OPERATING AND SERVICE MANUAL

(HP PART NO. 00412-90003)

MODEL 412A/AR
DC VACUUM TUBE VOLTMETER

SERIALS PREFIXED: 301-, 316-, 424-, 649-

P. O. Box 301, Loveland, Colorado, 80537 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 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
.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	3.16 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 0.3 to 3 on Ohms scale

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	100μ A
X100K	1 V	10μ A
X1M	1 V	1μ A
X10M	1 V	.1μ A
X100M	1 V	.01μ A

AMPLIFIER

Voltage Gain: 1000 maximum

AC Rejection: 3 dB at 1 Hz, 80 dB at 50 and 60 Hz

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 5 mV RMS on any range

Drift: negligible

GENERAL

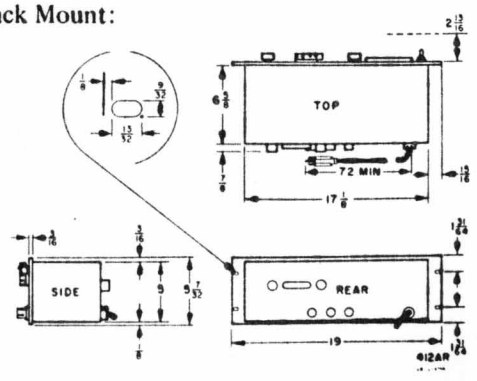
Isolation Resistance: At least 100 megohms shunted by 0.1μ F between common terminal and case (power line) ground

Common Mode Rejection: May be operated up to 500 Vdc or 130 Vac from ground

Power: 115/230 V ±10%, 50-60 Hz, 35 W

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

Rack Mount:



SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Hewlett-Packard Model 412A/AR DC Vacuum Tube Voltmeter is a multifunction instrument which measures the entire range of dc voltages, current, and resistance normally encountered in electronic equipment.

1-3. The Model 412A/AR measures dc voltage from 1.0 mV full scale to 1000 V full scale in thirteen ranges arranged in a 1, 3, 10 sequence. Voltmeter accuracy is 1% of full scale. The input circuit is isolated from the case and from power line ground.

1-4. The Model 412A/AR measures positive or negative dc current from 1.0μA full scale to 1.0 A full scale with an accuracy of 2% of full scale. Current ranges are also in a 1, 3, 10 sequence.

1-5. Resistance measurement capability of the Model 412A/AR is from 1.0 ohm center scale to 100 megohms center scale in nine decade ranges. Resistance measurement accuracy is 5% between .3 and 3 on the resistance scale.

1-6. The Model 412A/AR has a dc amplifier output voltage proportional to the input. Amplifier gain is from -1000 to +1000, depending on range selected.

1-7. SPECIFICATIONS.

1-8. Complete specifications for the -hp- Model 412A/AR are listed in Table 1-1.

1-9. INSTRUMENT AND MANUAL IDENTIFICATION.

1-10. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number of your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will explain the differences between your instrument and the Model 412A/AR described in this manual.

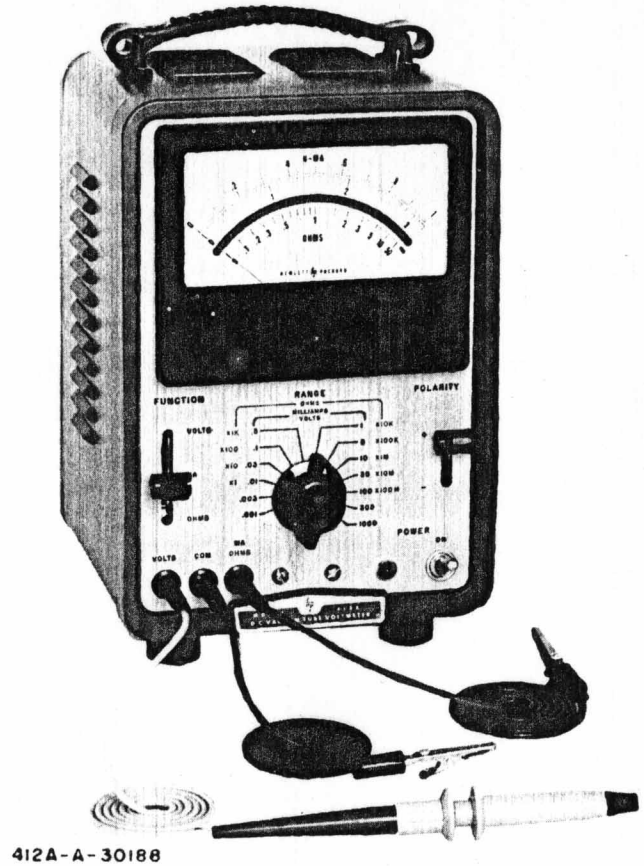


Figure 1-1. Model 412A DC Vacuum Tube Voltmeter

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains instructions necessary for installation of the Model 412A/AR DC Vacuum Tube Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of mars or scratches, and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also test the electrical performance of the instrument, using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 412A/AR can be operated from any source of 115 or 230 volts at 50 or 60 Hz. The 115/230 V slide switch on the rear panel selects the desired voltage. Power dissipation is approximately 35 watts.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

NOTE

Operating the Model 412A/AR without grounding the third (power line ground) wire of the power cable will result in a zero offset of the meter and oscillation of the pointer.

2-10. INSTALLATION.

2-11. The Model 412A is intended for use as a bench instrument, having a top-mounted handle and rubber feet.

2-12. The Model 412AR is intended for rack mounting. Front panel height is 5-7/32 inches.

2-13. REPACKAGING FOR SHIPMENT.

2-14. The following paragraphs contain a general guide for repackaging of the instrument. Refer to Paragraph 2-15 if the original container is to be used; 2-16 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. Include the model number of the instrument. In any correspondence, identify the instrument by model number, serial number prefix, and serial number.

2-15. Place the instrument in original container with suitable packing material and seal well with strong tape or metal bands. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

2-16. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal well with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT," "FRAGILE," etc.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The -hp- Model 412A/AR DC Vacuum Tube Voltmeter measures dc voltages from 1.0 mV full scale to 1000 V full scale with an accuracy of 1% of full scale. Current measurement ranges are from 0.001 mA full scale to 1000 mA full scale, with accuracy of 2% of full scale. The Model 412A/AR makes resistance measurements from 1.0 ohm center scale to 100 megohms center scale. Resistance measurement accuracy is 5% of reading between .3 and 3 on the ohms scale. A dc amplifier output is also provided. Voltage gain of the amplifier is from -1000 to +1000, depending on range selected. Amplifier output is 1.0 V at full scale, and maximum current load is 1.0 mA.

3-3. LOW-LEVEL ELECTRICAL PHENOMENA.

3-4. Stray low-level electrical phenomena may cause error in low voltage measurements. When using the lower voltages of the Model 412A, consider the possibility of low-level voltages produced by thermoelectric effects, residual charges on capacitors, battery action, or flexing of coaxial cables.

3-5. The voltage probe, current/resistance lead, and common lead of the Model 412A/AR are all designed to have a very low thermoelectric effect with copper, the most commonly used conductor. However, some component leads such as transistors and reed relays may have leads made of such alloys as nickel-iron, which produce a thermoelectric voltage when joined with copper. Whenever possible, connect the 412A leads to copper. If this is not possible, the voltage probe and common lead should both be connected to the same kind of metal component lead, and both connection points maintained at the same temperature.

3-6. To minimize the possibility of battery action when making low voltage measurements, make sure the 412A probe tip and common lead alligator clip are clean. Also be sure the component leads or other points of connection are clean. The presence of some chemicals such as solder flux may cause noticeable measurement error due to battery action.

NOTE

Operating the Model 412A/AR without grounding the third (power line ground) wire of the power cable will result in a zero offset of the meter and oscillation of the pointer.

3-7. TURN-ON PROCEDURE.

CAUTION

BEFORE CONNECTING PRIMARY POWER, MAKE SURE THE REAR PANEL 115/230 V SLIDE SWITCH IS SET TO THE POWER LINE VOLTAGE TO BE USED. INCORRECT SETTING MAY RESULT IN DAMAGE TO THE INSTRUMENT.

a. Make sure the proper fuse is installed for operation with the power line voltage to be used. A 0.6 A slow-blow fuse should be used for 115 V operation, and a 0.4 A slow-blow fuse for 230 V operation.

b. Connect to ac power and turn instrument ON. Allow a 5-minute warm-up period.

3-8. VOLTAGE MEASUREMENT.

a. Set FUNCTION switch to VOLTS, and select proper polarity.

b. Set RANGE switch to desired range. If in doubt, set switch to high range and downrange as necessary.

c. Connect VOLTS and COM leads across circuit or component, and read voltage.

CAUTION

DO NOT OVERLOAD THE INSTRUMENT. MOMENTARY OVERLOADS UP TO TEN TIMES FULL SCALE WILL NOT DAMAGE THE INSTRUMENT; HOWEVER, CURRENT SHUNTS, AND INTERNAL RESISTANCE STANDARDS ARE NOT PROTECTED FROM EXTREME OVERLOAD.

3-9. CURRENT MEASUREMENT.

a. Set FUNCTION switch to MA.

b. Set RANGE switch to desired range. If in doubt, select high range and downrange as necessary.

c. De-energize circuit to be measured.

d. Connect 412A into circuit, using MA/OHMS and COM leads.

e. Energize circuit, set POLARITY switch for up-scale indication, and read current.

NOTE

When making current measurements, make sure there is no connection between the circuit common (⏚) and power line ground (⏚) terminals on rear panel.

3-10. RESISTANCE MEASUREMENT.

a. Set FUNCTION switch to OHMS.

b. If resistance to be measured is part of a circuit, make sure power is turned off.

c. Connect 412A across circuit or component to be measured, using MA/OHMS and COM leads.

d. Set RANGE switch so that meter indication is as near center scale as possible, and read resistance on OHMS scale.

3-11. When measuring the resistance of non-linear devices such as transistors and diodes, it is often desirable to know what voltage and current were present in obtaining the resistance measurement. Table 3-1 lists the open-circuit voltage and short-circuit current available at the 412A leads during resistance measurements. Voltage and current are read on the top scale of the meter for all resistance ranges. The meter reading is directly proportional to the voltage across the device being measured, and inversely proportional to the current. As an example, assume that a device being measured on the X10 range gives a reading of .25 on the resistance scale. The meter also indicates .2 on the top scale. Since full-scale voltage for the X10 range is 100 mV (Table 3-1), this indicates a voltage of 20 mV across the device. To determine the current, subtract the meter reading of .2 from the full scale reading of 1, and multiply by the short-circuit current listed in Table 3-1 . Since the current shown for the X10 range is 10 mA, this indicates a current of 8 mA through the device being measured. The resistance measurement, then, indicates an equivalent resistance of 2.5 ohms, with an applied voltage of 20 mV, and a current of 8 mA.

Table 3-1. Voltage and Current in Resistance Measurements

Resistance Range	Open-Circuit Volts (at 1 on top scale)	Short-Circuit Current (at 0 on top scale)
X1	10 mV	10 mA
X10	100 mV	10 mA
X100	1 V	10 mA
X1K	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

3-12. AMPLIFIER OPERATION.

3-13. The Model 412A/AR DC Amplifier Output may be used to drive devices such as an analog recorder to provide a permanent record of measurements. Output level is 1.0 volt at full scale; maximum rated load current is 1.0 mA. Load currents in excess of 1.0 mA (less than 1000 ohms load resistance) may cause errors in meter indication and amplifier gain. Amplifier gain is from +1000 on the .001 range to -1000 on the 1000 range.

SECTION IV
THEORY OF OPERATION

4-1. GENERAL.

4-2. The -hp- Model 412A/AR uses a chopper-stabilized amplifier circuit to produce a meter indication proportional to the voltage, current, or resistance being measured.

4-3. BLOCK DIAGRAM ANALYSIS.

4-4. Figure 4-1 is a block diagram of the Model 412A/AR. The following paragraphs describe operation of the various circuits.

4-5. RANGE AND FUNCTION SELECTION.

4-6. The Voltage Divider, Current Shunts, and Resistance Standards circuits provide a 0.9 mV output for full-scale input in all ranges and functions. Full scale is defined as a reading of 1 on the top scale of the meter for all ranges. Simplified schematics of the switching circuits for all ranges and functions are shown in Figures 5-8 through 5-10.

4-7. FILTERS.

4-8. Input filtering is provided to attenuate any ac components present in the input signal. The second filter section filters the Demodulator output.

4-9. MODULATOR, AMPLIFIER, DEMODULATOR, AND CHOPPER.

4-10. A light-beam chopper driven by a synchronous motor sets the Modulator/Demodulator frequency at 5/6 power line frequency. The Modulator output is an ac signal proportional to the Model 412A input. The amplifier gain is stabilized at 1,111 by the feedback network, resulting in an output of 1.0 volt for a full-scale input. The Demodulator is synchronized with the Modulator so that the amplified ac signal is converted to a steady dc, which is applied to the Cathode Follower. This voltage is the same polarity as the input signal.

4-11. CATHODE FOLLOWER AND POLARITY SELECTION.

4-12. The Cathode Follower drives the Meter and the DC Amplifier Output. Polarity selection provides up-scale meter reading for either polarity input. The Polarity switch is disabled in the OHMS function.

