TM 11-2654

WAR DEPARTMENT TECHNICAL MANUAL

VACUUM TUBE VOLTMETER

HICKOK MODEL 110-B

WAR DEPARTMENT • 27 NOVEMBER 1945

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-2654

VACUUM TUBE VOLTMETER

HICKOK MODEL 110-B

WAR DEPARTMENT • 27 NOVEMBER 1945

United States Government Printing Office
Washington : 1947

WAR DEPARTMENT
WASHINGTON 25, D. C., 27 NOVEMBER 1945

TM 11-2654, Vacuum Tube Voltmeter (Hickok Model 110-B), is published for the information and guidance of all concerned.

(A. G. 300.7 (9 Sep 44).

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL,
Major General,
Acting the Adjutant General.

DISTRIBUTION:

AAF(5); AGF(5); ASF(2); S Div ASF(1); Three (3) copies to each of the following: T/O & E 11-107; 11-127; 11-237; 11-587; 11-592; 11-597.

(For explanation of symbols see FM 21-6).

TABLE OF CONTENTS ★★

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW — 1. *Smash*—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. *Cut*—Use axes, handaxes, machetes.

3. *Burn*—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. *Explosives*—Use firearms, grenades, TNT.

5. *Disposal*—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT—1. *Smash*—Probe, tubes, meter, transformer, rotary switches, and cabinet.

2. *Cut*—Cables and cords.

3. *Burn*—Cables, cords, circuit diagrams, instruction books, etc.

4. *Bend*—Panel and chassis.

5. *Bury or scatter*—All equipment.

DESTROY EVERYTHING

SAFETY NOTICE

Voltages as high as 10,000 volts may be used in the operation of this instrument. These voltages are dangerous to life. Follow the procedures given in paragraph 42b when making voltage measurements.

First Aid for Electric Shock

RESCUE.

In case of electric shock, shut off the high voltage at once and ground the circuits. If the high voltage cannot be turned off without delay, free the victim from contact with the live conductor as promptly as possible. Avoid direct contact with either the live conductor or the victim's body. Use a dry board, dry clothing, or other nonconductor to free the victim. An ax may be used to cut the high-voltage wire. Use extreme caution to avoid the resulting electric flash.

SYMPTOMS.

a. Breathing stops abruptly in electric shock if the current passes through the breathing center at the base of the brain. If the shock has not been too severe, the breath center recovers after a while and normal breathing is resumed, provided that a sufficient supply of air has been furnished meanwhile by artificial respiration.

b. The victim is usually very white or blue. The pulse is very weak or entirely absent and unconsciousness is complete. Burns are usually present. The victim's body may become rigid or stiff in a very few minutes. This condition is due to the action of electricity and is not to be considered rigor mortis. Artificial respiration must still be given, as several such cases are reported to have recovered. The ordinary and general tests for death should never be accepted.

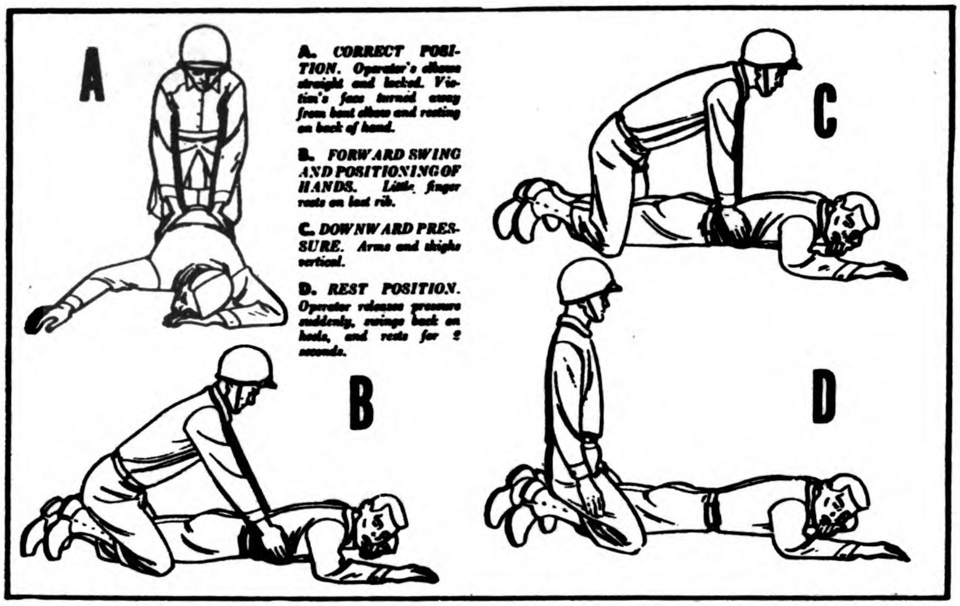
TREATMENT.

a. Start artificial respiration immediately. At the same time send for a medical officer, if assistance is available. Do not leave the victim unattended. Perform artificial respiration at the scene of the accident, unless the victim's or operator's life is endangered from such action. *In this case only*, remove the victim to another location, but no farther than is necessary for safety. If the new location is more than a few feet away, artificial respiration should be given while the victim is being moved. If the method of transportation prohibits the use of the Shaeffer prone pressure method, other methods of resuscitation may be used. Pressure may be exerted on the front of the victim's diaphragm, or the direct mouth-to-mouth method may be used. Artificial respiration, once started, must be continued, without loss of rhythm.

b. Lay the victim in a prone position, one arm extended directly overhead, and the other arm bent at the elbow so that the back of the hand supports the head. The face should be turned away from the bent elbow so that the nose and mouth are free for breathing.

c. Open the victim's mouth and remove any foreign bodies, such as false teeth, chewing gum, or tobacco. The mouth should remain open,

TL15338-A



A. CORRECT POSITION. *Operator's elbows straight and locked. Victim's face turned away from bent elbow and resting on back of hand.*

B. FORWARD SWING AND POSITIONING OF HANDS. *Little finger rests on last rib.*

C. DOWNWARD PRESSURE. *Arms and thighs vertical.*

D. REST POSITION. *Operator releases pressure suddenly, swings back on heels, and rests for 2 seconds.*

with the tongue extended. Do not permit the victim to draw his tongue back into his mouth or throat.

d. If an assistant is available during resuscitation, he should loosen any tight clothing to permit free circulation of blood and to prevent restriction of breathing. He should see that the victim is kept warm, by applying blankets or other covering, or by applying hot rocks or bricks wrapped in cloth or paper to prevent injury to the victim. The assistant should also be ever watchful to see that the victim does not swallow his tongue. He should continually wipe from the victim's mouth any frothy mucus or saliva that may collect and interfere with respiration.

e. The resuscitating operator should straddle the victim's thighs, or one leg, in such manner that:

(*1*) the operator's arms and thighs will be vertical while applying pressure on the small of the victim's back;

(*2*) the operator's fingers are in a natural position on the victim's back with the little finger lying on the last rib;

(*3*) the heels of the hands rest on either side of the spine as far apart as convenient without allowing the hands to slip off the victim;

(*4*) the operator's elbows are straight and locked.

f. The resuscitation procedure is as follows:

(*1*) Exert downward pressure, not exceeding 60 pounds, for 1 second.

(*2*) Swing back, suddenly releasing pressure, and sit on the heels.

(*3*) After 2 seconds, swing forward again, positioning the hands exactly as before, and apply pressure for another second.

g. The forward swing, positioning of the hands, and the downward pressure should be accomplished in one continuous motion, which requires 1 second. The release and backward swing require 1 second. The addition of the 2-second rest makes a total of 4 seconds for a complete cycle. Until the operator is thoroughly familiar with the correct cadence

TL15338-B

of the cycle, he should count the seconds aloud, speaking distinctly and counting evenly in thousands. Example: one thousand and one, one thousand and two, etc.

h. Artificial respiration should be continued until the victim regains normal breathing or is pronounced dead by a medical officer. Since it may be necessary to continue resuscitation for several hours, relief operators should be used if available.

RELIEVING OPERATOR.

The relief operator kneels beside the operator and follows him through several complete cycles. When the relief operator is sure he has the correct rhythm, he places his hands on the operator's hands without applying pressure. This indicates that he is ready to take over. On the backward swing, the operator moves and the relief operator takes his position. The relieved operator follows through several complete cycles to be sure that the new operator has the correct rhythm. He remains alert to take over instantly if the new operator falters or hesitates on the cycle.

STIMULANTS.

a. If an inhalant stimulant is used, such as aromatic spirits of ammonia, the individual administering the stimulant should first test it himself to see how close he can hold the inhalant to his own nostril for comfortable breathing. Be sure that the inhalant is not held any closer to the victim's nostrils, and then for only 1 or 2 seconds every minute,

b. After the victim has regained consciousness, he may be given hot coffee, hot tea, or a glass of water containing ½ teaspoon of aromatic spirits of ammonia. *Do not give any liquids to an unconscious victim.*

CAUTIONS.

a. After the victim revives, keep him LYING QUIETLY. Any injury a person may have received may cause a condition of shock. Shock is present if the victim is pale and has a cold sweat, his pulse is weak and rapid, and his breathing is short and gasping.

b. Keep the victim lying flat on his back, with his head lower than the rest of his body and his hips elevated. Be sure that there is no tight clothing to restrict the free circulation of blood or hinder natural breathing. Keep him warm and quiet.

c. A resuscitated victim must be watched carefully as he may suddenly stop breathing. ***Never leave a resuscitated person alone until it is CERTAIN that he is fully conscious and breathing normally.***

TL15338-C

758241 O - 47 - 2

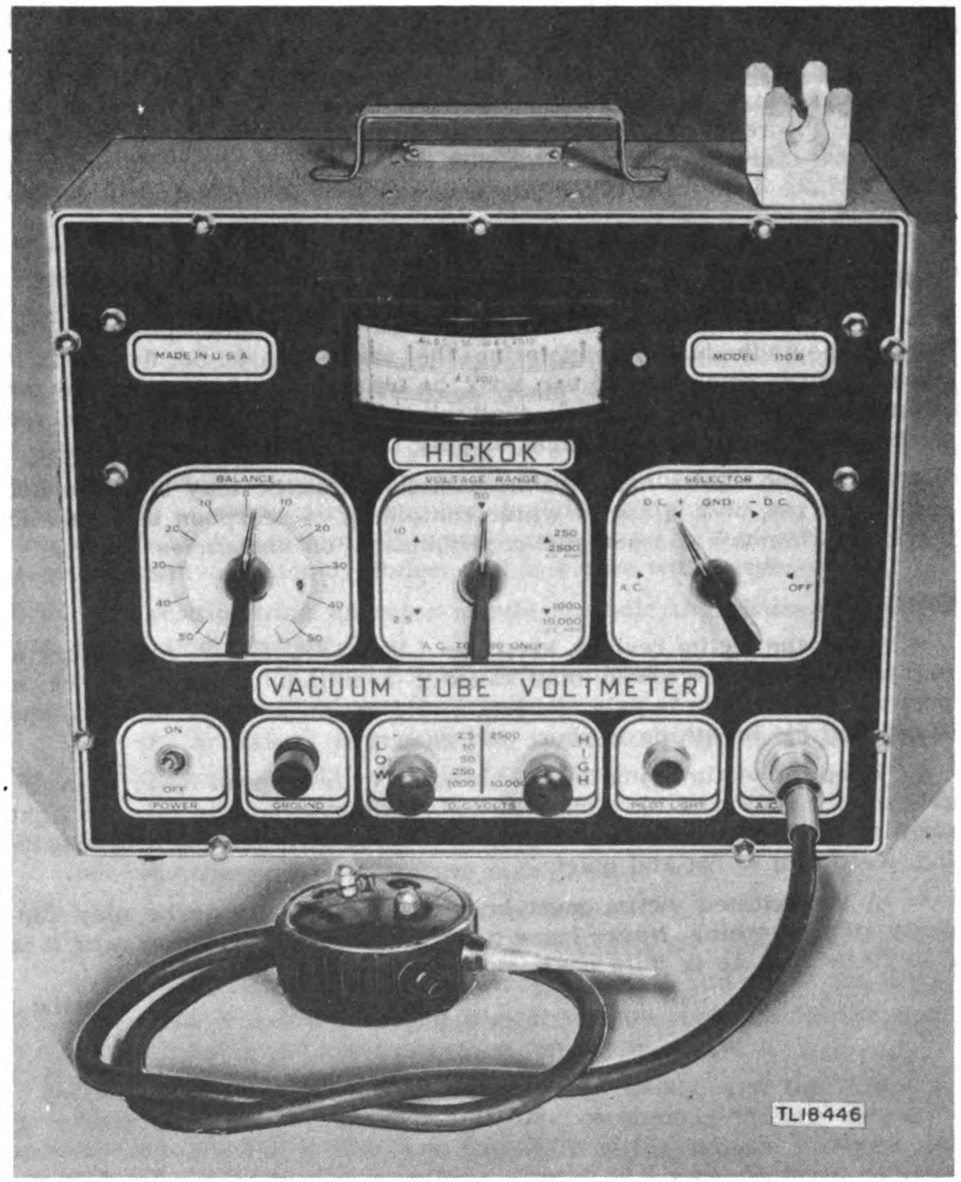


Figure 1. Vacuum tube voltmeter, general view.

PART ONE
INTRODUCTION

SECTION I. DESCRIPTION

1. GENERAL.

Vacuum tube voltmeter (Hickok model 110-B) is an electronic test unit used to measure either d-c (direct-current) or a-c (alternating-current) voltages. Readings are registered on a single meter which has five scales. The circuits are designed, primarily, to accurately measure d-c voltages between 0 and 10,000 volts, or a-c voltages between 0 and 250 volts. Seven d-c and four a-c voltage ranges are provided.

a. When the instrument is connected, properly adjusted for operation, and no voltage is being measured, the pointer on the meter remains at zero, regardless of the voltage range selected.

b. The input impedance is so high that measurements may be made without appreciably loading the circuit under test.

