OPERATING AND SERVICE MANUAL

MODEL 412A/AR

SERIALS PREFIXED: 134-

DC VACUUM TUBE VOLTMETER

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

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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 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
.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

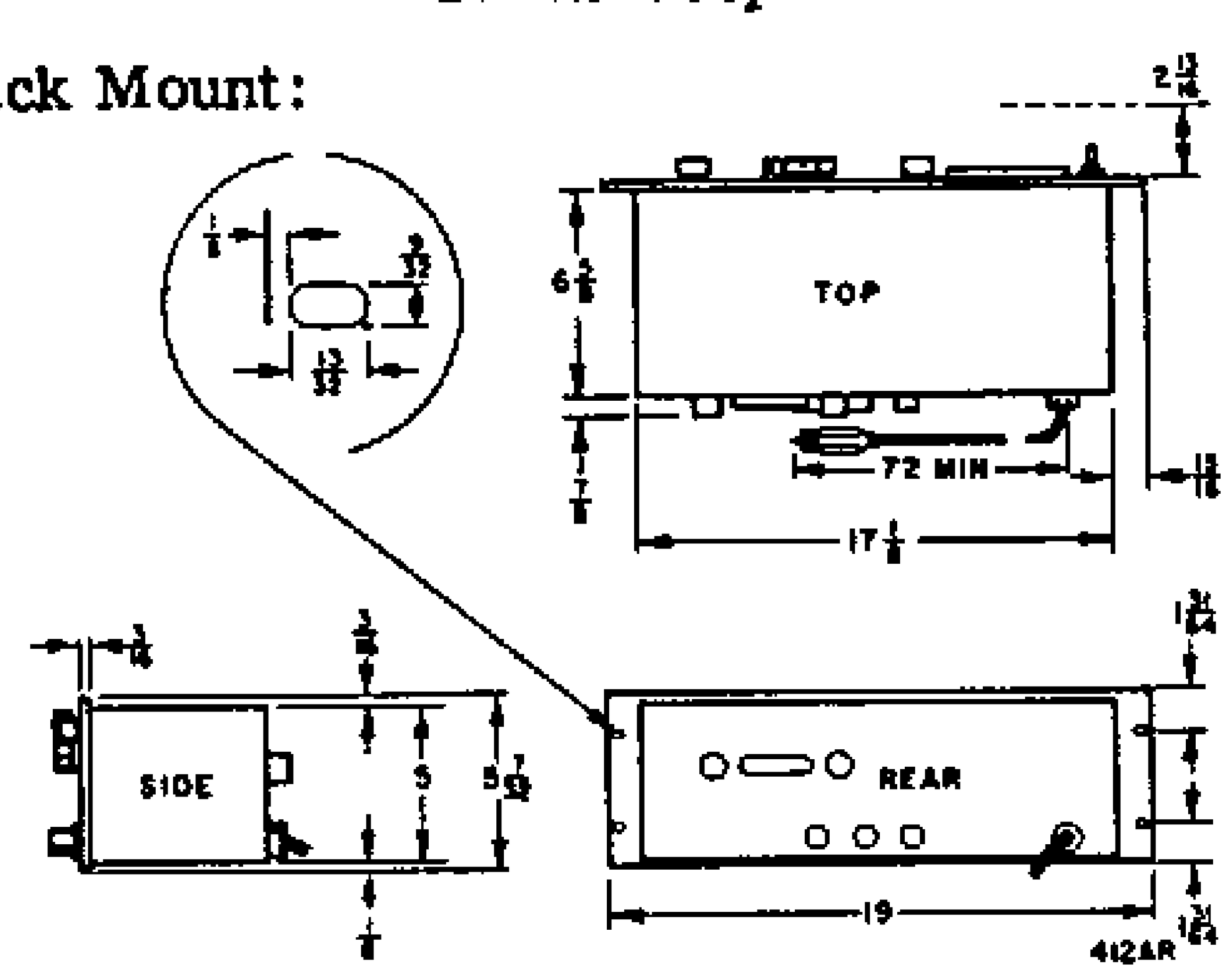
Isolation Resistance:
At least 100 megohms shunted by 0.1 uf between common terminal and case (power line) ground

Common Mode Rejection:
May be 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 ±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.

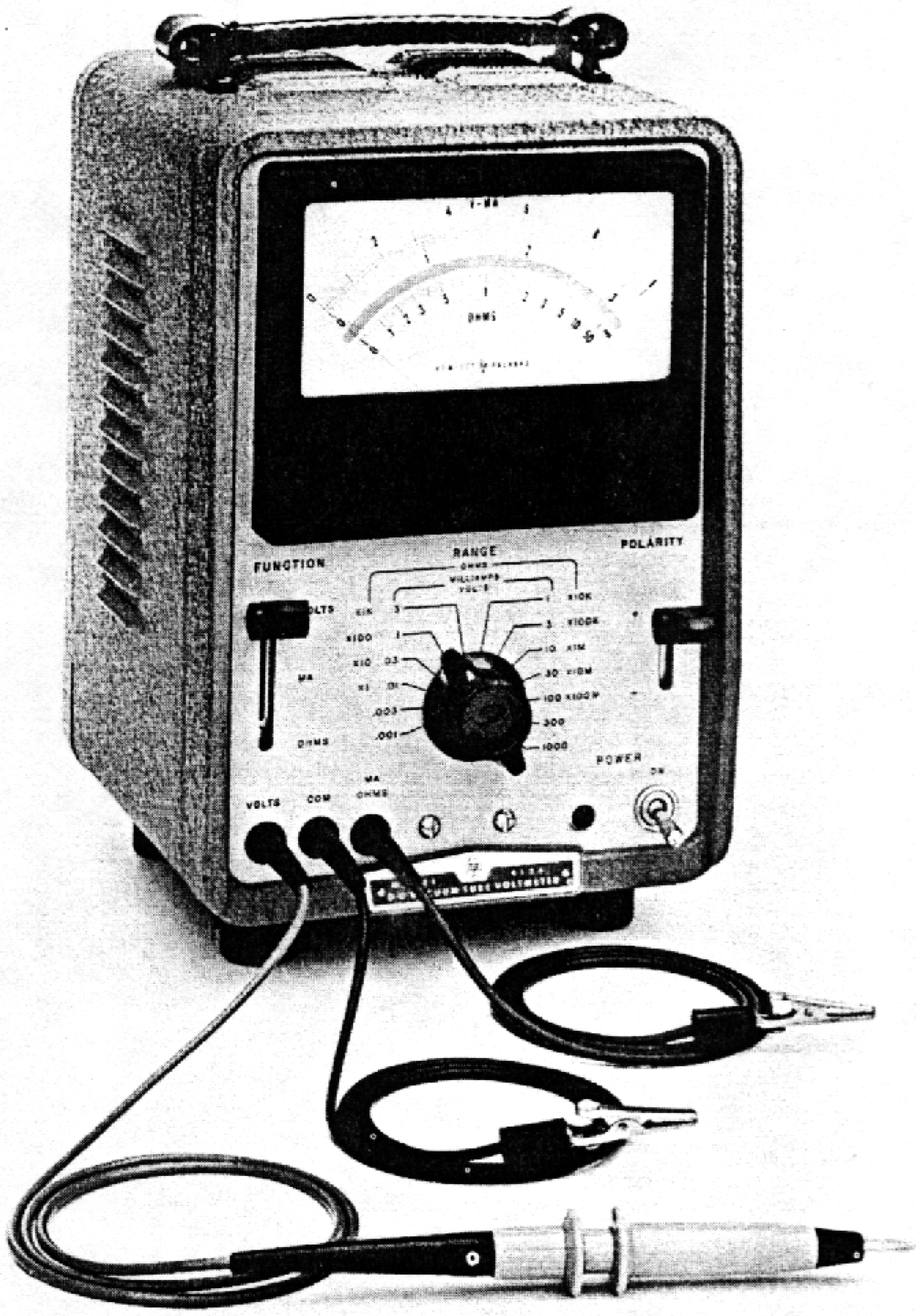


Figure 1-1. Model 412A/AR

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 II
OPERATING INSTRUCTIONS

2-1. LOW-LEVEL ELECTRICAL PHENOMENA.

2-2. 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.

2-3. The 412A voltage probe, current/resistance lead and common lead are designed to have a very low thermoelectric effect with copper, the most complete 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 uv/^{o}C with respect to a reference junction.

2-4. 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.

2-5. 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.

2-6. Turn the Model 412A on and allow a few minutes warmup.

2-7. VOLTAGE MEASUREMENT.

a. Set FUNCTION selector to VOLTS.

b. Set POLARITY switch to desired polarity.

c. Set RANGE switch to desired range.

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

2-8. CURRENT MEASUREMENT.

a. Set FUNCTION selector to MA.

b. Set RANGE switch to desired range.

c. De-energize circuit to be tested.

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

e. 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.

2-9. RESISTANCE MEASUREMENT.

a. Set FUNCTION selector to OHMS.

b. De-energize circuit to be measured.

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

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

2-10. 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.

2-11. OPERATION WITH A RECORDER.

2-12. 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.

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.

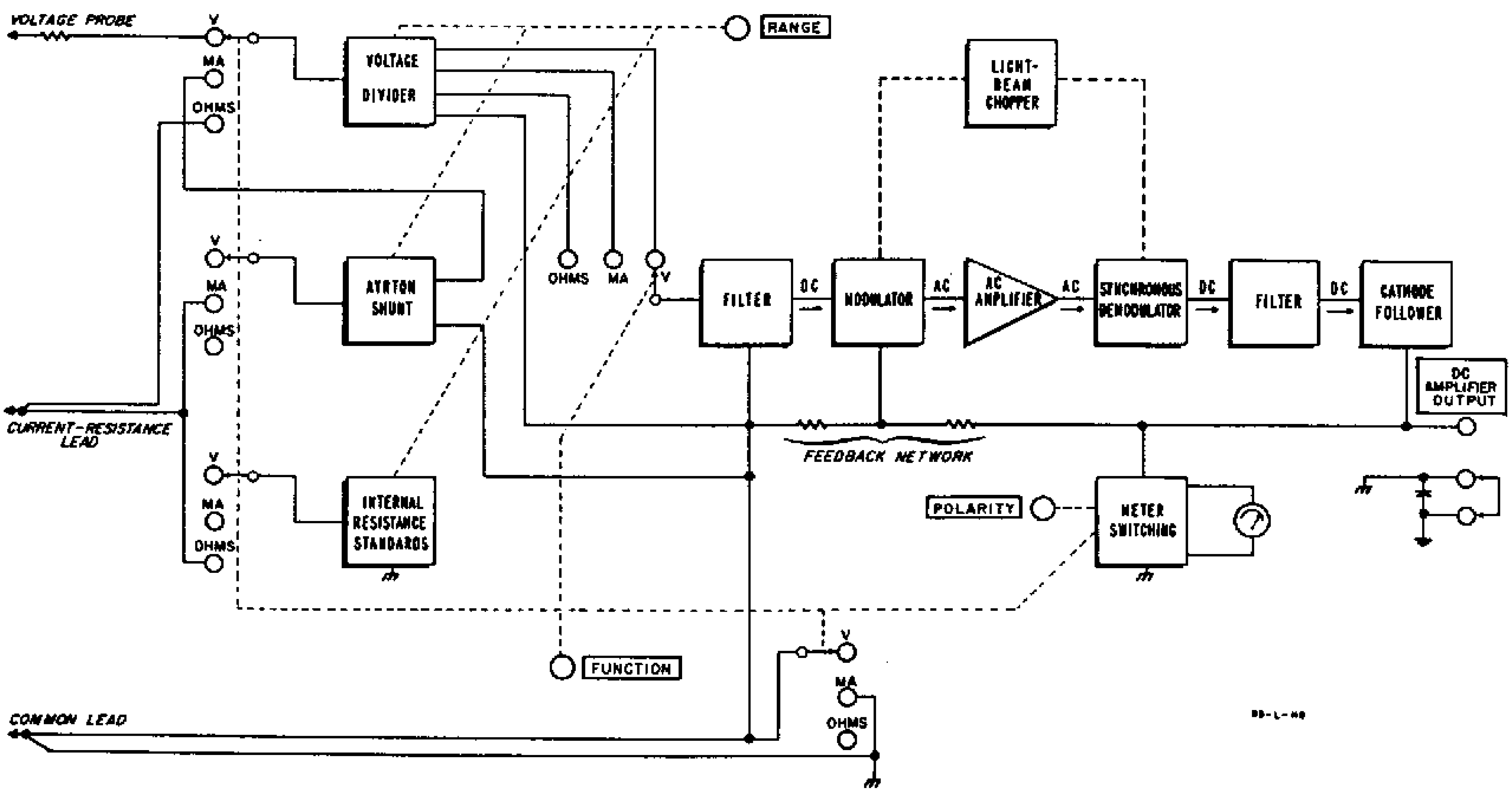


Figure 3-1. Model 412A Block Diagram

SECTION IV
MAINTANCE

4-1. INTRODUCTION.

4-2. 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.

4-3. 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.

4-4. When ordering parts, specify instrument model and serial number plus the component description and stock number appearing in the Table of Replaceable Parts.

4-5. Your local hp Representative maintains complete facilities and specially trained personnel to assist you with hp instruments.

4-6. REQUIRED TEST EQUIPMENT.

4-7. To carry out the instructions in this section, you will need the following test equipment:

a. 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.

b. 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.

c. 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.

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

e. 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.

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

4-8. PERFORMANCE CHECK.

4-9. You can check instrument performance without moving the cabinet. Before starting, check the mechanical zero of the meter; if the meter requires adjustment, see paragraph 4-15.

4-10. VOLTMETER CHECK.

a. Turn Voltmeter Calibration Generator on and allow 5-minute warmup.

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

c. Set FUNCTION selector to VOLTS and POLARITY switch to +.

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

e. 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 Model 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+.

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

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

4-11. MILLIAMMETER CHECK.

a. Set line voltage to 115 volts.

b. Set FUNCTION selector to MA and POLARITY switch to +.

c. Connect 412A to Voltmeter Calibration Generator as shown in figure 4-2.

d. Check 412A as shown in table 4-1.

Note

Switching through the current ranges from 10 to 1000 does not change the current shunt. Only the voltage attenuator, checked in paragraph 4-10 above, changes. (See figures 4-6, 4-7, and 4-8 for simplified switching details.)

