TM 11-6625-1514-15

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

ORGANIZATIONAL, DS, GS, AND DEPOT MAINTENANCE MANUAL

HEWLETT-PACKARD VACUUM TUBE VOLTMETER MODELS 400D, 400H, 4001 AND H02-400D

This copy is a reprint which includes current pages from Changes 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY
23 MAY 1967

WARNING

DANGEROUS VOLTAGES

EXIST IN THIS EQUIPMENT

Be careful when working on the power supplies and their circuits, or on the 230 or 115-volt ac line connections.

DO NOT TAKE CHANCES

CHANGE No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington DC, *28 September 1982*

Organizational, Direct Support, General Support and Depot Maintenance Manual
HEWLETT–PACKARD VACUUM TUBE VOLTMETER MODELS 400D, 400H, 400L, and H02-400D
(NSN 6625-00-643-1670)

TM 11-6625-1514-15, 23 May 1967, is changed as follows:

1. Title of manual is changed as shown above.
2. New or changed material is indicated by a vertical bar in the margin.
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i and 1-0	i, ii and 1-0
1-0.1	1-0.1
10-5	10-5

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5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

1. DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL
2. IF POSSIBLE , TURN OFF THE ELECTRICAL POWER
3. IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH, OR LIFT THE PERSON TO SAFETY USING A WOODEN POLE OR A ROPE OR SOME OTHER INSULATING MATERIAL
4. SEND FOR HELP AS SOON AS POSSIBLE
5. AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

TM 11-6625-1514-15

Technical Manual No. 11-6625-1514-15

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, *23 May 1967*

ORGANIZATIONAL, DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE MANUAL

HEWLETT-PACKARD VACUUM TUBE VOLTMETER MODELS 400D, 400H, 400L, AND H02-400D (NSN 6625-00-643-1670)

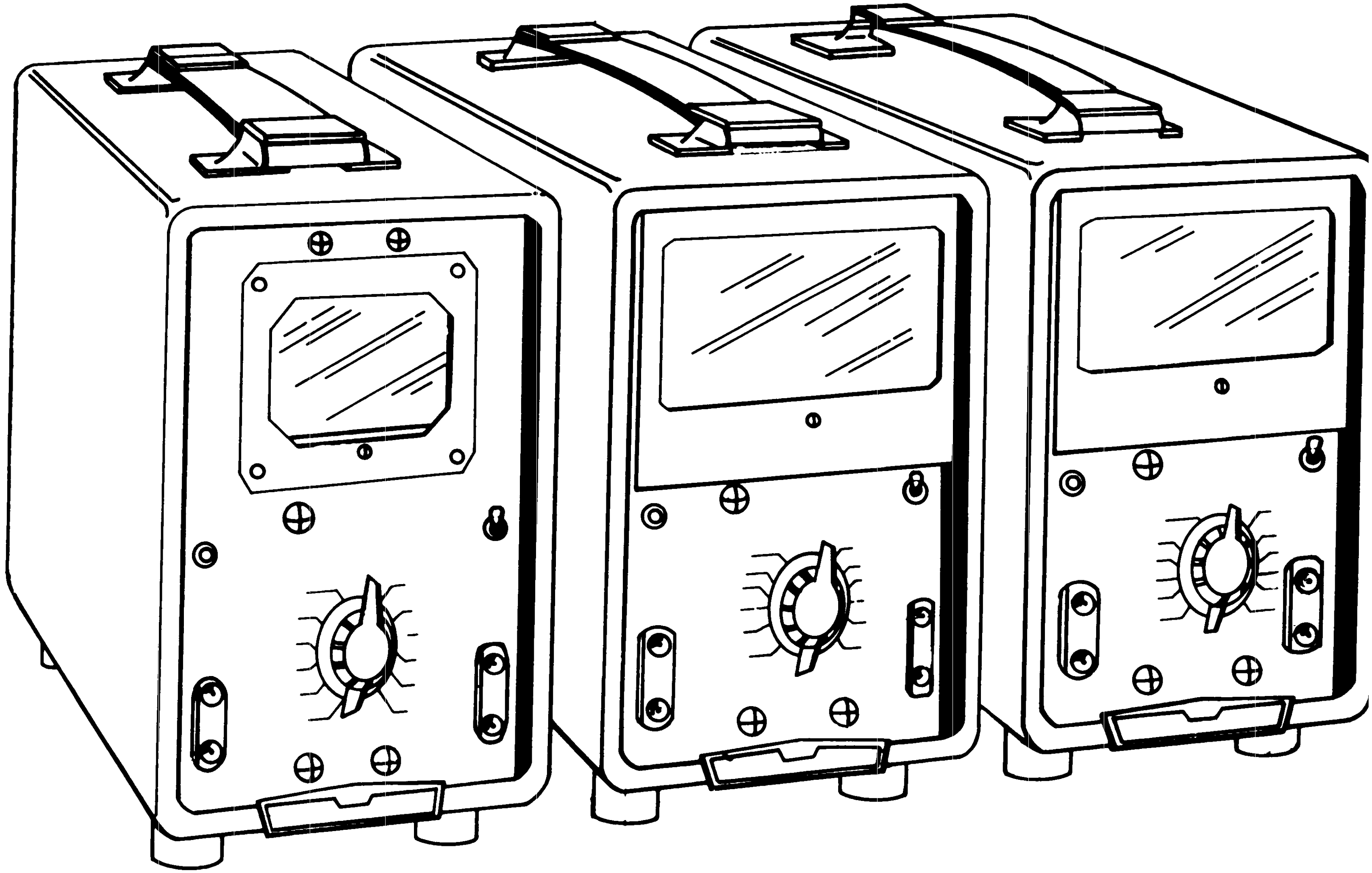

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Figure 1-1. Vacuum Tube Voltmeters Models 400D, 400H, 400L.

SECTION I
GENERAL DESCRIPTION

1-A.1. Scope

This manual includes installation and operation instructions and covers operator's, organizational, direct support (DS), general support (GS), and depot maintenance. It describes Hewlett-Packard (Federal Supply Code 28480) Vacuum Tube Voltmeter Models 400D and H02-400D, serial numbers 310-45571 and higher; and Models 400H and 400L, serial numbers 313-22177 and higher. A basic issue items list for this equipment is not included in this manual.

1-A.2. Index of Technical Publications

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes or additional publications pertaining to the equipment.

1-A.3. Maintenance Forms, Records, and Reports

a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by TM 38-750, The Army Maintenance Management System (Army). Air Force personnel will use AFR 66-1 for maintenance reporting and TO-00-35D54 for unsatisfactory equipment reporting.

b. Report of Packaging and Handling Deficiencies. Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2/DLAR 4140.55/NAVMATINST 4355.73/AFR 400-54/MCO 4430.3E.

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33B/AFR 75-18/MCO P4610.19C/DLAR 4500.15.

1-A.4. Reporting Errors and Recommending Improvements

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703. A reply will be furnished direct to you.

1-A.5. Report Equipment Improvement Recommendations (EIR)

If your vacuum tube voltmeter needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Tell us why a procedure is hard to perform. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703. We'll send you a reply.

1-A.6. Administrative Storage

Administrative storage of equipment issued to and used by Army activities will have preventive maintenance performed before storing. When removing the equipment from administrative storage, the PMCS should be performed to assure operational readiness.

1-A.7. Destruction of Army Electronics Materiel

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

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

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. 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 in Figure 1-2.

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. Models 400 D/H measure a-c voltages from 0.001 to 300 volts and Model 400L from .003 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 input 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: 400D/H - 0.1 millivolt to 300 volts; 400L - 0.3 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 µµf) 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 to 1000 cps, approximately 100 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-blue, 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. Instruments designated Models 400DR, 400HR, and 400LR are rack mount configurations of the 400D, 400H, and 400L, respectively. They are identical to their cabinet model counterparts in every other respect. They are designed to be mounted in a standard 19 inch wide x 7 inch high relay rack space. Refer to Appendix C for Replacement Parts information.

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 or deficiency, refer to paragraph 1-A.3.

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 equipped 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.

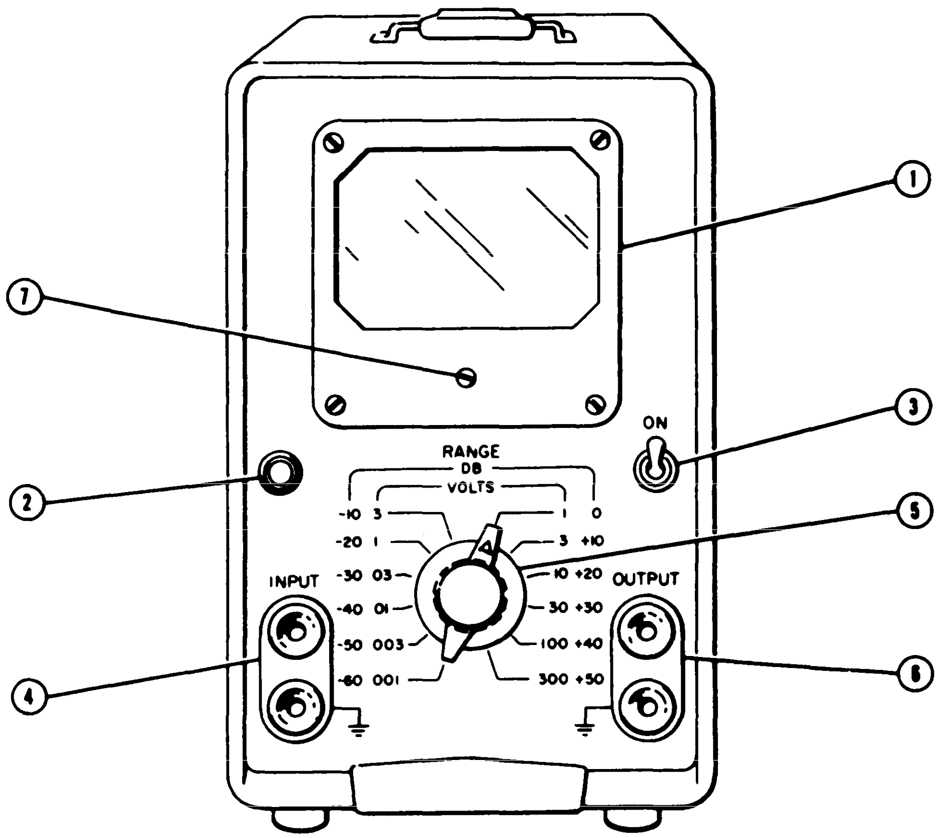
2-10. OPERATION CHECK.

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

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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 de 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

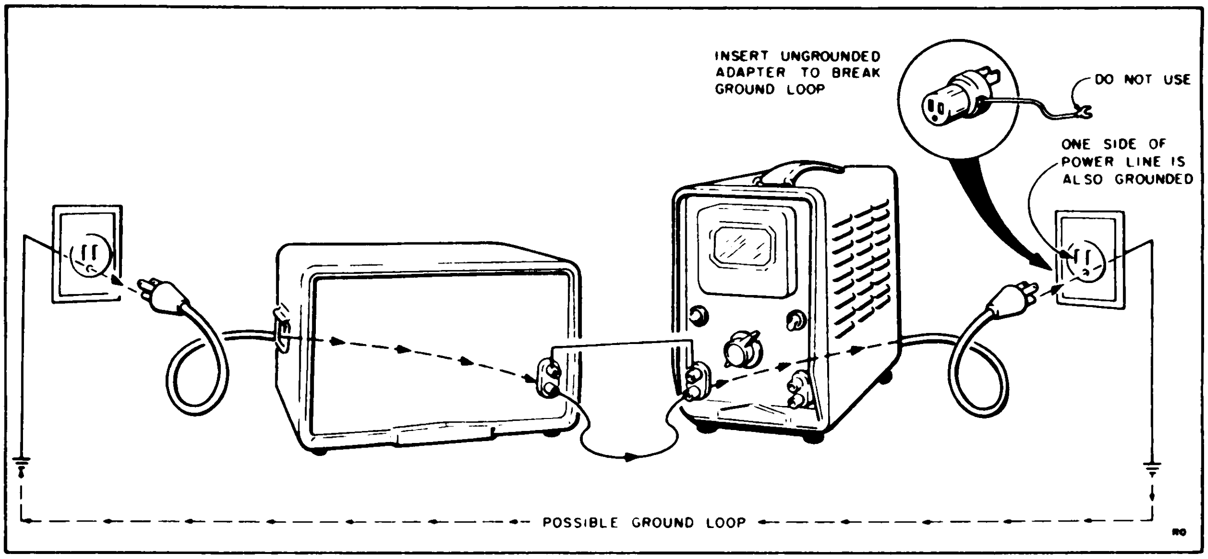

Figure 3-3. Test Setup for Avoiding Ground Loop

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 microvolt, 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 scaIe. If the meter indicates .64 on that scale, the voltage being measured is:

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

Example 2
When the WGE 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:

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

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.