2. TECHNICAL CHARACTERISTICS.

Voltage ranges:	
D-c ranges	0 to 2.5 volts.
	0 to 10 volts.
	0 to 50 volts.
	0 to 250 volts.
	0 to 1,000 volts.
	0 to 2,500 volts.
	0 to 10,000 volts.
A-c ranges	0 to 2.5 rms volts.
	0 to 10 rms volts.
	0 to 50 rms volts.
	0 to 250 rms volts.
Input impedance:	
2.5-, 10-, 50-, 250-, and 1,000-volt d-c ranges	14 megohms (approx).
2,500- and 10,000-volt d-c ranges	118 megohms (approx).
60-cycle a-c voltages	above 10 megohms (approx).
20 kc-cycle a-c voltages	1 megohm (approx).
200 kc-cycle r-f voltages	100,000 ohms (approx).
2,000-kc r-f voltages	10,000 ohms (approx).
20-mc r-f voltages	1,000 ohms (approx).
Frequency range	10 cycles per second to approximately 200 mc per second.

Accuracy	
2,500 and 10,000 volt ranges	**±5%**
All other ranges	**±3%**
Number of tubes	**5**
Power source	**105 to 125 volts, 50 to 70 cycles ac, or 220 volts, 50 to 70 cycles ac.**

3. DESCRIPTION.

The vacuum tube voltmeter is encased in a portable metal cabinet, 13¼ inches long, 12¾ inches high, and 7¾ inches wide (figs. 1 and 2). It weighs approximately 16 pounds. The nameplate, carrying handle, and probe brackets are on top of the cabinet. On the left side is the 7-foot a-c line cord which connects the instrument to the power source. When not in use, the cord is wound around the two hooks attached to the same side. The meter is superimposed upon the face of the front panel. Directly beneath it are three operating controls, the BALANCE, VOLTAGE RANGE, and SELECTOR. Lined at the base are the power switch, the pilot light, GROUND terminal, terminals for d-c test leads, and the A.C. PROBE socket.

a. The probe (fig. 7) is contained in a circular plastic case which has a removable cover. Its metal test prod extends approximately 2⅜ inches. The components within the probe (fig. 9) include: one h-f (high-frequency) diode Tube JAN-9006, a resistor, a capacitor, a mounting bracket, and connecting leads.

b. Ventilation grilles are located on the back of the vtvm (vacuum tube voltmeter) (fig. 6) in addition to a snap button which, when removed, makes a screwdriver control accessible. This control is used, when necessary, for making meter zero adjustments on a-c voltage ranges.

4. LIST OF COMPONENTS.

The following table gives the weights and dimensions of the major components of the vtvm.

a. Equipment Supplied.

Quantity	Name of component	Dimensions (in.)				Vol. (cu ft)	Unit weight (lb)
		Height	*Width*	*Depth*	*Length*		
1	Cabinet (major equipment)	12¾	13¼	7¾	......	0.7	15.5
1	A-c probe and cable assembly	......	......	......	42		0.6
1	D-c test lead	......	......	......	42		0.25
1	Ground lead	......	......	......	42		0.12
1	Ground lead	......	......	......	8		0.1
2	TM 11-2654	8½	5½	......	......		......

b. Tube Complement Supplied.

Quantity	Tube	Reference symbol*	Function
1	JAN-6SN7GT (VT-231)	VT1	Contact potential bucking tube.
1	JAN-6SN7GT (VT-231)	VT2	Bridge tube.
1	JAN-0D3/VR150 (VT-139)	VT3	Voltage regulator tube.
1	JAN-6X5GT/G (VT-126-B)	VT4	Power supply rectifier tube.
1	JAN-9006	VT5	A-c input diode rectifier tube.

*These symbols are for reference purposes only and are not Signal Corps nomenclature.

NOTE: This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

5. PACKAGING DATA.

The vtvm and accessories are packed in a wooden box, 20½ inches long, 18 inches wide and 14 inches deep. This box occupies 3 cu ft of space. The shipping weight is 58 pounds. For dimensions of the unpacked vtvm, see paragraph 4.

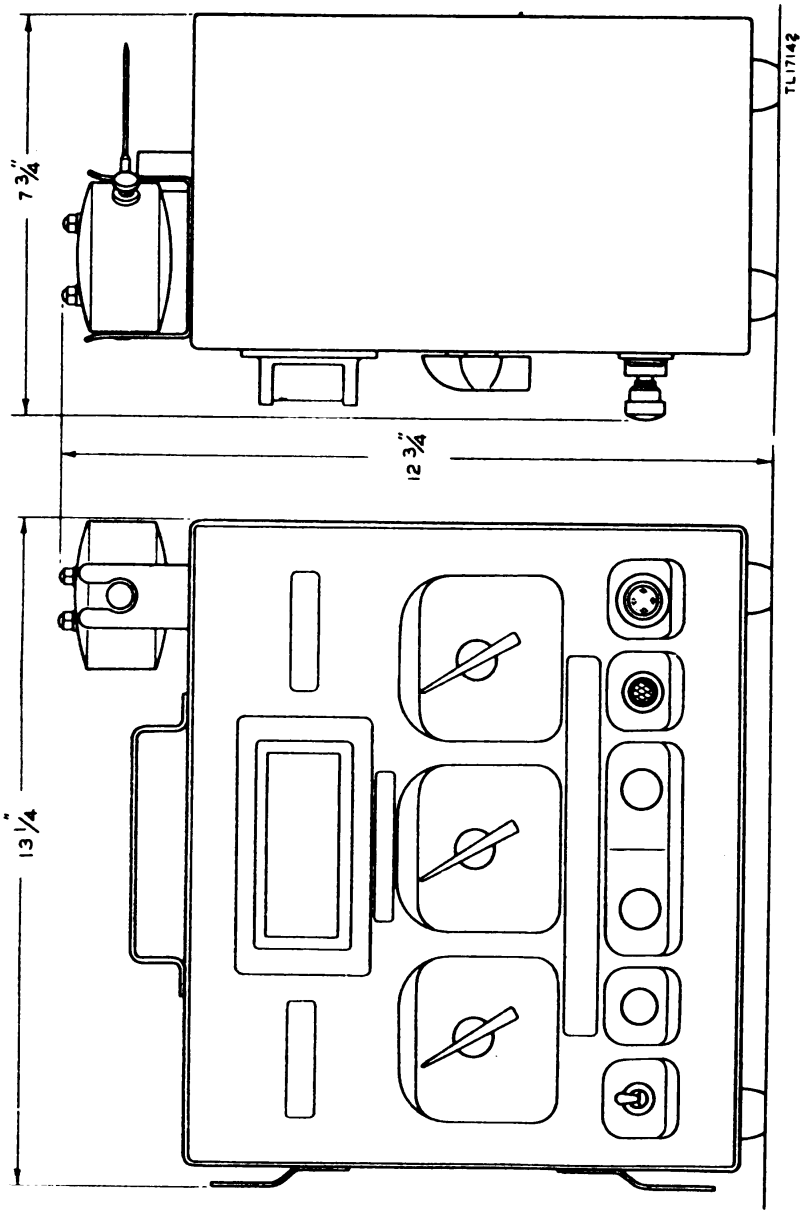


Figure 2. Vacuum tube voltmeter, dimensional drawing.

SECTION II.
INSTALLATION AND ASSEMBLY

6. UNPACKING, CHECKING, AND ASSEMBLY.

NOTE: Be careful when unpacking and handling this equipment. It may be damaged easily when not protected by the packing case.

a. Unpacking. When unpacking the equipment, follow the steps outlined below:

(*1*) Place the wooden box in a location where it may be opened easily.

(*2*) Cut and remove the metal bands on the outside of the box.

(*3*) Remove the top.

(*4*) Tear away the case liner and open the top of the outer carton (fig. 3).

(*5*) Remove the moisture-vapor-proof bag from the outer carton.

(*6*) Open the side of the bag and pull out the inner carton.

(*7*) Open the top of the inner carton.

(*8*) Remove the dunnage and lift the instrument from the inner carton.

b. Checking.

(*1*) Thoroughly inspect the instrument for evidence of possible damage during shipment.

(*2*) Check the components against the master packing slip and the list of components in paragraph 4.

(*3*) Remove the chassis from the cabinet after taking off the *nine* hex nuts on the edges of the front panel. Then make certain that all vacuum tubes are seated properly in the correct sockets.

NOTE: Do not remove any of the protective varnish from the parts or chassis as this a protection against moisture and fungus growth.

c. Assembly.

(*1*) Insert the four-prong plug on the probe cable into the A.C. PROBE socket which is located on the front panel of the vtvm. Lock the plug in place by tightening the ring nut.

(*2*) Connect the lug end of the 8-inch test lead to the ground terminal on the a-c probe housing (fig. 7).

(*3*) Connect the lug end of the d-c test lead with the alligator clip to the GROUND terminal on the front panel of the cabinet.

(*4*) Connect the lug end of the other d-c test lead to the LOW terminal on the front panel of the cabinet.

(5) The instrument is now ready to be placed in operation. See sections III, IV and V for initial adjustments, preoperational and operational procedures.

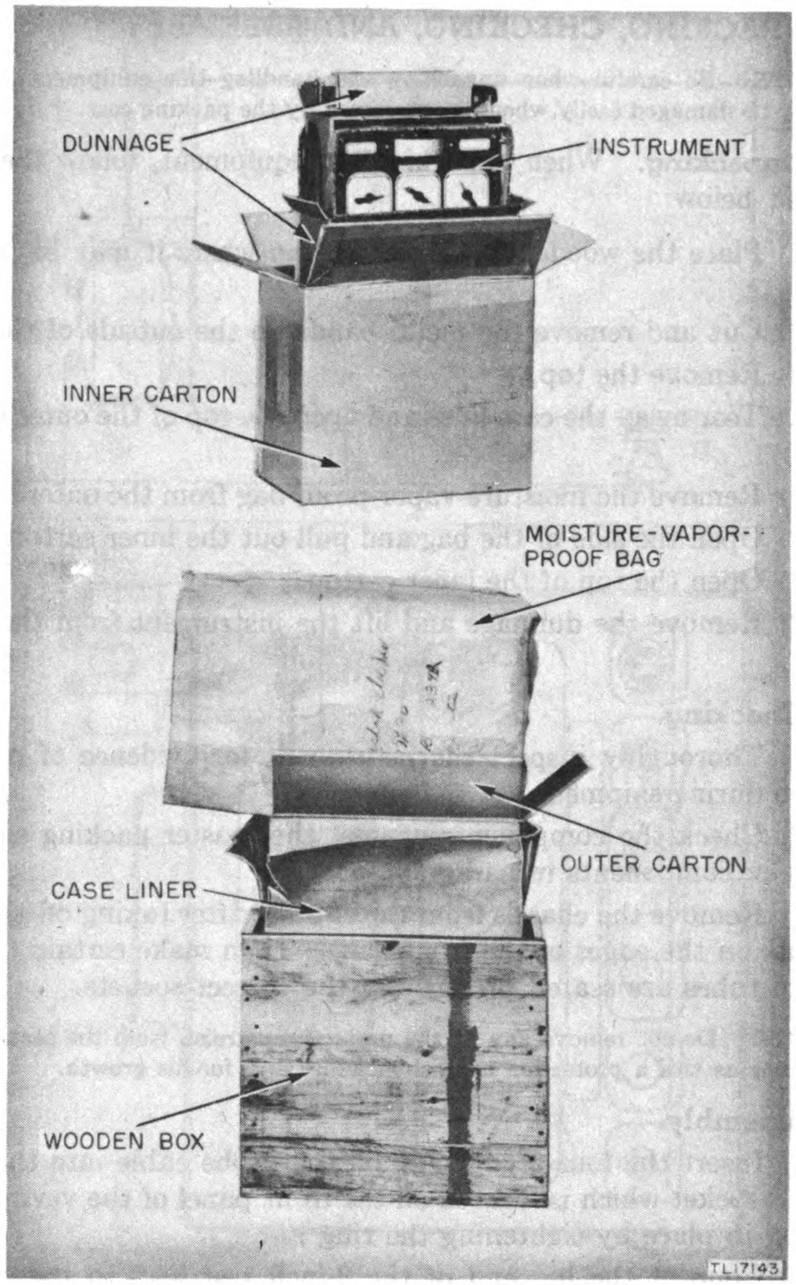


Figure 3. Packaging data.

7. REMOVAL FROM SERVICE.

When the equipment is not in use, always be sure that the POWER switch is OFF, that the probe is placed in the holding brackets on top of the cabinet, and that the line cord is removed from the a-c power source and wound around the two hooks on the left side of the cabinet (fig. 6). If the equipment must be stored for a period *exceeding 2 weeks* or if it must be shipped to a new location, carefully repack the components into the wooden container from which they were initially removed (fig. 3). If this container is not available, use another wooden container of approximately the same dimensions (par. 5).

NOTE: Care must be used in the packing operations since the probe contains a small vacuum tube with a glass envelope. Particular care must also be taken to make certain that no pressure is placed on the glass face of the meter on the front panel of the cabinet.

758241 O - 47 - 3

SECTION III. INITIAL ADJUSTMENTS

8. TRANSFORMER CONNECTIONS.

The connections for the primary windings of transformer T1 are made by the manufacturer to permit proper operation of the equipment on a power source of 105 to 125 volts, 50 to 70 cycles ac (fig. 4A). If, however, the available power source is rated at 220 volts, 50 to 70 cycles ac, proper operation may also be obtained by reconnecting the primary windings of this transformer as shown in figure 4B.

