HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

400D/H/L

VACUUM TUBE VOLTMETER

INCLUDING H02-400D

400D/H/L

OPERATING AND SERVICE MANUAL

MODEL 400D
MODEL 400H
MODEL 400L
AND
SPECIF. H02-400D

SERIALS PREFIXED: 017-, 048-, & 116-

VACUUM TUBE VOLTMETER

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

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SECTION I
GENERAL DESCRIPTION

1-1. INTRODUCTION. (See figure 1-1.)

1-2. This manual contains operating and servicing instructions, and a parts breakdown, for the Models 400D, 400H, and 400L Vacuum Tube Voltmeters manufactured by the Hewlett-Packard Company, Palo Alto, California. This manual applies to all Models 400D, 400H, and 400L Voltmeters having the serial number prefix 017-. The Model 400D Voltmeter is similar to a military counterpart, Electronic Voltmeter ME-30A/U, in appearance and operation, but contains modified electrical circuits to obtain improved performance. Applicable Federal Stock Numbers for the voltmeters are as follows:

Model 400D: 6625-643-1670
Model 400H: 6625-557-8261
Model 400L: 6625-729-8360

1-3. The Models 400D, 400H, and 400L Voltmeters are the same except for the differences listed below:

a. The front panel meters are different in each model, as described in paragraph 1-6.

b. The accuracy specifications are different for each model, as described in figure 1-2.

1-4. DESCRIPTION.

1-5. The Hewlett-Packard Models 400D, 400H, and 400L Vacuum Tube Voltmeters are general purpose, portable electronic a-c voltmeters of high sensitivity and stability. They are suited to both laboratory and field use. All three voltmeter models measure a-c voltages from 0.001 to 300 volts rms full scale, with a frequency bandwidth covering 10 cps to 4 megacycles. The voltmeters are compact, accurate, and rugged and have fast meter response, high imput impedance, stable calibration accuracy, and freedom from the effects of normal line voltage variations. The voltmeters are designed for long instrument life with a minimum of servicing.

a. Voltage Range: 0:1 millivolt to 300 volts in 12 ranges providing full scale readings of the following voltages:

0.001	0.100	10.00
0.003	0.300	30.00
0.010	1.000	100.00
0.030	3.000	300.00

b. Decibel Range: -72 to +52 db, in 12 ranges.

c. Frequency Range: 10 cps to 4 mc.

d. Input Impedance: 10 megohms shunted by 15 pf (15 $\mu\mu$f) on ranges 1.0 volt to 300 volts; 25 pf on ranges 0.001 volt to 0.3 volt.

e. Stability: Line voltage variations of ±10% do not reduce the specified accuracy, and line voltage transients are not reflected in the meter reading. Electron tube deterioration to 75% of normal transconductance affects accuracy less than 0.5% from 20 cps to 1 mc.

f. Amplifier: OUTPUT terminals are provided so that the voltmeter can be used to amplify small signals or to enable monitoring of waveforms under test with an oscilloscope. Output voltage is approximately 0.15 volt rms on all ranges with full-scale meter deflection. Amplifier frequency response is same as the voltmeter. Internal impedance is approximately 50 ohms over entire frequency range.

g. Accuracy: Model 400D -

±2% of full scale, 20 cps to 1 mc;
±3% of full scale, 20 cps to 2 mc;
±5% of full scale, 10 cps to 4 mc.

Model 400H -

±1% of full scale, 50 cps to 500 kc;
±2% of full scale, 20 cps to 1 mc;
±3% of full scale, 20 cps to 2 mc;
±5% of full scale, 10 cps to 4 mc.

Model 400L -

±2% of reading or ±1% of full scale, whichever is more accurate, 50 cps to 500 kc.
±3% of reading or ±2% of full scale, whichever is more accurate, 20 cps to 1 mc.
±4% of reading or ±3% of full scale, whichever is more accurate, 20 cps to 2 mc.
±5% of reading 10 cps to 4 mc.

h. Power Requirement: 115/230 volts ±10%, 50/1000 cps, approximately 80 watts.

i. Size: 11-3/4 in. high, 7-1/2 in. wide, 12 in. deep.

j. Weight: 18 lbs; shipping weight approximately 23 lbs.

Figure 1-2. Table of Specifications

1-6. Each model voltmeter has three calibrated scales on the panel meter. The Models 400D and 400H have two linear VOLTS scales, 0 to 1 and 0 to 3, and one DECIBELS scale, -12 to +2 db. The meters used in the Models 400H and 400L are larger and include a mirror to eliminate parallax in viewing and to facilitate use of the higher scale calibration accuracy of these models. The Model 400L VOLTS scales are logarithmic in calibration, from 0.3 to 1 and 0.8 to 3; and the DECIBELS scale is linear. In all models, the VOLTS scales are calibrated to indicate the root-mean-square (rms) value of an applied sine wave. Actual meter deflection is proportional to the average value of the applied signal, thereby minimizing additional meter deflection due to noise and harmonic distortion.

1-7. A voltmeter output signal is provided at the front panel OUTPUT terminals. This output is proportional to the meter reading and has a waveshape similar to the applied signal. This signal level is about 0.15 volts rms for a full-scale meter reading, regardless of the input signal level. The internal impedance at the OUTPUT terminal is 50 ohms over the full frequency range. High-impedance loads (above 100K) will not adversely affect the accuracy of the voltmeter. This output is valuable for increasing the sensitivity of bridges, etc., where distortion added to the waveform is not a factor.

1-8. The voltmeter chassis is constructed of aluminum alloy throughout. The panel is finished in non-reflecting, light-grey baked enamel; the cabinet is finished in dark-grey, baked wrinkle paint. The cabinet is equipped with rubber feet and a leather carrying handle. Control markings on the front panel are engraved and black filled. INPUT and OUTPUT terminals are special binding posts which accept either bare wire or banana plugs; the 3/4-inch spacing between binding posts accepts standard dual-banana plugs. The "ground" side of the INPUT and OUTPUT terminals is connected to the instrument chassis which is in turn connected to the power line ground through the third (round) prong of the plug on the power cable.

1-9. The voltmeter is equipped with a non-detachable power cord. Test leads, which may be plain wire leads or coaxial cable, and test probes must be supplied by the user.

1-10. ACCESSORIES.

1-11. Accessory instruments for the voltmeter are available (not supplied) to increase its range of operation and application, such as increasing voltage measurement range and input impedance, converting to current measurement, providing line matching, etc., as follows:

a. H-P AC-60A Line Matching Transformer. Provides balanced 135-ohm or 600-ohm input, 5 kc to 600 kc.

b. H-P AC-60B Bridging Transformer. Allows voltage measurement on balanced lines. 20 cps to 45 kc.

c. H-P 452A Capacitive Voltage Divider. Safely measures power-frequency voltages to 25 kilovolts. Division ratio, 1000:1. Input capacity, 15 pf ±1 pf.

d. H-P 454A Capacitive Voltage Divider. Accuracy ±3%. Division ratio, 100:1. Input impedance, 50 megohms, resistive, shunted with 2.75 pf capacity. Maximum voltage, 1500 volts.

e. H-P 456A AC Current Probe. Allows current measurements without breaking the circuit. Sensitivity 1 mv/ma ±2% at 1 kc. Maximum input 1 amp rms; 2 amp peak. Output noise less than 50 μv rms.

f. H-P 470A-470F Shunt Resistors. For measuring currents as small as 1 microamp full scale. Accuracy ±1% to 100 kc, ±5% to 4 mc (470A, ±5% to 1 mc). Maximum power dissipation, 1 watt.

SECTION II
INSTALLATION

2-1. UNPACKING AND INSPECTION.

2-2. There are no special precautions for unpacking the voltmeter. Save the shipping carton and packing materials for possible storage or reshipment. When unpacking, inspect instrument and packing materials for signs of damage in shipment. Make an operation check as directed in paragraph 2-10 to determine if performance is satisfactory. If there is any indication of damage, immediately file a claim with the transport service used or other cognizant authority.

2-3. LINE VOLTAGE REQUIREMENT.

2-4. The voltmeter is wired at the factory for use on 115-volt a-c power. This voltage may vary ±10% without adverse effect upon voltmeter performance. The voltmeter can be wired for use on 230-volt a-c power by reconnecting the dual primary windings on the power transformer as shown in the schematic diagram in Section V. When using 230-volt power, change from a 1-amp to a 1/2-amp slow-blow fuse. If necessary, provide an adapter for attaching the standard 115-volt plug on the voltmeter to the 230-volt outlet.

2-5. POWER LINE CONNECTION.

2-6. The three-conductor power cable on the voltmeter is terminated in a polarized three-prong male connector. The third contact is an offset round pin added to a standard two-blade connector, which grounds the instrument chassis when used with the appropriate receptacle. To connect this plug in a standard two-contact receptacle, use an adapter. The chassis ground connection is brought out of the adapter in a green pigtail lead for connection to a suitable ground.

2-7. The power plug normally supplied with the voltmeter is made of molded rubber and is an integral part of the power cable. On certain military contracts, a modification of the Model 400D, termed the H02-400D, is equiped with a removable plug having the same pin configuration but constructed of corrosion-resistant material. In all other respects the H02-400D is the same as the Model 400D and carries the same Federal Stock Number.

WARNING

The lower INPUT and OUTPUT signal terminals on the panel of the voltmeter are connected directly to the chassis of the voltmeter. Any voltage applied to the lower terminal will be shorted directly to ground. If the ground connection in the power cord is disconnected by use of an adapter, the entire voltmeter cabinet will carry whatever potential is applied to the lower terminal and may be a hazard to the operator.

2-8. INSTALLATION.

2-9. The voltmeter is a portable instrument requiring no permanent installation. The voltmeter is for bench-top operation, standing on its rubber feet with its front panel near the vertical plane. A bail is provided for raising the front of the cabinet to obtain a better viewing angle.

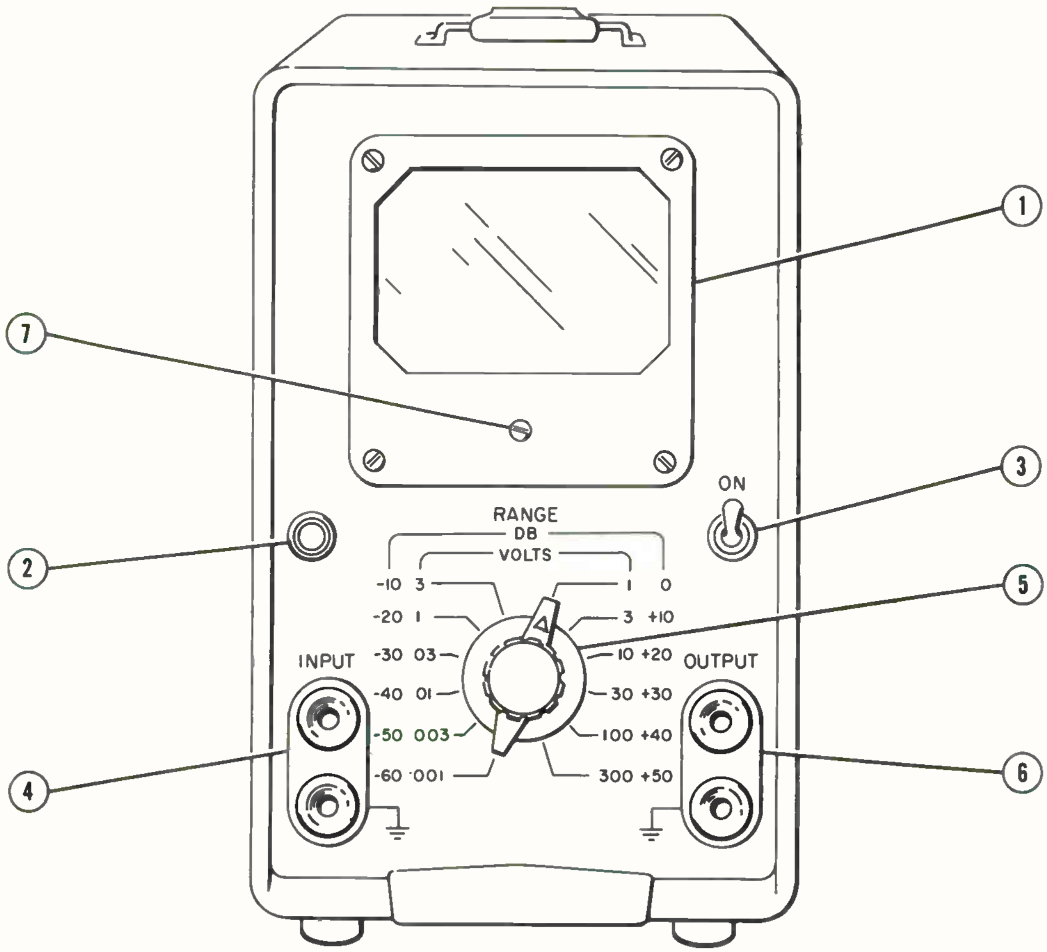
2-10. OPERATION CHECK.

2-11. The voltmeter is ready for use as received from the factory. The simple check described below can be made by incoming inspectors to determine if electrical damage was incurred in shipment. If more complete proof of instrument performance is required, the over-all performance check described in paragraph 5-22 must be used. Make a simple performance check as follows:

a. Connect voltmeter to the power line through a variable transformer. Set transformer for 115 volts, turn on and allow a five-minute warmup.

b. Measure any sine wave voltage, excepting the power line, from 0.01 to 300 volts whose exact voltage is known. Note that the lower INPUT terminal is connected to the power line ground.

c. While making the above measurement, adjust the line voltage from 103 to 127 volts. The reading on the meter must not change by more than the width of the pointer.



REFERENCE NUMBER	DESIGNATION	FUNCTION
1	Panel meter	Indicates rms volts and decibels of sine wave signals.
2	Indicator light	Indicates that voltmeter is turned on.
3	ON Power switch	Applies line power to voltmeter.
4	INPUT terminals	Receive voltage to be measured or signal to be amplified.
5	RANGE (DB-VOLTS) switch	Selects full-scale deflection sensitivity.
6	OUTPUT terminals	Supply signal level proportional to meter reading,with same waveform as applied to INPUT terminals.
7	Zero adjust screw	Meter zero adjust screw (for 400D and 400H only).

Figure 3-1. Voltmeter Front Panel, Showing Controls and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INSTRUMENT TURN-ON.

3-2. The voltmeter is ready for use as received from the factory and will give specified performance after a few minutes warmup. See Section II for information regarding connection to the power source and to the voltage to be measured. Controls are shown in figure 3-1.

3-3. GENERAL OPERATING INFORMATION.

3-4. METER ZERO CHARACTERISTIC. When the Model 400D and 400H Voltmeters are turned off, the meter pointer should rest exactly on the zero calibration mark on the meter scale. If it does not, zero-set the meter as instructed in paragraph 5-7. The meter supplied in the Model 400L Voltmeter is not provided with a mechanical meter zero adjustment. When the voltmeter is turned on with the INPUT terminals shorted, the meter pointer may deflect upscale slightly; this deflection does not affect the accuracy of a reading.

NOTE

When the voltmeter RANGE switch is set to the lowest ranges and the INPUT terminals are not terminated or shielded, noise pickup can be enough to produce up to full-scale meter deflection. This condition is normal and is caused by stray voltages in the vicinity of the instrument. For maximum accuracy on the .001-volt range, the voltage under measurement should be applied to the voltmeter through a shielded test lead.

3-5. METER SCALES. The two voltage scales on each of the voltmeter models are related to each other by a factor of $1:\sqrt{10}$ (10 db). In conjunction with the calibrated RANGE switch steps, this provides an intermediate range step spaced 10 db between "power of ten" ranges, which are 20 db apart. The relationship of the DECIBELS scale to the 0 to 1 VOLT scale is determined by making 0 db on the DECIBELS scale equal to the voltage required to produce 1 milliwatt in 600 ohms (0.775 volts). Thus, the DECIBELS scale reads directly in dbm (decibels referred to one milliwatt) across a 600-ohm circuit, and can be used to measure absolute level of sine wave signals. It can also be used to measure relative levels of any group of signals which have the same waveform, across any constant circuit impedance. The RANGE switch changes voltmeter sensitivity in 10-db steps accurate to within ±1/8 db. The RANGE switch position indicates the value of a full-scale meter reading.

3-6. CONNECTIONS. Voltmeter test leads must be provided by the user. The type of leads and probes used will depend upon the application, as listed below:

a For connection to low-impedance signal sources, plain wire leads often are sufficient.

b. For high-impedance sources, or where noise pickup is a problem, low-capacity shielded wire must be used with a shielded, dual banana plug for connection to the voltmeter terminals.

c. If a probe is used, it should also be shielded to prevent pickup from the hand.

d. For signals above a few hundred kilocycles, the capacity of the test leads must be kept to a minimum by using very short leads, preferably unshielded. An alligator clip should be used at the test end so that connection can be made without adding the capacity of the user's hands.

3-7. MAXIMUM INPUT VOLTAGE. Do not apply more than 600 volts dc to the INPUT terminals. To do so exceeds the voltage rating of the input capacitor.

3-8. If an applied voltage momentarily exceeds the selected full-scale voltmeter sensitivity, a few seconds may be required for circuit recovery, but no damage will result.

3-9. INPUT VOLTAGE WAVEFORM. The voltmeter is calibrated to indicate the root-mean-square value of a sine wave; however, meter pointer deflection is proportional to the average value of whatever waveform is applied to the input. If the input signal waveform is not a sine wave, the reading will be in error by an amount dependent upon the amount and phase of the harmonics present, as shown in figure 3-2 below. When harmonic distortion is less than about 10%, the error which results is negligible.

INPUT VOLTAGE CHARACTERISTICS	TRUE RMS VALUE	METER INDICATION
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100.5	100
Fundamental +20% 2nd harmonic	102	100-102
Fundamental +50% 2nd harmonic	112	100-110
Fundamental +10% 3rd harmonic	100.5	96-104
Fundamental +20% 3rd harmonic	102	94-108
Fundamental +50% 3rd harmonic	112	90-116

Note: This chart is universal in application since these errors are inherent in all average-responding type voltage-measuring instruments.

Figure 3-2. Effect of Harmonics on Voltage Measurements

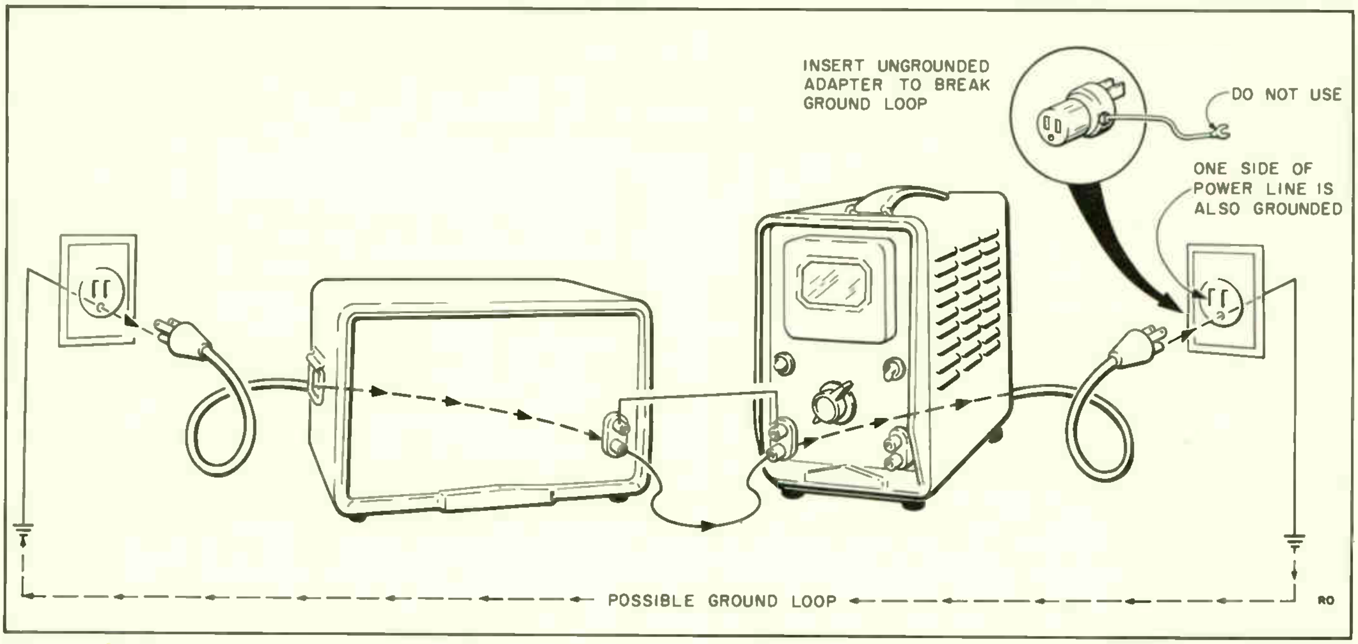


Figure 3-3. Test Setup for Avoiding Ground Loop

3-10. Since the voltmeter meter deflection is proportional to the average value of the input waveform, it is not adversely affected by moderate levels of random noise. The effect that noise has on the accuracy of the meter reading depends upon the waveform of the noise and upon the signal-to-noise ratio. A square wave has the greatest effect, a sine wave intermediate effect, and "white" noise has the least effect on the meter reading.

3-11. If the noise signal is a 50% duty cycle square wave and the signal-to-noise ratio is 10:1 (between peak voltages), the error will be about 1% of the meter reading. If the noise signal is "white" noise and the signal-to-noise ratio 10:1, the error is negligible.

3-12. LOW-LEVEL MEASUREMENTS AND GROUND CURRENTS.

3-13. When the voltmeter is used to measure signal levels below a few millivolts, ground currents in the meter test leads can cause an error in meter reading. Such currents are created when two or more ground connections are made between the instruments of a test setup and/or between the instruments and the power line ground. Two ground connections complete an electrical circuit (ground loop) for the voltages which are generated across all instrument chassis by stray fields, particularly the fields of transformers. These ground currents can be minimized by disconnecting the ground lead in the power cord from either the voltmeter or the signal source being measured, at the power outlet as shown in figure 3-3, and by making sure that in the test setup no other ground loop is formed that can cause a ground current to flow in the voltmeter test leads. Although the resultant voltage developed across a test lead is in the order of microvolts, it is enough to cause noticeable errors in measurements of a few millivolts. The presence of ground currents can sometimes be determined by simply changing the grounds for the instruments in the setup and watching for a change in meter reading. If changing the ground system causes a change in meter reading, ground currents are present.

