HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

425A

DC MICROVOLT-AMMETER

hp 425A

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

HP FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

OPERATING AND SERVICE MANUAL

MODEL 425A

SERIALS PREFIXED: 142 -

DC MICROVOLT-AMMETER

00130-4

Printed: DEC 1963

MANUAL CHANGES

MODEL 425A

DC MICROVOLT-AMMETER

Manual Serial Prefixed: 142-
Manual Printed: 12/63

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
142-	ERRATA		

ERRATA:

Figure 5-12, Schematic Diagram,
R12: Change value to 0.953 ohms
R13: Change value to 0.28 ohms

Table 6-1, Index by Reference Designator,
CR1, CR2: Change G-29A-74 to hp Stock No. 1902-0108.
J2: Change to following description,

5060-0625	Binding post and ground link: black
5060-0633	Binding post: red
0340-0087	Insulator, triple: black, internal
0340-0091	Insulator, triple: black, external

J3: Change to following description,

5060-0632	Binding post: black (rmo)
5060-0633	Binding post: red (rmo)
0340-0087	Insulator, triple: black, internal (rmo)
0340-0091	Insulator, triple: black, external (rmo)

M1: Change G-81E to hp Stock No. 1120-0306
R68: Change resistor tolerance from 10% to 1%
V7, V8: Delete stock number and change description to "Part of A5; not separately replaceable."
XV7, XV8: Delete stock number and change description to "Part of A5; not separately replaceable."
Under MISCELLANEOUS,
Change G74 to hp Stock No. 0370-0025.
Change G74D to hp Stock No. 0370-0026.
Change G74N to hp Stock No. 0370-0035.

Table 6-2, Replaceable Parts.
Change hp Stock No. AC-10C to 5060-0632.
Change hp Stock No. AC-10D to 5060-0633.
Change hp Stock No. AC-54B to 0340-0087.
Change hp Stock No. AC-54F to 0340-0091.
Change hp Stock No. G-29A-74 to 1902-0108.

G30A, G30B: Delete entire listing.

Change hp Stock No. G-74 to 0370-0025.
Change hp Stock No. G-74D to 0370-0026.
Change hp Stock No. G-74N to 0370-0035.
Change hp Stock No. G-76J to 5060-0625.
Change hp Stock No. G-81E to 1120-0306.

G-83P: Delete entire listing.

0727-0077: Change resistor tolerance from 10% to 1%.
9110-0038: Change description to "60 cycle."
9110-0039: Change description to "50 cycle."

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Table 1-1. Specifications

VOLTMETER

Voltage Range:
Positive and negative voltages from 10 microvolt end scale to 1 volt end scale in an eleven-step, 1, 3, 10 sequence

Accuracy:
Within ±3% of end scale; power-line frequency variations of ±5 cps affect accuracy less than 2%.

Input Impedance:
1 megohm ±3%

MICROAMMETER

Current Range:
Positive and negative currents from 10 micro-microamperes end scale to 3 milliamperes end scale in an eighteen-step, 1, 3, 10 sequence

Accuracy:
Within ±3% of end scale; power-line frequency variations of ±5 cps affect accuracy less than 2%.

Input Impedance:
Depends on range, 1 megohm to 0.33 ohm

Range	Impedance
10 μμa	1.000 megohm
30 μμa	1.000 megohm
100 μμa	1.000 megohm
.3 mμa	1.000 megohm
1 mμa	1.000 megohm
3 mμa	0.333 megohm
10 mμa	0.100 megohm
30 mμa	0.033 megohm
.1 μa	0.010 megohm
.3 μa	3300 ohms
1 μa	1000 ohms
.003 ma	333 ohms
.01 ma	100 ohms
.03 ma	33 ohms
.1 ma	10 ohms
.3 ma	3.3 ohms
1 ma	1.0 ohms
3 ma	0.33 ohm

AMPLIFIER

Gain: 100,000 maximum

AC Rejection:
At least 3 db at 1.0 cps, 50 db at 50 cps and approximately 60 db or more above 60 cps; a power-line or twice-power-line frequency signal 40 db greater than end scale causes less than 1% error.

AMPLIFIER (Cont'd)

Output:
0 to 1 volt for end scale reading, adjustable (5000-ohm shunt potentiometer) 1 ma maximum at 1-volt output

Output Impedance:
Depends on setting of output potentiometer; 10 ohms when potentiometer is set for maximum output

Noise:
Less than 0.2 μv rms (typically less than 1.2 μv peak-to-peak) referred to the input

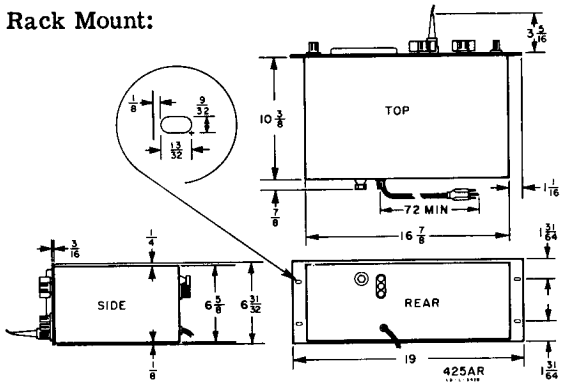
Drift:
After 15 minutes warmup, drift is less than ±4 μv per day referred to the input

GENERAL

Power:
115 or 230 volts ±10%, 60 cps, 40 watts
50-cycle operation also available

Dimensions:
Cabinet Mount: 7-3/8 in. (18.73 cm) wide, 11-3/4 in. (29.83 cm) high, 12 in. (30.48 cm) deep

Rack Mount:



Weight:
Cabinet Mount: Net 17 lb (7.718 kg)
Rack Mount: Net 21 lb (9.534 kg)

Accessory Available:
11021A (formerly 425A-21B) 1000:1 Divider Probe increases range of Model 425A to 1000 volts. Division accuracy ±2%, input resistance 10 megohms

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Model 425A DC Microvolt-Ammeter is an extremely sensitive measuring device which measures voltages from 1 microvolt to 1 volt and currents from 1 picoampere to 3 milliamperes. An input resistance of 1 megohm on all voltage ranges minimizes errors due to circuit loading. The Model 425A can make measurements in circuits which are off ground potential, for the chassis and input circuit may be isolated from the cabinet. The Model 425A provides an output which will drive either potentiometer or galvanometer recorders. It will deliver up to 1 milliampere at 1 volt.

1-3. APPLICATIONS.

1-4. The Model 425A has many applications. For example, in engineering: it is an excellent null detector or dc amplifier, and it will measure vacuum tube grid currents and leakage currents in insulators and capacitors; in medicine and biology: it will measure nerve potentials and plant cell potentials; and in physics and chemistry: the Model 425A is useful in ionization chamber measurements and can monitor thermocouple and galvanic actions.

1-5. DIFFERENCES BETWEEN INSTRUMENTS.

1-6. The Model 425A carries a five digit serial number with a three digit prefix (000-00000). The prefix changes only when a change is made in the instrument. The prefix, then, is an identifier, and is on the title page of this manual to indicate to which instrument this manual applies directly. A supplement may be included with this manual to indicate the necessary changes to be made in the manual to make the manual apply directly to Models 425A which carry a different serial number prefix.

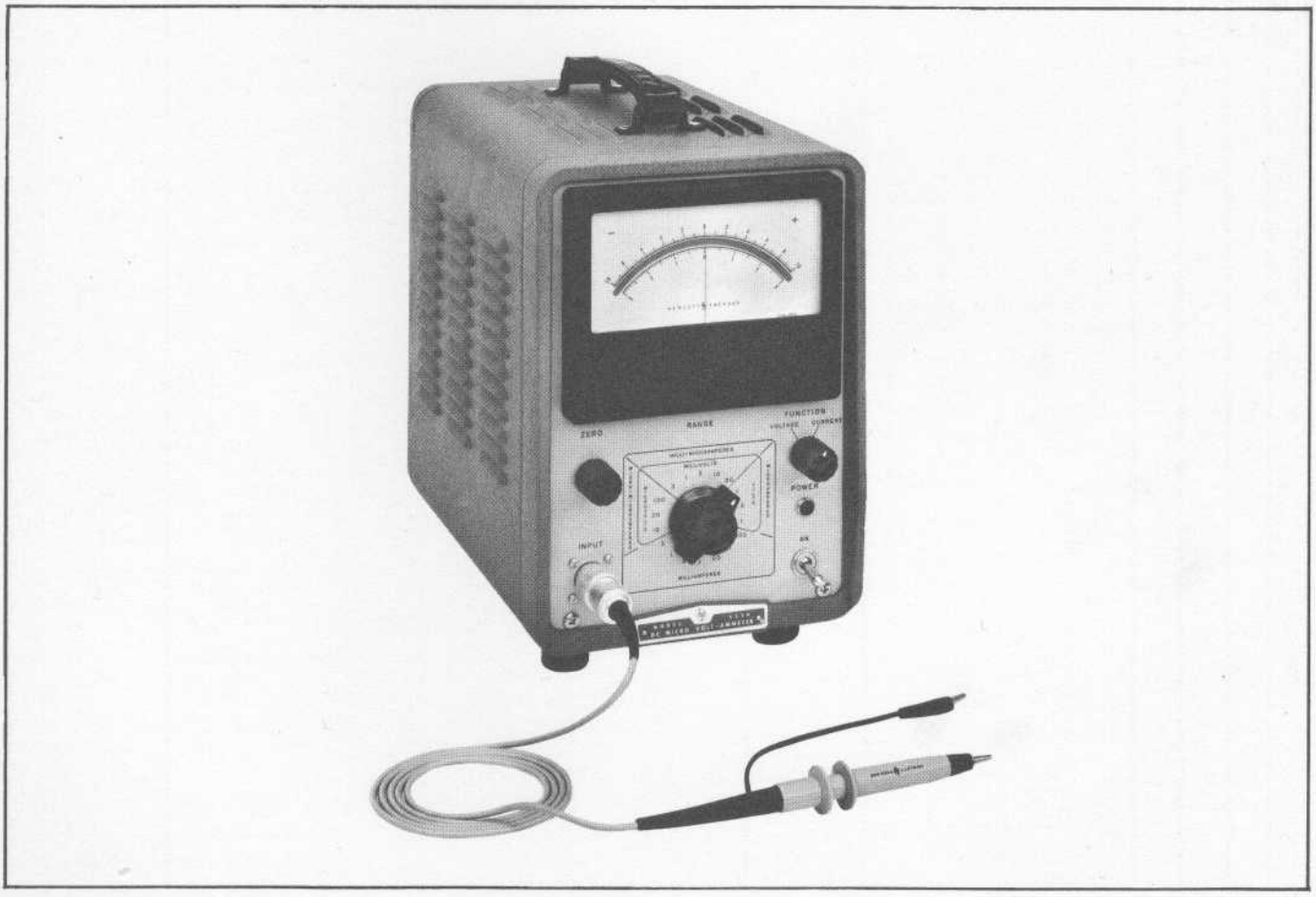


Figure 1-1. Model 425A DC Microvolt-Ammeter

SECTION II
PREPARATION FOR USE

2-1. INTRODUCTION.

2-2. This section contains information on unpacking, inspection, repacking and installation of the Model 425A.

2-3. UNPACKING AND INSPECTION.

2-4. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page at the rear of this manual.

2-5. An electrical inspection should be performed as soon as possible after receipt. To aid in electrical inspection, a list of performance checks are in section V, paragraph 5-46. These procedures make a good test as part of incoming quality-control inspection.

2-6. POWER REQUIREMENTS.

2-7. The Model 425A is normally wired for use with a 115-volt 60 cps power supply, but it can easily be converted for use from a 230-volt, 60 cps source by changing the dual 115-volt primary windings of the power transformer from a parallel configuration to a series configuration. At the time of the change, replace the 1 ampere, slow-blow line fuse with a 0.5 ampere, slow-blow fuse. See the schematic diagram, figure 5-13, for details.

2-8. The Model 425A uses an ac-coupled amplifier which is tuned to a frequency 5/6 designated power line frequency. A synchronous motor determines frequency of the signal applied to the amplifier. Thus the instrument must be operated from a power source which does not vary in frequency more than ± 5 cps. Most commercial power systems maintain frequency well within these limits; however, small portable power plants may not. Variations from designated power line frequency do not completely disable the instrument, but if large variations exist they will cause sluggish meter response and loss of accuracy.

2-9. The Model 425A is normally shipped from the factory equipped to operate from a 60-cps power source. To convert it to operate from a 50-cps power source, you must change the rejection frequency of two twin-T filters from 50 cps to 41.7 cps. Both filters are contained in a single plug-in unit. Units designed to operate at 41.7 cps are available from the factory under stock number 9110-0039.

2-10. POWER CABLE.

2-11. This Hewlett-Packard instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

2-12. To preserve the protection feature when operating instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect to pigtail on the adapter to ground.

2-13. INSTALLATION.

2-14. The Model 425A is a portable instrument requiring no permanent installation. The Model 425A is for bench top operation. The Model 425AR rack mount mounts in a standard 19-inch rack.

2-15. REPACKAGING FOR SHIPMENT.

2-16. The following list is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Hewlett-Packard sales representative.

a. If possible, use the original container designed for the instrument.

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

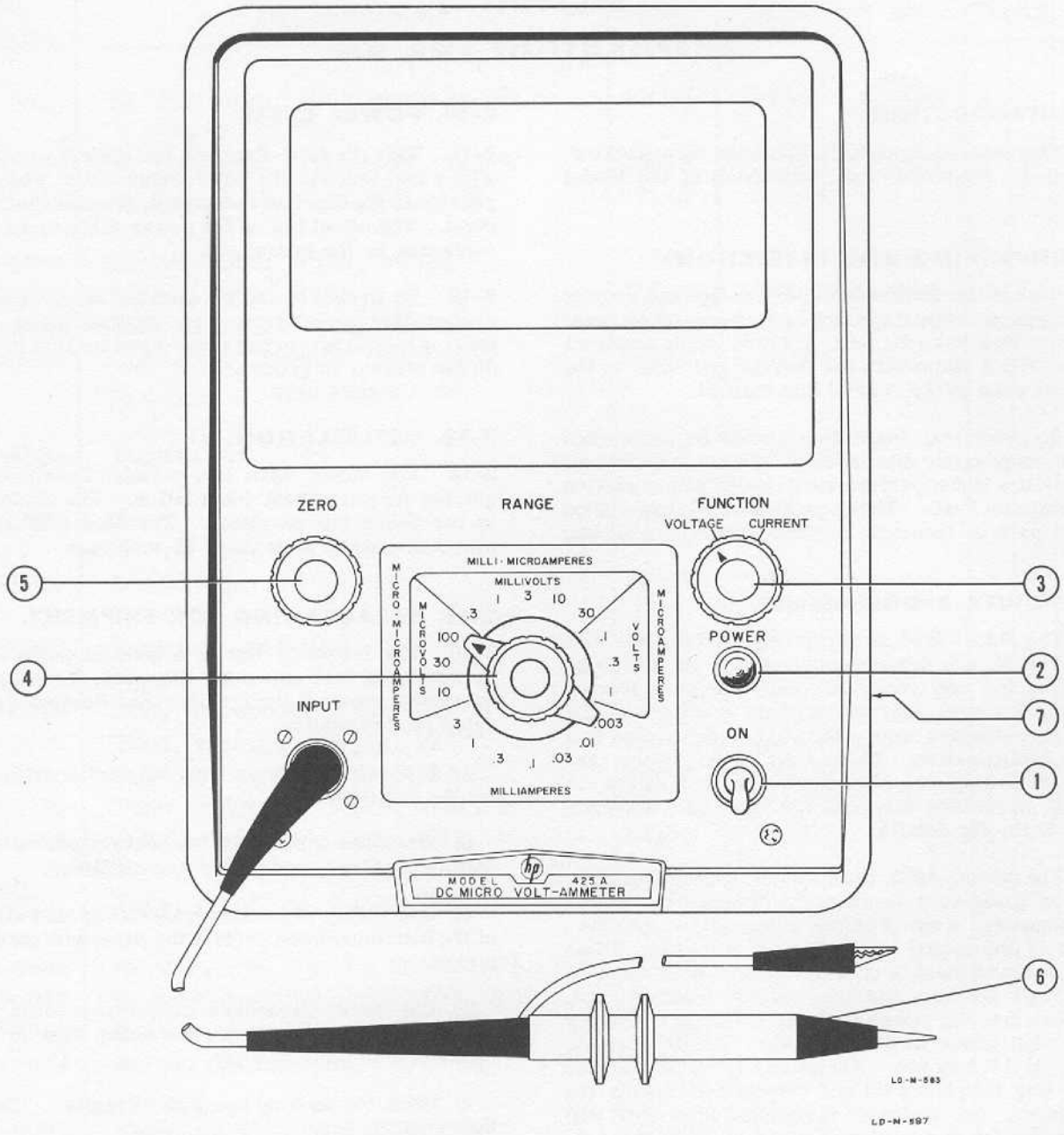
c. Use plenty of packing material around all sides of the instrument and protect the panel with cardboard strips.

d. Use heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

e. Mark the packing box with "Fragile", "Delicate Instrument", etc.