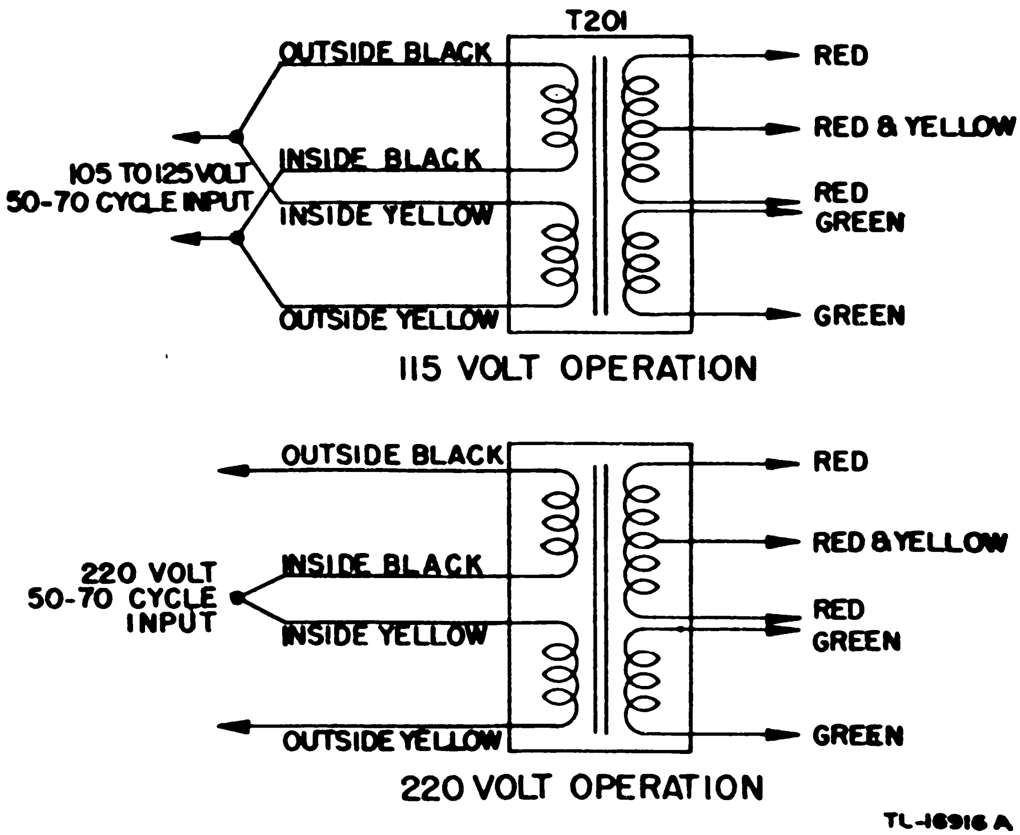


Figure 4. Wiring diagram for transformer T1.

PART TWO
OPERATING INSTRUCTIONS

NOTE: For information on destroying the equipment to prevent enemy use, refer to the destruction notice at the front of the manual.

SECTION IV. PREOPERATIONAL PROCEDURES

9. STARTING THE VTVM (fig. 5).

Before using the voltmeter, carefully read the instructions on its use. The components are delicate electrical instruments and must be handled with care. *Pay particular attention to all cautions*; they are inserted to guide the user and to protect the equipment. Check the over-all operation by following the procedure outlined below:

a. Step 1. Rotate the BALANCE control to 0.

b. Step 2. Rotate the VOLTAGE RANGE switch to the 2.5 position.

c. Step 3. Set the SELECTOR switch at the OFF position.

d. Step 4. Make certain that the meter pointer rests at zero. If not, adjust the zero-set screw on top of the meter.

> **CAUTION: Never make the above adjustment with power applied to the instrument unless the SELECTOR switch is first rotated to OFF position.**

e. Step 5. Connect the plug of the line cord to a 105 to 125-volt, 50- to 70-cycle a-c power source. If only a 220-volt, 50- to 70-cycle power source is available, operation may be obtained by making changes in the transformer wiring as shown in figure 4B.

f. Step 6. Rotate the SELECTOR switch to the −D.C. position.

g. Step 7. Throw the POWER switch to ON.

(*1*) The red pilot lamp on the panel will light.

(*2*) Watch the meter for approximately 1 minute, after which time the needle of the meter will remain at, or within a few divisions of, the zero mark. If it does not, see subparagraph h below.

> **CAUTION: If the pointer jumps off scale, it is an indication of trouble. Immediately rotate the SELECTOR switch to OFF and throw the POWER switch to OFF.**

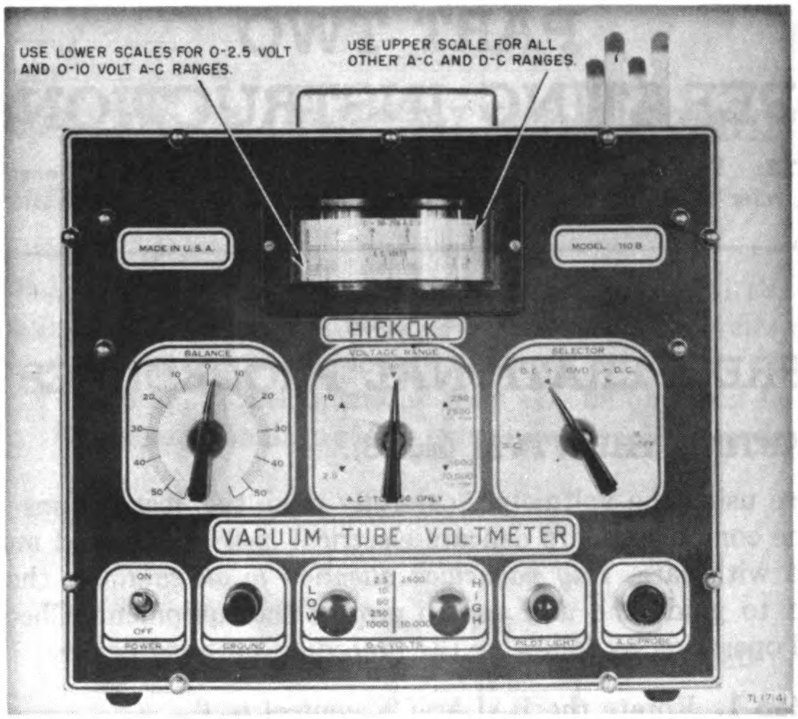


Figure 5. Vacuum tube voltmeter, panel view.

h. Step 8. Rotate the BALANCE control, if necessary, to bring the meter pointer to zero. Clockwise rotation of control causes the pointer to swing to the right; counterclockwise rotation causes the pointer to swing to the left.

(*1*) If it is not possible to make this adjustment, or if it is necessary to rotate the control more than 15 divisions from its original position, repairs are necessary.

(*2*) If it is necessary to rotate the control more than 10 but less than 15 divisions to make this adjustment, the vtvm should be checked for a poor tube or a defective part as soon as practicable.

i. Step 9. Rotate the SELECTOR switch to the D.C. + position. The meter pointer will remain within one-half division of zero. If it does not, either servicing is necessary, or the adjustments indicated in subparagraphs d and h above have not been properly made.

j. Step 10. Rotate the VOLTAGE RANGE switch to each of the other ranges. The meter pointer will remain within one division of zero at all positions. If it does not, readjustment of the BALANCE control will usually allow temporary operation of the instrument until repairs can be made.

k. Step 11. Set the SELECTOR switch at the A.C. position and rotate the VOLTAGE RANGE switch to each of the range positions. The meter pointer will remain within one division of zero in all positions. If it does not, take the following steps:

(*1*) Remove the snap cover on the back of the cabinet by prying it out with a small screwdriver (fig. 6). A screwdriver type control (a-c zero adjustment rheostat P5) will then be visible.

(*2*) Set the SELECTOR switch at the D.C. + position; set the VOLTAGE RANGE switch at the 2.5 position, and adjust the BALANCE control until the meter reads exactly zero.

(*3*) Rotate the SELECTOR switch to the A.C. position.

(*4*) Rotate the a-c zero adjustment rheostat P5 to the setting which brings the meter pointer back to zero. Allow approximately 1 minute for the reading to stabilize after the rheostat is adjusted. This waiting period is necessary because rheostat P5 is wired into the heater circuit of tube VT1 to regulate the amount of cathode emission.

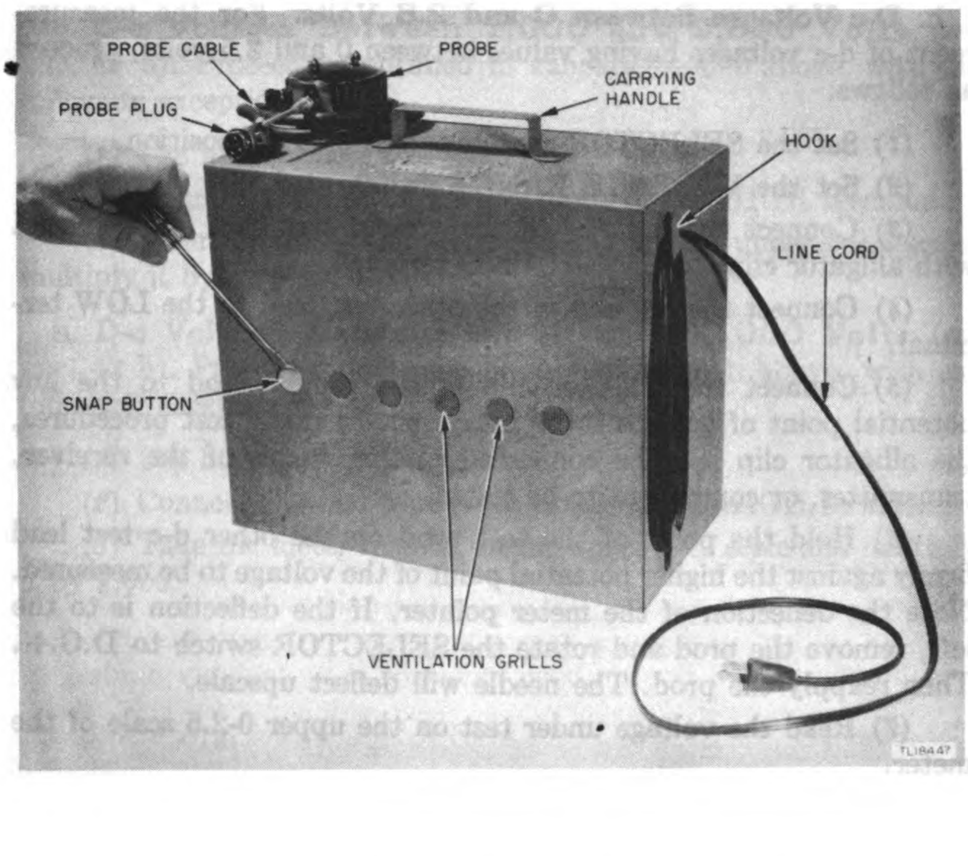


Figure 6. Vacuum tube voltmeter, back of cabinet.

SECTION V. OPERATION

10. D-C VOLTAGE MEASUREMENTS.

CAUTION: Read paragraph 42b before checking voltages higher than 300 volts.

a. General.

(*1*) To measure d-c voltages having values between 0 and 1,000 volts, connect d-c test leads to the LOW and GROUND terminals (fig. 5).

(*2*) To measure d-c voltages having values between 1,000 and 10,000 volts, connect d-c test leads to the HIGH and GROUND terminals (fig. 5).

(*3*) To determine the approximate value for an unknown d-c voltage, always set the VOLTAGE RANGE switch at the 1,000-10,000 position before connecting test leads to the voltage source. The VOLTAGE RANGE switch can then, if necessary, be rotated to progressively lower voltage positions until the meter pointer swings upscale.

b. D-c Voltages Between 0 and 2.5 Volts. For the measurement of d-c voltages having values between 0 and 2.5 volts, proceed as follows:

(*1*) Set the SELECTOR switch at the —D.C. position.

(*2*) Set the VOLTAGE RANGE switch at 2.5.

(*3*) Connect the lug end of the ground test lead (42-inch lead with alligator clip) to the GROUND terminal.

(*4*) Connect the lug end of the other test lead to the LOW terminal.

(*5*) Connect the alligator clip of the ground lead to the low potential point of voltage to be measured. In many test procedures, the alligator clip may be connected to the chassis of the receiver, transmitter, or component to be tested.

(*6*) Hold the point of the test prod on the other d-c test lead firmly against the higher potential point of the voltage to be measured. Note the deflection of the meter pointer. If the deflection is to the left, remove the prod and rotate the SELECTOR switch to D.C.+. Then reapply the prod. The needle will deflect upscale.

(*7*) Read the voltage under test on the upper 0-2.5 scale of the meter.

(*8*) Remove the test leads when tests are completed.

c. D-c Voltages Between 2.5 and 10 Volts. Proceed as outlined in subparagraph b above with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 10.

(*2*) Take the meter reading on the upper 0-10 scale.

d. D-c Voltages Between 10 and 50 Volts. Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 50.

(*2*) Take the meter reading on the 0-50 scale.

e. D-c Voltages Between 50 and 250 Volts. Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 250.

(*2*) Take the meter reading on the upper 0-25 scale and multiply it by 10.

f. D-c Voltages Between 250 and 1,000 Volts (see par. 42b). Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 1,000.

(*2*) Take the meter reading on the upper 0-10 scale and multiply it by 100.

g. D-c Voltages Between 1,000 and 2,500 Volts (see par. 42 b). Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Use high-voltage test leads.