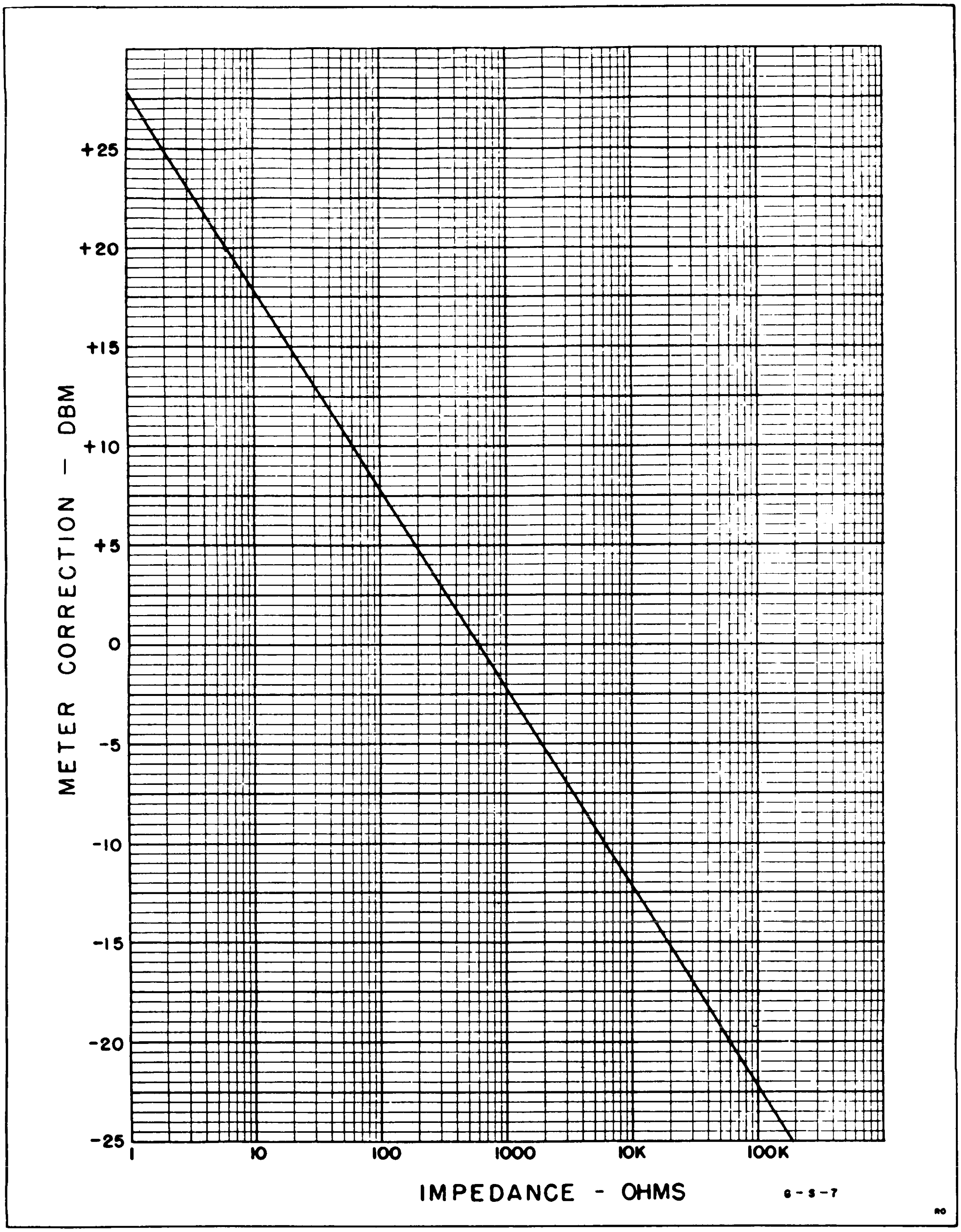

Figure 3-4. Impedance Correction Graph

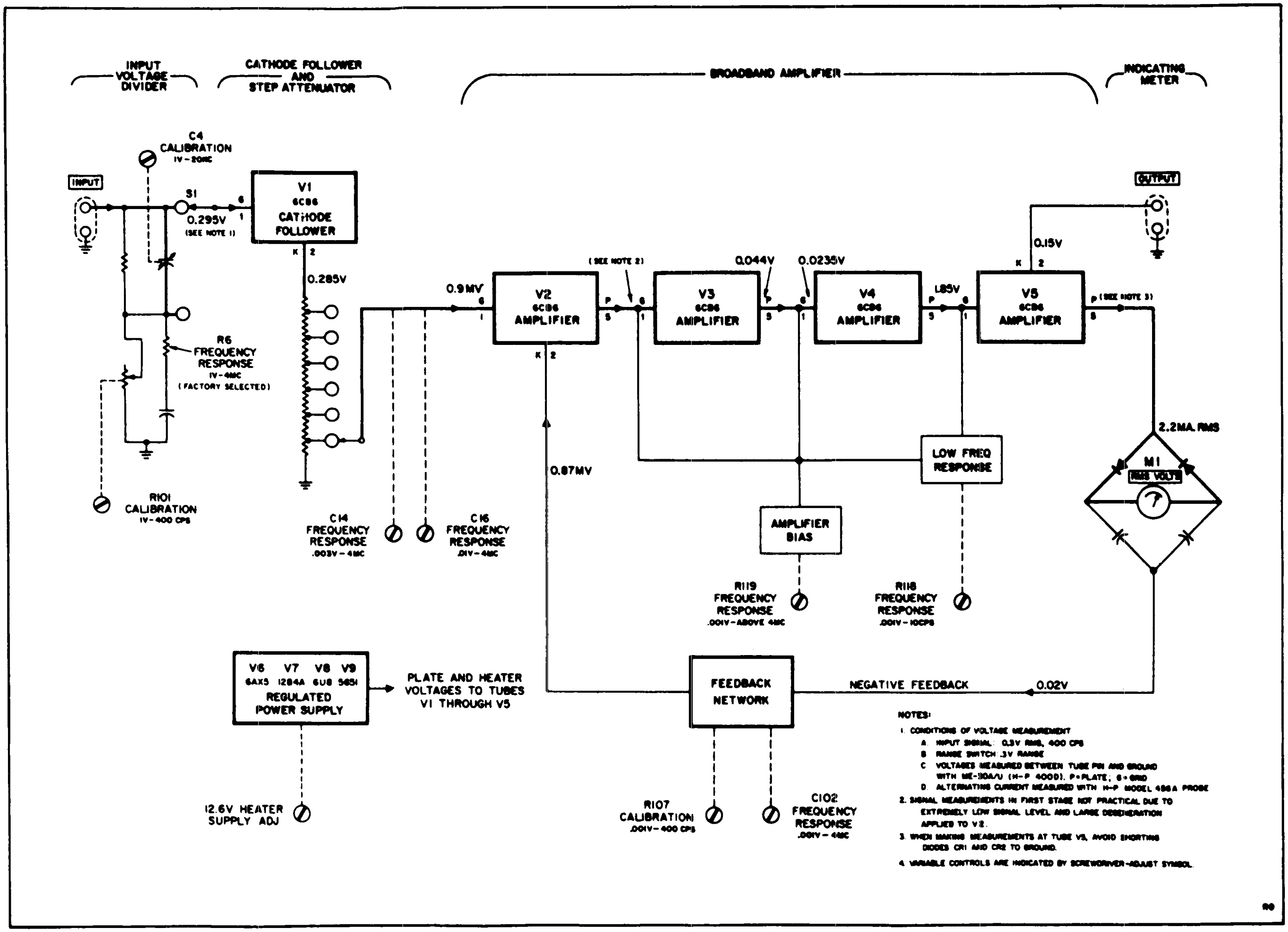

Figure 4-1. Voltmeter Block Diagram

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 contractors (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 V8 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

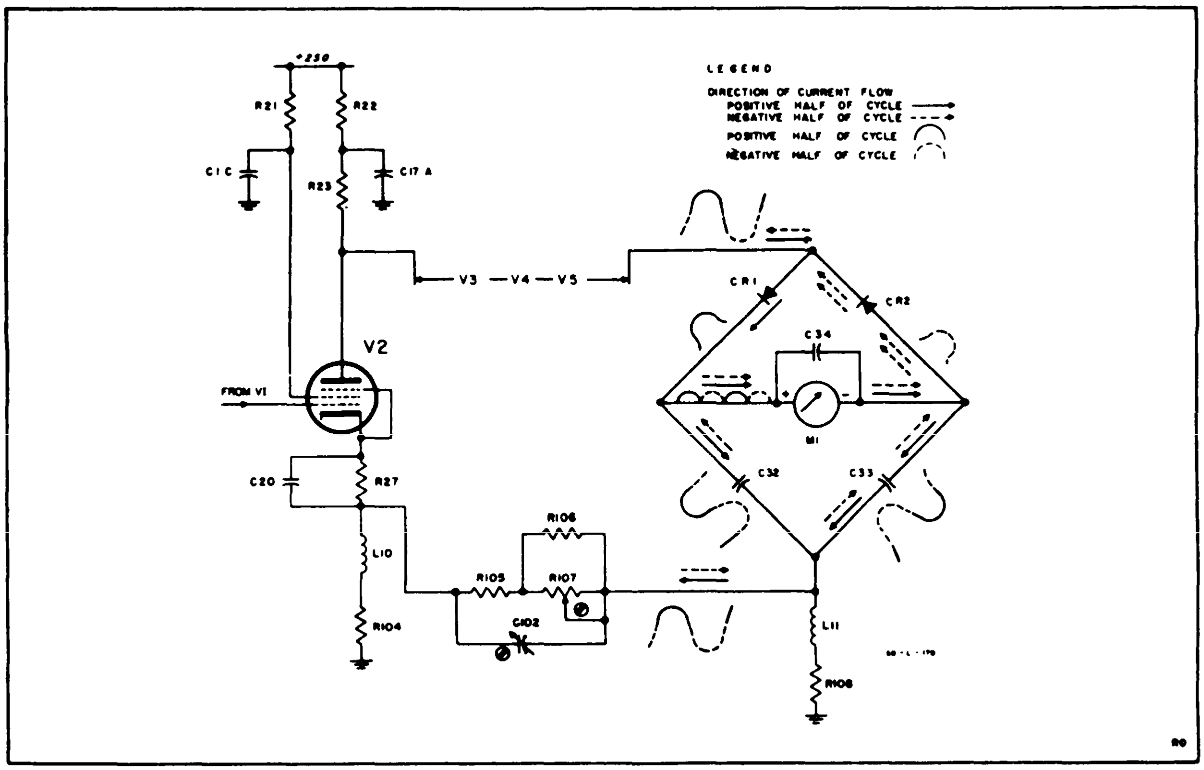

Figure 4-2. Simplified Schematic of Meter Bridge Circuit

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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 -26 B/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 738BR
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 160B 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 428B

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 d.

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	

* Note that V1 must be replaced by a 6CB6, aged and selected for low noise and microphonics (hp Part No. 5080-0621).