3-14. MEASUREMENT OF VOLTAGE.

3-15. The meter has two VOLTS scales, 0 to 1 and 0 to 3. When the RANGE switch is set to .001, .01, .1, 1, 10, or 100 VOLTS, read the 0 to 1 scale. When the RANGE switch is set to .003, .03, .3, 3, 30, or 300 VOLTS, read the 0 to 3 scale.

CAUTION

The lower (black) signal INPUT and OUTPUT terminals and the instrument case are connected to the power system ground when the instrument is used with a standard three-terminal (grounding) receptacle. Connect only ground-potential circuits to the black INPUT and OUTPUT terminals.

3-16. Operate the instrument as follows:

a. Connect the voltmeter to the a-c power source.

b. Turn the Power switch ON and allow a warmup period of approximately five minutes.

c. Disconnect any external equipment from the OUTPUT terminals.

d. Set the RANGE switch to the VOLTS range which will read the voltage to be measured at mid-scale or above. If in doubt, select a higher VOLTS range.

e. Connect the voltage to be measured to the INPUT terminals.

CAUTION

AVOID A SHORT CIRCUIT ACROSS THE POWER LINE! To measure power line voltage, first connect only the upper (red) INPUT terminal to each side of the power line, in turn, leaving it connected to the side that causes meter indication. Then connect the lower (black) INPUT terminal (grounded internally) to the other side of the line. If this procedure is not followed, the power line may be short-circuited through the grounded INPUT terminal of the voltmeter.

f. Read the meter indication on the appropriate VOLTS scale, in accordance with the full-scale value indicated on the RANGE switch. Evaluate the reading in terms of the full-scale value indicated on the RANGE switch. Study the following examples:

Example 1
When the RANGE switch is in the .1 VOLTS range, read the 0 to 1 VOLTS scale. If the meter indicates .64 on that scale, the voltage being measured is:

$$.64 \text{ (meter indication) } \times \frac{.1 \begin{bmatrix}\text{switch-selected}\\ \text{voltage range}\end{bmatrix}}{1 \text{ (full-scale value)}} = .064 \text{ volt}$$

Example 2
When the RANGE switch is in the 30 VOLTS range, read the 0 to 3 VOLTS scale. If the meter indicates 1.6 on that scale, the voltage being measured is:

$$1.6 \text{ (meter indication) } \times \frac{30 \begin{bmatrix}\text{switch-selected}\\ \text{voltage range}\end{bmatrix}}{3 \text{ (full-scale value)}} = 16 \text{ volts}$$

3-17. MEASUREMENT OF DECIBELS.

3-18. The DECIBELS meter scale is provided for measuring dbm directly across 600 ohms and for measuring db ratio for comparison purposes when each measurement is made across the same circuit impedance. To measure signal level directly in dbm (0 dbm equals 1 milliwatt into 600 ohms) proceed as follows:

a. Connect the voltmeter to the a-c power source.

b. Turn the Power switch ON and allow a warmup period of approximately five minutes.

c. Disconnect any external equipment from the OUTPUT terminals.

d. Set the RANGE switch to the DB range which will give an upscale reading of the signal to be measured. If in doubt, select a higher-level scale.

e. Connect the voltage to be measured to the INPUT terminals.

f. Note the meter indication on the DECIBELS scale (-12 to +2 db). The signal level is the algebraic sum of the meter indication and the db value indicated by the RANGE selector. Study the following examples:

Example 1
If the indication on the DECIBELS scale is +2 and the RANGE switch is in the +20 DB position, the level is +22 dbm.

Example 2
If the indication on the DECIBELS scale is +1.5 and the RANGE switch is in the -40 DB position, the level is -38.5 dbm.

3-19. To measure db across impedances other than 600 ohms, follow the above procedure and evaluate the results as follows:

NOTE

Since the measurement is made across other than 600 ohms, the level obtained in step f is in db, but not in dbm.

a. To obtain the difference in db between measurements made across equal impedances, algebraically subtract the levels being compared.

b. To obtain the reading of a single measurement in dbm, note the impedance across which the measurement is made and refer to the Impedance Correction Graph, described in paragraph 3-20.

c. To obtain the difference in dbm between measurements made across different impedances, convert each measurement to dbm using the Impedance Correction Graph described in paragraph 3-20. Then algebraically subtract the dbm levels being compared.

3-20. IMPEDANCE CORRECTION GRAPH.

3-21. As the voltmeter DECIBELS scale is calibrated to indicate dbm for measurements made across 600-ohm circuits, a correction factor must be used when measurements are made across circuit impedances other than 600 ohms, if absolute dbm levels are desired. The correction factor is not necessary in measuring relative db levels (not dbm) across the same impedance, but it is required for comparison of db levels measured across different impedances. The Impedance Correction Graph in figure 3-4 gives the correction factor for conversion of the meter reading to dbm when the impedance of the circuit under test is known. To use the graph, read the conversion factor corresponding to the test circuit impedance and add it to the meter reading determined by the method of paragraph 3-17. Observe the algebraic sign of the correction factor in making the algebraic addition. Use the following examples:

Example 1
If the measurement is made across 90 ohms, the indication on the DECIBELS scale is +2, and the RANGE switch is at the +30 DB position, the level in dbm is obtained as follows:

+ 2 (meter indication)
+30 (RANGE switch position)
+32 (sum)
+ 8 (correction factor from the Impedance
+40 dbm Correction Graph)

Example 2
For the same conditions as given above, except that the measurement is made across an impedance of 60,000 ohms, the level in dbm is obtained as follows:

+ 2 (meter indication)
+30 (RANGE switch position)
+32 (sum)
-20 (Correction factor from the Impedance
+12 dbm Correction Graph)

3-22. USE OF VOLTMETER AMPLIFIER.

3-23. The amplifier in the voltmeter may be used for amplifying weak signals. With full-scale meter deflection, the open-circuit output of the amplifier is approximately 0.15 volt rms regardless of the RANGE switch position. The impedance looking into the OUTPUT terminals is approximately 50 ohms. The frequency response and calibration of the voltmeter may be affected by the impedance of a load applied to the OUTPUT terminals. To check the effect of the applied load: observe the meter reading obtained with no load connected to the OUTPUT terminals and then note any shift of reading when the external circuit is connected to the OUTPUT terminals. If the shift is negligible, the measurement is not being affected appreciably by the load. Whenever the input signal is changed, i.e., a different frequency or band of frequencies is applied, repeat the quick check described above.

3-24. Maximum gain from the amplifier is obtainable only on the lowest (.001 volts) range, since output level is the same for all bands. This is due to the 10-db amplification loss per step inserted by the RANGE switch as it is turned clockwise. Amplification may also be obtained on the .003, .01, .03, and 1 volt ranges.

3-25. When the voltmeter is used as an amplifier, select a range which gives a meter deflection near full scale. Off-scale signals more than twice the value of the position of the RANGE switch will cause severe distortion.

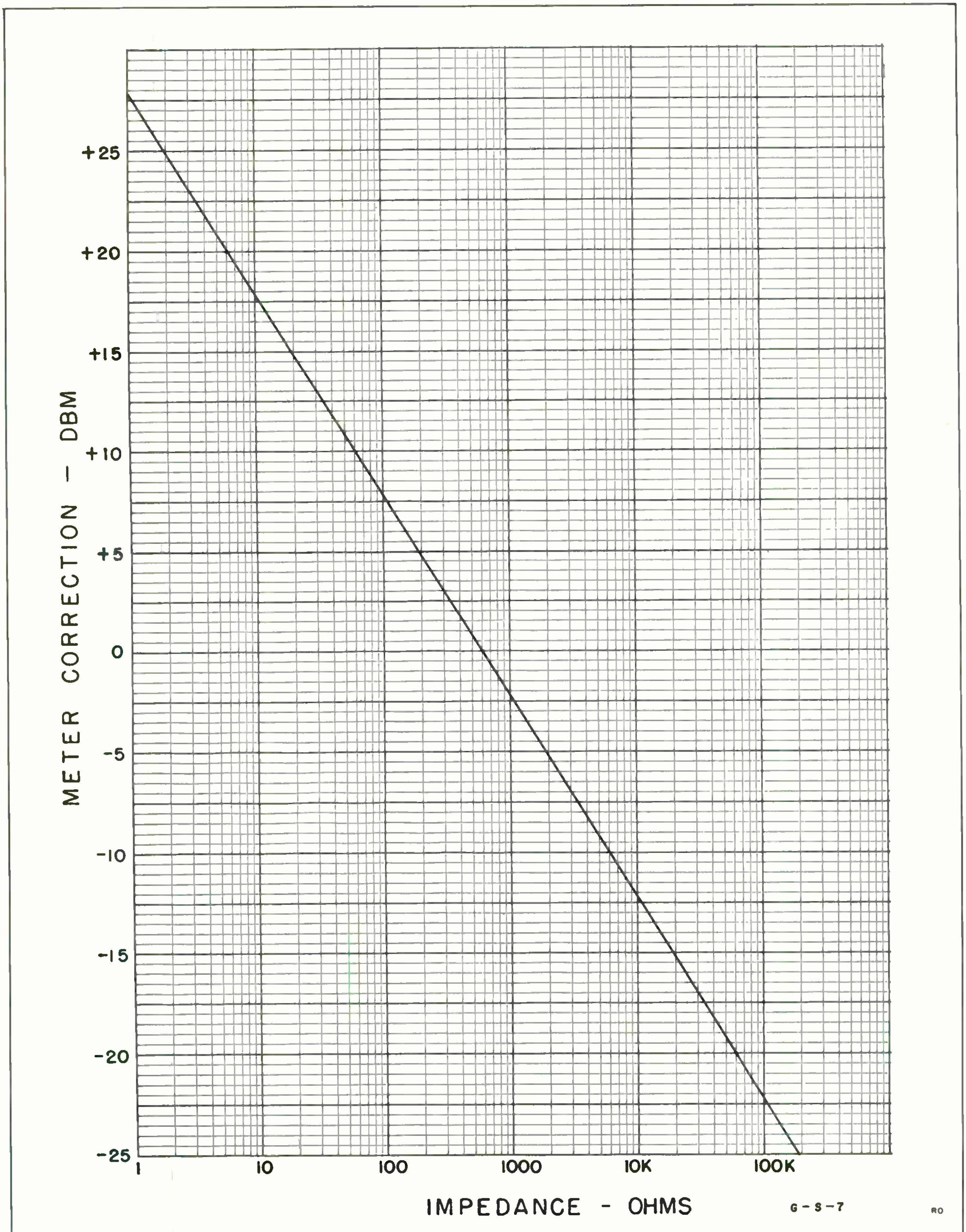


Figure 3-4. Impedance Correction Graph

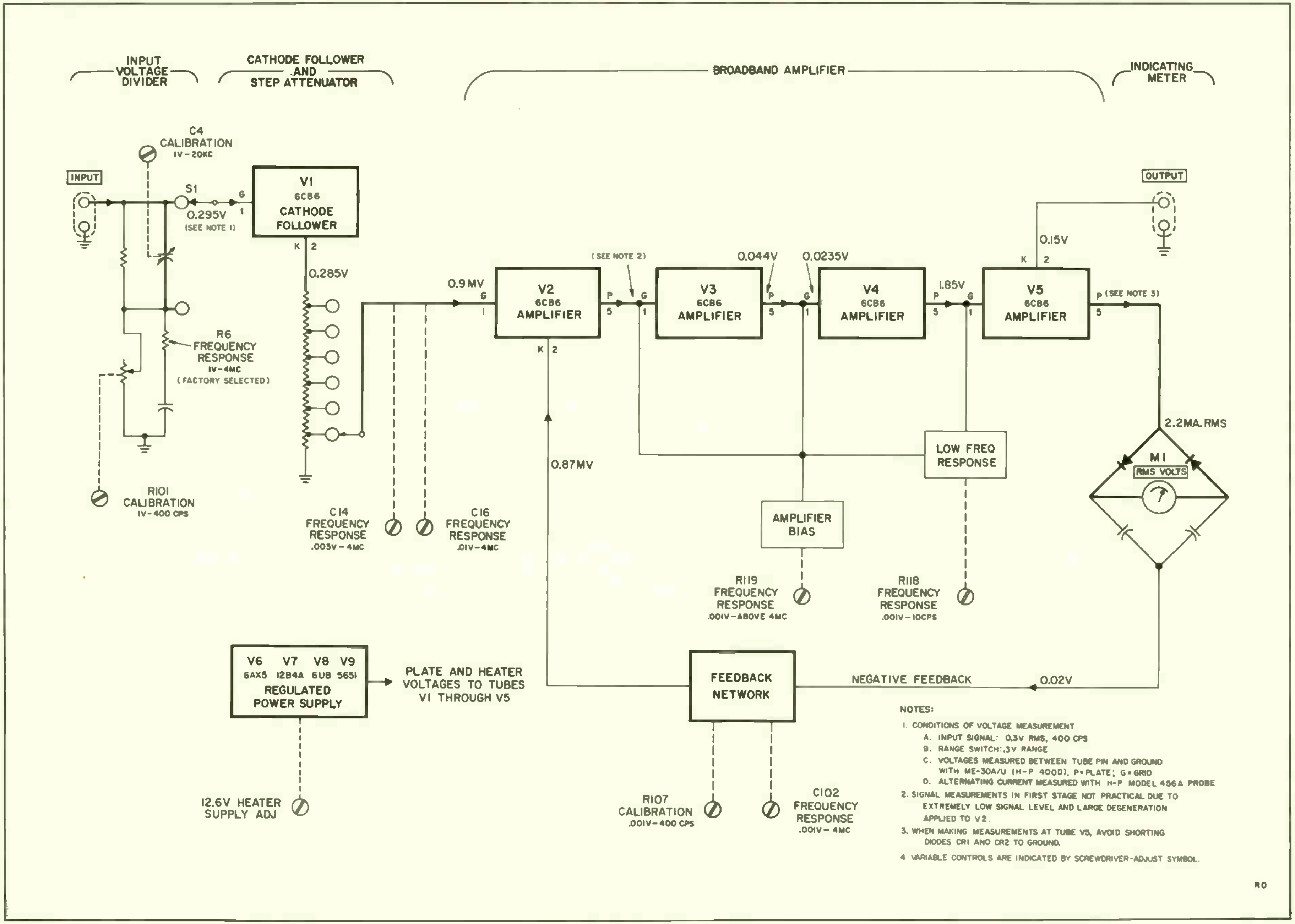


Figure 4-1. Voltmeter Block Diagram

SECTION IV

CIRCUIT DESCRIPTION

4-1. BLOCK DIAGRAM.

4-2. The electrical circuits of the voltmeter are shown in the block diagram in figure 4-1; they consist of an input voltage divider controlled by the RANGE switch, a cathode follower input tube, a precision step attenuator controlled by the RANGE switch, a broadband amplifier, an indicating meter, and a regulated power supply. The voltage applied to the INPUT terminals for measurement is divided by 1000 before application to the input cathode follower when the RANGE switch is set to the 1-volt range and higher; the input voltage is applied directly to the cathode follower on the lower ranges. The voltage from the cathode follower is divided in the precision attenuator to be less than 1 millivolt for application to the voltmeter amplifier. The output of the amplifier is rectified in a full-wave bridge rectifier with a d-c milliammeter across its midpoints. The resultant direct current through the meter is directly proportional to the input voltage.

4-3. INPUT VOLTAGE DIVIDER AND STEP ATTENUATOR.

4-4. The input voltage divider limits the signal level applied to the input cathode follower to less than 0.3 volt rms when voltages above this level are measured with the RANGE switch set at the 1-volt range or above. The divider consists of a resistive branch with one element made adjustable to obtain exact 1000:1 division at middle frequencies and a parallel capacitive branch with one element made adjustable to maintain exact 1000:1 division to beyond 4 megacycles. The input impedance of the voltmeter is established by this divider and is the same for all positions of the RANGE switch. On the six low-voltage positions of the RANGE switch, the input divider provides no attenuation of the input voltage. (See figure 5-10 for the complete schematic.)

4-5. The step attenuator in the cathode circuit of the input cathode follower reduces the voltage to be measured to 1 millivolt or less for application to the voltmeter amplifier. Each step of the attenuator lowers the signal level by exactly 10 db ($1:\sqrt{10}$). The attenuator consists of six precision wirewound resistors which are selected to very high accuracy and carefully mounted on a 12-position rotary switch. The RANGE switch rotor has two contactors (see figures 5-9 and 5-10); the first contacts each resistor in turn while the input divider is in the non-attenuating position; the second rotor finger repeats these contacts while the input attenuator is in the attenuating position. On the .001-volt range a fixed capacitor (C15) is automatically connected to provide flat frequency response beyond 4 megacycles. In the .003- and the .01-volt ranges, separate adjustable capacitors (C14, C16) are automatically connected to the attenuator to permit setting the frequency response at 4 megacycles. C14 and C16 are also connected to the attenuator on the 3- and 10-volt ranges. Fixed capacitor C106 (permanently connected) flattens frequency response on the .03- and 30-volt ranges.

4-6. Cathode follower V1 provides a constant, high input impedance to the input voltage divider and INPUT terminals of the voltmeter and provides a relatively low impedance in its cathode circuit to drive the step attenuator. The voltage gain factor across V1 is 0.95.

4-7. BROADBAND VOLTMETER AMPLIFIER.

4-8. Amplification of the signal voltage is provided by a four-stage stabilized amplifier consisting of tubes V2 through V5 and associated circuits. The amplifier provides between 55- and 60-db gain with about 55 db of negative feedback at mid-frequencies. The feedback signal is taken from the plate of the output amplifier (V5) through the meter rectifiers and gain-adjusting circuit to the cathode of the input amplifier (V2). Variable resistor R107 in the feedback network adjusts the negative feedback level to set the basic gain of the amplifier at mid-frequencies, while adjustable capacitor C102 permits setting amplifier gain at 4 megacycles. Variable resistor R118 in the coupling circuit between V4 and V5 permits adjusting the gain of the amplifier at 10 cycles per second by controlling the phase shift of low-frequency signals between these two stages (increasing phase shift decreases degeneration and increases gain).

4-9. Variable resistor R119 in the grid return path for V3, V4, and V5 adjusts the total transconductance of these tubes in order to restrict the maximum gain-bandwidth product of the amplifier. The gain-bandwidth product must be restricted to give a smooth frequency response rolloff above 4 megacycles and to prevent possible unstable operation at frequencies far above 4 megacycles when tubes having unusually high transconductance are used (tube transconductance tolerances during manufacture permit wide variations in new tubes; the adjustment permits the use of such tubes). The plate voltage from V5 is rectified by the meter rectifiers and drives the feedback network. The cathode voltage of V5 is fed to the meter OUTPUT terminals for monitoring purposes. The current through V5, and thus the signal voltage at the cathode, is affected by the loading of the meter rectifiers. For signal levels causing third-scale or more meter deflection, this distortion consists of a very small irregularity near 0 volts on the waveform as each diode begins conduction.

4-10. INDICATING METER CIRCUIT.

4-11. The meter rectifier circuit consists of two silicon diodes and two capacitors connected as a bridge with the indicating meter across the mid-points as shown in figure 4-2. The diodes provide full-wave rectification of the signal current for operating the meter. Electron flow through the meter is supplied in the following manner (see figure 4-2). During the positive-going half cycle of plate voltage on V5, rectifier CR1 conducts electrons from both C32 and C33 back to the B+ buss. The portion of electrons from C33 flows through the meter on the way to B+. At this point in the cycle, both C32 and C33 are charged to the potential of B+ less some small drop in R51 and R52.

4-12. During the negative-going half cycle of the plate voltage of V5, rectifier CR2 conducts electrons back to both C32 and C33 from the plate of V5. That portion of electrons going back to C32 flows through the meter on the way (in the same direction that the electrons flowed in the first, positive, half cycle). At this point in the cycle, both C32 and C33 are discharged. The pulsating current through the meter is smoothed by C34 to prevent meter pointer vibration when measuring low-frequency signals. The current is proportional to the arithmetic average value of the waveform amplitude of the signal. Meter calibration in rms volts is based on the mathematical ratio between the average and rms values of true sine wave current.

4-13. In addition, the bridge serves as a segment of a voltage divider (in series with L11 and R108) connected across the output of the amplifier. The negative feedback voltage fed to the input of the amplifier is obtained across L11 and R108. The alternating charge and discharge of C32 and C33 produce at their junction with L11 an alternating current of the same phase and waveform as that at the plate of V5. This phase is negative with respect to the input signal applied to the first stage of the amplifier (V2), and drives the negative feedback network.

4-14. POWER SUPPLY.

4-15. The power supply consists of tubes V6 through V9 and the associated circuits, as shown in the complete schematic diagram, figure 5-10. The power supply furnishes regulated +250V d-c voltage for the grid and plate bias circuits of tubes V1 through V5, unregulated 12.6V d-c voltage for the heater supply of tubes V1 through V4, and 6.3V a-c voltage for the heater supply of tubes V5 through V8. The power supply is designed to operate from either a 115-volt (±10%) or a 230-volt (±10%) a-c power source of 50 to 1000 cps. The primary winding of power transformer T1 is arranged in two sections, which can be strapped either in parallel or in series, to permit operation on 115V or 230V, respectively.