(*2*) Connect the test lead (with prod) to the HIGH terminal.

(*3*) After obtaining the meter reading on the upper 0-2.5 scale, multiply it by 1,000.

h. D-c Voltages Between 2,500 and 10,000 Volts (see par. 42 b). Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Use high-voltage test leads.

(*2*) Connect the test lead (with prod) to the HIGH terminal.

(*3*) Take the meter reading on the upper 0-10 scale and multiply it by 1,000.

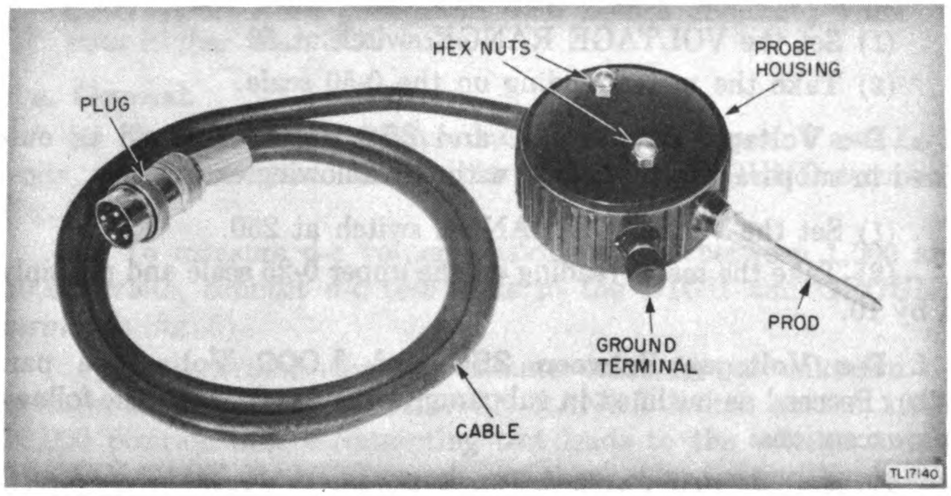


Figure 7. Probe, outside view.

11. A-C VOLTAGE MEASUREMENTS.

a. General.

(*1*) A-c voltage measurements above 250 volts must not be attempted with this instrument. Higher voltages may damage diode Tube JAN-9006 in the a-c probe.

(*2*) Always set the SELECTOR switch at the A.C. position for a-c or r-f (radio-frequency) measurements.

(*3*) If necessary, make the a-c zero adjustment (par. 9).

b. A-c Voltages Between 0 and 2.5 Volts.

(*1*) Set the VOLTAGE RANGE switch at 2.5.

(*2*) Connect the alligator clip of the 8-inch a-c probe lead to one terminal of the voltage source being measured.

(*3*) Apply the point of the a-c probe test prod to the other terminal of voltage source.

(*4*) Take the meter reading on the lower 0-2.5 scale.

c. A-c Voltages Between 2.5 and 10 Volts. Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 10.

(*2*) Take the meter reading on the lower 0-10 scale.

d. A-c Voltages Between 10 and 50 Volts. Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 50.

(*2*) Take the meter reading on the upper 0-50 scale.

e. A-c Voltages Between 50 and 250 Volts. Proceed as outlined in subparagraph b above, with the following exceptions:

(*1*) Set the VOLTAGE RANGE switch at 250.

(*2*) Take the meter reading on the upper 0-2.5 scale and multiply it by 100.

NOTE: The circuits are so designed that the application of excessively high a-c voltages will not damage the meter. A-c voltages in excess of 250 volts may, however, damage the probe tube.

12. APPLICATION.

Paragraphs 13 through 19 explain some of the applications of the vtvm. For this purpose, a basic radio receiver (fig. 8) has been selected arbitrarily to point out the major features in a sample performance.

13. CHECKING OPEN CAPACITORS.

Capacitors need not be removed from the circuit for checking.

a. Good Capacitor. When a capacitor by-passes r-f, a-f (audio-frequency), or l-f (low-frequency) a-c voltages, the alternating voltage across its terminals is approximately zero. For example, negligible a-c voltage readings would normally be obtained across capacitors C5, C6, C7, C8, C9, C10, C11, C12, etc. in figure 8.

NOTE: Since the probe contains a built-in blocking capacitor, the d-c voltage appearing across the terminals does not effect the reading on the meter.

b. Open Capacitors. When the capacitor is open, an a-c voltage appears across the terminals.

14. CHECKING R-F AMPLIFIER.

Since the vtvm has a full-scale sensitivity of 2.5 volts, rms (root mean square) on the lowest range, and since most r-f signal generators are capable of delivering at least 0.1 volt, the output from the signal generator can generally be read directly on the meter scale.

758241 O - 47 - 4

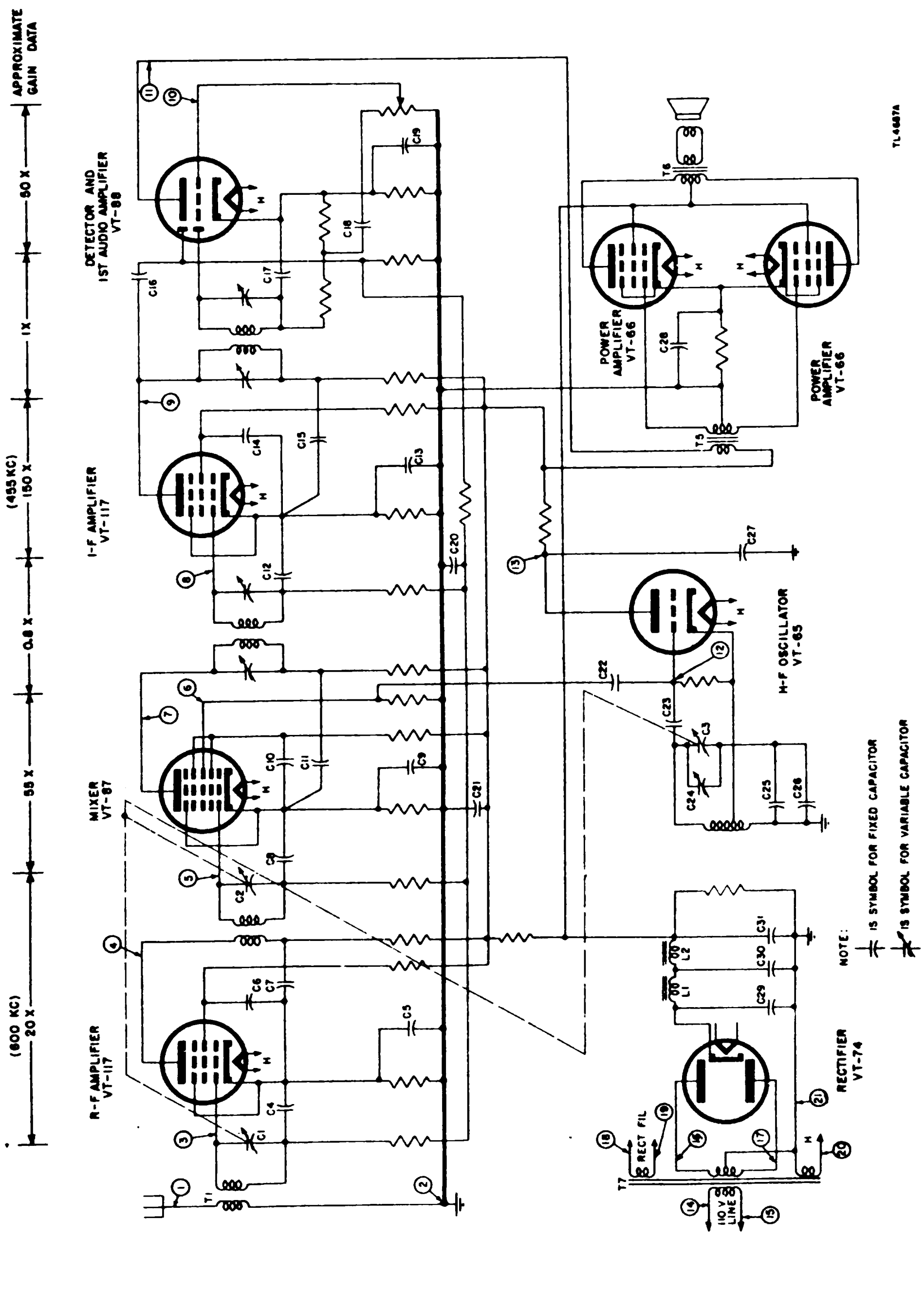


Figure 8. Typical receiver, schematic diagram.

a. When the output of a signal generator is connected to the input terminals of a receiver (test points 1 and 2 in fig. 8), a load is imposed on the signal generator output by the input circuit of the receiver. As a result of this loading, the output voltage of the signal generator is reduced. If the vtvm is also connected across the input terminals, there may be no readable deflection of the meter pointer (see NOTE).

b. If the vtvm is connected between the grid of the first r-f amplifier tube and the chassis (test points 3 and 2 in fig. 8), a deflection may occur when the signal generator and the first r-f grid circuit are tuned to the same frequency. Such a reading indicates that the input circuit is operating.

> **NOTE:** The loading imposed by the vtvm on the circuits under test is negligible. Paragraph 2 lists table showing vtvm input impedance.

c. The r-f voltage at the output of the first r-f amplifier tube is measured between the plate of the tube and the chassis (test points 4 and 2). By comparing the voltage reading at the plate with the reading at the grid of the tube, the gain or amplification of the tube may be computed. For example, if the grid reading is 0.1 volt and the plate reading is 1 volt, the gain of the tube would be 10.

d. When only one stage of r-f amplification is used, compare voltage readings at the plate of the r-f amplifier tube and the grid of the mixer tube (test points 4 and 5 in fig. 8) to gauge the efficiency of transformer action.

> **NOTE:** In making this test, it is imperative that the signal generator and the receiver are tuned to the same frequency; otherwise the transformer may cause a reduction in voltage.

e. Transformer action test:

(*1*) The signal generator is connected to the input terminals, and the vtvm is connected between the grid of Tube VT-87 and the chassis (fig. 8).

(*2*) Rotate the receiver tuning capacitor (C2 tunes the grid circuit of Tube VT-87) and note the reading on the meter.

(*3*) The voltage should increase sharply as the capacitor is rotated towards the frequency to which the signal generator is tuned.

(*4*) Conversely, set the receiver tuning control at any predetermined frequency, such as 1,000 kc; then tune the signal generator from some lower frequency to a higher frequency through 1,000 kc.

(*5*) The voltage reading should increase sharply as the signal generator tuning approaches 1,000 kc, reach a peak at 1,000 kc, and then decrease as the frequency of the signal generator is increased above 1,000 kc.

15. CHECKING OSCILLATOR OPERATION.

a. The oscillator output voltage is checked by measuring the a-c voltage between the grid of the oscillator tube and the chassis (test points 12 and 2 in fig. 8). As an alternative, the a-c voltage between the plate of the tube and the chassis (test points 13 and 2) may be measured if it is physically more convenient.

b. The oscillator output voltage must remain reasonably constant as the receiver tuning control is rotated through all the frequencies in its tuning range. It is hardly probable that the oscillator circuit will maintain a uniform voltage in the progression. The vtvm will indicate the relative output which helps the operator locate a condition where the oscillator voltage drops off rapidly or even completely.

c. For multiband receivers, the same procedure may be used throughout all frequency bands.

d. If the oscillator tube is a single-ended type in which the control grid connection is not made at the tube cap, measurement may be made, for convenience, between the stator plates of the oscillator capacitor (C3 in fig. 8) and the chassis.

e. In a few cases, it may be found that the tests given above for oscillator operation show a normal condition, although the receiver is dead. This may be caused by the fact that no oscillator voltage is being applied at the injector grid of the mixer tube (test point 6). If the blocking capacitor (C22 in fig. 8) is shorted or open, the receiver will not operate normally.

(*1*) If the capacitor is open, the normal oscillator output voltage will not reach the injector grid.

(*2*) Faulty operation of the mixer stage will occur if the capacitor is shorted, because a d-c potential is applied to the injector grid. In this case, a check of the a-c voltage at the injector grid may indicate a normal condition since the probe would not indicate the presence of the abnormal d-c voltage present. Therefore, it is necessary to change over and use the d-c section of the vtvm which ignores the presence of a-c voltage and measures only d-c potentials.

f. The d-c section of the vtvm is also useful in checking oscillator operation. Measurement of the d-c voltage at the grid of the oscillator tube will show a negative bias with respect to the chassis if the oscillator a-c output is normal. If the oscillator should fail at any frequency, no voltage reading will be obtained. Furthermore, a decrease of oscillator output voltage will be accompanied by a decrease of negative bias voltage.

16. CHECKING I-F AMPLIFIER.

a. The procedure for checking the i-f (intermediate-frequency) amplifier is very similar to that used in checking the r-f amplifier.

b. The a-c voltage measured between the plate of the mixer tube and the chassis (test points 7 and 2 in fig. 8) is a resultant of the following:

(*1*) The signal voltage applied to the mixer control grid.

(*2*) The oscillator output voltage applied to the injector grid.

(*3*) A voltage existing at a frequency equal to the sum of the signal and oscillator frequencies.