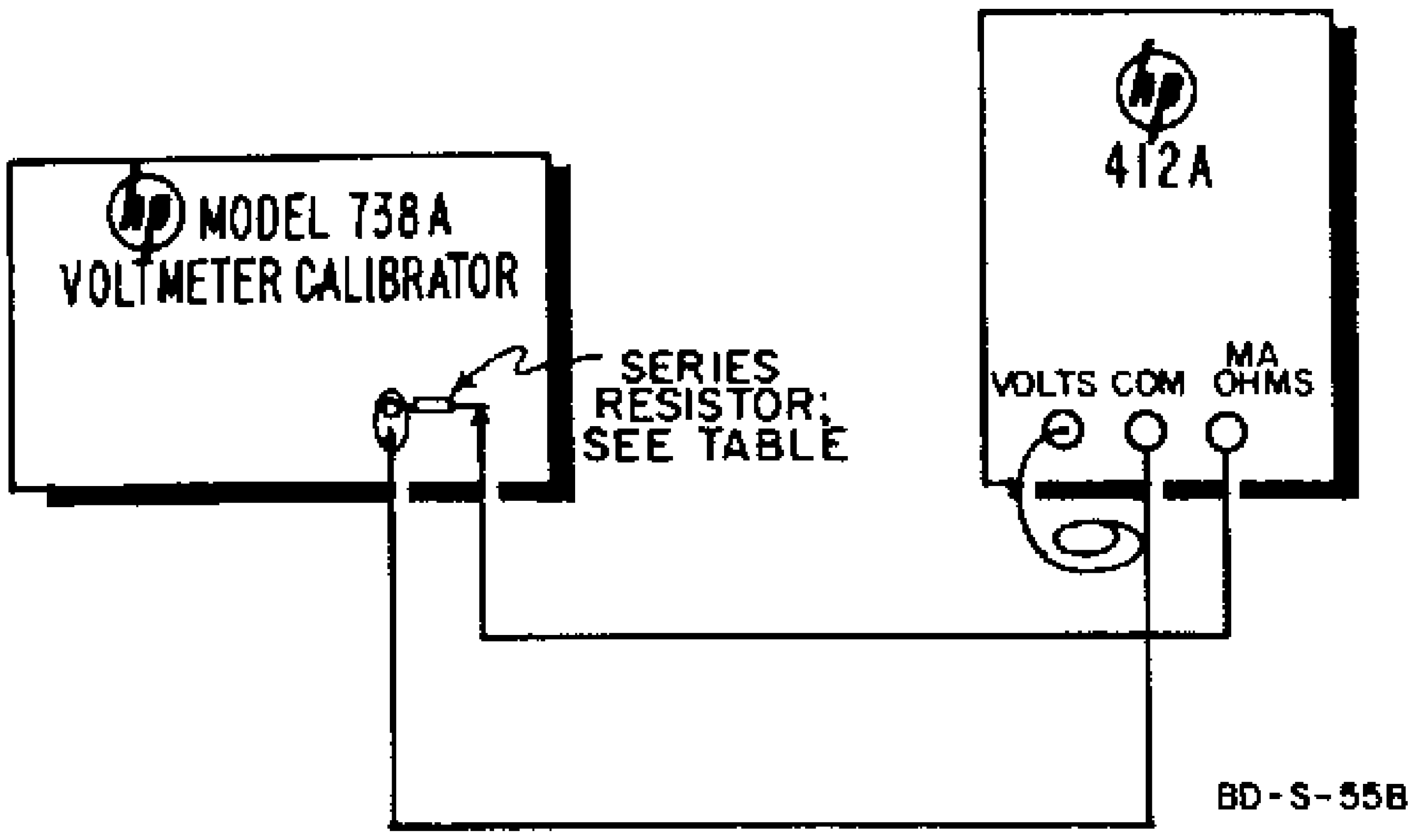


Figure 4-2. Equipment Setup for Current Check

4-12. OHMMETER CHECK.

a. Set FUNCTION selector to OHMS.

b. Connect 1% resistor of 1, 10, 100, 1000, 10K, 100K, 1M, 10M and 100M ohms between MA/OHMS and COM leads. With appropriate range selected, meter should indicate between 0.95 and 1.05 in each case.

4-13. CABINET REMOVAL.

a. Unplug power cord from power source.

b. Remove two retaining screws from instrument rear.

c. 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.

4-14. ADJUSTMENTS.

4-15. MECHANICAL ADJUSTMENT OF METER ZERO.

4-16. When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step you must repeat steps c through e.

4-17. HUM BALANCE ADJUSTMENT.

a. Turn instrument on and allow a few minutes warmup.

b. Set FUNCTION selector to VOLTS.

c. Connect oscilloscope to DC AMPLIFIER OUTPUT connector.

d. 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 4-11 for location of R126.

Note

The Hum Bal. control does not affect the 120-cps ripple. Adjust only for minimum 10-cps (or 8-1/3 cps) ripple. With the VOLTS lead connected to COM., and the POLARITY selector to +, the 412A meter will show a minimum reading when the hum balance adjustment is correctly made.

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%	1.0	1.0
300 volts	100K ± 0.1%	3.0	3.0
300 volts	30K ± 0.1% (5 watts)	10.0	1.0
300 volts	30K ± 0.1% (5 watts)	30.0	1.0 (on 0-3 scale)

4-18. CATHODE FOLLOWER BIAS ADJUSTMENT.

a. Set RANGE switch full clockwise - one step beyond 1000.

b. 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.

4-19. AMPLIFIER GAIN CALIBRATION AND METER CALIBRATION.

a. Connect equipment as shown in figure 4-3. You may replace the test voltmeter with any high resistance meter device which can resolve 10 mv.

b. Set Voltmeter Calibration Generator output to +1 volt.

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

d. Adjust Gain Cal (R119), for zero on test voltmeter. For location of R119 see figure 4-11. A 10-mv reading on test voltmeter indicates 1% error in gain calibration.

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

f. Disconnect test voltmeter.

g. Check 412A reading versus Voltmeter Calibration Generator output on each range. See note in step e of paragraph 4-10. If any reading is in error more than 1% of full scale, readjust Gain Cal. (R119), to bring all readings within 1%.

4-20. OHMMETER ADJUSTMENT.

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

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

4-21. TUBE REPLACEMENT.

4-22. 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 in table 4-2.

Table 4-2. Tube Replacement

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

4-23. TROUBLESHOOTING.

4-24. When isolating trouble, consider the Model 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

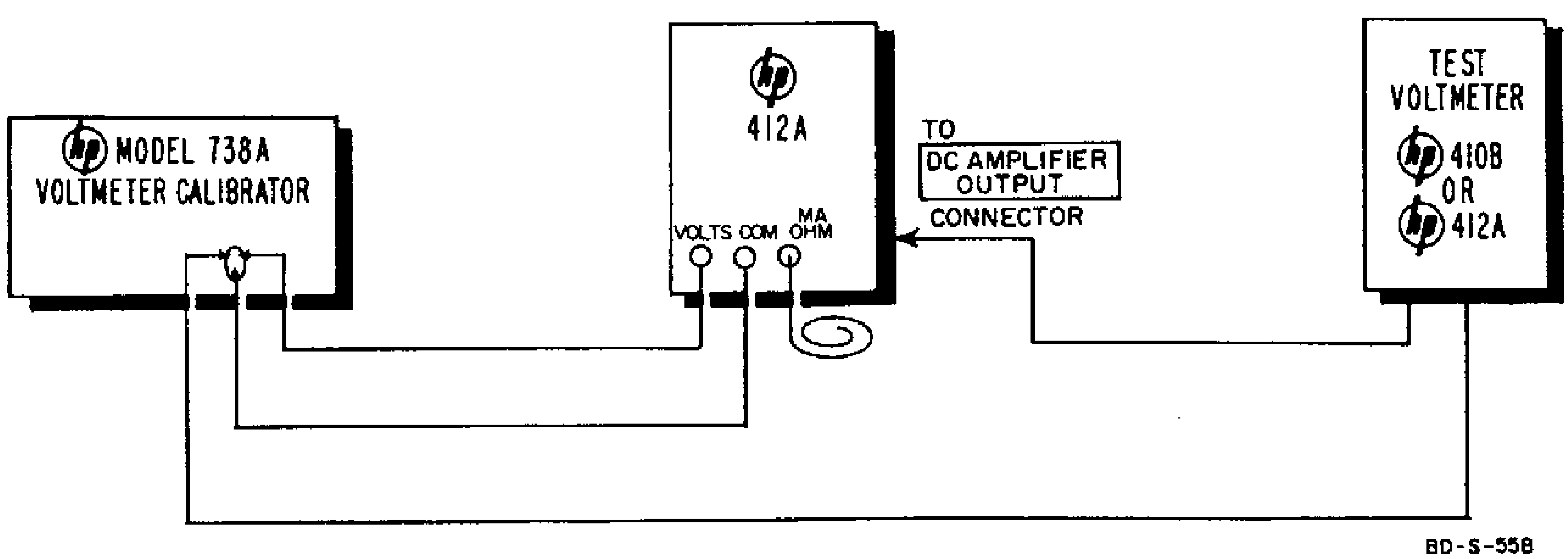


Figure 4-3. Equipment Setup for Amplifier Gain Calibration

the switching sequence, see figures 4-6, 4-7 and 4-8. Figure 4-13 identifies 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 wafer can degrade instrument performance. When soldering to the switch, use a minimum of heat. Excessive heat will melt the wafer material. Use a low-flux (2%) solder, and remove any traces of flux after soldering connections on the RANGE switch, modulator/amplifier assembly, or cable terminal board. A cotton swab soaked in alcohol is recommended for this purpose.

4-25. 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.

4-26. 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 4-9) before troubleshooting.

4-27. 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.

4-28. MODULATOR CHECK.

a. Unplug the 412A from the power source, and remove the cabinet.

b. Remove V101 and reconnect the 412A to the power source.

c. Connect a clip lead from the 412A input terminals to the center arm of R116, Bias Adjust Potentiometer.

d. Set RANGE (VOLTS) to .001.

e. Set oscilloscope input to DC.

f. Connect one lead of an 8.2-megohm resistor to oscilloscope signal connector (or probe). Using a jumper wire, connect the other resistor lead to the junction of R101 and C101 (point F in figure 4-11). Connect oscilloscope common lead to 412A common connector.

g. Observe amplitude of the dc voltage at point F.

h. Move oscilloscope probe (with resistor) to point A in figure 4-11.

i. Waveform should be similar to that shown in figure 4-4, and should have a peak-to-peak amplitude approximately equal to the deflection found in step g. Signal frequency should be 5/6 line frequency.

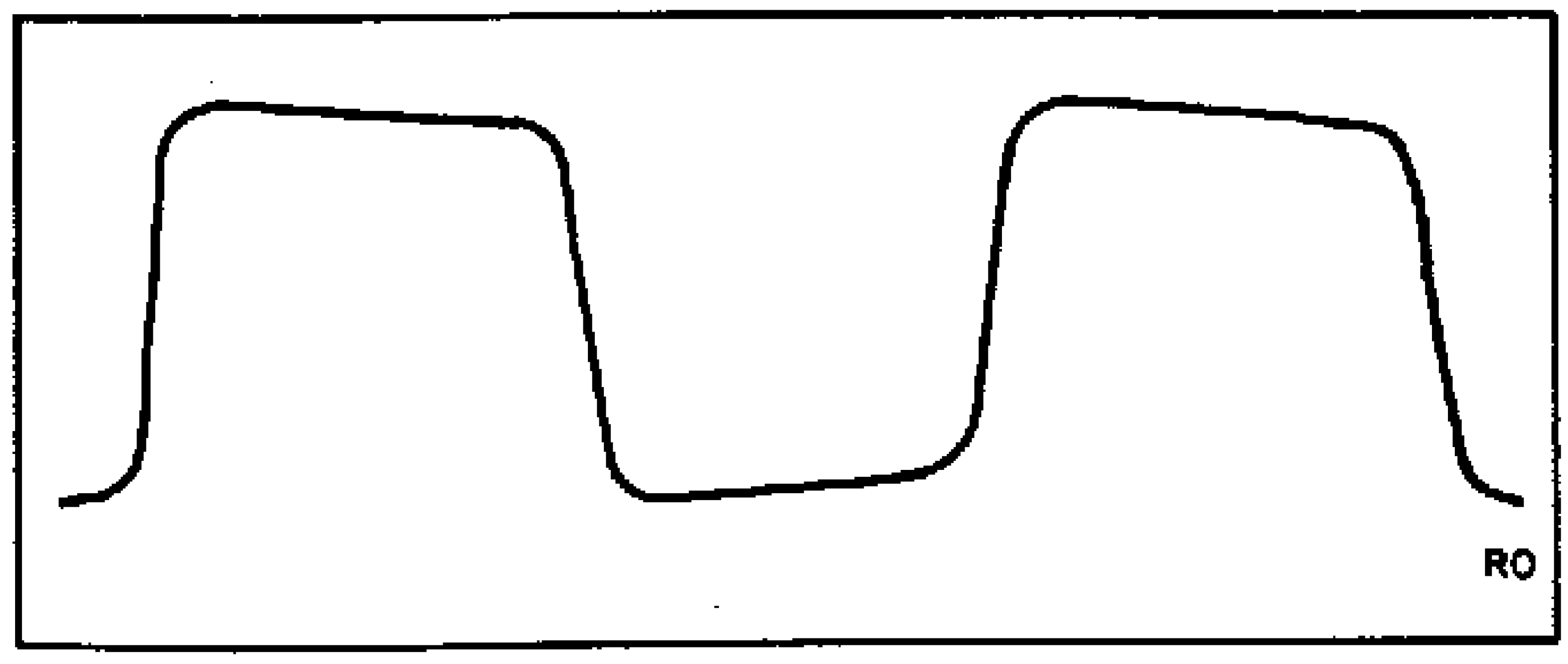


Figure 4-4. Modulator Waveform

4-29. MODULATOR REPLACEMENT.

