



OPERATING AND SERVICE MANUAL

MODEL 412A/AR

SERIALS PREFIXED: 134-

DC VACUUM TUBE
VOLTMETER

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1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.



Table 1-1. Specifications

VOLTMETER

Voltage Range:

Positive and negative voltages from 1 millivolt full scale to 1000 volts full scale in 13 ranges

Accuracy:

±1% of full scale on any range

Input Resistance:

10 megohms ±1% on 1mv, 3mv, and 10mv ranges
30 megohms ±1% on 30 mv range
100 megohms ±1% on 100mv range
200 megohms ±1% on 300mv 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 micro-ampere 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
.001 ma	1000 ohms	1 mv
.003 ma	316 ohms	0.9486 mv
.01 ma	100 ohms	1 mv
.03 ma	31.6 ohms	0.9486 mv
.1 ma	10 ohms	1 mv
.3 ma	31.6 ohms	0.9486 mv
1 ma	1 ohm	1 mv
3 ma	.316 ohm	0.9486 mv
10 ma	.1 ohm	1 mv
30 ma	.1 ohm	3 mv
100 ma	.1 ohm	10 mv
300 ma	.1 ohm	30 mv
1000 ma	.1 ohm	100 mv

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

OHMMETER

Resistance Range:

Resistance from 1 ohm center-scale to 100-megohms center-scale in nine decade ranges

Accuracy:

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

Voltages and Currents:

Range	Open Circuit Volts	Short Circuit Current
x1	10 mv	10 ma
x10	100 mv	10 ma
x100	1 v	10 ma
x1000	1 v	1 ma
x10K	1 v	100 ua
x100K	1 v	10 ua
x1M	1 v	1 ua
x10M	1 v	.1 ua
x100M	1 v	.01 ua

AMPLIFIER

Voltage Gain: 1000 maximum

AC Rejection:

3 db at 1 cps, approximately 80 db at 50 and 60 cps

Output:

Proportional to meter indication; 1 volt at full scale; maximum current, 1 ma. (Full scale corresponds to 1.0 on upper scale.)

Output Impedance:

Less than 2 ohms at dc

Noise:

Less than 0.1% of full scale on any range

Drift: negligible

GENERAL

Isolation Resistance:

At least 100 megohms shunted by 0.1 uf between common terminal and case (power line) ground

Common Mode Rejection:

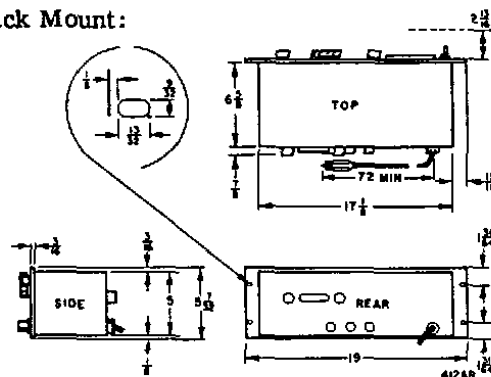
Maybe operated up to 500 vdc or 130 vac from ground

Power: 115/230v ±1%, 50-60 cps, 35 w

Dimensions:

Cabinet Mount: 11-1/2 in. high, 7-1/2 in. wide, 10 in. deep

Rack Mount:



Weight: Cabinet Mount: Net 12 lbs, shipping 17 lbs
Rack Mount: Net 12 lbs, shipping 20 lbs

SECTION I

GENERAL DESCRIPTION

1-1. GENERAL.

1-2. The Model 412A/AR DC Vacuum Tube Voltmeter is a precision, wide range, multipurpose instrument which covers the entire range of dc voltage, current, and resistance measurements normally encountered in electronic equipment.

1-3. It measures dc voltages over the wide range of 0.02 millivolts to 1000 volts on thirteen ranges arranged in a 1, 3, 10 sequence from 1 mv full scale to 1000 v full scale. Overall accuracy on all thirteen ranges is within $\pm 1\%$ of full scale. Voltage differences can be measured easily since the input circuit is isolated from the case and from the power line ground.

1-4. DAMAGE IN SHIPMENT.

1-5. 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 back of this manual.

1-6. POWER CABLE.

1-7. 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.

1-8. 115-230 VOLT OPERATION.

1-9. A switch located on the instrument rear converts the Model 412A/AR for use from either a 115-volt or 230-volt, 50-60 cps power source. The switch changes the connection of the dual 115-volt primary windings of the power transformer from a parallel combination to a series combination, or vice versa. Switch positions are marked 115 and 230.