4-16. The output of rectifier V6 is applied to the voltage regulator circuit consisting of V7 through V9 which supplies a constant, +250 volts dc to the stabilized amplifier circuit of the voltmeter. Tube V7 is the series regulator tube, and V9 provides a fixed reference voltage drop, with which the output voltage is compared in amplifier V8B. V8A is a cathode follower which couples the reference voltage from V9 to V8B without loading V9. The regulated output voltage is applied to the control grid of V8B, while the reference voltage is applied to its cathode. The difference between the control grid and cathode voltages controls the operating point of V8B and thus its plate voltage, which in turn supplies the grid voltage for regulator V7. Any change in the regulated output of V7 produces a correcting change in the grid bias of V7 through the action of V8B, thus maintaining an essentially constant output voltage despite changes in line voltage or load on the supply. The gain of V8B is high enough to keep the output at the V7 cathode regulated

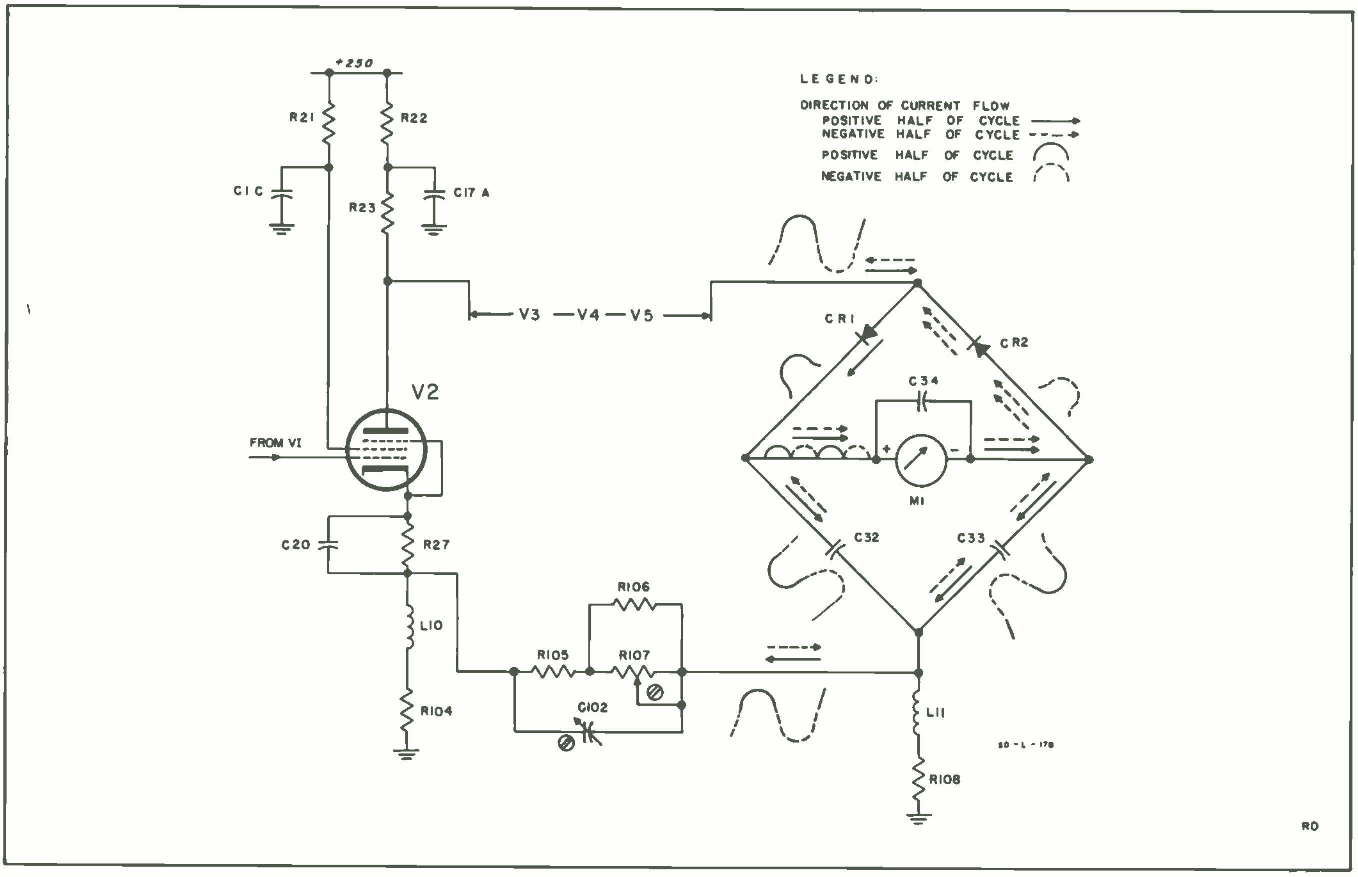


Figure 4-2. Simplified Schematic of Meter Bridge Circuit

to within ±1 volt dc as the V7 plate voltage is varied ±10%, with about 60 ma of load current. The response of the regulating circuits is fast enough to reduce ripple in the output voltage to less than 1 millivolt, supplementing the filtering action of C30. C36 couples the ripple component in the regulated output directly to V8B to avoid attenuation in R62. R57 shunts a small portion of the load current around V7 to prevent excessive V7 plate dissipation at high line voltages. R63 and C35 constitute a low-pass filter which prevents noise generated in V9 from reaching V8B.

4-17. The heater supply for the voltmeter tubes is divided into two sections. One section supplies d-c voltage for the tubes in the input cathode follower and the amplifier. The other section supplies a-c voltage for the tubes in the power supply. The voltage required for the heaters of tubes V1 through V4 is obtained from 6.3V and 7.3V secondary windings of transformer T1, which are series connected. The voltage developed across the two series-connected windings is rectified by full-wave rectifier CR3, reduced to 12.6 volts by R66 and R68 in parallel, and applied to the series-parallel-connected heaters of V1 through V4, as shown in figure 5-10. The series-parallel connection of the four heaters establishes a voltage of 6.3V for each. The heater of V5 receives 6.3V ac from one of the windings which drives CR3. The heaters of V6, V7, and V8 receive 6.3V ac from a separate 6.3V secondary winding on T1.

SECTION V
MAINTENANCE

5-1. SCOPE.

5-2. This section contains complete instructions for repairing and calibrating the voltmeter. This material is covered in the following groups of paragraphs:

Lead Paragraph	Topic
5-3.	Precautions
5-5.	Test Equipment Required
5-7.	Meter Zero Adjustment
5-9.	Cabinet Removal
5-10.	Tube Replacement
5-13.	Replacement of Special Parts
5-17.	Trouble Shooting
5-20.	Testing the Power Supply
5-22.	Testing Voltmeter Performance
5-24.	Calibration and Frequency Response Adjustments

5-3. PRECAUTIONS.

5-4. Observe the following precautions:

a. Make no adjustments and replace no parts in the voltmeter except as described in one of the following procedures. If an adjustment or replacement of parts is made without following instructions or understanding the effects, further trouble shooting may be complicated.

b. Do not remove tubes when the voltmeter is turned on. Before replacing tubes refer to paragraph 5-10.

5-5. TEST EQUIPMENT REQUIRED.

5-6. The test equipment required for complete testing of the voltmeter is listed in figure 5-1. Equivalent instruments may be substituted for those listed.

5-7. METER ZERO ADJUSTMENT.

5-8. The meter is properly zero-set when its pointer rests over the zero calibration mark on the meter scale when the instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Adjust the zero-set if necessary, as follows:

a. Allow the voltmeter to operate for 20 minutes so that the meter movement will reach normal operating temperature.

b. Turn the voltmeter off and allow one minute for all capacitors to discharge.

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	DESIGNATION
Electronic Multimeter	0 to 300 a-c and d-c volts; accuracy of ±3% or better; input impedance 100 megohms.	Voltage and resistance measurement.	ME-26B/U or H-P 410B
Oscillator	10 cps to 300 kc; 3 volts output into 50-ohm load.	Signal source for testing and calibration	H-P 200S
Voltmeter Calibrator (Precision Voltage Source)	400-cps output voltage; 0.001 to 300 volts in 10-db steps ±0.2%; 0.1 to 1.0 volt in 0.1 volt steps ±0.2%.	Calibrating voltmeter at mid-frequencies.	H-P 738A
Frequency Response Test Set	300-kc to 4-mc range; 3 volts output into 50-ohm load; 10-db steps, 0 to 70 db.	Calibrating voltmeter frequency response.	H-P 739A
Oscilloscope or AC Voltmeter	10-cps to 4-mc range.	Trouble shooting by signal tracing.	H-P 160A or H-P 400D
Variable Transformer	Adjust line voltage between 103 and 127V ac with 1-amp load.	Checking voltmeter. operation with varying line voltage.	CN-16/U or Ohmite VT2
D-C Current Test Set (Milliammeter)	Clip-on type measurement; current range up to 100 ma.	Checking load on power supply.	H-P 428A

Figure 5-1. Test Equipment Required

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

d. Continue to rotate adjustment screw clockwise; stop when pointer is exactly 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 the zero adjustment screw from the meter suspension. If pointer moves during this step, because the adjustment screw is turned too far counterclockwise, repeat the procedure of steps c through e.

5-9. CABINET REMOVAL.

a. Remove the two cabinet retaining screws at the rear of the instrument.

b. Push the instrument chassis forward out of the cabinet. The bezel ring remains attached to the front panel.

c. When replacing cabinet, pull power cable through opening at rear of cabinet. Be sure power cable is not caught between chassis and cabinet. Replace retaining screws.

5-10. TUBE REPLACEMENT.

CAUTION

Do not remove tubes from the voltmeter when power is applied. To do so may damage the voltmeter.

5-11. In many cases instrument malfunction can be corrected by replacing a weak or defective tube. Check tubes by substitution while following the voltmeter performance check procedure in paragraph 5-22. Results obtained through the use of a "tube checker" can be misleading. Before removing the tubes from the instrument, mark the original tubes so they can be returned to the same socket if they are not defective. Replace only those tubes proven to be defective.

5-12. Figure 5-2 lists each tube in the voltmeter with its function and the check or adjustment required if the tube is replaced.

5-13. REPLACEMENT OF SPECIAL PARTS.

5-14. PRECISION RESISTORS AND INDUCTORS. Several parts used in the voltmeter have closer tolerances than those used in most test equipment. Resistors R104, R105, R108, and R111 through R116 are precision components. If these resistors require replacement, use the same value and type as the original, as shown in the parts breakdown. If different values are used or component positions are moved, the calibration of the voltmeter may be inaccurate or the frequency response may be altered. The inductance of L10 and L11 affects the frequency response of the voltmeter. Do not alter the shape or position of these coils. Install replacement components in the same positions the original components occupied, as nearly as possible.

5-15. DIODE RECTIFIERS. Special high-performance silicon diodes selected by the Hewlett-Packard Co. are used for CR1 and CR2. When replacing the silicon diodes, be careful in soldering; heat can damage them. Place a heat sink (such as a long-nose pliers) on each diode lead close to the diode body to conduct the heat away. If CR1 and CR2 are replaced, the voltmeter calibration and frequency response must be checked as described in paragraph 5-22.

5-16. RANGE SWITCH. Because of the critical construction and wiring of switch S1, it is not practical to attempt a major repair on the switch. When mechanical failure occurs in switch S1, replace the complete

CIRCUIT REF.	TYPE	FUNCTION	CHECK OR ADJUSTMENT
V1	6CB6	Cathode Follower	Calibration and frequency response (para. 5-22)
V2	6CB6	1st Amplifier	
V3	6CB6	2nd Amplifier	
V4	6CB6	3rd Amplifier	
V5	6CB6	4th Amplifier	
V6	6AX5	High Voltage Rectifier	Test of the power supply (para. 5-20)
V7	12B4A	Series Regulator	
V8	6U8	Control Tube	
V9	5651	Reference Tube	

Figure 5-2. Adjustments Required When Tubes Are Replaced

switch assembly. Use the following procedure. (Locate parts by referring to figures 5-3 and 5-4; RANGE switch connections are shown in figure 5-9.)

a. Remove voltmeter cabinet. (See paragraph 5-9.)

b. Loosen setscrews in RANGE switch knob and remove knob.

c. Disconnect capacitor C104 from switch S1.

d. Disconnect white leads from capacitors C14 and C16. Label each lead with a tag.

e. Remove the two screws and one nut which retain the switch shield plate.

f. Disconnect white leads from switch contacts. Tag each lead to permit easy connection to the new switch.

g. Disconnect the heavy dark-green switch lead, the heavy light-green switch lead, and the heavy black switch lead at terminal strips. Tag each lead.

NOTE

The input shield must be removed for access to the terminal board connection of the dark-green lead.

h. Remove the nut which holds the switch bushing to the front panel.

i. Remove RANGE switch assembly.

j. The sequence for installing the replacement RANGE switch assembly is the reverse of the removal procedure.

k. After replacement of switch S1, check the calibration and frequency response of the voltmeter and make necessary adjustments.

5-17. TROUBLE SHOOTING.

5-18. The first step in trouble shooting is to learn the nature of the symptoms of the malfunction with as much detail as possible. Inspect the test setup being used when symptoms of malfunction were observed, to be sure that the source of trouble is not external to the voltmeter. Then remove the voltmeter cabinet as directed in paragraph 5-9 and inspect the circuits of the voltmeter, looking for signs of overheating, deterioration, and physical damage or tampering. Check the fuse. If the fuse is blown, try another fuse to see if it blows; if it does, measure the d-c resistance of filter capacitors C1, C17, C30, C39, rectifier CR3, and the windings of transformer T1 to locate the short circuit without applying power to the voltmeter.

5-19. If the voltmeter can be turned on safely (without the fuse blowing), measure the line voltage applied to T1 and the voltmeter power supply output voltages (see paragraph 5-20). Check the tubes of the power supply if the regulated voltage is not the proper value or is unstable. Use the procedures of figure 5-5 and the tests described in paragraph 5-22 to learn the full nature of the trouble symptom. Watch for marginal operation by operating the voltmeter at 103 and 127 line volts while making tests. Check the tubes in the voltmeter amplifier. Measure the tube element voltages at the tube sockets and compare readings with the values shown in the voltage and resistance diagram in figure 5-8. Apply a test signal to the input and measure the voltage of the test signal while tracing it through each coupling network and each stage of amplification. Compare readings with those shown in the block diagram, figure 4-1. In figure 4-1, an a-c current probe, H-P Model 456A, is recommended for the measurement of a-c current in the meter circuit without breaking any leads. If this current probe is not available, avoid measurement of the a-c current. Check meter indications as directed in paragraph 5-22 instead. An oscilloscope may be used for observing test signal waveshape and measuring amplitude, if desired.

5-20. TESTING THE POWER SUPPLY.

5-21. The regulated power supply produces a constant +250 vdc to operate all the tubes in the amplifier section. The stability of the voltmeter depends directly upon the stability of the +250 volts from the supply. When the supply is operating satisfactorily, the +250 volt output remains constant and the ripple level on it remains less than about 1 millivolt for line voltages between 103 and 127 volts. Weak tubes (V6, V7, and V8) are the usual causes of instability. An unstable regulator tube is indicated by excessive line frequency ripple and varying output voltage as the line voltage is changed. Marginal operation is indicated if a trouble symptom appears only when a low or high line voltage is applied. To test the complete power supply proceed as follows:

a. Connect the voltmeter to an adjustable line transformer so the applied line voltage can be varied between 103 and 127 volts. Set line voltage to 115 volts, turn on the voltmeter, and allow a five-minute warmup period.

b. Measure the d-c voltage between V6 (pin 8) and ground. Normal value is 410 ± 10 volts with exactly 115 volt power line input. Lower line voltage 10% to 103 volts for 2 minutes. If the d-c voltage slowly drops below 360 volts, replace V6.

c. Measure the d-c voltage between V7 (pin 1) and ground with line voltage adjusted to 115 volts. Correct value is 250 ± 5 volts.

d. Vary line voltage from 103 to 127 volts. The d-c voltage observed in step c must not change more than ± 1 volt. For wrong voltage and/or poor regulation, replace V7, V8 or V9.

e. Measure the a-c voltage between V7 (pin 1) and ground. Ripple voltage must be less than 3 mv for any line voltage (103 to 127 volts). High ripple voltage is caused by defective V8, V7, V6 or V9. Replace in this order.

f. Measure the direct current in the lead from V7 (pin 1) which must be less than 60 milliamperes. If the current is much too high, the regulator circuit will not function properly. Excessive current indicates

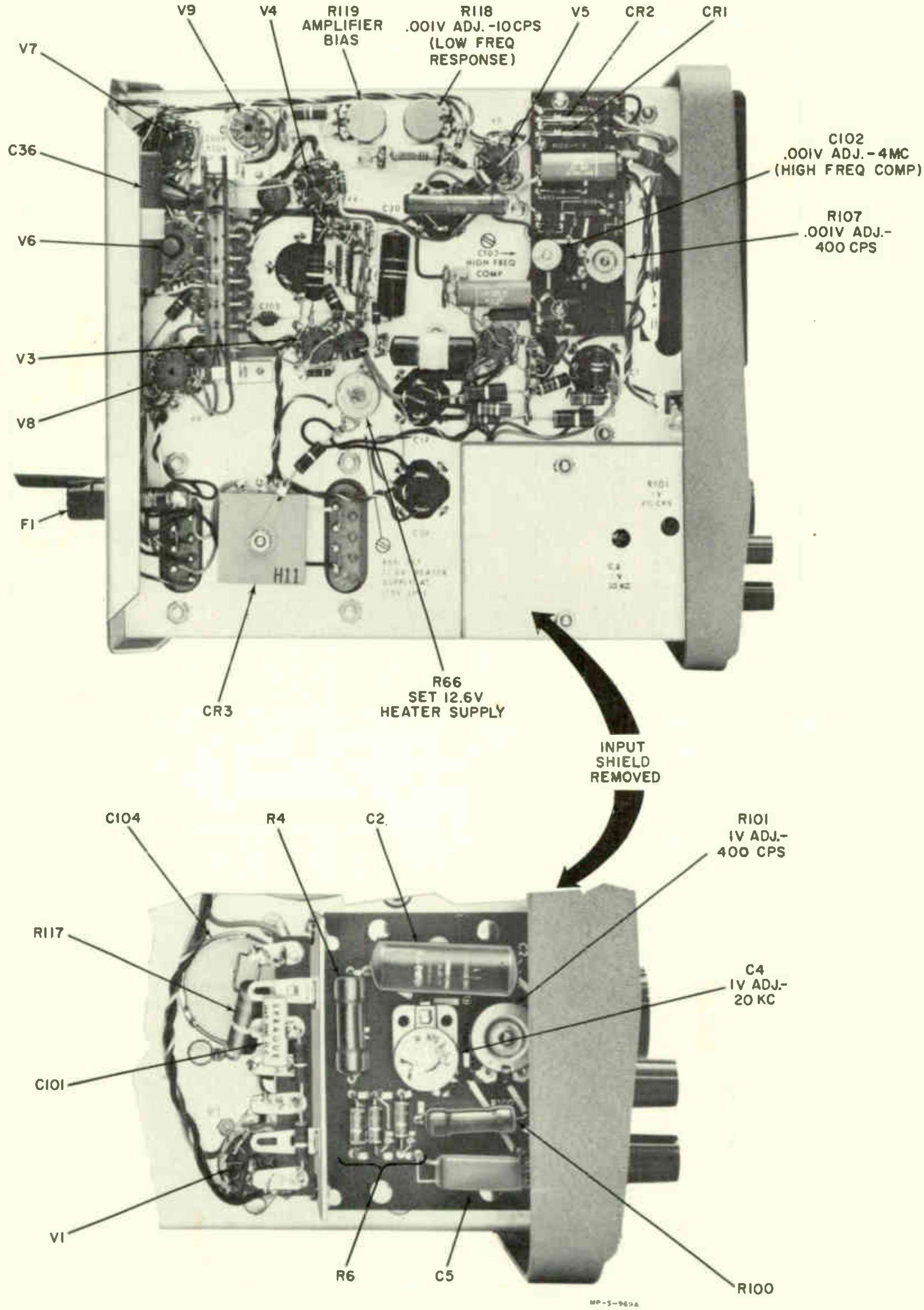


Figure 5-3. Left Side View of Voltmeter Chassis

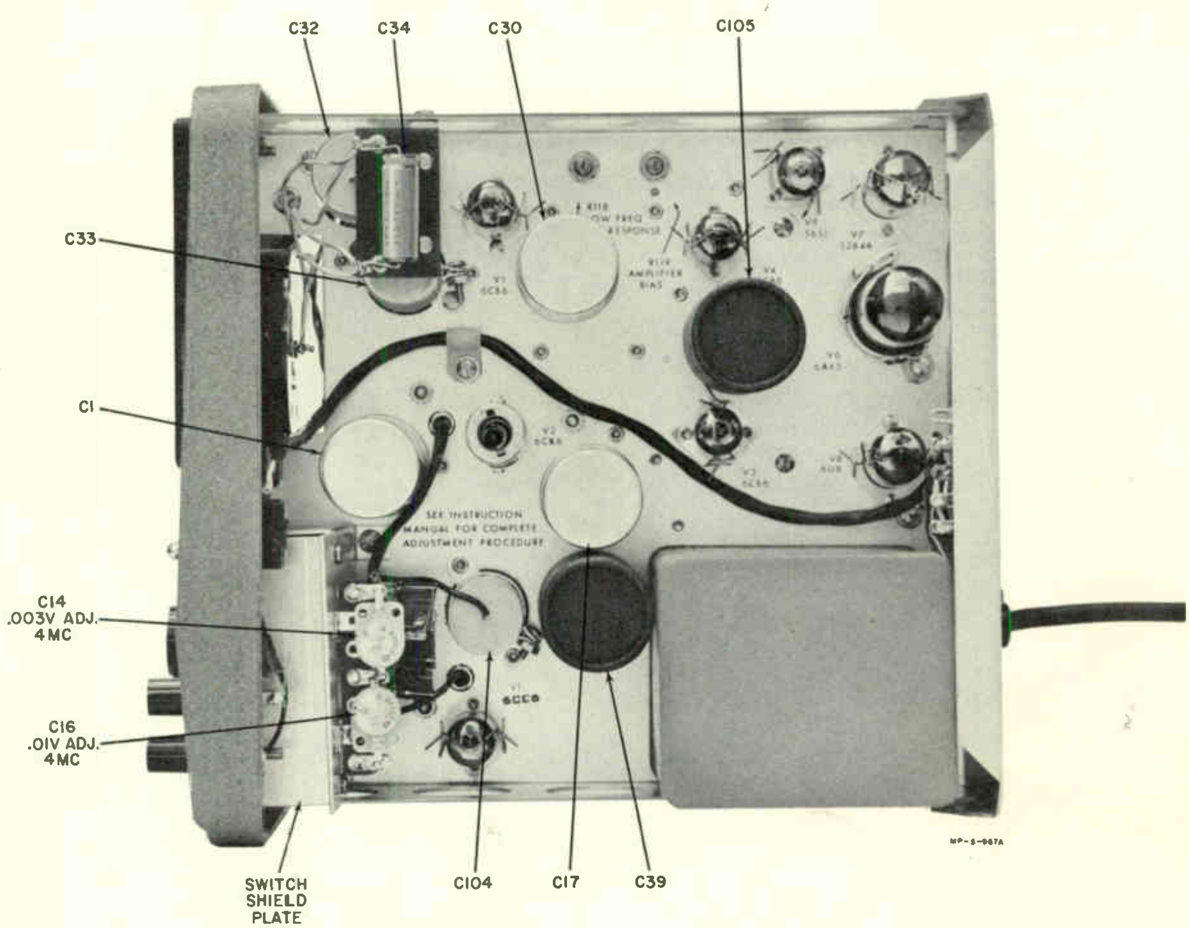


Figure 5-4. Right Side View of Voltmeter Chassis

a short circuit or partial short in the circuits of the voltmeter amplifier section. A clip-on type milliammeter should be used for this measurement.

g. If the output voltage is stable but is incorrect, measure the resistance of R62 and R64. The ratio of these two resistors determines what the output voltage will be. If the value of one of these resistors is incorrect and produces the wrong output voltage, replace it with a resistor which provides the correct output voltage.

h. Measure the d-c voltage across C39A which must be 12.6 volts with a line voltage of 115 volts. If necessary, adjust R66 to obtain 12.6 volts. If the voltage cannot be set to 12.6 volts, check the a-c voltage from the associated transformer windings; also check CR3 and C39.