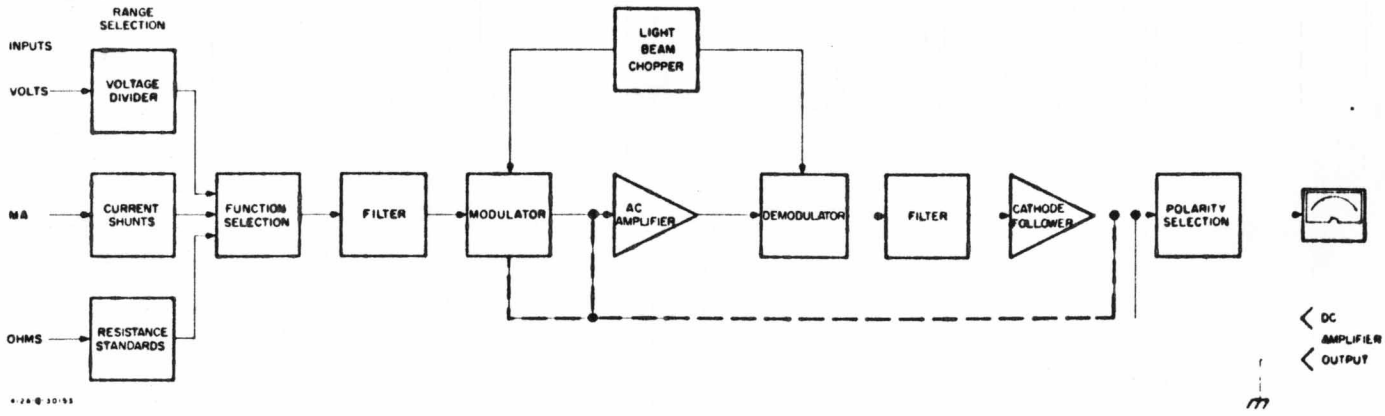


Figure 4-1. Block Diagram

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
DC Voltage Standard	Range: 0-300 V Accuracy: 0.1% Current Rating: 10 mA	-hp- 738BR Voltmeter Calibrator
Variable Line Transformer	Output Voltage: to 127 Vac (or 253 Vac)	Superior Electric Powerstat 3PF116 (for 115 V line) 3PF216 (for 230 V line)
DC Voltmeter	Range: 1 V to 300 V Resolution: 10 mV Input Resistance: 100 MΩ	-hp- 427A Voltmeter
AC Voltmeter	Range: to 300 V	-hp- 427A Voltmeter
Ohmmeter	Range: to 10 MΩ	-hp- 427A Voltmeter
Oscilloscope	Sensitivity: 0.01 V/cm	-hp- 120B Oscilloscope
Precision Resistors	Resistance: Accuracy: 1 ±1.0% 10 ±1.0% 100 ±1.0% 1 K ±1.0% 10 K ±1.0% 30 K 5 W ±0.1% 100 K 1 W ±0.1% 300 K 1/2 W ±0.1% 1 M ±0.1% 10 M ±1.0% 100 M ±1.0% 10 M ±0.1%	Part Number: -hp- 0811-0060 -hp- 0757-0346 -hp- 0757-0401 -hp- 0757-0280 -hp- 0757-0442 Daven DAS-5 Dale MF-1 Dale MFS-1/2 -hp- 0698-4161 -hp- 0698-5049 -hp- 0733-0017 -hp- 0811-2475
Oscillator	Frequency: 60 Hz Output: 10 V peak	-hp- 200CD Wide Range Oscillator

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the -hp- Model 412A/AR. The following paragraphs describe the Performance Checks, Calibration Procedures, Troubleshooting, and Servicing Procedures.

5-3. REQUIRED TEST EQUIPMENT.

5-4. Recommended test equipment for maintaining and checking performance of the Model 412A is listed in Table 5-1. Test instruments other than those recommended may be used if their specifications equal or exceed the required characteristics.

5-5. PERFORMANCE CHECKS.

5-6. Use the following procedures to verify proper operation of the Model 412A. The 412A and test equipment should be operated at 115/230 Vac unless otherwise specified. A Performance Test Card is provided at the end of this section for recording the performance of the Model 412A. The card may be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance check. If the Model 412A does not meet specifications at any point in this procedure, refer to Paragraph 5-15, Adjustment and Calibration procedure.

5-7. METER ZERO.

5-8. The meter pointer should rest over the zero calibration mark when the instrument is at normal operating temperature, is turned off, and is in the normal operating position. If the pointer is off zero, perform the mechanical adjustment procedure outlined in Paragraph 5-18 before proceeding with the performance checks.

5-9. Turn the Model 412A POWER switch ON. After a 5-minute warm-up period, the meter pointer should rest on zero when the input leads are shorted. If not, perform the electrical zero adjustment outlined in Paragraph 5-22.

NOTE

Operating the Model 412A/AR without grounding the third (power line ground) wire of the power cable will result in a zero offset of the meter and oscillation of the printer.

5-10. VOLTMETER ACCURACY CHECK.

a. A dc voltage standard and a variable line transformer are required for this check. If an -hp- Model 738BR Voltmeter Calibrator is used, it should be allowed a 30-minute warm-up period.

b. Connect 412A to variable line transformer, and set line voltage switch (115/230) to correspond to line voltage being used. Turn 412A ON and allow 5-minute warm-up period.

c. Set 412A FUNCTION to VOLTS, POLARITY to +.

d. Connect VOLTS and COM leads to dc standard output.

e. Check 412A indication against dc standard output at full scale on each 412A range. Maximum error should be no greater than ± 1% of full scale (one small division on top scale).

NOTE

When checking the Model 412A on the .001 and .003 volt ranges, turn off the dc standard output and note any 412A zero offset due to thermoelectric voltage. Add or subtract as necessary any offset from the 412A reading.

f. Check 412A meter tracking on the 1 V range at all cardinal points on the meter scale. Maximum error should be no greater than 0.01 V with either polarity input.

g. Repeat step e on 1 V range at line voltages of 103 and 127 volts (or 207 and 253 V).

5-11. MILLIAMMETER ACCURACY CHECK.

a. A dc voltage standard and the precision resistors listed in Table 5-2 required for this check.

b. Set 412A FUNCTION to MA, POLARITY to +.

Table 5-2. Milliammeter Accuracy Check

Model 412A Range	DC Standard Output	Series Resistance	Model 412A Reading (2% of full scale)
.001	1 V	1.00M ± 0.1%	1.0
.003	3 V	1.00M ± 0.1%	3.0
.01	10 V	1.00M ± 0.1%	1.0
.03	30 V	1.00M ± 0.1%	3.0
.1	100 V	1.00M ± 0.1%	1.0
.3	300 V	1.00M ± 0.1%	3.0
1	300 V	300K ± 0.1% 1/2 W	1.0
3	300 V	100K ± 0.1% 1 W	3.0
10	300 V	30K ± 0.1% 5 W	1.0
30	300 V	30K ± 0.1% 5 W	1.0 (on 3 scale)

c. Connect Precision Resistor in series with MA lead and positive side of dc standard output. Connect 412A COM lead to dc standard negative output terminal.

d. Perform checks listed in Table 5-2.

NOTE

It is not necessary to check higher current ranges. On current ranges 10 through 1000, the current shunt does not change. Only the voltage divider, checked in Paragraph 5-10, changes. Figure 5-9 shows simplified ammeter switching circuits.

5-12. OHMMETER ACCURACY CHECK.

a. Set FUNCTION selector to OHMS.

b. Connect, in turn, resistor of 1, 10, 100, 1 K, 10 K, 100 K, 1 M, 10 M, and 100 M ohms ±1.0% between MA/OHMS and COM leads. With appropriate RANGE setting, meter should indicate between 0.95 and 1.05 in each case.

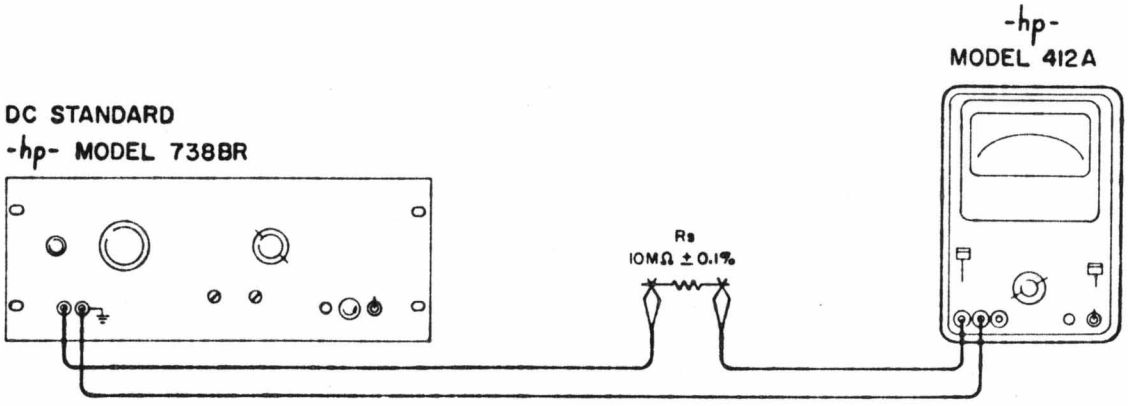


Figure 5-1. Input Resistance Check

5-13. INPUT RESISTANCE CHECK.

a. Connect the Model 412A/AR, dc standard and 10 megohm resistor as shown in Figure 5-1.

b. Set 412A FUNCTION to VOLTS, POLARITY to +.

c. Adjust 412A RANGE and dc standard output to voltages listed in Table 5-3. A correct meter reading in each case verifies the input resistance where:

$$E_{in} = E_{applied}\left[\frac{R_{in}}{R_{in} + R_s}\right]$$

Table 5-3. Input Resistance Checks

412A Range	Applied Voltage	412A Meter Reading (±1%)	412A Input Resistance
.01 V	10 mV	5.0 mV	10 MΩ
.03 V	30 mV	22.5 mV	30 MΩ
.1	100 mV	90.9 mV	100 MΩ
.1 V	1 V	0.95 V	200 MΩ

5-14. AC REJECTION CHECK.

a. Connect the Model 412A/AR, oscillator, and ac voltmeter as shown in Figure 5-2.

b. Set 412A FUNCTION to VOLTS, POLARITY to +, and RANGE to 0.1 V.

c. Set ac voltmeter FUNCTION to AC VOLTS, RANGE to 10 V.

d. Adjust oscillator frequency to 60 Hz, and adjust output for an indication of 7.07 V on ac voltmeter. This corresponds to a 10 V peak ac noise signal at the 412A input.

e. The 412A meter reading should be 0 ± 1% (1 minor division on upper scale).

5-15. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-16. The following procedures should be performed only if it has been determined by the Performance Checks outlined in Paragraph 5-5 that the Model 412A/AR does not meet specifications.

5-17. CABINET REMOVAL.

a. Disconnect power cord from power source.

b. On cabinet model, remove two retaining screws near center of rear panel. On rack model, remove three retaining screws in rear of cover.

c. Slide instrument chassis forward out of cabinet.

5-18. MECHANICAL ADJUSTMENT OF METER ZERO.

5-19. If mechanical zero of meter is correct, pointer rests over the zero calibration mark on the meter scale when instrument is at normal operating temperature, in its normal operating position, and turned off. If mechanical zero is not correct, perform the following adjustment procedure.

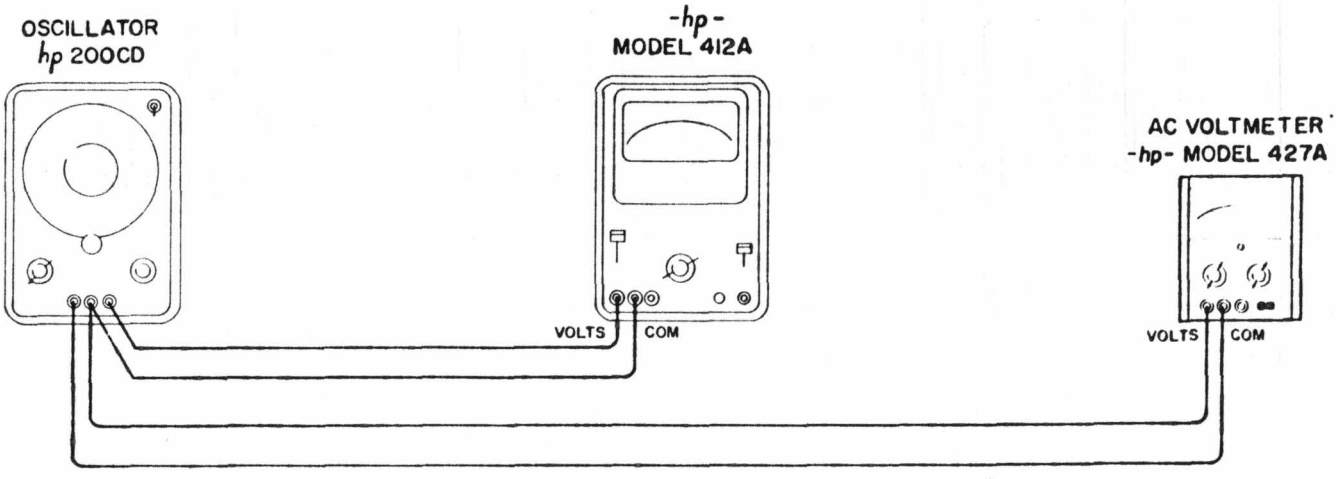


Figure 5-2. AC Rejection Check

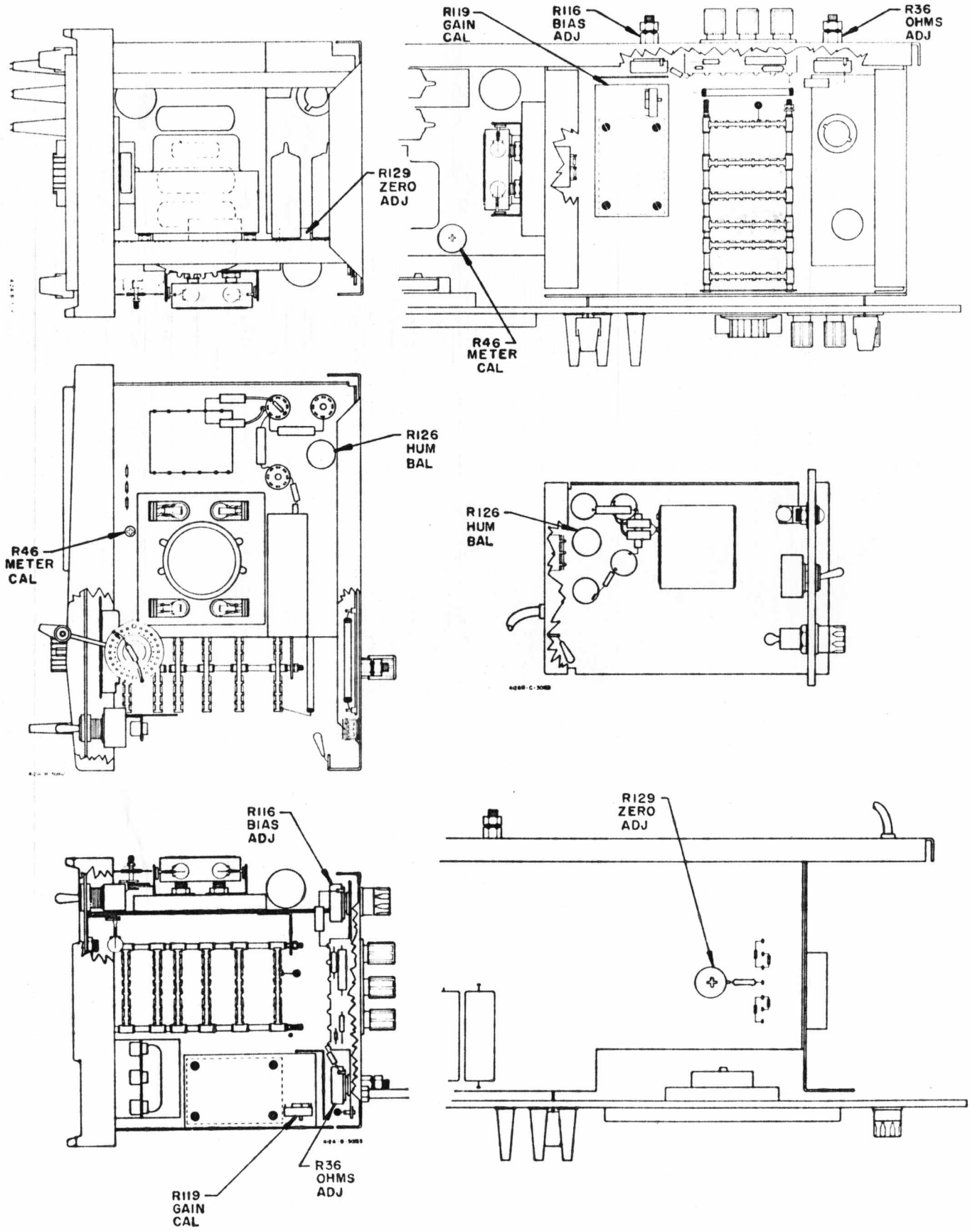


Figure 5-3. Location of Adjustments

a. Turn 412A ON and allow a 20-minute warm-up period. 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 and stop when pointer is exactly over zero mark. If pointer overshoots zero, repeat steps c and d.

e. With pointer exactly on zero, rotate adjustment screw counterclockwise approximately 10 degrees. This frees adjustment screw from meter suspension. If pointer moves during this step, repeat steps c through e.