Note

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



1. Power switch. Turns instrument on.
2. Pilot Light. Lights when instrument is on.
3. FUNCTION switch. For selecting mode of operation; VOLTAGE or CURRENT.
4. RANGE switch. For selecting voltage or current range desired.
5. ZERO control. Used to adjust electrical zero setting of meter.
6. Probe. Connected to INPUT connector, apply voltage or current to be measured here.
7. OUTPUT connector (rear of instrument, not shown). Provides an output voltage which will drive either potentiometer or galvanometer recorders.

Figure 3-1. Operating Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section gives preliminary considerations and information on the function and use of all controls on the Model 425A Microvolt-Ammeter.

3-3. PRELIMINARY CONSIDERATIONS.

3-4. LOW-LEVEL ELECTRICAL PHENOMENA.

3-5. Stray low-level electrical phenomena are present, in one form or another, in nearly all electrical circuits. The Model 425A does not distinguish between stray and signal voltages; it measures net voltage. Thus, when using the lower 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 Model 425A.

3-6. Errors due to thermal voltages alone can be appreciable. The probe of the Model 425A is designed to have a very low thermoelectric effect with copper, the most common electrical conductor. In use other materials may be encountered. Some likely materials (with their approximate temperature-emf characteristics versus copper) are constantan (40 $\mu v/^{o}C$), steel (8$\mu v/^{o}C$), manganin (3 $\mu v/^{o}C$), aluminum (3 $\mu v/^{o}C$), and brass (2 $\mu v/^{o}C$). As an example, some high-grade wirewound resistors are wound with constantan wire (known under the trade names of "Eureka", "Advance", and "Ideal"). If the Model 425A is connected across such a resistor and there is a 1.0^{o}C temperature difference between the ends of the resistor, 40 microvolts will be developed.

3-7. GROUND CURRENTS.

3-8. Ground currents may cause an offset of meter zero on lower ranges of the Model 425A. These currents occur when the potential of the Model 425A cabinet differs from ground potential of the circuit under test. They flow through the probe cable and ground lead of the power cable, producing a voltage drop which is added to the input signal. To break the ground loop and eliminate the ground currents, remove the metal shorting strap between chassis-ground and cabinet-ground terminals of OUTPUT connector on the rear of the instrument (front panel on rack mount instruments). This procedure isolates chassis from cabinet.

3-9. AC VOLTAGES.

3-10. The low-pass filter in the input circuit of the Model 425A provides adequate rejection of ac and transients when measuring dc signals within the range of the instrument. By using a modulator frequency different than the line frequency, stray line-frequency pickup is prevented from producing any error unless the ac amplifier is actually overdriven.

3-11. AC voltages can exist between chassis and cabinet without affecting accuracy of the instrument. For example, line frequency potential difference between chassis and cabinet can be 80 to 100 db greater than the full-scale dc value of the range selected. Maximum voltages between chassis and cabinet must not exceed 500 volts peak.

3-12. OPERATING PROCEDURE.

3-13. The following is a step-by-step procedure for operating the Model 425A. Proceed as follows:

a. Attach probe to input connector.

b. Turn instrument on. Warmup time of about one minute is required. For maximum stability on lower ranges, allow approximately 15 minutes warmup.

c. Set FUNCTION switch to desired function.

d. Set RANGE switch to desired range.

e. Clip probe and common clip together and adjust meter to zero with ZERO control. ZERO control has maximum range of about ± 50 μv; thus it has diminishing effect on higher ranges.

Note

Do not handle the probe for three or four minutes prior to making zero adjustment on two most sensitive voltage and current ranges. Static charges and temperature gradients within the probe must have time to dissipate.

f. Connect probe to circuit. On more sensitive ranges, allow sufficient time for probe, common clip, and circuit connection points to reach thermal equilibrium before considering reading final.

Note

Do not overload the instrument excessively on higher current ranges, for current-shunting resistors are not protected from extreme overload.

If the one-megohm input-shunting resistor is disconnected in your instrument, calibration of the nine lowest current ranges is altered. To use these ranges, either shunt instrument externally with a one-megohm resistor or reconnect input-shunting resistor (see paragraphs 5-30 to 5-33).

3-14. ISOLATING THE CHASSIS.

3-15. To isolate chassis of the Model 425A, remove the metal shorting strap between chassis-ground and

cabinet-ground terminals of OUTPUT connector located on rear of instrument. Potential difference between chassis and cabinet must not exceed 500 volts peak. Isolate chassis under following conditions:

a. Measurement is between two points which are both above ground potential.

b. Measurement is with respect to a ground which is itself isolated.

c. Measurement is made on a more sensitive range (precaution against ground currents).

3-16. OPERATION WITH A RECORDER.

a. If conditions require isolation of Model 425A chassis, also isolate recorder chassis.

b. Connect recorder to OUTPUT connector of Model 425A.

c. Clip probe and common clip together and select 1 VOLT range.

d. Set recorder zero to desired position on its scale.

e. Select 30 MICROVOLT range on Model 425A, and adjust ZERO control to produce end-scale deflection on meter (30 microvolts).

f. Calibrate system by adjusting output AMPLITUDE control to produce desired deflection on recorder.

g. Set meter of Model 425A to zero with ZERO control. The system is now ready to record your measurements. Remember that deflection of recorder is proportional to meter deflection of Model 425A regardless of range selected.

SECTION IV
CIRCUIT DESCRIPTION

4-1. GENERAL.

4-2. If the Model 425A is considered a black box with two input terminals and two output terminals, it is a dc amplifier. Block diagram of figure 4-1 indicates what is between input and output terminals. The input signal is applied across the input resistance, and any ac superimposed on the signal is attenuated by the low-pass filter. A photoconductive modulator converts the filtered dc to a square wave whose frequency is set at 5/6 power-line frequency by a light-beam chopper. The output of the modulator is amplified by a high-gain, ac-coupled amplifier tuned to modulator frequency by feedback through a rejection-type filter. A synchronous demodulator, synchronized with the modulator by the light-beam chopper, converts amplifier output to dc. A second-rejection-type filter attenuates any remaining fundamental frequency component of the demodulator output. A dc cathode follower drives a meter, output circuit, and feedback attenuator which determines voltage gain of the instrument.

4-3. When operated as an ammeter, the Model 425A actually measures voltage drop across a calibrated input resistance. However, this resistance varies on all but five lowest ranges to keep full scale voltage drop across the input of the instrument to a maximum of one millivolt.

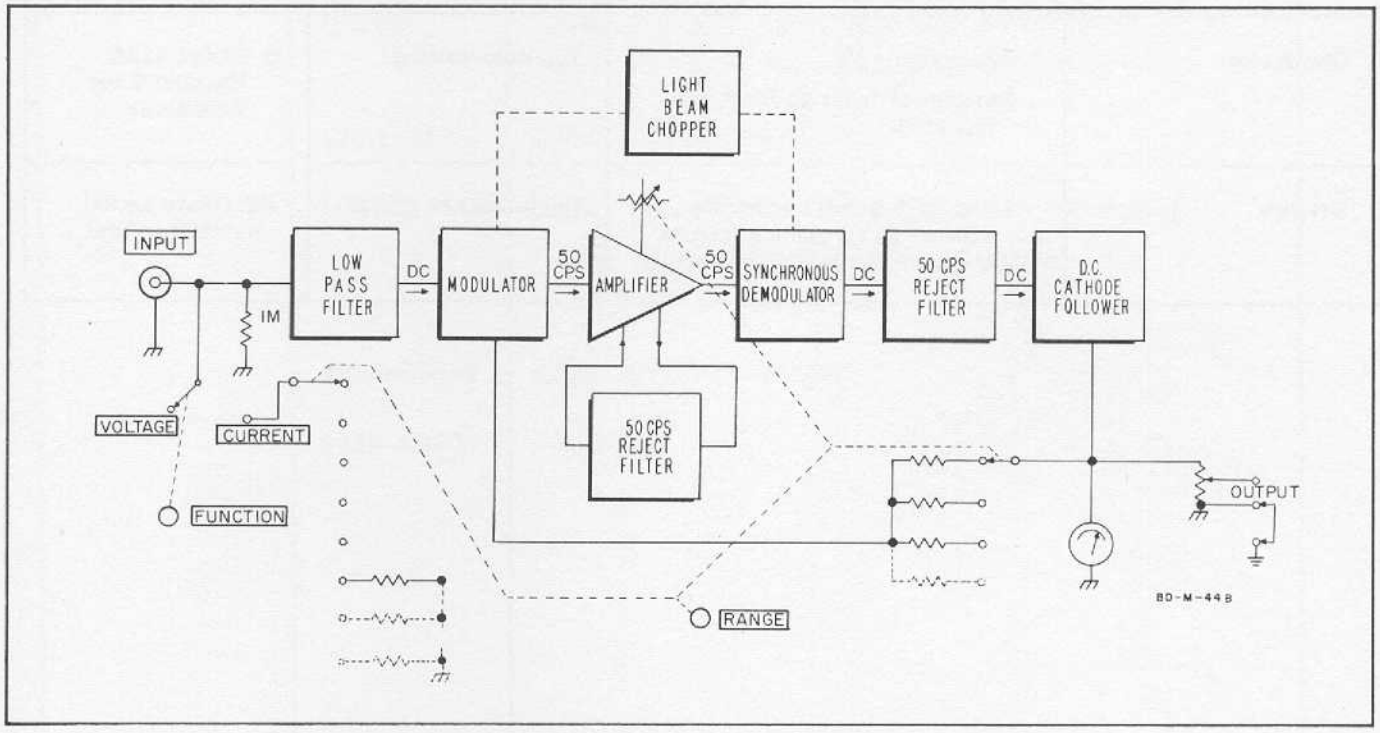


Figure 4-1. Block Diagram of Model 425A (power-line frequency = 60 cps)

Table 5-1. Equipment Required

Instrument Type	Minimum Required Specifications	Use	Recommended Instrument
Voltmeter Calibrator	Output Voltage Range: .001 to 300 volts Signal Frequency: dc Accuracy: ±0.25%	Calibration and Performance Check	hp Model 738AR Voltmeter Calibrator
Low Frequency Oscilloscope	Sensitivity: 0.01 volt/cm minimum Frequency Response: flat down to 10 cps	Troubleshooting	hp Model 120B Oscilloscope
Electronic Voltmeter	Sensitivity: 1.0 volt full scale to 400 volts full scale Input Resistance: 10 megohms or higher	Troubleshooting and adjustments of Twin-T filters	hp Model 410B or hp Model 412A Vacuum Tube Voltmeters
Ohmmeter	Accuracy: ±5% Ranges: at least 25 megohms full scale	Troubleshooting	hp Model 412A Vacuum Tube Voltmeter
Divider	100:1 with a ratio accurate within ±0.1% and a total resistance of 100,000 ohms ±1%	Performance check	Fabricate as described in text

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains test and maintenance information for Model 425A Microvolt-Ammeter. A performance check is included (paragraph 5-46) that may be used to verify operation within published specifications. This check should be made with the instrument in its cabinet. This section also includes recommended test equipment, troubleshooting, repair and adjustment procedures.

5-3. TEST EQUIPMENT.

5-4. GENERAL. Required test equipment is listed in table 5-1. Note that some equipment needs to be fabricated.

5-5. 100:1 DIVIDER. Fabricate one 100:1 resistive voltage divider, with a ratio accurate within ±0.1%, and a total resistance of 100,000 ohms ±1% (see figure 5-9). Manganin wire should be specified for the resistors and the divider assembly should minimize thermal gradients.

5-6. MECHANICAL ADJUSTMENT OF METER ZERO.

5-7. 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.

5-8. TROUBLESHOOTING.

5-9. INTRODUCTION.

5-10. The following section gives information to aid in the localizing of troubles in the Model 425A. In many cases a visual inspection of the instrument will reveal the area of the faulty component if not the component itself. To further assist in troubleshooting, table 5-2 and a voltage-resistance chart figure 5-11 have been included in this section. Table 5-2, Troubleshooting, gives a list of symptoms and their possible causes.

5-11. AMPLIFIER-POWER SUPPLY.

5-12. Amplifier and power supply operation is best checked by voltage-resistance readings and tube substitution. If tube substitution does not correct the difficulty, return the original tube to the instrument. Voltages and resistances are indicated in figure 5-11; these are typical voltages and may vary somewhat from instrument to instrument.

5-13. CHOPPER ASSEMBLY.

5-14. Before the modulator or demodulator can be checked, it must be determined if the chopper assembly, A6, is working properly. Refer to figure 5-1 for location of parts in the following steps. Proceed as follows:

a. Remove cabinet (paragraph 5-23).

b. Check all four lamps (DS1-4) to make sure they glow when power is applied.

c. Check the light interrupter in the cut away portion of the chopper assembly to see if the chopper blades are rotating.