4-30. 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:

a. Unplug 412A from power source and remove cabinet. Remove shield from left side of chassis to expose modulator assembly.

b. Disconnect black and black-white leads from modulator assembly (point A in figure 4-10).

c. Disconnect white-orange lead (point B in figure 4-10).

d. Disconnect white lead at Gain Cal potentiometer R119 (point C in figure 4-10).

e. Disconnect green lead (point F in figure 4-11).

f. Disconnect cable to amplifier at amplifier (point D in figure 4-10).

g. Remove four machine screws and nuts holding light beam chopper (figure 4-9) and let it hang by its leads.

h. Spread collars on modulator light rods (figure 4-10) and slide rods out of modulator assembly.

i. Remove four screws holding modulator/amplifier input assembly to main chassis. Each screw has an insulating shoulder washer, as the modulator/amplifier input assembly is insulated from the chassis. Be sure to seat the washers in the chassis holes when replacing the screws. Replace insulating wafer between modulator assembly and chassis.

j. Lift out modulator/amplifier input assembly. Take care not to damage precision resistors mounted on RANGE switch. Do not touch RANGE switch wafers.

k. Reverse above procedure to install replacement assembly.

4-31. DEMODULATOR CHECK.

4-32. The demodulator assembly is located between the main chassis and power transformer. See figure 4-11. Proceed as follows:

a. Unplug instrument from power source and remove cabinet.

b. Remove V102.

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

d. Connect 1 uf capacitor across input terminals of ohmmeter.

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

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

g. Plug instrument into power source and turn it ON.

h. Note resistance indicated by ohmmeter. Typical resistance is between 1 meg. and 2 meg.

i. Turn instrument off and unplug it from power source.

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

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

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

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

o. Turn instrument off; replace lamp and V102.

4-33. DEMODULATOR REPLACEMENT.

4-34. Check with your ℗ Representative about a replacement demodulator.

a. Turn instrument off.

b. Remove three leads connected to demodulator.

c. 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 4-9) and let assembly hang by its leads.

4-35. 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.

4-36. CABLE REPLACEMENT.

4-37. Figure 4-5 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 and length of the leads on terminal post #3 affects the accuracy of the instrument. Connect the leads as shown in detail (figure 4-5).

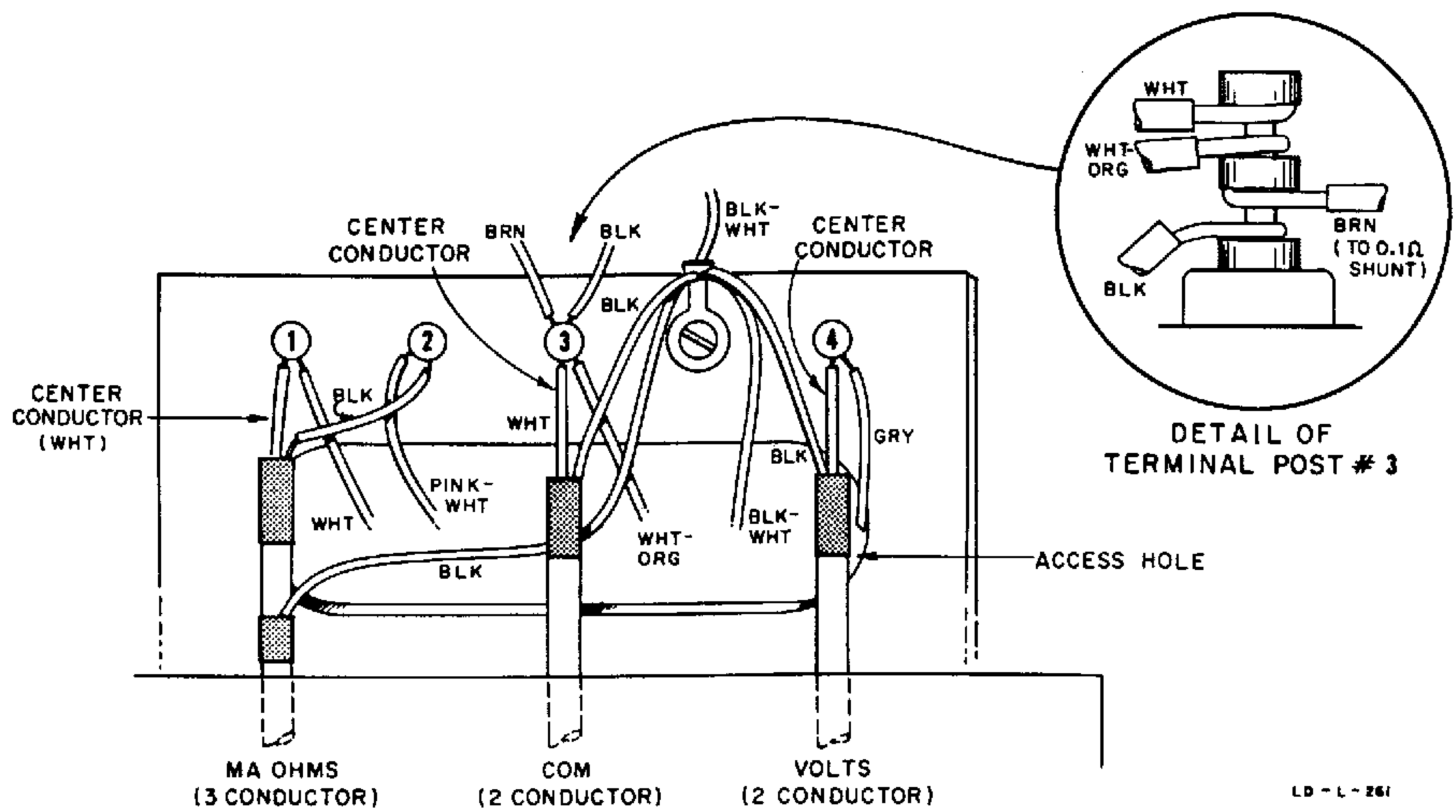
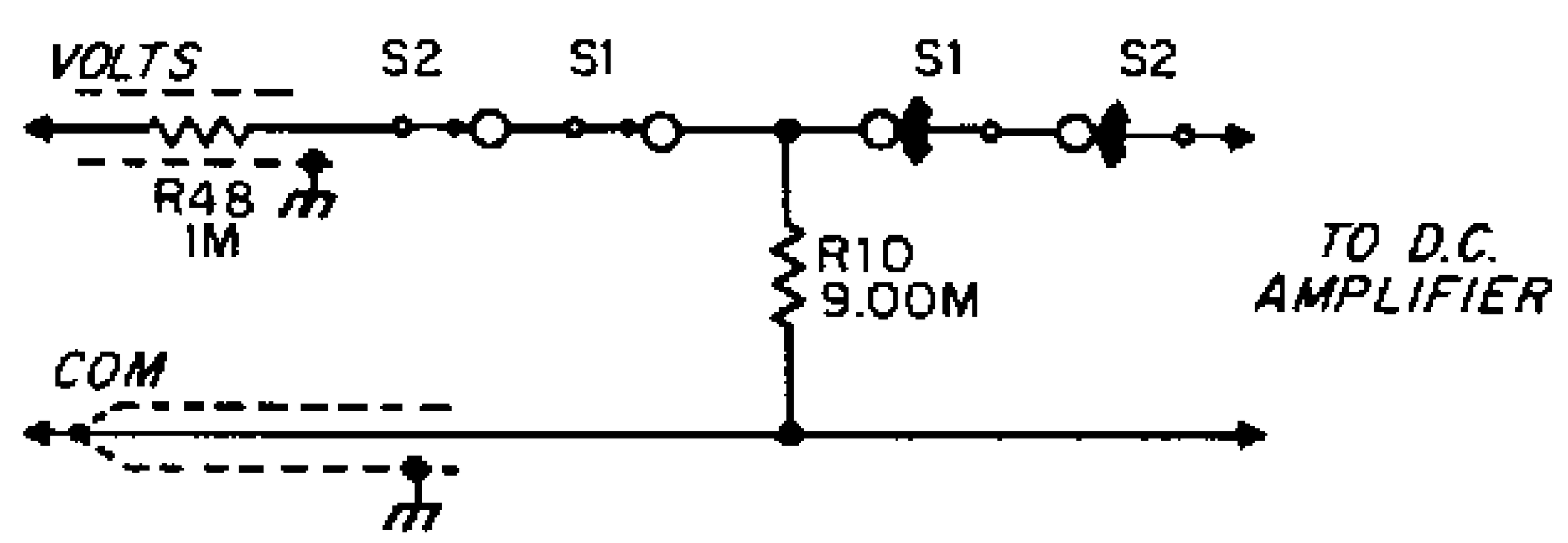
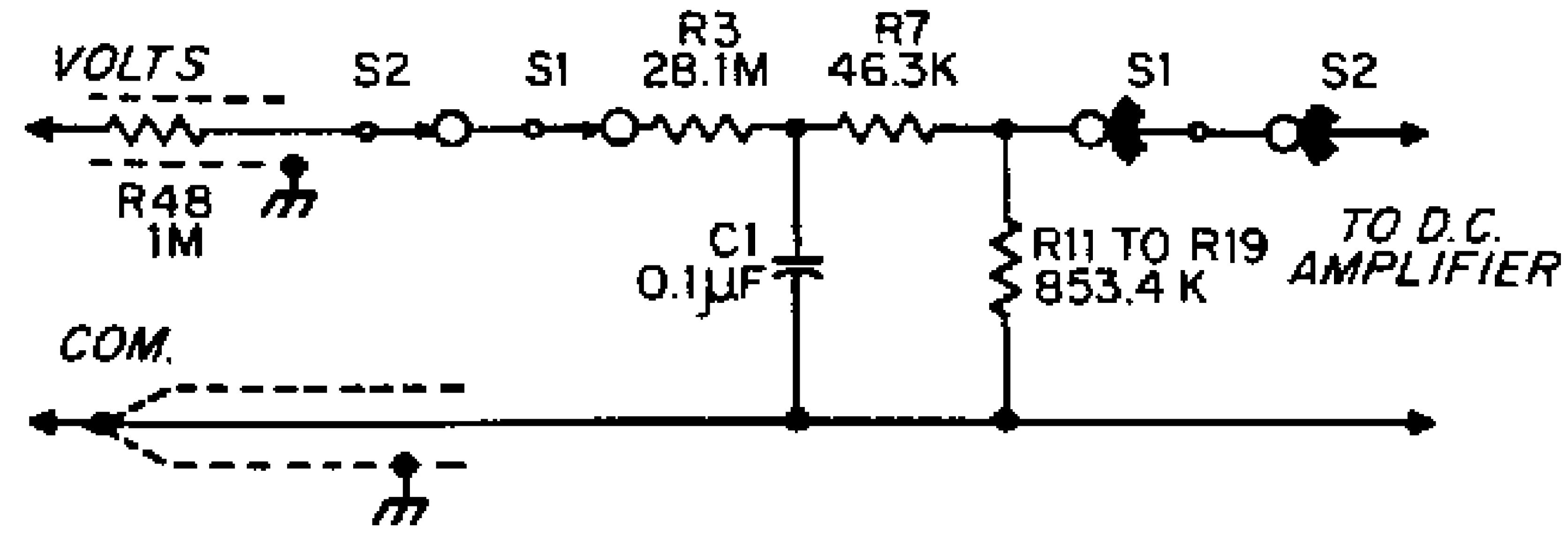


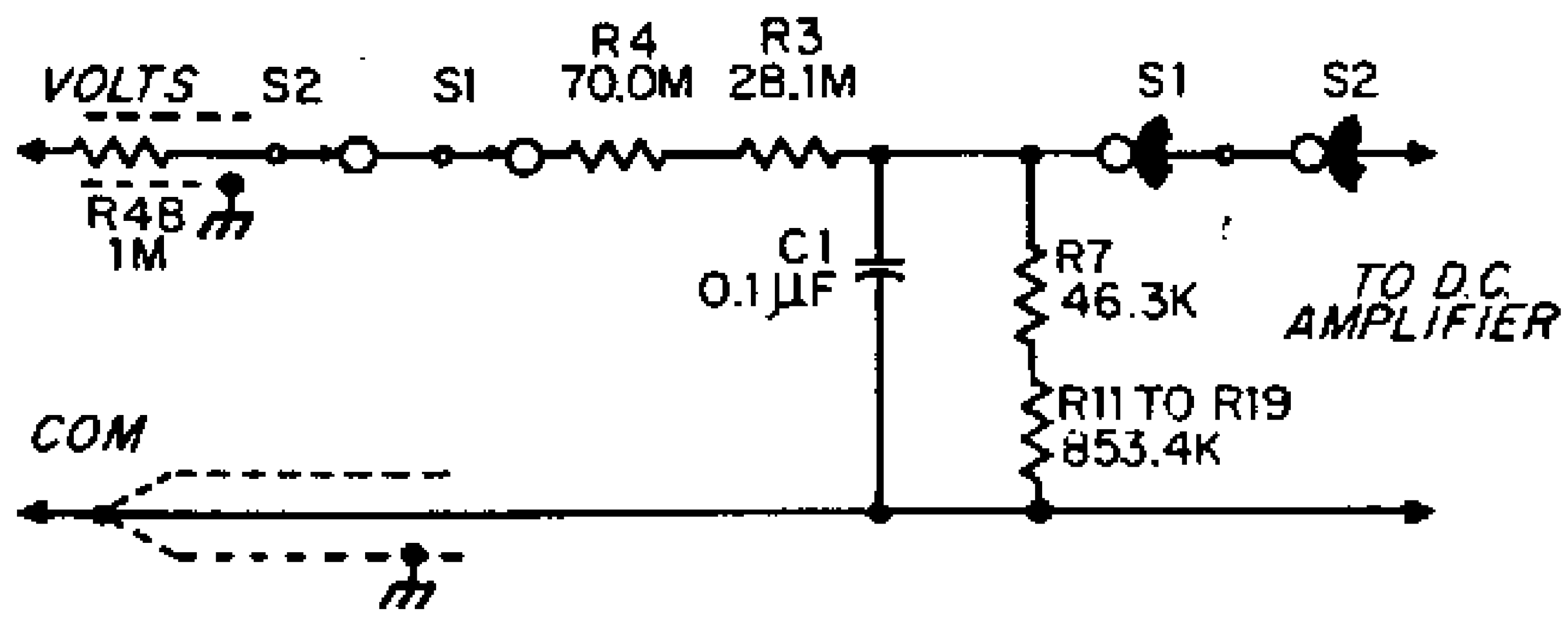
Figure 4-5. Connection Diagram for Volts, MA/OHMS and COM Cables