5-20. HUM BALANCE ADJUSTMENT.

a. Turn 412A ON and allow 5-minute warm-up period.

b. Set FUNCTION to VOLTS.

c. Connect oscilloscope to DC AMPLIFIER OUTPUT.

d. Adjust HUM BAL (R126, Figure 5-3) for minimum 10 Hz signal on oscilloscope. (If power line frequency is 50 Hz, beat frequency will be 8-1/3 Hz instead of 10 Hz.)

NOTE

The Hum Bal. control does not affect the 120 Hz ripple. Adjust only for minimum 10 Hz (or 8-1/3 Hz) signal. With the VOLTS lead shorted to COM lead and POLARITY set to +, the 412A meter will show a minimum deflection when the Hum Bal. is correctly adjusted.

5-21. CATHODE FOLLOWER BIAS ADJUSTMENT.

a. Set 412A RANGE switch fully clockwise (one step beyond 1000).

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

5-22. METER ELECTRICAL ZERO ADJUSTMENT.

NOTE

Meter electrical zero adjust circuit may not be installed in 412A cabinet model instruments with serial number 424-14482 and below, or in 412AR rack mount instruments with serial number 424-15082 and below.

a. Turn 412A ON and allow a 30-minute warm-up period.

b. Set FUNCTION to VOLTS, RANGE to .001.

c. Short VOLTS probe to COM lead.

d. Adjust ZERO ADJ (R129) for zero deflection of the meter pointer. Check the zero adjustment by switching POLARITY from + to - When zero is adjusted properly, this action should produce a minimum amount of deflection.

5-23. AMPLIFIER GAIN ADJUSTMENT AND METER CALIBRATION.

a. A dc standard and a dc voltmeter are required for these adjustments.

b. Connect 412A VOLTS probe and COM lead to dc standard output. Set FUNCTION to VOLTS, RANGE to 1 V, POLARITY to +.

c. Connect dc voltmeter between dc standard output (+) and 412A DC AMPLIFIER OUTPUT high.

d. Set dc standard output to +1 V.

e. Adjust 412A GAIN CAL (R119) for zero indication on test voltmeter. A 10 mV reading on test voltmeter indicates 1% error in 412A gain calibration.

f. Adjust METER CAL (R46) to set 412A meter pointer on 1.0 on top scale. Disconnect test voltmeter.

g. Check 412A calibration at full scale on all ranges as outlined in Paragraph 5-10. If any reading is in error more than 1%, readjust GAIN CAL (R119) to bring all readings within ±1%.

5-24. OHMMETER ADJUSTMENT.

a. Set 412A FUNCTION to OHMS, RANGE to X1K. Make certain MA/OHMS and COM leads are not connected through some external resistance.

b. Adjust rear panel OHMS ADJ (R36) for meter indication of ∞ (corresponding to 1.0 on upper scale).

5-25. TROUBLESHOOTING.

5-26. When the Model 412A/AR operates improperly, first adjust and calibrate it according to the procedures outlined in Paragraph 5-15. If calibration is not possible, proceed with the troubleshooting steps.

CAUTION

CONTAMINATION OR FINGERPRINTS ON THE RANGE SWITCH OR THE COMPONENTS MOUNTED ON THE RANGE SWITCH MAY REDUCE ACCURACY OF INSTRUMENT.

5-27. FRONT PANEL INDICATIONS.

5-28. If the malfunction is common to all ranges and functions, the trouble may be in the amplifier or power supply areas. If the instrument operates improperly on only one range or function, the trouble is probably in the switching section or input cables.

5-29. POWER SUPPLY AND AMPLIFIER CHECKS.

5-30. Check power supply voltages at points listed in Table 5-4. Voltages are measured with respect to circuit common (⏚). Figure 7-2 shows the location of components.

Table 5-4. Power Supply Voltages

Check Point	Voltage
V104 pin 1 or 5	+150 V ± 5%
V105 pin 1 or 5	+255 V ±10%
CR101 Anode	-7 V ± 5%

5-31. Tubes are a common source of trouble and are most easily checked by substitution. Following replacement of a particular tube, make the adjustments indicated in Table 5-5.

5-32. Additional checks of amplifier operation may be made by checking voltages shown on the amplifier section of the schematic diagram. Be sure to observe conditions in Note 11 in Paragraph 7-2. Allow a tolerance of ±10%.

Table 5-5. Tube Replacement

Tube Replaced	Adjustment
V101 (12AX7) Amplifier	Hum Bal. Par. 5-20 Gain Cal. Par. 5-23
V102 (6AU8) Amplifier/ Cathode Follower	Bias Adj. Par. 5-21 Gain Cal. Par. 5-23
V103 (6X4) Rectifier	None
V104 (OA2) Regulator	Ohms Adj. Par. 5-24
V105 (OB2) Regulator	None

5-33. MODULATOR CHECK.

a. An oscilloscope and a 10 MΩ resistor are required for this test.

b. Disconnect 412A from power source and remove cabinet.

c. Remove V101 and reconnect 412A to power source.

d. Connect a clip lead from the center arm of R116 (rear panel BIAS ADJ) to the termination of the VOLTS input cable (terminal 4 in Figure 5-7).

e. Set 412A FUNCTION to VOLTS, RANGE to .001.

f. Set oscilloscope input to DC.

g. Connect a 10 MΩ resistor in series with oscilloscope vertical input. Using a clip lead, connect resistor to junction of R101 and C101 (input circuit board, Figure 5-4). Connect oscilloscope common to 412A COM lead. Set Vertical Sensitivity to 0.2 V/cm.

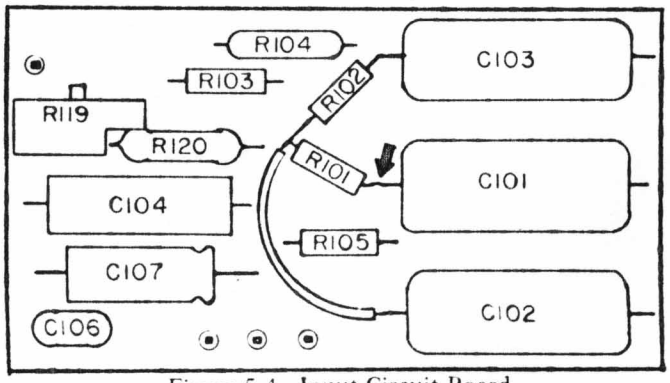


Figure 5-4. Input Circuit Board

h. Turn 412A ON and allow 30-second warm-up period. Observe dc voltage amplitude on oscilloscope.

i. Move oscilloscope input (with series resistor) to Modulator output at junction of green lead from Modulator and C104 (0.01 Microfarads).

j. Waveform should be similar to that shown in Figure 5-5. Peak-to-peak amplitude should be approximately equal to dc voltage observed in step h. Signal frequency should be 5/6 power line frequency.

k. If waveform is not satisfactory, check chopper motor and assembly or Modulator and input circuit as indicated by deficiency in waveform.

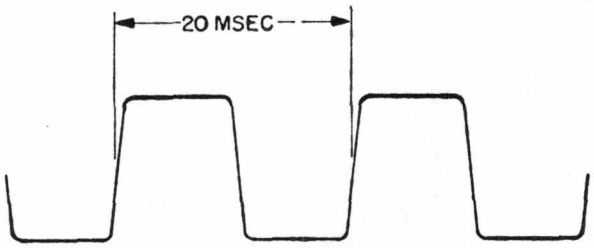


Figure 5-5. Modulator Waveform

5-34. MODULATOR REPLACEMENT.

5-35. The photoconductor cells in the Modulator (V110A/B) are not separately replaceable. If a cell is defective, the Modulator block assembly should be replaced, using the following procedure.

a. Disconnect 412A from power source and remove cabinet.

CAUTION

CONTAMINATION OR FINGERPRINTS ON THE RANGE SWITCH OR COMPONENTS MOUNTED ON THE RANGE SWITCH MAY REDUCE ACCURACY OF THE INSTRUMENT.

b. In 412A cabinet model, remove side shield.

c. Note and record color code of wires before removing from Modulator assembly printed circuit board.

d. Remove four screws holding light-beam chopper assembly. It is not necessary to disconnect wires.

e. Spread grip rings on Modulator light rods and slide rods out of Modulator block.

f. Remove four screws holding modulator assembly to chassis.

NOTE

Be sure to seat the four insulating shoulder washers in mounting holes when replacing the assembly.

g. Lift out Modulator assembly. If it is necessary to replace Modulator block assembly only, remove four screws holding printed circuit board to block. Note color and location of wires between block and printed circuit board before disconnecting.

5-36. DEMODULATOR CHECK.

a. Disconnect 412A from power source and remove cabinet.

b. Remove V102 (on Amplifier Assembly).

c. On light-beam chopper assembly, remove upper lamp nearest front of instrument. This lamp illuminates V111A.

d. Connect a 1.0 microfarad capacitor across input terminals of test ohmmeter.

e. Connect test ohmmeter common lead to Demodulator terminal with pink/orange wire. See Figure 5-6.

f. Connect other test ohmmeter lead to terminal with white/orange wire.

g. Connect 412A to power source and turn ON.

h. Resistance indicated on test ohmmeter should be 1 to 2 megohms.

i. Turn 412A OFF.

j. Replace lamp in light-beam chopper and remove upper lamp nearest rear of instrument. This lamp illuminates V111B.

k. Connect test ohmmeter common lead to Demodulator terminal with brown/orange wire.

l. Connect other test ohmmeter lead to terminal with white/orange wire.

m. Turn 412A ON.

n. Resistance indicated on test ohmmeter should be 1 to 2 megohms.

o. Turn 412A OFF and replace lamp and V102.

5-37. DEMODULATOR REPLACEMENT.

5-38. The photoconductors in the Demodulator are not separately replaceable. If a cell is defective, the Demodulator assembly should be replaced, using the following procedure:

a. Disconnect instrument from power source and remove cabinet.

b. Disconnect the three wires to Demodulator assembly. Figure 5-6 shows wire color codes for both cabinet (412A) and rack (412AR) models.

c. Remove four screws holding light-beam chopper. It is not necessary to disconnect wires.

d. Remove nuts from four screws holding Demodulator assembly and remove assembly from instrument.

5-39. SWITCH CHECKS.

CAUTION

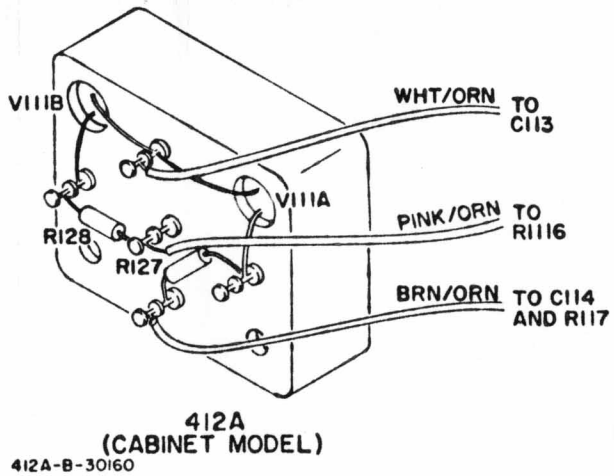
CLEAN RUBBER GLOVES SHOULD BE WORN WHEN WORKING ON THE RANGE SWITCH. CONTAMINATION OR FINGERPRINTS MAY REDUCE ACCURACY OF INSTRUMENT. IN ADDITION, LOW ROSIN CONTENT SOLDER SHOULD BE USED WHEN REPLACING COMPONENTS. USE A MINIMUM OF HEAT WHEN SOLDERING, AND REMOVE TRACES OF FLUX FROM CONNECTIONS. IF NECESSARY, RANGE SWITCH MAY BE CLEANED USING A SOLUTION OF MILD DETERGENT AND WARM WATER. RINSE THOROUGHLY IN DISTILLED WATER AND DRY IMMEDIATELY.

5-40. If the malfunction is peculiar to one range or function, trouble may be in the switching circuits. Either a component or switch contact may be defective. Figures 5-8 through 5-10 show simplified schematics of range and function switching, and may be used to isolate the trouble. For example, if the instrument operates properly on all voltage ranges except .003; R1, R9, or the associated switch contacts may be defective. Figure 7-3 identifies the components mounted on the range switch.

5-41. ADJUSTMENT OF FACTORY SELECTED COMPONENTS.

5-42. R34*.