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

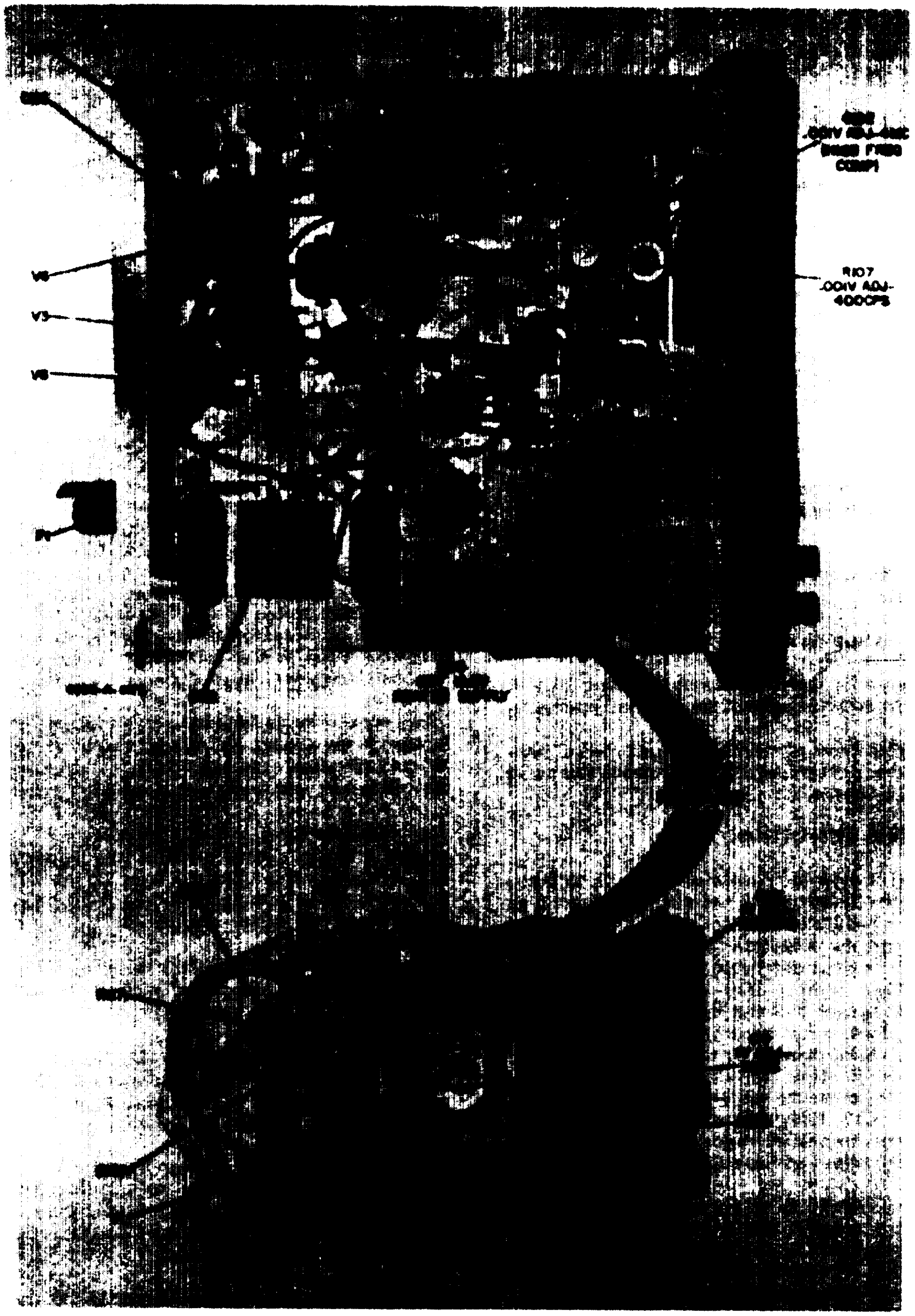

Figure 5-3. Left Side View of Voltmeter Chassis

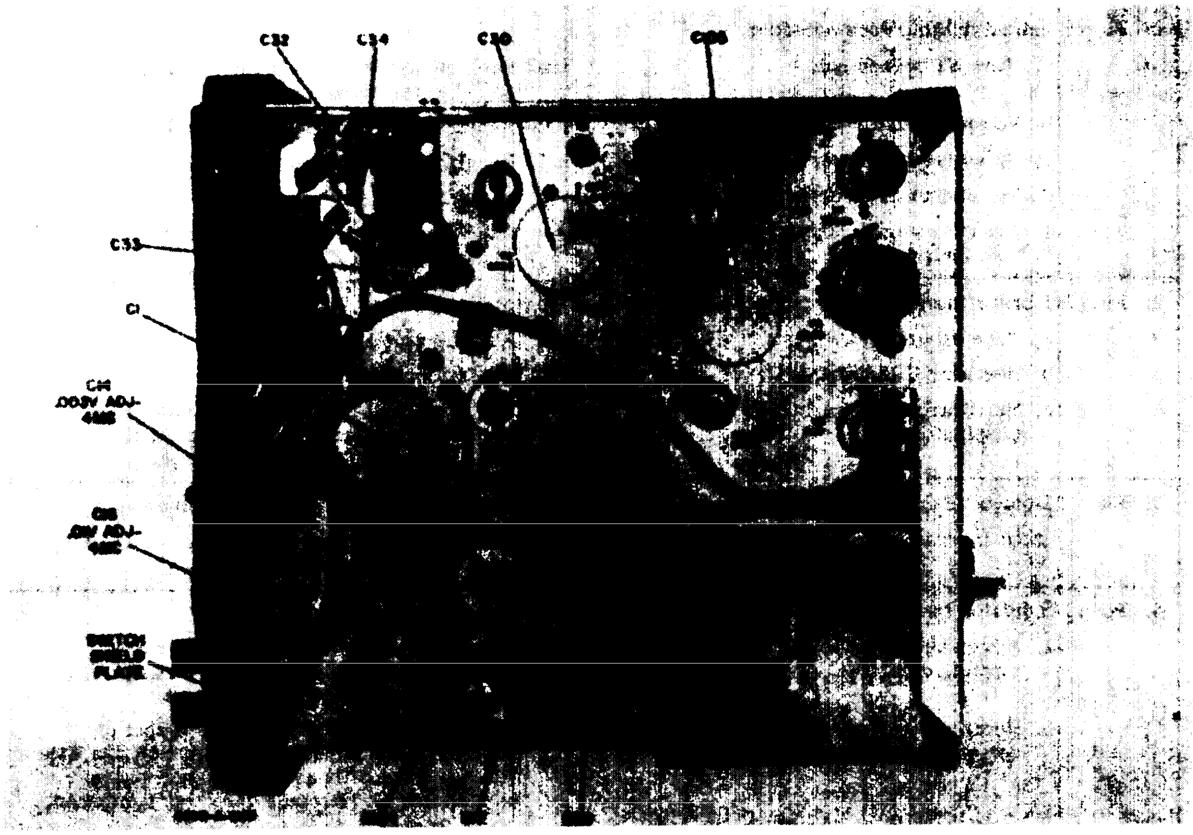

Figure 5-4. Right Side View of Voltmeter Chassis

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 set voltmeter calibrator VOLTAGE SELECTOR 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

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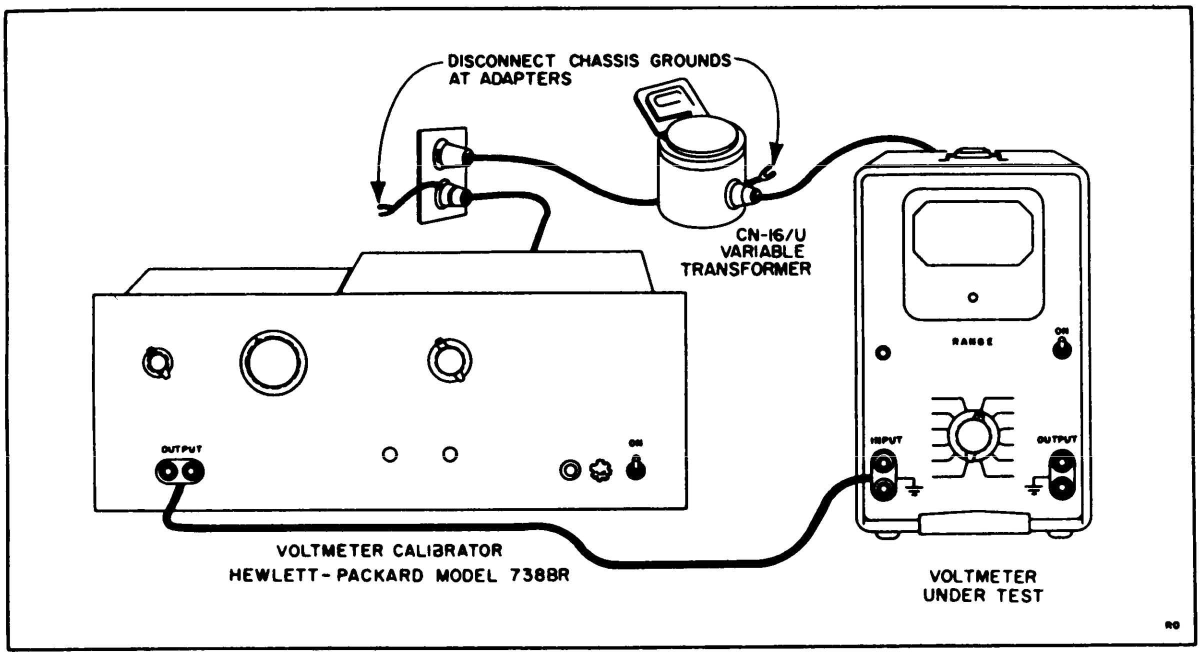


Figure 5-6. Test Setup for Calibration Check and Adjustments

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. 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. Record deviation of voltmeter reading from 1 on the voltmeter scale.

g. Still using the voltmeter l-volt range, reduce the voltmeter calibrator output in 0.1 volt steps. 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.

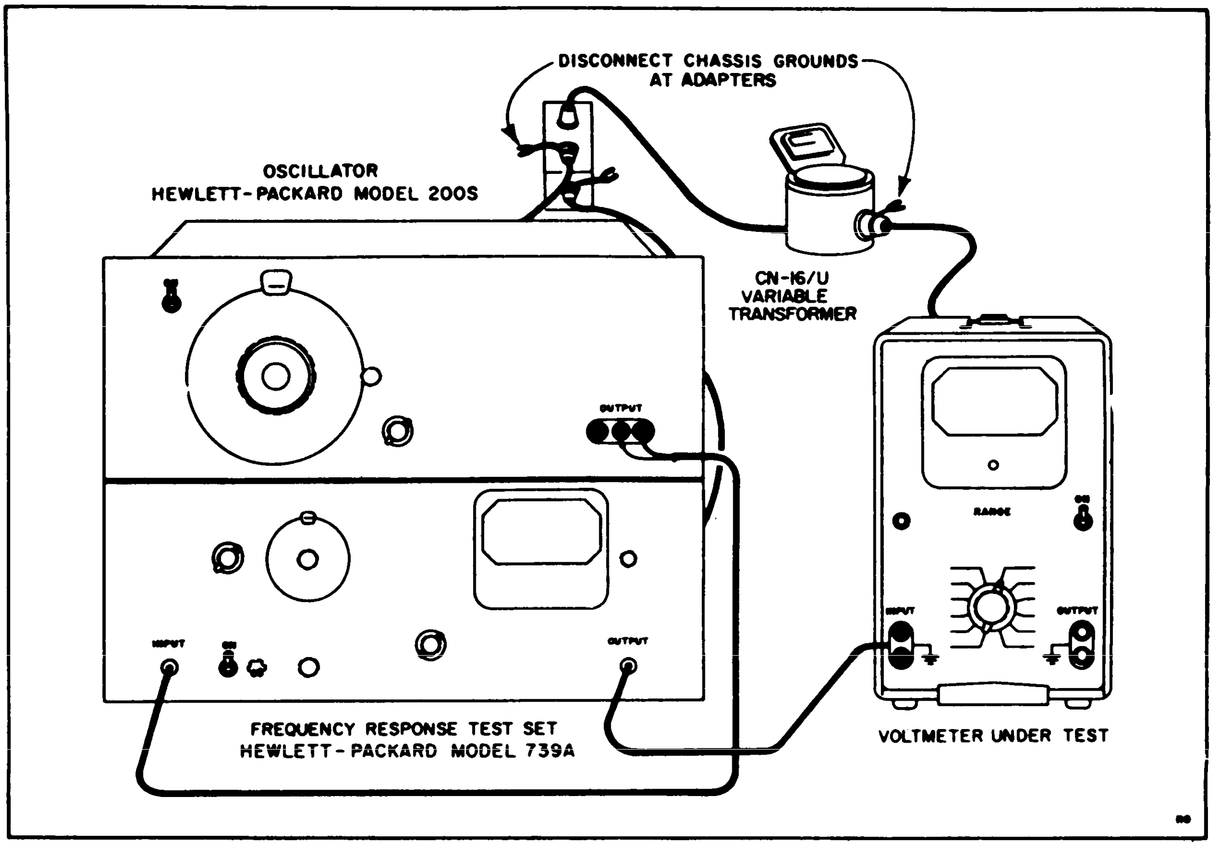


Figure 5-7. Test Setup for Frequency Response Check and Adjustment

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 response 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
RANGE SELECTOR switch to 1.5-5
VOLTAGE SELECTOR 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 the manual for the Model 738BR 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 to .001 volt 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 to 1 volt, 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 Mc while holding output level constant with AMPLITUDE control. The frequency response curve increases from 4 to approximately 6 Mc and then drops off from approximately 6 to 10 Mc. The frequency response of instrument is within specification if voltmeter reading remains in 0 to 0.92 range. If not in specifications adjust R119 and repeat steps g through l.

NOTE

Whenever R119 is adjusted, both lo- and hi-freq. 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.