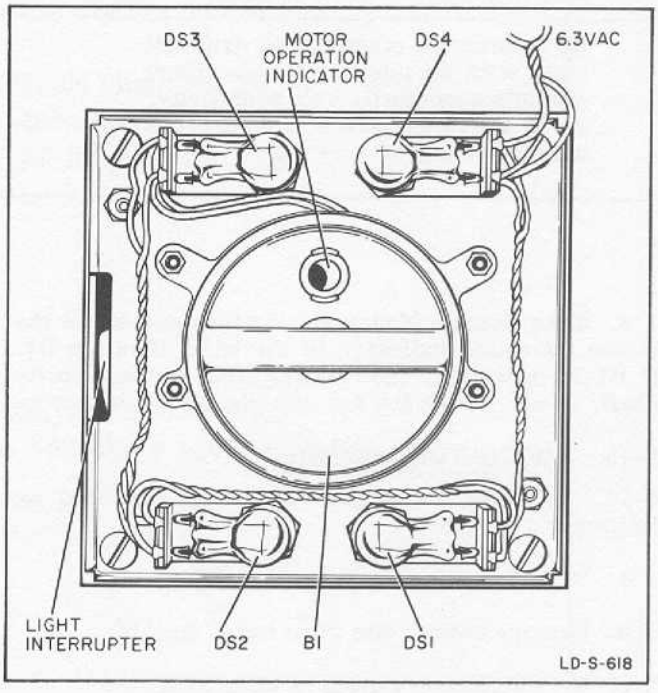


Figure 5-1. A6, Chopper Assembly

Table 5-2. Troubleshooting

SYMPTOM	POSSIBLE CAUSE
Meter fails to respond to input signal, but responds to ZERO control.	Probe assembly defective. INPUT connector defective. Cable from INPUT connector to modular defective. Modulator assembly defective.
Meter fails to respond to either input signal or ZERO control, but responds to bias control.	V1 and/or V2 and/or V3 defective. Modulator assembly defective. Demodulator assembly defective.
Meter fails to respond to either input signal or ZERO control on one range only.	Contact on section D of RANGE switch defective.
Meter driven off negative end of scale.	Loss of B+. V3 heater open.
Meter driven off positive end of scale.	Grid-cathode short in V3B. V5 open.
Excessive noise indicated on meter.	V1 noisy. Poor contact between V1 pins and socket contacts. Noisy breakdown diode, CR1 or CR2.
Instrument operates normally except meter has slight zero offset on higher ranges, large switching transients on three lowest ranges.	Bias adjustment incorrect. R47 open.
Meter response very sluggish.	Weak amplifier tubes. Demodulator assembly defective. Chopper light misaligned.
Meter response to ZERO control limited to positive side of zero.	CR1 shorted.
On a particular range, meter drifts off zero with no input and instrument exhibits abnormally high sensitivity, but it operates normally on the two adjacent ranges.	Contact on Section A of RANGE switch defective. Corresponding range resistor open.

d. If the chopper blades are not turning, look at the motor operation indicator in the back of motor B1. If B1 is operating, the chopper blade is loose on its shaft. If not, check the 6.3 volt circuit to the motor.

5-15. MODULATOR ASSEMBLY.

5-16. To check modulator operation, proceed as follows:

a. Remove cabinet (paragraph 5-23).

b. Remove cover plate from input-circuit.

c. Set FUNCTION switch to VOLTAGE.

d. Set RANGE switch to 1 MA.

e. Connect probe to a dc signal between 1 and 5 volts.

f. Connect an oscilloscope to point where C4 is connected to circuit board. Connect common lead of oscilloscope to inner chassis. See figure 5-2.

g. Energize Model 425A and observe modulator assembly output on oscilloscope. Figure 5-3 shows a typical waveform on oscilloscope having input impedance of 1 megohm. The waveform should have peak-to-peak amplitude approximately equal to test signal voltage and frequency 5/6 power-line frequency.

h. Disconnect test signal and oscilloscope. Replace cover of input-circuit assembly.

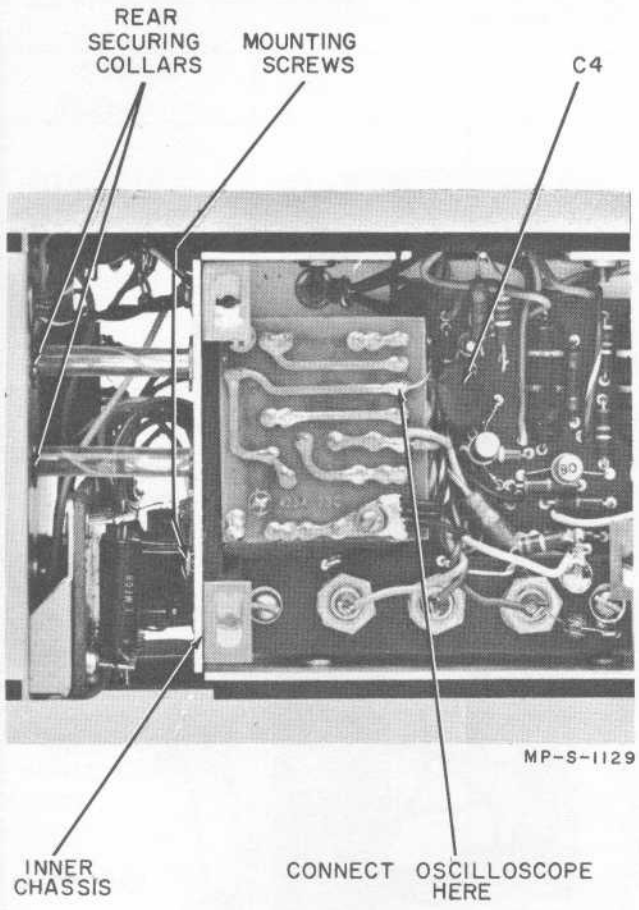


Figure 5-2. Modulator Assembly

5-17. To check modulator input resistance follow the instructions outlined in paragraph 5-52.

5-18. DEMODULATOR ASSEMBLY.

5-19. To check demodulator operation, proceed as follows:

a. Remove cabinet (paragraph 5-23).

b. Locate demodulator assembly. It is mounted straight back from the RANGE switch above a resistor board (see figure 5-4).

c. Remove all leads connected to terminals of assembly. The leads are color-coded and connected to terminals in the following order: purple-white (one lead) to terminal farthest from main chassis; blue-white (one lead) to middle terminal; and blue (one lead) to terminal nearest main chassis.

d. Connect a dc voltage between 1 and 5 volts across assembly (the two outer terminals).

e. Connect oscilloscope between middle terminal and either outer terminal. Oscilloscope must not present a dc path between its input terminals for this measurement.

f. Energize Model 425A and observe waveform on oscilloscope. Figure 5-3 shows a typical waveform on oscilloscope having input impedance of 1 megohm. Waveform should have peak-to-peak amplitude approximately equal to test signal voltage and frequency 5/6 power-line frequency.

5-20. REPAIR AND REPLACEMENT.

5-21. INTRODUCTION.

5-22. This section is intended to simplify repair problems in the Model 425A.

5-23. CABINET REMOVAL.

a. Remove the two retaining screws located on rear of cabinet.

b. Slide instrument forward out of cabinet. Bezel ring remains attached to front panel.

5-24. MODULATOR REPLACEMENT.

5-25. Replace the modulator assembly, A4, as a unit; do not attempt to repair individual components. See figure 5-2 and proceed as follows:

a. Disconnect C4 and leads from modulator assembly circuit board; they are connected to the board in the following order, starting from end closest to V1: brown, red, C4, orange, input and pink (to the same point), yellow, black, black, and black. (Note coded letters along edge of board.)

b. Remove the two mounting screws which hold assembly in place. These screws are located above and below two plastic rods which enter input-circuit container from rear.

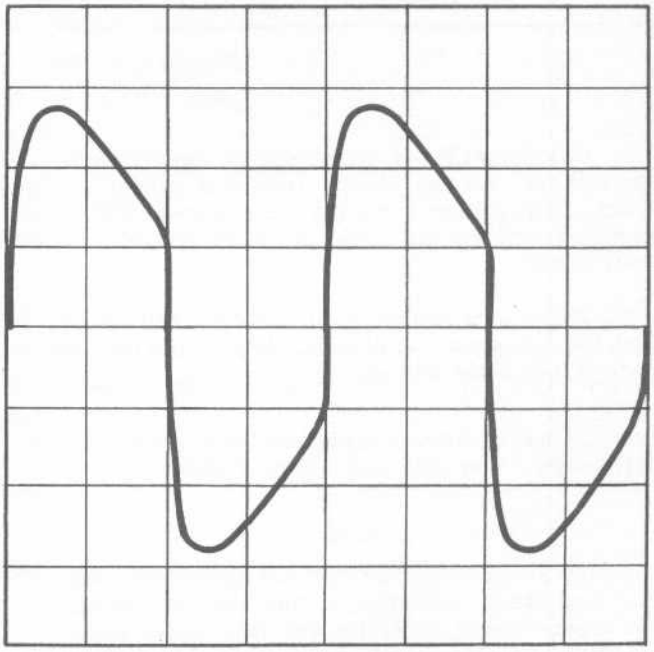


Figure 5-3. Modulator Waveform

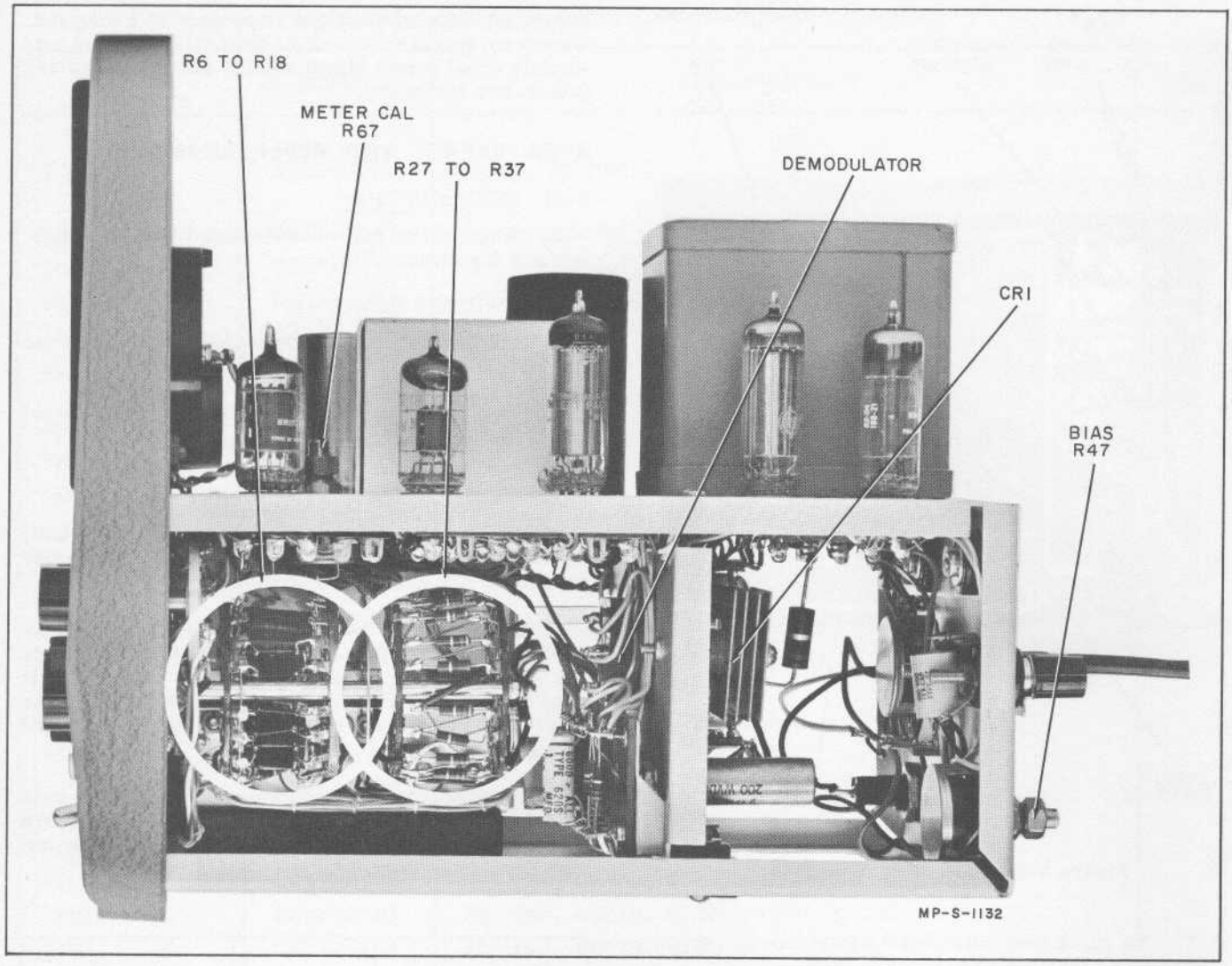


Figure 5-4. Right Side View Model 425A

c. Carefully lift out the modulator assembly; do not force it out, for the plastic rods may hinder its removal. If you must move the rods, spread their rear securing collars and slide the rods toward rear of instrument.

d. Place new assembly in position and secure it with the two mounting screws. Reposition the plastic rods if they were moved.

e. Connect external leads and C4 to assembly circuit board. Use only rosin-core solder.

Note

Use small soldering iron and apply minimum heat when soldering to the circuit board. Clean board carefully and thoroughly when finished. Be sure to remove all solder flux.

f. Check new modulator assembly as described in paragraph 5-15.

5-26. DEMODULATOR REPLACEMENT.

5-27. To replace demodulator assembly, A5, proceed as follows:

a. Disconnect the three leads to the demodulator.

b. Remove the two mounting screws which hold assembly in place; remove the demodulator from the instrument.

c. Place new assembly in position and secure it with the two mounting screws.

d. Reconnect the three leads to the demodulator.

5-28. RANGE SWITCH REPLACEMENT.

5-29. Figure 5-5 shows the location of all parts and wire destinations for the replacement of the RANGE switch. The Model 425A should be checked for correct calibration after replacing this switch. (See paragraph 5-46.)

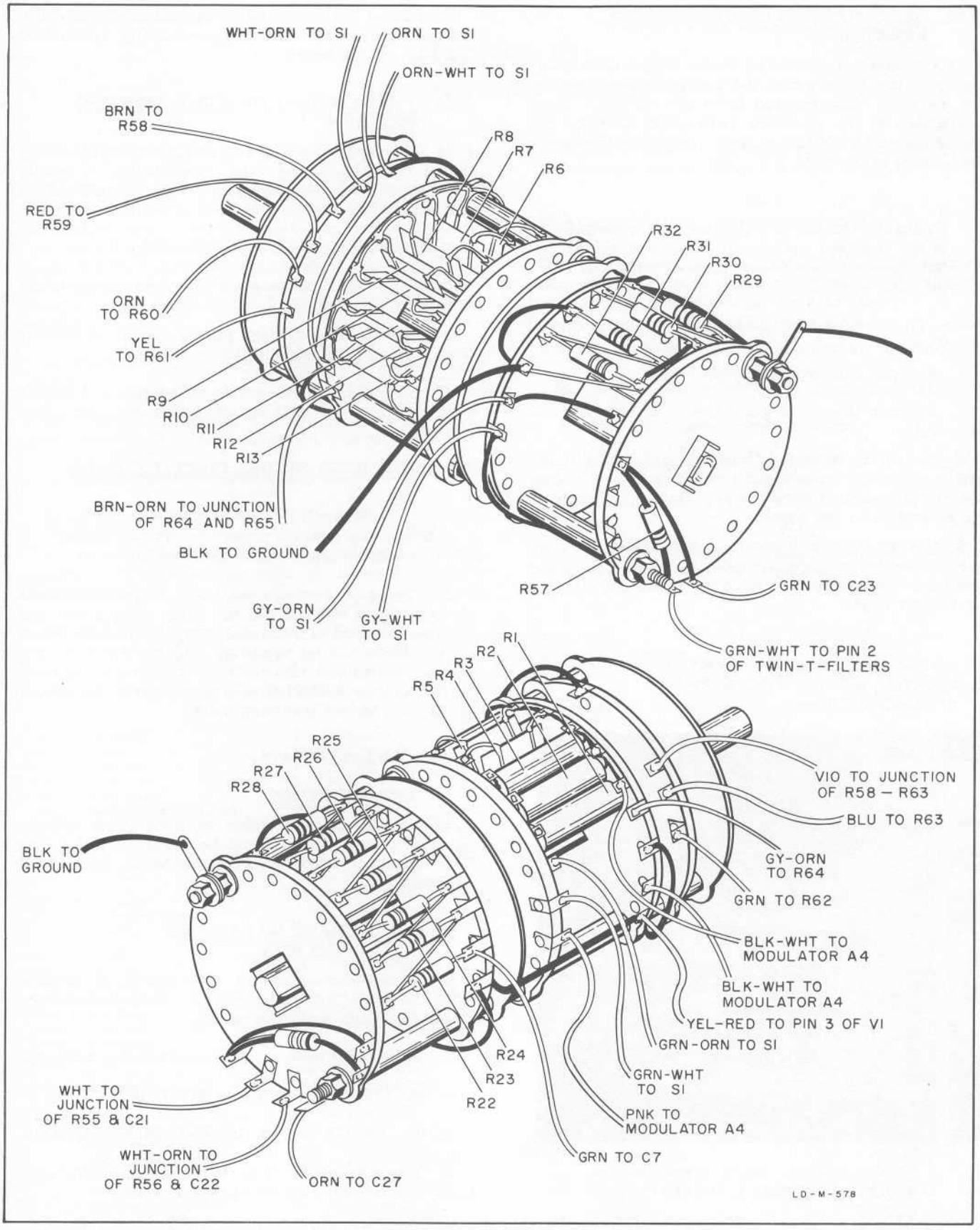


Figure 5-5. Range Switch Detail

5-30. DISCONNECTING INPUT-SHUNTING RESISTOR.