5-43. The value of R34* is selected to bring the OHMS ADJ potentiometer within the proper range, and is dependent upon the power supply voltage and the value of other resistors in the ohmmeter circuit. Replacement of R34* should not be necessary unless V104 has been replaced or the range switch components have been changed. If the



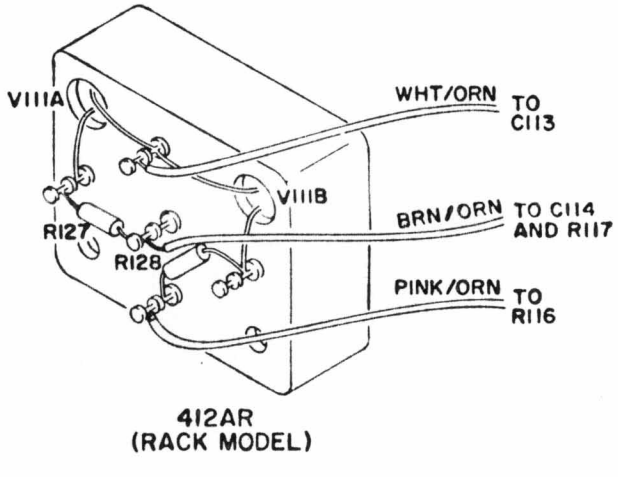
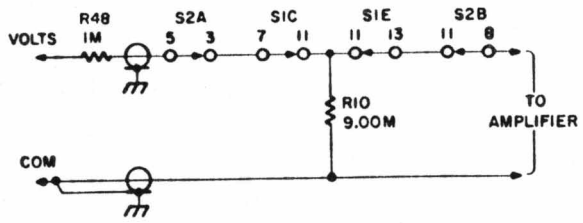
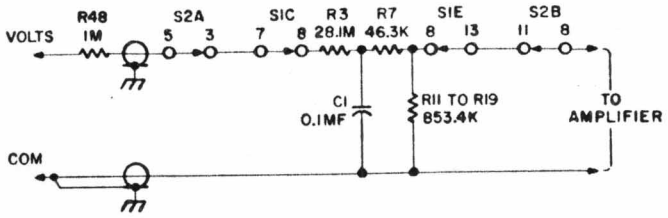


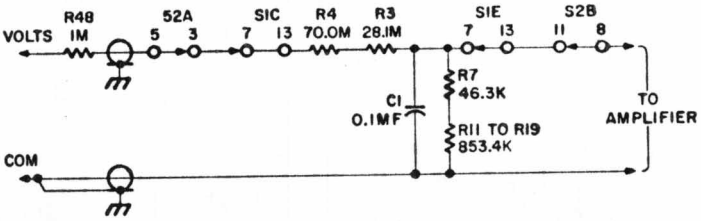
Figure 5-6. Demodulator Assembly



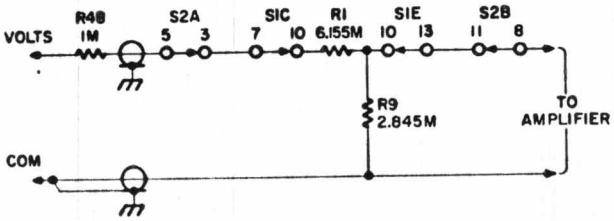
.001V RANGE



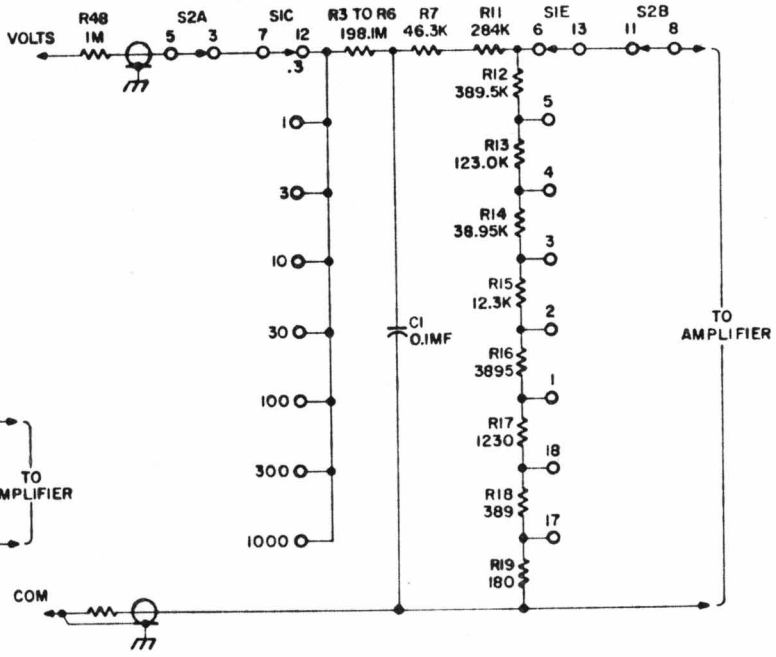
.03V RANGE



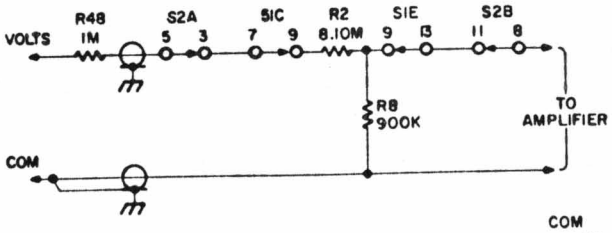
.1V RANGE



.003V RANGE



.3 TO 1000V RANGES



.01V RANGE

Figure 5-8. Simplified Schematic, Voltmeter Switching

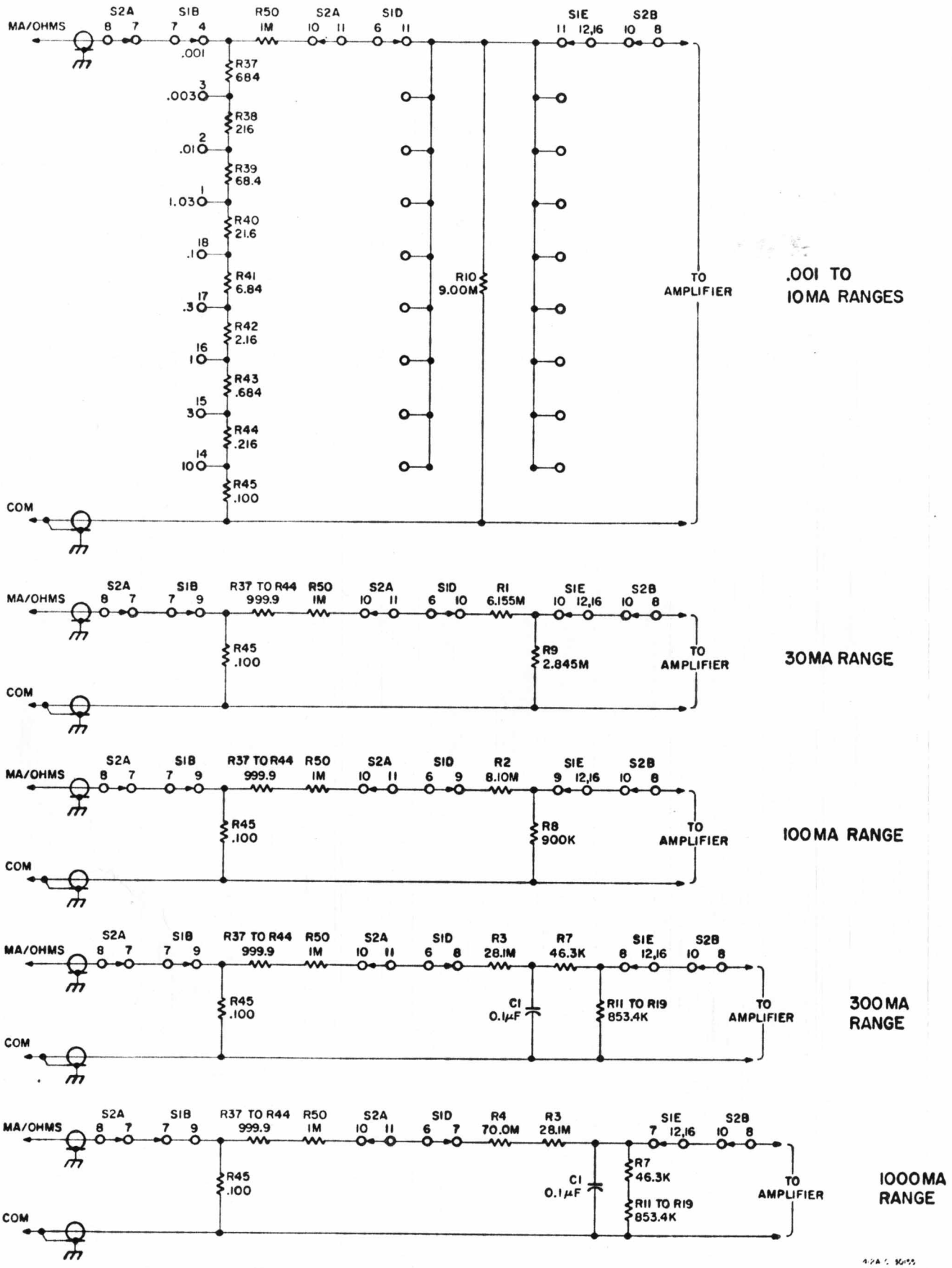


Figure 5-9. Simplified Schematic, Ammeter Switching

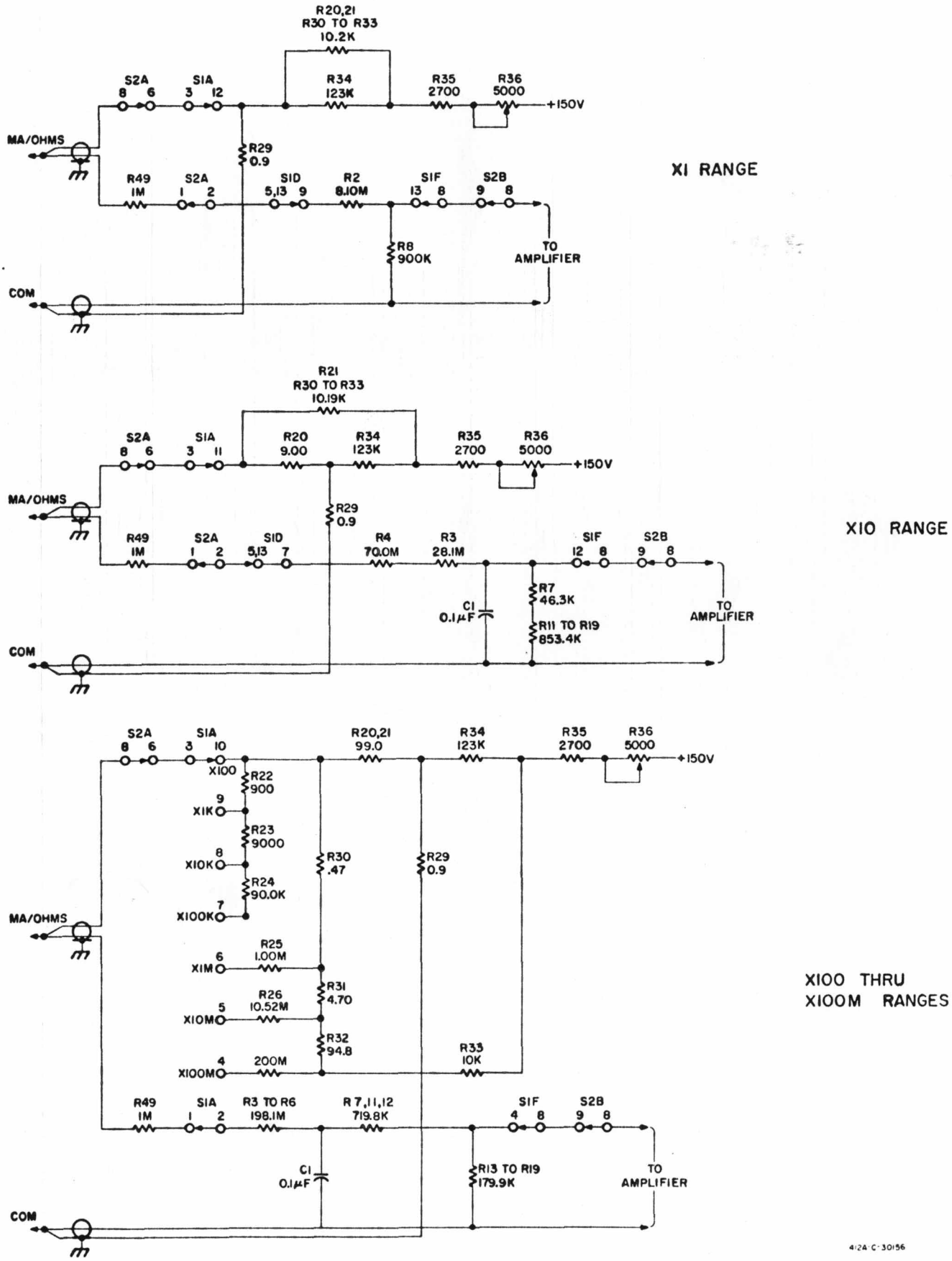


Figure 5-10. Simplified Schematic, Ohmmeter Switching

PERFORMANCE TEST CARD

Hewlett-Packard Model 412A/AR
Vacuum Tube Voltmeter

Tests Performed by _____
Date _____

Serial No. __ - _____

PARAGRAPH	DESCRIPTION	CHECK	
	Meter Zero		
5-8	Mechanical	OK _____	
5-9	Electrical	OK _____	
5-10	Voltmeter Accuracy Check	Reading	Limits
	Range:		
	.001	_____	± 1%
	.003	_____	± 1%
	.01	_____	± 1%
	.03	_____	± 1%
	.1	_____	± 1%
	.3	_____	± 1%
	1	_____	± 1%
	3	_____	± 1%
	10	_____	± 1%
	30	_____	± 1%
	100	_____	± 1%
	300	_____	± 1%
	1000	_____	± 1%
5-11	Milliammeter Accuracy Check		
	Range:		
	.001	_____	± 2%
	.003	_____	± 2%
	.01	_____	± 2%
	.03	_____	± 2%
	.1	_____	± 2%
	.3	_____	± 2%
	1	_____	± 2%
	3	_____	± 2%
	10	_____	± 2%
	30	_____	± 2%
5-12	Ohmmeter Accuracy Check		
	Range:		
	X1	_____	0.95 to 1.05
	X10	_____	0.95 to 1.05
	X100	_____	0.95 to 1.05
	X1K	_____	0.95 to 1.05
	X10K	_____	0.95 to 1.05
	X100K	_____	0.95 to 1.05
	X1M	_____	0.95 to 1.05

PERFORMANCE TEST CARD (Cont'd)

PARAGRAPH	DESCRIPTION	CHECK	
		Reading	Limits
	Ohmmeter Accuracy Check Range:		
	X10M	_____	0.95 to 1.05
	X100M	_____	0.95 to 1.05
5-13	Input Resistance Check Range:		
	.01	_____	±1%
	.03	_____	±1%
	.1	_____	±1%
	1	_____	±1%
5-14	AC Rejection Check	_____	0±1%