5-22. TESTING VOLTMETER PERFORMANCE.

5-23. The following test procedure checks the accuracy and stability of the voltmeter at low and high frequencies and with low and high line voltages. It can be used for comprehensive incoming inspection, for proof of performance, and for trouble shooting. If the readings are within specifications during these tests, the voltmeter is operating properly. This test is made without removing the cabinet. Instruments used to test the accuracy of the voltmeter (see paragraph 5-5) must be known to have sufficient accuracy to make valid measurements. Proceed as follows:

a. Connect the voltmeter as shown in figure 5-6. (This setup measures calibration accuracy at mid-frequencies.)

b. Set the line voltage to 115 volts, turn the voltmeter on and allow a 30-minute warmup period.

c. Check the instrument meter zero setting as instructed in paragraph 5-7.

d. Connect the voltmeter to the voltmeter calibrator; set voltmeter RANGE switch to .001, and adjust voltmeter calibrator MULTIPLIER switch to provide 0 volts output.

TROUBLE	PROBABLE CAUSE	REMEDY
1. Power indicator lamp does not light.		
	a. Fuse F1 burned out.	a. Replace fuse F1. If replaced fuse blows, check items 2 and 3 below.
	b. Power indicator lamp DS1 defective.	b. Replace power indicator lamp DS1.
	c. Defective a-c power cable.	c. Repair or replace power cable.
	d. Power switch S2 defective.	d. Replace Power switch S2.
	e. Transformer T1 primary winding terminals incorrectly connected.	e. Check connections of transformer T1 primary winding; rewire if necessary.
2. Fuse F1 blows immediately when Power switch S2 is operated to ON.		
	a. Tube V6 shorted.	a. Replace rectifier tube V6.
	b. Rectifier CR3 defective.	b. Replace heater rectifier CR3.
	c. Short circuit in transformer T1 or in circuit wiring.	c. Remove all tubes, and check transformer windings. Replace transformer T1 if defective. Check for short circuit.
3. Fuse F1 blows after Power switch S2 has been operated to ON and tube heaters have warmed up.		
	Short in power supply circuit.	Check for short circuit at cathodes V6 and V7. Replace defective component.
4. Power indicator lamp lights; voltmeter does not indicate on all ranges.		
	a. Power supply or voltage regulator circuits defective.	a. Check tubes V6, V9, V7, and V8 in turn. Check high-voltage winding of transformer T1. Replace defective component.
	b. Rectifier CR3 or circuit component defective.	b. Check for 12.6 volts dc across output of rectifier CR3. Check resistors R66 and R68. If tubes V1 and V2 are not lighted, check capacitor C39. Replace defective component.
	c. Diode CR1 or CR2 defective.	c. Replace diode (paragraph 5-15).
5. Meter indication normal on low ranges (.001 to .3 volts). Meter sensitivity distorted on high-voltage ranges (1 to 300 volts).		
	Compensated 1000:1 divider defective.	Check C4 and R4. Replace defective component.
6. Meter indicates low on all ranges.		
	a. Low amplifier gain.	a. Check B+ voltage (paragraph 5-20). Check tubes V2 through V5 for low emission. If any tube is replaced, check and recalibrate the voltmeter (paragraph 5-22).
	b. Diode CR1 or CR2 defective.	b. Replace diode (paragraph 5-15).
7. Meter indication unstable or erratic.		
	a. Power supply, circuit defective.	a. Check heaters and B+ voltage. Replace defective component.
	b. Amplifier tube V1, V2, V3, V4, and V5 defective.	b. Check V1 through V5 for microphonics or noise. If tube is replaced, check and recalibrate the voltmeter (paragraph 5-22).
8. Meter indication normal on .001 and 1 volt range. Meter sensitivity distorted on all other ranges (.003, .01, .03, .1, .3, 3, 10, 30, 100, and 300 volts).		
	Faulty RANGE switch S1.	Check switch contacts of S1. Replace RANGE switch S1 if defective (paragraph 5-16).

Figure 5-5. Trouble-Shooting Procedure

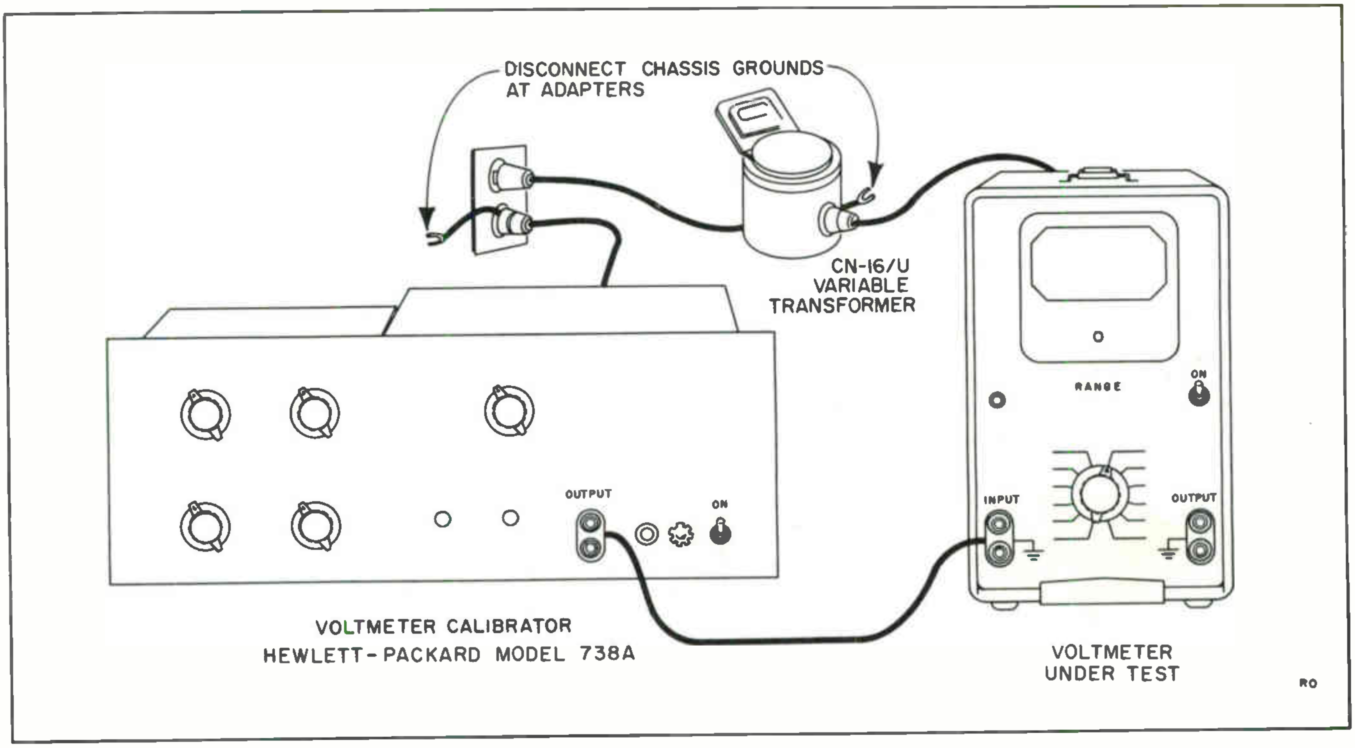


Figure 5-6. Test Setup for Calibration Check and Adjustments

The residual reading on voltmeter must be no higher than the residual reading obtained with voltmeter INPUT terminated with a 10-megohm resistor and shielded to prevent stray pickup. If the residual reading is higher when connected to the calibrator, refer to paragraph 3-12.

e. Set the voltmeter RANGE switch to .001. Set the voltmeter calibrator to provide .001 volt rms (400 cps) output by setting the MULTIPLIER switch to .001, the RANGE switch to 1, and the OUTPUT SELECTOR to 400 RMS. Record deviation of voltmeter reading from 1 on the voltmeter scale.

f. Set the voltmeter RANGE switch to 1. Set the voltmeter calibrator to provide 1 volt rms output by setting the MULTIPLIER switch to 1. Record deviation of voltmeter reading from 1 on the voltmeter scale.

g. Still using the voltmeter 1-volt range, reduce the voltmeter calibrator output in 0.1 volt steps using the TRACKING control. Record deviation of voltmeter readings from each 0.1 volt calibration mark.

h. Compare recorded deviations with the permissible errors listed in the performance specifications in figure 1-2.

i. Connect the voltmeter as shown in figure 5-7 and set line voltage to 115. (This setup measures calibration accuracy at low and high frequencies.)

j. Set voltmeter RANGE switch to .001. Set frequency response test set OUTPUT ATTENUATOR to .001 to measure the lowest voltmeter range; initially set AMPLITUDE control for 0 volts output. Then note voltmeter reading; it must not be higher than the residual reading noted in step d.

k. Turn the frequency response test set RANGE SELECTOR to EXTERNAL. Set the external oscillator frequency to 400 cps; adjust the oscillator output level to obtain a reading of .9 on the 0 to 1 VOLTS scale of the voltmeter. Then adjust the METER SET control on the frequency response test set to obtain a standard meter indication at the SET LEVEL mark on the test set meter.

l. Tune the external oscillator to 10 cps and adjust its output level to keep the frequency response test set meter reading at SET LEVEL. Do not adjust the METER SET control as this would alter the fixed monitoring point of the meter. Record the voltmeter deviation from .9 on the scale. This reading must be between 0.85 and 0.95 to be within specifications.

m. Set the RANGE SELECTOR on the test set to 3-10 mc, set the FREQ. TUNING dial to 4, and adjust the AMPLITUDE control to keep the frequency response test set meter reading at SET LEVEL. Record the voltmeter deviation from .9 on the scale. This reading must be between 0.85 and 0.95 to be within specifications. The gain and frequency response of the basic voltmeter amplifier is now tested.

n. Repeat step m using line voltages of 103 and 127. Record voltmeter deviation from .9 on the scale.

o. Set voltmeter RANGE switch to .003 and also set the frequency response test set OUTPUT ATTENUATOR to .003 to check this voltmeter range. Repeat steps k and m. Record voltmeter deviation from .9 on the scale.

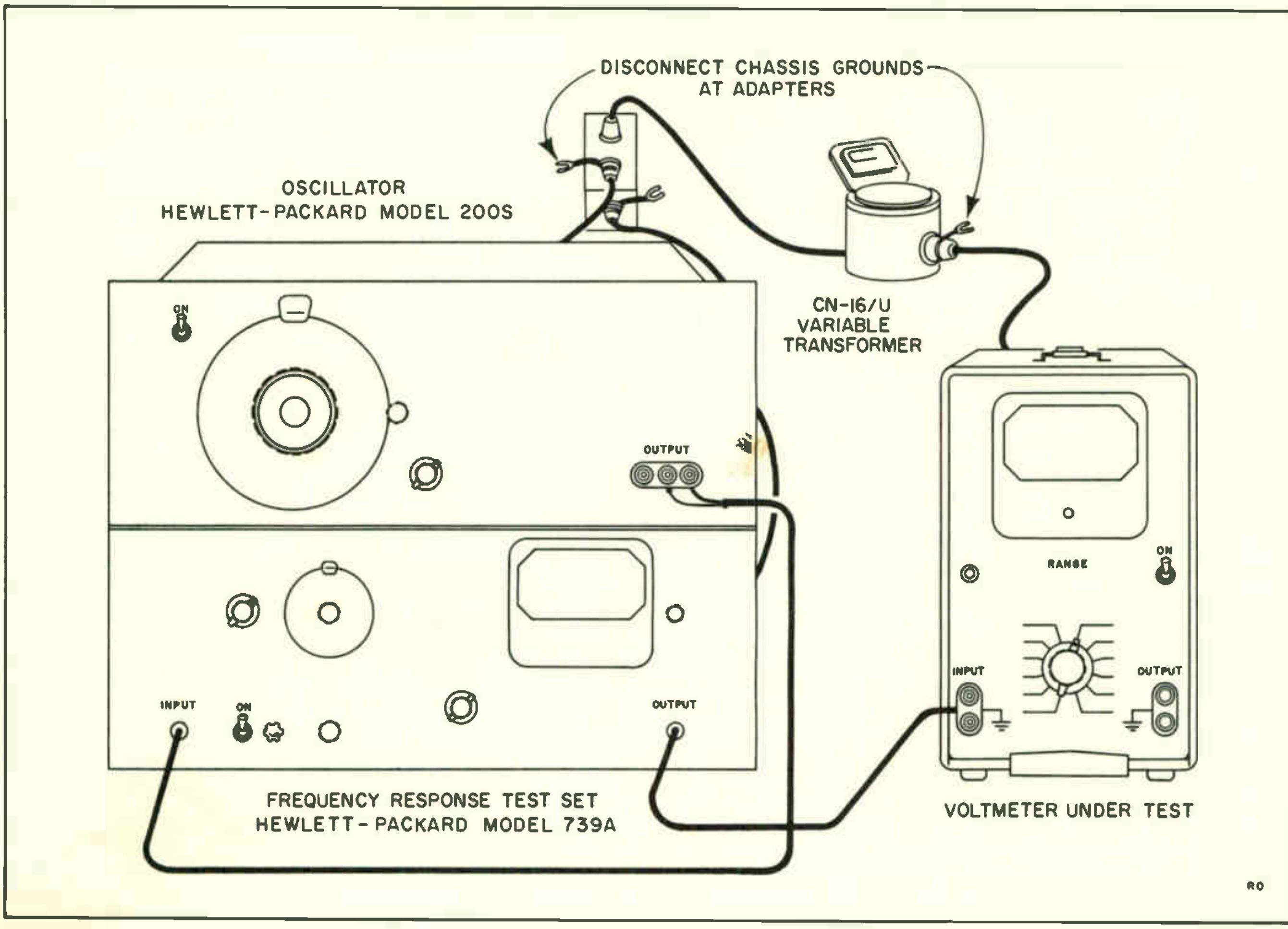


Figure 5-7. Test Setup for Frequency Response Check and Adjustment

p. Set voltmeter RANGE switch to .01 and also set the frequency response test set OUTPUT ATTENUATOR to .01 to check this voltmeter range. Repeat steps k and m. Record voltmeter deviation from .9 on the scale.

q. Set voltmeter RANGE switch to 1 and also set the frequency response test set OUTPUT ATTENUATOR to 1. Repeat step k.

r. Turn the frequency response test set RANGE SELECTOR to EXTERNAL. Set external oscillator frequency to 20 kc and adjust output level to keep the frequency response test set meter reading at SET LEVEL. Record voltmeter deviation from .9 on the scale.

s. Repeat step m and record voltmeter deviation from .9 on the scale.

t. The voltmeter is now completely tested. If the measurements made have shown the voltmeter reading to be within the tolerances given in the performance specifications in Section I, the voltmeter is operating satisfactorily. If operation is unsatisfactory, make calibration and frequency reponse adjustments as directed in paragraph 5-24.

5-24. CALIBRATION AND FREQUENCY RESPONSE ADJUSTMENTS.

5-25. Calibration and frequency response adjustments may be required when components other than those in the power supply circuit are replaced. After replacing any of these components, carry out the voltmeter performance test of paragraph 5-22 to see if adjustments are necessary. If the voltmeter operates within specifications during the test of paragraph 5-22, with respect to both calibration (at mid-frequencies) and frequency response, no adjustments are needed. If operation at mid-frequencies meets calibration specifications, only the frequency response adjustments need be made. Otherwise, make all calibration and frequency response adjustments in the order listed in the following procedure.

5-26. Calibration of the voltmeter consists of five parts:

a. Setting the basic gain of the amplifier at 400 cps.

b. Setting the division ratio of the input attenuator at 400 cps.

c. Setting the frequency response of the amplifier.

d. Setting the 4-mc frequency response of the step attenuator.

e. Setting the 20-kc and 4-mc frequency response of the input divider.

NOTE

It is important to follow the complete procedure in the order given, instead of attempting individual adjustments which might appear to correct a certain fault in calibration.

5-27. Although a special voltmeter calibrator instrument and frequency response test set (listed in paragraph 5-5) are shown for calibrating the voltmeter, other precision a-c voltage sources having the required accuracy may be used for this calibration procedure. In the following procedure, the mechanical meter zero-set and the regulated B+ voltage must already be correctly set (see paragraphs 5-7 and 5-20, respectively). Proceed as follows:

a. Connect voltmeter calibrator and voltmeter under test as shown in figure 5-6. (Do not turn on.)

b. Provide a ground-level input to the voltmeter to check for stray pickup between the instruments by setting the voltmeter calibrator controls as follows:

OUTPUT SELECTOR	to	400 RMS
FUNCTION switch	to	CALIBRATE
MULTIPLIER switch	to	0
POWER switch	to	ON

c. Set the RANGE switch on the voltmeter under test to .001 volt, and the Power switch to ON. Allow at least a ten-minute warmup. Refer to paragraph 3-12 of this manual and to paragraph 2-3 of the manual for the Model 738A Voltmeter Calibrator for a procedure to test for ground currents. Eliminate any ground currents by breaking ground loops as directed in paragraph 3-12.

d. To test the .001 volt range, set the voltmeter calibrator MULTIPLIER switch to .001 and the voltmeter RANGE switch to .001. If necessary, adjust R107 (figure 5-3) to obtain a reading of exactly 1 on the 0 to 1 VOLTS scale on the panel meter of the voltmeter under test. This sets the gain of the amplifier at audio frequencies.

e. Set the RANGE switch on the voltmeter to the 1-volt range. Set the voltmeter calibrator MULTIPLIER switch to 1, to test this range. If necessary, adjust R101 (figure 5-3) to obtain a reading of exactly 1 volt on the voltmeter. This sets the division ratio of the input voltage divider at audio frequencies.

f. Connect the frequency response test set, the oscillator, and the voltmeter under test as shown in figure 5-7. Observe grounding precautions described in step c.

g. On the frequency response test set, set the OUTPUT ATTENUATOR to .001, the RANGE SELECTOR to EXTERNAL, and turn the Power switch ON. This adjusts the frequency response test set to provide an output from the external oscillator for the voltmeter .001-volt range.

h. Set the RANGE switch on the voltmeter under test to .001.

i. Set the oscillator for 400 cps output frequency and adjust its output level to obtain a reading at 0.9 on the voltmeter scale.

j. Adjust the frequency response test set METER SET control to obtain a meter reading at SET LEVEL on the test set. This standardizes the monitoring point of the output level.

k. Set the RANGE SELECTOR and FREQ. TUNING controls of the frequency response test set for 4-mc output frequency and adjust the AMPLITUDE control to provide a reading at SET LEVEL on the meter.

l. If necessary adjust C102 (figure 5-3) to obtain a reading at 0.9 on the voltmeter under test. This sets amplifier gain at video frequencies.

m. While watching voltmeter under test, adjust the frequency response test set FREQ. TUNING control from 4 to 10 megacycles while holding output level constant with the AMPLITUDE control. If voltmeter reading increases beyond 0.92 on the scale (+2%), adjust R119 to limit this peak to 0.92 and repeat steps g through l.

NOTE

Whenever R119 is adjusted, both the low- and high-frequency response is affected and must be retested.

n. Readjust oscillator and frequency response test set for 20 cps output and a SET LEVEL indication on the test set meter. If necessary adjust R118 (figure 5-4) to obtain a reading at exactly 0.9 on the voltmeter under test.

o. Repeat step n at a frequency of 10 cps, for a voltmeter reading between 0.85 and 0.95 (±5%). If 10 cps response is outside this range, readjust R118 slightly to bring 10 cps response within the specified limits.

p. Repeat the 400-cps to 4-mc frequency response check (steps g through k) on the .003 volt range of the voltmeter and if necessary adjust C14 (figure 5-4) to obtain a reading of 0.9 on the voltmeter at 4 mc.

q. Repeat the 400-cps to 4-mc frequency response check (steps g through k) on the 0.01 volt range of the voltmeter and if necessary adjust C16 (figure 5-4) to obtain a reading of 0.9 on the voltmeter at 4 mc.

r. On the 1-volt range of the voltmeter, measure frequency response at both 20 kc and 4 mc using a procedure similar to steps g through k. At 20 kc if necessary adjust C4 (figure 5-3) to obtain a reading of 0.9 on the voltmeter. At 4 mc if necessary pad the value of R6 (figure 5-3) to obtain a reading between 0.85 and 0.95 (±5%). R6 consists of several resistors connected in parallel. Increasing the value of one of these resistors raises the meter reading at 4 mc. The input shield must be in place on the voltmeter chassis when making this reading.