5-31. On special order, the Model 425A will be shipped from the factory with the 1 megohm input-shunting resistor disconnected from the circuit. Input resistance of the modified instrument exceeds 100 megohms on all voltage ranges. Modification can be performed in the field.

Note

Calibration of the nine lowest current ranges of the modified instrument is altered unless the input is externally shunted with a 1.0 megohm resistor.

5-32. To disconnect input-shunting resistor, proceed as follows:

a. Remove cabinet (paragraph 5-23).

b. Remove the cover plate from the input-circuit assembly.

c. Locate the indicated conductor strip on the modulator assembly circuit board in figure 5-5. Note that the strip is located between two leads coming from the underside of the board.

d. Cut the narrow conducting strip at each end. Do not cut into the eyelets of conducting material immediately around the leads. Use a sharp cutting tool such as a razor blade.

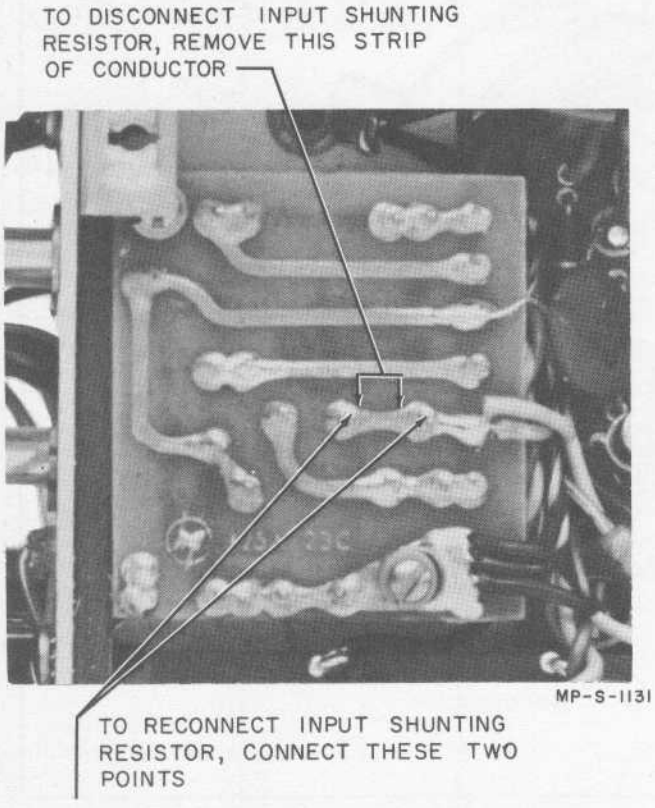


Figure 5-6. Connection Point of Input-Shunting Resistor

e. Lift out the narrow strip of conducting material. Be careful not to lift any of the remaining conducting material off the board.

5-33. REPLACEMENT OF INPUT-SHUNTING RESISTOR.

5-34. The input-shunting resistor remains physically in the instrument when the modification is made, whether at the factory or in the field. To restore the instrument to standard, proceed as follows:

a. Remove cabinet (paragraph 5-23).

b. Remove the cover plate from the input-circuit assembly.

c. Locate the indicated points on the modulator assembly circuit board in figure 5-6.

d. Connect these two points with a piece of copper wire. Solder both ends neatly, using only rosin core solder.

5-35. SERVICING ETCHED CIRCUIT BOARDS.

Note

Excessive heat or pressure can lift copper conductors from etched circuit boards.

5-36. To remove components from board, clip leads on component side of board. New components can then be soldered to the leads extending from the board or the leads can be removed. If the leads are removed, clean holes with a toothpick or wooden splinter (metal awls or soldering aids may destroy the copper conductor) before inserting leads.

5-37. ADJUSTMENTS.

5-38. INTRODUCTION.

5-39. The following section is a complete adjustment procedure and should be made only if it has been definitely determined that the Model 425A is out of adjustment.

5-40. ADJUSTMENT OF CATHODE FOLLOWER BIAS.

5-41. The cathode follower bias should be checked when the Model 425A is received. Only an occasional check is necessary thereafter.

a. Turn instrument on. Allow 15 minutes warmup.

b. Set FUNCTION switch to VOLTAGE.

c. Set RANGE switch to .003 MILLIAMPERES.

d. Observe meter. If it reads approximately zero (±5% of end scale) the check is complete.

e. If the meter does not read approximately zero, adjust R47, BIAS adjustment potentiometer (see figure 5-4), to approximately zero meter. The meter response to this adjustment is slow.

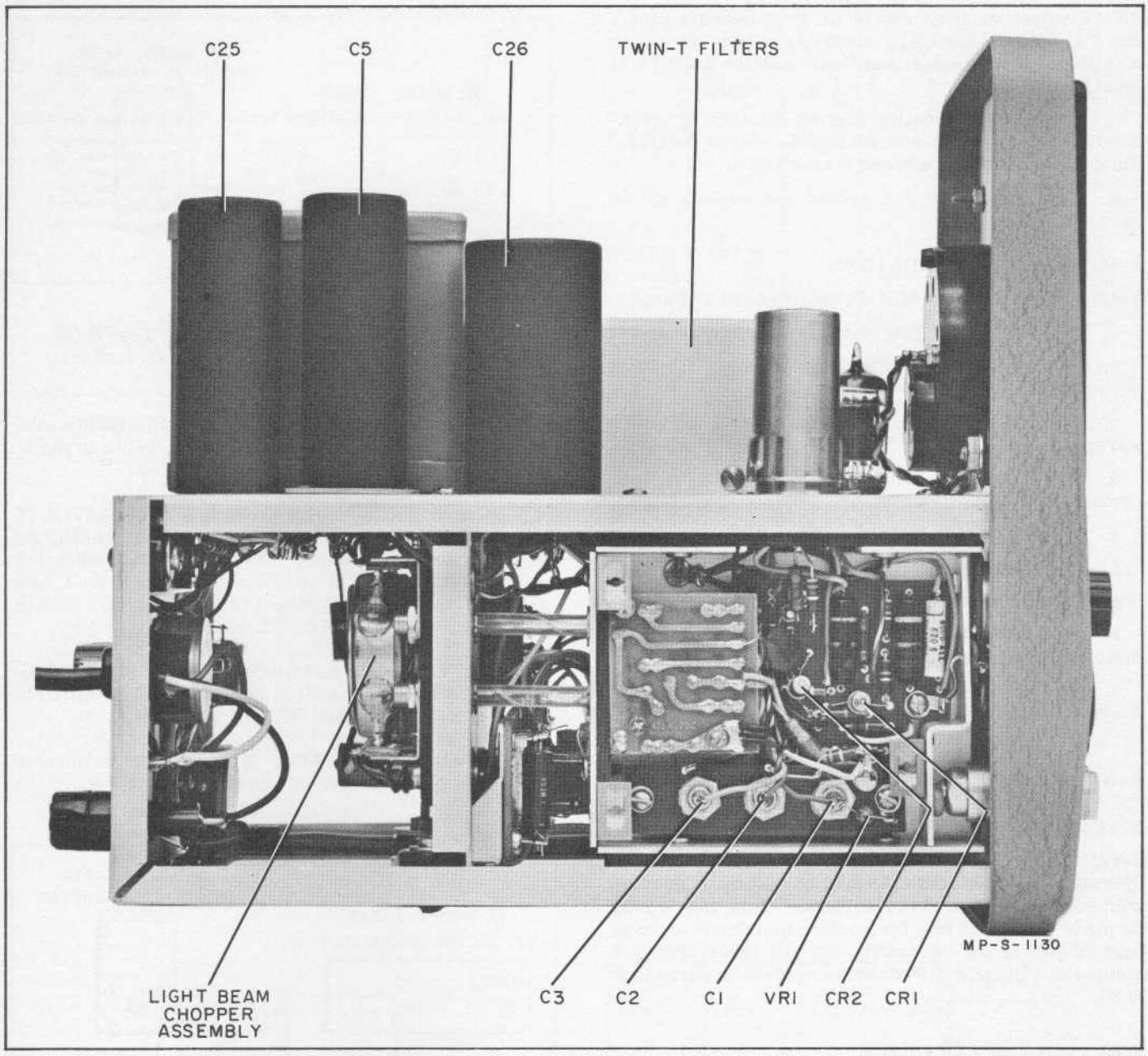


Figure 5-7. Left Side View Model 425A

5-42. ADJUSTMENT OF TWIN-T FILTERS.

5-43. The twin filters are contained in a single plug-in unit which should be removed for adjustment. A filter for either a 60 cps power line or a 50 cps power line may be adjusted as follows:

a. Remove two screws holding shield-cover over filter, remove cover and pull filter out of socket.

b. Connect a harmonic-free sine wave signal source between pins 6 and 8 (ground) of filter. Set signal source for an output frequency which is 5/6 of power line frequency for which filter is designed. Correct power line frequency for a particular filter may be determined by stock number as shown in Replaceable Parts table in Section VI.

Note

Instrument performance may be degraded if test signal is not set as closely as possible to correct frequency.

c. Connect an oscilloscope or ac vtvm between pins 7 and 8 of filter. Compare signal amplitude here with amplitude of applied signal. Attenuation must be at least 60 db.

d. Maximum attenuation may be obtained by alternately adjusting R39 and R41 (blue-colored controls) for minimum output between pins 7 and 8.

e. Connect same test signal used in step b between pins 3 and 8 on filter.

f. Connect oscilloscope or ac vtvm between pins 2 and 8 of filter. Compare signal amplitude here with amplitude of applied signal. Attenuation must be at least 60 db.

g. Maximum attenuation may be obtained by alternately adjusting R50 and R52 (red-colored controls) for minimum output between pins 2 and 8.

h. Plug filter unit into socket and replace shield cover.

5-44. METER CALIBRATION.

5-45. To calibrate the Model 425A proceed as follows:

a. Remove cabinet (see paragraph 5-23).

b. Set the mechanical adjustment of meter zero (see paragraph 5-6).

c. Turn the instrument on and allow 15 minutes warmup.

d. Check cathode follower bias adjustment (see paragraph 5-40).

e. Set FUNCTION switch to VOLTAGE.

f. Set RANGE switch to 1-volt range.

g. Connect probe to 1.0 volt ±1% dc source.

h. Adjust R67 METER CAL. (see figure 5-4) to set meter pointer to exactly +1.0.

i. To check the calibration, see paragraph 5-49, Voltmeter Check.

5-46. PERFORMANCE CHECK.

5-47. INTRODUCTION.

5-48. The following procedure is to verify proper operation of the Model 425A and should be performed with the instrument in the cabinet. This check may be made as a final test for routine maintenance or as part of the incoming quality control inspection. A complete Adjustment Procedure is given in paragraph 5-36.

5-49. VOLTMETER CHECK.

5-50. CALIBRATION. To check calibration, proceed as follows:

a. Adjust mechanical meter zero (see paragraph 5-6).

b. Adjust Cathode Follower Bias (see paragraph 5-40).

c. Turn voltmeter calibrator on and allow a one-half-hour warmup.

d. Set voltmeter calibrator OUTPUT SELECTOR to DC+, FUNCTION switch to CALIBRATE, MULTIPLIER switch to 0, and RANGE switch to 1.

e. Connect Model 425A to voltmeter calibrator as shown in figure 5-8.

f. Set Model 425A FUNCTION switch to VOLTAGE and RANGE switch to 10 MICROVOLTS.

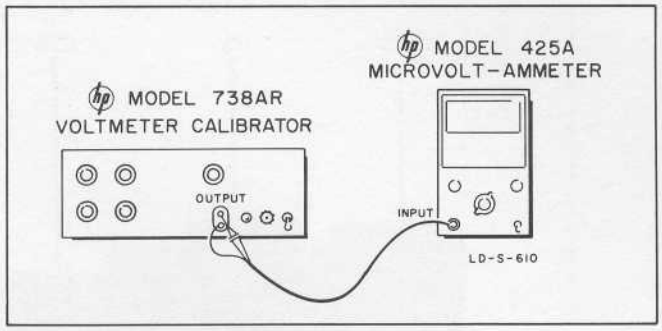


Figure 5-8. Voltmeter Calibration Test Setup (1 VOLTS through .3 MILLIVOLTS ranges)

g. Zero meter of Model 425A with panel ZERO control. If Model 425A cannot be zeroed, refer to paragraph 3-8.

h. Check the 1 VOLTS through 0.3 MILLIVOLTS ranges by setting switches of the voltmeter calibrator and Model 425A as shown in table 5-3. The voltmeter calibrator FUNCTION switch will remain in the CALIBRATE position. The Model 425A FUNCTION switch will remain in the VOLTAGE position.

i. Set voltmeter calibrator OUTPUT SELECTOR to DC+, FUNCTION switch to CALIBRATE, MULTIPLIER switch to 0, and RANGE switch to 1.

j. Connect Model 425A to voltmeter calibrator using the 100:1 divider as shown in figure 5-9.

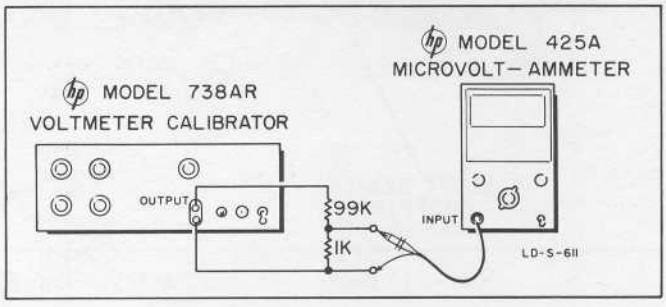


Figure 5-9. Voltmeter Calibration Test Setup (100 MICROVOLTS through 10 MICROVOLTS ranges)

k. Repeat steps f and g.

m. Check 100 MICROVOLTS through 10 MICROVOLTS ranges by setting the switches of voltmeter calibrator and Model 425A as shown in table 5-4. The voltmeter calibrator FUNCTION switch will remain in the CALIBRATE position. The Model 425A FUNCTION switch will remain in the VOLTAGE position.

5-51. METER TRACKING. To check the meter tracking, proceed as follows:

a. Connect Model 425A to the voltmeter calibrator as shown in figure 5-8.