(*4*) A voltage existing at a frequency equal to the difference between the signal and oscillator frequencies. When the i-f amplifier input transformer is producing normal transformer action, this difference frequency voltage is the only one reaching the grid of the i-f amplifier Tube VT-117.

c. Since the vtvm measures voltages at all frequencies without discrimination, the measurement at the plate of the mixer tube will show the total voltage appearing at this point as a resultant of all voltages given in subparagraph b above. On the other hand, a measurement made between test points 8 and 2 in figure 8 will indicate only the i-f voltage at the grid.

d. After noting the voltage appearing at the grid of Tube VT-117, another reading taken at the plate of the tube (test points 9 and 2) may be used to compute the amplification of the tube. When more than one i-f amplifier stage is used in a receiver, this same procedure is used. After the signal reaches the detector, however, it is demodulated and the i-f carrier is removed, leaving only the modulated component. When tracing voltages through the r-f and i-f sections of a receiver, the signal generator output may be either modulated or unmodulated. However, when the vtvm is used beyond the detector to measure voltages introduced from a signal generator, it is necessary that the signal be modulated. After demodulation, only the a-f component remains.

17. CHECKING A-F AMPLIFIER.

a. When checking a-f voltages, the signal may be supplied from one of the two following sources:

(*1*) From a modulated signal generator whose output is fed to the antenna and ground terminals of the receiver. In this case, the signal is amplified by the r-f and i-f stages, demodulated by the detector, and the audio component measured at the a-f section by the vtvm.

(2) From an audio oscillator or other a-f signal source, directly to the control grid of the first a-f amplifier tube. This method is advantageous since any possible trouble in the r-f and i-f sections will not influence the tests, and most audio oscillators are capable of supplying any a-f voltage from approximately 100 to 10,000 cps (cycles per second). This permits voltage measurements to be made at various audio frequencies and, in this way, the frequency response characteristics of the a-f amplifier may be determined.

b. The audio input signal voltage may be measured between the grid of the first a-f amplifier tube and the chassis (test points 10 and 2 in fig. 8). Another measurement may be made between the plate of this tube and the chassis (test points 11 and 2) to determine the gain of the tube. This gain is, of course, the voltage and not the power gain of the amplifier. The power amplifier may be checked in the same manner.

18. TRANSFORMER MEASUREMENTS.

a. The turns ratio of a transformer may be determined by the vtvm, since the turns ratio is directly proportional to the voltage ratio of the primary and secondary windings. For example: if the primary voltage of a transformer were measured and found to be 100 volts, and the voltage of the secondary were measured at 10 volts, the turns ratio would be 10-to-1.

b. Transformer voltages up to 250 volts may be checked with the a-c section of the vtvm. For example, in figure 8 the 110-volt line voltage across the primary of transformer T7 may be checked by connecting the vtvm to points 14 and 15. The high-voltage secondary may be checked by connecting a high-voltage a-c voltmeter between points 16 and 17, the low-voltage rectifier secondary by connecting the vtvm between points 18 and 19, and the low-voltage heater secondary across points 20 and 21.

CAUTION: Never attempt to use the a-c section of the vtvm for measuring voltages in excess of 250 rms volts.

19. CHECKING A-V-C VOLTAGES.

A-v-c (automatic-volume-control) voltages in a receiver may be checked at any control grid which receives its bias directly from the a-v-c system. A test made between points 3, 5, or 8 and the chassis, will indicate the a-v-c voltage. The d-c section of the vtvm is used for making these tests. The vtvm will not interfere with the normal function of the receiver.

PART THREE
MAINTENANCE INSTRUCTIONS

SECTION VI. PREVENTIVE MAINTENANCE TECHNIQUES

20. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment, when turned off, to eliminate major break-downs and unwanted interruptions in service, and to keep the equipment operating at top efficiency. To understand what is meant by preventive maintenance, it is necessary to distinguish between preventive maintenance, trouble shooting, and repair. The prime function of preventive maintenance is to *prevent breakdowns* and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct *existing* defects. The importance of preventive maintenance cannot be overemphasized. The entire system of communications depends upon the readiness and operating efficiency of each item of equipment when it is needed. In a similar manner, the test equipment by which this condition of readiness in communications equipment is realized must be kept in excellent operating condition at all times.

NOTE: The operations in sections VI and VII are user maintenance operations.

21. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

a. General. Most of the electrical parts used in the vtvm require routine preventive maintenance. This preventive maintenance varies. Some parts require a different kind of maintenance than others. Some require more, some less. Definite and specific instructions must be followed. Hit-or-miss maintenance techniques cannot be applied. This section of the manual contains these specific instructions to guide personnel assigned to perform the six basic maintenance operations: Feel, Inspect, Tighten, Clean, Adjust, and Lubricate. Throughout this manual the lettering system for the six operations will be as follows:

F — Feel.
I — Inspect.
T — Tighten.
C — Clean.
A — Adjust.
*L — Lubricate.

The first two operations show if the other four are needed. Selection of operations is based on a knowledge of field needs. For example, dust encountered on dirt roads during cross-country travel filters into equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat), excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections and the necessary tightening and cleaning operations, equipment becomes undependable and subject to break-down when it is most needed.

b. Feel. The feel operation for the vtvm is confined to checking the temperature of the power transformer for evidences of overheating. The maintenance man *must* become familiar with the normal operating temperature of the transformer to recognize signs of overheating.

c. Inspect. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook evidence of minor trouble. Although these defects may not at the moment interfere with performance of the equipment, invaluable time and effort can be saved if they are corrected *before* they lead to major and costly break-downs. To be able to recognize the signs of a defective set, make every effort to become thoroughly familiar with indications of *normal* functioning. Inspection consists of *carefully* observing all parts of the equipment, noticing their color, placement, state of cleanliness, etc. Inspect for the following conditions:

(*1*) Overheating, as indicated by discoloration, blistering, or bulging of the parts or surface of the container; leakage of insulating compounds; and oxidation of metal contact surfaces.

(*2*) Placement, by observing that all leads and cabling are in their original positions.

(*3*) Cleanliness, by carefully examining all recesses in the units for accumulation of dust, especially between connecting terminals and binding posts. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity areas, look for fungus growth and mildew.

*The Lubricate operation does not apply to this instrument.

(*4*) Tightness, by testing any connection or mounting which appears to be loose.

d. Tighten, Clean, and Adjust. These operations explain themselves. Specific procedures to be followed in performing them are given wherever necessary throughout part three.

CAUTION: Screws, bolts, and nuts should not be tightened carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

Whenever a loose connection is tightened, it should be moistureproofed and fungiproofed again by applying the varnish with a small brush. See section IX for details of moistureproofing and fungiproofing.

e. Lubricate. No lubrication operations are required for maintenance of this equipment.

22. VACUUM TUBES.

NOTE: Avoid working on the tubes immediately after shut-down. Severe burns may result from contact with the envelopes of hot tubes.

a. Inspect (I).

(*1*) Inspect glass tube envelopes for accumulation of dirt and for corrosion.

(*2*) Determine the firmness of tubes in their sockets by pressing the tubes down in the sockets and testing them in that position. Do *not* partly withdraw the tubes and jiggle them from side to side. Movement of a tube tends to weaken the pins in the base and to spread the socket contacts unnecessarily. It is desirable to inspect the sockets of the tubes at the time the tubes are removed.

(*3*) When it is necessary to remove a tube from its socket, care must be used. Never jar a warm tube.

b. Tighten (T). Tighten all loose connections to the tube sockets or to the tubes. If the connections are dirty or corroded, clean them before tightening them.

c. Clean (C).

(*1*) Clean the tubes, but only if inspection shows cleaning to be necessary. Remove dust and dirt from the glass or metal envelopes with a clean, lint-free, dry cloth.

(*2*) When tube sockets are cleaned and the contacts are accessible, fine sandpaper may be used to remove corrosion, oxidation, and dirt.

758241 O - 47 - 5

23. CAPACITORS.

a. Inspect (I).

(*1*) Inspect the terminals of fixed capacitors for corrosion and loose connections. Carefully inspect the mountings to discover loose studs or brackets. Examine the leads for poor insulation, for cracks, and for evidence of dry rot. Cut away frayed strands on the insulation. If the wire is exposed, wrap it with friction tape. The terminals of the capacitors should not be cracked or broken.

(*2*) Thoroughly inspect the case of fixed capacitors for leaks, bulges, and discoloration.

b. Tighten (T). Tighten loose terminals, mountings, and connections on the capacitors, when necessary.

c. Clean (C). Remove accumulation of dirt, dust, corrosion, or fungus, using a small brush.

24. RESISTORS.

a. Inspect (I). Examine the bodies of all resistors for blistering, discoloration, and other indications of overheating. Inspect leads and all other connections for corrosion, dirt, dust, looseness, and broken strands in the connecting wires. Check the security of all mountings. Do not attempt to move resistors with pigtail connections, because there is danger of breaking the connections at the point where they enter the body of the resistor. Such defects cannot be repaired.

b. Tighten (T). Tighten resistor connections and mountings whenever they are found loose. If a resistor is allowed to remain loose, vibration may break the connection or damage the body.

c. Clean (C).

(*1*) Clean all carbon resistors with a small brush.

(*2*) Resistors with discolored bodies cannot be cleaned. Discoloration indicates that there has been overloading and overheating at some time prior to the inspection. The discoloration is probably due to circuit trouble which requires analysis and correction. Troubleshooting procedures are described in part five.

25. METER.

Meters are extremely delicate instruments and must be handled carefully. They require very little maintenance. They are precision instruments and ordinarily cannot be repaired in the field.

a. Inspect (I). Inspect the leads and connections of the meter. Look for loose, dirty, and corroded connections. Look for cracked or broken cover glasses. Since the movement of a meter is extremely delicate, its accuracy will be seriously affected if the glass is broken and dirt and water filter through.

b. Tighten (**T**). Tighten all loose connections. Loose meter wires should be inspected for dirt or corrosion before they are tightened. The tightening of meter connections requires a special technique because careless handling or too much pressure can easily crack the meter case.

c. Clean (**C**). The meter case may be cleaned with a dry cloth. If cleaning is difficult, the cloth should be dampened with a dry-cleaning solvent. Dirty connections may be cleaned with a small brush dipped in dry-cleaning solvent (SD) or with a small piece of cloth dipped in the solvent.

d. Adjust (**A**). Normally, the meter in the vtvm should indicate zero when the equipment is turned off. Before deciding that a meter needs readjusting, tap the meter case *lightly* with the tip of one finger. This will help the needle to overcome the slight friction which sometimes exists at the bearings and prevents an otherwise normal unit from coming to rest at zero. If adjustment is needed, insert the tip of the thinnest screwdriver available into the slotted screwhead located above the meter glass and *slowly* turn the adjusting screw until the pointer is at zero. Lightly tap the meter case again and view the meter face and pointer *full on* and not from either side. Avoid turning the screw too far, because the needle may be bent or the hairspring damaged.

26. SWITCHES.

a. Inspect (**I**).

(*1*) Inspect the mechanical action of each switch and, while so doing, look for signs of dirt or corrosion on all exposed elements. In some cases, it will be necessary to examine the elements of the switch visually; in others, check the action of the switch by flipping the toggle.

(*2*) Examine ganged switches (S2 and S3) to see if contacts are clean. Inspection is visual. Do not pry the leaves of the switch apart. The rotary members should make good contact with the stationary members; and as the former slide into the latter, a spreading of the stationary contact leaves should be visible. Switch action should be free. Wiping action of contacts usually removes any dirt at the point of contact.

b. Clean (**C**). Clean the exterior surfaces of switches with a stiff brush, moistened with dry-cleaning solvents (SD).

27. TERMINAL BLOCKS.

a. Inspect (I).

(*1*) Inspect terminal blocks for cracks, breakage, dirt, and loose connections or mounting screws.

(*2*) Carefully examine connections for mechanical defects, dirt, and corrosion.

b. Tighten (T). Tighten loose screws, lugs, and mounting bolts. When tightening screws, be sure to select a screwdriver of correct size; do not exert too much pressure. Remove loose connections and clean them when they are dirty or corroded.

c. Clean (C). Clean terminal blocks, when they require it, with a dry brush. When necessary, use a cloth moistened with a dry-cleaning solvent (SD). If a solvent is used, the block must be thoroughly wiped with a cloth and then brushed to remove the lint.

SECTION VII.
ITEMIZED PREVENTIVE MAINTENANCE

28. INTRODUCTION.

For ease and efficiency of performance, preventive maintenance on the vtvm will be broken down into operations which may be performed at different time intervals. In this section the preventive maintenance work to be performed on the equipment at the specified time intervals is broken down into units of work called items. The general techniques involved and the application of the FITCAL operations in performing preventive maintenance on individual parts are discussed in section VI. These general instructions are not repeated in this section. When performing preventive maintenance, refer to section VI if more information is required for the following items. Perform all work with the power removed from the equipment. After preventive maintenance has been performed on a given day, put the equipment into operation and check for satisfactory performance.

29. PREVENTIVE MAINTENANCE TOOLS AND MATERIALS.

The following preventive maintenance tools and materials will be needed:

Common hand tools (TE-41 or equivalent).
Clean cloth.
Small brush.
No. 0000 sandpaper.
Crocus cloth.
Socket wrenches (sizes ¼″ to ⅜″).
Dry-cleaning solvent (SD).

NOTE: Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry-cleaning, is available as a cleaning fluid through established channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent (SD) is not at hand.

30. ITEM 1, PROBE ASSEMBLY.

PRELIMINARY STEPS. Remove the d-c test leads from the panel terminals. Remove the probe cable plug from the panel socket. Remove the cover from the probe housing by taking off the two hex. nuts (fig. 9).

OPERATIONS.

ITC Probe cable and plug.
ITC Tube and socket.
ITC Capacitor.
ITC Resistor.
ITC Connections.

REMARKS. Do not disturb position of any part or wire when performing work.