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	IC	= integrated circuit	QCR	= transistor-diode	W	= cable
CR	= diode	J	= jack	R	= resistor	X	= socket
DL	= delay line	K	= relay	RT	= thermistor	XDS	= lampholder
DS	= lamp	L	= inductor	S	= switch	XF	= fuseholder
E	= misc electronic part	M	= meter	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)	Ω	= ohm (s)		
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	obd	= order by description	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	OD	= outside diameter	TC	= temperature coefficient
coef	= coefficient	L	= inductor	p	= peak	TiO_2	= titanium dioxide
com	= common	lin	= linear taper	pc	= printed circuit	tog	= toggle
comp	= composition	log	= logarithmic taper	pF	= picofarad (s) = 10^{-12} farads	tol	= tolerance
conn	= connection	m	= milli = 10^{-3}	piv	= peak inverse voltage	trim	= trimmer
dep	= deposited	mA	= milliampere (s) = 10^{-3} amperes	p/o	= part of	TSTR	= transistor
DPDT	= double-pole double-throw	MHz	= megahertz = 10^{+6} hertz	pos	= position (s)	V	= volt (s)
DPST	= double-pole single-throw	MΩ	= megohm (s) = 10^{+6} ohms	poly	= polystyrene	vacw	= alternating current working voltage
elect	= electrolytic	met flm	= metal film	pot	= potentiometer	var	= variable
encap	= encapsulated	mfr	= manufacturer	p-p	= peak-to-peak	vdcw	= direct current working voltage
F	= farad (s)	mtg	= mounting	ppm	= parts per million	W	= watt (s)
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
fxd	= fixed	μ	= micro = 10^{-6}			wiv	= working inverse voltage
GaAs	= gallium arsenide	μV	= microvolt (s) = 10^{-6} volts			w/o	= without
GHz	= gigahertz = 10^{+9} hertz	my	= Mylar ®			ww	= wirewound
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	*	= optimum value selected at factory, average value shown (part may be omitted)
Ge	= germanium	NC	= normally closed	Rh	= rhodium		
grd	= ground (ed)	Ne	= neon	rms	= root-mean-square		
H	= henry (ies)	NO	= normally open	rot	= rotary	**	= no standard type number assigned (selected or special type)
Hg	= mercury	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium		
Hz	= hertz (cycle (s) per second)			sect	= section (s)		
				Si	= silicon		

REV G

® Dupont de Nemours

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
B1 thru B100				Not assigned			
B101	3140-0013		1	Motor: synchronous type 6.3 Vac	73061	610 (6.3 V)	
C1	0170-0019		1	C: fxd my 0.01 microfarads 5% 200 vdcw	84411	620S	
C2	0180-0105		1	C: fxd semi-polarized 50 microfarads 25 vdcw	56289	S97441	
C3 thru C100				Not assigned			
C101 thru C103	0160-2641		1	C: fxd poly 0.1 microfarads 10% 50 vdcw	56289	Special 275P	
C104	0170-0029		1	C: fxd poly 0.01 microfarads 10% 50 vdcw	56289	114P1039R5S2	
C105A/B	0180-0086		1	C: fxd Al elect 2 sect 20 microfarads/sect 450 vdcw	56289	D32477	
C106	0140-0151		1	C: fxd mica 820 pF 2%	72136	RDM15F821G3S	
C107	0180-0033		2	C: fxd Al elect 50 microfarads 6 vdcw +100% -10%	56289	30D506G006CB2-DSM	
C108, C109	0150-0012		3	C: fxd cer 0.01 microfarads 20% 1000 vdcw	56289	29C214A3-H-1038	
C110	0180-0033			C: fxd Al elect 50 microfarads 6 vdcw +100% -10%	56289	30D506G006CB2-DSM	
C111	0160-0015		3	C: fxd paper 0.47 microfarads 10% 200 vdcw	56289	109P47492	
C112	0150-0024		1	C: fxd cer 0.02 microfarads +80% -20% 600 vdcw	91418	B-02GMV	
C113	0150-0012			C: fxd cer 0.01 microfarads 20% 1000 vdcw	56289	29C214A3-H-1038	
C114	0170-0003		1	C: fxd my 0.051 microfarads 10% 200 vdcw	00853	33M02152	
C115, C116	0160-0015			C: fxd paper 0.47 microfarads 10% 200 vdcw	56289	109P47492	
C117	0160-0019		1	C: fxd paper 0.01 microfarads 5% 600 vdcw	56289	160P10356	
C118	0180-0054		1	C: fxd Al elect 1 sect 1.5 k microfarads 10 vdcw	56289	D32495	
C119A/B	0150-0119		1	C: fxd cer 2 sect 0.01 microfarads/sect 250 vdcw	71590	DA171CB	
CR100				Not assigned			
CR101	1902-0048		1	Diode: Si EIA 15 A 200 piv	04713	1N3210	
CR102, CR103	1901-0025		2	Diode: Si 100 piv 12 pF 100 mA	07263	FD2387	
DS100				Not assigned			
DS101 thru DS105	2140-0012		5 1	Lamp: miniature 2 pin	24455	No. 12	
F101	2110-0016		1	Fuse: cartridge 0.6 A slow-blow (for 115 V operation)	71400	MDL6/10	
	2110-0017		1	Fuse: cartridge 0.4 A slow-blow (for 230 V operation)	75915	313-400	
J101	1510-0006		2	Binding post assembly: black no solder turret	-hp-		
	1510-0007		1	Binding post assembly: red no solder turret	-hp-		
	0340-0087		1	Insulator: BP triple	-hp-		
	0340-0091		1	Insulator: BP triple	-hp-		
M1	1120-0305		1	Meter	-hp-		
P101	8120-0050		1	Power cord	70903	CS-9941/PH-1511	
R1	0730-0128		1	R: fxd C flm 6.155 megohms 0.5% 1 W	19701	DC1R5	obd
R2	0730-0134		1	R: fxd C flm 8.1 megohms 0.5% 1 W	19701	DC1R5	obd
R3	0730-0149		1	R: fxd C flm 28.1 megohms 0.5% 1 W	03888	PT1000	
R4	0733-0014		1	R: fxd C flm 70 megohms 0.5% 2 W	03888	PT2000	obd
R5, R6	0730-0150		2	R: fxd C flm 50 megohms 0.5% 1 W	19701	DC1R5	obd
R7	0727-0192		1	R: fxd C flm 46.3 kilohms 0.5% 1/2 W	19701	MF7C	obd
R8	0727-0262		1	R: fxd C flm 900 kilohms 0.5% 1/2 W	19701	MF7C	obd
R9	0730-0117		1	R: fxd C flm 2.845 megohms 0.5% 1 W	19701	DC1R5	obd
R10	0730-0139		1	R: fxd C flm 9 megohms 0.5% 1 W	19701	DC1R5	obd
R11	0727-0231		1	R. fxd C flm 284 kilohms 0.5% 1/2 W	19701	MF7C	obd
R12	0727-0239		1	R: fxd C flm 389.5 kilohms 0.5% 1/2 W	19701	MF7C	obd
R13	0727-0215		1	R: fxd C flm 123 kilohms 0.5% 1/2 W	19701	MF7C	obd
R14	0727-0188		1	R: fxd C flm 38.95 kilohms 0.5% 1/2 W	19701	MF7C	obd
R15	0727-0164		1	R: fxd C flm 12.3 kilohms 0.5% 1/2 W	19701	MF7C	obd
R16	0727-0130		1	R: fxd C flm 3.895 kilohms 0.5% 1/2 W	19701	MF7C	obd
R17	0727-0106		1	R: fxd C flm 1230 ohms 0.5% 1/2 W	19701	MF7C	obd
R18	0727-0070		1	R: fxd C flm 389 ohms 0.5% 1/2 W	19701	MF7C	obd
R19	0727-0051		1	R: fxd C flm 180 ohms 0.5% 1/2 W	19701	MF7C	obd
R20	412A-26G		1	R: fxd ww 9 ohms	-hp-		
R21	0727-0039		1	R: fxd C flm 3795 ohms 0.5% 1/2 W	19701	MF7C	obd
R22	0727-0095		1	R: fxd C flm 900 ohms 1% 1/2 W	91637	DCS-1/2-15	obd
R23	0727-0152		1	R: fxd C flm 9000 ohms 1% 1 W	19701	CF1/2	obd
R24	0727-0204		1	R: fxd C flm 90 kilohms 1% 1 W	19701	CF1/2	obd
R25	0727-0274		3	R: fxd C flm 1 megohm 1% 1/2 W	19701	MF7C	obd
R26	0730-0144		1	R: fxd C flm 10.52 megohms 1% 1 W	19701	DC-1	obd
R27, R28	0733-0017		1	R: fxd C flm 100 megohms 1% 2 W	03888	PT2000	obd
R29	412A-26D		1	R: fxd ww 0.900 ohms	-hp-		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R30	0813-0019		1	R: fxd ww 0.47 ohms 1% 1/2 W	-hp-	
R31	0698-0001		1	R: fxd comp 4.7 ohms 5% 1/2 W	01121	EB47G5
R32	0727-0040		1	R: fxd C film 94.8 ohms 1% 1/2 W	19701	MF7C obd
R33	0811-0007		1	R: fxd ww 10 kilohms 1% 5 W	91637	RS-5
R34*				Factory Selected Value. See Paragraph 5-41.		
R35	0690-2721		1	R: fxd comp 2700 ohms 10% 1 W	01121	GB2721
R36	2100-0011		1	R: var comp lin 5000 ohms 20% 1/2 W	11237	Type 45 obd
R37	0727-0086		1	R: fxd C film 684 ohms 0.5% 1/2 W	19701	MF7C obd
R38	0727-0056		1	R: fxd C film 216 ohms 0.5% 1/2 W	19701	MF7C obd
R39	0727-0035		1	R: fxd C film 68.4 ohms 0.5% 1/2 W	19701	MF7C obd
R40	412A-26H		1	R: fxd ww 21.6 ohms	-hp-	
R41	412A-26F		1	R: fxd 6.84 ohms	-hp-	
R42	412A-26E		1	R: fxd ww 2.16 ohms	-hp-	
R43	412A-26C		1	R: fxd ww 0.684 ohms	-hp-	
R44	412A-26B		1	R: fxd ww 0.216 ohms	-hp-	
R45	412A-26A		1	R: fxd ww 0.1 ohms	-hp-	
R46	2100-0021		1	R: var ww lin 100 ohms 20% 2 W	11236	Type 112
R47*				Factory Selected Value. See Paragraph 5-41.		
R48				nsr; part of voltage probe assembly		
R49, R50	0727-0274			R: fxd C film 1 megohm 1% 1/2 W	19701	MF7C obd
R51 thru R100				Not assigned		
R101	0687-4741		1	R: fxd comp 470 kilohms 10% 1/2 W	01121	EB4741
R102	0686-1045		1	R: fxd comp 100 kilohms 5% 1/2 W	01121	EB1045
R103	0687-1821		2	R: fxd comp 1800 ohms 10% 1/2 W	01121	EB1821
R104	0757-0178		1	R: fxd met film 100 ohms 1% 1/4 W	19701	MF6C T-0 obd
R105	0687-4751		1	R: fxd comp 4.7 megohms 10% 1/2 W	01121	EB4751
R106	0687-1051		2	R: fxd comp 1 megohm 10% 1/2 W	01121	EB1051
R107	0687-1031		2	R: fxd comp 10 kilohms 10% 1/2 W	01121	EB1031
R108	0687-2261		1	R: fxd comp 22 megohms 10% 1/2 W	01121	EB2261
R109	0687-1051			R: fxd comp 1 megohm 10% 1/2 W	01121	EB1051
R110	0687-4731		1	R: fxd comp 47 kilohms 10% 1/2 W	01121	EB4731
R111	0687-2751		2	R: fxd comp 2.7 megohms 10% 1/2 W	01121	EB2751
R112	0687-1021		1	R: fxd comp 1000 ohms 10% 1/2 W	01121	EB1021
R113	0687-1041		1	R: fxd comp 100 kilohms 10% 1/2 W	01121	EB1041
R114	0687-8241		1	R: fxd comp 820 kilohms 10% 1/2 W	01121	EB8241
R115	0687-3331		1	R: fxd comp 33 kilohms 10% 1/2 W	01121	EB3331
R116	2100-0009		1	R: var comp 25 kilohms 20% 1/3 W	11237	Type 45 obd
R117	0687-2751			R: fxd comp 2.7 megohms 10% 1/2 W	01121	EB2751
R118	0687-1031			R: fxd comp 10 kilohms 10% 1/2 W	01121	EB1031
R119	2100-1436		1	R: var comp lin 10 kilohms 30% 1/8 W	71450	QS200
R120	0727-0209		1	R: fxd C film 108 kilohms 1% 1/2 W	19701	MF7C obd
R121	0687-1821			R: fxd comp 1800 ohms 10% 1/2 W	01121	EB1821
R122	0690-1211		1	R: fxd comp 120 ohms 10% 1 W	01121	GB1211
R123	0690-5611		1	R: fxd comp 560 ohms 10% 1 W	01121	GB5611
R124	0811-1512		1	R: fxd ww 4000 ohms 5% 5 W	56289	243E
R125	0811-1867		1	R: fxd ww 15 kilohms 5% 5 W	56289	243E
R126	2100-0078		1	R: var comp lin 500 ohms 30% 3/10 W	11237	Model 70
R127, R128	0684-4741		2	R: fxd comp 470 kilohms 10% 1/2 W	01121	EB4741
R129	2100-1567		1	R: var ww lin 10 kilohms 10% 2 W	71450	117
R130	0683-1045		1	R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R131	0683-4325		1	R: fxd comp 4300 ohms 5% 1/4 W	01121	CB4325
R132	0757-0156		1	R: fxd met film 1.5 megohms 1% 1/2 W	75042	CEC T-0 obd
S1	412A-19A		1	Assembly: range switch for cabinet model (include S2, S3)	-hp-	
	412A-19B		1	Assembly: range switch for rack model (include S2, S3)	-hp-	
S2	3100-0183		1	Switch: lever 2 sect 3 position	76854	190503-187-N2C
S3	3100-0184		1	Switch: lever 1 sect 2 position	76854	189777-187-K1
S4 thru S100				Not assigned		
S101	3101-0001		1	Switch: toggle SPST 250 V 3 A	04009	80994-H
S102	3101-0033		1	Switch: slide DPDT	42190	4633
T1 thru T100				Not assigned		
T101	9100-0238		1	Transformer: power (used in instruments serial number 316-08283 and above)	-hp-	
	9100-0021		1	Transformer: power (used in instruments serial number 301-08282 and below)	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
V1 thru V100				Not assigned		
V101	1932-0030		1	Tube: electron 12AX7	80131	12AX7
V102	1933-0007		1	Tube: electron 6AU8	80131	6AU8
V103	1930-0016		1	Tube: electron 6X4	80131	6X4
V104	1940-0004		1	Tube: electron OA2	80131	OA2
V105	1940-0007		1	Tube: electron OB2	80131	OB2
				MISCELLANEOUS		
	0370-0035		1	Knob: range switch	-hp-	
	0370-0081		1	Knob: function switch/polarity switch	-hp-	
	00412-62101		1	Probe and cable assembly: voltage (include R48)	-hp-	
				For breakdown of parts for voltage probe and cable assembly, see Figure 6-3.		
	412A-16A		1	Cable: Modulator (for 412A cabinet model only)	-hp-	
	412A-16F		1	Cable: Modulator (for 412AR rack model only)	-hp-	
	412A-21E		1	Cable assembly: Common	-hp-	
	412A-21F		1	Cable assembly: Ohm-Ma	-hp-	
	412A-23B		1	Demodulator block assembly: (includes V111A/B, R127, R128)	-hp-	
	412A-37A		2	Light rod: modulator for Model 412A	-hp-	
	412A-37B		2	Light rod: modulator for Model 412AR	-hp-	
	412A-95A		1	Modulator block assembly: (includes V110A/B)	-hp-	
	412A-30A		1	Modulator assembly: (includes 412A-58C, V110A/B)	-hp-	
	412A-58C		1	Input circuit assembly: (does not include V110A/B)	-hp-	
	412A-65A		1	Amplifier assembly	-hp-	
	412A-97A		1	Chopper assembly: (includes motor, lamps and leads)	-hp-	
	1220-0009		1	Tube: shield	71785	12627
	1400-0084		1	Fuseholder: extractor post type	75915	342014
	1400-0088		2	Alligator clip	75915	obd
	1400-0089		1	Insulator: alligator clip	75915	obd
	1450-0022		5	Lampholder: for 2 pin lamp	72765	2020AE

