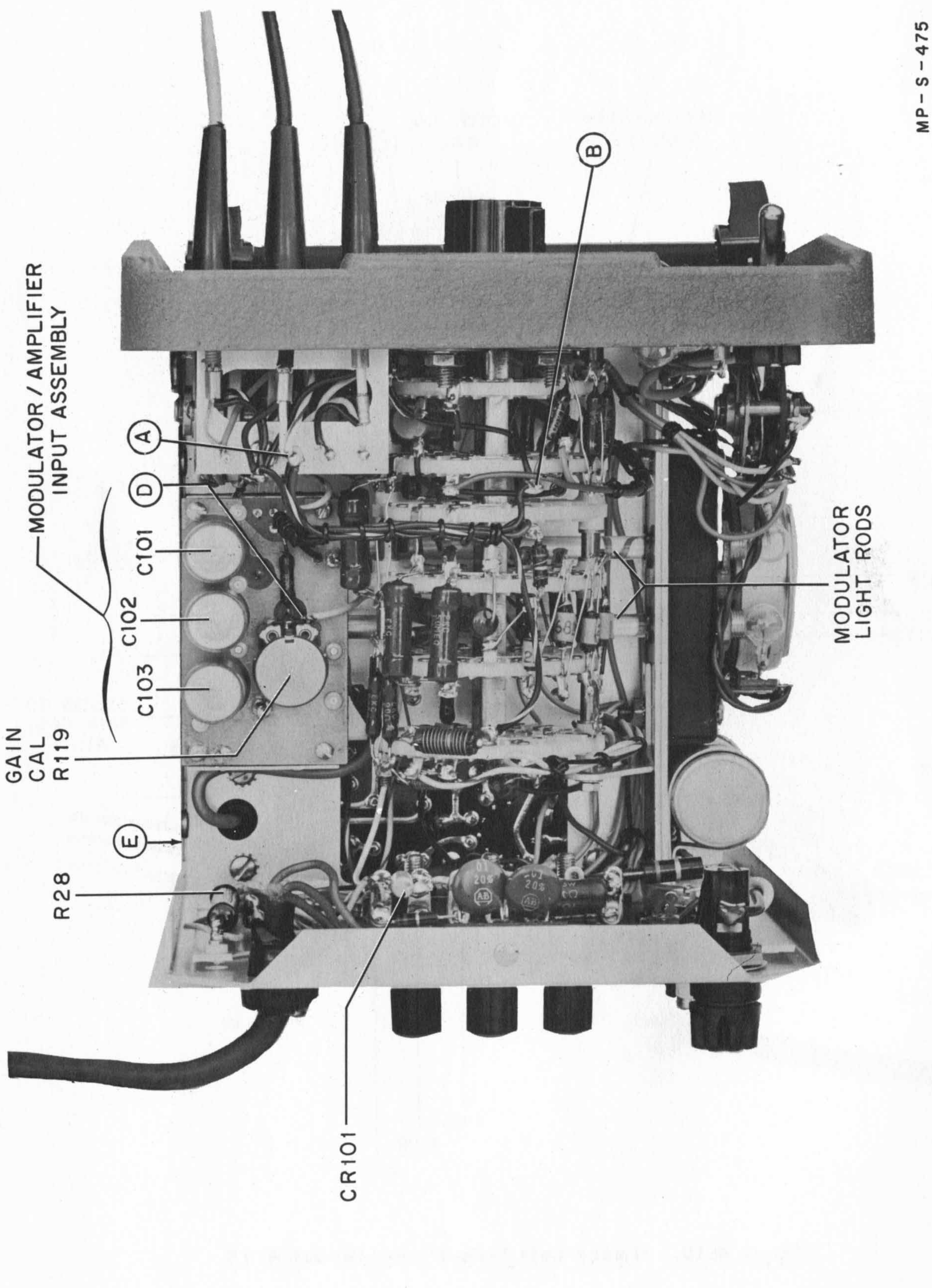


Figure 4-9. Bottom View Model 412A

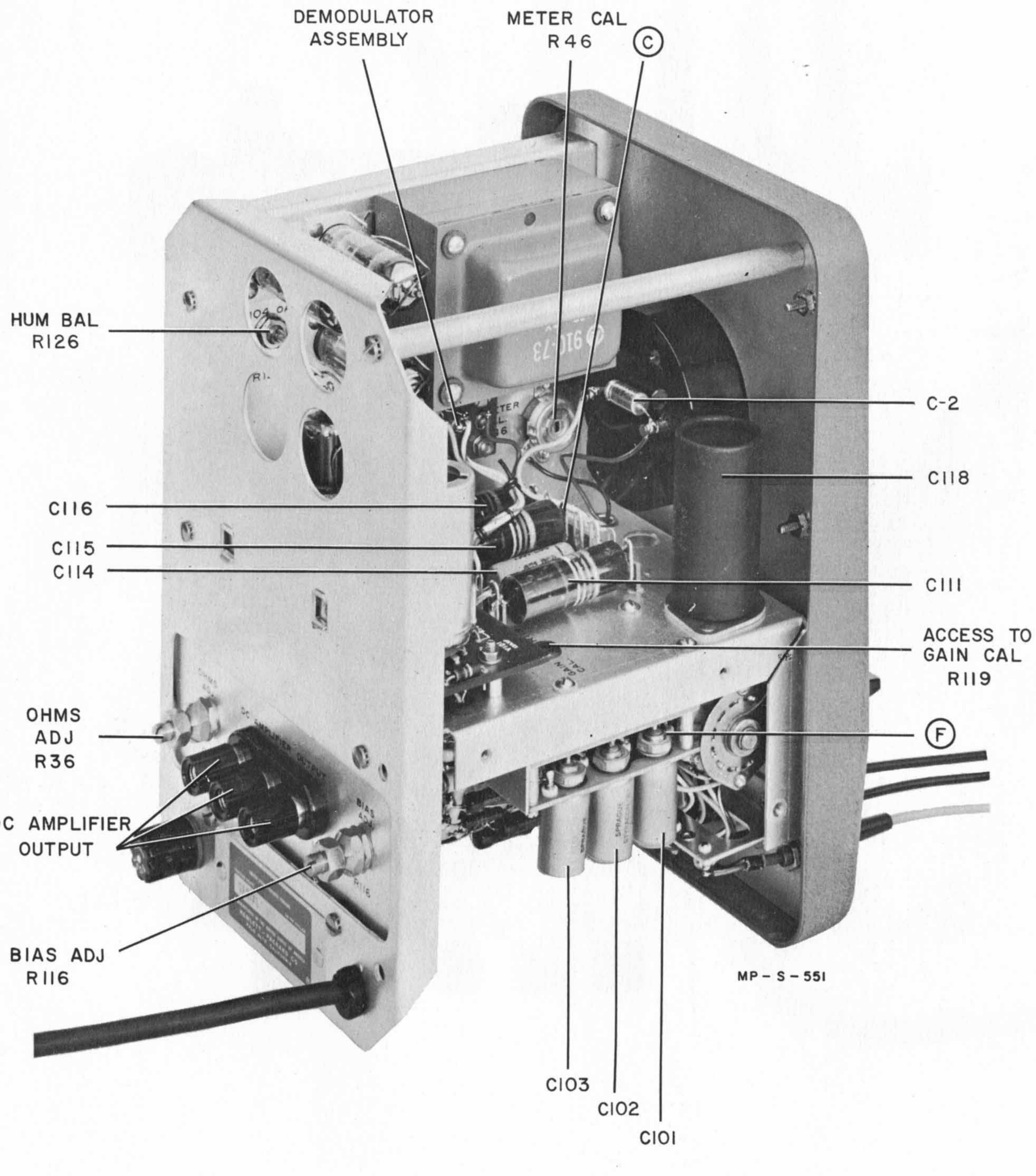


Figure 4-10. Upper Left Side View Model 412A

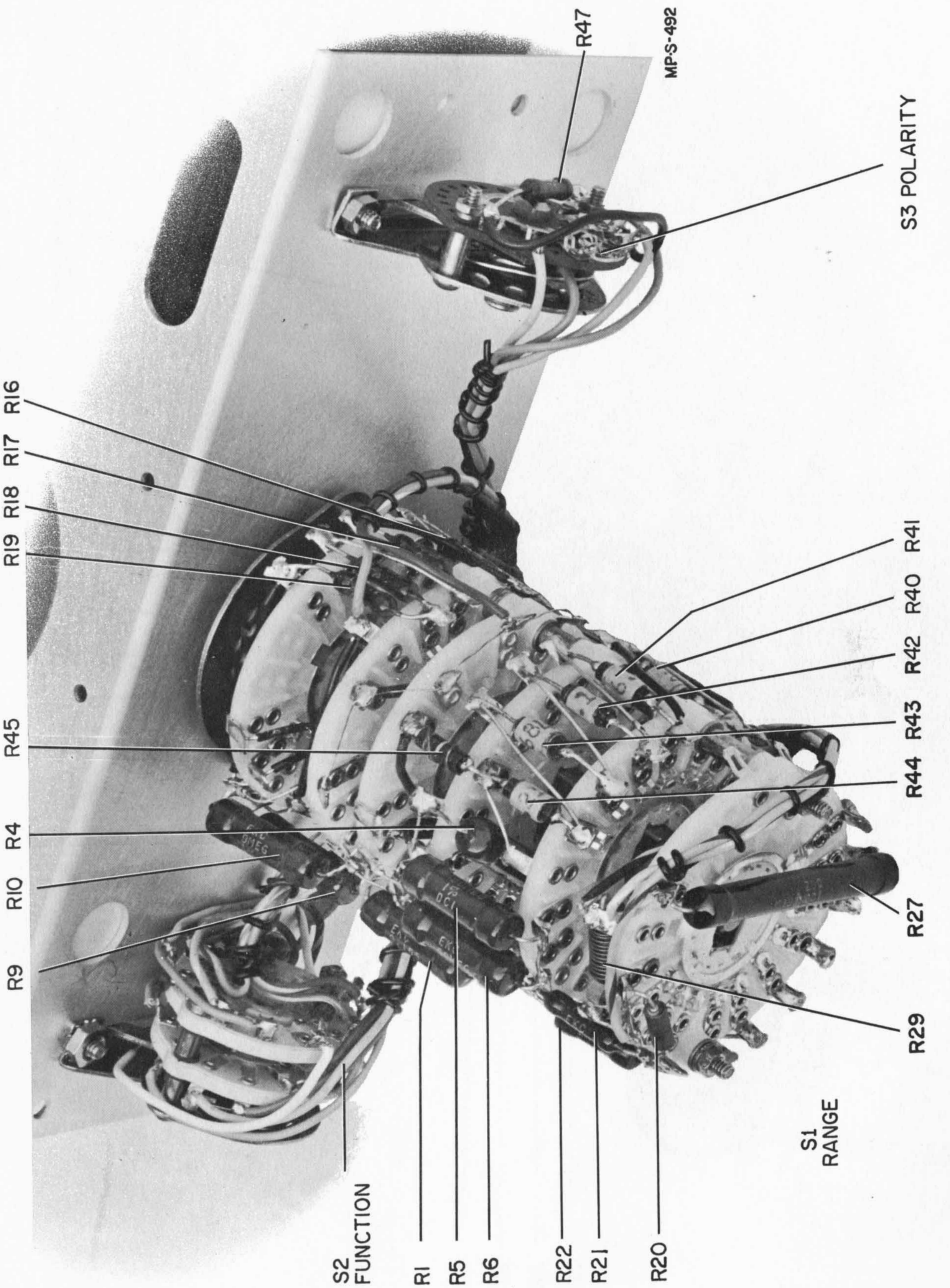


Figure 4-11. Location of Parts Mounted on Range, Function, and Polarity Switches

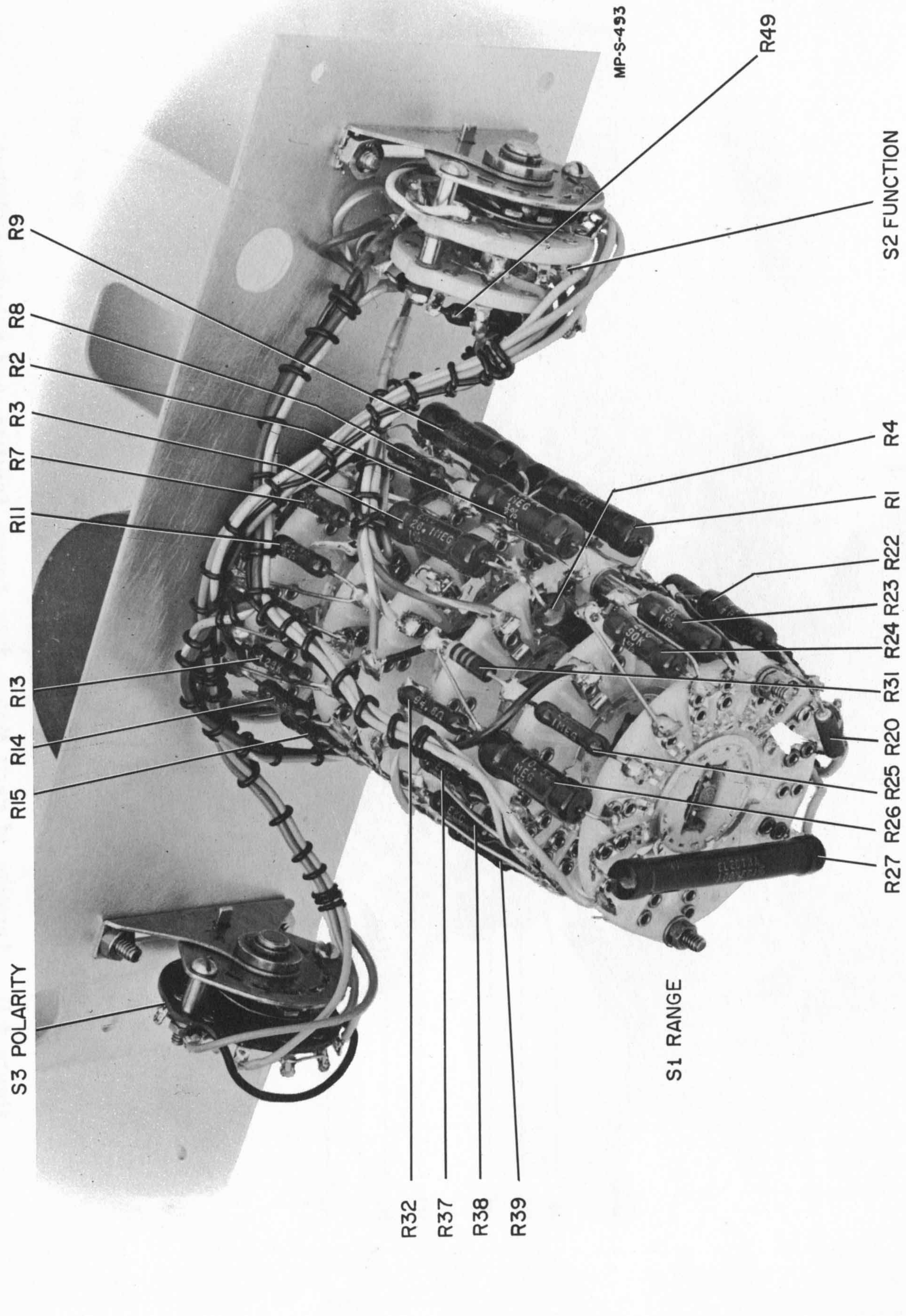


Figure 4-12. Location of Parts Mounted on Range, Function, and Polarity Switches

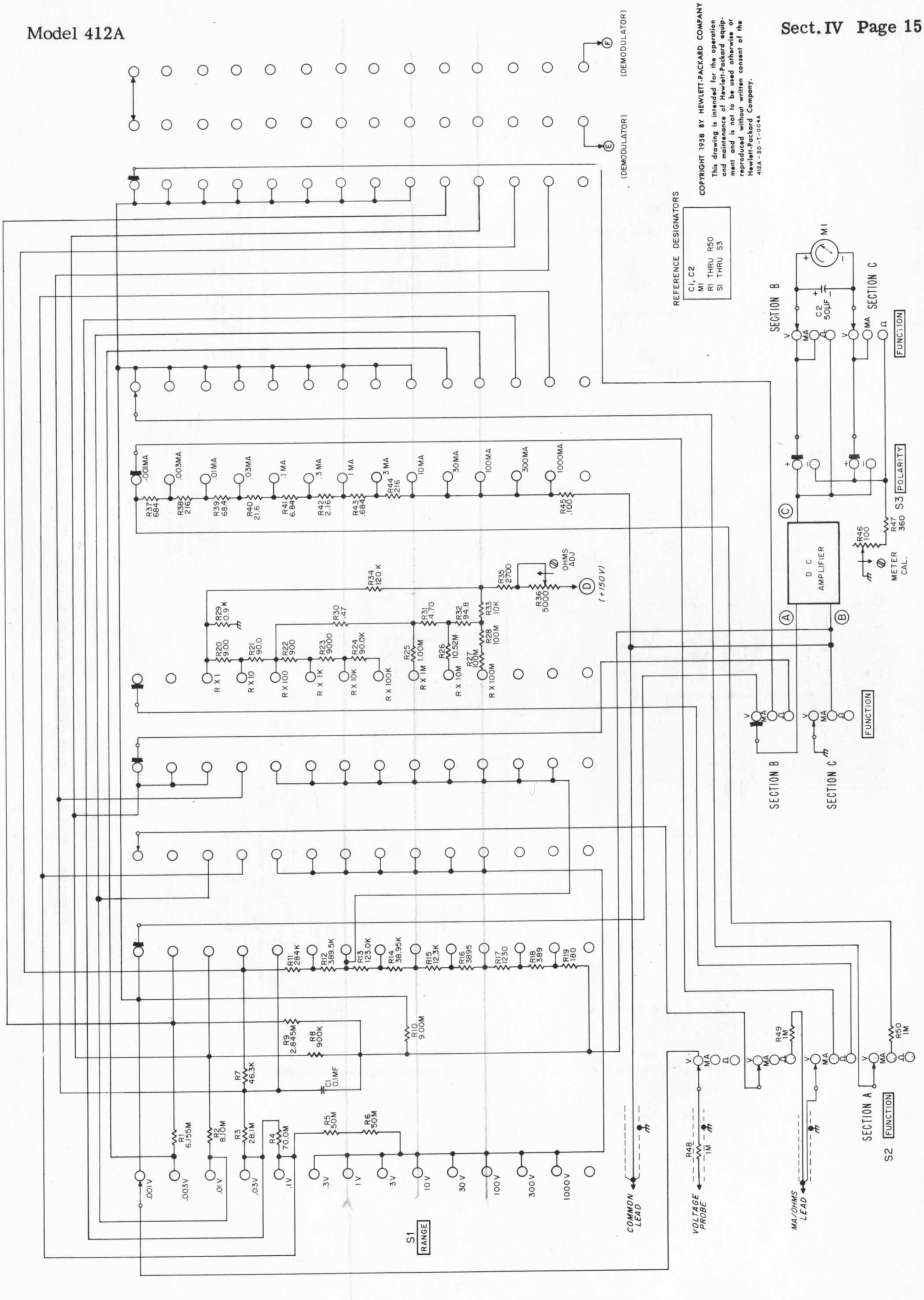


Figure 4-13. Range, Function and Polarity Switches Figure

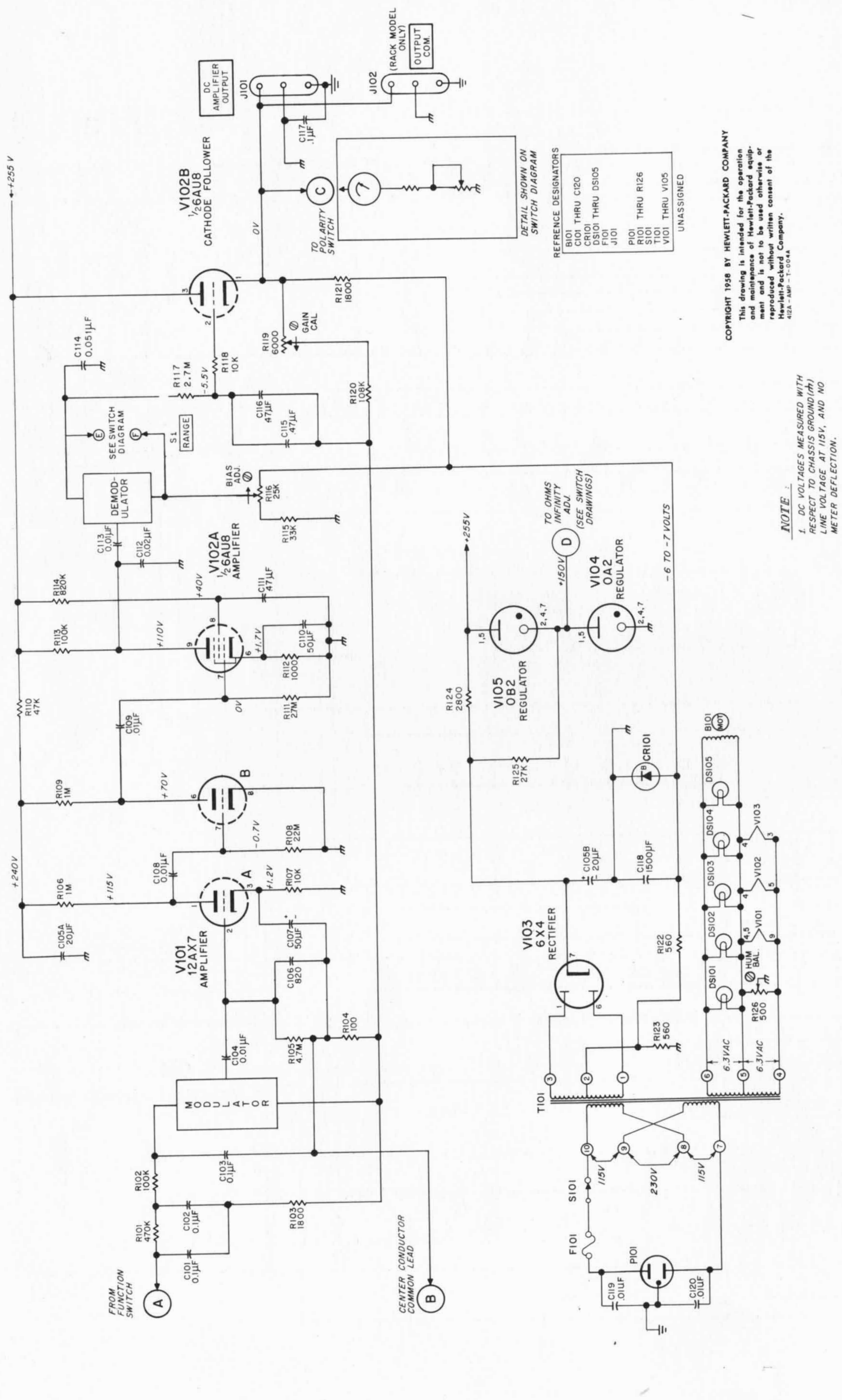