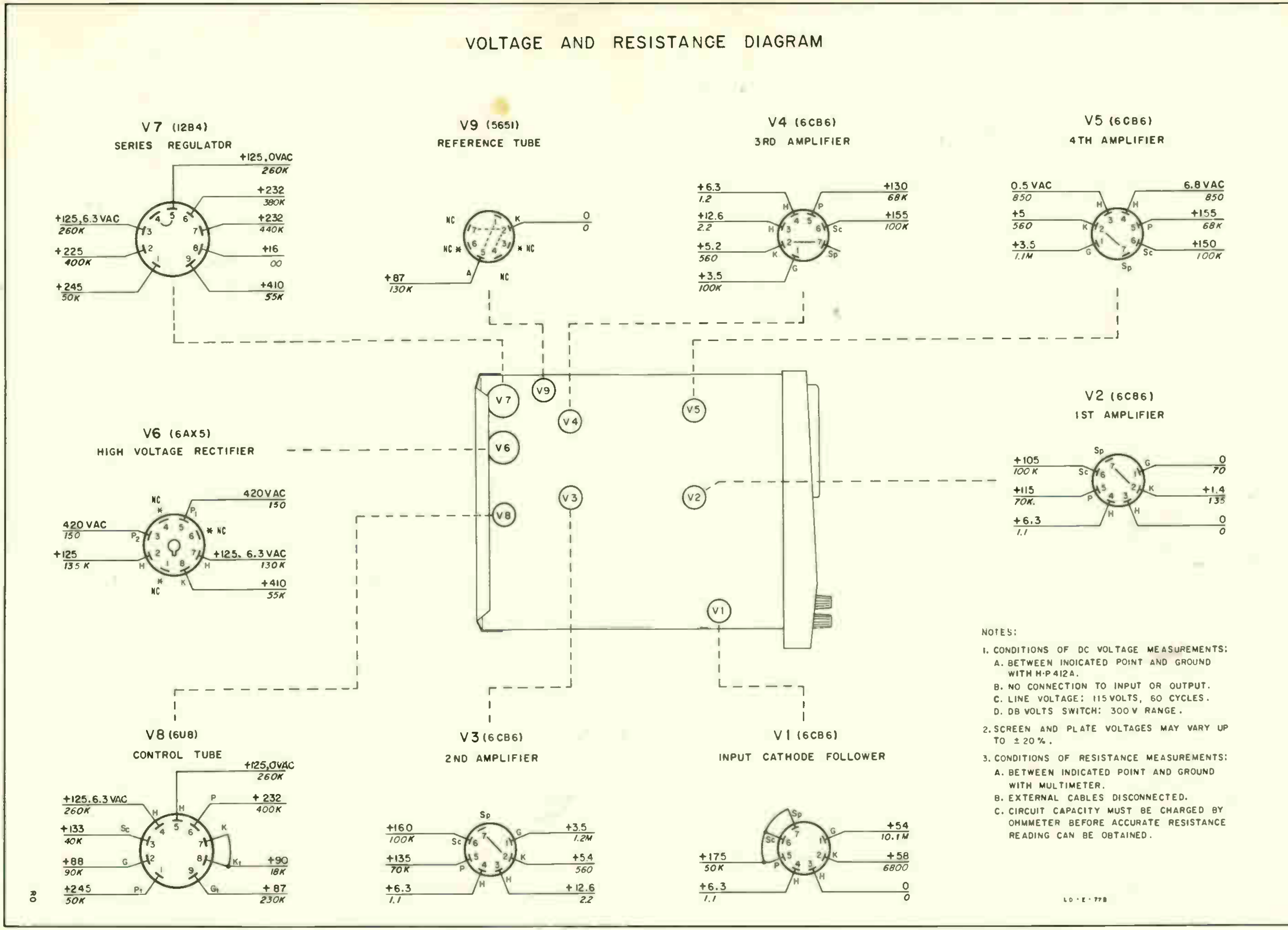


Figure 5-8. Voltage and Resistance Diagram

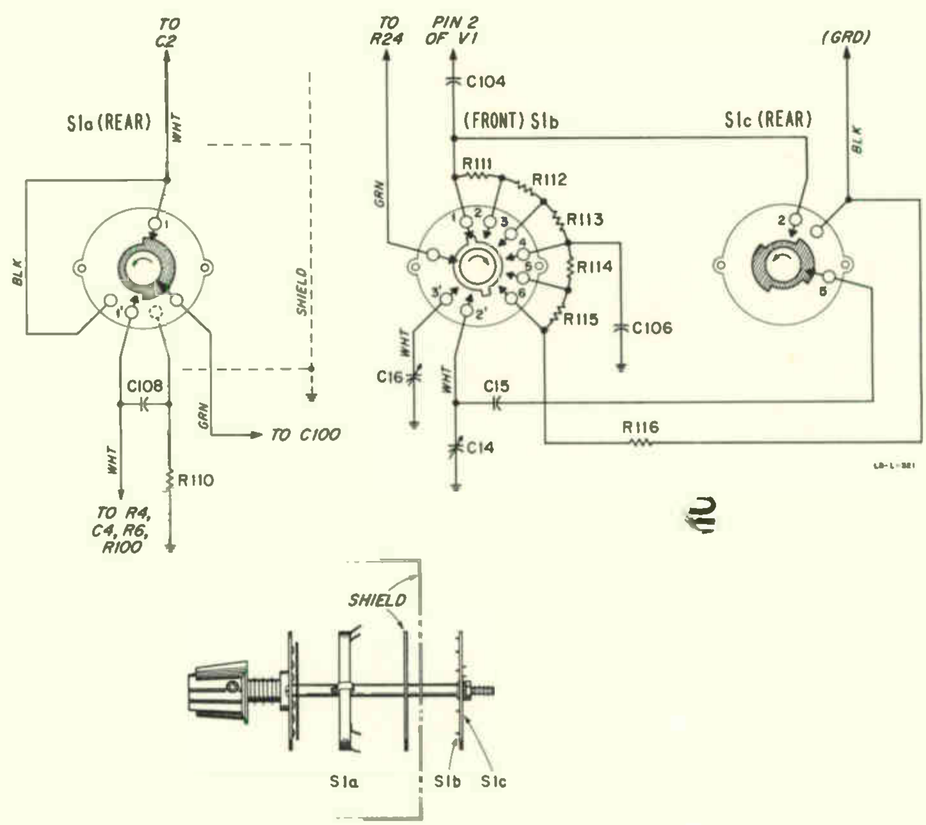
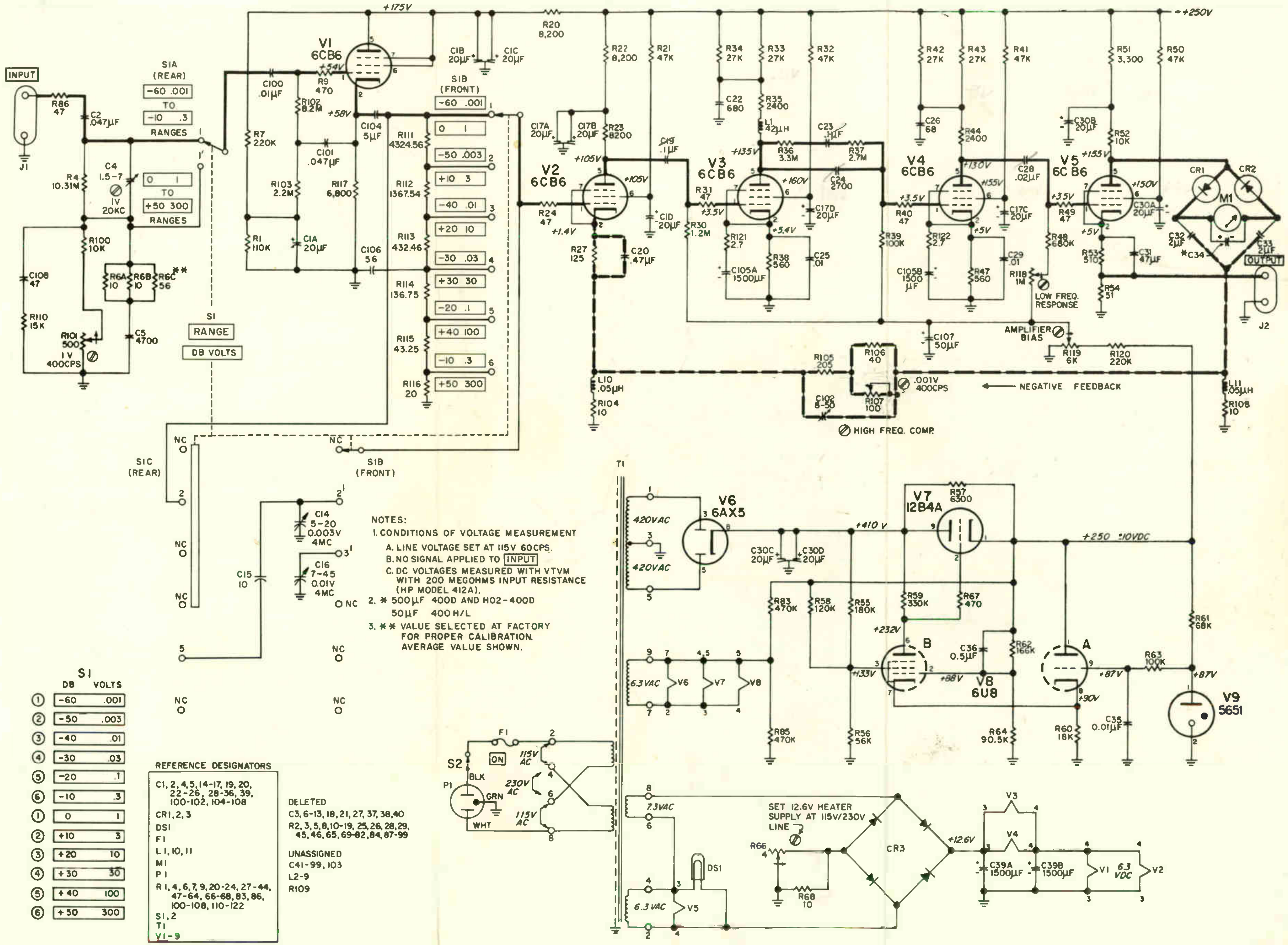


Figure 5-9. Diagram of RANGE Switch



00102-2

Figure 5-10. Voltmeter Schematic Diagram

SECTION VI

INTRODUCTION TO ILLUSTRATED PARTS BREAK DOWN

6-1. GENERAL.

6-2. This Illustrated Parts Breakdown lists and describes the parts applicable to the Vacuum Tube Voltmeters, Models 400D, 400H, 400L, and H02-400D, manufactured by Hewlett-Packard Co., Palo Alto, California, U. S. A. The breakdown consists of four sections as shown in the Table of Contents.

6-3. GROUP ASSEMBLY PARTS LIST. The Group Assembly Parts List (Section VII) consists of the complete Voltmeter divided into six main assemblies or components as shown in the Table of Contents. Each assembly listed is followed immediately by its component parts indented to show relationship to the assembly.

6-4. Part numbers are used to identify parts. A MIL-type part number or a typical manufacturer and part number are listed for each vendor part in the Group Assembly Parts List. The actual part used may be supplied by a different vendor, but in all cases the Hewlett-Packard stock number remains the same. The H-P Stock No. column is adjacent to the manufacturer or military Part No. column.

6-5. The index numbers are numerically arranged in the Group Assembly Parts List and are used mainly to assist in locating a part in the Group Assembly Parts List after it has been found in the Numerical Indexes (Section VIII) or located on the figure which illustrates that particular assembly.

6-6. The nomenclature of each part in the Group Assembly Parts List is indented to indicate assembly relationship. Each part is indented one column to the right of the next higher assembly. When the details of an assembly are shown on a different figure and parts list, the nomenclature of that assembly is followed by a parenthetical note stating in which figure and parts list the details will be found.

6-7. Attaching parts are shown in the same indent as the parts which they attach, and immediately following the part. They are separated from the parts which they attach by the words (ATTACHING PARTS). The attaching parts are separated from the following assembly, or the details of the assembly which they attach, by the symbol ---*---. When attaching parts are shown as attaching two or more parts, the quantities of the attaching parts are those required to attach the total number of the assemblies or parts being attached.

6-8. The quantities listed in the "Units per Assy" column of the Group Assembly Parts List are, in the case of assemblies, the total quantity used in the Voltmeter at the location indicated. In the case of component parts indented under the assembly, the quantity listed is the quantity used per assembly. The quantities specified in any one entry, therefore, are not necessarily the total used per complete Voltmeter. Refer to the Numerical Indexes (Section VIII) for the total quantities used per complete voltmeter.

6-9. USABLE ON CODE. Part variations within the voltmeters are indicated by a letter symbol or combination of letter symbols in parentheses immediately following the figure and index number in the same column. An explanation of the symbols used is outlined below. In cases where the "Usable on Code" column has been left blank, parts listed apply to all models covered by this book.

USABLE ON CODE	MODEL NUMBER
D	400D
H	400H
L	400L
H02	H02-400D

6-10. PART NO. NUMERICAL INDEX. The Part Number Numerical Index (Section VIII) is compiled in accordance with the numerical part number filing system described below:

a. Part number numerical arrangement starts at the left-hand position of the part number and continues from left to right, one position at a time, until part number numerical arrangement is determined for all the part numbers. In the Part No. Numerical Index the federal stock number consists of a class code prefix followed by a serial number or the part number; that is, when a serial number has been assigned, the class code and serial number form the stock number; when a serial number has not been assigned, the class code and part number form the federal stock number.

b. The order of precedence in the arrangement of the part number is as follows:

(1) Space (blank position in the number)

(2) Dash (-)

(3) Letters A through Z

(4) Numerals 0 through 9
Alphabetical O's shall be considered as numerical zeros

6-11. In cases where the same part appears in several assemblies and therefore has several different figure and/or index numbers, the Part No. Numerical Index lists the figure and index number of each appearance, and the total quantity of the part used is given on the line with the first figure and index number entry.

6-12. HEWLETT-PACKARD STOCK NO. INDEX. The Hewlett-Packard Stock No. Index is a numerical index of Hewlett-Packard stock numbers, arranged in alphanumerical form in the same manner as the Part No. Numerical Index. The Hewlett-Packard Stock No. Index follows the Part No. Numerical Index in Section VIII.

6-13. REFERENCE DESIGNATION INDEX. The Reference Designation Index (Section IX) lists electrical parts by reference designator and is compiled with reference designators in alpha-numerical order. It provides a convenient method for locating parts within the Group Assembly Parts List when the reference designator is known.

6-14. SOURCE CODING. Source coding as applied to the Numerical Indexes has been assigned by Department representatives.

SOURCE CODE DEFINITIONS

a. CODE "P" - PARTS UNDER INVENTORY STOCK CONTROL

(1) CODE "P" is applied to the parts which are procured in view of relatively high usage. Code "P" parts may be requisitioned and installed by any maintenance level, unless followed by the letter - "O", which restricts requisition and replacement to Depot (O&R) level only. Restricted service manufacture is considered practicable but only after an attempt has been made to procure from Supply Sources. In lieu of the procurement of "P" coded parts, the Department may designate a Depot (O&R) level activity to manufacture supply requirements for the Program.

(2) CODE "P1" is applied to parts which are very difficult or uneconomical to manufacture. Service manufacture is considered impracticable. Code "P1" parts may be requisitioned and installed by any maintenance level, unless followed by the letter - "O" which restricts the requisition and replacement to Depot (O&R) level only.

b. CODE "M" MANUFACTURE, PARTS NOT PROCURED

(1) CODE "M" is applied to parts which are within the facilities of any activity to manufacture. Procurement and stocking are not justified in view of the relatively low usage, or storage and installation factors, of these parts. Needs are to be met by local manufacture as required.

(2) CODE "M1" is applied to parts which can be manufactured only by utilizing the facilities of the Depot (O&R) activity. Procurement and stocking of these parts are not justified in view of their relatively low usage and installation factors. The needs of all activities are to be met through salvage, or by Depot (O&R) level manufacture.

c. CODE "A" ASSEMBLE - ASSEMBLY NOT PROCURED

(1) CODE "A" is applied to assemblies made up of two or more units each of which carry individual part numbers and descriptions, and which may be assembled by any maintenance level.

(2) CODE "A1" is applied to assemblies made up of two or more parts each of which carry individual part numbers and descriptions, and which may be assembled only by activities having Depot (O&R) facilities.

d. CODE "X" PARTS CONSIDERED IMPRACTICABLE FOR MANUFACTURE OR PROCUREMENT

(1) CODE "X" is applied to the Main Structural Members or similar parts which, if required, would suggest extensive aircraft or equipment reconditioning. The need of a part, or parts, coded "X" (wing spar caps, center section structure) should normally result in a recommendation to reture the aircraft or equipment from Service.

(2) CODE "X1" is applied to parts for which the procurement of the next larger assembly is justified; e.g., an integral detail part, such as welded segments, inseparable from its assembly; a part machined in a matched set; or a part of an assembly which, if required, would suggest extensive reconditioning of each assembly.

(3) CODE "X2" is applied to parts which are neither procured nor stocked. Activities requiring such parts shall attempt to obtain from salvage; if not obtainable from salvage, such parts shall be requisitioned through normal supply channels with supporting justification.

e. CODE * PARTS NOT PROCURED, MANUFACTURED OR STOCKED

(1) CODE * applies to installation drawings, diagrams, instructions or field service drawings, basic drawing numbers which cannot be procured or manufactured, and obsolete parts.

6-15. VENDOR'S CODE. Vendor's code numbers have been assigned in accordance with Federal Supply Code H-4-1. The vendor's code appears in parentheses following the item name or within the description of each item in the Group Assembly Parts List (Section VII). The vendor's codes used in this Illustrated Parts Breakdown are listed below for convenience.

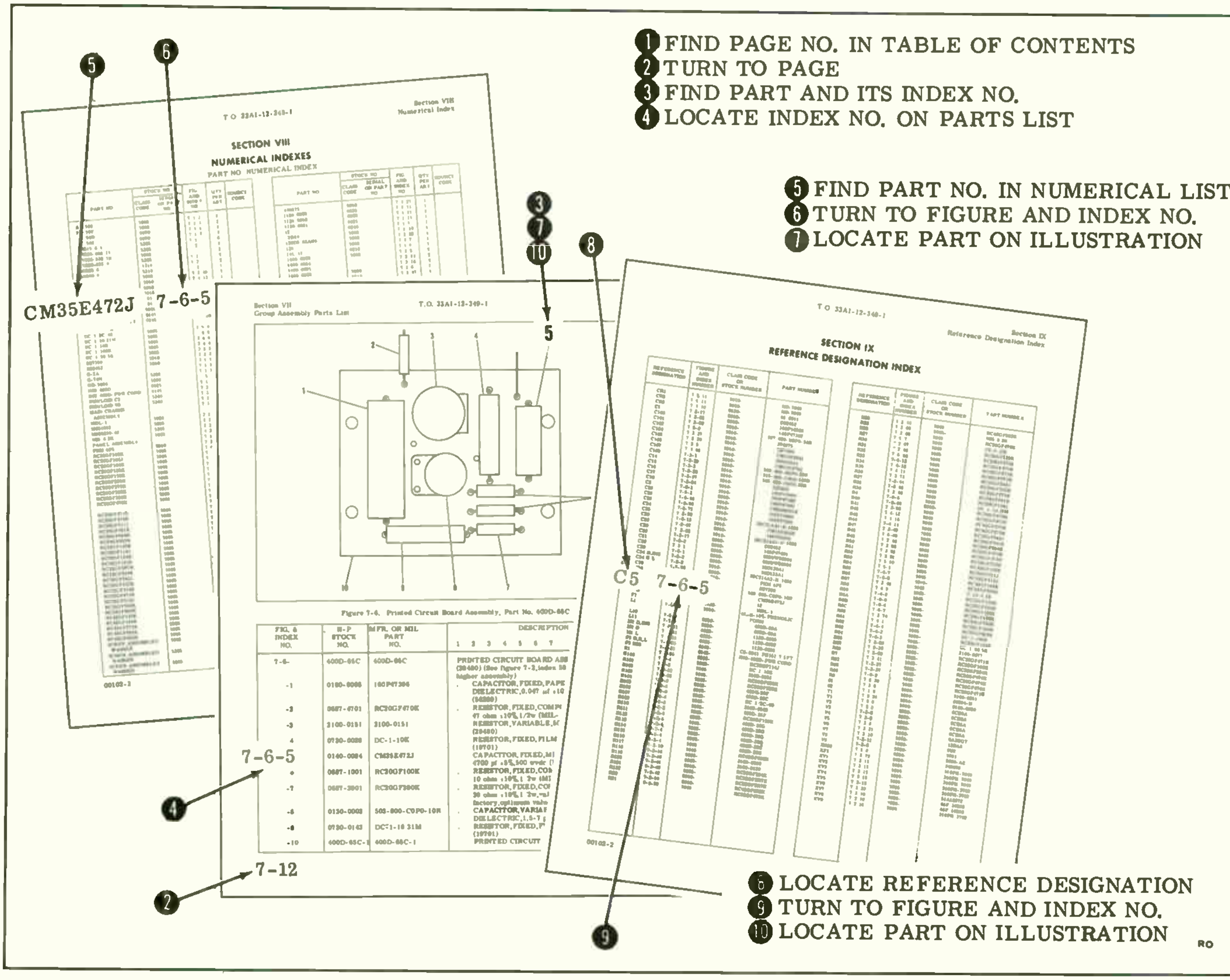
VENDOR'S CODE

CODE	NAME AND ADDRESS
04009	Arrow, Hart, and Hegeman Electric Co., Hartford, Conn.
14655	Cornell Dubilier Electric Corp., South Plainfield, N.J.
14674	Corning Glass Works, Corning, N.Y.
19701	Electra Mfg. Co., Kansas City, Mo.
24446	General Electric Co., Schenectady, N.Y.

CODE	NAME AND ADDRESS
28480	Hewlett-Packard Co., Palo Alto, Calif.
28520	Heyman Mfg. Co., Kenilworth, N.J.
35434	Lectrohm, Inc., Chicago, Ill.
56289	Sprague Electric Co., North Adams, Mass.
70903	Belden Mfg. Co., Chicago, Ill.
71400	Bussman Fuse, Division of McGraw-Edison Co., St. Louis, Mo.
71785	Cinch Mfg. Corp., Chicago, Ill.
72765	Drake Mfg. Co., Chicago, Ill.
72982	Erie Resistor Corp., Erie, Pa.
73734	Federal Screw Products Co., Chicago, Ill.
78189	Shakeproof, Division of Illinois Tool Works, Elgin, Ill.
81482	Cooperative Industries, Inc., Chester, N.J.
82577	Hughes Aircraft Co., Culver City, Calif.

CODE	NAME AND ADDRESS
83330	Smith, Herman H., Inc., Brooklyn, N.Y.
83380	Buckley, C.E., Leominster, Mass.
84411	Good All Electric Mfg. Co., Ogalala, Nebr.
85628	King Engineering Co., Baltimore, Md.
85682	Ringel Bros., Newark, N.J.
86684	RCA Electron Tube, Division of Radio Corp. of America, Harrison, N.J.
88044	Aeronautical Standards Group, Departments of Navy and Air Force, Washington, D.C.
91506	Augat Bros., Inc., Attleboro, Mass.
91637	Dale Products, Inc., Columbus, Nebr.
91662	Elco Corp., Philadelphia, Pa.
93519	General Electric Co., Lamp Works, Oakland, Calif.
96906	Military Standards
99849	St. Louis Blow Pipe and Heater Co., Inc., St. Louis, Mo.