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
MP1	5060-0698		1	Cabinet assembly		
	2510-0001		2	Screw: 8-32 x 5/8"		
MP2	412A-1C		1	Chassis: rear deck		
	0510-0189		2	Nut: retaining 8-32		
MP3	412A-47A		1	Support: chassis		
	2550-0007		1	Screw: 8-32 binding head		
	2530-0010		1	Screw: 8-32 flat head		
MP4	412A-1A		1	Chassis: main deck		
MP5	412A-1B		1	Chassis: side deck		
MP6	412A-2		1	Panel: front		
	2520-0009		2	Screw: 8-32 round head		
	0340-0089		6	Insulator		
MP7	5020-0653		1	Bezel		
	2360-0142		6	Screw: 6-32 x 1/4"		
MP8	1450-0020		1	Jewel: indicator		
MP9	412A-83A		3	Boot: cable		
MP10	412A-12C		1	Bracket: cable		
MP11	412A-12A		1	Bracket: cable		
MP12	412A-6A		1	Shield: input circuit		
	2360-0195		3	Screw: 6-32 x 5/16"		
	3050-0066		3	Washer: No. 6 flat		
	2190-0007		3	Lockwasher: No. 6 internal tooth		

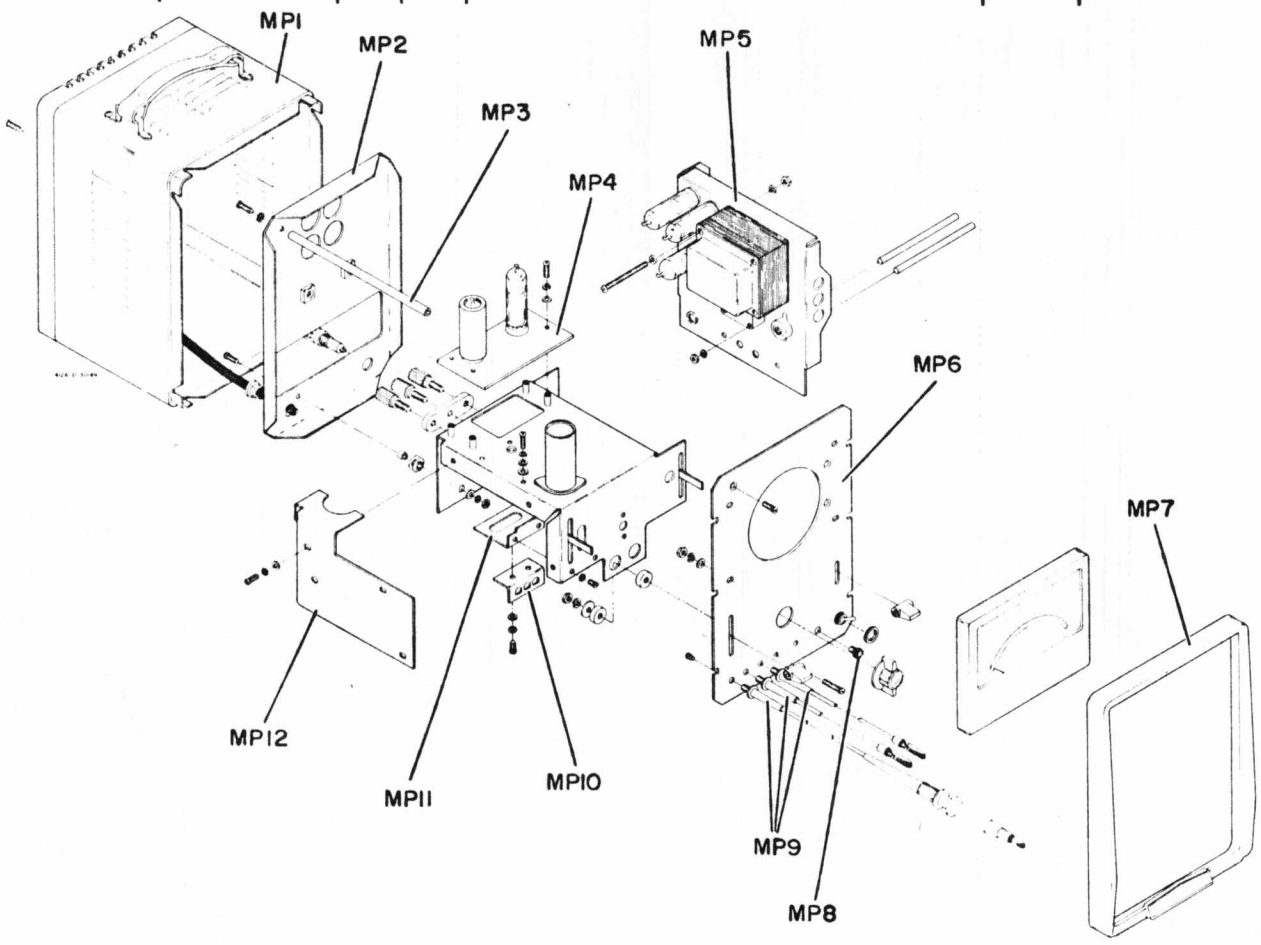


Figure 6-1. Location of Mechanical Parts, Cabinet Model

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR.
MP13	412A-44R		1	Dust cover assembly		
	2510-0001		3	Screw: 8-32 x 5/8"		
MP14	412A-1E		1	Chassis: rear deck		
	0510-0189		3	Nut: retaining 8-32		
MP15	412A-1G		1	Chassis: motor mount		
MP16	412A-1D		1	Chassis: main deck		
MP17	412A-6D		1	Shield: modulator		
	2360-0228		2	Screw: 6-32 x 1/4"		
	2420-0001		8	Nut: 6-32 w/lock		
MP18	412A-2R		1	Panel: front		
	2520-0009		4	Screw: 8-32 x 1"		
	0340-0089		10	Insulator		
	3050-0055		6	Washer: flat No. 8		
	2190-0017		6	Lockwasher: No. 8		
	2580-0005		6	Nut: 8-32		
MP19	1450-0022		1	Lampholder		
MP20	412A-1F		1	Chassis: power supply		
	2530-0006		2	Screw: 8-32 x 1" flat head		
	0340-0089			Insulator		
	3050-0055			Washer: flat No. 8		
	2190-0017			Lockwasher: No. 8		
	2580-0005			Nut: 8-32		
	2390-0010		6	Screw: 6-32 x 1/2"		
	2190-0006		2	Lockwasher: No. 6		
	3050-0066		6	Washer: flat No. 6		
	1400-0031		2	Clamp: cable		
	2420-0001			Nut: 6-32 w/lock		
	0380-0018		4	Spacer: No. 6 x 1/4"		
	0400-0010		4	Grommet: rubber 3/8"		

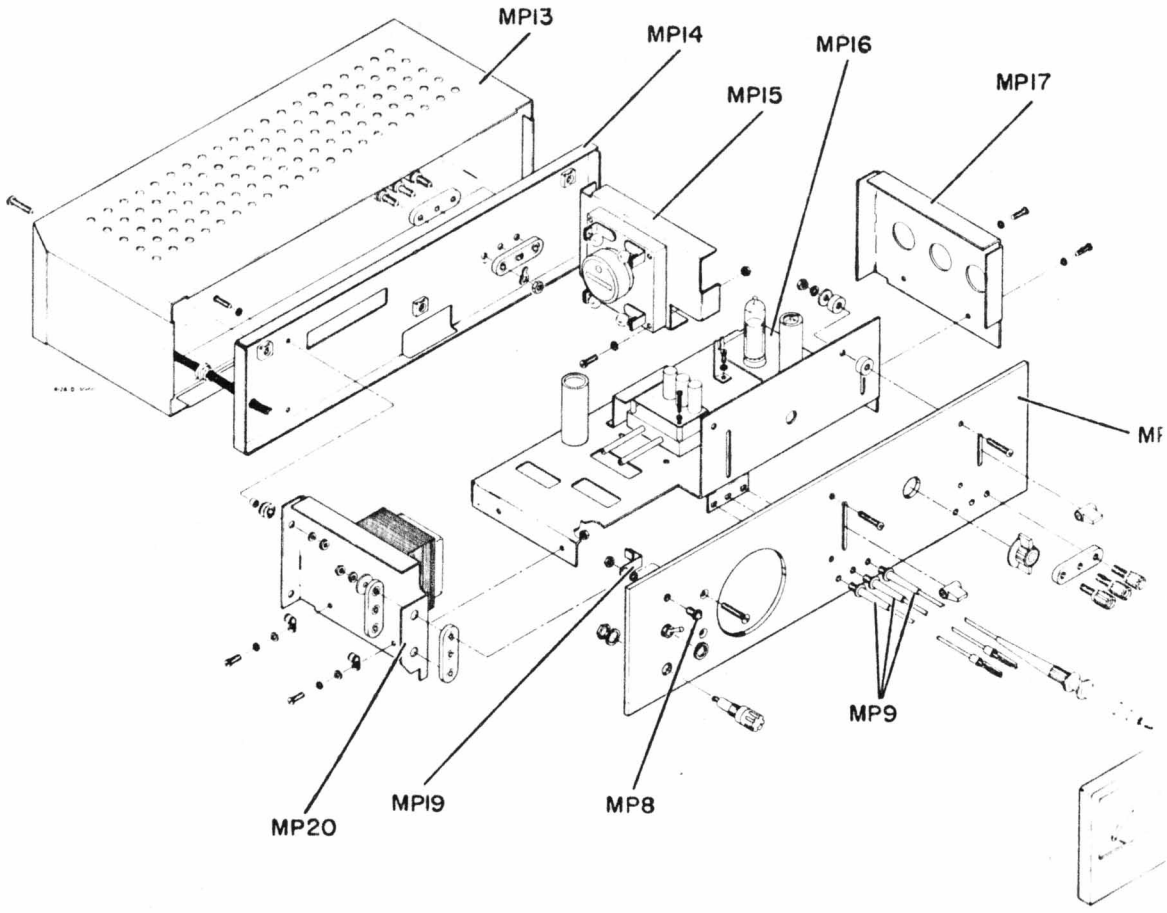
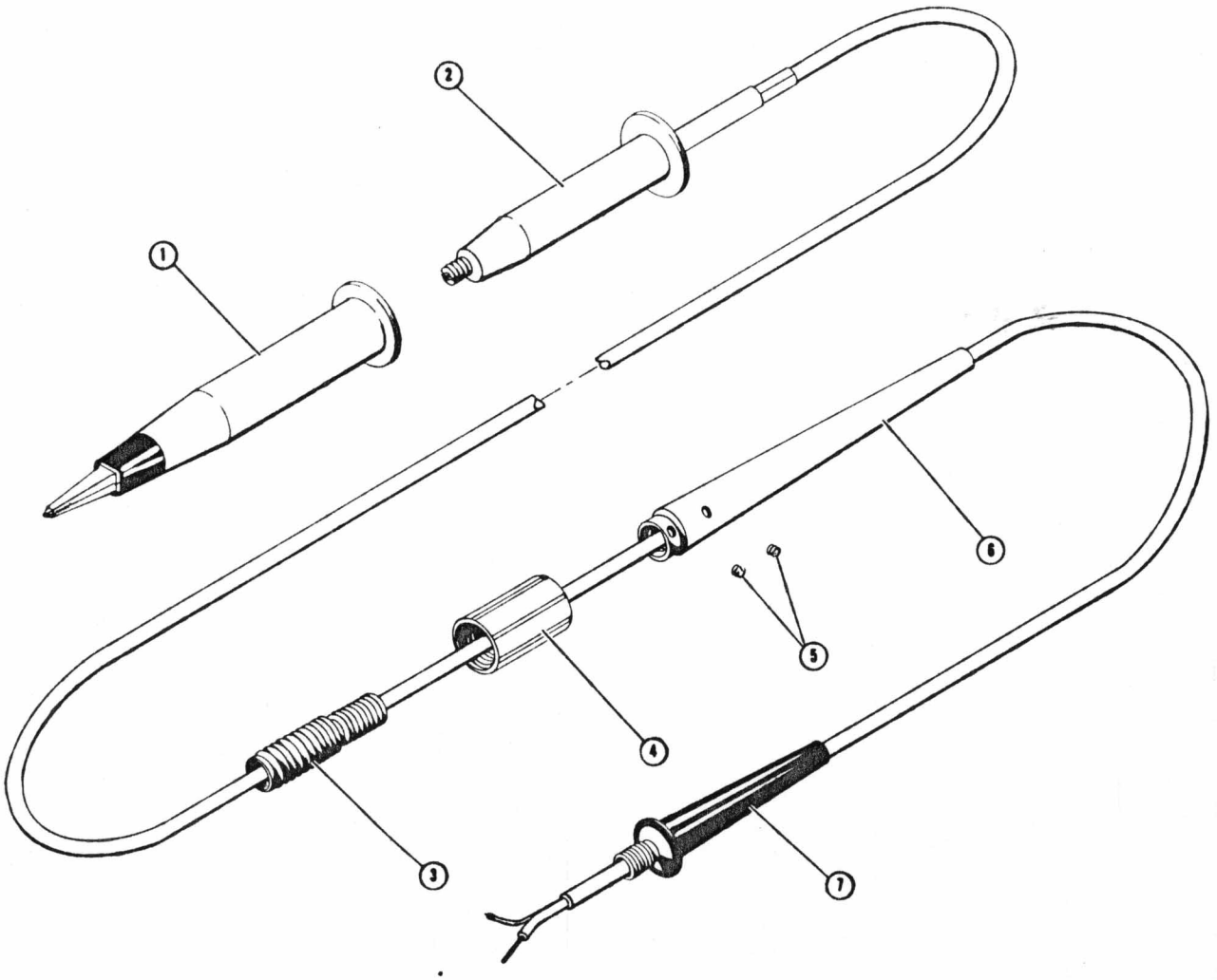


Figure 6-2. Location of Mechanical Parts, Rack Model



ITEM	DESCRIPTION	-hp- PART NO.
1 thru 7	Complete Probe Assembly	00412-62101
1 thru 6	Probe Assembly less Cable Boot	412A-21G
2 thru 7	Probe Assembly less Jaw Assembly	00412-62103
1	Jaw and Sleeve Assembly	5060-0416
2	Probe Sleeve Assembly (includes cable and R48)	00412-62102
3	Ground Body	5020-0648
4	Locknut	5040-0407
5	4-40 Allen setscrew (2 required)	3030-0051
6	Handle	5040-0405
7	Cable Boot	412A-83A

Figure 6-3. Voltage Probe Assembly

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains information necessary to maintain the Model 412A/AR. Figure 7-3 shows the location of components mounted on the range switch. Figures 7-1 and 7-2 give the location of other components within the cabinet model and rack model instruments, respectively. Figure 7-4 is a schematic diagram of the Model 412A/AR, and includes pictorial views of the circuit boards.