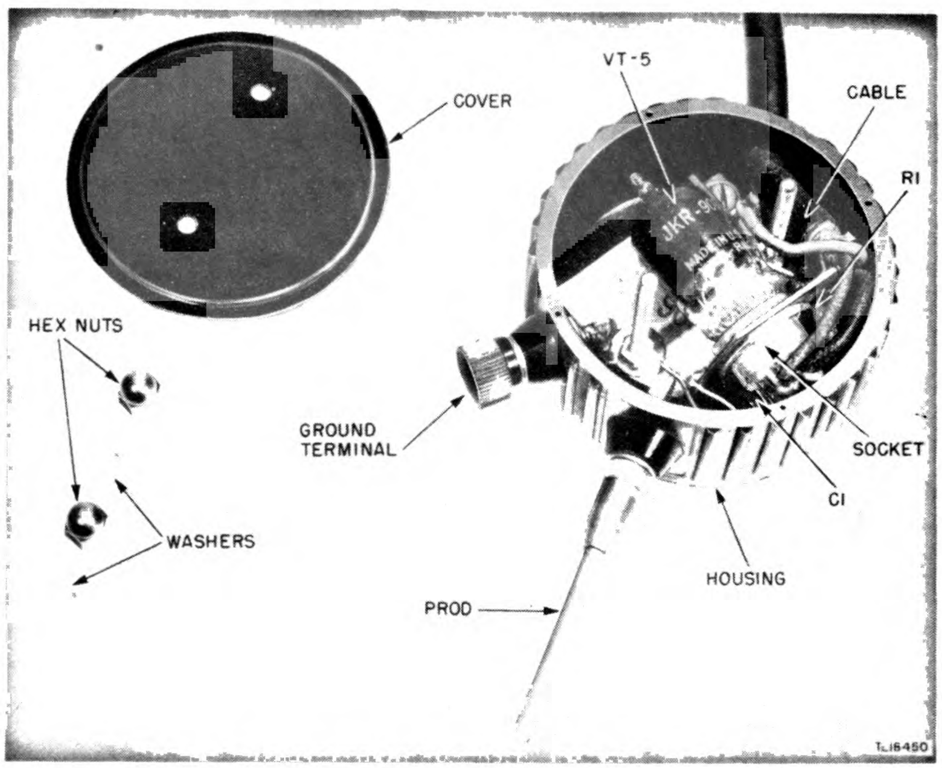


Figure 9. **Probe, inside view.**

31. ITEM 2, INTERIOR OF CABINET (figs. 10 and 11).

PRELIMINARY STEPS. Remove the probe cable plug from the panel socket. Remove the panel and chassis from the cabinet by taking off the *nine* hex. nuts along the edges of the front panel.

OPERATIONS.

FITC	Transformer T1.
ITC	Tubes and sockets.
ITC	Capacitors.
ITC	Resistors.
ITC	Rheostat P5 and potentiometers.
ITC	Insulators.
ITC	Terminals and terminal blocks.
ITC	Switches.
ITC	Pilot light and socket.
ICA	Meter.
ITC	A.C. PROBE socket.
ITC	Connections.
ITC	Wires and leads.

REMARKS. Do not disturb position of shafts on rheostat P5 or on potentiometers P1, P2, and P3.

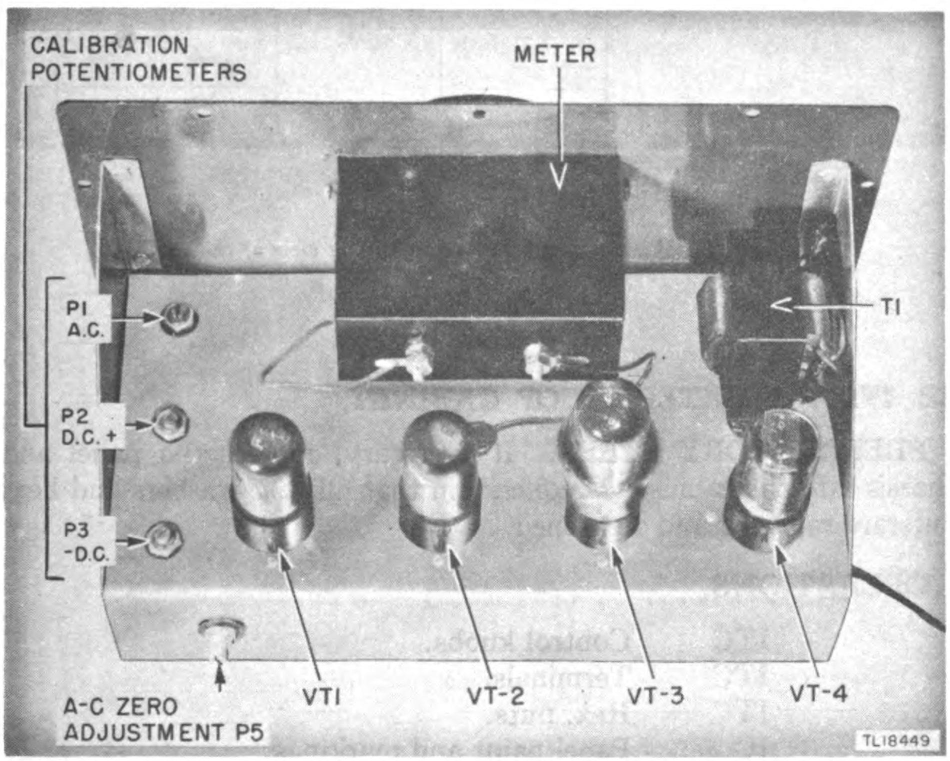


Figure 10. Vacuum tube voltmeter, top inside view.

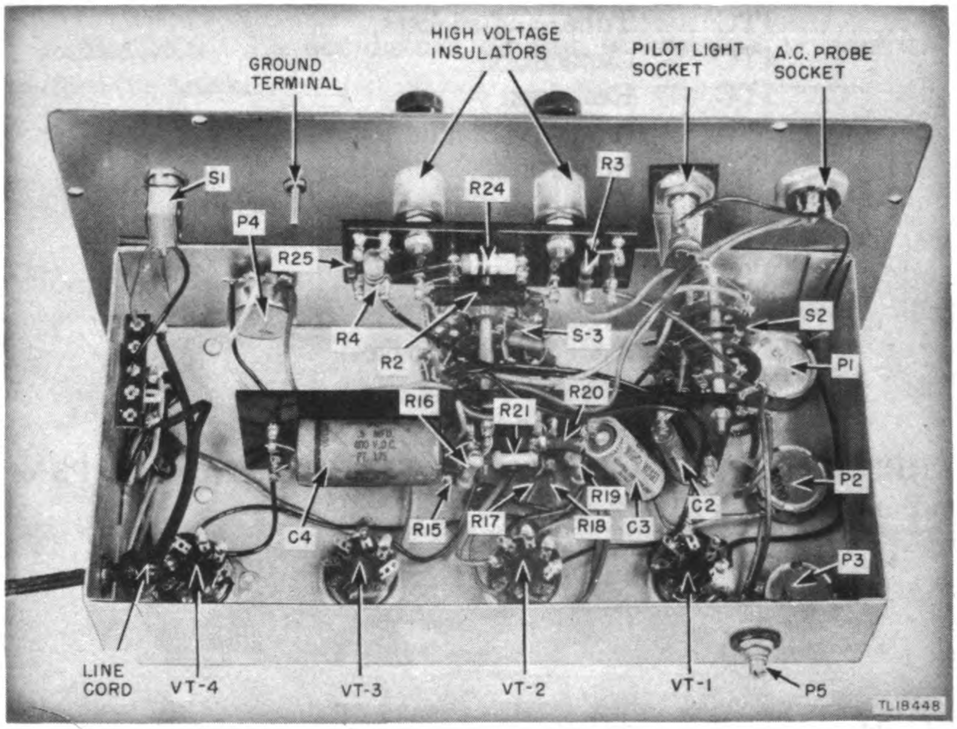


Figure 11. Vacuum tube voltmeter, bottom view of chassis.

32. ITEM 3, EXTERIOR OF CABINET.

PREPARATORY STEPS. If necessary, replace the panel and chassis into the cabinet. Make certain that all *nine* washers and hex. nuts are replaced and tightened.

OPERATIONS.

ITC	Control knobs.
ITC	Terminals.
ITC	Hex. nuts.
IC	Panel paint and markings.
ITC	Cabinet.
ITC	D-c test leads.

33. PREVENTIVE MAINTENANCE CHECK LIST.

The following check list is a summary of the preventive maintenance operations to be performed on the vtvm. The time intervals shown on the check list may be reduced at any time by the local commander. For best performance of the equipment, perform operations at least as frequently as called for in the check list. The echelon column indicates which operations are first echelon maintenance and which operations are second echelon maintenance. Operations are indicated by the letters of the word FITCAL. For example, if the letters ITCA appear in the "Operations" column, the item to be treated must be inspected (I), tightened (T), cleaned (C), and adjusted (A).

Item No.	Operations	Description of item	When performed		Echelon
			Daily	*Monthly*	
1	ITC	Probe assembly		X	2d
2	FITCA	Interior of cabinet		X	2d
3	ITC	Exterior of cabinet	X		1st

NOTE: X indicates when operations are to be performed.

F	I	T	C	A	L
Feel	Inspect	Tighten	Clean	Adjust	Lubricate*

*The Lubricate operation does not apply for maintenance of the vtvm.

SECTION VIII. LUBRICATION

NOTE: Lubrication for the vtvm is not required.

SECTION IX. MOISTUREPROOFING AND FUNGIPROOFING

34. GENERAL.

a. Excessive failure of parts and loss of operating efficiency are usually caused, not by inferior parts or equipment, but by the accumulated effects of moisture in high-humidity areas. Rapid temperature changes coupled with conditions of fog, rain, and dew or high humidity promote such failures.

b. The effects of moisture (and fungus growth) on resistors, capacitors, coils, chokes, transformer windings, terminal boards, and insulating strips can be recognized in the form of corrosion, low insulation resistance, flash-overs, and crosstalk.

35. TREATMENT TO REDUCE FAILURES.

a. To reduce the above failures, a moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. The treatment consists of applying a film of moisture- and fungi-resistant varnish to all susceptible parts of the equipment. This film provides a nonwetting surface which forms a moisture barrier. Fungus growth is prevented by a fungicide in the varnish. Equipments which have been so treated are marked "MFP" and dated. Equipments not so marked should be examined and if it is obvious that the treatment has not been applied, the equipment should be returned at the first opportunity to third or higher echelon maintenance units for treatment.

b. Re-treatment may be required after a period of use. The need for this re-treatment will be indicated by excessive failures or the effects outlined above (par. 34b).

36. MOISTUREPROOFING AND FUNGIPROOFING PROCEDURE.

For a detailed description of the varnish-spray method of moistureproofing and fungiproofing, refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment. TB SIG 13 with changes thereto, gives the necessary procedure for treating the equipment.

37. MOISTUREPROOFING AND FUNGIPROOFING AFTER REPAIRS.

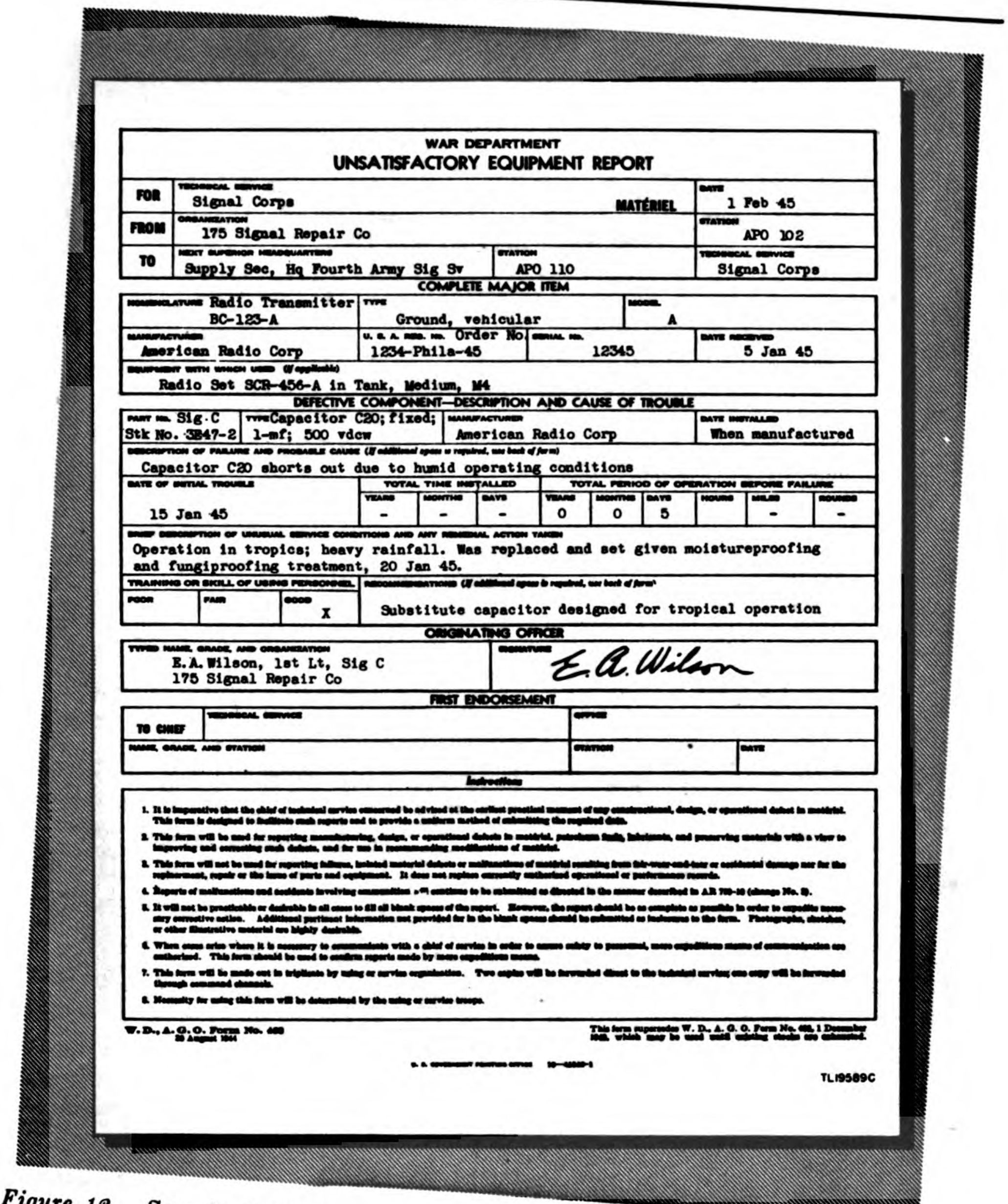
If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

PART FOUR
AUXILIARY EQUIPMENT
NOT USED

PART FIVE

REPAIR INSTRUCTIONS

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form No. 54 (Unsatisfactory Report). If either form is not available, prepare the data according to the sample form reproduced in figure 12.