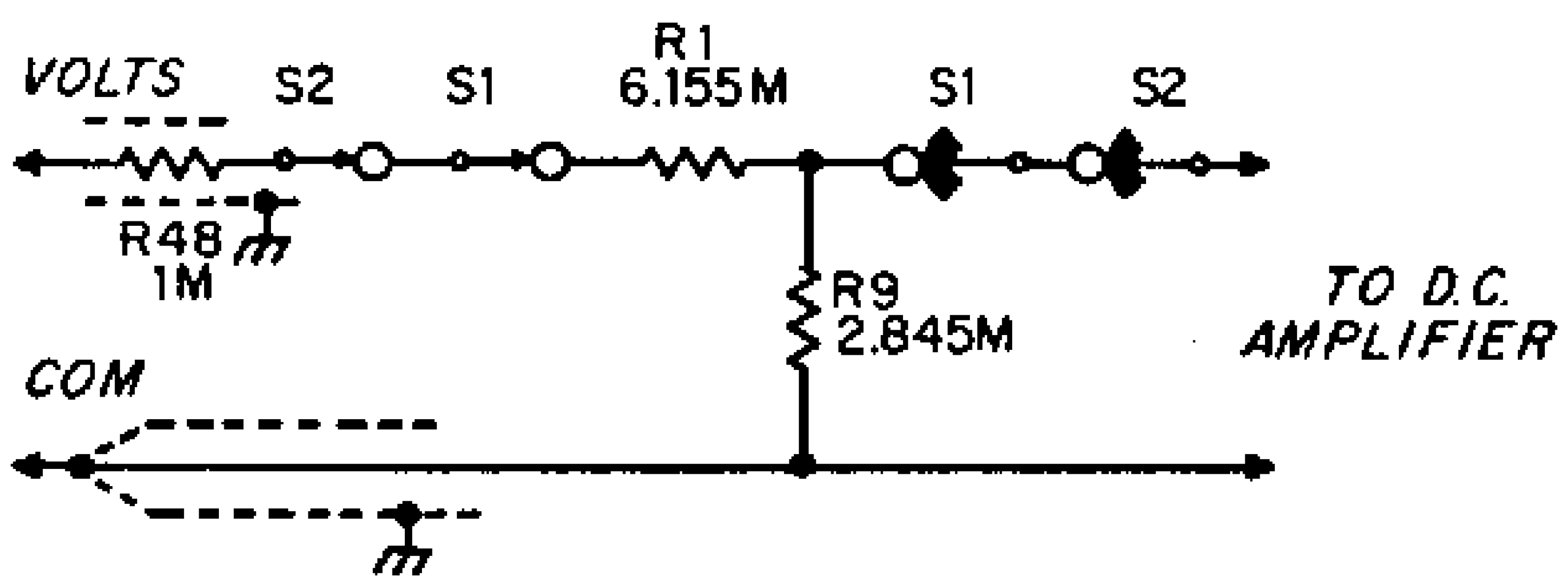
.001-volt range



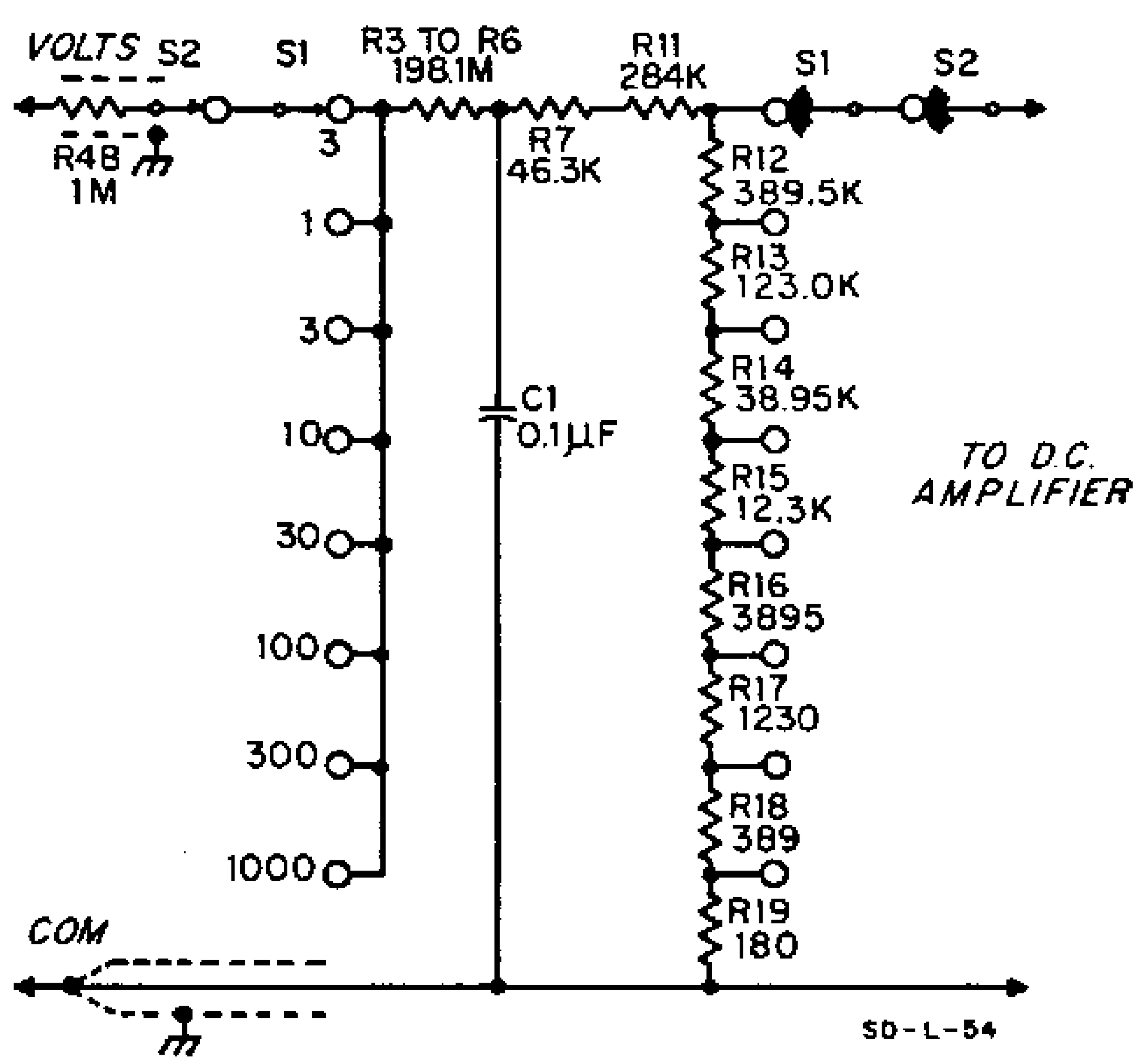
.03-volt range

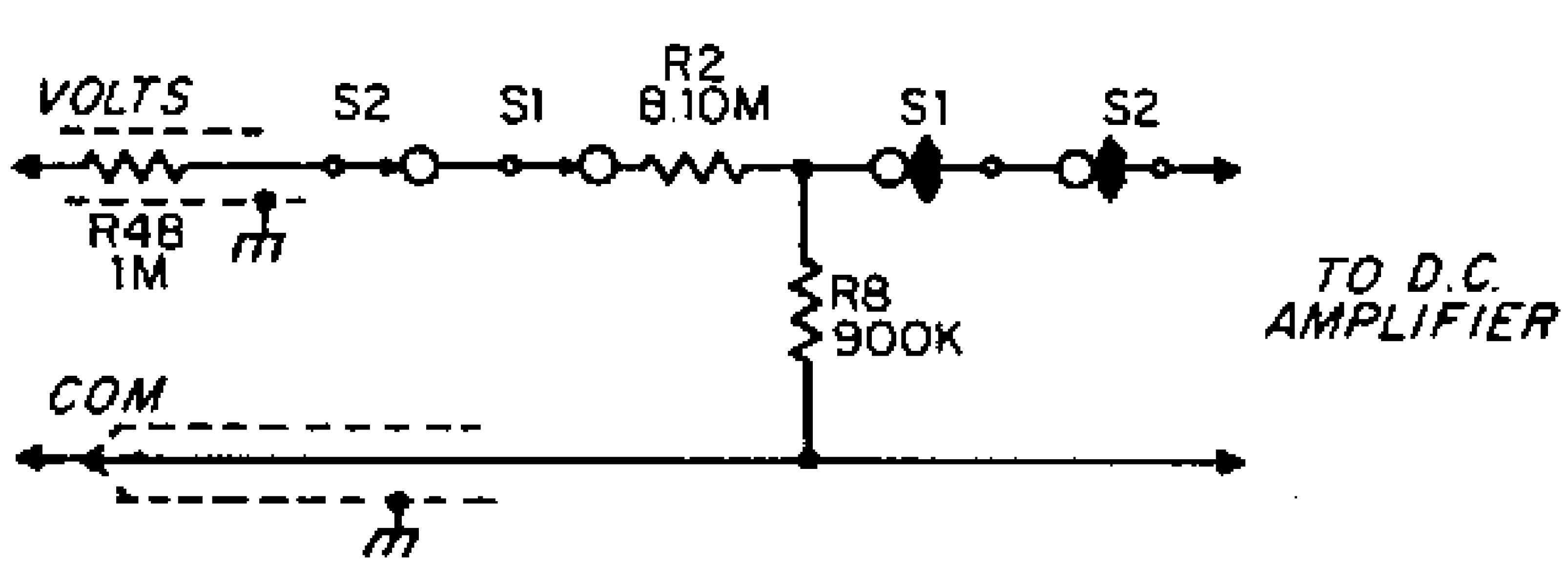


.1-volt range



.003-volt range





.01-volt range

.3 to 1000-volt ranges

Figure 4-6. Simplified Diagram of Voltmeter Switching

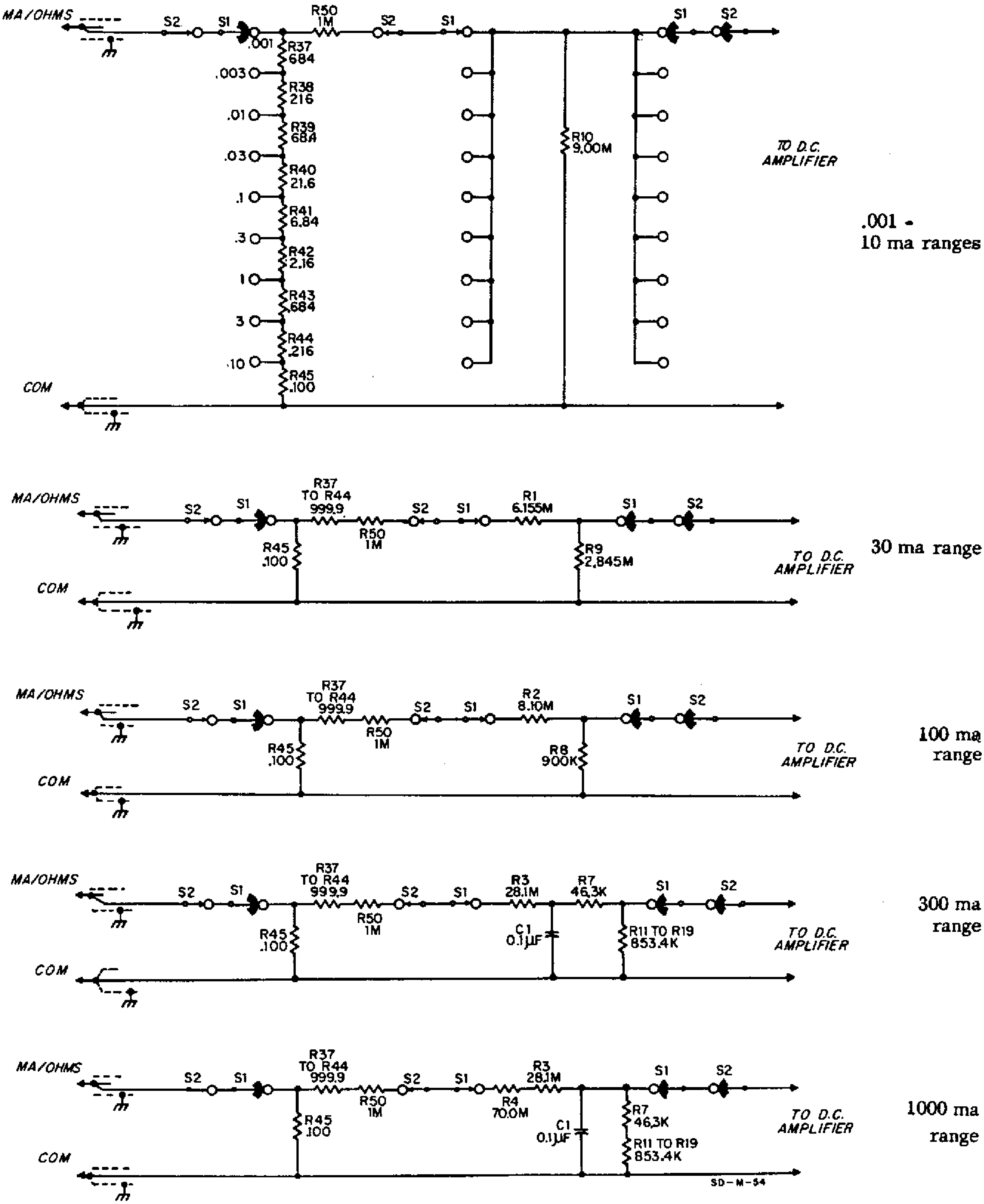


Figure 4-7. Simplified Diagram of of Ammeter Switching

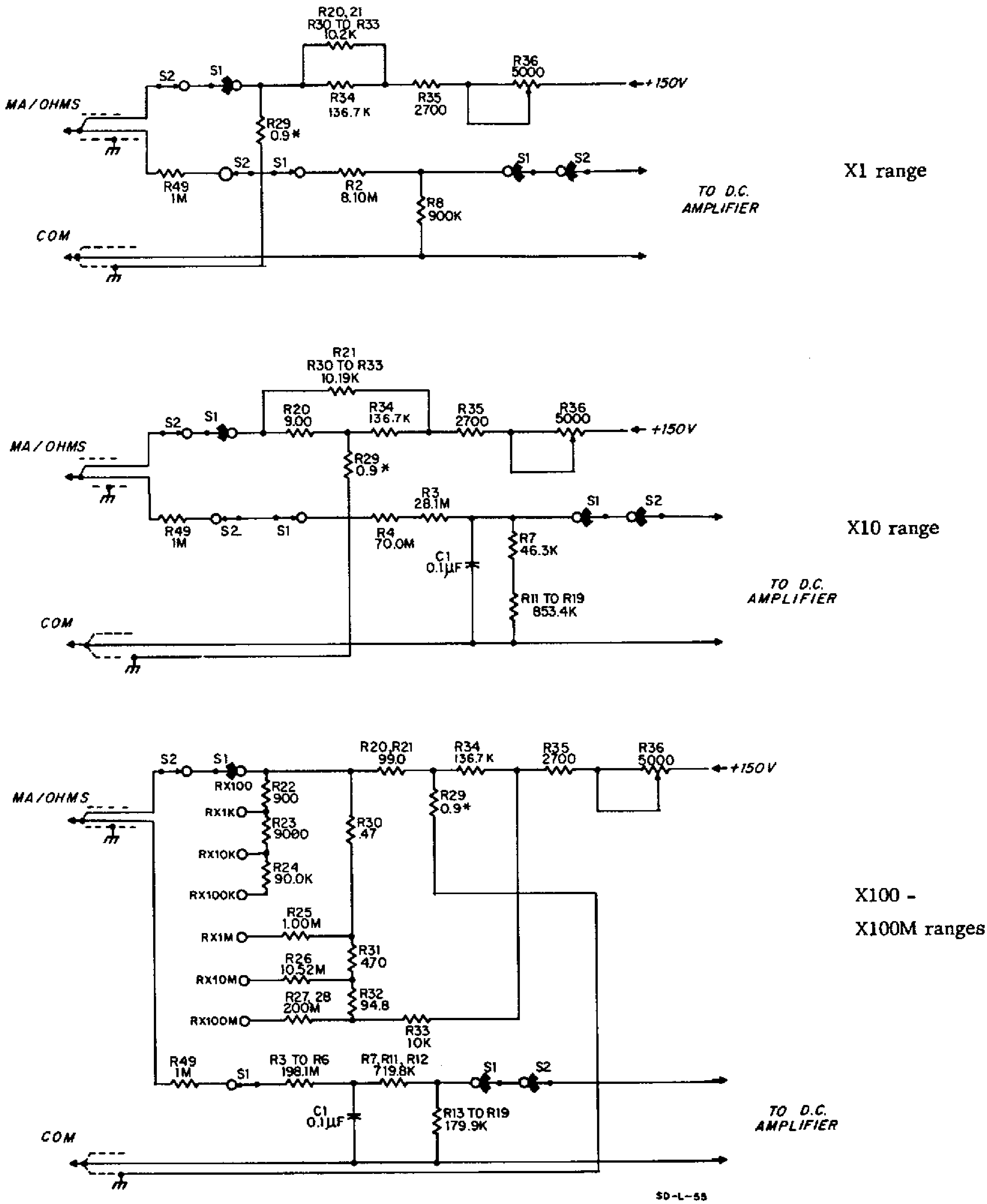


Figure 4-8. Simplified Diagram of Ohmmeter Switching Figure

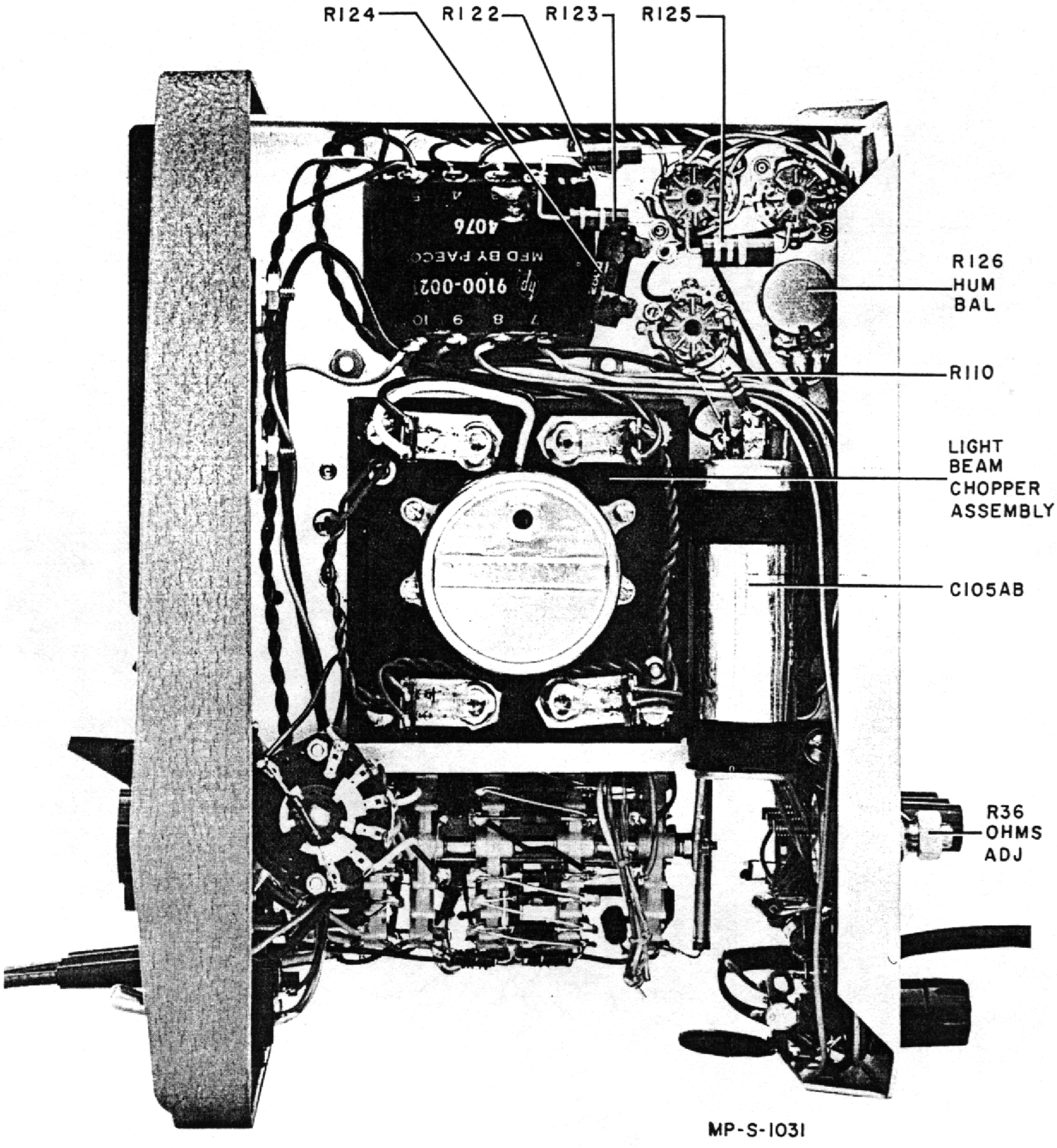


Figure 4-9. Right Side View Model 412A

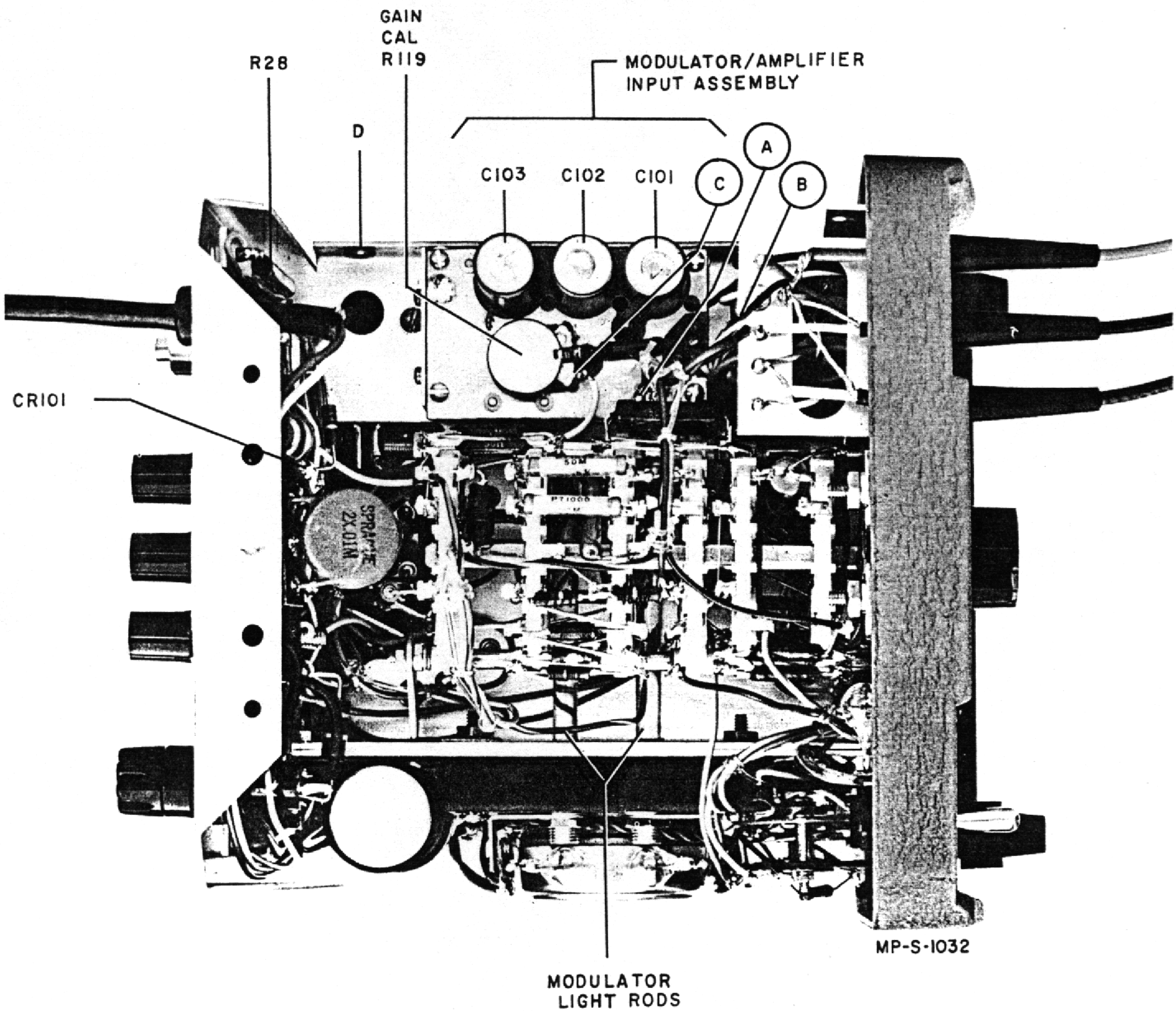


Figure 4-10. Bottom View Model 412A

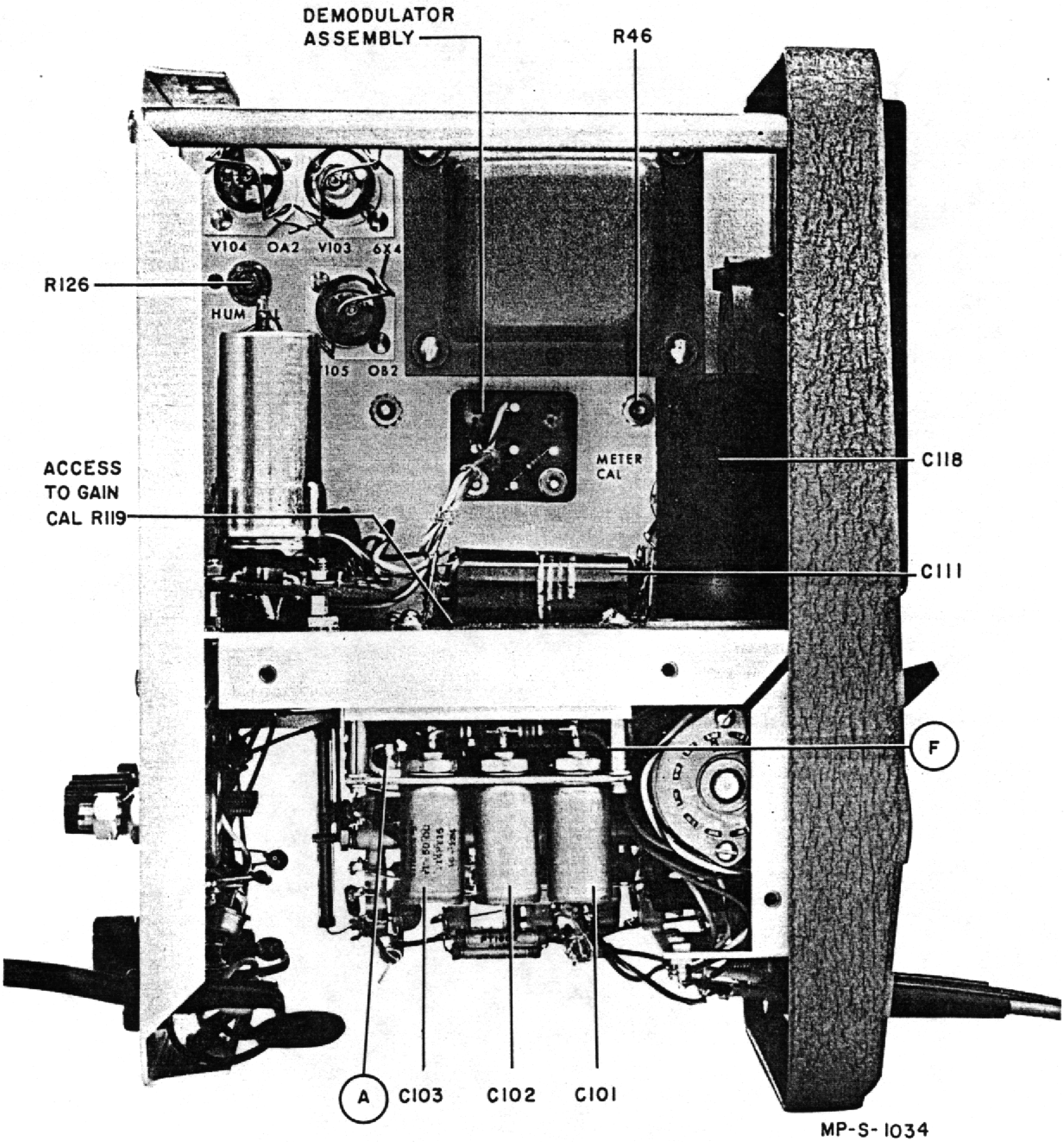


Figure 4-11. Left Side View Model 412A

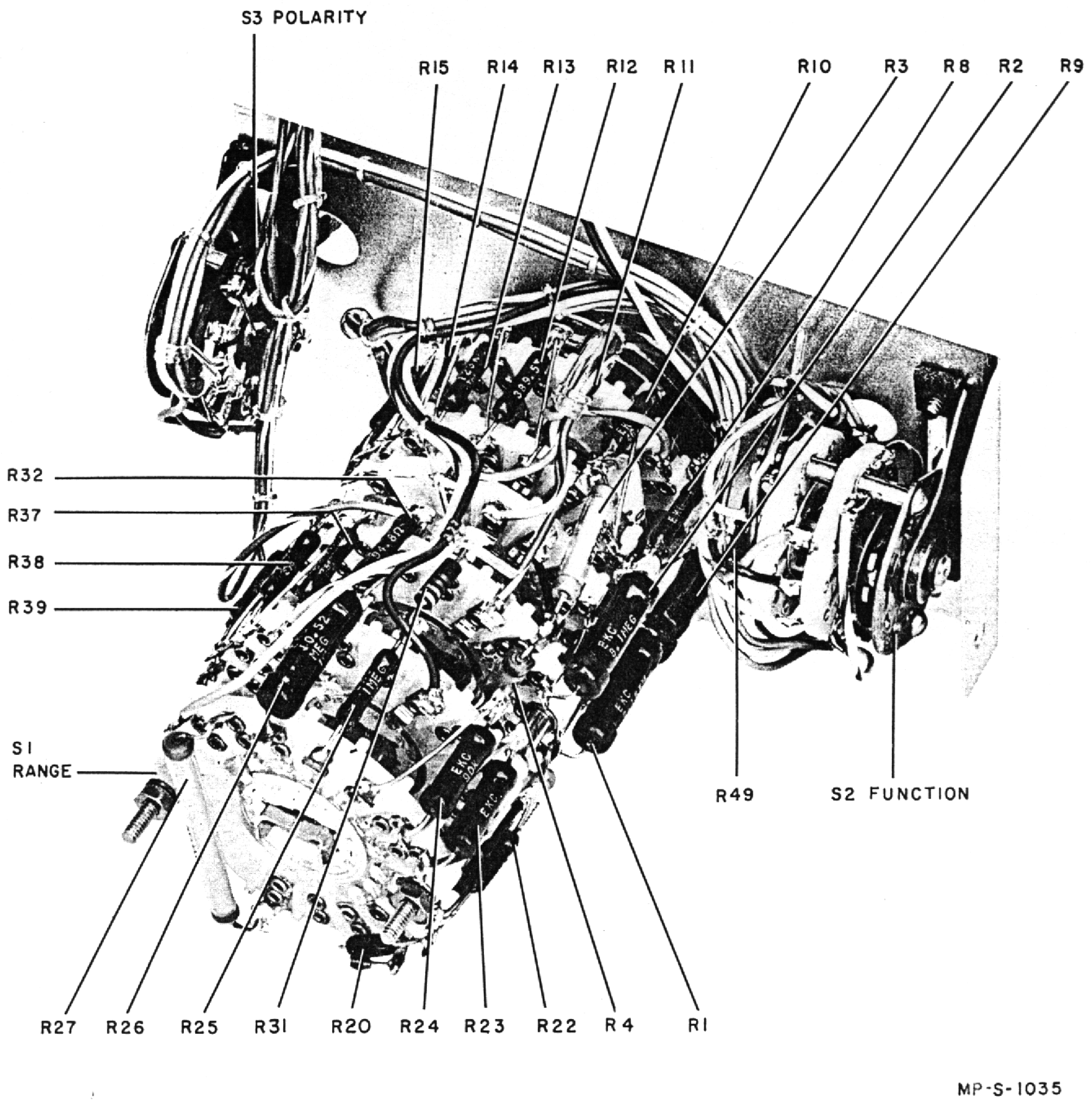


Figure 4-13. Location of Parts Mounted on Range, Function, and Polarity Switches (Top)

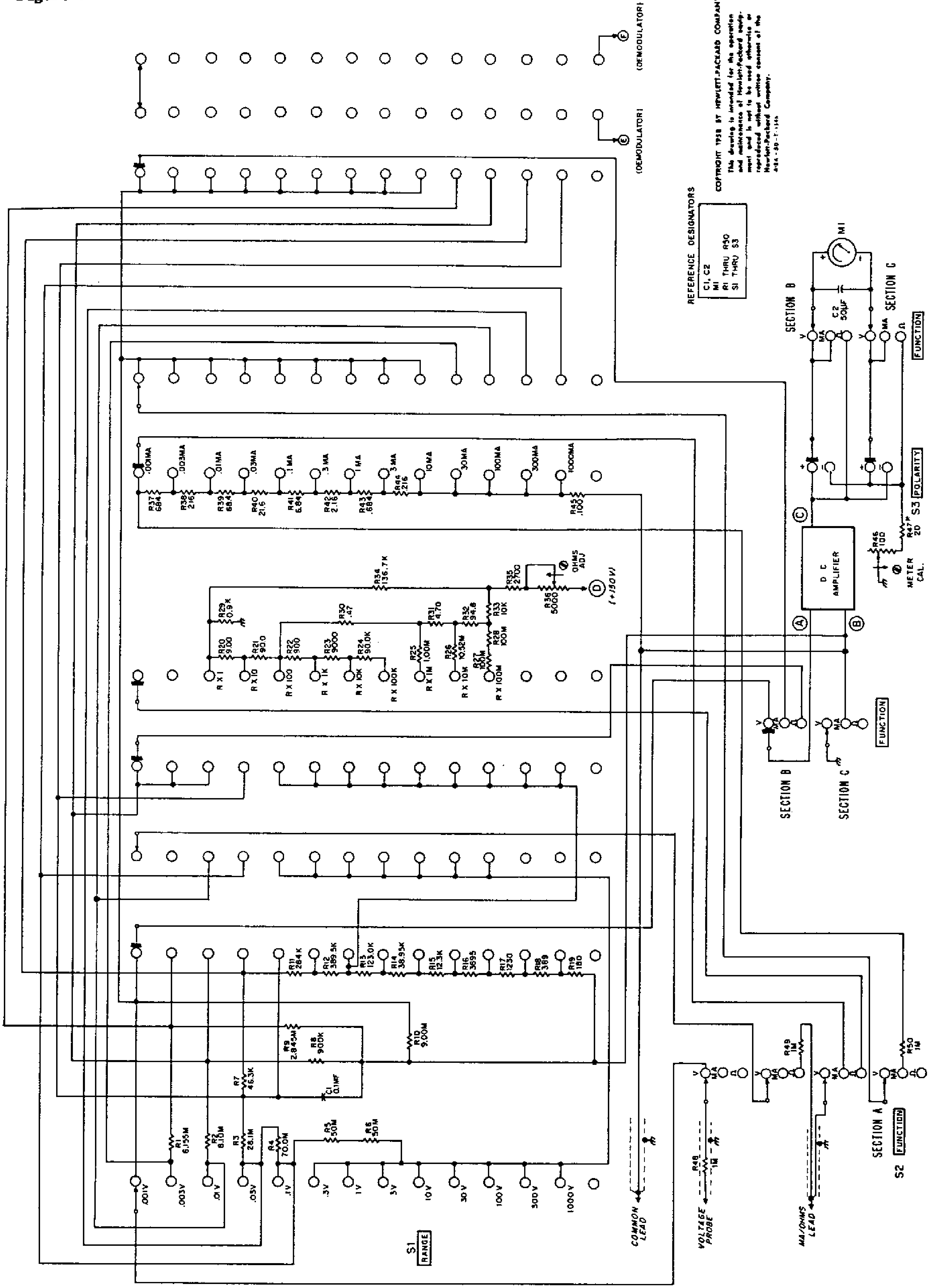
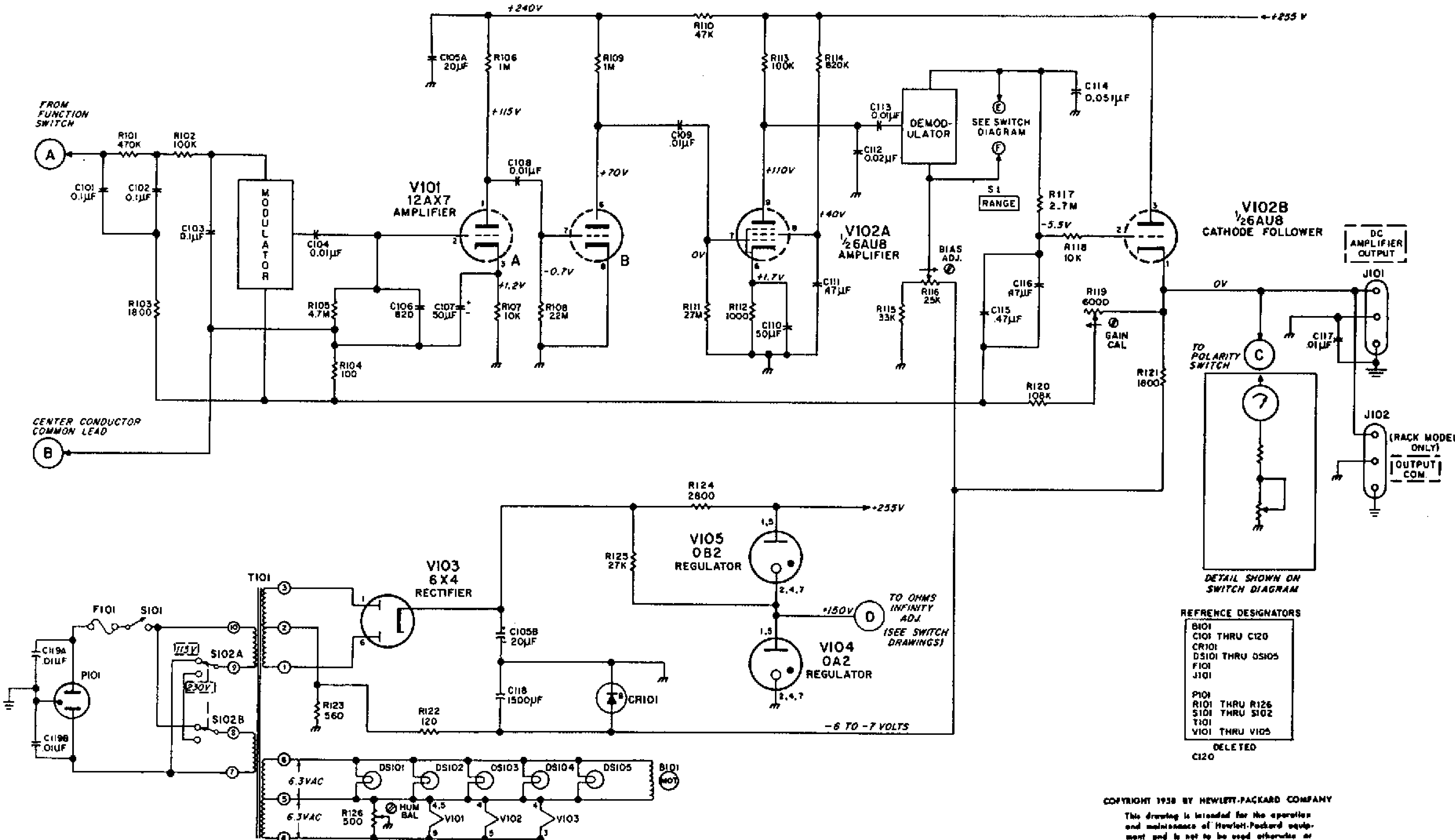


Figure 4-14. Range, Function and Polarity Switches Figure.



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412A-AMP-T-134 A

NOTE :

1. DC VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND, LINE VOLTAGE AT 115V, AND NO METER DEFLECTION.