NOTES

1. COMPONENT VALUES SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

   RESISTANCE IN OHMS

   CAPACITANCE IN MICROFARADS

2. ⏚ DENOTES CIRCUIT COMMON.

3. ⏚ DENOTES POWER LINE GROUND.

4. ——— – – ——— DENOTES ASSEMBLY.

5. ——————— DENOTES MAIN SIGNAL PATH.

6. —▬—▬—▬—▬— DENOTES FEEDBACK PATH.

7. ▭ DENOTES FRONT PANEL MARKING.

8. ⊏ – – ⊐ DENOTES REAR PANEL MARKING.

9. ◨ DENOTES SCREWDRIVER ADJUST.

10. ✱ AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.

11. DC VOLTAGES MEASURED WITH RESPECT TO CIRCUIT COMMON (⏚), LINE VOLTAGE AT 115 V, AND NO METER DEFLECTION.

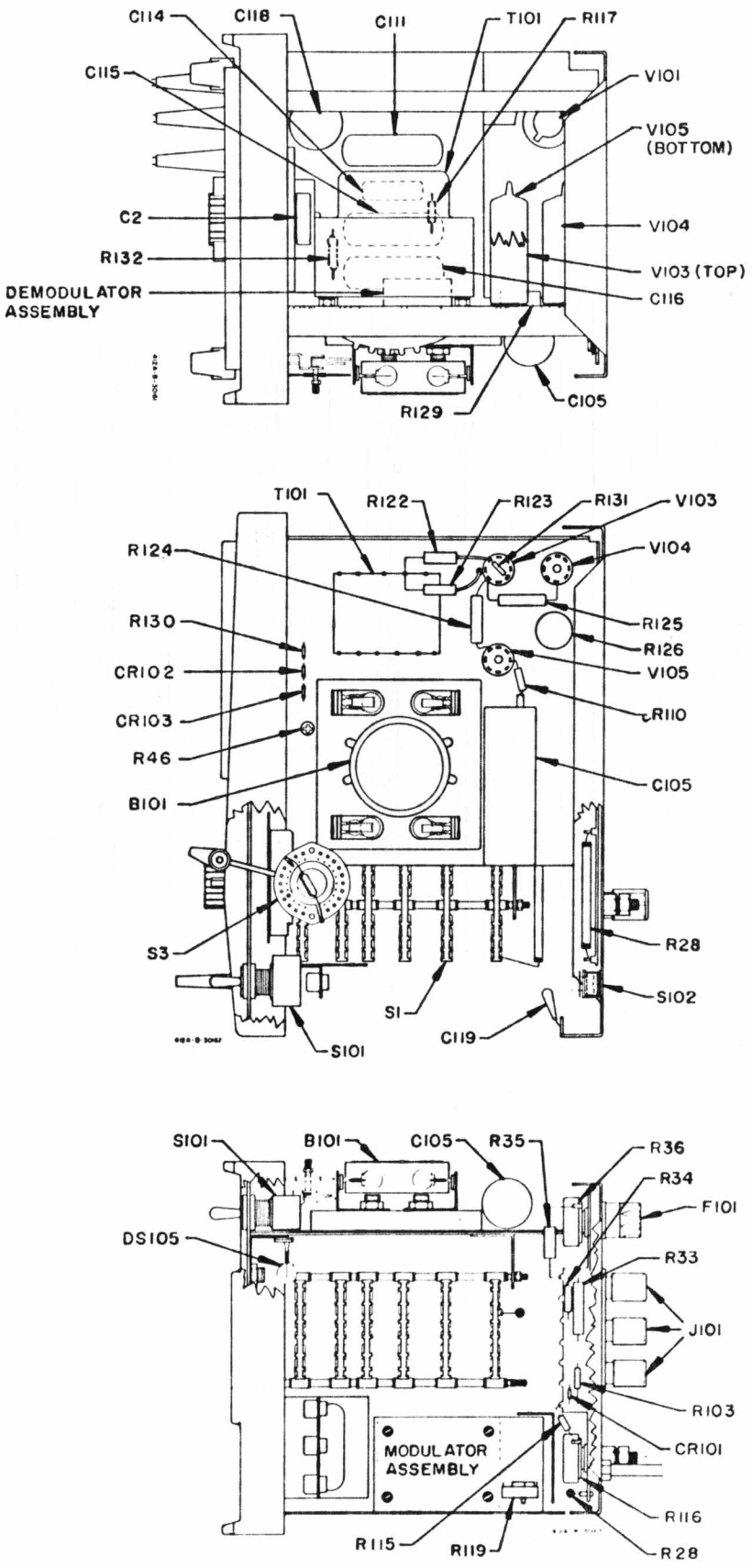


Figure 7-1. Location of Chassis Mounted Parts, Cabinet Model

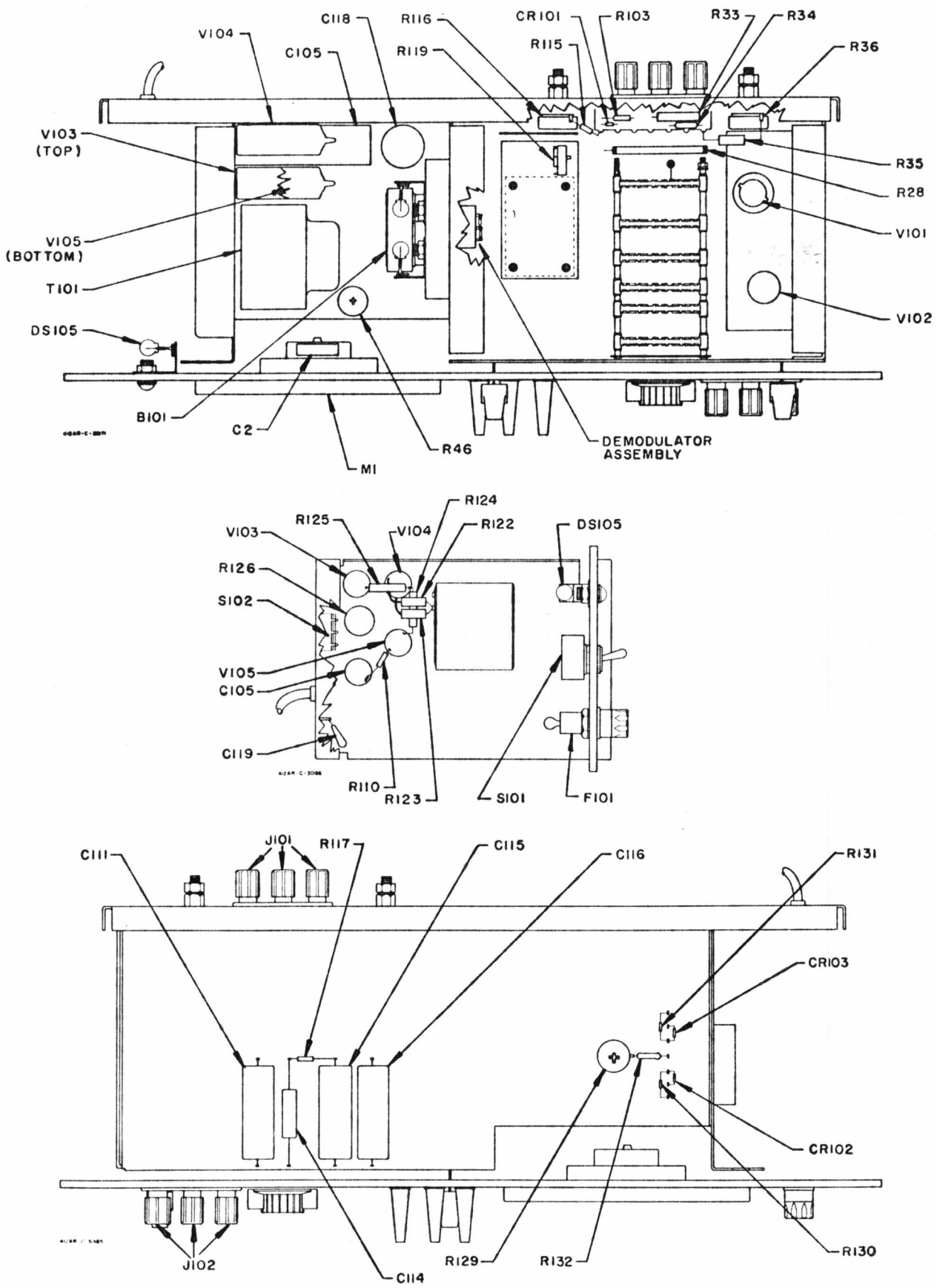


Figure 7-2. Location of Chassis Mounted Parts, Rack Model

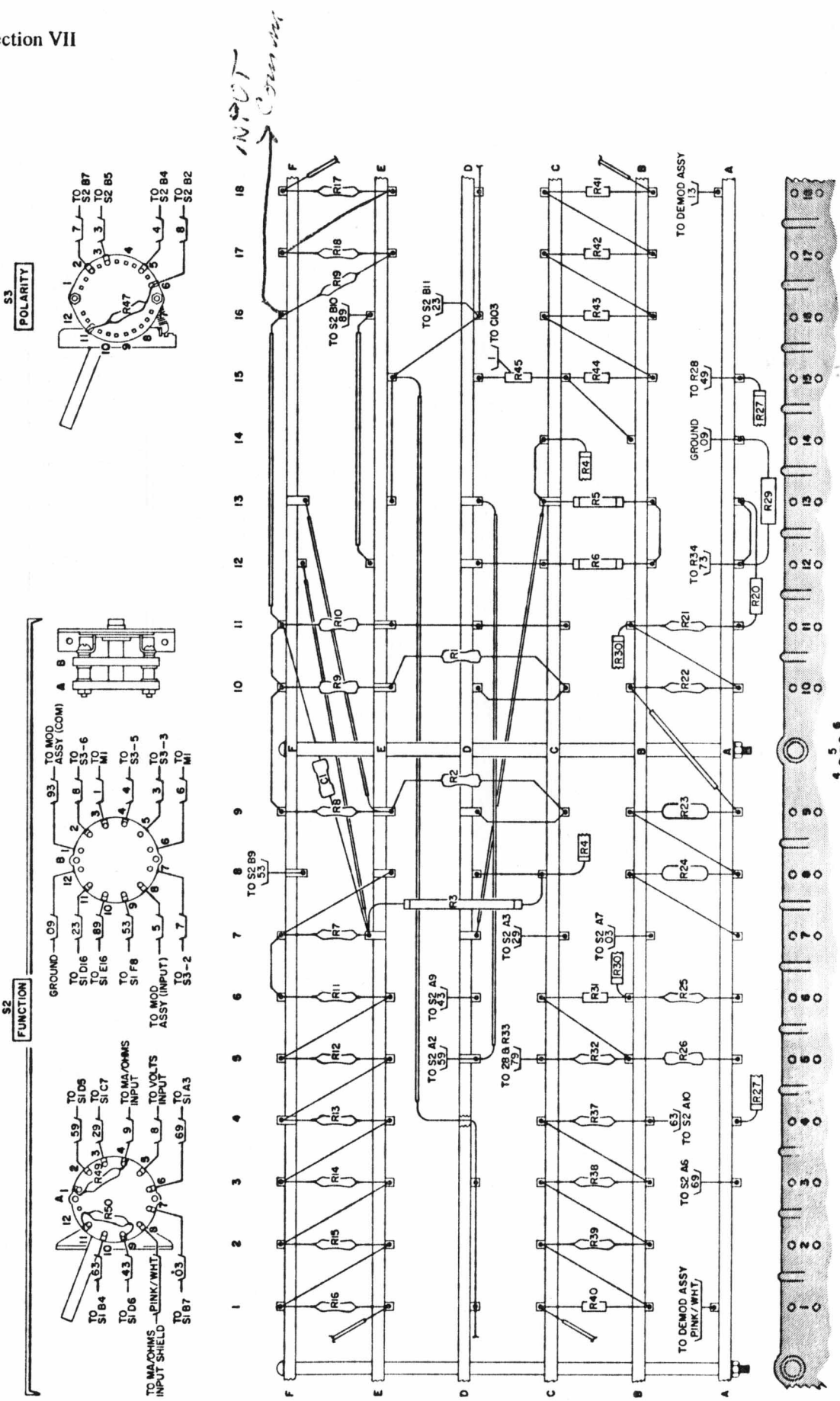
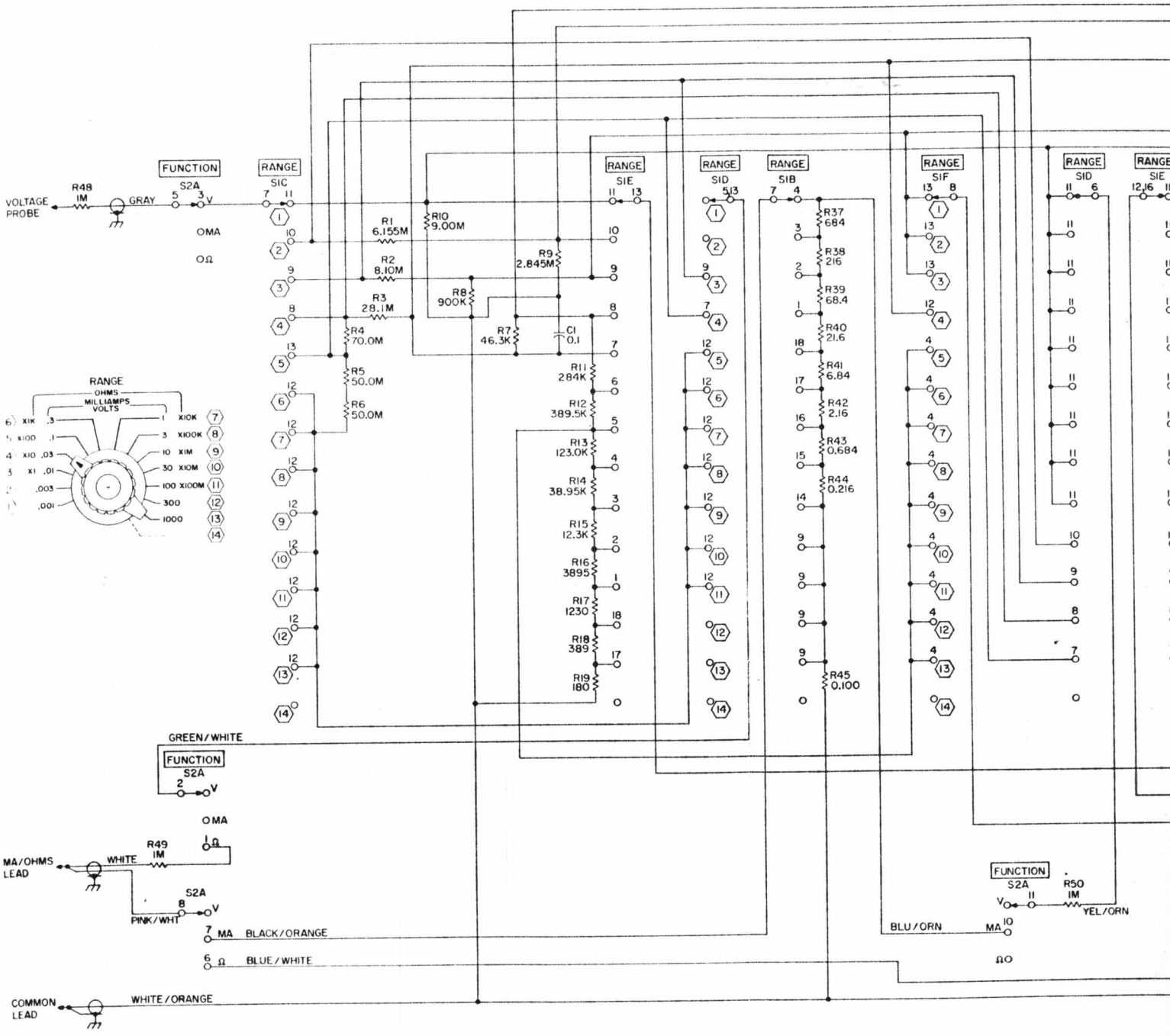
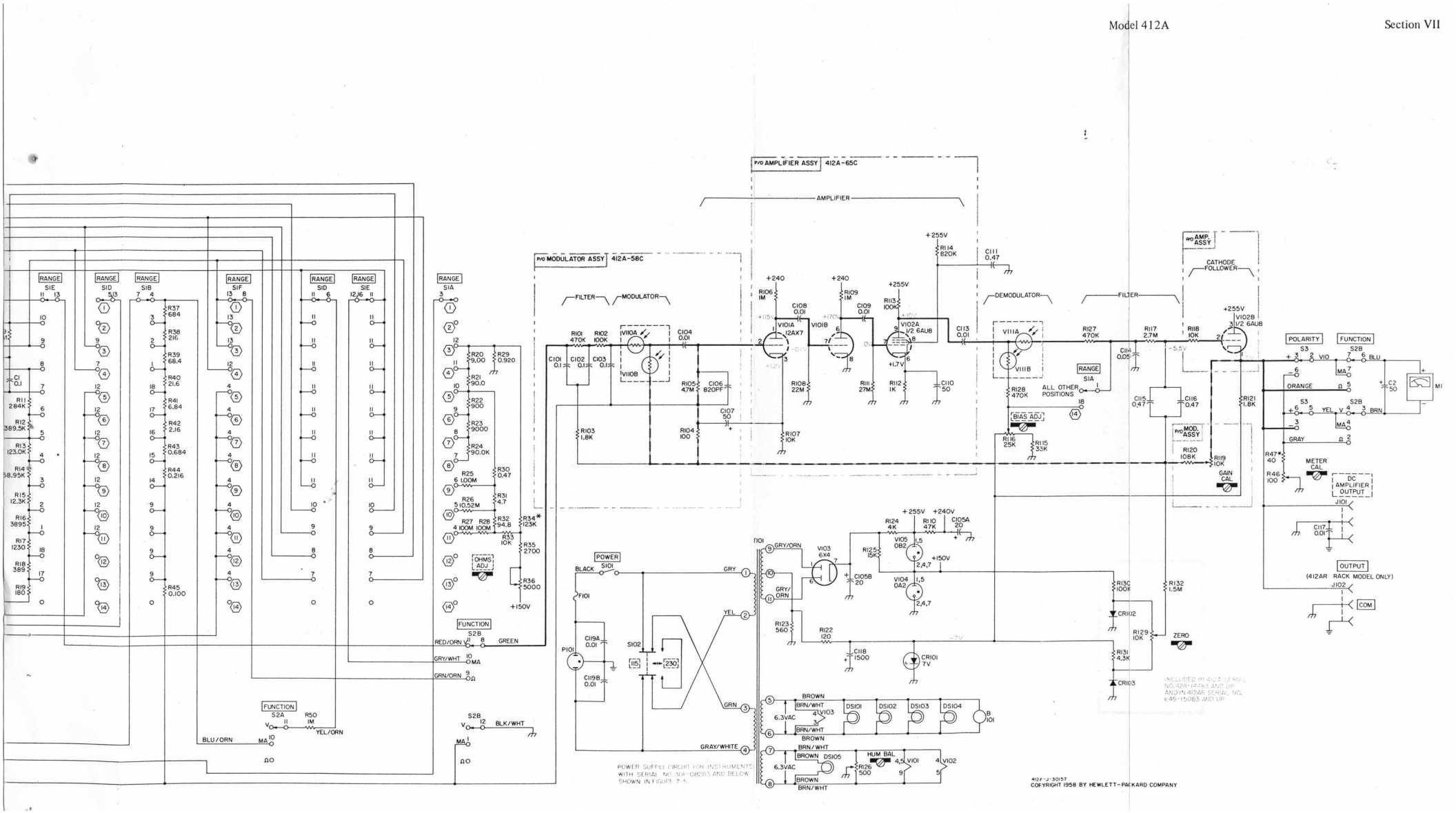


Figure 7-3. Location of Switch Components


FUNCTION
S2A
RANGE
SIC
SIE
SID
SIB
SIF
VOLTAGE PROBE
R48 1M
GRAY
5
3
V
OMA
OΩ
R1 6.155M
R2 8.10M
R3 28.1M
R4 70.0M
R5 50.0M
R6 50.0M
R7 46.3K
R8 900K
R9 2.845M
R10 9.00M
C1 0.1
R11 284K
R12 389.5K
R13 123.0K
R14 38.95K
R15 12.3K
R16 3895
R17 1230
R18 389
R19 180
R37 684
R38 216
R39 68.4
R40 21.6
R41 6.84
R42 2.16
R43 0.684
R44 0.216