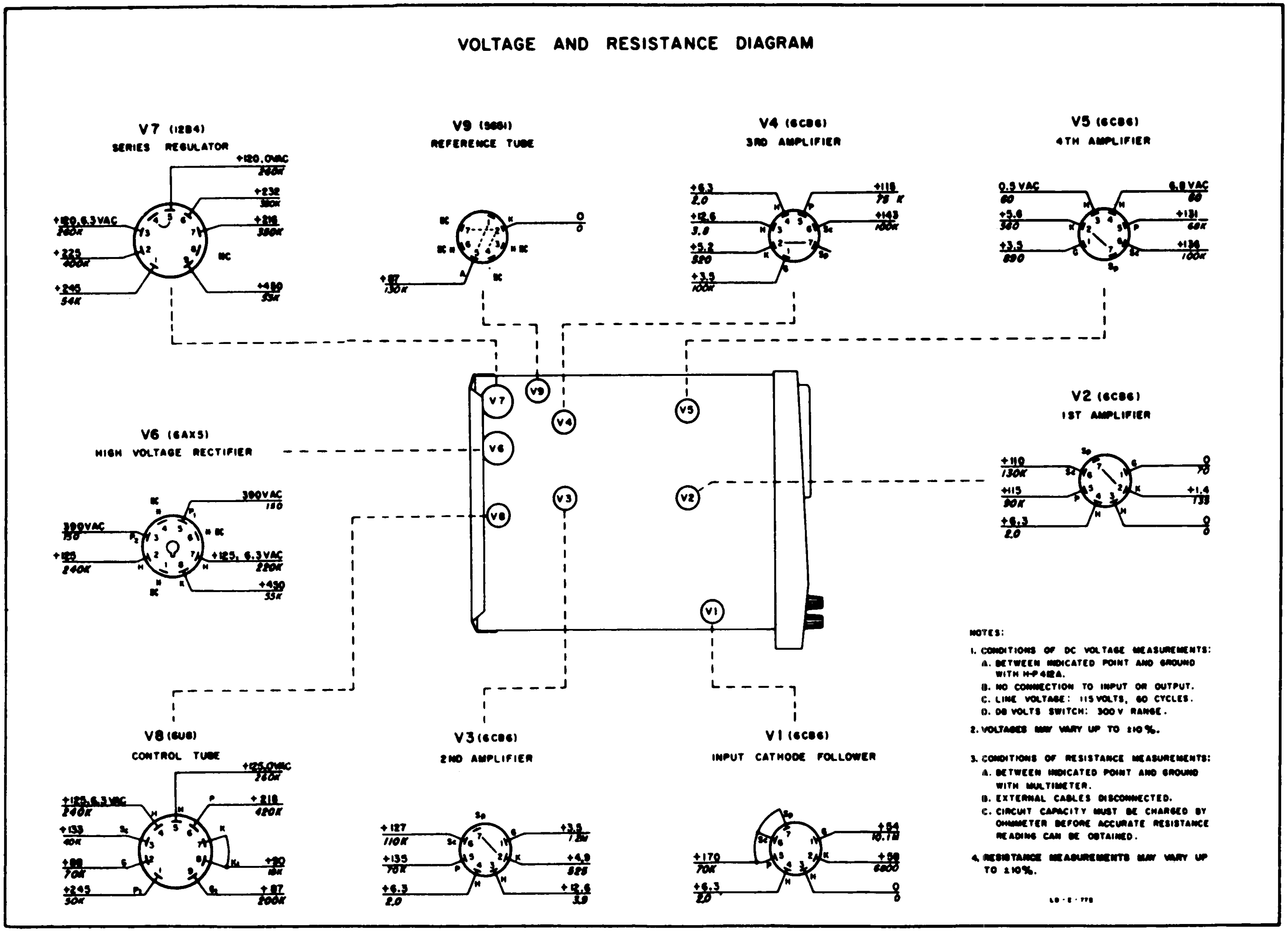


Figure 5-8. Voltage and Resistance Diagram

00102-3

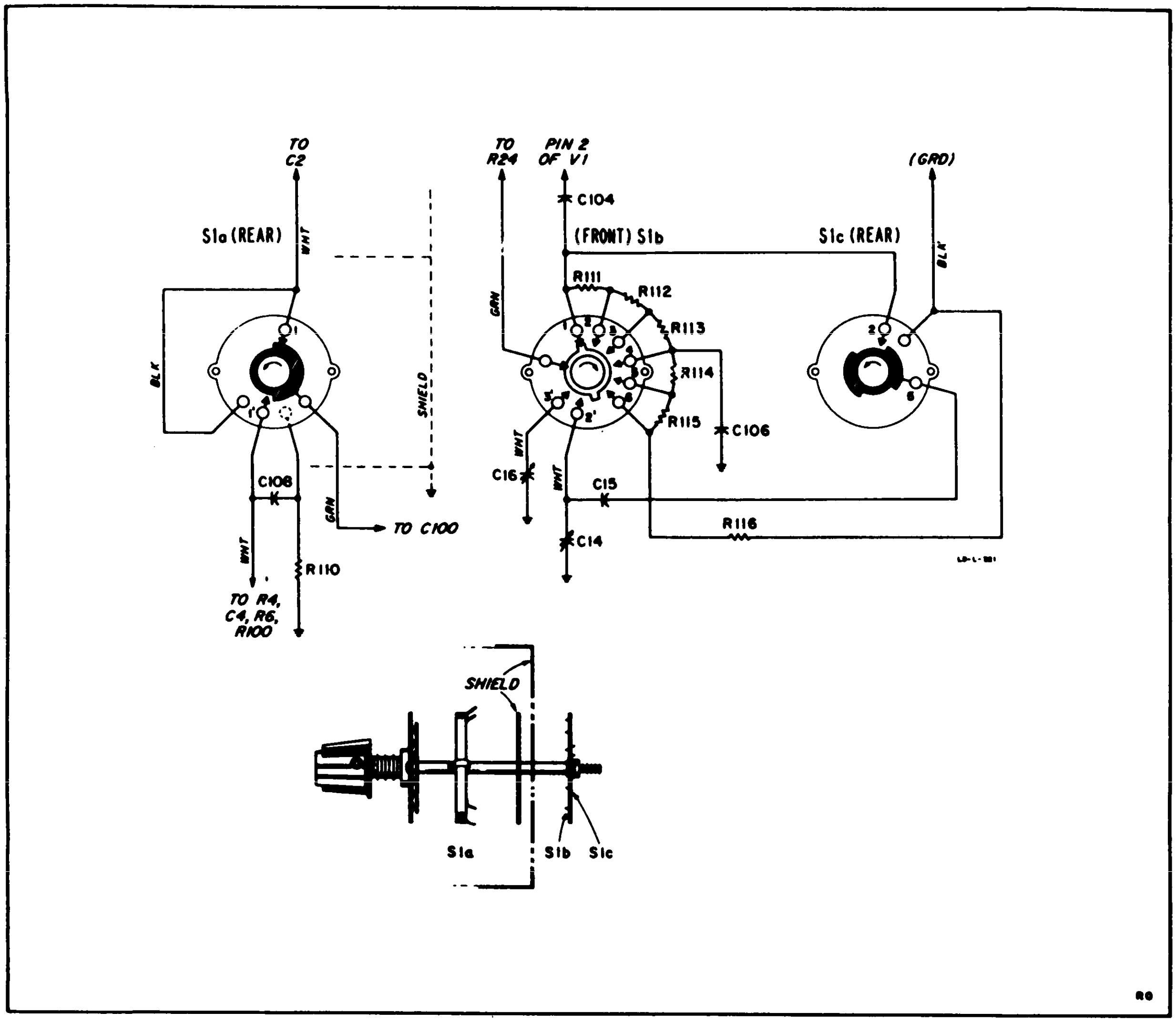


Figure 5-9. Diagram of RANGE Switch

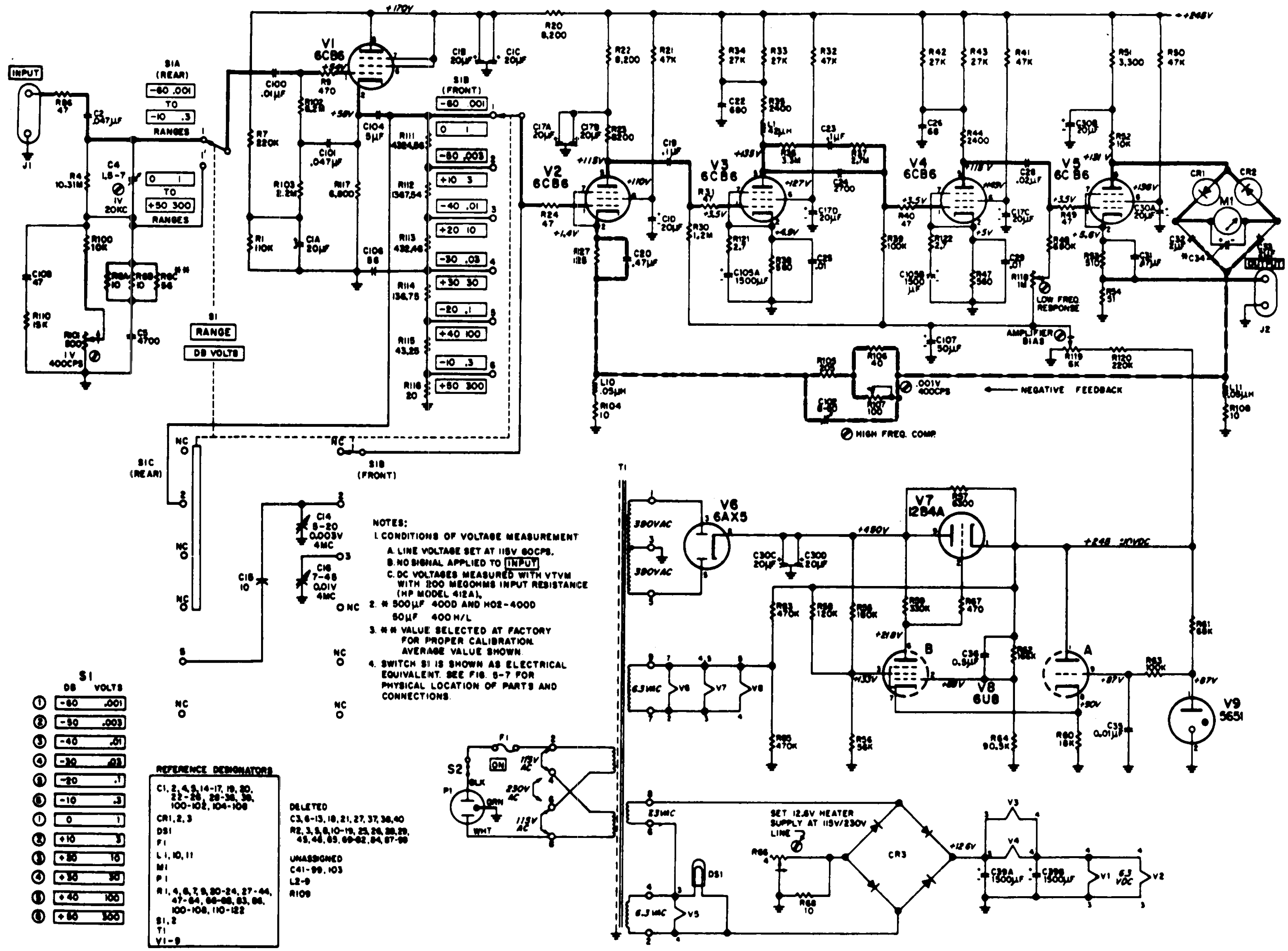


Figure 5-10. Voltmeter Schematic Diagram

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. 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	MODE L 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 0'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 description, 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 retire 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 apply 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.

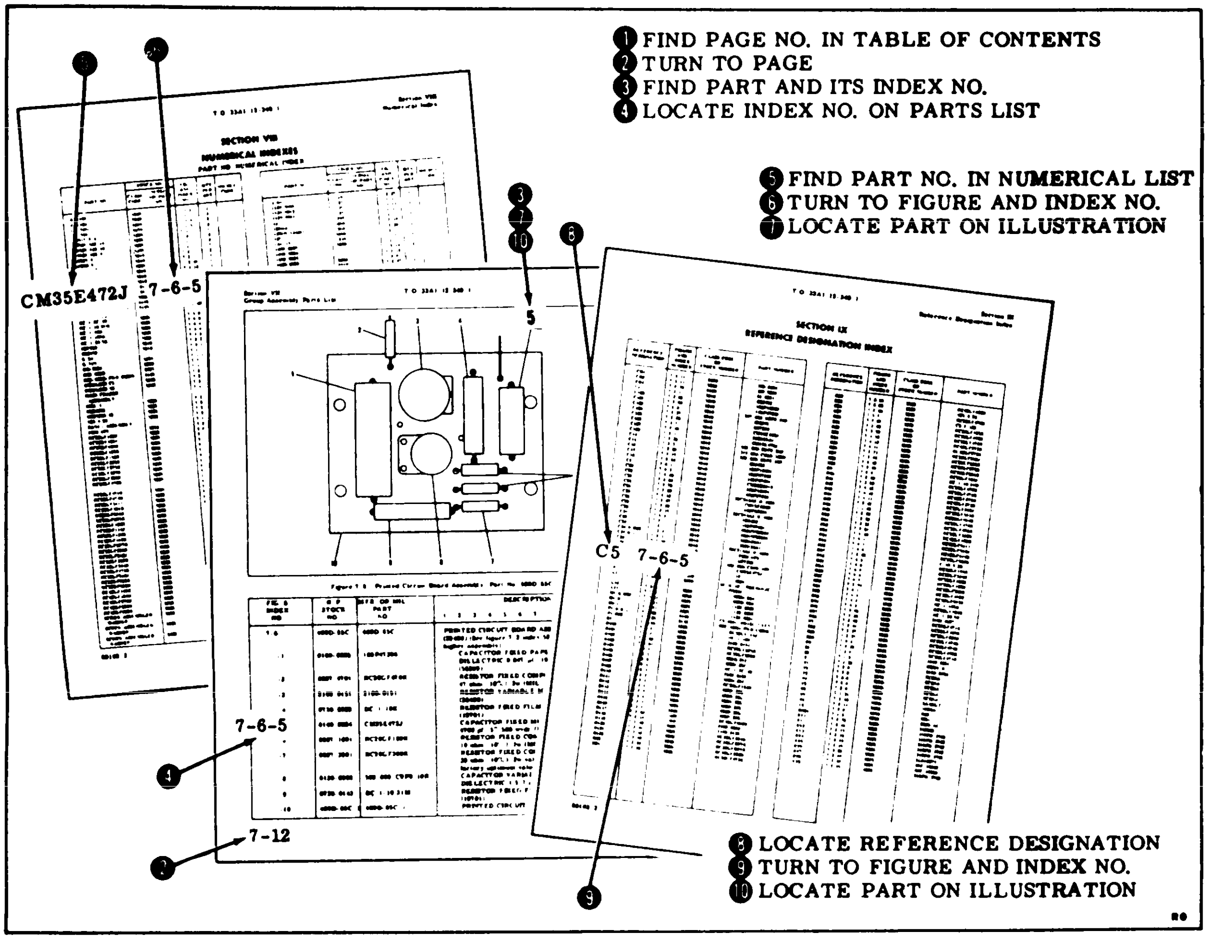
VENDOR'S CODE

CODE	NAME AND ADDRESS
04009	Arrow, Hart, and Hegeman Electric Co., Hartford, Corm.
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.
75915	Littlefuse, Inc., Des Plaines, 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
89849	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 LX, 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

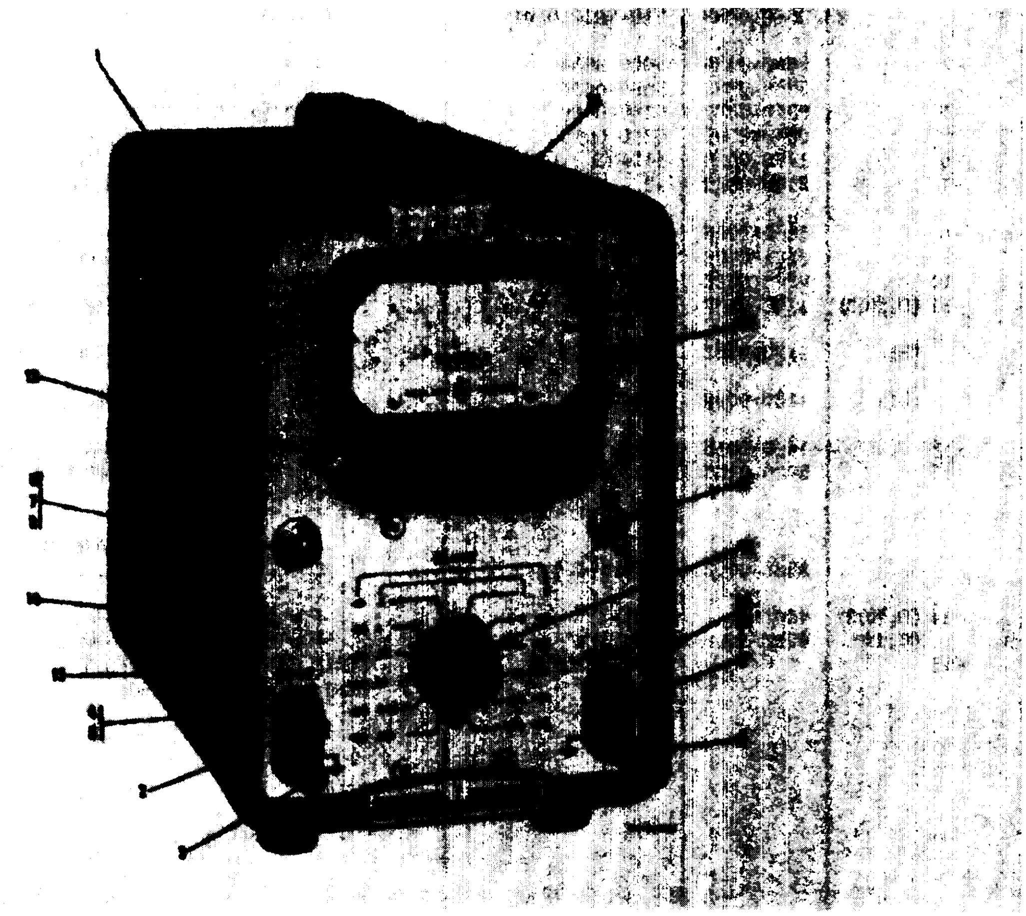


Figure 7-1. 400D/H/L Vacuum Tube Voltmeter

FIG. & INDEX NO.	H-P STOCK NO.	MRF. 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-44B	400D-44B	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, ASSEMBLIED WASHER (78189) . .	1
			---*---	
-2	5060-0634	5060-0634	. . POST, BINDING, Red (28480)	2
-3	5060-0635	5060-0635	. . POST, BINDING, Black (28480) . . .	2
-4	0340-0089	0340-0089	. . INSULATOR, STANDOFF (28480) . .	2
-5	0340-0090	0340-0090	. . 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	0370-0035	0370-0035	. . KNOB (28480)	1
-11 (D, H02)	1120-0005	1120-0005	. . MULTIMETER, REPLACEMENT . . (28480)	1
(H)	1120-0301	1120-0301	. . MULTIMETER, REPLACEMENT . . (28480)	1
(L)	1120-0098	1120-0098	. . MULTIMETER, REPLACEMENT . . (28480)	1
-12	1400-0015	1550	. . CLAMP, LOOP (73734)	1
-13	5020-0137	5020-0137	. . 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