HOW TO USE THIS ILLUSTRATED PARTS BREAKDOWN



HOW TO FIND THE PART NUMBER IF THE MAJOR ASSEMBLY IN WHICH THE PART IS USED IS KNOWN.

(1) Turn to the Table of Contents and find the page number for the major assembly in which the part is used.

(2) Turn to the page determined in step (1).

(3) Locate the part and its index number on the illustration.

(4) Find the index number on the Group Assembly Parts List page to determine the complete description.

HOW TO FIND THE ILLUSTRATION FOR A PART IF THE PART NUMBER IS KNOWN.

(5) Refer to the Part No. Numerical Index in Section VIII and find the part number.

(6) Turn to Section VII and find the first figure and index number that was indicated in the Part No. Numerical Index for that part. If this figure shows the part in a major assembly other than the one desired, refer to the other figure numbers listed in the Part No. Numerical Index.

(7) On the face of the illustration, find the index number determined in step (6).

HOW TO FIND THE PART AND ILLUSTRATION NUMBER FOR AN ELECTRONIC OR ELECTRICAL PART IF THE REFERENCE DESIGNATION IS KNOWN.

(8) Refer to Section IX, Reference Designation Index, and find the reference designation. The part number and the figure and index number will be shown in the right-hand columns opposite the reference designation.

(9) Turn to Section VII and find the figure and index number shown for the part in the "FIG. AND INDEX NO." column of the Reference Designation Index.

(10) On the face of the illustration, find the index number determined in step (9).

SECTION VII
GROUP ASSEMBLY PARTS LIST

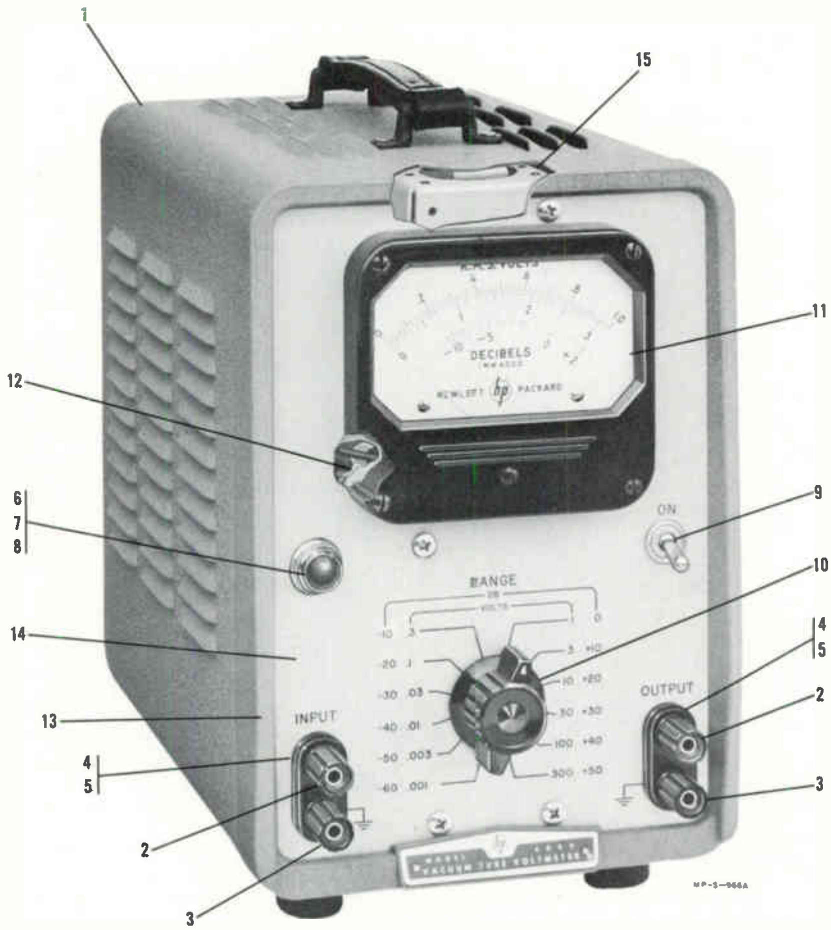


Figure 7-1. 400D/H/L Vacuum Tube Voltmeter

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-1- (D)	400D	400D	VACUUM TUBE VOLTMETER (28480) . . .	1
(H)	400H	400H	VACUUM TUBE VOLTMETER (28480) . . .	1
(L)	400L	400L	VACUUM TUBE VOLTMETER (28480) . . .	1
(H02)	H02-400D	H02-400D	VACUUM TUBE VOLTMETER (28480) . . .	1
-1	400D-44	400D-44	. CABINET ASSEMBLY (28480)	1
			(ATTACHING PARTS)	
	2520-0006	AN526-832-10	. SCREW,MACHINE	2
			---*---	

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-1-		NO NUMBER	. PANEL ASSEMBLY,FRONT	1
			(ATTACHING PARTS)	
	2520-0003	AN526-832-8	. SCREW,MACHINE	5
	2580-0003	510-081810-01	. NUT,ASSEMBLED WASHER (78189) . . .	1
			---*---	
-2	AC-10E	AC-10E	. . POST,BINDING,Red (28480)	2
-3	AC-10F	AC-10F	. . POST,BINDING,Black (28480) . . .	2
-4	AC-54D	AC-54D	. . INSULATOR,STANDOFF (28480) . .	2
-5	AC-54E	AC-54E	. . INSULATOR,STANDOFF (28480) .	2
-6	1450-0020	14L-15	. . LENS,INDICATOR LIGHT (72765) .	1
-7	2140-0012	12	. . LAMP,INCANDESCENT,6-8 volt, 2 pin base (93519)	1
-8	1450-0022	2020-AE	. . LAMPHOLDER,2 pin base (72765) .	1
-9	3101-0001	80994-H	. . SWITCH,TOGGLE,SPST (04009) . .	1
-10	G-74N	G-74N	. . KNOB (28480)	1
-11 (D,H02)	1120-0005	1120-0005	. . MULTIMETER,REPLACEMENT . . (28480)	1
(H)	1120-0062	1120-0062	. . MULTIMETER,REPLACEMENT . . (28480)	1
(L)	1120-0081	1120-0081	. . MULTIMETER,REPLACEMENT . . (28480)	1
-12	1400-0015	1550	. . CLAMP,LOOP (73734)	1
-13	G-2A	G-2A	. . BEZEL,INSTRUMENT MOUNTING (28480)	1
			(ATTACHING PARTS)	
	2360-0003	AN515-6-4	. . SCREW,MACHINE	6
			---*---	
-14 (D,H02)	400D-2	400D-2	. . PANEL,FRONT (28480)	1
(H,L)	400H-2A	400H-2A	. . PANEL,FRONT (28480)	1
-15		NO NUMBER	. MAIN CHASSIS ASSEMBLY . . . . (See figure 7-2) (28480)	1

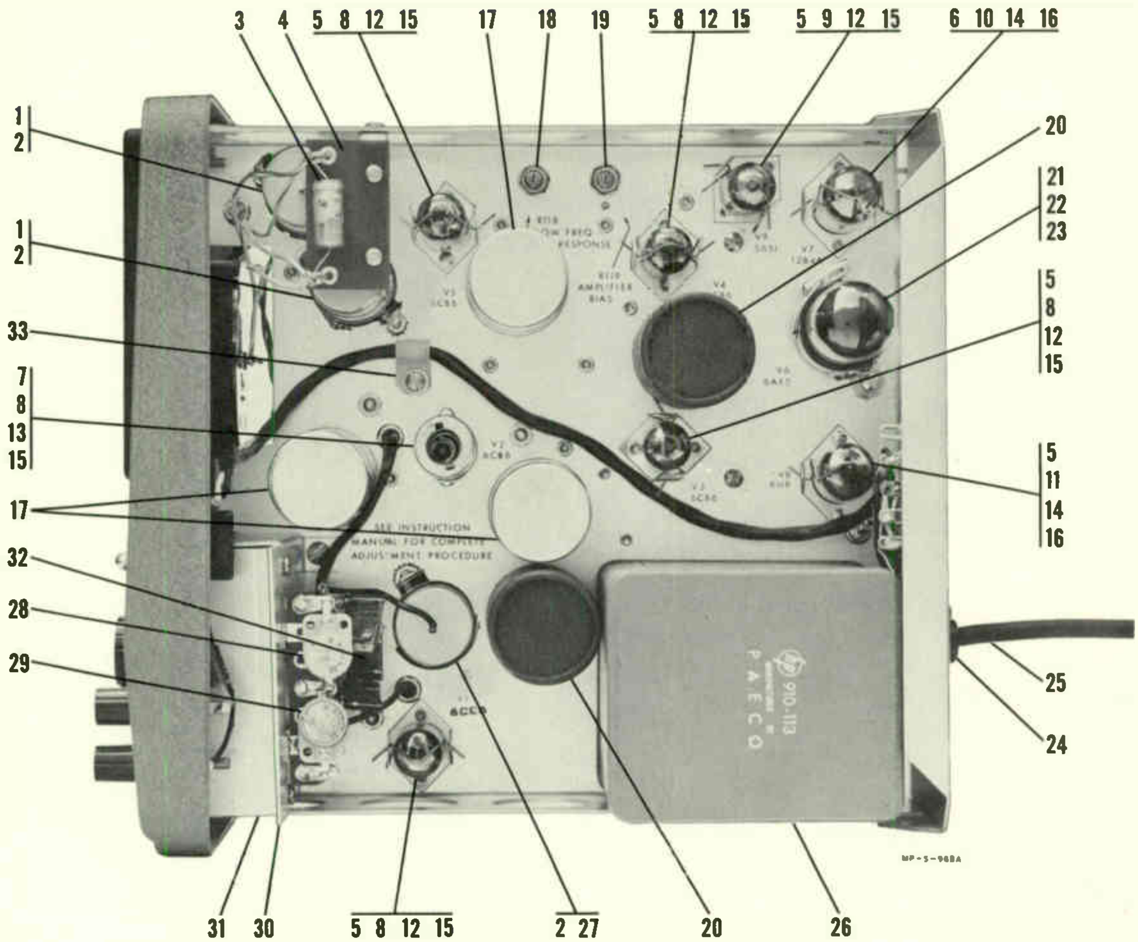


Figure 7-2. Main Chassis Assembly (Sheet 1 of 2)

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-2-		NO NUMBER	MAIN CHASSIS ASSEMBLY (28480) . . . . . (See figure 7-1,index 15 for next higher assembly)	REF
-1	0170-0002	663UW20504	. CAPACITOR,FIXED,PAPER . . . . . . DIELECTRIC,2.0 μf ±20%,400 wvdc (84411)	2
-2	1390-0020	INSULOID N3	. CLAMP,LOOP (85628)	3
			(ATTACHING PARTS)	
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . . . ---*---	3
-3 (D,H02)	0180-0063	30D120A1	. CAPACITOR,FIXED,ELECTROLYTIC, . 500 μf +100%,-10%,3 wvdc (56289)	1
(H,L)	0180-0033	30D133A1	. CAPACITOR,FIXED,ELECTROLYTIC, . 50 μf,600 wvdc (56289)	1
-4	400D-75H	400D-75H	. BRACKET,CAPACITOR (28480)	1
			(ATTACHING PARTS)	
	2390-0009	COML	. SCREW,ASSEMBLED WASHER, ... 6-32 by 3/8 in. lg,s.s. ---*---	1

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-2-5	1400-0005	1400-0005	. RETAINER,ELECTRON TUBE (28480) .	6
-6	1400-0039	1400-0039	. RETAINER,ELECTRON TUBE (28480) .	1
-7	1220-0010	126	. SHIELD,ELECTRON TUBE (91662) . . .	1
-8	1923-0028	6CB6A	. ELECTRON TUBE (24446)	5
-9	1940-0001	5651	. ELECTRON TUBE (86684)	1
-10	1921-0010	12B4A	. ELECTRON TUBE (24446)	1
-11	1933-0004	6U8	. ELECTRON TUBE (24446)	1
-12	1400-0035	1400-0035	. RETAINER,ELECTRON TUBE SOCKET (28480)	5
-13	1220-0005	429-.125	. BASE,Tube shield (91662)	1
-14	1400-0034	1400-0034	. RETAINER,ELECTRON TUBE SOCKET (28480)	2
-15	1200-0009	316PH-3702	. SOCKET,ELECTRON TUBE (91662) . . .	6
-16	1200-0008	44F-16388	. SOCKET,ELECTRON TUBE (71785) . . .	2
-17	0180-0025	D32452	. CAPACITOR,FIXED,ELECTROLYTIC, . 4 section,20 μf per section,450 wvdc (56289)	3
-18	2100-0080	2100-0080	. RESISTOR,VARIABLE,1M ±30%,0.2w . . (28480)	1
-19	2100-0136	2100-0136	. RESISTOR,VARIABLE,6K ±20%,0.3w . . (28480)	1
-20	0180-0028	D27390	. CAPACITOR,FIXED,ELECTROLYTIC, . 2 section,1500 μf per section,15 wvdc (56289)	2
-21	1930-0014	6AX5-GT	. ELECTRON TUBE (86684)	1
-22	1400-0033	120D5-63AHS	. RETAINER,ELECTRON TUBE (91506) .	1
-23	1200-0020	51A12272	. SOCKET,ELECTRON TUBE (71785) . . .	1
-24	0400-0013	5P-1	. GROMMET,PLASTIC (28520)	1
-25 (D,H,L)	8120-0050	CS-9941/PH151/ 7.5FT	. CABLE ASSEMBLY,POWER, ... ELECTRICAL (70903)	1
(H02)	H02-400D-PWR-CORD	H02-400D-PWR-CORD	. CABLE ASSEMBLY,POWER, ... ELECTRICAL (28480)	1
(H02)		CS-9941/PH151/ 7.5FTW/O PLUG	. . CABLE,POWER,ELECTRICAL (70903)	1
(H02)	1251-0037	MS24663	. . CONNECTOR,PLUG,ELECTRICAL (96906)	1
-26	9100-0050	9100-0050	. TRANSFORMER,POWER,STEP-DOWN AND STEP-UP (28480)	1
			(ATTACHING PARTS)	
	2900-0001	510-101810-51	. NUT,ASSEMBLED WASHER (78189) . . . ---*---	4
-27	0170-0057	S70375	. CAPACITOR,FIXED,PAPER . . . . . . DIELECTRIC,5 μf ±10%,100 wvdc (56289)	1
-28	0130-0006	503-000-B2P0-28R	. CAPACITOR,VARIABLE,CERAMIC . . DIELECTRIC,5-20 pf,500 wvdc (72982) .	1
-29	0130-0001	503-000-D2P0-33R	. CAPACITOR,VARIABLE,CERAMIC . . DIELECTRIC,7-45 pf,500 wvdc (72982) .	1
-30	400D-6J	400D-6J	. SHIELD,ROTARY SWITCH (28480) . . .	1
			(ATTACHING PARTS)	
	2550-0007	COML	. SCREW,ASSEMBLED WASHER,8-32 by 3/8 in. lg,s.s. ---*---	2
-31	400D-6K	400D-6K	. BRACKET,ANGLE (28480)	1
			(ATTACHING PARTS)	
	2390-0009	COML	. SCREW,ASSEMBLED WASHER,6-32 by 3/8 in. lg,s.s. ---*---	2
-32	400D-19A	400D-19A	. RANGE SWITCH ASSEMBLY (28480) . . (See figure 7-3)	1

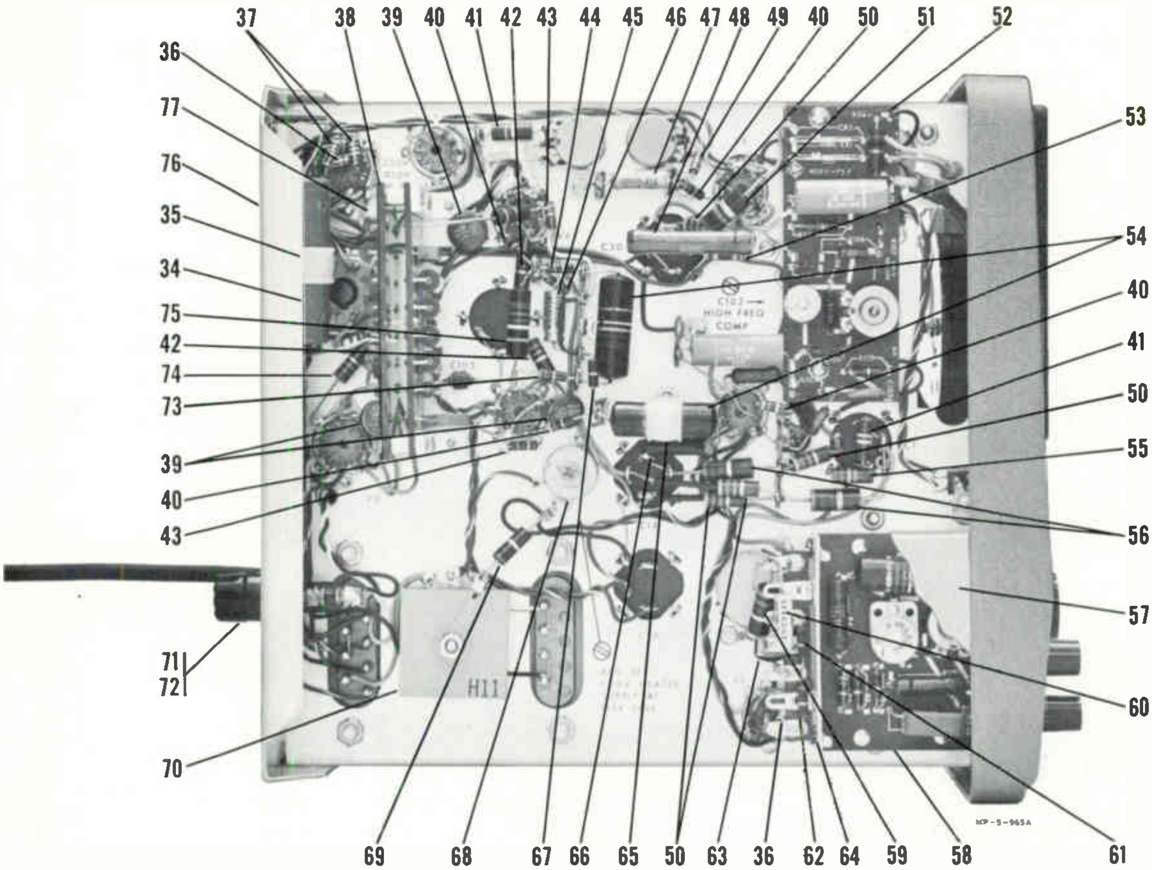


Figure 7-2. Main Chassis Assembly (Sheet 2 of 2)

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-2-33	1400-0074	INSULOID C3	. CLAMP,LOOP (85682)	1
			(ATTACHING PARTS)	
	2390-0009	COML	. SCREW,ASSEMBLED WASHER,6-32 by 3/8 in. lg,s.s.	1
	3050-0100	AN960-6	. WASHER,FLAT (88044)	1
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . . .	1
			---*---	
-34	0160-0024	PKM 4P5	. CAPACITOR,FIXED,PAPER . . . . . . DIELECTRIC,0.5 μf ±10%,400 wvdc (14655)	1
-35	1400-0016	781	. CLAMP,LOOP (83330)	1
			(ATTACHING PARTS)	
	2390-0001	COML	. SCREW,ASSEMBLED WASHER,6-32 by 1/2 in. lg,s.s. (78189)	1
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . .	1
			---*---	
-36	0687-4711	RC20GF471K	. RESISTOR,FIXED,COMPOSITION, . . 470 ohm ±10%,1/2w (MIL-R-11)	2
-37	0687-4741	RC20GF474K	. RESISTOR,FIXED,COMPOSITION, . . 470K ±10%,1/2w (MIL-R-11)	2

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-2-38	400D-75G	400D-75G	. PRINTED CIRCUIT BOARD ASSEMBLY (28480) (See figure 7-4)	1
			(ATTACHING PARTS)	
	2390-0009	COML	. SCREW,ASSEMBLED WASHER,6-32 by 3/8 in. lg,s.s.	2
			---*---	
-39	0150-0012	29C214A3-H-1038	. CAPACITOR,FIXED,CERAMIC .... DIELECTRIC,0.01 μf ±20%,1000 wvdc (56289)	3
-40	0687-4701	RC20GF470K	. RESISTOR,FIXED,COMPOSITION, ... 47 ohm ±10%,1/2w (MIL-R-11)	4
-41	0690-2241	RC32GF224K	. RESISTOR,FIXED,COMPOSITION, ... 220K ±10%,1w (MIL-R-11)	2
-42	0699-0005	RC32GF2R7K	. RESISTOR,FIXED,COMPOSITION, ... 2.7 ohm ±10%,1w (MIL-R-11)	2
-43	0687-5611	RC20GF561K	. RESISTOR,FIXED,COMPOSITION, ... 560 ohm ±10%,1/2w (MIL-R-11)	2
-44	0687-2751	RC20GF275K	. RESISTOR,FIXED,COMPOSITION, ... 2.7M ±10%,1/2w (MIL-R-11)	1
-45	0180-0033	30D133A1	. CAPACITOR,FIXED,ELECTROLYTIC, 50 μf,600 wvdc (56289)	1
-46	0687-1041	RC20GF104K	. RESISTOR,FIXED,COMPOSITION, ... 100K ±10%,1/2w (MIL-R-11)	1
-47	0170-0063	148P22394	. CAPACITOR,FIXED,PLASTIC ... DIELECTRIC,0.020 μf ±10%,400 wvdc (56289)	1
-48	0816-0017	C-10-6.3K	. RESISTOR,FIXED, WIRE WOUND, .. 6.3K ±10%,10w (35434)	1
-49	0687-6841	RC20GF684K	. RESISTOR,FIXED,COMPOSITION, .. 680K ±10%,1/2w (MIL-R-11)	1
-50	0690-4731	RC32GF473K	. RESISTOR,FIXED,COMPOSITION, .. 47K ±10%,1w (MIL-R-11)	4
-51	0693-1031	RC42GF103K	. RESISTOR,FIXED,COMPOSITION, .. 10K ±10%,2w (MIL-R-11)	1
-52	400D-75F	400D-75F	. PRINTED CIRCUIT BOARD ASSEMBLY (28480) (See figure 7-5)	1
			(ATTACHING PARTS)	
	2360-0012	AN526-632-14	. SCREW,MACHINE (88044)	2
	2190-0006	AN935-6	. WASHER,LOCK (88044)	2
	0380-0008	2102	. SPACER,SLEEVE (83330)	2
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) ..	2
			---*---	
-53	0690-3321	RC32GF332K	. RESISTOR,FIXED,COMPOSITION, .. 3.3K ±10%,1w (MIL-R-11)	1
-54	0160-0013	160P10494	. CAPACITOR,FIXED,PAPER ..... DIELECTRIC,0.1 μf ±10%,400 wvdc (56289)	2
-55	0689-1145	RC32GF114J	. RESISTOR,FIXED,COMPOSITION, .. 110K ±5%,1w (MIL-R-11)	1
-56	0693-8221	RC42GF822K	. RESISTOR,FIXED,COMPOSITION, .. 8.2K ±10%,2w (MIL-R-11)	2
-57	400D-6H	400D-6H	. SHIELD,Input printed circuit board .. assembly (28480)	1
			(ATTACHING PARTS)	
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) ..	2
			---*---	