1-10. To convert the instrument from 115-volt operation to 230-volt operation, or vice versa, insert a screwdriver blade into the switch slot and slide the slot until the marking indicates the line voltage. At

the time of the change, replace the line fuse. A one-half ampere slow-blow fuse should be used for 115-volt operation; a 0.4 ampere slow-blow fuse should be used for 230-volt operation.

CAUTION

Be sure the 115/230 V switch is set at the proper position before applying power to the instrument. Incorrect setting of the switch can result in damage to the instrument.

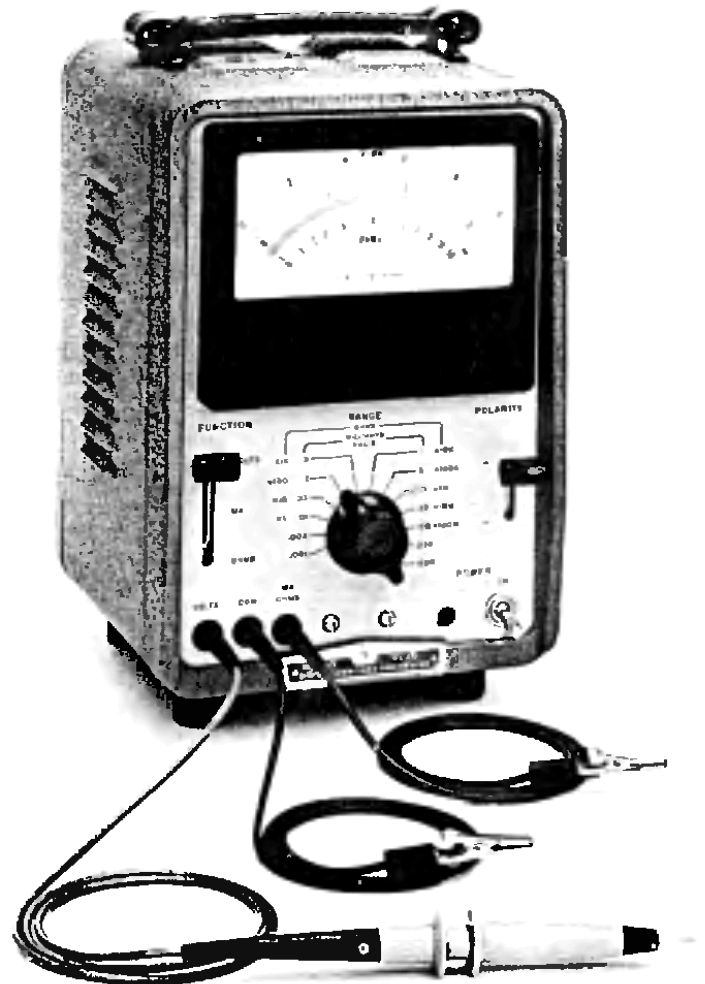


Figure 1-1. Model 412A/AR

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 ua
X100K	1 v	10 ua
X1M	1 v	1 ua
X10M	1 v	0.1 ua
X100M	1 v	0.01 ua

SECTION III

CIRCUIT OPERATION

3-1. GENERAL

3-2. The Model 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.

3-3. CIRCUIT OPERATION.

3-4. 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.