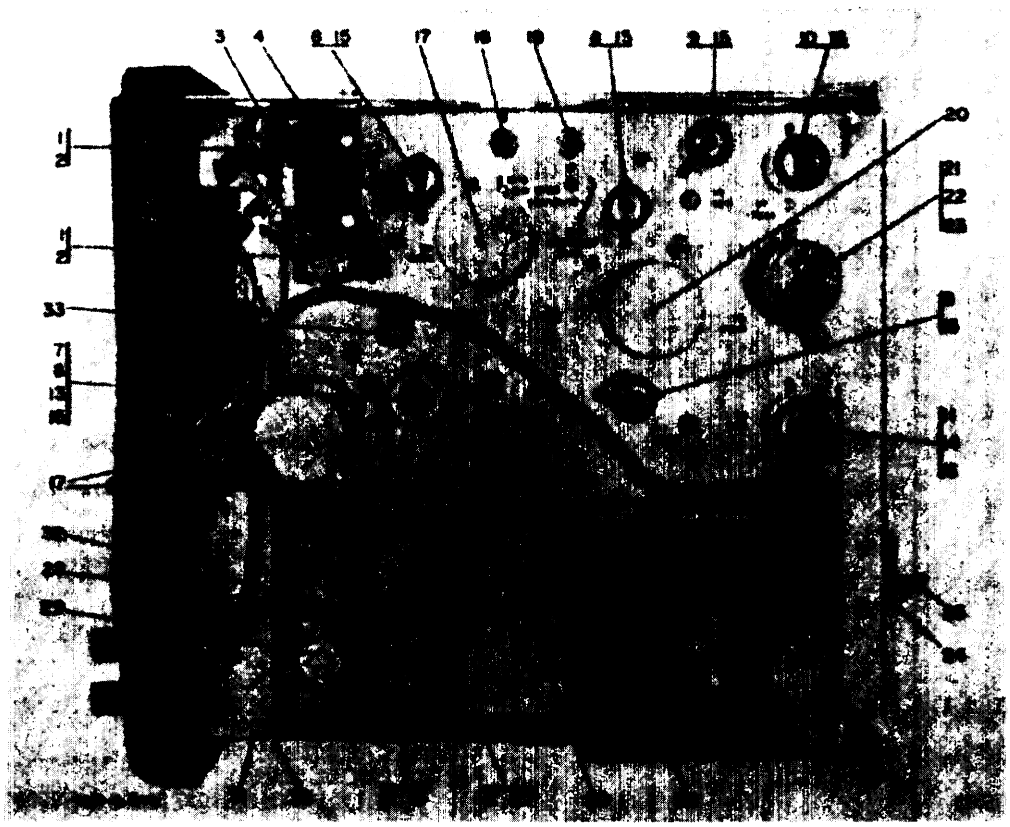


Figure 7-2. Main Chassis Assembly (Sheet 1 of 2)

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, 6 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-				
-7	1220-0010	126	. SHIELD, ELECTRON TUBE (91662) . . .	1
-8	1923-0028	6CB6	. ELECTRON TUBE (24446)	5
-9	1940-0001	5651	. ELECTRON TUBE (86684)	1
-10	1921-0010	12B4	. ELECTRON TUBE (24446)	1
-11	1933-0004	6U8	. ELECTRON TUBE (24446)	1
-12	5080-0621	6CB6	. ELECTRON TUBE (24446)	1
-13	1220-0005	429-.125	. BASE, Tube shield (91662)	1
-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 (56280)	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/ 7.5 FT	: 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/ 7.5 FT W/O PLUG	. . CABLE, POWER, ELECTRICAL (70003)	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

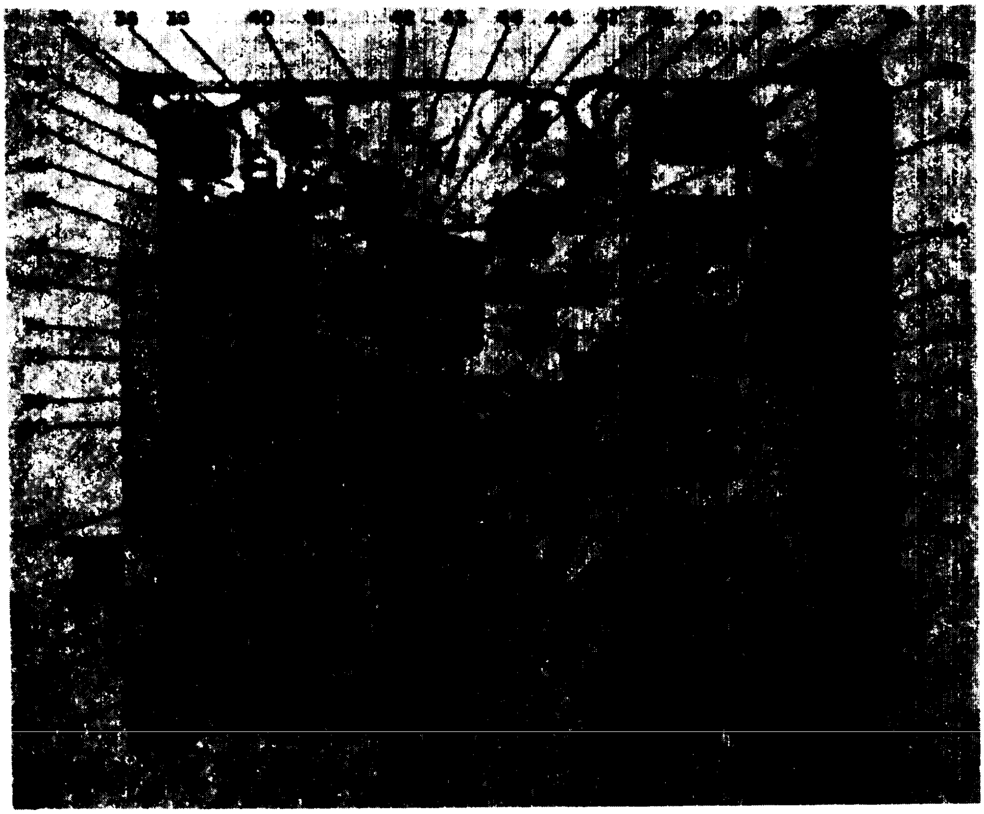


Figure 7-2. Main Chassis Assembly (Sheet 2 of 2)

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 (ML-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	01504012	29C214A3-H-1038	. CAPACITOR, FIXED, CERAMIC . . . . DIELECTRIC, 0.01 µf ±20%, 1000 wvdc (56289)	3
-40	0687-4701	RC20GF470K	. RESISTOR, FXXED, COMPOSITION, . . . 47 ohm ±10%, 1/2w (ML-R-11)	4
-41	0890-2241	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 (ML-R-11)	2
-44	0687-2751	RC20GF275K	. RESISTOR, FIXED, COMPOSITION, . . . 2.7M ±10%, 1/2w (ML-R-11)	1
-45	0180-0033	30D133A1	. CAPACITOR, FIXED, ELECTROLYTIC, 50 µf, 6 wvdc (56289)	1
-46	0887-1041	RC20GF104K	. RESISTOR, FIXED, COMPOSITON, . . . 100K ±10%, 1/2w (ML-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	510-081810-01	. NUT, ASSEMBLED WASHER (78189) . .	2
			---*---	
-53	0890-3321	RC32GFS32K	. 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 (56269)	2
-55	0689-1145	RC32GF114J	. RESISTOR, FIXED, COMPOSITION, . . 110K ±5%, 1w (MIL-R-11)	1
-56	0893-8221	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	510-081810-01	. 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	0160-0002	160P10396	. CAPACITOR, FIXED, PAPER DIELECTRIC, 0.01 µf ±10%, 600 wvdc (56289)	1
-64	400D-6F	400D-6F	. MOUNTING PLATE, Shield (56289) . . .	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	1400-0084	342014	. FUSEHOLDER (75915)	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
	2110-0008		F1 fuse (230 v only) 1/2 amp slow blow	

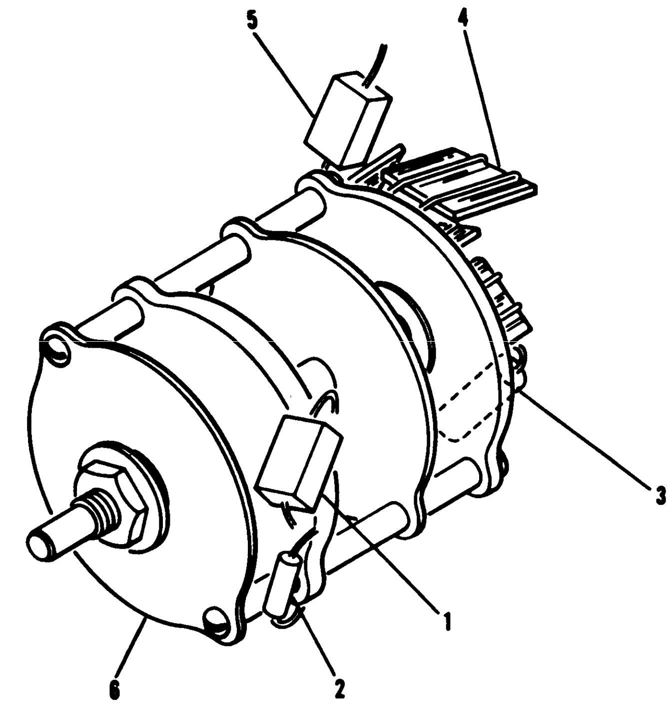


Figure 7-3. Range Switch Assembly

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	0887-1531	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

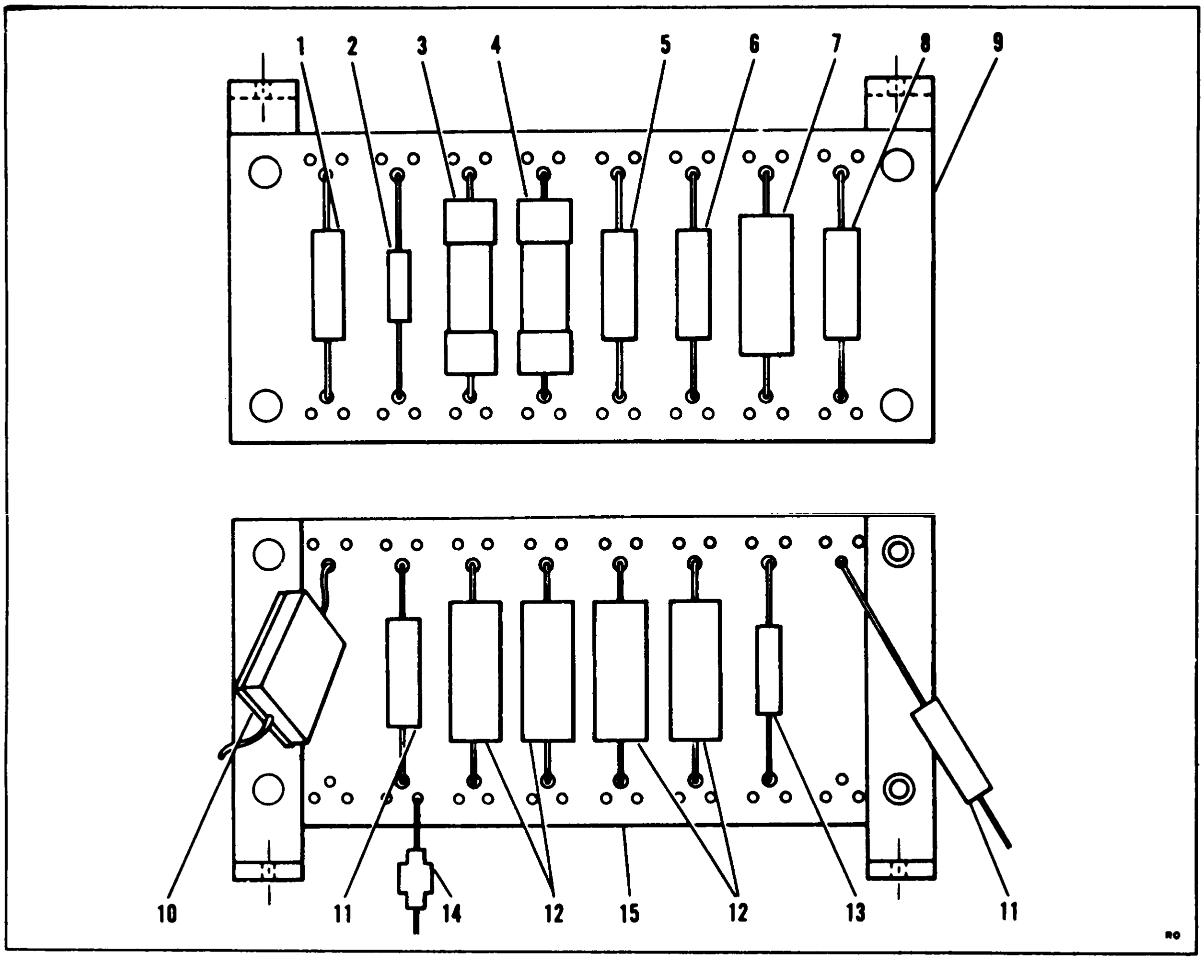


Figure 7-4. Printed Circuit Board Assembly, Part No. 400D-75G

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	400W75G-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	RC32GE142J	. 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