WAR DEPARTMENT
UNSATISFACTORY EQUIPMENT REPORT

FOR — Technical service: Signal Corps — MATÉRIEL — Date: 1 Feb 45
FROM — Organization: 175 Signal Repair Co — Station: APO 102
TO — Next superior headquarters: Supply Sec, Hq Fourth Army Sig Sv — Station: APO 110 — Technical service: Signal Corps

COMPLETE MAJOR ITEM

Nomenclature: Radio Transmitter BC-123-A — Type: Ground, vehicular — Model: A
Manufacturer: American Radio Corp — U. S. A. reg. no. Order No. 1234-Phila-45 — Serial no.: 12345 — Date received: 5 Jan 45
Equipment with which used (if applicable): Radio Set SCR-456-A in Tank, Medium, M4

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

Part no.: Sig C Stk No. 3E47-2 — Type: Capacitor C20; fixed; 1-mf; 500 vdcw — Manufacturer: American Radio Corp — Date installed: When manufactured
Description of failure and probable cause (If additional space is required, use back of form): Capacitor C20 shorts out due to humid operating conditions
Date of initial trouble: 15 Jan 45
Total time installed: Years – Months – Days –
Total period of operation before failure: Years 0 Months 0 Days 5 Hours Miles – Rounds –
Brief description of unusual service conditions and any remedial action taken: Operation in tropics; heavy rainfall. Was replaced and set given moistureproofing and fungiproofing treatment, 20 Jan 45.
Training or skill of using personnel: Poor Fair Good X
Recommendations (If additional space is required, use back of form): Substitute capacitor designed for tropical operation

ORIGINATING OFFICER

Typed name, grade, and organization: E. A. Wilson, 1st Lt, Sig C 175 Signal Repair Co — Signature: E. A. Wilson

FIRST ENDORSEMENT

TO CHIEF — Technical service — Office
Name, grade, and station — Station — Date

Instructions

W. D., A. G. O. Form No. 468

TL19589C

Figure 12. Sample of W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report.)

SECTION X. THEORY OF EQUIPMENT

38. BASIC THEORY.

The vtvm consists of a five-tube circuit which accurately measures d-c, a-c, and r-f voltages. Although a single meter is used as the indicating device, a wide range of voltage measurements may be made by operating the switches on the front panel of the instrument.

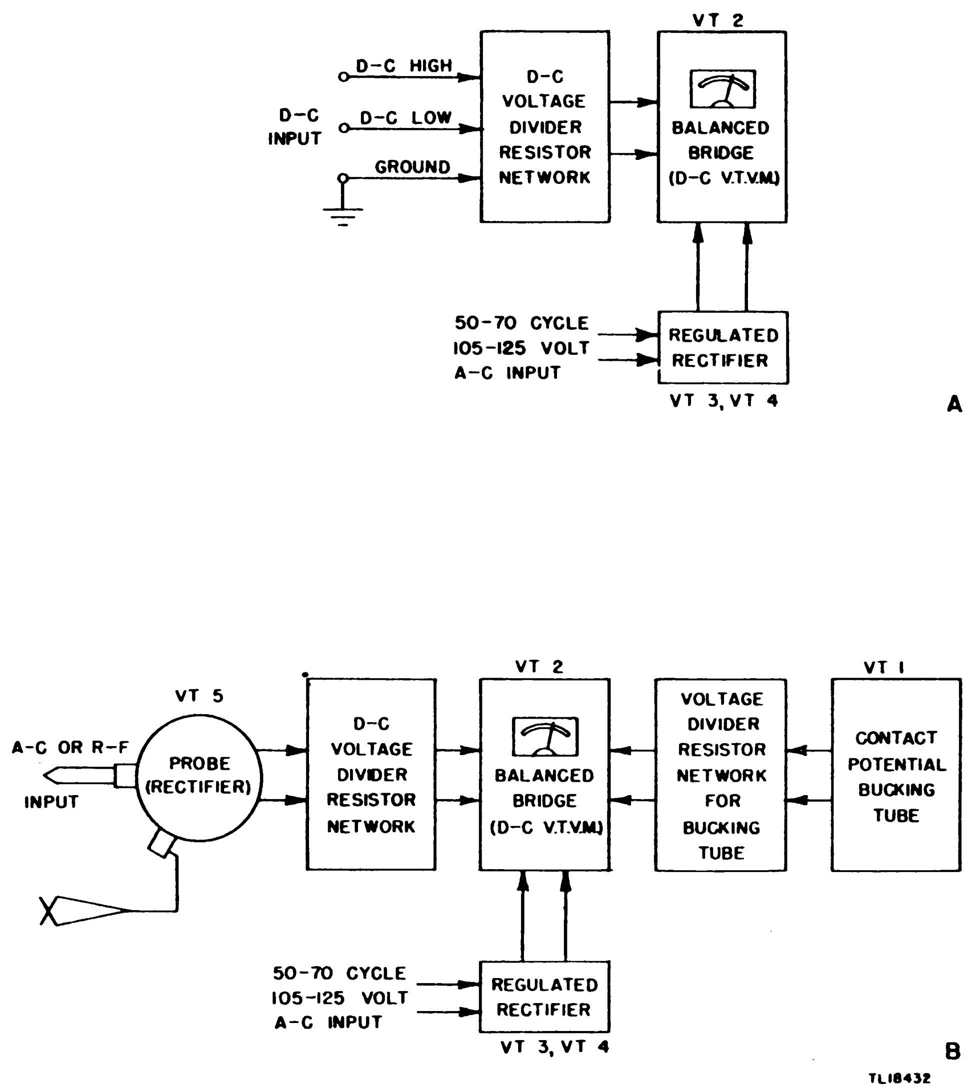


Figure 13. Vacuum tube voltmeter, block diagrams.

a. D-c Voltage Measurements Block Diagram. Figure 13A shows a simplified block diagram of the circuits used when the instrument is adjusted for d-c measurements.

(*1*) In normal operation, with no voltage applied to the input terminals, the zero indicated on the meter signifies a balance in the bridge circuit. The application of a d-c input voltage upsets this balance and causes a deflection of the pointer. The amount of deflection is proportional to the amount of the applied voltage.

(*2*) The d-c vtvm is basically designed to measure d-c voltages between 0 and 2½ volts. This range is extended, however, through the use of a voltage-divider resistor network in the input circuit. The switch marked VOLTAGE RANGE (fig. 5) selects the proper resistor combination for the desired range. For measurement of d-c voltages under 1,000 volts, the input is made to the D.C. VOLTS LOW and GROUND terminals. Potentials between 1,000 and 10,000 volts are applied to the D.C. VOLTS HIGH and GROUND terminals.

(*3*) The twin-triode tube VT2 in the bridge circuit receives its plate voltage from a full-wave rectifier circuit. The rectifier is equipped with a gas voltage regulator tube to permit normal operation of the equipment with line voltage fluctuations from approximately 95 to 135 volts without affecting the accuracy of the equipment or necessitating an adjustment of the balance control.

b. A-c and R-f Voltage Measurements Block Diagram. Figure 13B shows a simplified block diagram of the circuits used when the instrument is adjusted for a-c and r-f measurements.

(*1*) A high-frequency diode tube VT5 fitted into a probe housing converts a-c and r-f voltages to d-c voltages. The rectified d-c voltage is then filtered and applied to the d-c voltage-divider resistor network for measurement by the d-c vtvm.

(*2*) When no a-c or r-f voltage is applied to the diode probe, a zero-signal plate current flows in the probe tube and causes a contact potential of approximately 1¼ volts, which develops across the d-c voltage-divider resistor network. This voltage will upset the balance of the d-c voltmeter, and, although no voltage is being measured, a reading will appear on the meter unless some compensation is provided. Diode tube VT1, called a contact potential bucking tube in figure 13B, is incorporated in the circuit. This diode in combination with its resistance network develops a voltage which cancels the contact potential developed by diode tube VT5. This circuit makes it possible to switch from one voltage range to another without readjusting the BALANCE control.

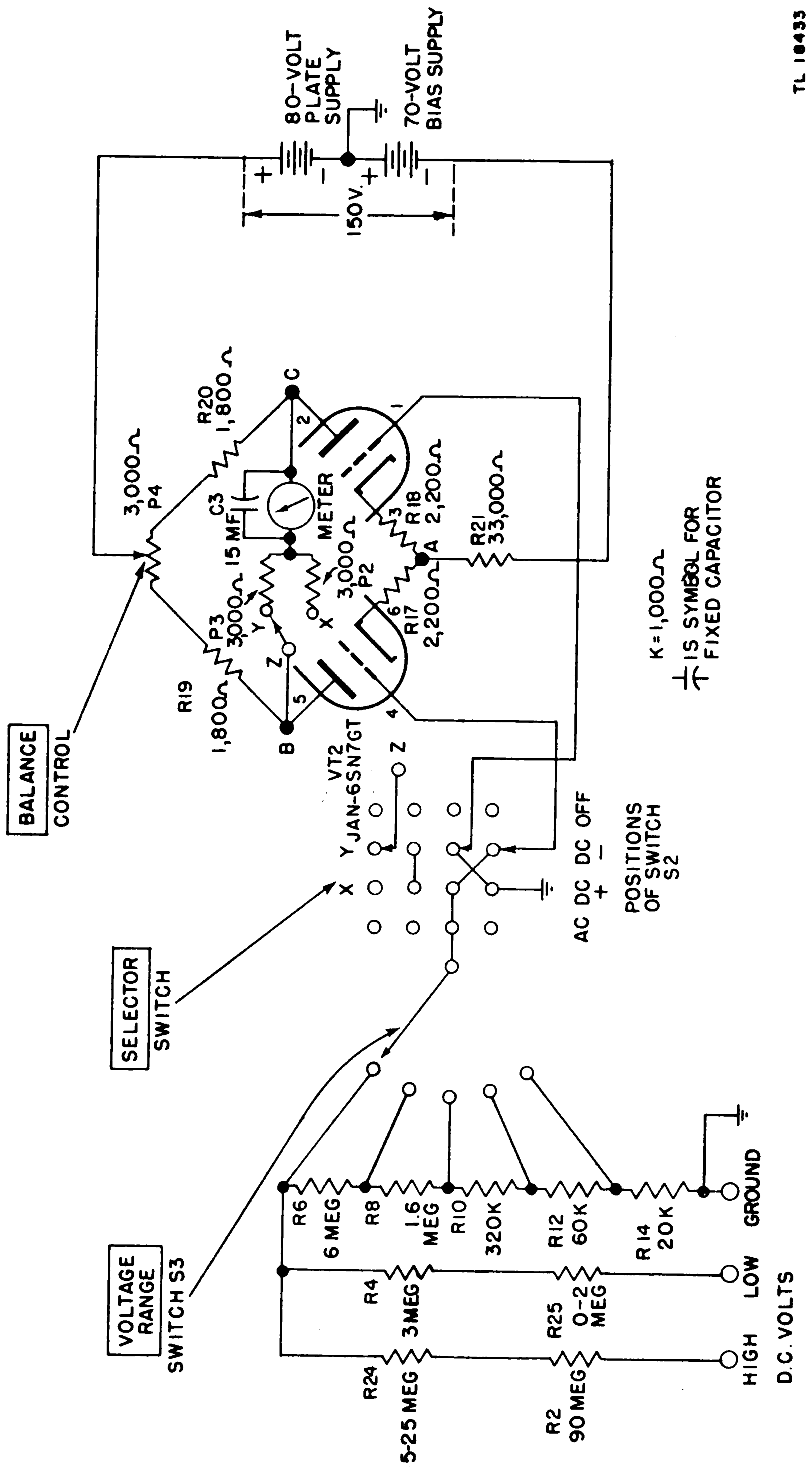


Figure 14. Simplified schematic diagram of d-c measurements circuit.

39. D-C VOLTAGE MEASUREMENTS CIRCUIT.

a. General. The d-c vtvm utilizes a balanced-bridge arrangement. Two triode sections of Tube JAN-6SN7GT, (VT2) serve as part of two legs of the bridge. Figure 14 shows a simplified schematic diagram of the circuit with batteries substituted for the regulated rectifier. Figure 18 shows a complete schematic diagram of the instrument.

b. Bridge Circuit. Stability of operation without greatly reduced sensitivity, is made possible, by the use of a large value of cathode resistance in this bridge circuit. The circuit operates as follows:

(*1*) When a positive voltage is applied to the grid of the left section of the tube (triode section shown at left side of diagram in figure 14) the internal resistance of the tube decreases, causing an increase of current flow through resistors R21, R17, R19, and part of the balancing potentiometer P4. This increase of current flow produces a more positive potential at point A and a more negative potential at point B. Simultaneously, the more positive potential at point A makes the cathode of the right section of the tube more positive, and decreases the current flow through this section of the tube, through resistors R21, R18, R20, and through the other part of potentiometer P4. This decrease of current flow causes point C to become more positive. Thus, as point B becomes more negative, point C becomes more positive and a current flows through the meter circuit. The amount of current flow produced in this manner is proportional to the applied d-c voltage at the grid of the left section of the tube. Because of the large value of cathode resistor R21 (33,000 ohms), the increase in current flow through the left section of the tube is approximately equal to the decrease in current flow through the right section. This results in a push-pull action on the meter and greater sensitivity is obtained.