Figure 4-15. Amplifier and Power Supply

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts. Table 5-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 5-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Typical manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

5-3. Miscellaneous parts not indexed in table 5-1 are listed at the end of table 5-2.

5-4. ORDERING INFORMATION.

5-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California,

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly	F = fuse	P = plug	V = vacuum tube, neon bulb, photocell, etc.
B = motor	FL = filter	Q = transistor	W = cable
C = capacitor	J = jack	R = resistor	X = socket
CR = diode	K = relay	RT = thermistor	XF = fuseholder
DL = delay line	L = inductor	S = switch	XV = tube socket
DS = device signaling (lamp)	M = meter	T = transformer	XDS = lampholder
E = misc electronic part			

ABBREVIATIONS

bp = bandpass	elect = electrolytic	mtg = mounting	rot = rotary
bwo = backward wave oscillator	encap = encapsulated	my = mylar	rms = root-mean-square
c = carbon	f = farads	NC = normally closed	rmo = rack mount only
cer = ceramic	fxd = fixed	Ne = neon	s-b = slow-blow
cmo = cabinet mount only	Ge = germanium	NO = normally open	Se = selenium
coef = coefficient	grd = ground (ed)	NPO = negative positive zero-zero temperature coefficient	sect = section(s)
com = common	h = henries	nsr = not separately replaceable	Si = silicon
comp = composition	Hg = mercury	obd = order by description	sl = slide
conn = connection	impg = impregnated	p = peak	td = time delay
crt = cathode-ray tube	incd = incandescent	pc = printed circuit board	TiO_2 = titanium dioxide
dep = deposited	ins = insulation (ed)	pf = picofarads = 10^{-12} farads	tog = toggle
det = detector	K = kilo	pp = peak-to-peak	tol = tolerance
EIA = Tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications	lin = linear taper	piv = peak inverse voltage	trim = trimmer
	log = logarithmic taper	pos = position(s)	twt = traveling wave tube
	m = milli = 10^{-3}	poly = polystyrene	var = variable
	M = megohms	pot = potentiometer	w/ = with
	ma = milliamperes	rect = rectifier	W = watts
	minat = miniature		ww = wirewound
	mfg = metal film on glass		w/o = without
	mfr = manufacturer		* = optimum value selected at factory, average value shown (part may be omitted)