R45 0.100
RANGE
OHMS
MILLIAMPS
VOLTS
X1K .3 1 X10K
X100 .1 3 X100K
X10 .03 10 X1M
X1 .01 30 X10M
.003 100 X100M
.001 300
1000
GREEN/WHITE
FUNCTION
S2A
2
V
OMA
1Ω
R49 1M
MA/OHMS LEAD
WHITE
S2A
8
V
PINK/WHT
7 MA BLACK/ORANGE
6 Ω BLUE/WHITE
COMMON LEAD
WHITE/ORANGE
FUNCTION
S2A
11
V
R50 1M
YEL/ORN
BLU/ORN
MA 10
ΩO


P/O AMPLIFIER ASSY 412A-65C
AMPLIFIER
P/O MODULATOR ASSY 412A-58C
FILTER
MODULATOR
DEMODULATOR
FILTER
P/O AMP. ASSY
CATHODE FOLLOWER
RANGE S1A
RANGE S1B
RANGE S1C
RANGE S1D
RANGE S1E
RANGE S1F
ALL OTHER POSITIONS
BIAS ADJ
P/O MOD. ASSY
GAIN CAL
POLARITY S3
FUNCTION S2B
METER CAL
DC AMPLIFIER OUTPUT J101
OUTPUT (412AR RACK MODEL ONLY) J102
COM
ZERO
POWER S101
OHMS ADJ
FUNCTION S2A
FUNCTION S2B
HUM BAL
+255V
+240V
+150V
6.3VAC
POWER SUPPLY CIRCUIT FOR INSTRUMENTS WITH SERIAL NO. 308-08283 AND BELOW SHOWN IN FIGURE 7-5.
412A-J-30157
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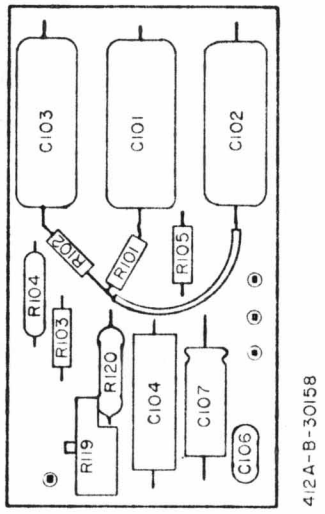
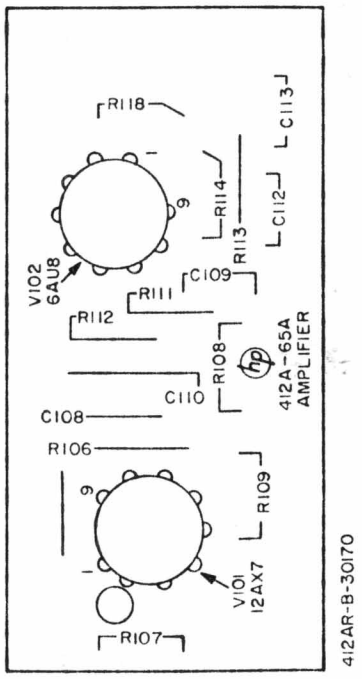
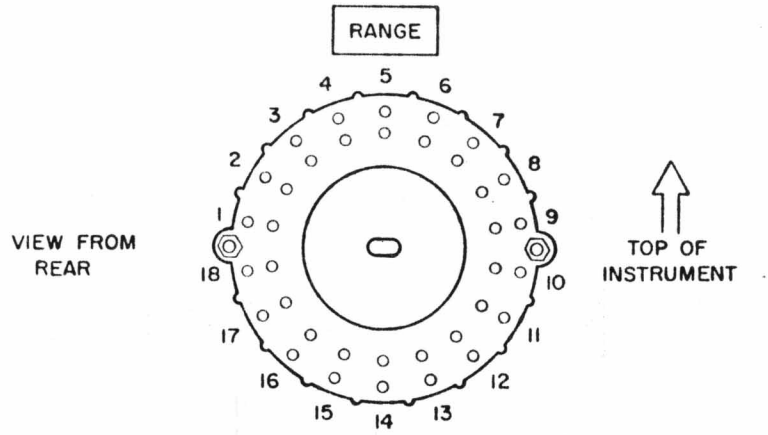
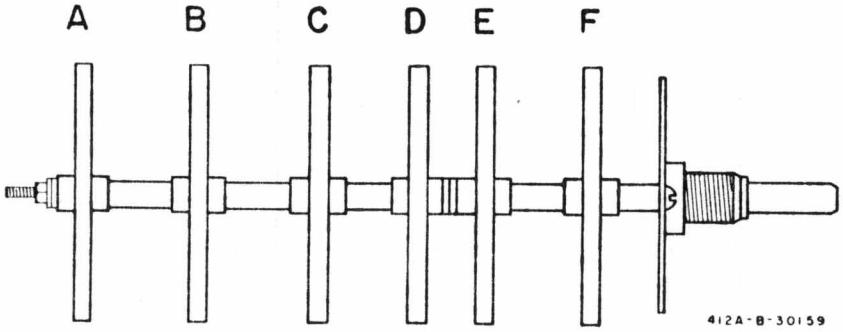


MODULATOR ASSEMBLY

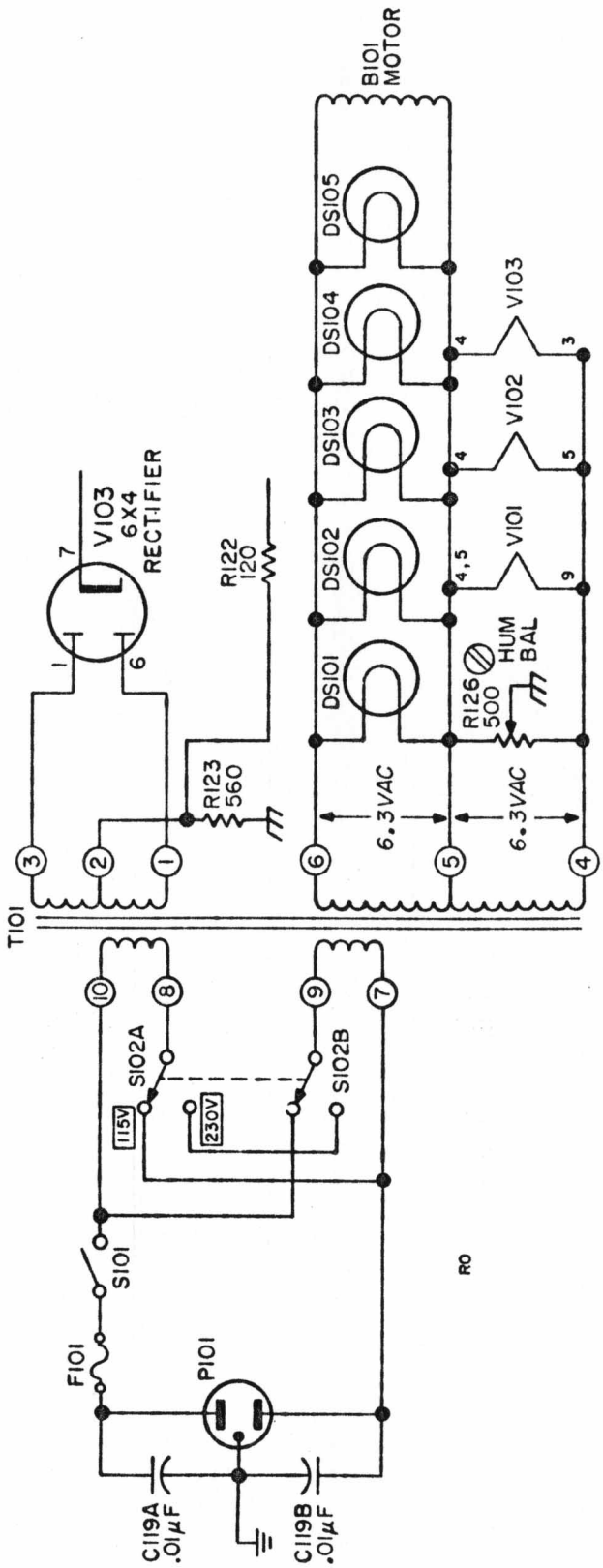


AMPLIFIER ASSEMBLY





SI RANGE SWITCH



This power supply schematic applies only to instruments Serial No. 301-08283 and below.

Figure 7-5. Power Supply Backdating