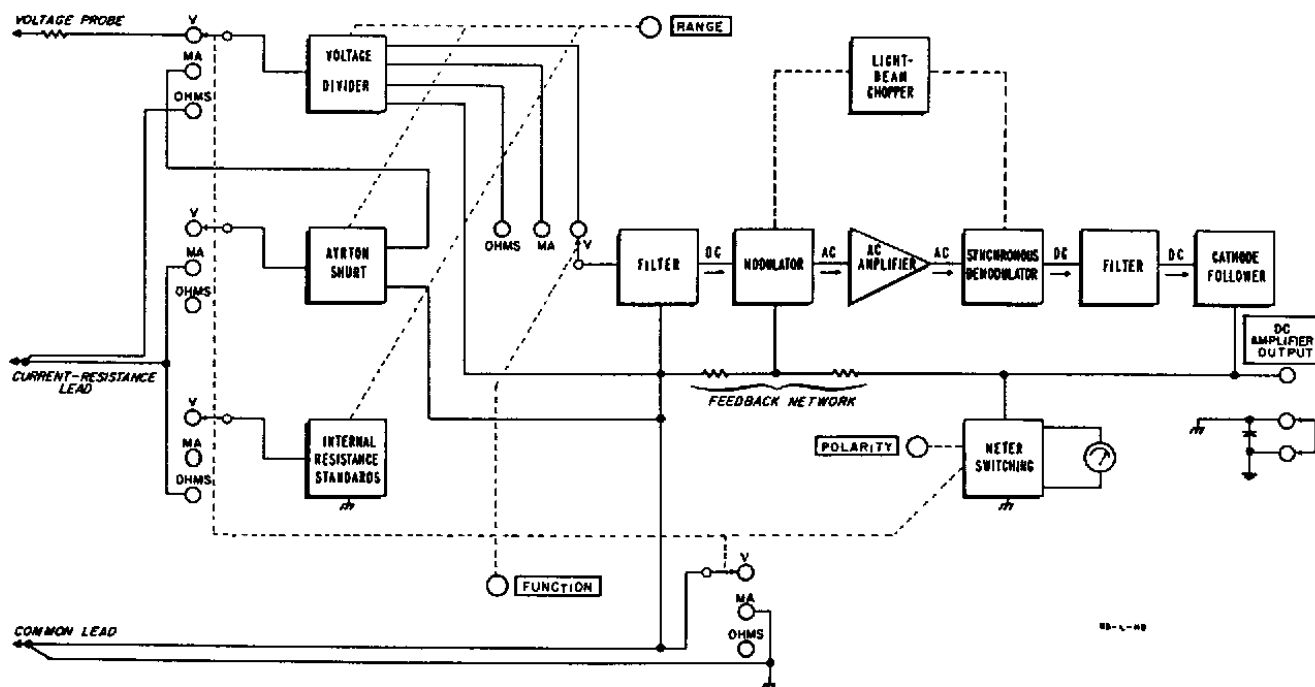
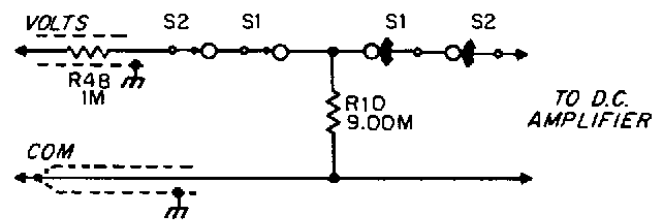
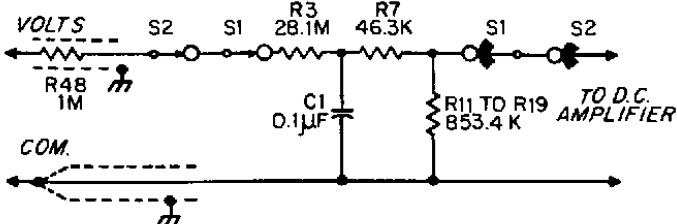