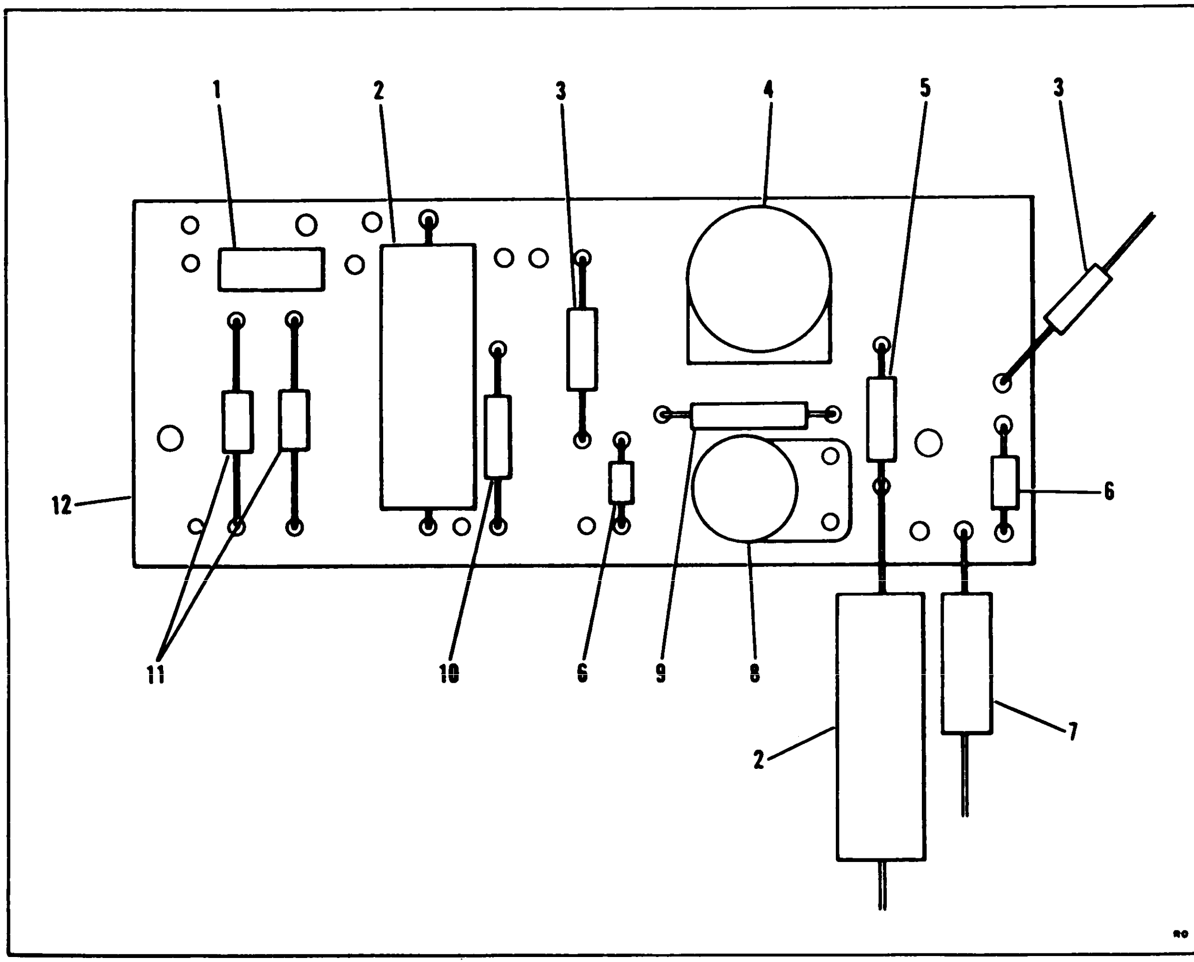


Figure 7-5. Printed Circuit Beard Assembly, Part No. 400D-75F

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	. RESISITOR, 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

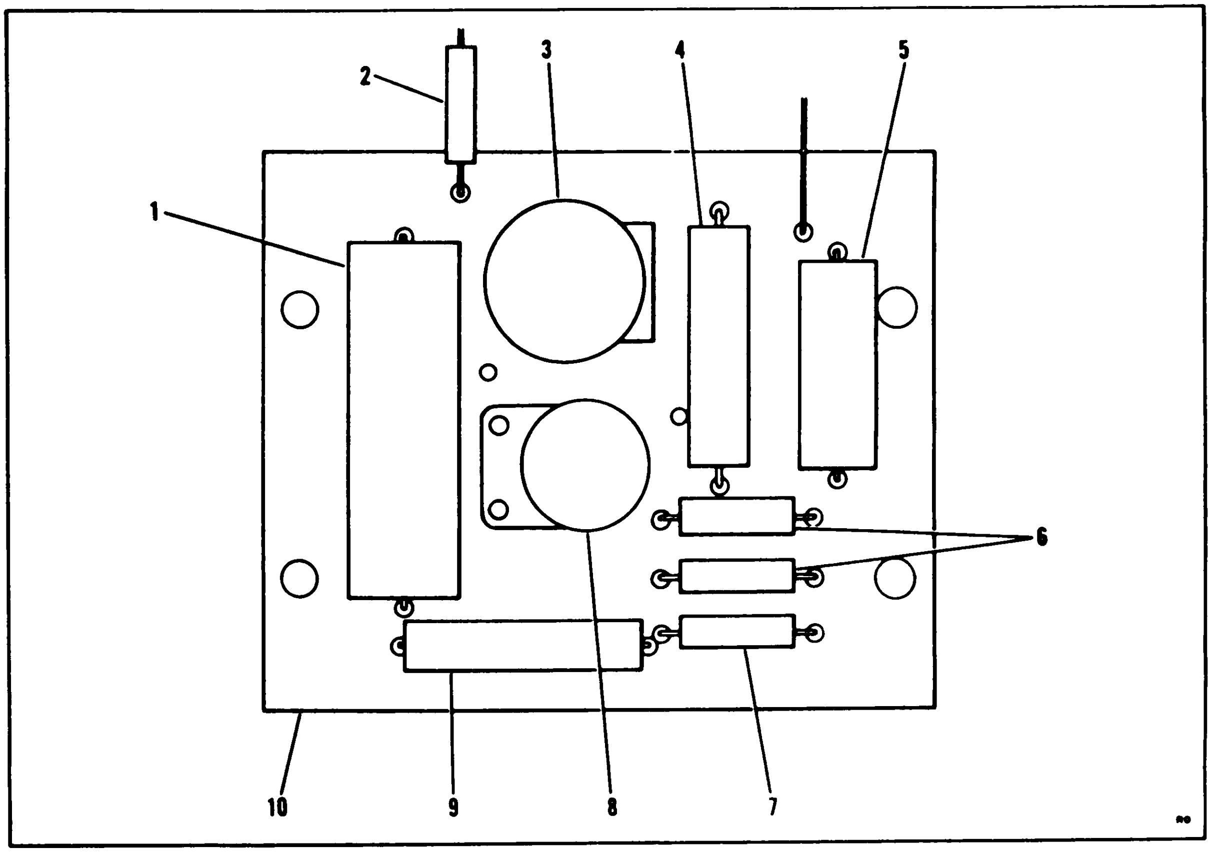


Figure 7-6. Printed Circuit Board Assembly, Part No. 400D-65C

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
-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	0757-0839	DC-1-10K	. RESISTOR. FIXED, FILM, 10 K ±1% metal film 1/2 w (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	0687-5601	RC20GF560K	. RESISTOR, FIXED, COMPOSITION, . . 56 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	0698-4116	DC-1-10.31M	. RESISTOR, FIXED, FILM, 10.31 meg ±1% metal film 1/2 w (19701)	1
-10	400D-65C-1	400D-65C-1	PRINTED CIRCUIT BOARD (28480) . .	1

00102-3

SECTION VII

NUMERICAL INDEXES

PART NO. NUMERICAL INDEX

MFR. OR MIL. PART NO.	STOCK NO.		FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE
	CLASS CODE	SERIAL OR PART NO.			
1120-0098	6625		7-1-11	1	
1120-0301	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	
148P22394	5910		7-2-47	1	
148P47392	5910		7-2-60	1	
148P47491	5910		7-5-2	2	
1550	5340		7-1-12	1	
160P10396	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	2	
			7-2-45		
3100-0251	5930		7-3-6	1	
315-000-C0G0-100D	5910		7-3-3	1	
316PH-3702	5935		7-2-15	6	
342014	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-44B			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	
5020-0137			7-1-13	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	
5060-0634	5940		7-1-2	2	
5060-0635	5940		7-1-3	2	
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	
6CB6	5960		7-2-8	5	
			7-2-12		
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	
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	
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	
RC20GF470K	5905		7-2-40	5	
			7-6-2		
RC20GF471K	5905		7-2-36	2	
RC20GF474K	5905		7-2-37	2	
RC20GF511J	5905		7-5-10	1	
RC20GF560K	5905		7-6-7	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	
S70375	5910		7-2-27	1	
0340-0089	5970		7-1-4	2	
0340-0090	5970		7-1-5	2	
0370-0035	5355		7-1-10	1	
1120-0005	6625		7-1-11	1	

HEWLETT-PACKARD STOCK NO. INDEX

H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES	H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES	H-P STOCK NUMBER	TOTAL QTY PER ART.	RECOM-MENDED SPARES
H02-400D	1		0689-5105	1	1	2100-0108	1	1
H02-400D-PWR CORD	1		0690-1001	1	1	2100-0136	1	1
			0690-1241	1	1	2100-0151	1	1
0130-0001	1	1	0690-1831	1	1	2110-0007	1	10
0130-0002	1	1	0690-2241	2	1	2140-0012	1	1
0130-0003	1	1	0690-3321	1	1	2190-0006	2	
0130-0006	1	1	0690-3341	1	1	2360-0003	6	
			0690-4731	4	1	2360-0012	2	
0140-0007	1	1	0690-5631	1	1	2370-0009	1	
0140-0014	1	1	0690-6831	1	1	2390-0001	1	
0140-0025	1	1	0693-1031	1	1	2390-0009	8	
0140-0039	1	1	0693-1841	1	1	2420-0001	14	
0140-0084	1	1	0693-2731	4	1	2520-0003	5	
0150-0009	1	1	0693-6821	1	1	2520-0006	2	
0150-0012	3	1	0693-8221	2	1	2550-0007	2	
0160-0002	1	1	0699-0005	2	1	2580-0003	1	
0160-0005	1	1	0727-0018	1	1	2900-0001	4	
0160-0013	2	1	0757-0839	1	1	3050-0100	1	
0160-0024	1	1	0730-0065	1	1	3101-0001	1	1
0160-0044	1	1	0730-0076	1	1	400D	1	
0170-0002	2	1	0698-4116	1	1	400D-1A	1	
0170-0040	1	1	0761-0001	1	1	400D-1B	1	
0170-0057	1	1	0813-0009	1	1	400D-19A	1	
0170-0063	1	1	0816-0017	1	1	400D-2	1	
0170-0064	2	1	1120-0005	1	1	400D-26C	1	1
0180-0025	3	1	1120-0091	1	1	400D-26F	2	1
0180-0028	2	1	1120-0301	1	1	400D-26G	1	1
0180-0033	2	1	1200-0008	2		400D-44B	1	
0180-0063	1	1	1200-0009	6		400D-6F	1	
0340-0089	2		1200-0020	1		400D-6H	1	
0340-0090	2		1220-0005	1		400D-6J	1	
0370-0035	1		1220-0010	1		400D-6K	1	
0380-0008	2		1251-0037	1		400D-60A	2	1
0400-0013	1		1390-0020	3		400D-65C	1	
0686-5115	1	1	1400-0015	1		400D-65C-1	1	
0687-1001	2	1	1400-0016	1		400D-75F	1	
0687-1041	2	2	1400-0025	1		400D-75F-1	1	
0687-1251	1	1	1400-0033	1		400D-75G	1	
0687-1531	1		1400-0074	1		400D-75G-1	1	
0687-2251	1	1	1400-0084	1		400D-75G-2	1	
0687-2751	1	1	1450-0020	1		400D-75H	1	
0687-3351	1	1	1450-0022	1		400H	1	
0687-4701	5	2	1882-0005	1	1	400H-2A	1	
0687-4711	2	1	1901-0027	2	2	400L	1	
0687-4741	2	1	1921-0010	1	1	5020-0137	1	
0687-5601	1	1	1923-0028	4	4	5060-0634	2	1
0687-5611	2	1	1930-0014	1	1	5060-0635	2	1
0687-6841	1	1	1933-0004	1	1	5080-0621	1	1
0687-8251	1	1	1940-0001	1	1	8120-0050	1	1
0689-1145	1	1	2100-0077	1	1	9100-0050	1	1
0689-2425	2	1	2100-0080	1	1	9140-0040	1	