Figure 4-14. Amplifier and Power Supply

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. hp Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
B101	Motor, synchronous type: 6.3V, AC HP*	3140-0013	1	1		
C1	Capacitor: fixed, mylar, 0.1μf ±5%, 200 vdcw CW*	0170-0019	1	1		
C2	Capacitor: fixed, electrolytic, 50μf, 6 vdcw CC*	0180-0033	1	1		
C3 thru C100	These circuit references not assigned					
C101 thru C103	Capacitor: fixed, polystyrene, 0.1μf ±10%, 50 vdcw CC*	0170-0030	3	1		
C104	Capacitor: fixed, polystyrene, 0.01 μf ±10%, 50 vdcw CC*	0170-0029	1	1		
C105A, 105B	Capacitor: fixed, electrolytic, 2 sections 20μf/sect. 450 vdcw CC*	0180-0012	2	1		
C106	Capacitor: fixed, mica, 820pf ± 10%, 500 vdcw V*	0140-0010	1	1		
C107	Same as C2					
C108, 109	Capacitor: fixed, ceramic, .01μf tol. -0% +100%, 1000 vdcw CC*	0150-0012	4	1		
C110	Same as C2					
C111	Capacitor: fixed, paper, .47 μf ± 10%, 200 vdcw CC*	0160-0015	3	1		
C112	Capacitor: fixed, ceramic, .02 μf ± 10%, 600 vdcw Radio Materials Corp.	0150-0024	1	1		
C113	Same as C108					
C114	Capacitor: fixed, paper, .051μf ±10%, 200 vdcw Z*	0170-0003	1	1		
C115, 116	Same as C111					