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-2-58	400D-65C	400D-65C	. PRINTED CIRCUIT BOARD ASSEMBLY (28480) (See figure 7-6)	1
			(ATTACHING PARTS)	
	2390-0009	COML	. SCREW,ASSEMBLED WASHER,6-32 by 3/8 in. lg,s.s.	2
			---*---	
-59	0693-6821	RC42GF682K	. RESISTOR,FIXED,COMPOSITION, . . . 6.8K ±10%,2w (MIL-R-11)	1
-60	0170-0040	148P47392	. CAPACITOR,FIXED,PLASTIC . . . . DIELECTRIC,0.047 μf ±10%,200 wvdc (56289)	1
-61	0687-2251	RC20GF225K	. RESISTOR,FIXED,COMPOSITION, . . . 2.2M ±10%,1/2w (MIL-R-11)	1
-62	0687-8251	RC20GF825K	. RESISTOR,FIXED,COMPOSITION, . . . 8.2M ±10%,1/2w (MIL-R-11)	1
-63	0160-0054	160P10306	. CAPACITOR,FIXED,PAPER DIELECTRIC, 0.01 μf ±20%,400 wvdc (56289)	1
-64	400D-6F	400D-6F	. MOUNTING PLATE,Shield (28480) . . .	1
			(ATTACHING PARTS)	
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . .	2
			---*---	
-65	1400-0025	777	. CLAMP,LOOP (83380)	1
			(ATTACHING PARTS)	
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . .	2
			---*---	
-66	0761-0001	N25-8.2K	. RESISTOR,FIXED,FILM,8.2K ±5%,1w . (14674)	1
-67	0687-1251	RC20GF125K	. RESISTOR,FIXED,COMPOSITION, . . . 1.2M ±10%,1/2w (MIL-R-11)	1
-68	2100-0077	2100-0077	. RESISTOR,VARIABLE,4 ohm ±20%,1w . (28480)	1
-69	0690-1001	RC32GF100K	. RESISTOR,FIXED,COMPOSITION, . . . 10 ohm ±10%,1w (MIL-R-11)	1
-70	1882-0005	61-6911	. RECTIFIER,METALLIC (81482) . . .	1
			(ATTACHING PARTS)	
	2370-0009	MS35239-42	. SCREW,MACHINE (96906)	1
	2420-0001	510-061810-01	. NUT,ASSEMBLED WASHER (78189) . .	1
			---*---	
-71	2110-0007	MDL-1	. FUSE,CARTRIDGE,1 amp,250v,slow . blow for 115v (71400)	1
-72	1400-0007	342003	. FUSEHOLDER (71400)	1
-73	0687-3351	RC20GF335K	. RESISTOR,FIXED,COMPOSITION, 3.3M ±10%,1/2w (MIL-R-11)	1
-74	0690-1831	RC32GF183K	. RESISTOR,FIXED,COMPOSITION, . . . 18K ±10%,1w (MIL-R-11)	1
-75	0160-0044	160P27296	. CAPACITOR,FIXED,PAPER . . . . . DIELECTRIC,0.0027 μf ±10%,600 wvdc (56289)	1
-76	400D-1A	400D-1A	. PANEL,Rear (28480)	1
-77	400D-1B	400D-1B	. CHASSIS,ELECTRICAL EQUIPMENT . (28480)	1

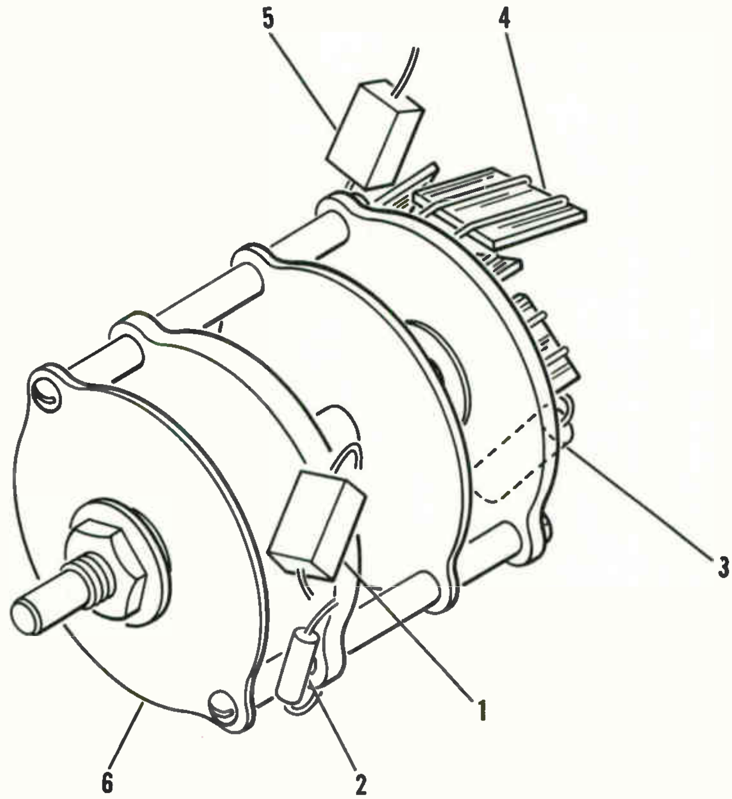


Figure 7-3. Range Switch Assembly

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-3-	400D-19A	400D-19A	RANGE SWITCH ASSEMBLY (28480) . . . . (See figure 7-2, index 32 for next higher assembly)	REF
-1	0140-0039	CM15E470J	. CAPACITOR, FIXED, MICA DIELECTRIC, 47 pf ±10%, 500 wvdc (MIL-C-5)	1
-2	0687-1531	RC20GF153K	. RESISTOR, FIXED, COMPOSITION, . . . 15K ±10%, 1/2w (MIL-R-11)	1
-3	0150-0009	315-000-C0G0-100D	. CAPACITOR, FIXED, CERAMIC . . . . DIELECTRIC, 10 pf ±0.5 pf, 500 wvdc (72982)	1
-4	400D-26G	400D-26G	. RESISTOR ASSEMBLY, Matched set of 6 wire wound resistors, replaceable only as a set (28480)	1
-5	0140-0014	CM15E560J	. CAPACITOR, FIXED, MICA DIELECTRIC, 56 pf ±10%, 500 wvdc (MIL-C-5)	1
-6	3100-0251	3100-0251	. SWITCH, ROTARY, Not separately . . . replaceable (28480)	1

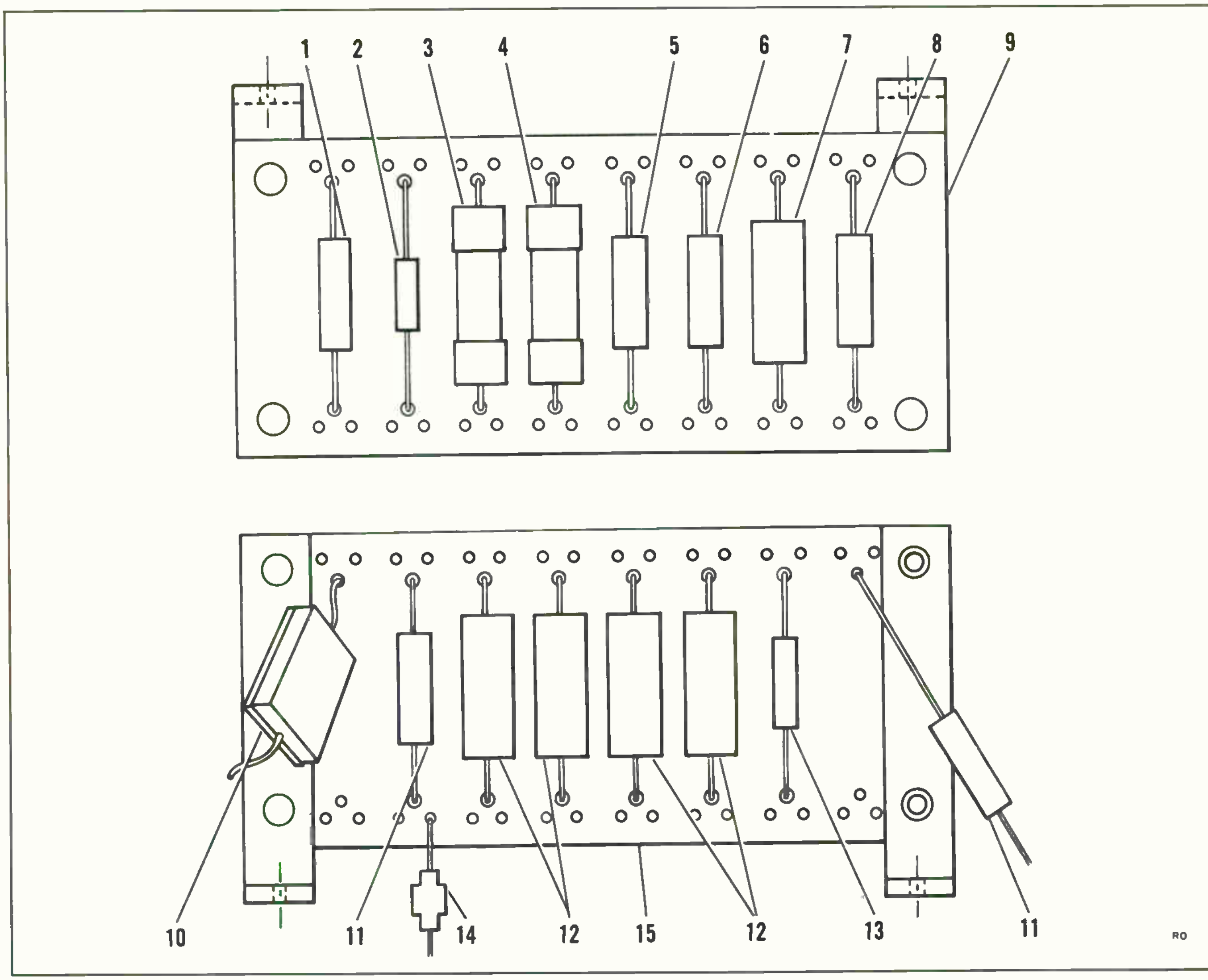


Figure 7-4. Printed Circuit Board Assembly, Part No. 400D-75G

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-4-	400D-75G	400D-75G	PRINTED CIRCUIT BOARD ASSEMBLY . . (28480) (See figure 7-2, index 38 for next higher assembly)	REF
-1	0690-6831	RC32GF683K	. RESISTOR, FIXED, COMPOSITION, . . . 68K ±10%, 1w (MIL-R-11)	1
-2	0687-1041	RC20GF104K	. RESISTOR, FIXED, COMPOSITION, . . . 100K ±10%, 1/2w (MIL-R-11)	1
-3	0730-0065	DC-1-90.5K	. RESISTOR, FIXED, FILM, 90.5K ±1%, 1w . (19701)	1
-4	0730-0076	DC-1-166K	. RESISTOR, FIXED, FILM, 166K ±1%, 1w . (19701)	1
-5	0690-1241	RC32GF124K	. RESISTOR, FIXED, COMPOSITION, . . 120K ±10%, 1w (MIL-R-11)	1
-6	0690-5631	RC32GF563K	. RESISTOR, FIXED, COMPOSITION, . . 56K ±10%, 1w (MIL-R-11)	1
-7	0693-1841	RC42GF184K	. RESISTOR, FIXED, COMPOSITION, . . 180K ±10%, 2w (MIL-R-11)	1

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-4-8	0690-3341	RC32GF334K	. RESISTOR, FIXED, COMPOSITION, . . . 330K ±10%, 1w (MIL-R-11)	1
-9	400D-75G-2	400D-75G-2	. PRINTED CIRCUIT BOARD (28480) . . .	1
-10	0140-0007	CM20B681K	. CAPACITOR, FIXED, MICA DIELECTRIC, 680 pf ±10%, 500 wvdc (MIL-C-5)	1
-11	0689-2425	RC32GF242J	. RESISTOR, FIXED, COMPOSITION, . . . 2.4K ±5%, 1w (MIL-R-11)	2
-12	0693-2731	RC42GF273K	. RESISTOR, FIXED, COMPOSITION, . . . 27K ±10%, 2w (MIL-R-11)	4
-13	0140-0025	CM15E680K	. CAPACITOR, FIXED, MICA DIELECTRIC, 68 pf ±10%, 500 wvdc (MIL-C-5)	1
-14	9140-0040	42μH-10%-PHENOLIC FORM	. COIL, RF, 42 μh ±10% (99849)	1
-15	400D-75G-1	400D-75G-1	. PRINTED CIRCUIT BOARD (28480) . . .	1

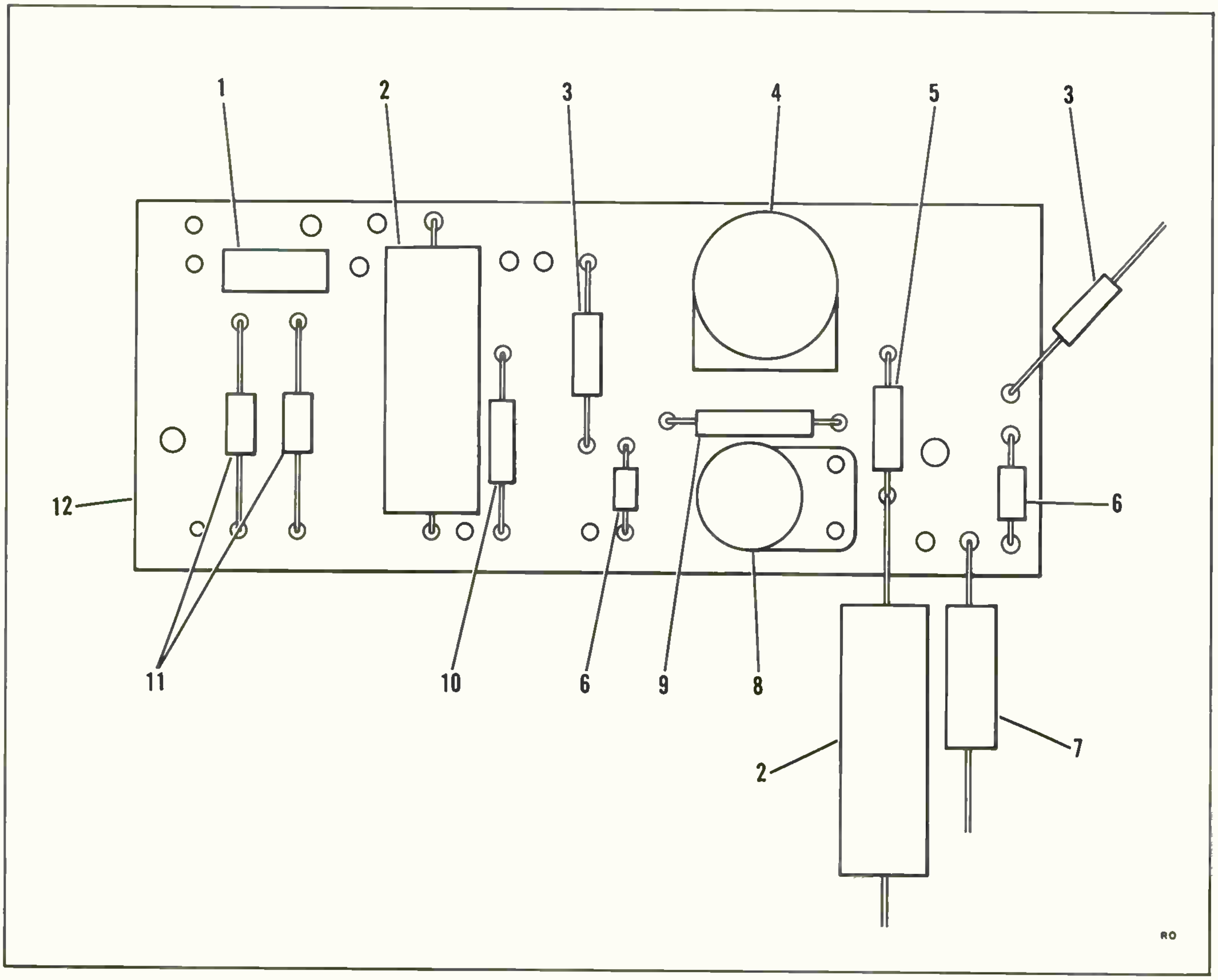


Figure 7-5. Printed Circuit Board Assembly, Part No. 400D-75F

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-5-	400D-75F	400D-75F	PRINTED CIRCUIT BOARD ASSEMBLY . . (28480) (See figure 7-2,index 52 for next higher assembly)	REF
-1	0689-5105	RC32GF510J	. RESISTOR,FIXED,COMPOSITION, . . 51 ohm ±5%,1w (MIL-R-11)	1
-2	0170-0064	148P47491	. CAPACITOR,FIXED,PAPER . . . . . DIELECTRIC,0.47 μf ±10%,100 wvdc (56289)	2
-3	400D-26F	400D-26F	. RESISTOR,FIXED,WIRE WOUND, . . . 10 ohm ±0.5%,1/2w (28480)	2
-4	2100-0108	2100-0108	. RESISTOR,VARIABLE,100 ohm ±30%,1/3w (28480)	1
-5	400D-26C	400D-26C	. RESISTOR,FIXED,WIRE WOUND, . . . 205 ohm ±0.5% (28480)	1
-6	400D-60A	400D-60A	. COIL,RADIO FREQUENCY,0.05 μh (28480)	2
-7	0813-0009	CS-2-125	. RESISTOR,FIXED,COMPOSITION, . . . 125 ohm ±10%,2w (91637)	1
-8	0130-0002	557-000-U2P0-34R	. CAPACITOR,VARIABLE,CERAMIC . . DIELECTRIC,8-50 pf,350 wvdc (72982)	1
-9	0727-0018	DC-1/2C-40	. RESISTOR,FIXED,FILM, ... 40 ohm ±1%, 1/2w (19701)	1
-10	0686-5115	RC20GF511J	. RESISTOR,FIXED,COMPOSITION, . . . 510 ohm ±5%,1/2w (MIL-R-11)	1
-11	1901-0027	HD-5004	. SEMICONDUCTOR DEVICE,DIODE (82577)	2
-12	400D-75F-1	400D-75F-1	. PRINTED CIRCUIT BOARD (28480) . .	1

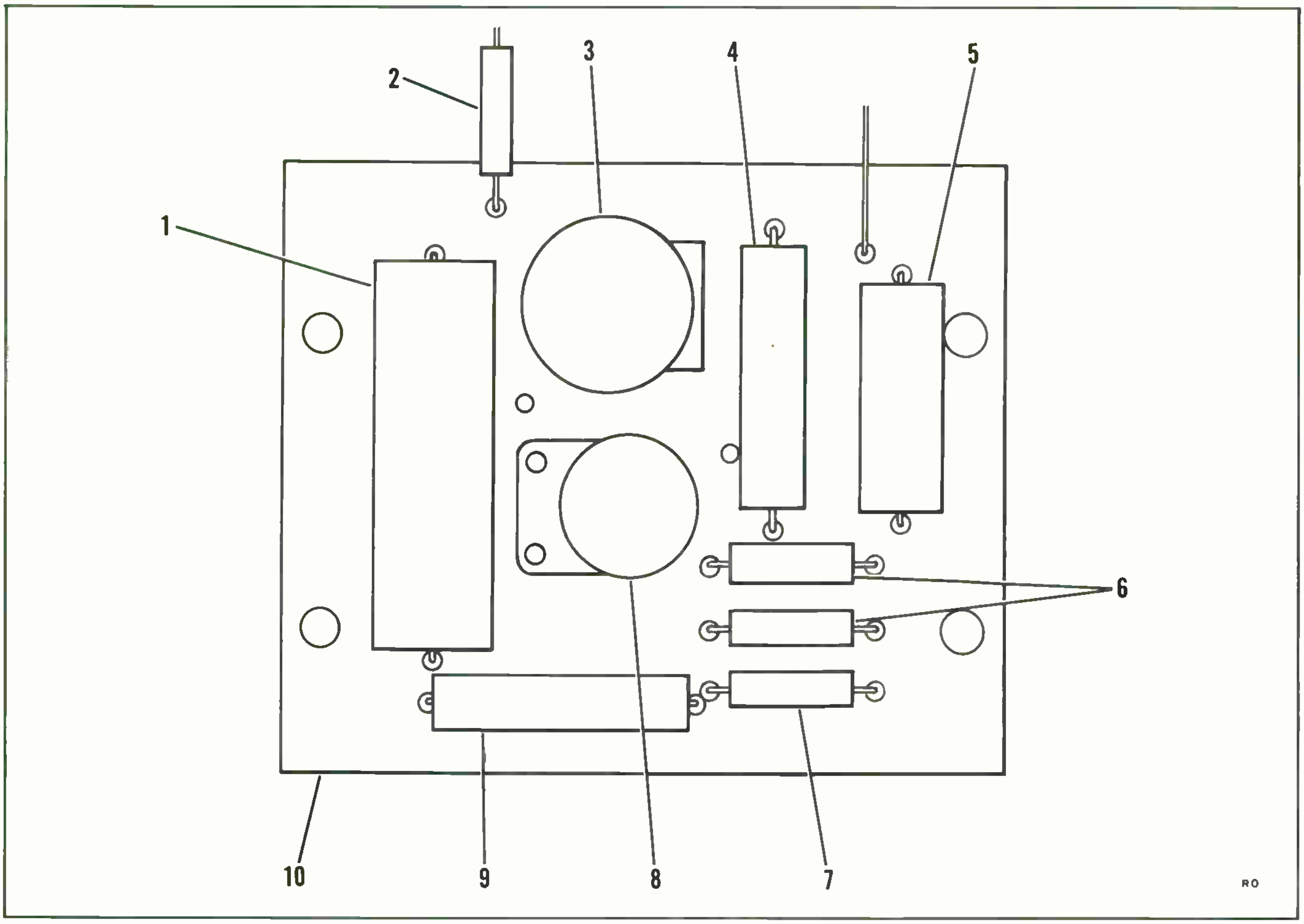


Figure 7-6. Printed Circuit Board Assembly, Part No. 400D-65C

FIG. & INDEX NO.	H-P STOCK NO.	MFR. OR MIL PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY
7-6-	400D-65C	400D-65C	PRINTED CIRCUIT BOARD ASSEMBLY . . (28480) (See figure 7-2, index 58 for next higher assembly)	REF
-1	0160-0005	160P47396	. CAPACITOR, FIXED, PAPER . . . . . DIELECTRIC, 0.047 µf ±10%, 600 wvdc (56289)	1 1
-2	0687-4701	RC20GF470K	. RESISTOR, FIXED, COMPOSITION, . . . 47 ohm ±10%, 1/2w (MIL-R-11)	1
-3	2100-0151	2100-0151	. RESISTOR, VARIABLE, 500 ohm ±20%, 1/5w (28480)	1
-4	0730-0029	DC-1-10K	. RESISTOR, FIXED, FILM, 10K ±1%, 1w . (19701)	1
-5	0140-0084	CM35E472J	. CAPACITOR, FIXED, MICA DIELECTRIC, 4700 pf ±5%, 500 wvdc (MIL-C-5)	1
-6	0687-1001	RC20GF100K	. RESISTOR, FIXED, COMPOSITION, . . 10 ohm ±10%, 1/2w (MIL-R-11)	2
-7	0687-3901	RC20GF390K	. RESISTOR, FIXED, COMPOSITION, . . 39 ohm ±10%, 1/2w, value selected at factory, optimum value show (MIL-R-11)	1
-8	0130-0003	503-000-C0P0-10R	. CAPACITOR, VARIABLE, CERAMIC DIELECTRIC, 1.5-7 pf, 500 wvdc (72982)	1
-9	0730-0143	DC-1-10.31M	. RESISTOR, FIXED, FILM, 10.31M ±1%, 1w (19701)	1
-10	400D-65C-1	400D-65C-1	. PRINTED CIRCUIT BOARD (28480) . .	1