01194-2

Table 5-1. Reference Designation Index

Circuit Reference	ⓗ Stock No.	Description #	Note
B101	3140-0013	Motor, synchronous type: 6.3V, AC	
C1	0170-0019	C, fxd, my, 0.1 μf ±5%, 200 vdcw	
C2	0180-0105	C, fxd, semi-polarized, 50 μf, 25 vdcw	
C3 thru C100		Not assigned	
C101 thru C103	0170-0030	C, fxd, poly, 0.1 μf ±10%, 50 vdcw	
C104	0170-0029	C, fxd, poly, 0.01 μf ±10%, 50 vdcw	
C105A/B	0180-0086	C, fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	
C106	0140-0010	C, fxd, mica, 820 pf ±10%, 500 vdcw	
C107	0180-0033	C, fxd, elect, 50 μf, 6 vdcw	
C108, 109	0150-0012	C, fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C110	0180-0033	C, fxd, elect, 50 μf, 6 vdcw	
C111	0160-0015	C, fxd, paper, 0.47 μf ±10%, 200 vdcw	
C112	0150-0024	C, fxd, cer, 0.02 μf +80% -20%, 600 vdcw	
C113	0150-0012	C, fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C114	0170-0003	C, fxd, my, 0.051 μf ±10%, 200 vdcw	
C115, 116	0160-0015	C, fxd, paper, 0.47 μf ±10%, 200 vdcw	
C117	0160-0019	C, fxd, paper, 0.01 μf ±5%, 600 vdcw	
C118	0180-0054	C, fxd, elect, 1 sect, 1.5K μf, 10 vdcw	
C119A/B	0150-0119	C, fxd, cer, 2 sect, 0.01 μf/sect, 250 vdcw	
CR101	G-29G-79	Diode, breakdown: 7V	
DS101 thru DS105	2140-0012	Lamp, minat: 2 pin	
F101	2110-0008	Fuse, cartridge: 1/2 amp, s-b (for 115V operation)	
	2110-0019	Fuse, cartridge: 0.4 amp, s-b (for 230V operation)	
J101	AC-10C AC-10D AC-54B	Binding post: black Binding post: red Insulator	
J102		Rack mount only	
	AC-10C AC-10D AC-54B	Binding post: black Binding post: red Insulator	
M1	G-81D	Meter	
P101	8120-0050	Power cord	
R1	0730-0128	R, fxd, dep c, 6.155M ±1/2%, 1 W	
R2	0730-0134	R, fxd, dep c, 8.1M ±1/2%, 1 W	
R3	0730-0149	R, fxd, dep c, 28.1M ±1/2%, 1 W	
R4	0733-0014	R, fxd, dep c, 70M ±1/2%, 2 W	
R5, 6	0730-0150	R, fxd, dep c, 50M ±1/2%, 1 W	
R7	0727-0192	R, fxd, dep c, 46.3K ohms ±1/2%, 1/2 W	
R8	0727-0262	R, fxd, dep c, 900K ohms ±1/2%, 1/2 W	
R9	0730-0117	R, fxd, dep c, 2.845M ±1/2%, 1 W	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description #	Note
R10	0730-0139	R, fxd, dep c, 9M ±1/2%, 1 W	
R11	0727-0231	R, fxd, dep c, 284K ohms ±1/2%, 1/2 W	
R12	0727-0239	R, fxd, dep c, 389.5K ohms ±1/2%, 1/2 W	
R13	0727-0215	R, fxd, dep c, 123K ohms ±1/2%, 1/2 W	
R14	0727-0188	R, fxd, dep c, 38.950 ohms ±1/2%, 1/2 W	
R15	0727-0164	R, fxd, dep c, 12.3K ohms ±1/2%, 1/2 W	
R16	0727-0130	R, fxd, dep c, 3895 ohms ±1/2%, 1/2 W	
R17	0727-0106	R, fxd, dep c, 1230 ohms ±1/2%, 1/2 W	
R18	0727-0070	R, fxd, dep c, 389 ohms ±1/2%, 1/2 W	
R19	0727-0051	R, fxd, dep c, 180 ohms ±1/2%, 1/2 W	
R20	412A-26G	R, fxd, ww, 9 ohms	
R21	0727-0039	R, fxd, dep c, 90 ohms ±1/2%, 1/2 W	
R22	0727-0095	R, fxd, dep c, 900 ohms ±1%, 1/2 W	
R23	0727-0152	R, fxd, dep c, 9K ohms ±1%, 1/2 W	
R24	0727-0203	R, fxd, dep c, 90K ohms ±1%, 1/2 W	
R25	0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	
R26	0730-0144	R, fxd, dep c, 10.52M ±1%, 1 W	
R27, 28	0733-0017	R, fxd, dep c, 100M ±1%, 2 W	
R29	412A-26D	R, fxd, ww, 0.900 ohms	
R30	0813-0019	R, fxd, ww, 0.47 ohms ±1%, 1/2 W	
R31	0698-0001	R, fxd, comp, 4.7 ohms ±5%, 1/2 W	
R32	0727-0040	R, fxd, dep c, 94.8 ohms ±1%, 1/2 W	
R33	0811-0007	R, fxd, ww, 10K ohms ±1%, 5 W	
R34	0727-0216	R, fxd, dep c, 136.7K* ohms ±1%, 1/2 W	
R35	0690-2721	R, fxd, comp, 2.7K ohms ±10%, 1 W	
R36	2100-0011	R, var, comp, lin, 5K ohms ±20%, 1/2 W	
R37	0727-0086	R, fxd, dep c, 684 ohms ±1/2%, 1/2 W	
R38	0727-0056	R, fxd, dep c, 216 ohms ±1%, 1/2 W	
R39	0727-0035	R, fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	
R40	412A-26H	R, fxd, ww, 21.6 ohms	
R41	412A-26F	R, fxd, ww, 6.84 ohms	
R42	412A-26E	R, fxd, ww, 2.16 ohms	
R43	412A-26C	R, fxd, ww, 0.684 ohms	
R44	412A-26B	R, fxd, ww, 0.216 ohms	
R45	412A-26A	R, fxd, ww, 0.1 ohms	
R46	2100-0021	R, var, ww, lin, 100 ohms ±20%, 2 W	
R47	0727-0012	R, fxd, dep c, 20*ohms ±1%, 1/2 W	
R48		nsr; part of voltage probe assy	
R49, 50	0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description #	Note
R51 thru R100		Not assigned	
R101	0687-4741	R, fxd, comp, 470K ohms ±10%, 1/2 W	
R102	0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	
R103	0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	
R104	0727-0043	R, fxd, dep c, 100 ohms ±1%, 1/2 W	
R105	0687-4751	R, fxd, comp, 4.7M ±10%, 1/2 W	
R106	0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	
R107	0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	
R108	0687-2261	R, fxd, comp, 22M ±10%, 1/2 W	
R109	0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	
R110	0687-4731	R, fxd, comp, 47K ohms ±10%, 1/2 W	
R111	0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	
R112	0687-1021	R, fxd, comp, 1K ohms ±10%, 1/2 W	
R113	0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	
R114	0687-8241	R, fxd, comp, 820K ohms ±10%, 1/2 W	
R115	0687-3331	R, fxd, comp, 33K ohms ±10%, 1/2 W	
R116	2100-0009	R, var, comp, 25K ohms ±20%, 1/3 W	
R117	0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	
R118	0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	
R119	2100-0136	R, var, comp, lin, 6K ohms ±20%, 3/10 W	
R120	0727-0209	R, fxd, dep c, 108K ohms ±1%, 1/2 W	
R121	0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	
R122	0690-1211	R, fxd, comp, 120 ohms ±10%, 1 W	
R123	0690-5611	R, fxd, comp, 560 ohms ±10%, 1 W	
R124	0813-0018	R, fxd, ww, 2.8K ohms ±10%, 5 W	
R125	0693-2731	R, fxd, comp, 27K ohms ±10%, 2 W	
R126	2100-0078	R, var, comp, lin, 500 ohms ±30%, 3/10 W	
S1	412A-19W-1	Assy, range switch	
S2	3100-0183	Switch, lever: 2 sect, 3 pos	
S3	3100-0184	Switch, lever: 1 sect, 2 pos	
S4 thru S100		Not assigned	
S101	3101-0001	Switch, tog: SPST, 250V, 3 amp	
S102	3101-0033	Switch, sl: DPDT	
T1 thru T100		Not assigned	
T101	9100-0021	Transformer, power	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
V1 thru V100		Not assigned	
V101	1932-0030	Tube, elect: 12AX7	
V102	1933-0007	Tube, elect: 6AU8	
V103	1930-0016	Tube, elect: 6X4	
V104	1940-0004	Tube, elect: OA2	
V105	1940-0007	Tube, elect: OB2	
		MISCELLANEOUS	
	AC-54F	Insulator: for J101 (bp side)	
	G-74N	Knob: range switch	
	G-74BX	Knob: function switch/polarity switch	
	412A-21A	Probe and cable assy, voltage	
	412A-21B	Cable assy, common	
	412A-21C	Cable assy, Ohm-Ma	
	412A-23B	Demodulator assy	
	412A-37A	Light rod: modulator	
	412A-37B	Light rod: modulator, for Model 412AR	
	412A-58A	Amplifier, input circuit (incl. modulator)	
	412A-65A	Amplifier assy	
	425A-97A	Chopper assy (incl. motor, lamps and leads)	
	1220-0009	Tube, shield	
	1400-0007	Fuseholder: extractor post type	
	1400-0084	Fuseholder: extractor post type	
	1450-0022	Lampholder: for 2 pin lamp	

See introduction to this section

Table 5-2. Replaceable Parts

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
AC-10C	Binding post: black	28480	AC-10C	2	1		
AC-10D	Binding post: red	28480	AC-10D	1	1		
AC-54B	Insulator	28480	AC-54B	1	1		
G-81D	Meter	28480	G-81D	1	1		
G-29G-79	Diode, breakdown: 7V	28480	G-29G-79	1	1		
412A-26A	R, fxd, ww, 0.1 ohms	28480	412A-26A	1	1		
412A-26B	R, fxd, ww, 0.216 ohms	28480	412A-26B	1	1		
412A-26C	R, fxd, ww, 0.684 ohms	28480	412A-26C	1	1		
412A-26D	R, fxd, ww, 0.900 ohms	28480	412A-26D	1	1		
412A-26E	R, fxd, ww, 2.16 ohms	28480	412A-26E	1	1		
412A-26F	R, fxd, ww, 6.84 ohms	28480	412A-26F	1	1		
412A-26G	R, fxd, ww, 9 ohms	28480	412A-26G	1	1		
412A-26H	R, fxd, ww, 21.6 ohms	28480	412A-26H	1	1		
412A-19W -1	Assy, range switch	28480	412A-19W-1	1	1		
0140-0010	C, fxd, mica, 820 pf ±10%, 500 vdcw	76433	RCM20B821K	1	1		
0150-0012	C, fxd, cer, 0.01 μf ±20%, 1000 vdcw	56289	29C214A3-H-1038	3	1		
0150-0024	C, fxd, cer, 0.02 μf +80% -20%, 600 vdcw	91418	B-02GMV	1	1		
0150-0119	C, fxd, cer, 2 sect, 0.01 μf/sect, 250 vdcw	71590	DA171CB	1	1		
0160-0015	C, fxd, paper, 0.47 μf ±10%, 200 vdcw	56289	109P47492	3	1		
0160-0019	C, fxd, paper, 0.01 μf ±5%, 600 vdcw	56289	160P10356	1	1		
0170-0003	C, fxd, my, 0.051 μf ±10%, 200 vdcw	00853	33M02152	1	1		
0170-0019	C, fxd, my, 0.1 μf ±5%, 200 vdcw	84411	620S	1	1		
0170-0029	C, fxd, poly, 0.01 μf ±10%, 50 vdcw	56289	114P1039R5S2	1	1		
0170-0030	C, fxd, poly, 0.1 μf ±10%, 50 vdcw	56289	type 114P, style T15	3	1		
0180-0033	C, fxd, elect, 50 μf, 6 vdcw	56289	30D133A1	2	1		
0180-0054	C, fxd, elect, 1 sect, 1.5K μf, 10 vdcw	56289	D32495	1	1		
0180-0086	C, fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	56289	D32477	1	1		
0180-0105	C, fxd, semi-polarized, 50 μf, 25 vdcw	56289	S97441	1	1		
0687-1021	R, fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB1021	1	1		
0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	01121	EB1031	2	1		
0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	01121	EB1041	2	1		
0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	01121	EB1051	2	1		
0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	01121	EB1821	2	1		
0687-2261	R, fxd, comp, 22M ±10%, 1/2 W	01121	EB2261	1	1		
0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	01121	EB2751	2	1		
0687-3331	R, fxd, comp, 33K ohms ±10%, 1/2 W	01121	EB3331	1	1		
0687-4731	R, fxd, comp, 47K ohms ±10%, 1/2 W	01121	EB4731	1	1		
0687-4741	R, fxd, comp, 470K ohms ±10%, 1/2 W	01121	EB4741	1	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0687-4751	R, fxd, comp, 4.7M ±10%, 1/2 W	01121	EB4751	1	1		
0687-8241	R, fxd, comp, 820K ohms ±10%, 1/2 W	01121	EB8241	1	1		
0690-1211	R, fxd, comp, 120 ohms ±10%, 1 W	01121	GB1211	1	1		
0690-2721	R, fxd, comp, 2.7K ohms ±10%, 1 W	01121	GB2721	1	1		
0693-2731	R, fxd, comp, 27K ohms ±10%, 2 W	01121	HB2731	1	1		
0698-0001	R, fxd, comp, 4.7 ohms ±5%, 1/2 W	01121	EB47G5	1	1		
0727-0012	R, fxd, dep c, 20* ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0035	R, fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0039	R, fxd, dep c, 90 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0040	R, fxd, dep c, 94.8 ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0043	R, fxd, dep c, 100 ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0051	R, fxd, dep c, 180 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0056	R, fxd, dep c, 216 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0070	R, fxd, dep c, 389 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0086	R, fxd, dep c, 684 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0095	R, fxd, dep c, 900 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0106	R, fxd, dep c, 1230 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0130	R, fxd, dep c, 3895 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0152	R, fxd, dep c, 9K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0164	R, fxd, dep c, 12.3K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0188	R, fxd, dep c, 38.95K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0192	R, fxd, dep c, 46.3K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0203	R, fxd, dep c, 90K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0209	R, fxd, dep c, 108K ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0215	R, fxd, dep c, 123K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0216	R, fxd, dep c, 136.7* ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0231	R, fxd, dep c, 284K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0239	R, fxd, dep c, 389.5K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0262	R, fxd, dep c, 900K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	19701	DC1/2AR5 obd#	3	1		
0730-0117	R, fxd, dep c, 2.845M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0128	R, fxd, dep c, 6.155M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0134	R, fxd, dep c, 8.1M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0139	R, fxd, dep c, 9M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0144	R, fxd, dep c, 10.52M ±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0149	R, fxd, dep c, 28.1M ±1/2%, 1 W	03888	PT1000 obd#	1	1		
0730-0150	R, fxd, dep c, 50M ±1/2%, 1 W	19701	DC1R5 obd#	2	1		
0733-0014	R, fxd, dep c, 70M ±1/2%, 2 W	03888	PT2000 obd#	1	1		
0733-0017	R, fxd, dep c, 100M ±1%, 2 W	03888	PT2000 obd#	2	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0811-0007	R, fxd, ww, 10K ohms ±1%, 5 W	91637	RS-5	1	1		
0813-0018	R, fxd, ww, 2.8K ohms ±10%, 5 W	35434	C-5-2800	1	1		
0813-0019	R, fxd, ww, 0.47 ohms ±1%, 1/2 W	75042	BW-1/2	1	1		
1930-0016	Tube, elect: 6X4	80131	6X4	1	1		
1932-0030	Tube, elect: 12AX7	80131	12AX7	1	1		
1933-0007	Tube, elect: 6AU8	80131	6AU8	1	1		
1940-0004	Tube, elect: OA2	80131	OA2	1	1		
1940-0007	Tube, elect: OB2	80131	OB2	1	1		
2100-0009	R, var, comp, 25K ohms ±20%, 1/3 W	11237	type 45 obd#	1	1		
2100-0011	R, var, comp, lin, 5K ohms ±20%, 1/2 W	11237	type 45 obd#	1	1		
2100-0021	R, var, ww, lin, 100 ohms ±20%, 2 W	11236	type 112	1	1		
2100-0078	R, var, comp, lin, 500 ohms ±30%, 3/10 W	11237	Model 70	1	1		
2100-0136	R, var, comp, lin, 6K ohms ±20%, 3/10 W	11237	type 70	1	1		
2110-0008	Fuse, cartridge: 1/2 amp, s-b (for 115V operation)	71400	MDL1/2	1	10		
2110-0019	Fuse, cartridge: 0.4 amp, s-b (for 230V operation)	75915	313-400				
2140-0012	Lamp, minat: 2 pin base	24455	No. 12	5	5		
3100-0183	Switch, lever: 2 sect, 3 pos	76854	190503-187-N2C	1	1		
3100-0184	Switch, lever: 1 sect, 2 pos	76854	189777-187-K1	1	1		
3101-0001	Switch, tog: SPST, 250V, 3 amp	04009	80994-H	1	1		
3101-0033	Switch, sl: DPDT	42190	4633	1	1		
3140-0013	Motor, synchronous type: 6.3V, AC	73061	"synchron" model 610 (6.3V)	1	1		
8120-0050	Power cord	70903	CS-9941/PH-151/ 7.5 ft	1	1		
9100-0021	Transformer, power	98734	4076	1	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
	MISCELLANEOUS						
AC-54F	Insulator: for J101 (bp side)	28480	AC-54F	1	1		
G-74N	Knob: range switch	28480	G-74N	1	1		
G-74BX	Knob: function switch/polarity switch	28480	G-74BX	2	1		
412A-21A	Probe and cable assy, voltage	28480	412A-21A	1	1		
412A-21B	Cable assy, common	28480	412A-21B	1	1		
412A-21C	Cable assy, Ohm-Ma	28480	412A-21C	1	1		
412A-23B	Demodulator assy	28480	412A-23B	1	1		
412A-37A	Light rod: modulator	28480	412A-37A	2	1		
412A-37B	Light rod: modulator for Model 412AR	28480	412A-37B	(2)	(1)		
412A-58A	Amplifier, input circuit (incl. modulator)	28480	412A-58A	1	1		
412A-65A	Amplifier assy	28480	412A-65A	1	1		
425A-97A	Chopper assy (incl motor, lamps and leads)	28480	425A-97A	1	1		
1220-0009	Tube, shield	71785	12627	1	1		
1400-0007	Fuseholder: extractor post type	75915	342003	1	1		
1400-0084	Fuseholder: extractor post type	75915	342014	1	1		
1450-0022	Lampholder: for 2 pin lamp	72765	2020AE	5	1		