C117	Capacitor: fixed, mylar, .1μf ±20%, 600 vdcw Texas Capacitor Co.	0170-0022	1	1		
C118	Capacitor: fixed, electrolytic, 1 section, 1500 μf 10 vdcw CC*	0180-0054	1	1		
C119, 120	Same as C108					

***-See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
CR101	Diode, breakdown: 7v	HP*	G-29C-74	1	1		
DS101 - DS105	Lamp, miniature: 2 pin base	O*	2140-0012	5	5		
F101	Fuse, cartridge: 1/2 amp, slow blow, for 115 volt operation	E*	2110-0008	1	10		
	Fuse, cartridge: 1/4 amp, slow blow, for 230 volt operation	E*	2110-0018				
J101	Binding post: black	HP*	G-10C	2	1		
	Binding post: red	HP*	G-10D	1	1		
	Insulator	HP*	AC-54B	1	1		
J102	Rack model only , same as J101						
M1	Meter	HP*	1120-0077	1	1		
P101	Power cord: type SV-18/. 3	Cornish	8120-0050	1	1		
R1	Resistor: fixed, deposited carbon, 6. 155 megohms ±1/2%, 1 W	NN*	0730-0128	1	1		
R2	Resistor: fixed, deposited carbon, 8. 1 megohms ±1/2%, 1 W	NN*	0730-0134	1	1		
R3	Resistor: fixed, deposited carbon, 28. 1 megohms ±1/2%, 1 W	NN*	0730-0149	1	1		
R4	Resistor: fixed, deposited carbon, 70 megohms ±1/2%, 2 W	NN*	0733-0014	1	1		
R5, 6	Resistor: fixed, deposited carbon, 50 megohms ±1/2%, 1 W	NN*	0730-0150	2	1		
R7	Resistor: fixed, deposited carbon, 46, 300 ohms ±1/2%, 1/2 W	NN*	0727-0192	1	1		
R8	Resistor: fixed, deposited carbon, 900, 000 ohms ±1/2%, 1 W	NN*	0727-0262	1	1		
R9	Resistor: fixed, deposited carbon, 2. 845 megohms ±1/2%, 1 W	NN*	0730-0117	1	1		
R10	Resistor: fixed, deposited carbon, 9 megohms ±1/2%, 1 W	NN*	0730-0139	1	1		
R111	Resistor: fixed, deposited carbon, 284, 000 ohms ±1/2%, 1/2 W	NN*	0727-0231	1	1		
R112	Resistor: fixed deposited carbon, 389, 500 ohms ±1/2%, 1/2 W	NN*	0727-0239	1	1		
R113	Resistor: fixed, deposited carbon, 123, 000 ohms ±1/2%, 1/2 W	NN*	0727-0215	1	1		