SECTION VIII

NUMERICAL INDEXES

PART NO. NUMERICAL INDEX

PART NO.	STOCK NO. CLASS CODE	STOCK NO. SERIAL OR PART NO.	FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE
AC-10E	5940		7-1-2	2	
AC-10F	5940		7-1-3	2	
AC-54D	5970		7-1-4	2	
AC-54E	5970		7-1-5	2	
AN515-6-4	5305		7-1-	6	
AN526-632-14	5305		7-2-	2	
AN526-832-10	5905		7-1-	2	
AN526-832-8	5305		7-1-	5	
AN935-6	5310		7-2-	2	
AN960-6	5310		7-2-	1	
C-10-6.3K	5905		7-2-48	1	
CM15B680K	5910		7-4-13	1	
CM15E470J	5910		7-3-1	1	
CM15E560J	5910		7-3-5	1	
CM20B681K	5910		7-4-10	1	
CM35E472J	5910		7-6-5	1	
CS-2-125	5905		7-5-7	1	
CS-9941/PH151/7.5FT	6145		7-2-25	1	
CS-9941/PH151/7.5FT W/O PLUG	6145		7-2-25	1	
DC-1/2C-40	5905		7-5-9	1	
DC-1-10.31M	5905		7-6-9	1	
DC-1-10K	5905		7-6-4	1	
DC-1-166K	5905		7-4-4	1	
DC-1-90.5K	5905		7-4-3	1	
D27390	5910		7-2-20	2	
D32452	5910		7-2-17	3	
G-2A			7-1-13	1	
G-74N	5355		7-1-10	1	
HD-5004	5960		7-5-11	2	
H02-400D	6625		7-1-	1	
H02-400D-PWR CORD	6145		7-2-25	1	
INSULOID C3	5340		7-2-33	1	
INSULOID N3	5340		7-2-2	3	
MAIN CHASSIS ASSEMBLY			7-1-15	1	
MDL-1	5920		7-2-71	1	
MS24663	5935		7-2-25	1	
MS35239-42	5305		7-2-	1	
N25-8.2K	5905		7-2-66	1	
PANEL ASSEMBLY			7-1-	1	
PKM 4P5	5910		7-2-34	1	
RC20GF100K	5905		7-6-6	2	
RC20GF104J	5905		7-2-46	1	
RC20GF104K	5905		7-4-2	1	
RC20GF125K	5905		7-2-67	1	
RC20GF153K	5905		7-3-2	1	
RC20GF225K	5905		7-2-61	1	
RC20GF275K	5905		7-2-44	1	
RC20GF335K	5905		7-2-73	1	
RC20GF390K	5905		7-6-7	1	
RC20GF470K	5905		7-2-40 7-6-2	5	
RC20GF471K	5905		7-2-36	2	
RC20GF474K	5905		7-2-37	2	
RC20GF511J	5905		7-5-10	1	
RC20GF561K	5905		7-2-43	2	
RC20GF684K	5905		7-2-49	1	
RC20GF825K	5905		7-2-62	1	
RC32GF100K	5905		7-2-69	1	
RC32GF114J	5905		7-2-55	1	
RC32GF124K	5905		7-4-5	1	
RC32GF183K	5905		7-2-74	1	
RC32GF2R7K	5905		7-2-42	2	
RC32GF224K	5905		7-2-41	2	
RC32GF242J	5905		7-4-11	2	
RC32GF332K	5905		7-2-53	1	
RC32GF334K	5905		7-4-8	1	
RC32GF473K	5905		7-2-50	4	
RC32GF510J	5905		7-5-1	1	
RC32GF563K	5905		7-4-6	1	
RC32GF683K	5905		7-4-1	1	
RC42GF103K	5905		7-2-51	1	
RC42GF184K	5905		7-4-7	1	
RC42GF273K	5905		7-4-12	4	
RC42GF682K	5905		7-2-59	1	
RC42GF822K	5905		7-2-56	2	
SCREW,ASSEMBLED WASHER	5305		7-2-	1	
SCREW,ASSEMBLED WASHER	5305		7-2-	8	
SCREW,ASSEMBLED WASHER	5305		7-2-	2	

PART NO.	STOCK NO. CLASS CODE	STOCK NO. SERIAL OR PART NO.	FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE
S70375	5910		7-2-27	1	
1120-0005	6625		7-1-11	1	
1120-0062	6625		7-1-11	1	
1120-0081	6625		7-1-11	1	
12	6240		7-1-7	1	
12B4A	5960		7-2-10	1	
120D5-63AHS	5960		7-2-22	1	
126	5960		7-2-7	1	
14L-15	6210		7-1-6	1	
1400-0005	5960		7-2-5	6	
1400-0034			7-2-14	2	
1400-0035			7-2-12	5	
1400-0039	5960		7-2-6	1	
148P22394	5910		7-2-47	1	
148P47392	5910		7-2-60	1	
148P47491	5910		7-5-2	2	
1550	5340		7-1-12	1	
160P10306	5910		7-2-63	1	
160P10494	5910		7-2-54	2	
160P27296	5910		7-2-75	1	
160P47396	5910		7-6-1	1	
2020-AE	6250		7-1-8	1	
2100-0077	5905		7-2-68	1	
2100-0080	5905		7-2-18	1	
2100-0108	5905		7-5-4	1	
2100-0136	5905		7-2-19	1	
2100-0151	5905		7-6-3	1	
2102	5340		7-2-	2	
29C214A3-H-1038	5910		7-2-39	3	
30D120A1	5910		7-2-3	1	
30D133A1	5910		7-2-3 7-2-45	2	
3100-0251	5930		7-3-6	1	
315-000-C0G0-100D	5910		7-3-3	1	
316PH-3702	5935		7-2-15	6	
342003	5920		7-2-72	1	
400D	6625-643-1670		7-1-	1	
400D-1A			7-2-76	1	
400D-1B	5999		7-2-77	1	
400D-19A			7-2-32	1	
400D-2			7-1-14	1	
400D-26C	5905		7-5-5	1	
400D-26F	5905		7-5-3	2	
400D-26G	5905		7-3-4	1	
400D-44			7-1-1	1	
400D-6F			7-2-64	1	
400D-6H			7-2-57	1	
400D-6J	5930		7-2-30	1	
400D-6K	5940		7-2-31	1	
400D-60A	5950		7-5-6	2	
400D-65C			7-2-58	1	
400D-65C-1	5999		7-6-10	1	
400D-75F			7-2-52	1	
400D-75F-1	5999		7-5-12	1	
400D-75G			7-2-38	1	
400D-75G-1	5999		7-4-15	1	
400D-75G-2	5999		7-4-9	1	
400D-75H			7-2-4	1	
400H	6625-557-8261		7-1-	1	
400H-2A			7-1-14	1	
400L	6625-729-8360		7-1-	1	
42µH-10%-PHENOLIC FORM	5950		7-4-14	1	
429-.125			7-2-13	1	
44F-16388	5935		7-2-16	2	
5P-1	5325		7-2-24	1	
503-000-B2P0-28R	5910		7-2-28	1	
503-000-C0P0-10R	5910		7-6-8	1	
503-000-D2P0-33R	5910		7-2-29	1	
51A12272	5935		7-2-23	1	
510-061810-01	5310		7-2-	12	
510-081810-01	5310		7-1-	1	
557-000-U2P0-34R	5910		7-5-8	1	
5651	5960		7-2-9	1	
6AX5-GT	5960		7-2-21	1	
6CB6A	5960		7-2-8	5	
6U8	5960		7-2-11	1	
61-6911	6130		7-2-70	1	
663UW20504	5910		7-2-1	2	
777	5340		7-2-65	1	
781	5340		7-2-35	1	
80994-H	5930		7-1-10	1	
9100-0050	5950		7-2-26	1	

HEWLETT-PACKARD STOCK NO. INDEX

H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES
AC-10E	2	1
AC-10F	2	1
AC-54D	2	
AC-54E	2	
G-2A	1	
G-74N	1	
H02-400D	1	
H02-400D-PWR CORD	1	
0130-0001	1	1
0130-0002	1	1
0130-0003	1	1
0130-0006	1	1
0140-0007	1	1
0140-0014	1	1
0140-0025	1	1
0140-0032	1	1
0140-0039	1	1
0140-0084	1	1
0150-0009	1	1
0150-0012	3	1
0160-0005	1	1
0160-0013	2	1
0160-0024	1	1
0160-0044	1	1
0160-0054	1	1
0170-0002	2	1
0170-0040	1	1
0170-0057	1	1
0170-0063	1	1
0170-0064	2	1
0180-0025	3	1
0180-0028	2	1
0180-0033	2	1
0180-0063	1	1
0380-0008	2	
0400-0013	1	
0686-5115	1	1
0687-1001	2	1
0687-1041	2	2
0687-1251	1	1
0687-1531	1	
0687-1831	1	1
0687-2251	1	1
0687-2751	1	1
0687-3351	1	1
0687-3901	1	1
0687-4701	5	2
0687-4711	2	1
0687-4741	2	1
0687-5611	2	1
0687-6841	1	1
0687-8251	1	1

H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES
0689-1145	1	1
0689-2425	2	1
0689-5105	1	1
0690-1001	1	1
0690-1241	1	1
0690-1831	1	1
0690-2241	2	1
0690-3321	1	1
0690-3341	1	1
0690-4731	4	1
0690-5631	1	1
0690-6831	1	1
0693-1031	1	1
0693-1841	1	1
0693-2731	4	1
0693-6821	1	1
0693-8221	2	1
0699-0005	2	1
0727-0018	1	1
0730-0029	1	1
0730-0065	1	1
0730-0076	1	1
0730-0143	1	1
0761-0001	1	1
0813-0009	1	1
0816-0017	1	1
1120-0005	1	1
1120-0062	1	1
1120-0081	1	1
1200-0008	2	
1200-0009	6	
1200-0020	1	
1220-0005	1	
1220-0010	1	
1251-0037	1	
1390-0020	3	
1400-0005	6	
1400-0007	1	
1400-0015	1	
1400-0016	1	
1400-0025	1	
1400-0033	1	
1400-0034	2	
1400-0035	5	
1400-0039	1	
1400-0074	1	
1450-0020	1	
1450-0022	1	
1882-0005	1	1
1901-0027	2	2
1921-0010	1	1
1923-0028	5	5

H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES
1930-0014	1	1
1933-0004	1	1
1940-0001	1	1
2100-0077	1	1
2100-0080	1	1
2100-0108	1	1
2100-0136	1	1
2100-0151	1	1
2110-0007	1	10
2140-0012	1	1
2190-0006	2	
2360-0003	6	
2360-0012	2	
2370-0009	1	
2390-0001	1	
2390-0009	8	
2420-0001	14	
2520-0003	5	
2520-0006	2	
2550-0007	2	
2580-0003	1	
2900-0001	4	
3050-0100	1	
3101-0001	1	1
400D	1	
400D-1A	1	
400D-1B	1	
400D-19A	1	
400D-2	1	
400D-26C	1	1
400D-26F	2	1
400D-26G	1	1
400D-44	1	
400D-6F	1	
400D-6H	1	
400D-6J	1	
400D-6K	1	
400D-60A	2	1
400D-65C	1	
400D-65C-1	1	
400D-75F	1	
400D-75F-1	1	
400D-75G	1	
400D-75G-1	1	
400D-75G-2	1	
400D-75H	1	
400H	1	
400H-2A	1	
400L	1	
8120-0050	1	1
9100-0050	1	1
9140-0040	1	

SECTION IX
REFERENCE DESIGNATION INDEX

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	CLASS CODE OR STOCK NUMBER	PART NUMBER
CR1	7-5-11	5960-	HD-5004
CR2	7-5-11	5960-	HD-5004
CR3	7-2-70	6130-	61-6911
C1	7-2-17	5910-	D32452
C100	7-2-63	5910-	160P10306
C101	7-2-60	5910-	148P47392
C102	7-5-8	5910-	557-000-U2P0-34R
C104	7-2-27	5910-	S70375
C105	7-2-20	5910-	D27390
C106	7-3-5	5910-	CM15E560J
C107	7-2-45	5910-	30D133A1
C108	7-3-1	5910-	CM15E470J
C14	7-2-28	5910-	503-000-B2P0-28R
C15	7-3-3	5910-	315-000-C0G0-100D
C16	7-2-29	5910-	503-000-D2P0-33R
C17	7-2-17	5910-	D32452
C19	7-2-54	5910-	160P10494
C2	7-6-1	5910-	160P47396
C20	7-5-2	5910-	148P47491
C22	7-4-10	5910-	CM20B681K
C23	7-2-54	5910-	160P10494
C24	7-2-75	5910-	160P27296
C25	7-2-39	5910-	29C214A3-H-1038
C26	7-4-13	5910-	CM15E680K
C28	7-2-47	5910-	148P22394
C29	7-2-39	5910-	29C214A3-H-1038
C30	7-2-17	5910-	D32452
C31	7-5-2	5910-	148P47491
C32	7-2-1	5910-	663UW20504
C33	7-2-1	5910-	663UW20504
C34 D,H02	7-2-3	5910-	30D120A1
C34 H,L	7-2-3	5910-	30D133A1
C35	7-2-39	5910-	29C214A3-H-1038
C36	7-2-34	5910-	PKM 4P5
C39	7-2-20	5910-	D27390
C4	7-6-8	5910-	503-000-C0P0-10R
C5	7-6-5	5910-	CM35E472J
DS1	7-1-7	6240-	12
F1	7-2-71	5920-	MDL-1
L1	7-4-14	5950-	42μH-10%-PHENOLIC FORM
L10	7-5-6	5950-	400D-60A
L11	7-5-6	5950-	400D-60A
M1 D,H02	7-1-11	6625-	1120-0005
M1 H	7-1-11	6625-	1120-0062
M1 L	7-1-11	6625-	1120-0081
P1 D,H,L	7-2-25	6145-	CS-9941/PH151/7.5FT
P1 H02	7-2-25	6145-	H02-400D-PWR CORD
R1	7-2-55	5905-	RC32GF114J
R100	7-6-4	5905-	DC-1-10K
R101	7-6-3	5905-	2100-0151
R102	7-2-62	5905-	RC20GF825K
R103	7-2-61	5905-	RC20GF225K
R104	7-5-3	5905-	400K-26F
R105	7-5-5	5905-	400D-26C
R106	7-5-9	5905-	DC-1/2C-40
R107	7-5-4	5905-	2100-0108
R108	7-5-3	5905-	400D-26F
R110	7-3-2	5905-	RC20GF153K
R111	7-3-4	5905-	400D-26G
R112	7-3-4	5905-	400D-26G
R113	7-3-4	5905-	400D-26G
R114	7-3-4	5905-	400D-26G
R115	7-3-4	5905-	400D-26G
R116	7-3-4	5905-	400D-26G
R117	7-2-59	5905-	RC42GF682K
R118	7-2-18	5905-	2100-0080
R119	7-2-19	5905-	2100-0136
R120	7-2-41	5905-	RC32GF224K
R121	7-2-42	5905-	RC32GF2R7K
R122	7-2-42	5905-	RC32GF2R7K
R20	7-2-56	5905-	RC42GF822K
R21	7-2-50	5905-	RC32GF473K

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	CLASS CODE OR STOCK NUMBER	PART NUMBER
R22	7-2-56	5905-	RC42GF822K
R23	7-2-66	5905-	N25-8.2K
R24	7-2-40	5905-	RC20GF470K
R27	7-5-7	5905-	CS-2-12S
R30	7-2-67	5905-	RC20GF125K
R31	7-2-40	5905-	RC20GF470K
R32	7-2-50	5905-	RC32GF473K
R33	7-4-12	5905-	RC42GF273K
R34	7-4-12	5905-	RC42GF273K
R35	7-4-11	5905-	RC32GF242J
R36	7-2-73	5905-	RC20GF335K
R37	7-2-44	5905-	RC20GF275K
R38	7-2-43	5905-	RC20GF561K
R39	7-2-46	5905-	RC20GF104J
R4	7-6-9	5905-	DC-1-10.31M
R40	7-2-40	5905-	RC20GF470K
R41	7-2-50	5905-	RC32GF473K
R42	7-4-12	5905-	RC42GF273K
R43	7-4-12	5905-	RC42GF273K
R44	7-4-11	5905-	RC32GF242J
R47	7-2-43	5905-	RC20GF561K
R48	7-2-49	5905-	RC20GF684K
R49	7-2-40	5905-	RC20GF470K
R50	7-2-50	5905-	RC32GF473K
R51	7-2-53	5905-	RC32GF332K
R52	7-2-51	5905-	RC42GF103K
R53	7-5-10	5905-	RC20GF511J
R54	7-5-1	5905-	RC32GF510J
R55	7-4-7	5905-	RC42GF184K
R56	7-4-6	5905-	RC32GF563K
R57	7-2-48	5905-	C-10-6.3K
R58	7-4-5	5905-	RC32GF124K
R59	7-4-8	5905-	RC32GF334K
R6A	7-6-6	5905-	RC20GF100K
R6B	7-6-6	5905-	RC20GF100K
R6C	7-6-7	5905-	RC20GF390K
R60	7-2-74	5905-	RC32GF183K
R61	7-4-1	5905-	RC32GF683K
R62	7-4-4	5905-	DC-1-166K
R63	7-4-2	5905-	RC20GF104K
R64	7-4-3	5905-	DC-1-90.5K
R66	7-2-68	5905-	2100-0077
R67	7-2-36	5905-	RC20GF471K
R68	7-2-69	5905-	RC32GF100K
R7	7-2-41	5905-	RC32GF224K
R83	7-2-37	5905-	RC20GF474K
R85	7-2-37	5905-	RC20GF474K
R86	7-6-2	5905-	RC20GF470K
R9	7-2-36	5905-	RC20GF471K
S1	7-3-6	5930-	3100-0251
S2	7-1-9	5930-	80994-H
T1	7-2-26	5950-	9100-0050
V1	7-2-8	5960-	6CB6A
V2	7-2-8	5960-	6CB6A
V3	7-2-8	5960-	6CB6A
V4	7-2-8	5960-	6CB6A
V5	7-2-8	5960-	6CB6A
V6	7-2-21	5960-	6AX5GT
V7	7-2-10	5960-	12B4A
V8	7-2-11	5960-	6U8
V9	7-2-9	5960-	5651
XDS1	7-1-8	6250-	2020-AE
XF1	7-2-72	5920-	342003
XV1	7-2-15	5935-	316PH-3702
XV2	7-2-15	5935-	316PH-3702
XV3	7-2-15	5935-	316PH-3702
XV4	7-2-15	5935-	316PH-3702
XV5	7-2-15	5935-	316PH-3702
XV6	7-2-23	5935-	51A12272
XV7	7-2-16	5935-	44F-16388
XV8	7-2-16	5935-	44F-16388
XV9	7-2-15	5935-	316PH-3702

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.
00853	Sangamo Electric Co., Cap. Div.	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. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
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 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	Special Tube Operations of Sylvania Electronic Systems	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.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
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.	Soquel, 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.
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.
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
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.
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.
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 Mfg. Co.	Waltham, 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.	Pittsburgh, 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.
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 Div. 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.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	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 Mfg. Co., Inc.	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.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
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.
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.
80411	Acro Manufacturing Co.	Columbus, 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.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, 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	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
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.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
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.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	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., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94148	Scientific Radio Products, Inc	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, 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.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96493	J. W. Miller Co.	Los Angeles, Calif.
96501	Excel Transformer Co.	Oakland, Calif.
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.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
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.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

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

0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
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.
0000V	Imperial Electronics, Inc.	Buena Park, Calif.
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.
000DD	General Transistor	Los Angeles, Calif.

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WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges.* Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

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