Table 5-3. Voltmeter Calibration
(1 VOLTS through .3 MILLIVOLTS ranges)

Voltmeter Calibrator			Model 425A	
OUTPUT SELECTOR	MULTIPLIER	RANGE (VOLTS)	RANGE	Meter Reading (±3% of end scale)
DC+	1.	1	1 VOLTS	+1
DC-	1.	1	1 VOLTS	-1
DC+	.1	3	.3 VOLT	+3
DC-	.1	3	.3 VOLT	-3
DC+	.1	1	.1 VOLT	+1
DC-	.1	1	.1 VOLT	-1
DC+	.01	3	30 MILLIVOLTS	+3
DC-	.01	3	30 MILLIVOLTS	-3
DC+	.01	1	10 MILLIVOLTS	+1
DC-	.01	1	10 MILLIVOLTS	-1
DC+	.001	3	3 MILLIVOLTS	+3
DC-	.001	3	3 MILLIVOLTS	-3
DC+	.001	1	1 MILLIVOLTS	+1
DC-	.001	1	1 MILLIVOLTS	-1
DC+	.001	.3	.3 MILLIVOLT	+3
DC-	.001	.3	.3 MILLIVOLT	-3

b. Set Model 425A FUNCTION switch to VOLTAGE, and RANGE switch to 1 VOLTS.

c. Check the positive section tracking by setting the voltmeter calibrator FUNCTION switch to 1 VOLTS TRACKING, and OUTPUT SELECTOR to DC+.

d. Reduce the voltmeter calibrator output in 0.1-volt steps by rotating the TRACKING control. The meter should indicate TRACKING voltages ±3%.

e. Check the negative section tracking by setting the voltmeter calibrator OUTPUT SELECTOR to DC-.

f. Reduce voltmeter calibrator output in 0.1-volt steps by rotating the TRACKING control. The meter should indicate TRACKING voltages ±3%.

5-52. INPUT IMPEDANCE. To check the input impedance, proceed as follows:

a. Connect a 1M ±0.1% resistor between the probe of Model 425A and the upper terminal of the voltmeter calibrator.

b. Set Model 425A RANGE switch to 1 VOLTS.

c. Set voltmeter calibrator OUTPUT SELECTOR to DC+, MULTIPLIER switch to 0, and RANGE switch to 2.

d. Zero meter of Model 425A with the front panel ZERO control.

e. Set voltmeter calibrator MULTIPLIER to the 1 position.

f. The Model 425A meter should indicate 1 volt within 0.03 volts. This check determines if the Model 425A meets its 1 megohm ±3% specification.

Table 5-4. Voltmeter Calibration
(100 MICROVOLTS through 10 MICROVOLTS ranges)

Voltmeter Calibrator			Model 425A	
OUTPUT SELECTOR	MULTIPLIER	RANGE (VOLTS)	RANGE	Meter Reading (±3% of end scale)
DC+	.01	1	100 MICROVOLTS	+1
DC-	.01	1	100 MICROVOLTS	-1
DC+	.001	3	30 MICROVOLTS	+3
DC-	.001	3	30 MICROVOLTS	-3
DC+	.001	1	10 MICROVOLTS	+1
DC-	.001	1	10 MICROVOLTS	-1

Table 5-5. Ammeter Calibration

Voltmeter Calibrator			Series Resistance	Model 425A	
OUTPUT SELECTOR	MULTIPLIER	RANGE (VOLTS)	Resistance	RANGE	Meter Reading (±3% of end scale)
DC+	100	3	100K	3 MILLIAMPERES	+3
DC-	100	3	100K	3 MILLIAMPERES	-3
DC+	100	3	300K	1 MILLIAMPERES	+1
DC-	100	3	300K	1 MILLIAMPERES	-1
DC+	100	3	1M	.3 MILLIAMPERE	+3
DC-	100	3	1M	.3 MILLIAMPERE	-3
DC+	100	1	1M	.1 MILLIAMPERE	+1
DC-	100	1	1M	.1 MILLIAMPERE	-1
DC+	10	3	1M	.03 MILLIAMPERE	+3
DC-	10	3	1M	.03 MILLIAMPERE	-3
DC+	10	1	1M	.01 MILLIAMPERE	+1
DC-	10	1	1M	.01 MILLIAMPERE	-1
DC+	1	3	1M	.003 MILLIAMPERE	+3
DC-	1	3	1M	.003 MILLIAMPERE	-3
DC+	1	1	1M	1 MICROAMPERES	+1
DC-	1	1	1M	1 MICROAMPERES	-1
DC+	.1	3	997K	.3 MICROAMPERE	+3
DC-	.1	3	997K	.3 MICROAMPERE	-3
DC+	.1	1	990K	.1 MICROAMPERE	+1
DC-	.1	1	990K	.1 MICROAMPERE	-1
DC+	.01	3	967K	30 MILLI-MICROAMPERES	+3
DC-	.01	3	967K	30 MILLI-MICROAMPERES	-3
DC+	.01	1	900K	10 MILLI-MICROAMPERES	+1
DC-	.01	1	900K	10 MILLI-MICROAMPERES	-1
DC+	.001	3	667K	3 MILLI-MICROAMPERES	+3
DC-	.001	3	667K	3 MILLI-MICROAMPERES	-3

Note: The five lowest current ranges (1 MILLI-MICROAMPERES through 10 MICRO-MICROAMPERES) are checked by the input impedance check and the voltmeter check of the same ranges. The Model 425A measures the IR drop across the one-megohm input impedance on the five lowest current ranges.

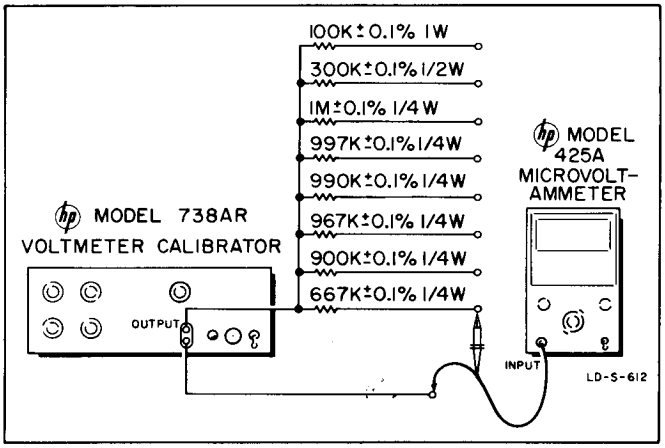


Figure 5-10. Ammeter Calibration Test Setup

5-53. AMMETER CHECK.

a. Set voltmeter calibrator OUTPUT SELECTOR to DC+, FUNCTION switch to CALIBRATE, MULTIPLIER switch to 0, and RANGE switch to 3.

b. Set Model 425A to the voltmeter calibrator using the series resistors as shown in figure 5-10.

c. Connect probe to 667K resistor and zero the meter of Model 425A with the panel ZERO control.

d. Check 3 MILLIAMPERES through 3 MILLI-MICROAMPERES ranges of Model 425A by setting the switches of the test circuit as shown in table 5-5. The voltmeter calibrator FUNCTION switch will remain in the CALIBRATE position. The Model 425A FUNCTION switch will remain in the CURRENT position.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.
2. Heavy box indicates front-panel engraving; light box indicates chassis marking.
3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counter-clockwise from the rectangular shaft end.
4. Resistance values in ohms, inductance in microhenries, and capacitance in micromicrofarads unless otherwise specified.
5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.
6. Relays shown in condition prevailing during normal instrument operation.
7. ‡ indicates a selected part. See parts list.
8. Interconnecting parts and assemblies are shown on cable diagram.
9. * Value adjusted at factory. Part may be omitted.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

1. Each tube socket terminal is numbered and lettered to indicate the tube element and pin number, as follows:

*	=	no tube element	P	=	plate
H	=	heater	T	=	target (plate)
K	=	cathode	R	=	reflector or repeller
G	=	control grid	A	=	anode (plate)
Sc	=	screen grid	S	=	spade
Sp	=	suppressor grid	Sh	=	shield
Hm	=	heater mid-tap	NC	=	no external connection to socket
IS	=	internal shield	Δ	=	indefinite reading due to circuit (see 2.)

The numerical subscript to tube-element designators indicates the section of a multiple-section tube; the letter subscript to tube-element designators indicates the functional difference between like elements in the same tube section, such as t for triode and p for pentode.

A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.
3. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.
4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

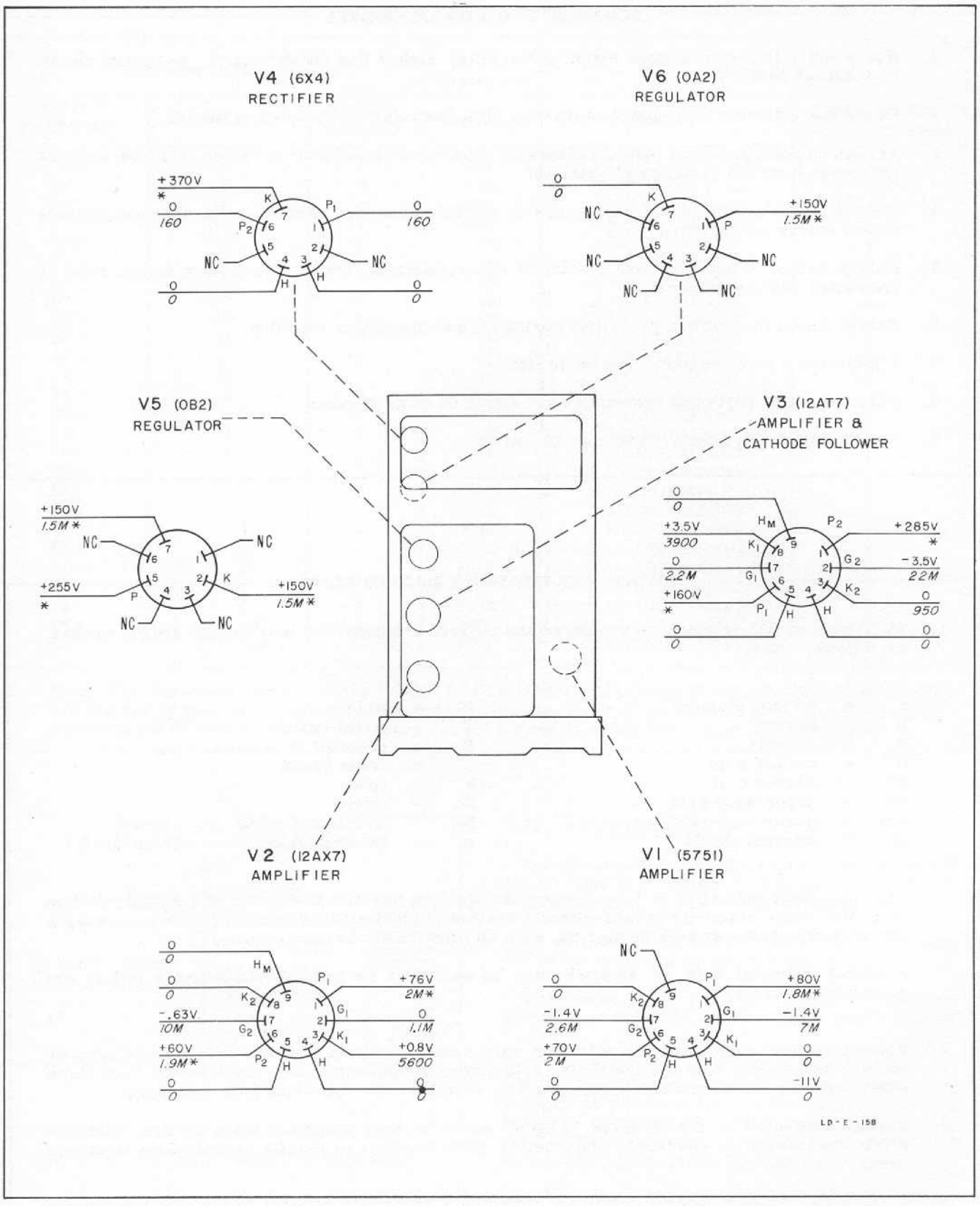
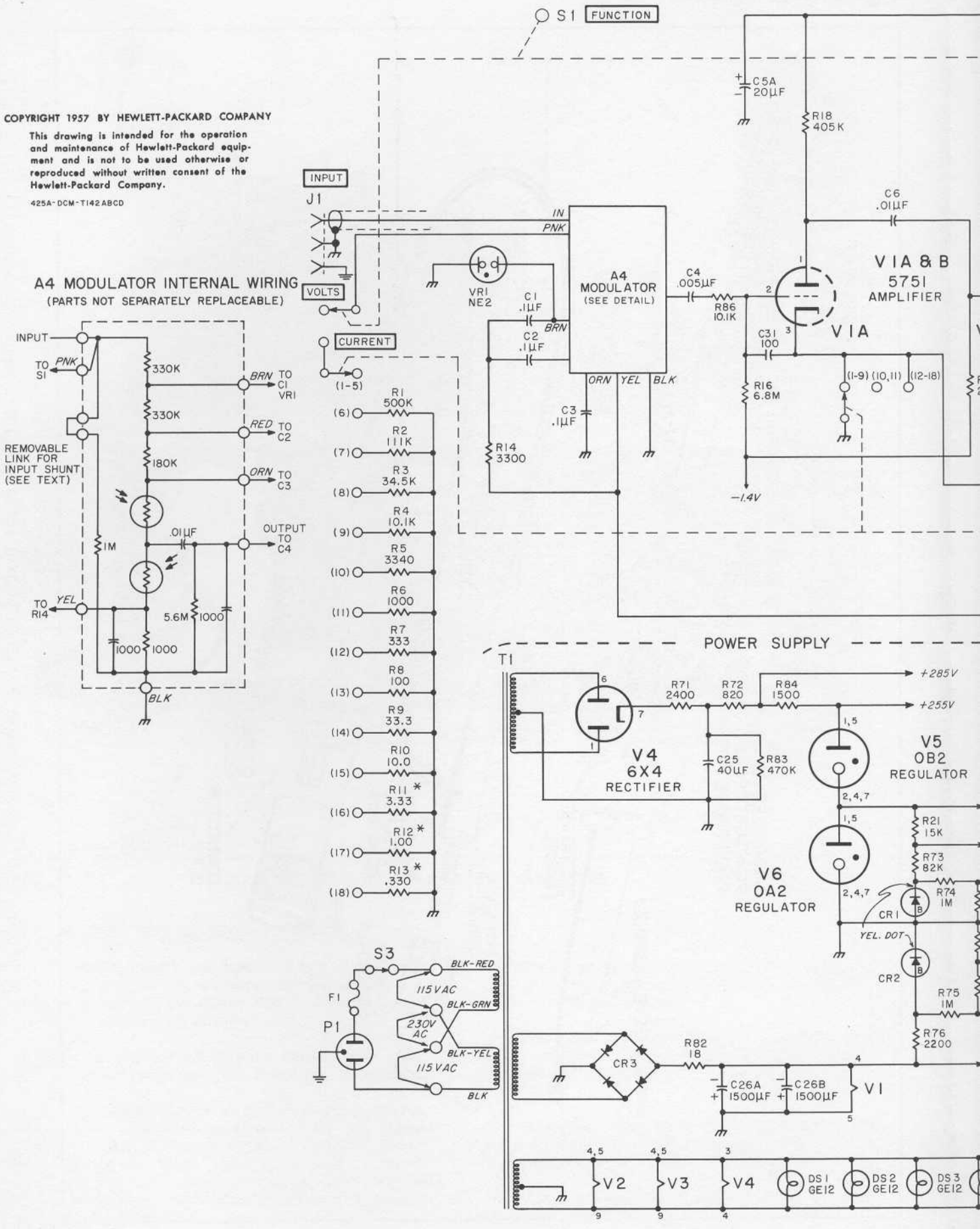