***-See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ -Total quantity used in the instrument.
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	TQ	RS		
R14	Resistor: fixed, deposited carbon, 38,950 ohms ±1/2%, 1/2 W	NN*	0727-0188	1	1		
R15	Resistor: fixed, deposited carbon, 12, 300 ohms ±1/2%, 1/2 W	NN*	0727-0164	1	1		
R16	Resistor: fixed, deposited carbon, 3895 ohms ±1/2%, 1/2 W	NN*	0727-0130	1	1		
R17	Resistor: fixed, deposited carbon, 1230 ohms ±1/2%, 1/2 W	NN*	0727-0106	1	1		
R18	Resistor: fixed, deposited carbon, 389 ohms ±1/2%, 1/2 W	NN*	0727-0070	1	1		
R19	Resistor: fixed, deposited carbon, 180 ohms ±1/2%, 1/2 W	NN*	0727-0051	1	1		
R20	Resistor: fixed, wirewound, 9 ohms	HP*	412A-26G	1	1		
R21	Resistor: fixed, deposited carbon, 90 ohms ±1/2%, 1/2 W	NN*	0727-0039	1	1		
R22	Resistor: fixed, deposited carbon, 900 ohms ±1%, 1/2 W	NN*	0727-0095	1	1		
R23	Resistor: fixed, deposited carbon, 9000 ohms ±1%, 1/2 W	NN*	0727-0152	1	1		
R24	Resistor: fixed, deposited carbon, 90, 000 ohms ±1%, 1/2 W	NN*	0727-0203	1	1		
R25	Resistor: fixed, deposited carbon, 1 megohm ±1%, 1/2 W	NN*	0727-0274	3	1		
R26	Resistor: fixed, deposited carbon, 10. 52 megohms ±1%, 1 W	NN*	0730-0144	1	1		
R27, 28	Resistor: fixed, deposited carbon, 100 megohms ±1%	NN*	0733-0017	2	1		
R29	Resistor: fixed, wirewound, . 900 ohms	HP*	412A-26D	1	1		
R30	Resistor: fixed, wirewound, 0. 47 ohms ±1%, 1/2 W	R*	0813-0019	1	1		
R31	Resistor: fixed, composition, 4. 7 ohms ±5%, 1/2 W	B*	0698-0001	1	1		
R32	Resistor: fixed, deposited carbon, 94. 8 ohms ± 1%, 1/2 W	NN*	0727-0040	1	1		

***- See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ- Total quantity used in the instrument.
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	TQ	RS		
R33	Resistor: fixed, wirewound, ±1%, 5 W AC*	0811-0007	1	1		
R34	Resistor: fixed, deposited carbon 136, 700 ohms ±1%, 1/2 W NN* Optimum value selected at factory Average value shown.	0727-0216	1	1		
R35	Resistor: fixed, composition, 2700 ohms ±10%, 1 W B*	0690-2721	1	1		
R36	Resistor: variable, composition, linear taper 5000 ohms, ± 20%, 1/2 W BO*	2110-0011	1	1		
R37	Resistor: fixed, deposited carbon, 684 ohms ±1/2%, 1/2 W NN*	0727-0086	1	1		
R38	Resistor: fixed, deposited carbon, 216 ohms ±1/2 %, 1/2 W NN*	0727-0056	1	1		
R39	Resistor: fixed, deposited carbon, 68. 4 ohms ±1/2%, 1/2 W NN*	0727-0035	1	1		
R40	Resistor: fixed, wirewound, 21. 6 ohms HP*	412A-26H	1	1		
R41	Resistor: fixed, wirewound, 6. 84 ohms HP*	412A-26F	1	1		
R42	Resistor: fixed, wirewound, 2.16 ohms HP*	412A-26E	1	1		
R43	Resistor: fixed, wirewound, . 684 ohms HP*	412A-26C	1	1		
R44	Resistor: fixed, wirewound, . 216 ohms HP*	412A-26B	1	1		
R45	Resistor: fixed, wirewound, . 1 ohms HP*	412A-26A	1	1		
R46	Resistor: variable, wirewound, linear taper 100 ohms, ± 20%, 2 W AT*	2100-0021	1	1		
R47	Resistor: fixed, deposited carbon, 360 ohms ±1%, 1/2 W NN* Optimum value selected at factory. Average value shown.	0727-0043	1	1		
R48	Resistor: fixed, deposited carbon, 1 megohm ±5%, 1/4 W NN*	0725-0001	1	1		
R49, 50	Same as R25					
R101	Resistor: fixed, composition, 470, 000 ohms ±10%, 1/2 W B*	0687-4741	1	1		