SECTION IX
REFERENCE DESIGNATION INDEX

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	CLASS CODE OR STOCK NUMBER	MFR. OR MIL. PART NUMBER	H-P PART NUMBER
CR1	7-5-11	5960-	HD-5004	1901-0027
CR2	7-5-11	5960-	HD-5004	1901-0027
CR3	7-2-70	6130-	61-6911	1882-0005
C1	7-2-17	5910-	D32452	0180-0025
C100	7-2-63	5910-	160P10396	0160-0002
C101	7-2-60	5910-	148P47392	0170-0040
C102	7-5-8	5910-	557-000-U2P0-34R	0130-0002
C104	7-2-27	5910-	S70375	0170-0057
C105	7-2-20	5910-	D27390	0180-0028
C106	7-3-5	5910-	CM15E560J	0140-0014
C107	7-2-45	5910-	30D133A1	0180-0033
C108	7-3-1	5910-	CM15E470J	0140-0039
C14	7-2-28	5910-	503-000-B2P0-28R	0130-0006
C15	7-3-3	5910-	315-000-C0G0-100D	0150-0009
C16	7-2-29	5910-	503-000-D2P-033R	0130-0001
C17	7-2-17	5910-	D32452	0180-0025
C19	7-2-54	5910-	160P10494	0160-0013
C2	7-6-1	5910-	160P47396	0160-0005
C20	7-5-2	5910-	148P47491	0170-0064
C22	7-4-10	5910-	CM20B681K	0140-0007
C23	7-2-54	5910-	160P10494	0160-0013
C24	7-2-75	5910-	160P27296	0160-0044
C25	7-2-39	5910-	29C214A3-H-1038	0150-0012
C26	7-4-13	5910-	CM15E680K	0140-0025
C28	7-2-47	5910-	148P22394	0170-0063
C29	7-2-39	5910-	29C214A3-H-1038	0150-0012
C30	7-2-17	5910-	D32452	0180-0025
C31	7-5-2	5910-	148P47491	0170-0064
C32	7-2-1	5910-	663UW20504	0170-0002
C33	7-2-1	5910-	663UW20504	0170-0002
C34 D, H02	7-2-3	5910-	30D120A1	0180-0063
C34 H, L	7-2-3	5910-	30D133A1	0180-0033
C35	7-2-39	5910-	29C214A3-H-1038	0150-0012
C36	7-2-34	5910-	PKM 4P5	0160-0024
C39	7-2-20	5910-	D27390	0180-0028
C4	7-6-8	5910-	503-000-C0P0-10R	0130-0003
C5	7-6-5	5910-	CM35E472J	0140-0084
DS1	7-1-7	6240-	12	2140-0012
F1	7-2-71	5920-	MDL-1	2110-0007
L1	7-4-14	5950-	42μH-10%-PHENOLIC FORM	9140-0040
L10	7-5-6	5950-	400D-60A	400D-60A
L11	7-5-6	5950-	400D-60A	400D-60A
M1 D, H02	7-1-11	6625-	1120-0005	1120-0005
M1 H	7-1-11	6625-	1120-0301	1120-0301
M1 L	7-1-11	6625-	1120-0098	1120-0098
P1 D, H, L	7-2-25	6145-	CS-9941/PH151/7.5FT	8120-0050
P1 H02	7-2-25	6145-	H02-400D-PWR CORD	H02-400D-PWR CORD
R1	7-2-55	5905-	RC32GF114J	0689-1145
R100	7-6-4	5905-	DC-1-10K	0730-0029
R101	7-6-3	5905-	2100-0151	2100-0151
R102	7-2-62	5905-	RC20GF825K	0687-8251
F1	7-2-71			2110-0008

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	CLASS CODE OR STOCK NUMBER	MFR. OR MIL. PART NUMBER	H-P PART NUMBER
R103	7-2-61	5905-	RC20GF225K	0687-2251
R104	7-5-3	5905-	400K-26F	400D-26F
R105	7-5-5	5905-	400D-26C	400D-26C
R106	7-5-9	5905-	DC-1/2C-40	0727-0018
R107	7-5-4	5905-	2100-0108	2100-0108
R108	7-5-3	5905-	400D-26F	400D-26F
R110	7-3-2	5905-	RC20GF153K	0687-1531
R111	7-3-4	5905-	400D-26G	400D-26G
R112	7-3-4	5905-	400D-26G	400D-26G
R113	7-3-4	5905-	400D-26G	400D-26G
R114	7-3-4	5905-	400D-26G	400D-26G
R115	7-3-4	5905-	400D-26G	400D-26G
R116	7-3-4	5905-	400D-26G	400D-26G
R117	7-2-59	5905-	RC42GF682K	0693-6821
R118	7-2-18	5905-	2100-0080	2100-0080
R119	7-2-19	5905-	2100-0136	2100-0136
R120	7-2-41	5905-	RC32GF224K	0690-2241
R121	7-2-42	5905-	RC32GF2R7K	0699-0005
R122	7-2-42	5905-	RC32GF2R7K	0699-0005
R20	7-2-56	5905-	RC42GF822K	0693-8221
R21	7-2-50	5905-	RC32GF473K	0690-4731
R22	7-2-56	5905-	RC42GF822K	0693-8221
R23	7-2-66	5905-	N25-8. 2K	0761-0001
R24	7-2-40	5905-	RC20GF470K	0687-4701
R27	7-5-7	5905-	CS-2-12S	0813-0009
R30	7-2-67	5905-	RC20GF125K	0687-1251
R31	7-2-40	5905-	RC20GF470K	0687-4701
R32	7-2-50	5905-	RC32GF473K	0690-4731
R33	7-4-12	5905-	RC42GF273K	0693-2731
R34	7-4-12	5905-	RC42GF273K	0693-2731
R35	7-4-11	5905-	RC32GF242J	0689-2425
R36	7-2-73	5905-	RC20GF335K	0687-3351
R37	7-2-44	5905-	RC20GF275K	0687-2751
R38	7-2-43	5905-	RC20GF561K	0687-5611
R39	7-2-46	5905-	RC20GF104J	0687-1041
R4	7-6-9	5905-	DC-1-10. 31M	0730-0143
R40	7-2-40	5905-	RC20GF470K	0687-4701
R41	7-2-50	5905-	RC32GF473K	0690-4731
R42	7-4-12	5905-	RC42GF273K	0693-2731
R43	7-4-12	5905-	RC42GF273K	0693-2731
R44	7-4-11	5905-	RC32GF242J	0689-2425
R47	7-2-43	5905-	RC20GF561K	0687-5611
R48	7-2-49	5905-	RC20GF684K	0687-6841
R49	7-2-40	5905-	RC20GF470K	0687-4701
R50	7-2-50	5905-	RC32GF473K	0687-4731
R51	7-2-53	5905-	RC32CF332K	0690-3321
R52	7-2-51	5905-	RC42GF103K	0693-1031
R53	7-5-10	5905-	RC20GF511J	0686-5115
R54	7-5-1	5905-	RC32GF510J	0689-5105
R55	7-4-7	5905-	RC42GF184K	0693-1841
R56	7-4-6	5905-	RC32GF563K	0690-5631
R57	7-2-48	5905-	C-10-6. 3K	0816-0017
R58	7-4-5	5905-	RC32GF124K	0690-1241
R59	7-4-8	5905-	RC32GF334K	0690-3341
R6A	7-6-6	5905-	RC20GF100K	0687-1001
R6B	7-6-6	5905-	RC20GF100K	0687-1001
R6C	7-6-7	5905-	RC20GF560K	0687-5601
R60	7-2-74	5905-	RC32GF183K	0690-1831
R61	7-4-1	5905-	RC32GF683K	0690-6831
R62	7-4-4	5905-	DC-1-166K	0730-0076

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	CLASS CODE OR STOCK NUMBER	MFR. OR MIL. PART NUMBER	H-P PART NUMBER
R63	7-4-2	5905-	RC20GF104K	0687-1041
R64	7-4-3	5905-	DC-1-90. 5K	0730-0065
R66	7-2-68	5905-	2100-0077	2100-0077
R67	7-2-36	5905-	RC20GF471K	0687-4711
R68	7-2-69	5905-	RC32GF100K	0690-1001
R7	7-2-41	5905-	RC32GF224K	0690-2241
R83	7-2-37	5905-	RC20GF474K	0687-4741
R85	7-2-37	5905-	RC20GF474K	0687-4741
R86	7-6-2	5905-	RC20GF470K	0687-4701
R9	7-2-36	5905-	RC20GF471K	0687-4711
S1	7-3-6	5930-	3100-0251	3100-0251
S2	7-1-9	5930-	80994-H	3101-0001
T1	7-2-26	5950-	9100-0050	9100-0050
V1	7-2-12	5960-	6CB6	5080-0621
V2	7-2-8	5960-	6CB6	1923-0028
V3	7-2-8	5960-	6CB6	1923-0028
V4	7-2-8	5960-	6CB6	1923-0028
V5	7-2-8	5960-	6CB6	1923-0028
V6	7-2-21	5960-	6AX5GT	1930-0014
V7	7-2-10	5960-	12B4	1921-0010
V8	7-2-11	5960-	6U8	1933-0004
V9	7-2-9	5960-	5651	1940-0001
XDS1	7-1-8	6250-	2020-AE	1450-0022
XF1	7-2-72	5920-	342014	1400-0084
XV1	7-2-15	5935-	316PH-3702	1200-0009
XV2	7-2-15	5935-	316PH-3702	1200-0009
XV3	7-2-15	5935-	316PH-3702	1200-0009
XV4	7-2-15	5935-	316PH-3702	1200-0009
XV5	7-2-15	5935-	316PH-3702	1200-0009
XV6	7-2-23	5935-	51A12272	1200-0020
XV7	7-2-16	5935-	44F-16388	1200-0008
XV8	7-2-16	5935-	44F-16388	1200-0008
XV9	7-2-15	5935-	316PH-3702	1200-0009

SECTION X

AUXILIARY EQUIPMENT

10-1. General

10-2. Auxiliary equipment extends the operation of the basic equipment, is not part of the basic equipment, and is not required for normal operation.

10-3. Line Matching Transformer Model 11004A

10-4. The Hewlett-Packard Line Matching Transformer Model 11004A is specifically designed to connect a balanced system to H-P Model 200-series Audio Oscillators, H-P Model 400-series Vacuum Tube Voltmeters, or similar equipment, for carrier currents or other measurements between 5 Kc to 600 Kc. With a Model 200CD it provides fully balanced 135- or 600-ohm output with attenuator in use. With an H–P Model 400 it provides voltage measurements on either 135- or 600-ohm balanced line without grounding one side, and permits bridging or terminated voltage measurements on both 135- and 600-ohm lines. The Model 11004A Line Matching Transformer is shown in Figure 10-1. Specifications are given in table 10-1.

Table 10-1. Specification

Frequency Range: 6 Kc to 600 Kc.	Frequency Response: Less than ±.5 db variation at 5 Kc and 600 Kc midfrequency value.
Impedance:	Balance: Better than 40 db over entire frequency range.
Primary: 135 ohms ±10% or 600 ohms ±10%* balanced line.	Power Handling Capacity: +22 dbm (10 volts across 600 ohms).
Secondary: 600 ohms, unbalanced line	Dimensions: 2 inches wide, 2 inches long, and 4 inches high.
Terminating Resistance: (secondary of transformer) 600 ohms or 10,000 ohms.	Weight: 12 oz.
Insertion Loss: Less than 0.3 db at 100 Kc.	

10-6. The Model 11004A is used to terminate a 600-ohm unbalanced line to a 135- or 600-ohm balanced line. A two-position toggle switch, the 600 Ω -BRIDGING switch, provides terminating or bridging voltage measurement capabilities for 135- and 600-ohm lines.

Measurements can be made in dbm directly for either 135 or 600 Ω connections provided the line is terminated. However, accurate voltage measurement can be read directly for the 600 Ω connection only. A schematic diagram of the Model 11004A is shown in Figure 10-2.

The following rules will be helpful when determining the position of the 600 Ω -BRIDGING switch for various applications:

a. Use the BRIDGING position of the switch (10K position) when bridging a balanced system for measurement with an unbalanced line.

b. Use the BRIDGING position (10K position) when driving a 600 Ω balanced system with a single ended oscillator which has a 600-ohm output impedance.

c. Use the 600 Ω position of the switch when terminating a balanced line into single ended measuring instruments.

Note. When connecting the Model 11004A into a system, the ground post (G) should be connected to the grounded side of the measuring equipment.

10-6. The Model 11004A is designed to increase the usefulness of the H-P Models

400D/H/L Vacuum Tube Voltmeters, the Models 403A/B AC Transistor Voltmeter, the Model 204B Transistorized Oscillator. In addition, the Model 11004A can be used with the 405BR/CR Automatic DC Digital Voltmeter or with the Model 457A AC-to-DC Converter (for ac measurements to obtain digital measurements).

The instrument can be connected to the output terminals of a Model 200CD Wide Range Oscillator to provide fully balanced output for a 135-ohm or 600-ohm balanced line.

A typical setup for a 600-ohm balanced line is shown in figure 10-3A; figure 10-3B shows the connection for 135-ohm balanced line.

Figure 10-4 shows a typical bridging type of measurement setup. The Model 11004A provides for voltage measurements on 135- or 600-ohm lines without grounding one side of the line.

Voltage measurement in dbm (0 dbm = 1 mw in 600 ohms) on a balanced 135-ohm line may be made without grounding one side of the line.

The Models 200CD and 400D may be used in conjunction with the Model 11004A to form a signal generator for measurement in the carrier frequency range. The Model 400D Voltmeter is connected across the output terminals of the Model 200CD Oscillator to monitor the output of the oscillator. The model 11004A couples the oscillator to the balanced line. Figure 10-5 shows the signal generator setup.