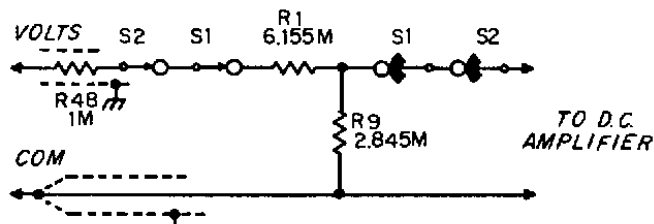
Figure 3-1. Model 412A Block Diagram



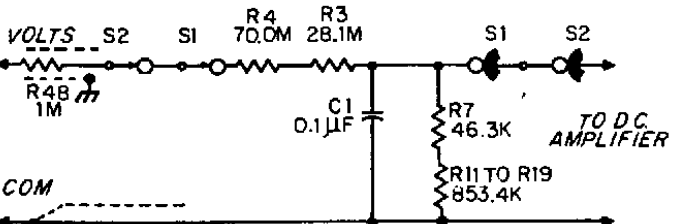
.001-volt range



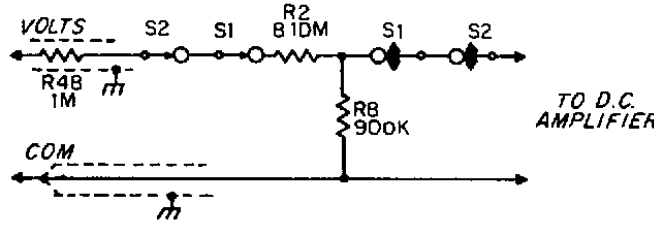
.03-volt range



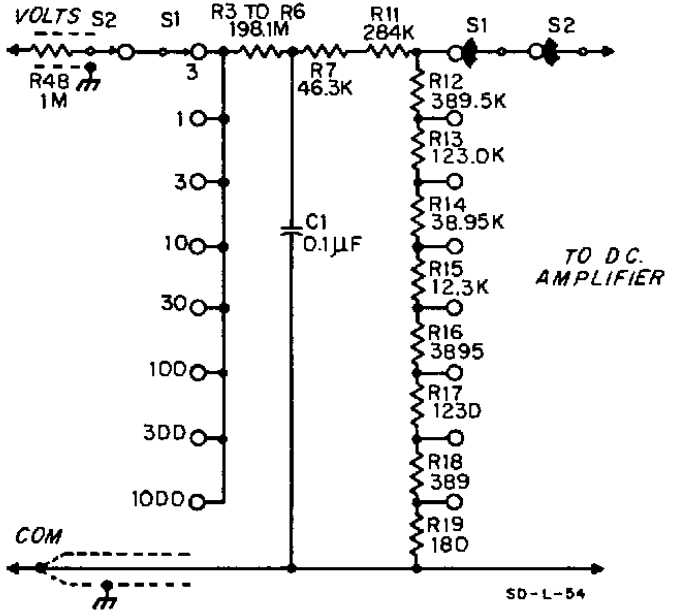