See introduction to this section

MANUAL CHANGES

MODEL 412A

VACUUM TUBE VOLTMETER

Manual Serial Prefixed: 134-
Manual Printed: 2/62

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
134-	1, ERRATA		
301-	1, 2, ERRATA		

ERRATA:

Table 1-1, under "Input Resistance",
For 0.3 ma range "Internal Shunt Resistance" column should read 3.16 ohms.

F101 (115V): Change to fuse, cartridge, 0.6 amp, s-b (for 115V operation); ℗ Stock No. 2110-0016.

Figure 4-15,
T101: Change terminal 8 to terminal 9 and terminal 9 to terminal 8.

Paragraph 4-35,
Change to read:
4-35 Installation of Replacement Demodulator:

a. Cabinet Model, reverse the procedure in paragraph 4-34 to install replacement assembly. Be sure to connect (white-orange) lead to terminal nearest top of instrument, (pink-orange) lead to center terminal and (brown-orange) lead to terminal nearest bottom of instrument.

b. Rack Mount Model, reverse the procedure in paragraph 4-34 to install replacement assembly. Be sure to connect (white-orange) lead to terminal nearest top of instrument, connect (brown-orange) lead to center terminal and (pink-orange) lead to terminal nearest bottom of instrument.

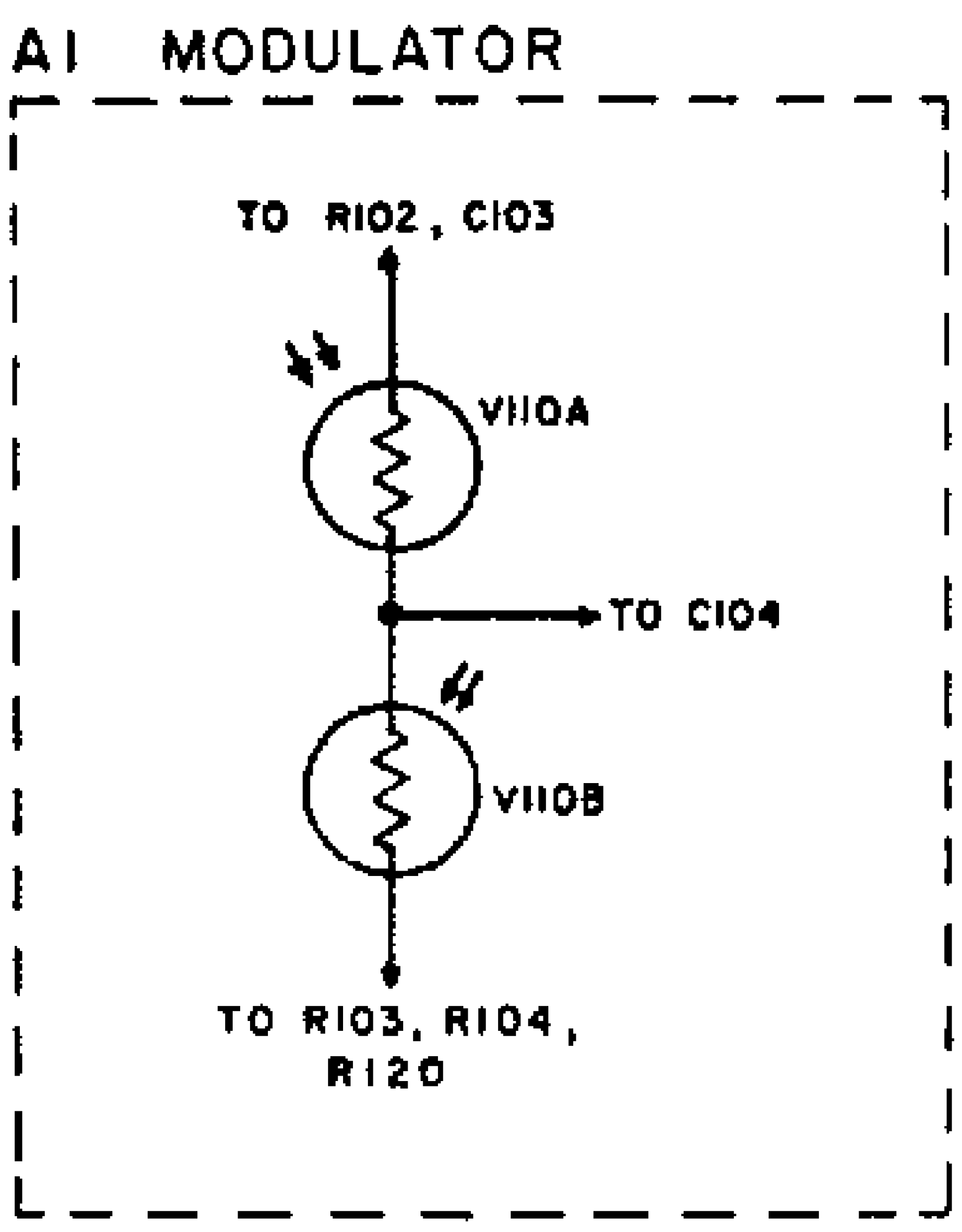
Table of Replaceable Parts,
Add R127, R128: Resistor, fixed, 470,000 ohms; ℗ Stock No 0684-4741.
Add V110A/B: ℗ Stock No. G-30C. These photo conductors are not field replaceable.
Add V111A/B: ℗ Stock No. G-30E. These photo conductors are field replaceable.

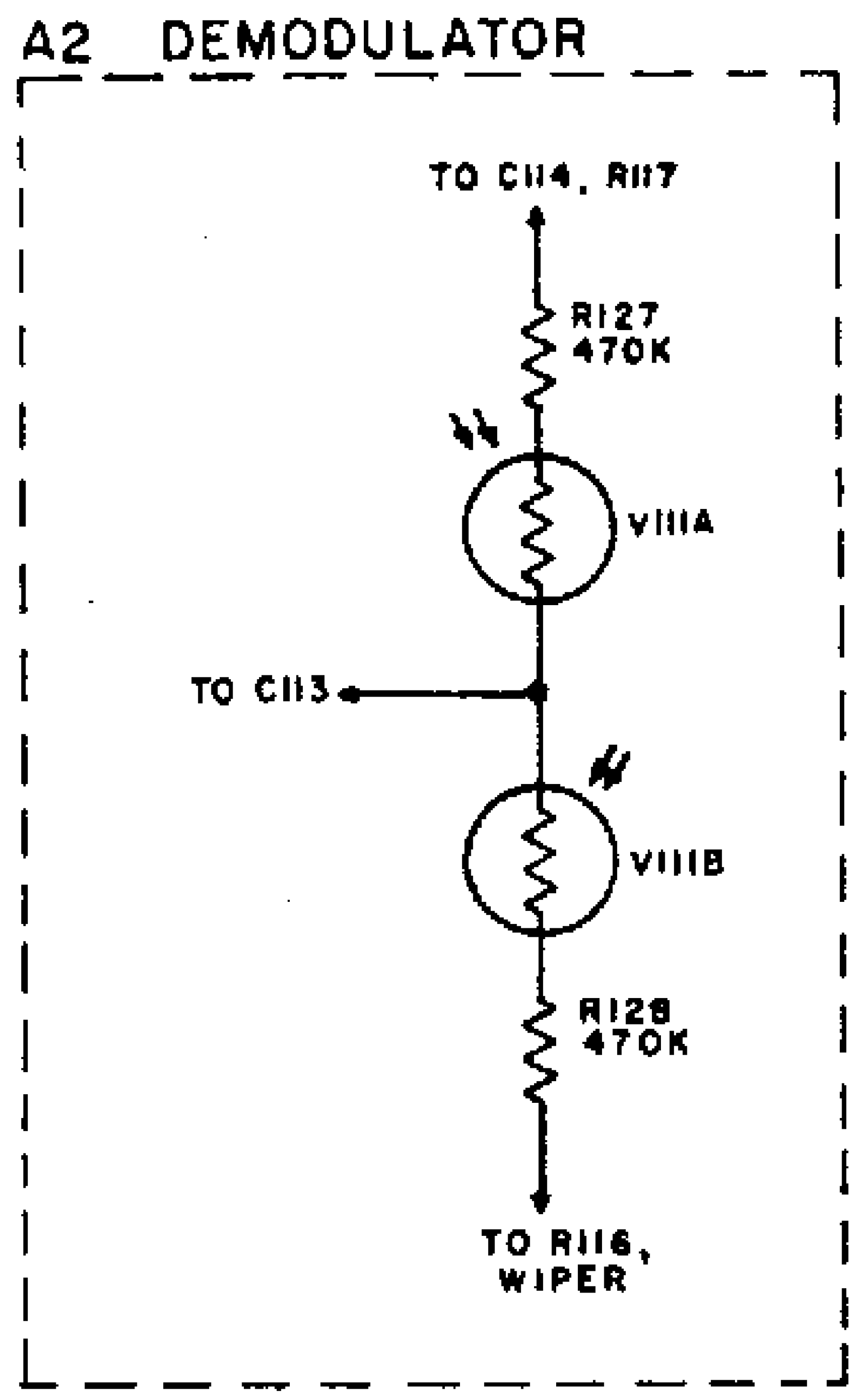
S1: Change to ℗ Stock No. 412A-19 W-1, assembly range switch (rack mount model).

S1: Change to ℗ Stock No. 412A-19 W, assembly range switch (cabinet model).

Figure 4-15, Schematic Diagram, Amplifier and Power Supply,
Add the following partial schematics, on page 2, in place of the modulator and demodulator blocks.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
134-	1, ERRATA		
301-	1, 2, ERRATA		





CHANGE 1

R29: Remove asterisk on schematic diagrams.
R34: Add asterisk on schematic diagrams.

CHANGE 2

Table 5-1, Replaceable Parts, under MISCELLANEOUS,
Change ℗ Stock No. 412A-21A to 412A-21D.
Change ℗ Stock No. 412A-21B to 412A-21E.
Change ℗ Stock No. 412A-21C to 412A-21F.