Figure 5-11. Voltage and Resistance Diagram (viewed from bottom)



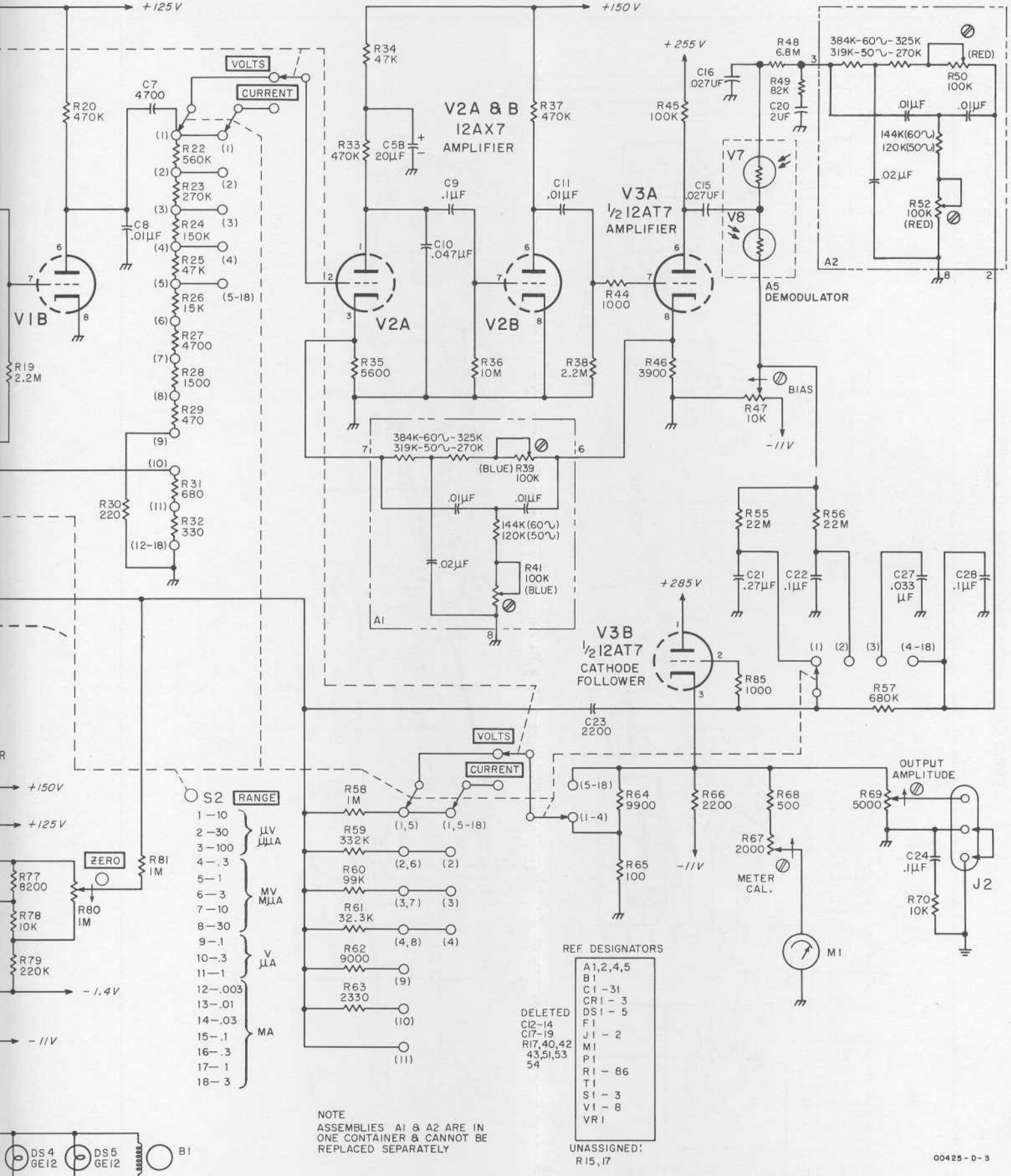


Figure 5-12. Model 425A DC Microvolt-Ammeter

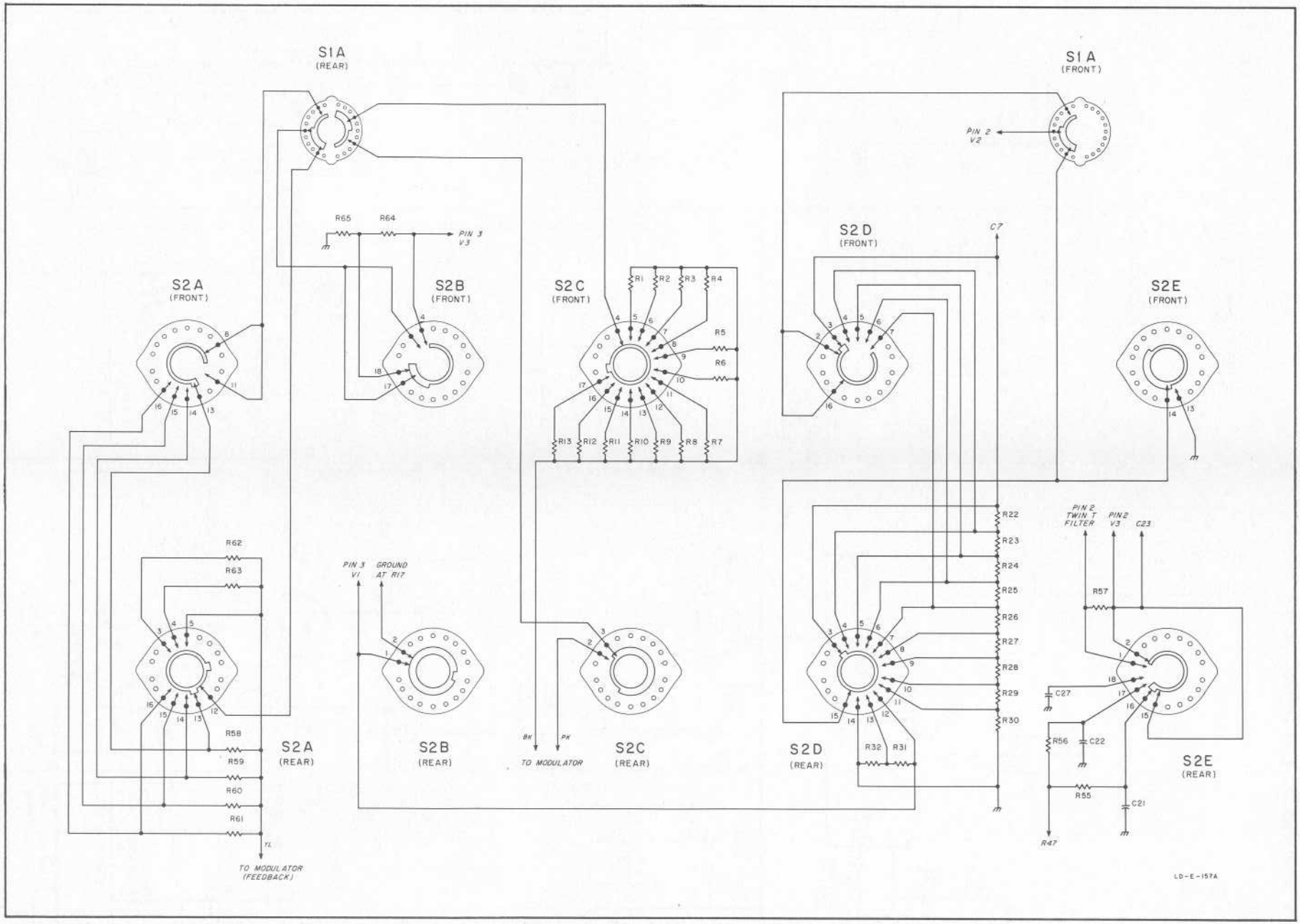


Figure 5-13. Function and Range Switch Detail

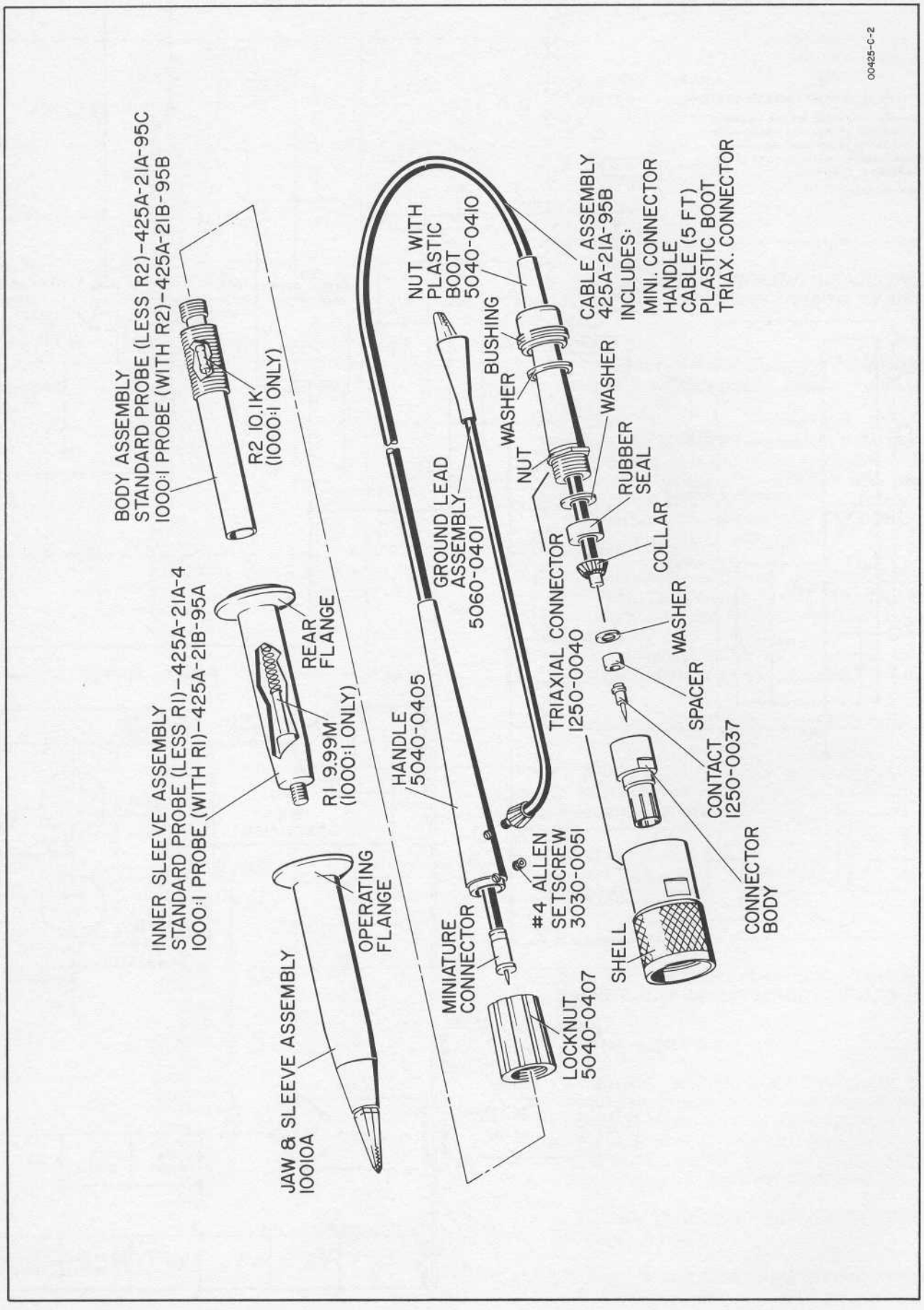


Figure 5-14. Exploded View of 425A-21A (Standard) and 11021A (1000:1 Divider) Probes

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 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 6-2 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. Typical manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. 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).

6-3. Miscellaneous parts not indexed in Table 6-1 are listed at the end of Table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry to your local Hewlett-Packard field office (see map at rear of this manual for addresses).

6-6. 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.

6-7. To order a part not listed in Tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

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

ABBREVIATIONS

a = amperes
bp = bandpass
bwo = backward wave oscillator
c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube
dep = deposited
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers.
elect = electrolytic
encap = encapsulated
f = farads
fxd = fixed
Ge = germanium
grd = ground (ed)
h = henries
Hg = mercury
impg = impregnated
incd = incandescent
ins = insulation (ed)
K = kilo = 1000
lin = linear taper
log = logarithmic taper
m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
minat = miniature
mfgl = metal film on glass
mfr = manufacturer
mtg = mounting
my = mylar
NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
nsr = not separately replaceable
obd = order by description
p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer
rect = rectifier
rot = rotary
rms = root-mean-square
rmo = rack mount only
s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sil = silver
sl = slide
td = time delay
TiO_2 = titanium dioxide
tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube
var = variable
w/ = with
W = watts
ww = wirewound
w/o = without
* = optimum value selected at factory, average value shown (part may be omitted)

01194-4

Table 6-1. Index by Reference Designator

Circuit Reference	ⓗp Stock No.	Description #	Note
A1, A2		Assy, Twin "T" Filter:	
	9110-0039	For 50 cycle power operation	
	9110-0038	For 60 cycle power operation	
A3	425A-58B	Assy, input amplifier: includes,	
		A4 R18 thru R20	
		C1 thru C3 R73 thru R79	
		C6 thru C8 R81	
		CR1, CR2 VR1	
		R14	
A4	425A-23C	Assy, modulator	
A5	425A-23B	Assy, demodulator: includes,	
		V7, V8, XV7	
A6	425A-97A	Assy, chopper: includes,	
		B1	
		DS2 thru DS5	
		XDS2 thru XDS5	
A7	425A-19A	Assy, range switch: includes,	
		R1 thru R13 R57	
		R22 thru R32 S2	
B1	3140-0013	Motor, synchronous type: 6.3V, AC	
C1 thru C3	0170-0030	C: fxd, poly, 0.1 μf ±10%, 50 vdcw	
C4	0150-0014	C: fxd, cer, 0.005 μf, 500 vdcw	
C5A/B	0180-0012	C: fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	
C6	0170-0017	C: fxd, my, 0.01 μf ±5%, 400 vdcw	
C7	0170-0021	C: fxd, my, 4700 pf ±10%, 400 vdcw	
C8	0170-0017	C: fxd, my, 0.01 μf ±5%, 400 vdcw	
C9	0160-0013	C: fxd, my, 0.1 μf ±10%, 400 vdcw	
C10	0160-0005	C: fxd, my, 0.047 μf ±10%, 600 vdcw	
C11	0160-0054	C: fxd, paper, 0.01 μf ±20%, 400 vdcw	
C12 thru C14		Not assigned	

See introduction to this section

Table 6-1. Index by Reference Designator (Cont'd)