.003-volt range



.1-volt range



.01-volt range



.3 to 1000-volt ranges

Figure 4-6. Simplified Diagram of Voltmeter Switching

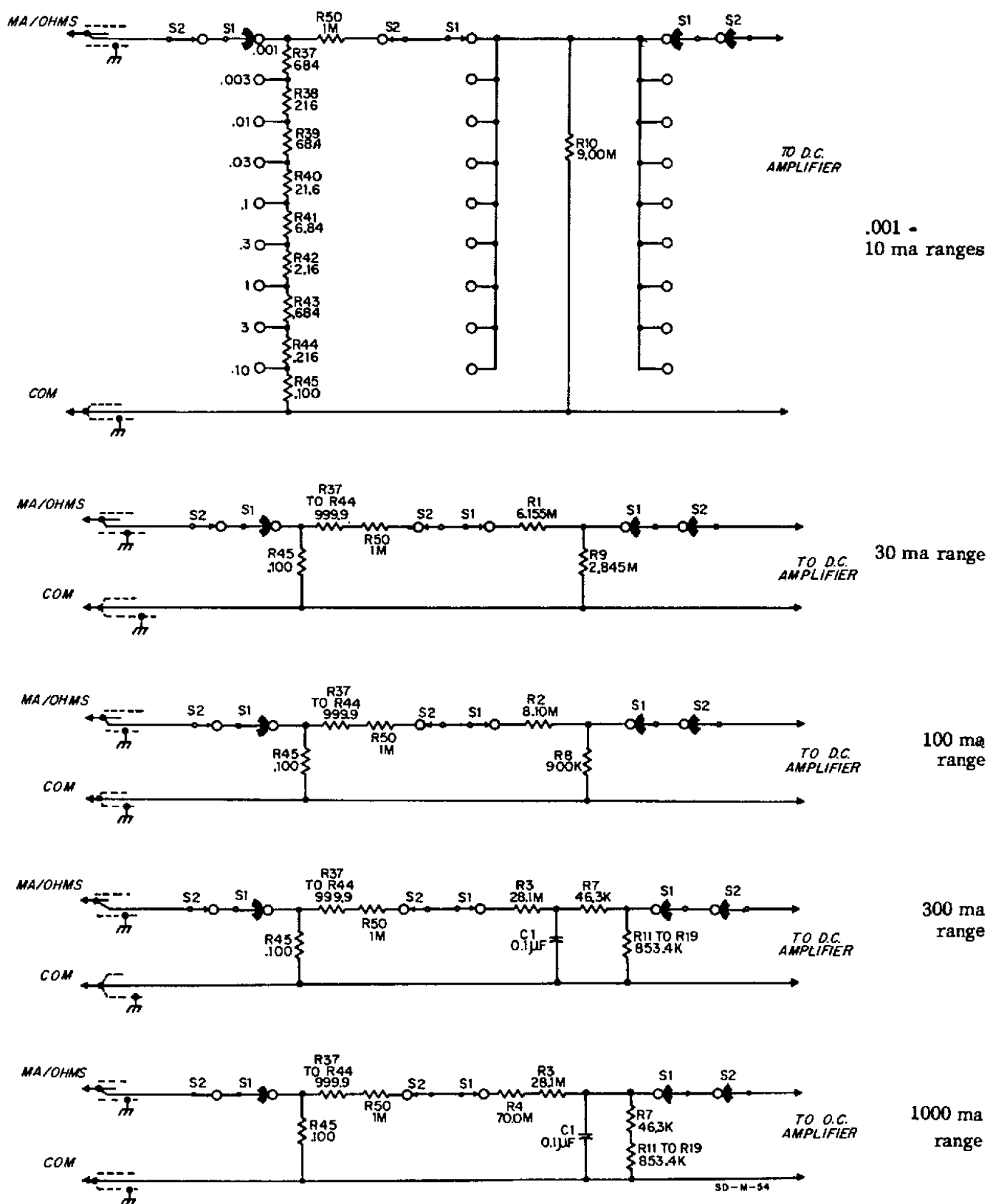


Figure 4-7. Simplified Diagram of Ammeter Switching