10-7. Bridging Transformer Model 11005A

10-8. The Hewlett-Packard Bridging Transformer Model 11005A operates at audio frequencies to match or bridge single ended measuring instruments and signal generators to balanced lines without disturbing the circuit under test. The Model 11005A is shown in figure 10-6; specifications are given in table 10-2.

The Model 11006A permits the use of single ended VTVM's such at the H-P Models 400D/H and 400L and Distortion and Wave Analyzers such as the H-P Models 330B/C and 330D to work from balanced lines without disturbing the circuits under test. It will bridge transmission lines at 10,000 ohms and is equipped with a switch to allow 600-ohm line termination.

10-9. When it is desired to terminate a balanced communications system into unbalanced measuring equipment, described under paragraph 10-10, the Model 11005A satisfies the dual requirements with the line terminated into the primary with the switch in the 600-ohm position. Figure 10-7 shows how the Model 11005A should be connected.

When measuring points with single ended instruments along a balanced system operating under normal conditions, the toggle switch should be in the 10,000-ohm bridging position. This prevents circuit loading and at the same time satisfies the transition from the balanced to the single-ended condition.

10-10. The following rules should be observed when using the Model 11005A.

a. Use 10 K position when bridging a balanced system for measurements with single ended instruments such as the H-P Model 330B/C/D Distortion Analyzers, Model 302A Harmonic Wave Analyzer, Model 400D VTVM or 400 H/L VTVM.

b. Use 10 K position when driving a 600 Ω balanced system with a single ended oscillator which has a 600-ohm output impedance such as the 201C Audio Oscillator or an unbalanced attenuator such as the H-P Model 200CD Audio Oscillator.

c. Use 600 Ω position when terminating a balanced line into single ended measuring instruments.

d. Use 600 Ω position with 400 Ω series resistor as shown for 1000 Ω unbalanced oscillator (fig. 10-7) .

10-11. The Model 11005A contains a 10,000-ohm bridging resistor across the secondary winding of the transformer. The toggle switch parallels this bridging resistance with a 638-ohm resistor when it is in the 600-ohm position to present a 600-ohm match to the line.

Table 10-2. Specifications

Frequency Range: 20 cps to 45 Kc.	Distortion: Less than 0.1%, 50 cps to 20 Kc; Less than 0.5%, at 20 cps.
Impedance, Primary: 600 ohms.	Balance: Better than 60 db.
Terminating Resistance: 600 ohms or 10,000 ohms.	Maximum Level: +15 dbm (4.5 volts at 600 ohms).
Insertion Loss: Less than 1 db at 1 Kc.	Size: 4 5/16" diam. 4 5/8" high overall.
Frequency Response: ±1 db, 20 cps to 20 Kc; ±2 db to 45 Kc.	Shipping Weight: 6 lbs.

Table 10-3. Replaceable Parts

H-P Part No.	Description	Mfr	Mfr part No.	TQ
0340-0090	Insulator, binding post	[1]28480	0340-0090	4
0730-0011	R: fxd, 638 ohms, 1 w	[2]99459	obd#	1
0730-0029	R: fxd, 10 K ohms, 1 w	[2]94459	obd#	1
1510-0006	Binding post, black	[1]28480	1510-0006	1
1610-0007	Binding post, red	[1]28480	1510-0007	3
3101-0001	Switch, toggle	[3]04009	obd#	1

[1] Hewlett-Packard Co., Palo Alto, Calif.
[2] Campbell Industries, Mahomet, Ill.
[3] Arrow, Hart, and Hegeman Electric Co., Hartford, Conn.

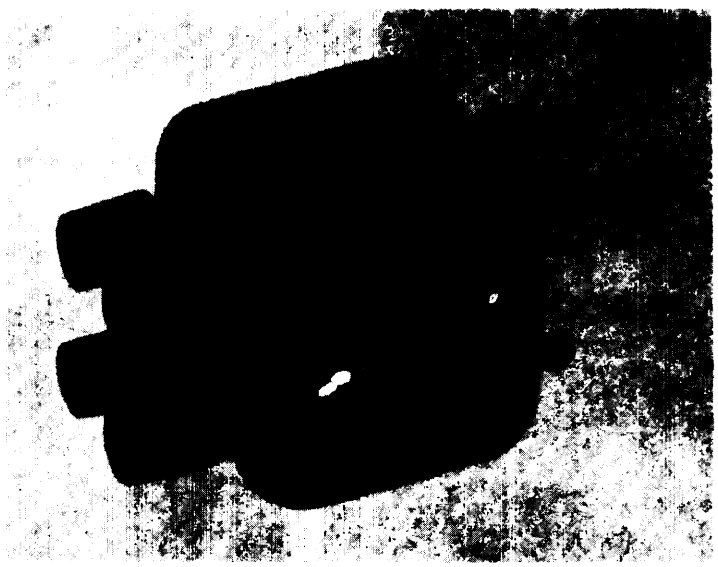


Figure 10-1. 11004A line matching transformer.

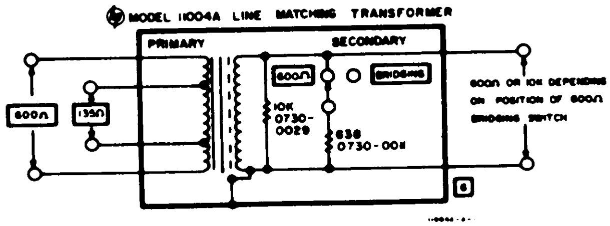


Figure 10-2. 11004A line matching transformer, schematic diagram.

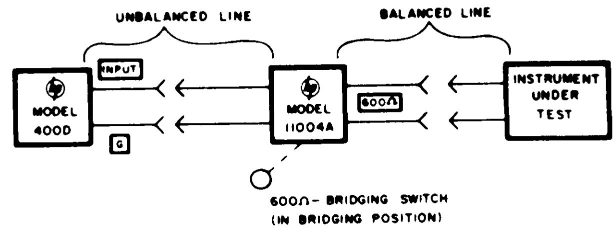


Figure 10–4. Typical measurement setup.

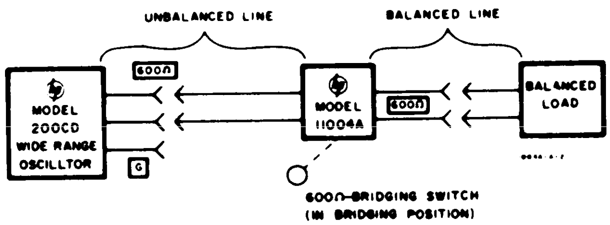


Figure 10-3A. Typical bridging type of 600-ohm setup showing balanced to unbalanced line confirmation.

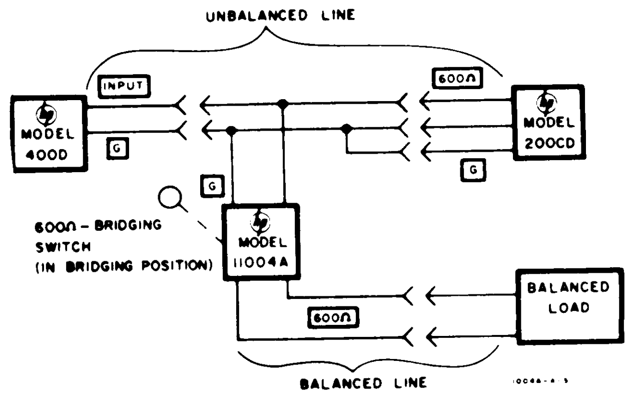


Figure 10-5. Signal generator setup.

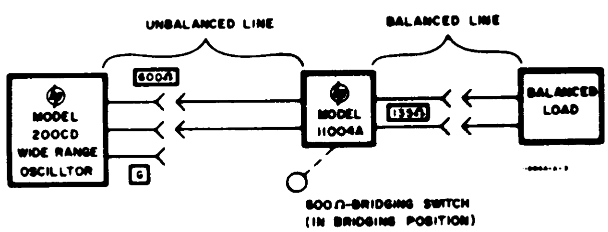


Figure 10-3B. Typical setup showing unbalanced to 135-ohm balanced line configuration.

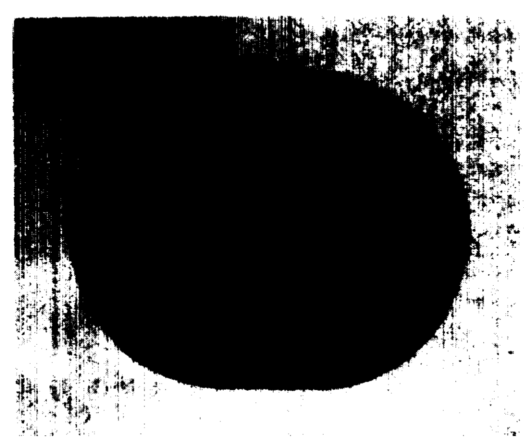


Figure 10-6. Model 11005A bridging transformer.

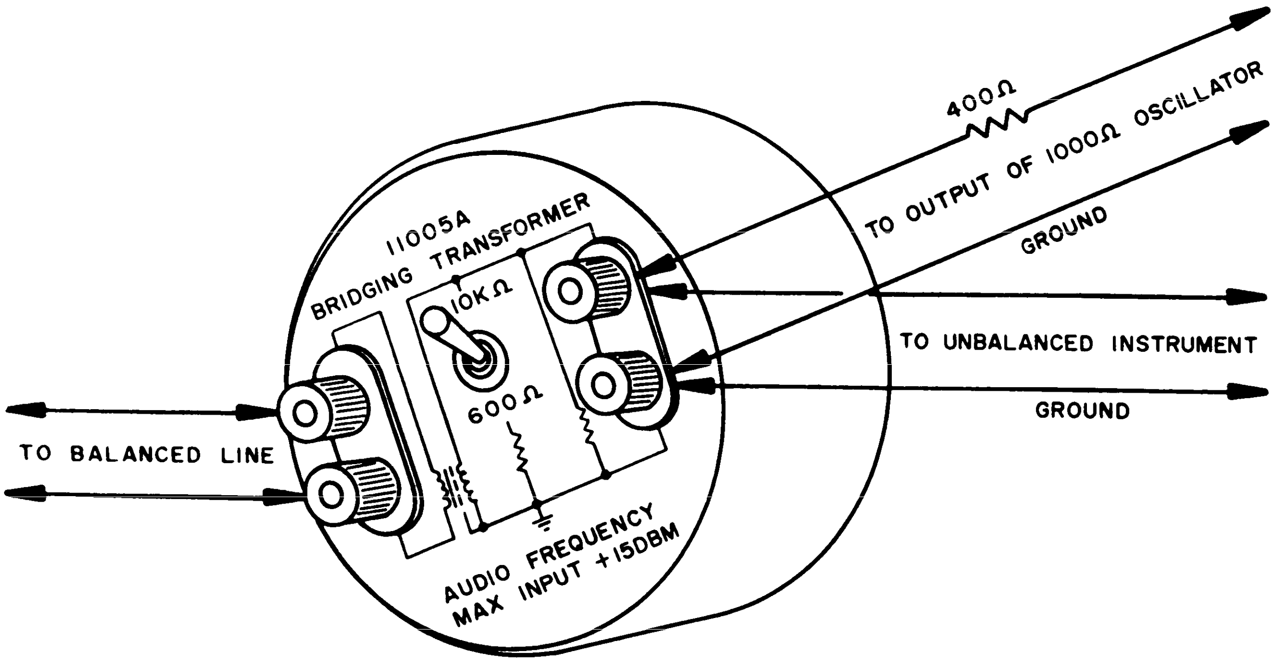


Figure 10-7. Application of Terminals on 11005A Bridging Transformer.

10-8. Final Performance Check

a. Line Matching Transformer HP-11004A.

(1) Connect Generator HP 200 CD and Voltmeter HP 400D to the secondary of the transformer.

(2) Switch the transformer to the bridging position, and adjust the generator for an output of 0 db at 100 KHz.

(3) Connect the meter to the 600 ohm primary of the transformer. There should be less than 0.3 db loss.

(4) Repeat the test in the range between 5 KHz and 600 KHz. The reading should not vary more than 1 db.

b. Bridging Transformer Model 11005A. Not applicable.

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NG: None
USAR: None
For explanation of abbreviations wed, see AR 320-50.

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'NEAR MEASURE

. Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 Kilometer = 1000 Meters = 0.621 Miles

'EIGHTS

Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

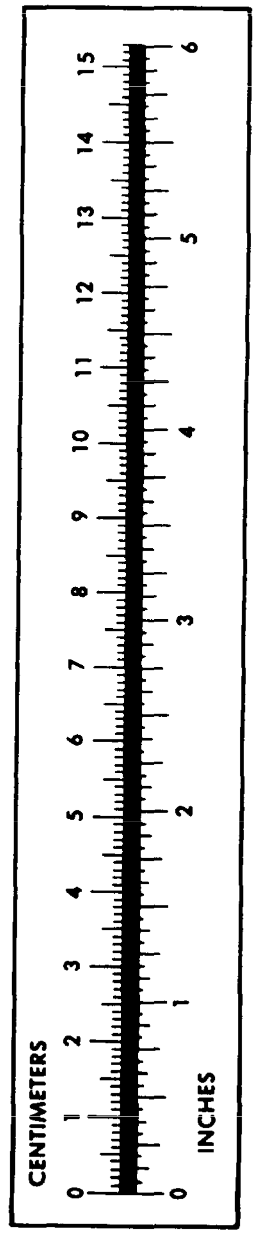
TEMPERATURE

5/9(°F - 32) = °C
212° Fahrenheit is evuivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5C° + 32 =°F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
ıts	Liters	0.473
arts	Liters	0.946
.allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
'ers	Gallons	0.264
.ms	Ounces	0.035
.ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
'lometers per Liter	Miles per Gallon	2.354
›meters per Hour	Miles per Hour	0.621



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