***-See "List of Manufacturers Code Letters For Replaceable Parts Table".**
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R102	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W B*	0687-1041	1	1		
R103	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W B*	0687-1821	2	1		
R104	Resistor: fixed, deposited carbon, 100 ohms ±1%, 1/2 W NN*	0727-0043	1	1		
R105	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2 W B*	0687-4741	1	1		
R106	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W B*	0687-1051	1	1		
R107	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W B*	0687-1031	2	1		
R108	Resistor: fixed, composition, 22 megohms ±10%, 1/2 W B*	0687-2261	1	1		
R109	Same as R106					
R110	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W B*	0687-4731	1	1		
R111	Resistor: fixed, composition, 2.7 megohms ±10%, 1/2 W B*	0687-2751	1	1		
R112	Resistor: fixed, composition, 1,000 ohms ±10%, 1/2 W B*	0687-1021	1	1		
R113	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W B*	0687-1041	1	1		
R114	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W B*	0687-8241	1	1		
R115	Resistor: fixed, composition, 33,000 ohms ±10%, 1/2 W B*	0687-3331	1	1		
R116	Resistor: variable, composition, 25,000 ohms ±20%, 1/3 W BO*	2100-0009	1	1		
R117	Resistor: fixed, composition, 2.7 megohms ±10%, 1/2 W B*	0687-2751	1	1		
R118	Same as R107					
R119	Resistor: variable, composition, linear taper 6,000 ohms ±20%, 1/4 W, BO*	2100-0136	1	1		
R120	Resistor: fixed, deposited carbon, 108,000 ohms ±1%, 1/2 W NN*	0727-0209	1	1		

***-See "List of Manufacturers Code Letters For Replaceable Parts Table".**
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R121	Same as R103					
R122, 123	Resistor: fixed, composition, 560 ohms ±10%, 1 W B*	0690-5611	2	1		
R124	Resistor: fixed, wirewound, 2800 ohms ±10%, 5 W S*	0813-0018	1	1		
R125	Resistor: fixed, composition, 27,000 ohms ±10%, 2 W B*	0693-2731	1	1		
R126	Resistor: variable, composition, linear taper 500 ohms ±30%, 3/10W, BO*	2100-0078	1	1		
S1	Range switch assembly HP*	412A-19W	1	1		
S2	Switch, rotary: 3 pos., 2 sect. W*	3100-0183	1	1		
S3	Switch, lever: 2 pos., 1 sect. W*	3100-0184	1	1		
S101	Switch, toggle: SPST, 250V, 3 amp CR*	3101-0001	1	1		
T101	Transformer, power HP*	9100-0021	1	1		
V101	Tube, electron: 12AX7 ZZ*	1932-0030	1	1		
V102	Tube, electron: 6AU8 ZZ*	1921-0003	1	1		
V103	Tube, electron: 6X4 ZZ*	1930-0016	1	1		
V104	Tube, electron: OA2 ZZ*	1940-0004	1	1		
V105	Tube, electron: OB2 ZZ*	1940-0007	1	1		
	MISCELLANEOUS					
	Amplifier assembly HP*	412A-65A	1	1		
	Amplifier, input circuit (incl. modulator) HP*	412A-58A	1	1		
	Cable assembly, common HP*	412A-21B	1	1		
	Cable assembly, Ohm-Ma HP*	412A-21C	1	1		
	Chopper assembly (incl. motor, lamps and leads) HP*	425A-97A	1	1		

*** - See "List of Manufacturers Code Letters For Replaceable Parts Table".**
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
	Demodulator assembly	HP*	412A-23B	1	1		
	Fuseholder: extractor post type	T*	1400-0007	1	1		
	Knob: range switch	HP*	G-74N	1	1		
	Knob: function switch/polarity switch	HP*	G-74BX	2	1		
	Lampholder: for 2 pin lamp	AD*	1450-0022	5	1		
	Light rod, modulator	HP*	412A-37A	2	1		
	Probe and cable assembly, voltage	HP*	412A-21A	1	1		
	Tube shield	H*	1220-0009	1	1		

***- See "List of Manufacturers Code Letters For Replaceable Parts Table".**
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LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

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

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 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. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. 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 when upon our examination it 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 and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. 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 Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or 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
275 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.
CABLE "HEWPACK"