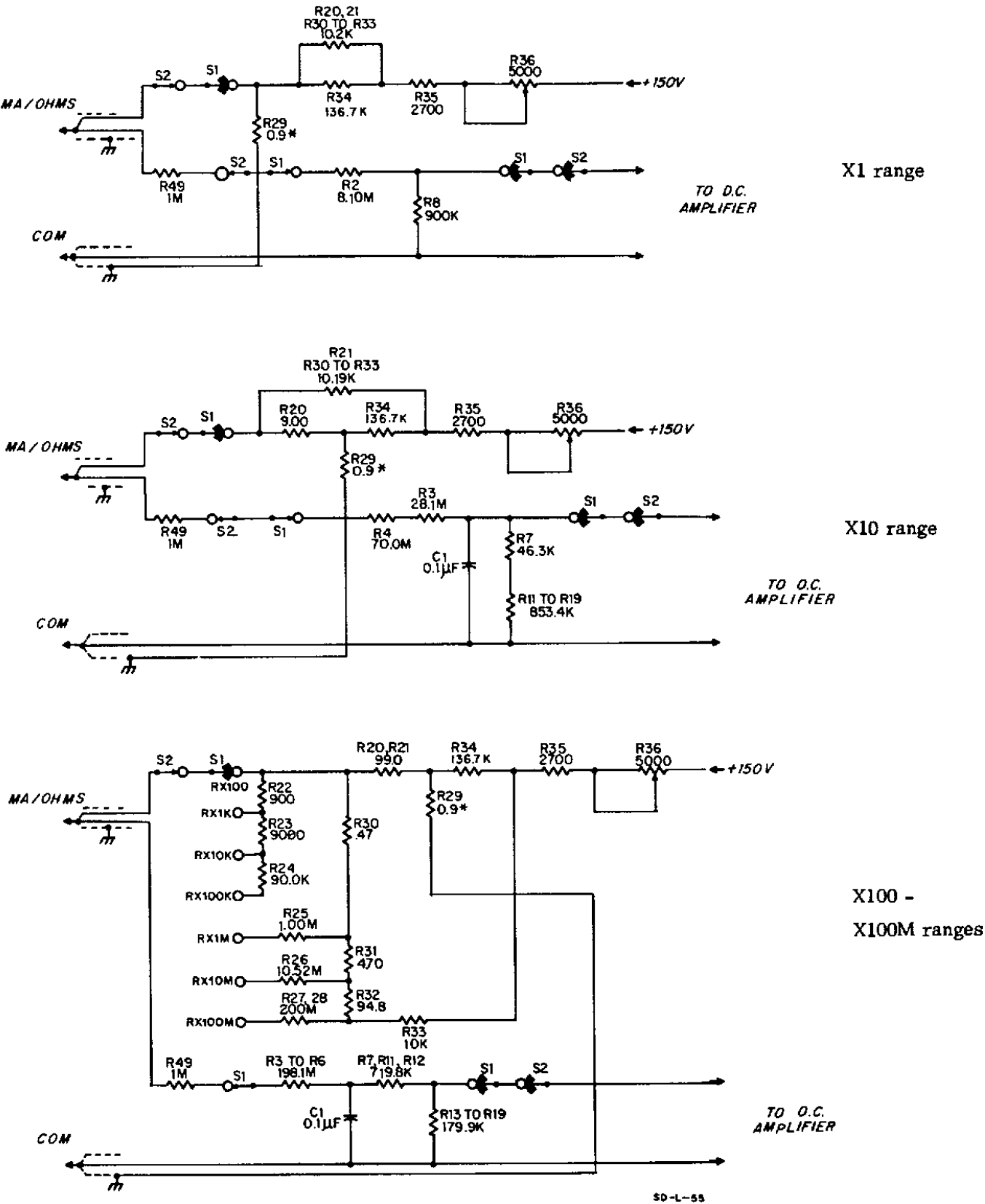


Figure 4-8. Simplified Diagram of Ohmmeter Switching Figure

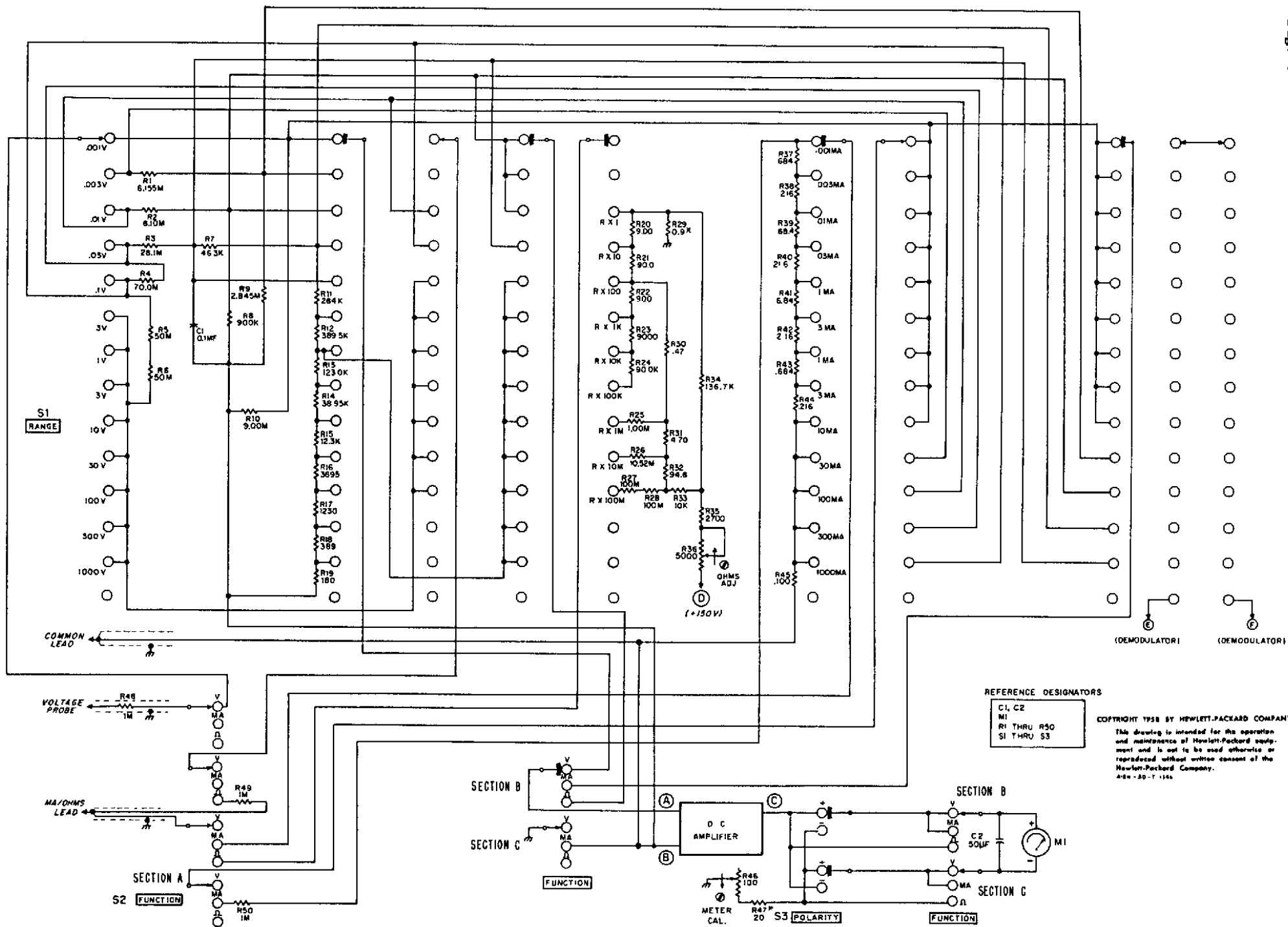


Figure 4-14. Range, Function and Polarity Switches Figure.