Circuit Reference	ℎ Stock No.	Description #	Note
C15, C16	0160-0026	C: fxd, my, 0.027 μf ±10%, 600 vdcw	
C17 thru C19		Not assigned	
C20	0160-0030	C: fxd, paper, 2 μf ±20%, 200 vdcw	
C21	0160-0039	C: fxd, my, 0.27 μf ±10%, 200 vdcw	
C22	0170-0019	C: fxd, my, 0.1 μf ±5%, 200 vdcw	
C23	0160-0007	C: fxd, my, 2200 pf ±10%, 600 vdcw	
C24	0170-0022	C: fxd, my, 0.1 μf ±20%, 600 vdcw	
C25	0180-0024	C: fxd, aluminum elect, 40 μf, 450 vdcw	
C26A/B	0180-0028	C: fxd, elect, 2 sect, 1.5K μf/sect, 15 vdcw	
C27	0160-0004	C: fxd, my, 0.033 μf ±10%, 600 vdcw	
C28	0170-0022	C: fxd, my, 0.1 μf ±20%, 600 vdcw	
C29, C30		Not assigned	
C31	0150-0073	C: fxd, cer, 100 pf ±10%, 500 vdcw	
CR1, CR2	G-29A-74	Diode, zener	
CR3	1882-0005	Rectifier, metallic	
DS1 thru DS5	2140-0012	Lamp, minat: 0.15 amp, 6.3 V	
F1	2110-0007	Fuse, cartridge: s-b, 1 amp (for 115 V operation)	
	2110-0008	Fuse, cartridge: s-b, 1/2 amp (for 230 V operation)	
J1	1250-0039	Connector, triaxial panel jack: input receptacle	
J2	AC-76J	Binding post and ground link: black (cmo)	
	AC-10C	Binding post: black (rmo)	
	AC-10D	Binding post: red	
	AC-54B	Insulator: inside	
	AC-54F	Insulator: outside	
J3		Rack Mount Only	
	AC-76J	Binding post and ground link: black	
	AC-10D	Binding post: red	
	AC-54B	Insulator: inside	
	AC-54F	Insulator: outside	
M1	G-81E	Meter, calibrated	

See introduction to this section

Table 6-1. Index by Reference Designator (Cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
P1	8120-0050	Cord, power	
R1	0757-0015	R: fxd, mfgl, 500K ohms ±1/2%, 1/2 W	
R2	0757-0013	R: fxd, mfgl, 111K ohms ±1/2%, 1/2 W	
R3	0757-0008	R: fxd, mfgl, 34.5K ohms ±1/2%, 1/2 W	
R4	425A-26A	R: ww	
R5	425A-26D	R: ww	
R6	425A-26F	R: ww	
R7	425A-26G	R: ww	
R8	425A-26H	R: ww	
R9	425A-26I	R: ww	
R10	425A-26J	R: ww	
R11	425A-26K	R: ww	
R12	425A-26L	R: ww	
R13	425A-26M	R: ww	
R14	0687-3321	R: fxd, comp, 3.3K ohms ±10%, 1/2 W	
R15		Not assigned	
R16	0687-6851	R: fxd, comp, 6.8M ±10%, 1/2 W	
R17		Not assigned	
R18	0727-0240	R: fxd, dep c, 405K ohms ±1%, 1/2 W	
R19	0687-2251	R: fxd, comp, 2.2M ±10%, 1/2 W	
R20	0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2 W	
R21	0687-1531	R: fxd, comp, 15K ohms ±10%, 1/2 W	
R22	0687-5641	R: fxd, comp, 560K ohms ±10%, 1/2 W	
R23	0687-2741	R: fxd, comp, 270K ohms ±10%, 1/2 W	
R24	0687-1541	R: fxd, comp, 150K ohms ±10%, 1/2 W	
R25	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 W	
R26	0687-1531	R: fxd, comp, 15K ohms ±10%, 1/2 W	
R27	0687-4721	R: fxd, comp, 4.7K ohms ±10%, 1/2 W	
R28	0687-1521	R: fxd, comp, 1.5K ohms ±10%, 1/2 W	
R29	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 W	
R30	0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 W	
R31	0687-6811	R: fxd, comp, 680 ohms ±10%, 1/2 W	
R32	0687-3311	R: fxd, comp, 330 ohms ±10%, 1/2 W	
R33	0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2 W	

See introduction to this section

Table 6-1. Index by Reference Designator (Cont'd)

Circuit Reference	Stock No.	Description #	Note
R34	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 W	
R35	0687-5621	R: fxd, comp, 5.6K ohms ±10%, 1/2 W	
R36	0687-1061	R: fxd, comp, 10M ±10%, 1/2 W	
R37	0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2 W	
R38	0687-2251	R: fxd, comp, 2.2M ±10%, 1/2 W	
R39		R: var, part of A1	
R40		Not assigned	
R41		R: var, part of A1	
R42, R43		Not assigned	
R44	0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	
R45	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 W	
R46	0687-3921	R: fxd, comp, 3.9K ohms ±10%, 1/2 W	
R47	2100-0053	R: var, ww, 10K ohms	
R48	0687-6851	R: fxd, comp, 6.8M ±10%, 1/2 W	
R49	0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 W	
R50		R: var, part of A2	
R51		Not assigned	
R52		R: var, part of A2	
R53, R54		Not assigned	
R55, R56	0687-2261	R: fxd, comp, 22M ±10%, 1/2 W	
R57	0687-6841	R: fxd, comp, 680K ohms ±10%, 1/2 W	
R58	0757-0017	R: fxd, mfgl, 1M ±1/2%, 1/2 W	
R59	0757-0014	R: fxd, mfgl, 332K ohms ±1/2%, 1/2 W	
R60	0757-0010	R: fxd, mfgl, 99K ohms ±1/2%, 1/2 W	
R61	0757-0007	R: fxd, mfgl, 32.3K ohms ±1/2%, 1/2 W	
R62	425A-26C	R: ww	
R63	425A-26E	R: ww	
R64	425A-26B	R: ww	
R65	425A-26H	R: ww	
R66	0687-2221	R: fxd, comp, 2.2K ohms ±10%, 1/2 W	
R67	2100-0005	R: var, ww, lin, 2K ohms ±10%, 2 W	
R68	0727-0077	R: fxd, dep c, 500 ohms ±10%, 1/2 W	

See introduction to this section

Table 6-1. Index by Reference Designator (Cont'd)

Circuit Reference	ℎ Stock No.	Description #	Note
R69	2100-0006	R: var, ww, 5K ohms ±10%, 3 W	
R70	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 W	
R71	0770-0002	R: fxd, 2.4K ohms ±5%, 4 W	
R72	0693-8211	R: fxd, comp, 820 ohms ±10%, 2 W	
R73	0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 W	
R74, R75	0686-1055	R: fxd, comp, 1M ±5%, 1/2 W	
R76	0687-2221	R: fxd, comp, 2.2K ohms ±10%, 1/2 W	
R77	0686-8225	R: fxd, comp, 8.2K ohms ±5%, 1/2 W	
R78	0686-1035	R: fxd, comp, 10K ohms ±5%, 1/2 W	
R79	0686-2245	R: fxd, comp, 220K ohms ±5%, 1/2 W	
R80	2100-0074	R: var, comp, lin, 1M ±30%, 1/4 W	
R81	0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	
R82	0693-1801	R: fxd, comp, 18 ohms ±10%, 2 W	
R83	0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2 W	
R84	0693-1521	R: fxd, comp, 1.5K ohms ±10%, 2 W	
R85	0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	
R86	0727-0158	R: fxd, dep c, 10.1K ohms ±1%, 1/2 W	
S1	3100-0157	Switch, rot: 2 pos, 1 sect	
S2	3100-0158	Switch, rot: 18 pos, 5 sect	
S3	3101-0001	Switch, tog: SPST, 250 V, 3 amp	
T1	9100-0094	Transformer, power	
V1	1932-0033	Tube, electron: 9 pin, 5751WA	
V2	1932-0030	Tube, electron: 9 pin, 12AX7	
V3	1932-0027	Tube, electron: 9 pin, 12AT7	
V4	1930-0016	Tube, electron: 7 pin, 6X4	
V5	1940-0007	Tube, electron: 7 pin, OB2	
V6	1940-0004	Tube, electron: 7 pin, OA2	
V7, V8	G-30B	Cell, photoconductive	
VR1	2140-0008	Lamp, neon	
XDS1 thru XDS5	1450-0022	Lampholder	

See introduction to this section

Table 6-1. Index by Reference Designator (Cont'd)

Circuit Reference	℗ Stock No.	Description #	Note
XF1	1400-0084	Fuseholder	
XV1 thru XV3	1200-0003	Socket, tube: 9 pin, minat	
XV4 thru XV6	1200-0017	Socket, tube: 7 pin, minat	
XV7	G-83P	Holder, photocell	
XV8		Not assigned	
XV9	1200-0005	Socket, tube: 8 pin	
		MISCELLANEOUS	
	G-74	Knob, ZERO: 3/4" black	
		Knob, AMPLITUDE: 3/4" black (rmo)	
	G-74D	Knob, FUNCTION: 3/4" black, w/arrow (cmo)	
	G-74N	Knob, RANGE: bar, skirted, w/arrow	
		Knob, FUNCTION: bar, skirted (rmo)	
	425A-21A	Assy, probe (complete)	
	10010A	Assy, probe, outer sleeve and jaw assembly	
		(See Figure 5-14 for identification of other probe parts)	
	425A-97A-5	Light rod: modulator	
	1450-0020	Jewel	

See introduction to this section

Table 6-2. Replaceable Parts

ℎp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
AC-10C	Binding post: black (rmo)	28480	AC-10C	1	1		
AC-10D	Binding post: red (rmo)	28480	AC-10D	4	2		
	Binding post: red (cmo)	28480	AC-10D	2	1		
AC-54B	Insulator: inside (cmo)	28480	AC-54B	1	1		
	Insulator: inside (rmo)	28480	AC-54B	2	1		
AC-54F	Insulator: outside (cmo)	28480	AC-54F	1	1		
AC-54F	Insulator: outside (rmo)	28480	AC-54F	2	1		
G-29A-74	Diode, zener	28480	G-29A-74	2	2		
G-30A	Cell, photoconductive	28480	G-30A	2	2		
G-30B	Cell, photoconductive	28480	G-30B	2	1		
G-74	Knob, ZERO: 3/4" black	28480	G-74	1	0		
	Knob, AMPLIFIER: 3/4" black (rmo)	28480	G-74	1	0		
G-74D	Knob, FUNCTION: 3/4" black, w/arrow (cmo)	28480	G-74D	1	0		
G-74N	Knob, RANGE: bar, skirted, w/arrow	28480	G-74N	1	0		
G-76J	Binding post and ground link: black (cmo) (rmo)	28480	G-76J	1	0		
G-81E	Meter, calibrated	28480	G-81	1	1		
				2	1		
G-83P	Holder, photocell	28480	G-83P	1	1		
425A-19A	Assy, range switch, includes: R1 thru R13 R57 R22 thru R32 S2	28480	425A-19A	1	1		
425A-21A	Assy, probe (complete)	28480	425A-21A	1	1		
	(See Figure 5-14 for identification of probe parts)	28480	425A-21A-95	1	1		
425A-23B	Assy, demodulator: includes, V9, V10 XV9	28480	425A-23B	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
425A-23C	Assy, modulator: includes, C101 thru C103 V7, V8 R101 thru R106	28480	425A-23C	1	1		
425A-26A	R: ww	28480	425A-26A	1	0		
425A-26B	R: ww	28480	425A-26B	1	0		
425A-26C	R: ww	28480	425A-26C	1	0		
425A-26D	R: ww	28480	425A-26D	1	0		
425A-26E	R: ww	28480	425A-26E	1	0		
425A-26F	R: ww	28480	425A-26F	1	0		
425A-26G	R: ww	28480	425A-26G	1	0		
425A-26H	R: ww	28480	425A-26H	2	0		
425A-26I	R: ww	28480	425A-26I	1	0		
425A-26J	R: ww	28480	425A-26J	1	0		
425A-26K	R: ww	28480	425A-26K	1	0		
425A-26L	R: ww	28480	425A-26L	1	0		
425A-26M	R: ww	28480	425A-26M	1	0		
425A-26N	R: ww	28480	425A-26N	1	0		
425A-58B	Assy, input amplifier: includes, C1 thru C3 R18 thru R20 C6 thru C8 R73 thru R79 CR1, CR2 R81 R14 VR1	28480	425A-58B	1	1		
425A-97A	Assy, chopper: includes, B1 DS2 thru DS5 XDS2 thru XDS5	28480	425A-97A	1	1		
425A-97A-5	Light rod: modulator	28480	425A-97A-5	2	1		
0150-0014	C: fxd, cer, 0.005 μf, 500 vdcw	04222	D1-4	1	1		
0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	OOORR	Type E	1	1		
0150-0073	C: fxd, cer, 100 pf ±10%, 500 vdcw	56289	40C200A2	2	1		
0160-0004	C: fxd, my, 0.033 μf ±10%, 600 vdcw	56289	160P33396	1	1		
0160-0005	C: fxd, my, 0.047 μf ±10%, 600 vdcw	56289	160P47396	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0160-0007	C: fxd, my, 0.022 μf ±10%, 600 vdcw	56289	160P22296	1	1		
0160-0013	C: fxd, my, 0.1 μf ±10%, 400 vdcw	56289	160P10494	1	1		
0160-0026	C: fxd, my, 0.027 μf ±10%, 600 vdcw	56289	160P27396	2	1		
0160-0030	C: fxd, paper, 2 μf ±20%, 200 vdcw	82376	MQCS-2-2M	1	1		
0160-0039	C: fxd, my, 0.27 μf ±10%, 200 vdcw	56289	160P27492	1	1		
0160-0054	C: fxd, paper, 0.01 μf ±20%, 400 vdcw	56289	109P10304	1	1		
0170-0017	C: fxd, my, 0.01 μf ±5%, 400 vdcw	84411	620S	2	1		
0170-0019	C: fxd, my, 0.1 μf ±5%, 200 vdcw	56289	192P10452	1	1		
0170-0021	C: fxd, my, 4700 pf ±10%, 400 vdcw	84411	620S	1	1		
0170-0022	C: fxd, my, 0.1 μf ±20%, 600 vdcw	09134	27	2	1		
0170-0029	C: fxd, poly, 0.01 μf ±10%, 50 vdcw	56289	1141P039R5S2	1	1		
0170-0030	C: fxd, poly, 0.1 μf ±10%, 50 vdcw	56289	114P	3	1		
0180-0012	C: fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	00853	PL1	1	1		
0180-0024	C: fxd, aluminum elect, 40 μf, 450 vdcw	56289	D32441	1	1		
0180-0028	C: fxd, elect, 2 sect, 1.5K μf/sect, 15 vdcw	56289	D32442	1	1		
0686-1035	R: fxd, comp, 10K ohms ±5%, 1/2 W	01121	EB1035	1	1		
0686-1055	R: fxd, comp, 1M ±5%, 1/2 W	01121	EB1055	2	1		
0686-2245	R: fxd, comp, 220K ohms ±5%, 1/2 W	01121	EB2245	1	1		
0686-8225	R: fxd, comp, 8.2K ohms ±5%, 1/2 W	01121	EB8225	1	1		
0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB1021	2	1		
0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 W	01121	EB1031	1	1		
0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2W	01121	EB1041	1	1		
0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	01121	EB1051	1	1		
0687-1061	R: fxd, comp, 10M ±10%, 1/2 W	01121	EB1061	1	1		
0687-1521	R: fxd, comp, 1.5K ohms ±10%, 1/2W	01121	EB1521	1	1		
0687-1531	R: fxd, comp, 15K ohms ±10%, 1/2 W	01121	EB1531	2	1		
0687-1541	R: fxd, comp, 150K ohms ±10%, 1/2W	01121	EB1541	1	1		
0687-1841	R: fxd, comp, 180K ohms ±10%, 1/2W	01121	EB1841	1	1		
0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 W	01121	EB2211	1	1		
0687-2221	R: fxd, comp, 2.2K ohms ±10%, 1/2W	01121	EB2221	2	1		
0687-2251	R: fxd, comp, 2.2M ±10%, 1/2 W	01121	EB2251	2	1		
0687-2261	R: fxd, comp, 22M ±10%, 1/2 W	01121	EB2261	2	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0687-2741	R: fxd, comp, 270K ohms ±10%, 1/2W	01121	EB2741	1	1		
0687-3311	R: fxd, comp, 330 ohms ±10%, 1/2 W	01121	EB3311	1	1		
0687-3321	R: fxd, comp, 3.3K ohms ±10%, 1/2W	01121	EB3321	1	1		
0687-3341	R: fxd, comp, 330K ohms ±10%, 1/2W	01121	EB3341	2	1		
0687-3921	R: fxd, comp, 3.9K ohms ±10%, 1/2W	01121	EB3921	1	1		
0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 W	01121	EB4711	1	1		
0687-4721	R: fxd, comp, 4.7K ohms ±10%, 1/2W	01121	EB4721	1	1		
0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2W	01121	EB4731	2	1		
0687-4741	R: fxd, comp, 470K ohms ±10%, 1/2W	01121	EB4741	4	1		
0687-5621	R: fxd, comp, 5.6K ohms ±10%, 1/2W	01121	EB5621	1	1		
0687-5641	R: fxd, comp, 560K ohms ±10%, 1/2W	01121	EB5641	1	1		
0687-5651	R: fxd, comp, 5.6M ±10%, 1/2 W	01121	EB5651	1	1		
0687-6811	R: fxd, comp, 680 ohms ±10%, 1/2 W	01121	EB6811	1	1		
0687-6841	R: fxd, comp, 680K ohms ±10%, 1/2W	01121	EB6841	1	1		
0687-6851	R: fxd, comp, 6.8M ±10%, 1/2 W	01121	EB6851	2	1		
0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2W	01121	EB8231	2	1		
0693-1521	R: fxd, comp, 1.5K ohms ±10%, 2 W	01121	HB1521	1	1		
0693-1801	R: fxd, comp, 18 ohms ±10%, 2 W	01121	HB1801	1	1		
0693-8211	R: fxd, comp, 820 ohms ±10%, 2 W	01121	HB8211	1	1		
0727-0077	R: fxd, dep c, 500 ohms ±10%, 1/2W	19701	DC1/2BR5 obd#	1	1		
0727-0158	R: fxd, dep c, 10.1K ohms ±1%, 1/2W	19701	DC1/2CR5 obd#	1	1		
0727-0240	R: fxd, dep c, 405K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727- 0274	R: fxd, dep c, 1M ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0757-0007	R: fxd, mfgl, 32.3K ohms ±1/2%, 1/2 W	65092	9851 obd#	1	1		
0757-0008	R: fxd, mfgl, 34.5K ohms ±1/2%, 1/2 W	65092	9851 obd#	1	1		
0757-0010	R: fxd, mfgl, 99K ohms ±1/2%, 1/2 W	65092	9852B obd#	1	1		
0757-0013	R: fxd, mfgl, 111K ohms ±1/2%, 1/2 W	65092	9852B obd#	1	1		
0757-0014	R: fxd, mfgl, 332K ohms ±1/2%, 1/2 W	65092	9852B obd#	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0757-0015	R: fxd, mfgl, 500K ohms ±1/2%, 1/2 W	65092	9852B obd#	1	1		
0757-0017	R: fxd, mfgl, 1M ±1/2%, 1/2 W	65092	9851 obd#	1	1		
0770-0002	R: fxd, 2.4K ohms ±5%, 4 W	07115	LPI-4	1	1		
1200-0003	Socket, tube: 9 pin, minat	71785	121-39-12-013	3	1		
1200-0005	Socket, tube: 8 pin	71785	101-29-11-024	1	1		
1200-0017	Socket, tube: 7 pin, minat	71785	111-39-11-014	3	1		
1250-0039	Connector, triaxial panel jack: input receptacle	91737	5632B	1	1		
1400-0084	Fuseholder	75915	342014	1	1		
1450-0020	Jewel	72765	14L-15	1	0		
1450-0022	Lampholder	72765	2020-AE	5	1		
1882-0005	Rectifier, metallic	81483	61-6911	1	1		
1930-0016	Tube, electron: 7 pin, 6X4	86684	6X4	1	1		
1932-0027	Tube, electron: 9 pin, 12AT7	33173	12AT7	1	1		
1932-0030	Tube, electron: 9 pin, 12AX7	86684	12AX7	1	1		
1932-0033	Tube, electron: 9 pin, 5751WA	33173	5751WA	1	1		
1940-0004	Tube, electron: 7 pin, OA2	86684	OA2	1	1		
1940-0007	Tube, electron: 7 pin, OB2	86684	OB2	1	1		
2100-0005	R: var, ww, lin, 2K ohms ±10%, 2 W	11237	252	1	1		
2100-0006	R: var, ww, 5K ohms ±10%, 3 W	71590	21-010-357	1	1		
2100-0053	R: var, ww, 10K ohms	11237	252	1	1		
2100-0074	R: var, comp, lin, 1M ±30%, 1/4 W	11237	45	1	1		
2110-0007	Fuse, cartridge: s-b, 1 amp (for 115 V operation)	71400	MDL1	1	10		
2110-0008	Fuse, cartridge: s-b, 1/2 amp (for 230 V operation)	75915	obd#				
2140-0008	Lamp, Ne	24455	NE2	1	1		
2140-0012	Lamp, minat: 0.15 amp, 6.3 V	24455	GE-12	5	5		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
3100-0157	Switch, rot: 2 pos, 1 sect	76854	188051-J1C	1	1		
3100-0158	Switch, rot: 18 pos, 5 sect	76854	187980-DL5X	1	1		
3101-0001	Switch, tog: SPST, 250 V, 3 amp	04009	AH&H 80994-H	1	1		
3140-0013	Motor, synchronous type: 6.3 V, AC	73061	Synchron model 610 (6.3 V)	1	0		
8120-0050	Cord, power	70903	CS-9941/PH-151/7.5 ft.	1	1		
9100-0094	Transformer, power	98734	7637	1	1		
9110-0038	Assy, Twin "T" Filter: for 50 cycle power operation	71590	obd#	1	1		
9110-0039	Assy, Twin "T" Filter: for 60 cycle power operation	71590	obd#	1	1		
10010A	Assy, probe, outer sleeve and jaw	28480	10010A	1	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08994	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