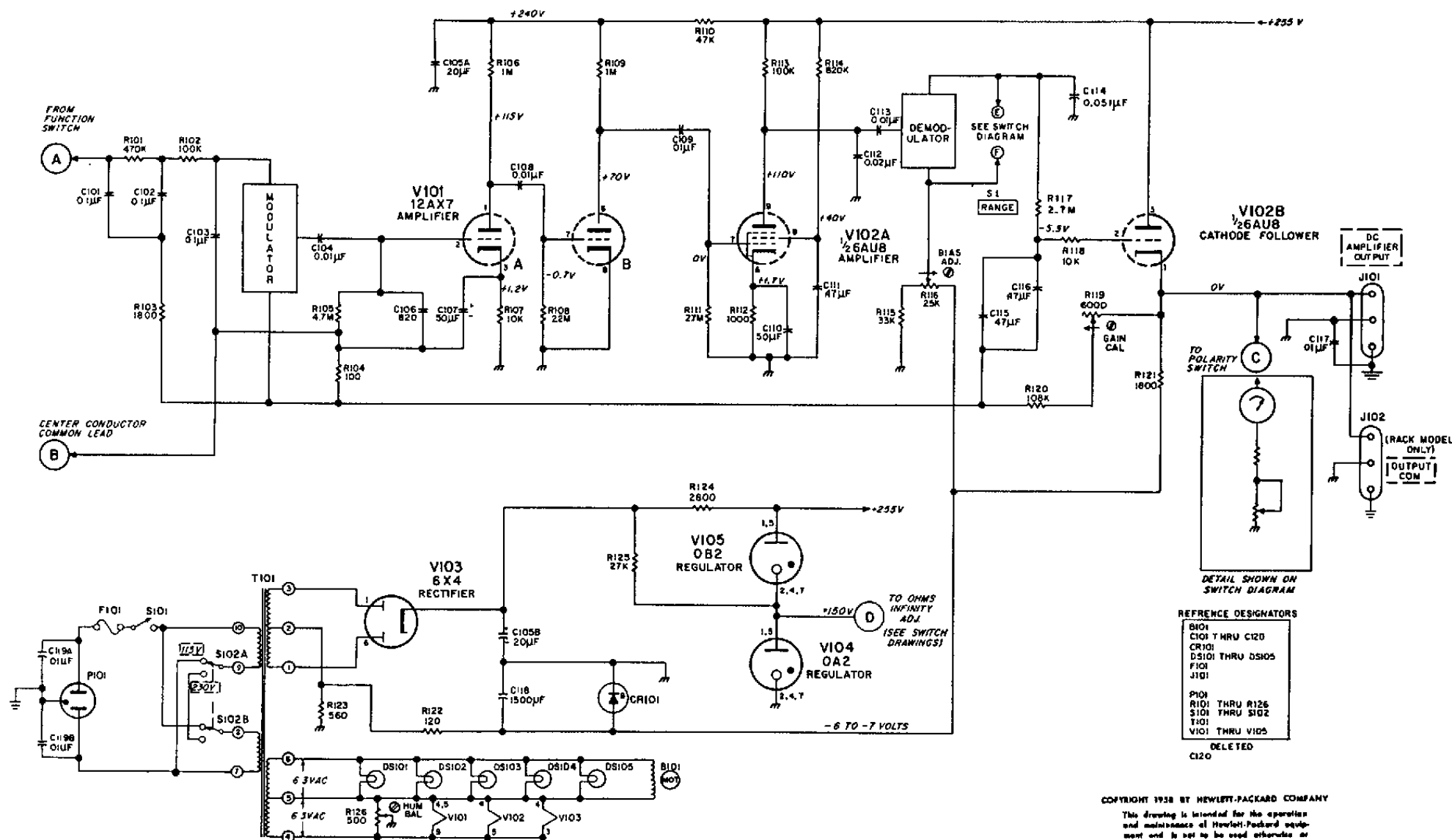


Figure 4-15. Amplifier and Power Supply

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