00015-26
Revised: 10 July 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

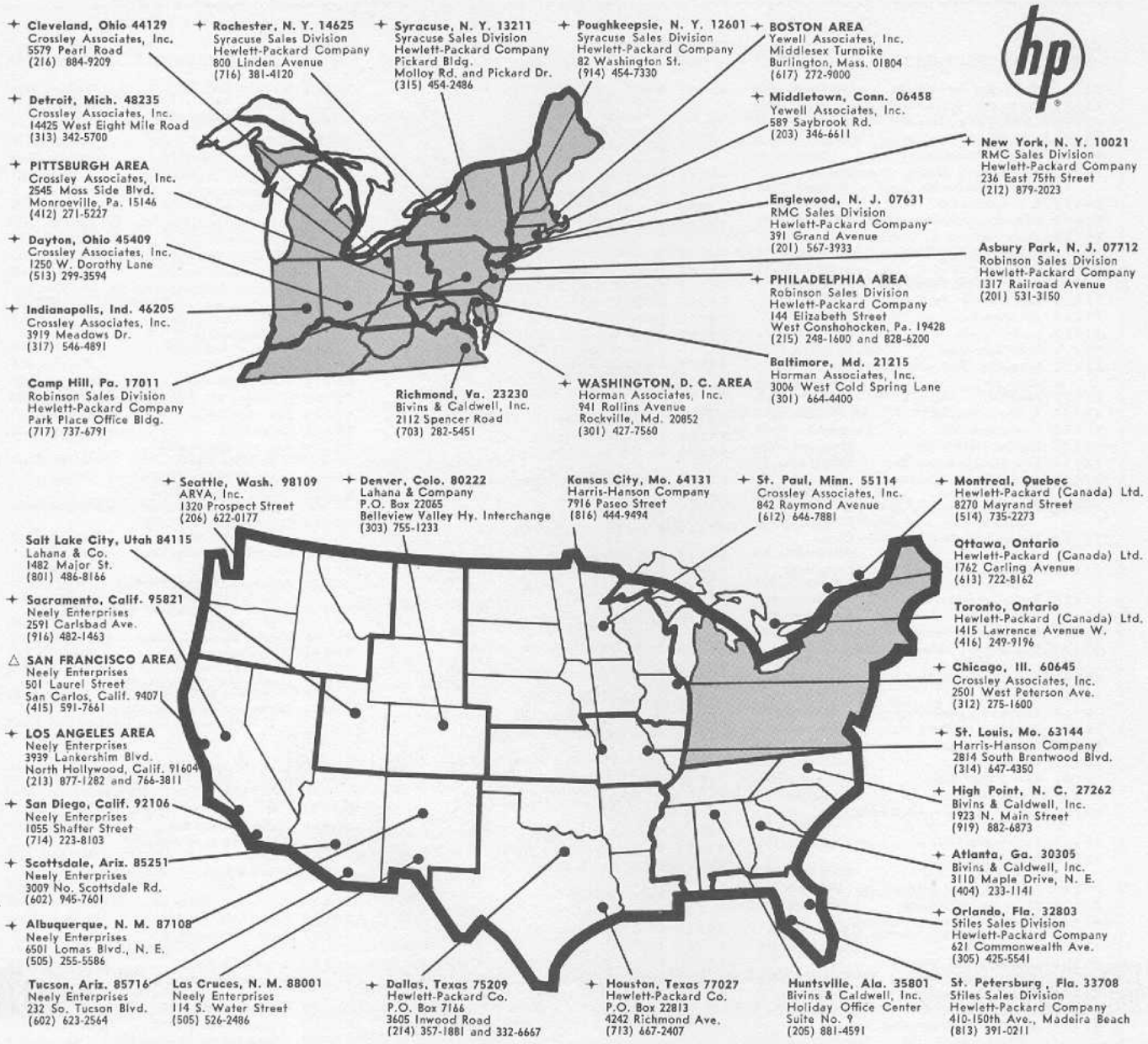
THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NNA	"N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.
000RR	Radio Industries	Des Plaines, Ill.
000SS	Control of Elgin Watch Co.	Burbank, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated: April 1962
H4-2 Dated: March 1962

00015-26
Revised: 10 July 1962

HEWLETT-PACKARD SALES AND SERVICE OFFICES IN NORTH AMERICA



△ For replacement parts and repair services in the San Francisco area, please contact Hewlett-Packard Company at: 395 Page Mill Road, Palo Alto, California 94306 (415) 326-3950.
+ Indicates Instrument Repair Stations

HEWLETT-PACKARD COMPANY
1501 Page Mill Road • Palo Alto, California 94304
Tel: (415) 326-7000 • TWX: 415-492-9200 • Cable: HEWPACK

DYMEC DIVISION
395 Page Mill Road • Palo Alto, California 94306
Tel: (415) 326-1755 • TWX: 415-492-9363

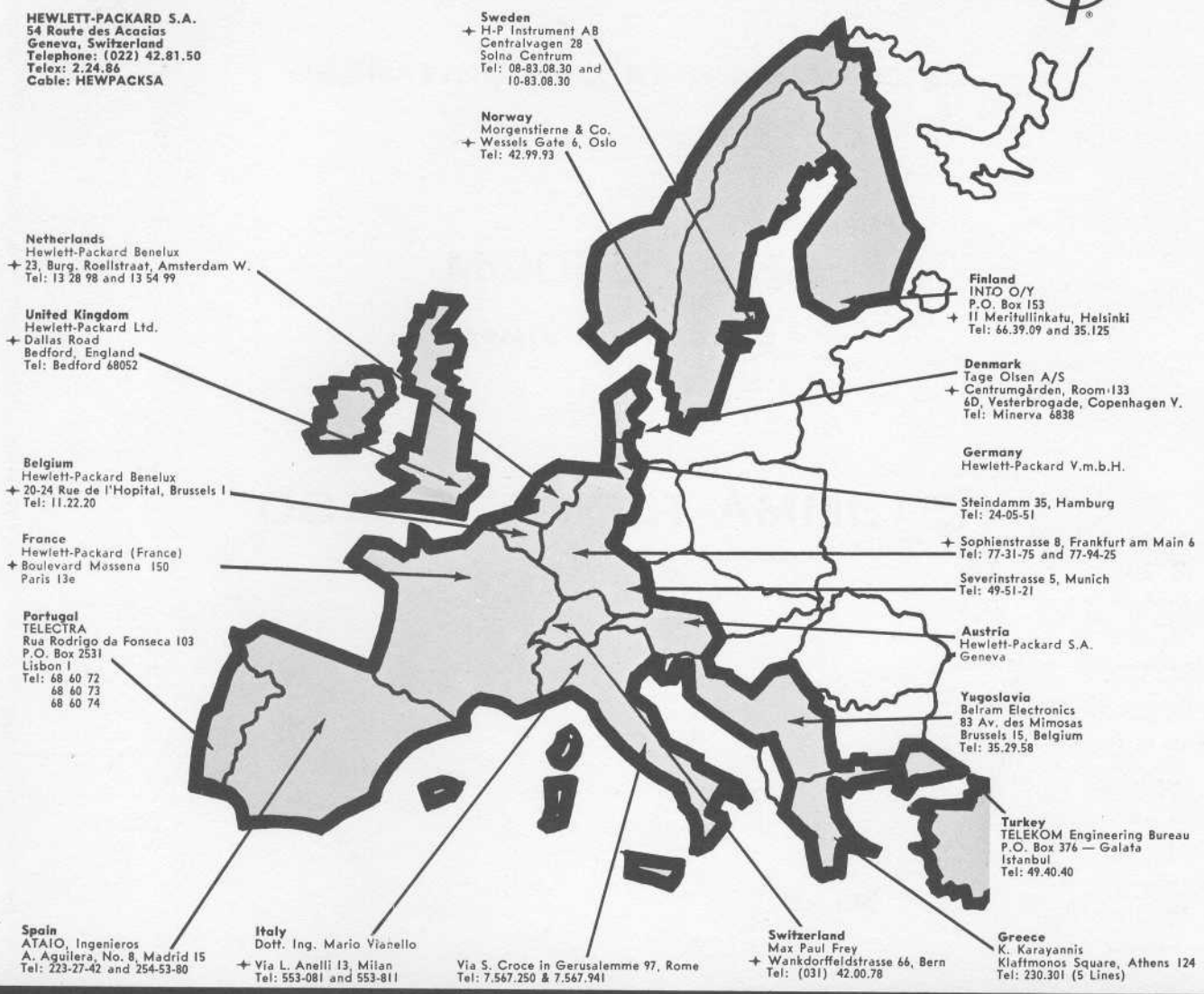
BOONTON RADIO COMPANY
Green Pond Road • Rockaway, New Jersey 07866
Tel: Oakwood 7-6400 • Cable: BOONRACO

HARRISON LABORATORIES
41 Industrial Road • Berkeley Heights, N. J. 07922
Tel: 464-1234 • TWX: Summit, N. J.

SANBORN COMPANY
Industrial Division • 175 Wyman St., Waltham, Mass. 02154
Tel: (617) TW 4-6300 • TWX: 617-894-0789

F. L. MOSELEY CO.
409 N. Fair Oaks Ave. • Pasadena, Calif. 91102 • Tel: (213) MUrray 1-0208 • TWX: PASA CAL 7687 • Cable MOCOPAS

AUTHORIZED SALES AND SERVICE OFFICES IN WESTERN EUROPE



HEWLETT-PACKARD S.A.
54 Route des Acacias
Geneva, Switzerland
Telephone: (022) 42.81.50
Telex: 2.24.86
Cable: HEWPACKSA

Sweden
+ H-P Instrument AB
Centralvagen 28
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