(*2*) The value of the individual cathode resistors R17 and R18 determines the sensitivity of the bridge. The circuit is so designed that the voltage drop across resistor R21 is slightly greater than the voltage of the bias supply (70 volts). This places point A above ground potential and allows resistors R17 and R18 to determine the actual bias on the tubes. The presence of these individual resistors also permits a certain amount of degeneration which increases the stability of the bridge and partially corrects for differences in the operating characteristics of various tubes. The degeneration, in addition, permits a more linear change in plate current with respect to a change in the d-c voltage being measured, and allows a linear d-c scale to be used on the meter. Because of the common connection of resistor R21 to the individual cathode resistors, a large amount of degeneration with its accompanying loss of sensitivity is avoided, even though R21 has a large resistance value.

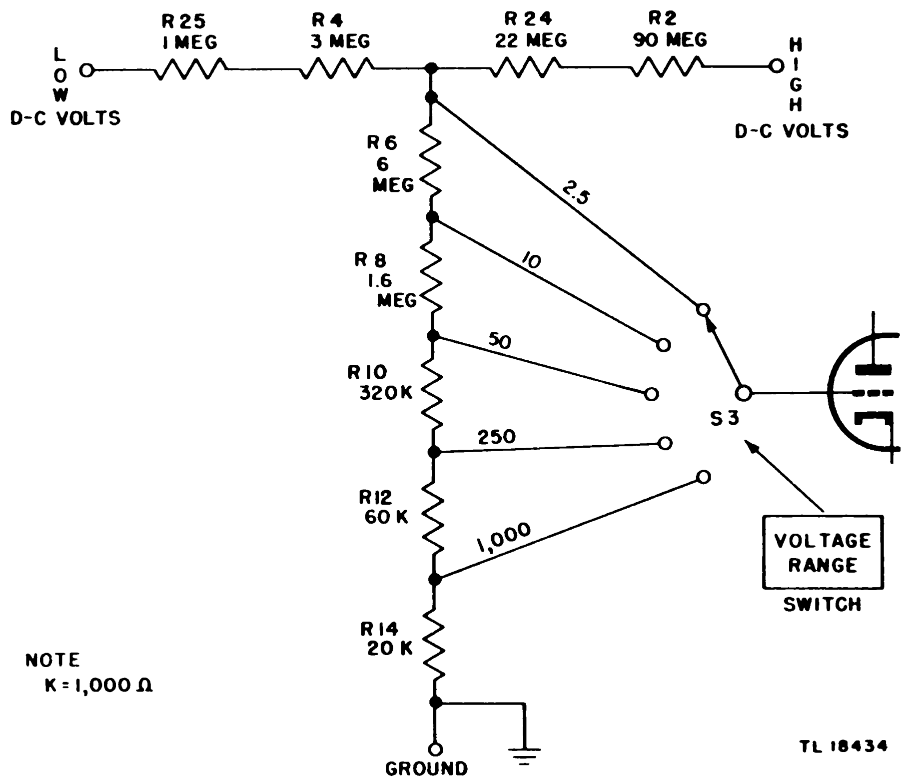


Figure 15. Simplified schematic diagram of d-c voltage divider resistor network.

c. **Voltage-divider Resistor Network.** If the voltage-divider resistor network were omitted from this circuit and a single resistor connected between the control grid of the bridge tube and ground, only voltages between 0 and approximately 1⅔ volts could be applied to the grid of the tube. This is true since a voltage of 1⅔ volts on the grid is made to cause full scale deflection of the meter when the calibration potentiometer (P2 or P3) is adjusted (see subpar. c(6) below). The bridge is so designed that meter readings are linear when voltages within this range are applied to the grid. The purpose of the voltage-divider network, therefore, is to reduce input voltages at the D.C. VOLTS LOW or D.C. VOLTS HIGH terminals to a proportionate value between 0 and 1⅔ volts before application to the control grid. A more detailed explanation follows.

(*1*) Figure 15 shows a simplified schematic diagram of the voltage-divider resistor network with R25 and R24 having values of 1 megohm and 22 megohms, respectively. In this diagram, the total resistance between the D.C. LOW and GROUND terminals is 12 megohms while the total resistance between the D.C. HIGH and GROUND terminals is 120 megohms.

(*2*) When 2½ volts is applied between the D.C. VOLTS LOW terminal and GROUND, a current of 0.000,000,208 amperes (0.208

microamperes) flows through the resistors (Ohm's law, $I = \frac{E}{R}$).

With the VOLTAGE RANGE switch (S3) set at the 2½-volt position, the voltage appearing at the grid of bridge tube VT2 will be equal to this current multiplied by the resistance between the control grid and ground, or 1.66 volts (0.208 microamperes times 8 megohms). This voltage, as explained above, will cause a full scale reading of the meter. One scale on the meter reads from 0 to 2½ volts.

(*3*) When 50 volts is applied between D.C. VOLTS LOW and GROUND terminals, a current of 0.000,004,166 amperes (4.166 microamperes) flows through the resistors. With switch S3 set at the 50-volt position, the voltage appearing at the grid will again be equal to this current multiplied by the resistance between the grid of the tube and ground (1.66 volts). This again will cause full scale deflection of the meter, although a different meter scale (0-50 volts) is used.

(*4*) The same procedure may be used for calculating different input voltages and different settings of the range switch. In each case, however, a full scale deflection of the meter will be caused by the application of 1⅔ volts to the grid of tube VT2. For intermediate values of voltages, of course, a partial deflection of the pointer on the meter will result.

(*5*) When the D.C. VOLTS HIGH terminal is used, the resistor values change and a greater voltage drop occurs before the lowered voltage is applied at the grid of the tube. When voltages in excess of 1,000 volts are to be measured, this terminal must be used instead of the D.C. VOLTS LOW terminal.

(*6*) The exact values of resistors R24 and R25 are determined by the manufacturer when the resistors in the network are initially matched. As the values of these resistors are increased or decreased, the grid voltage used for full-scale deflection is lowered or raised from the 1⅔-volt level.

d. Selector Switch. SELECTOR switch S2 reverses the connections to the control grids of the bridge tube as it is rotated from the D.C. + position to the —D.C. position. See figure 14. In the D.C. + position, the circuit operates normally with a positive d-c input voltage. In the —D.C. position, the connections to these grids are reversed and proper operation of the circuit is obtained with a negative d-c input. Another section of this switch selects either potentiometer P2 or P3 in the meter circuit. Other functions of this switch will be explained in paragraph 40.

e. Meter Circuit. The meter circuit (for d-c operation) is composed of the combination of potentiometers P2 and P3, capacitor C3 and the meter. The capacitor offers a low impedance to alternat-

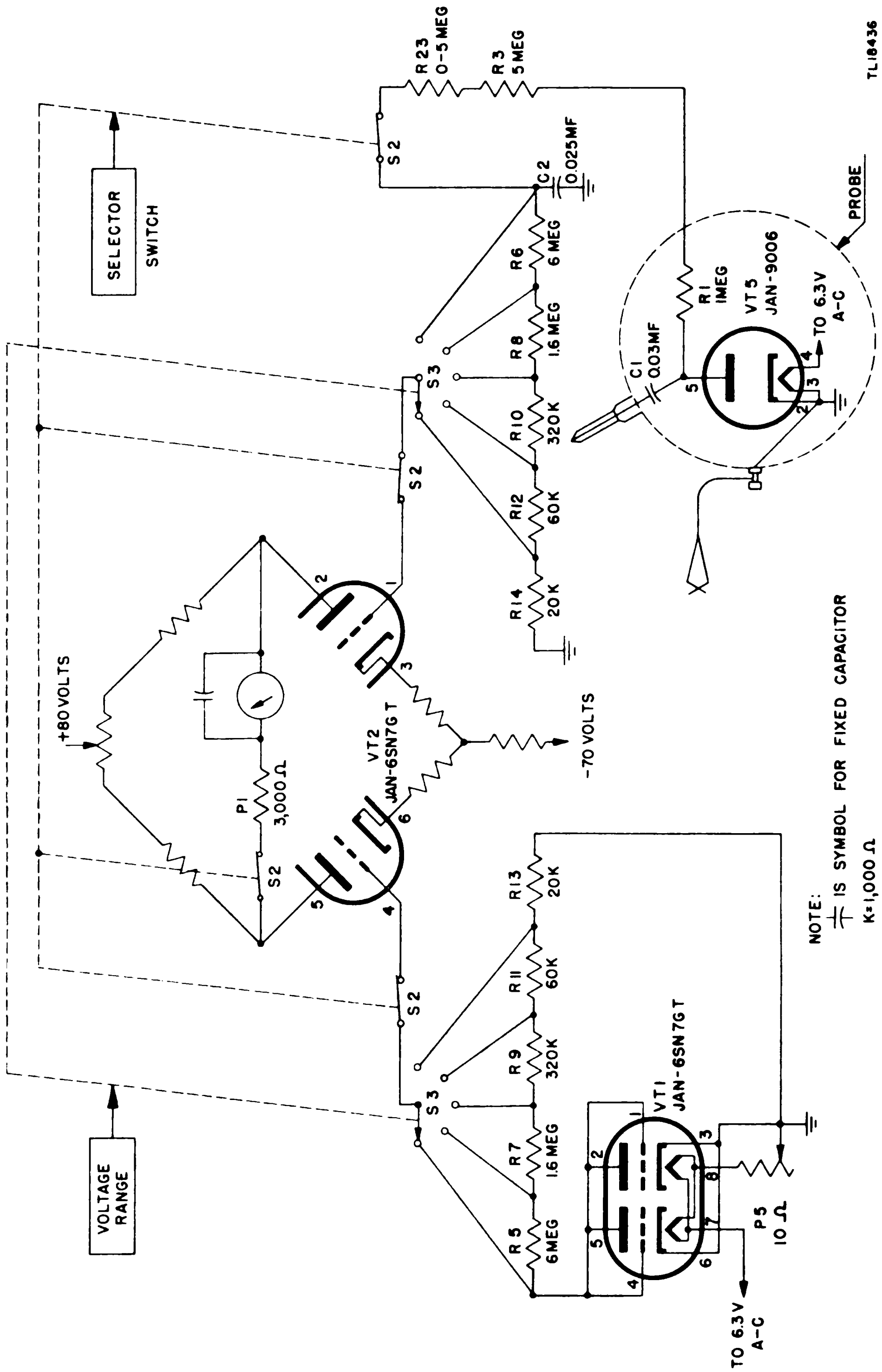


Figure 16. Simplified schematic diagram of a-c measurements circuit.

ing current and prevents any a-c voltage which might accidently be applied to the d-c input terminals from passing through the meter coil. The potentiometers are used in calibrating the instrument and are adjusted so that the meter will read correctly the voltage applied to the input terminals. Two potentiometers are incorporated because individual calibration is used on the D.C. + and —D.C. positions of the SELECTOR switch. This multiple switch selects the proper potentiometer as it is changed from the D.C. + to the —D.C. position.

f. Balance Control. BALANCE control P4 balances the right and left sections of the bridge by adjusting the plate voltage applied to these sections. With no voltage impressed at the input terminals, this control is adjusted for a zero reading of the meter which occurs when points B and C are at the same potential. After this control is initially adjusted, the meter pointer will remain at approximately zero for any position of other controls. In addition, neither changes in plate voltage supply or changes in heater voltage supply, will affect this zero reading since any change in the left section of the bridge is offset by a similar change in the right section of the bridge. Large changes in the plate and heater voltages will, however, create errors in the voltage readings.

40. A-C AND R-F VOLTAGE MEASUREMENTS CIRCUIT.

The a-c and r-f voltage measurements circuit consists of a diode probe, a contact potential bucking tube and its associated voltage-divider resistor network, and the d-c voltage measurements circuit. Figure 16 shows a simplified schematic diagram of this circuit with the probe components shown inside the circle.

a. Rectifier. The probe consists of tube VT5, a high-frequency diode Tube JAN-9006, resistor R1, and capacitor C1, all mounted in the probe housing as shown in figure 9. The extremely short leads and low shunt capacitance obtained by this arrangement allow use of the instrument for the measurement of high-frequency voltages.

(*1*) When an a-c or r-f voltage is applied to the input terminals of the probe, no current flows through the diode tube during the negative half-cycle of the applied voltage because of the unidirectional characteristics of a diode. On the positive alternation, however, the diode does conduct current and capacitor C1 is charged to almost the peak value of the applied voltage (fig. 17).

(*2*) Assuming the voltage being measured does not increase in amplitude, the polarity of the capacitor charge is such that the plate of the tube is biased highly negative in respect to the cathode. Because of this bias, the tube will not conduct again until some of this charge leaks out through resistors R1, R3, R23, R6, R8, R10, R12, and R14, all connected in series. Because of the long RC time constant of these resistors and capacitor C1 (approximately 0.5 second) in comparison with the time required for one cycle of the applied a-c or r-f voltage, the tube will only conduct at the very peak of the positive alternations. See figure 17A and 17B. Thus, only negligible power is consumed from the circuit under test.

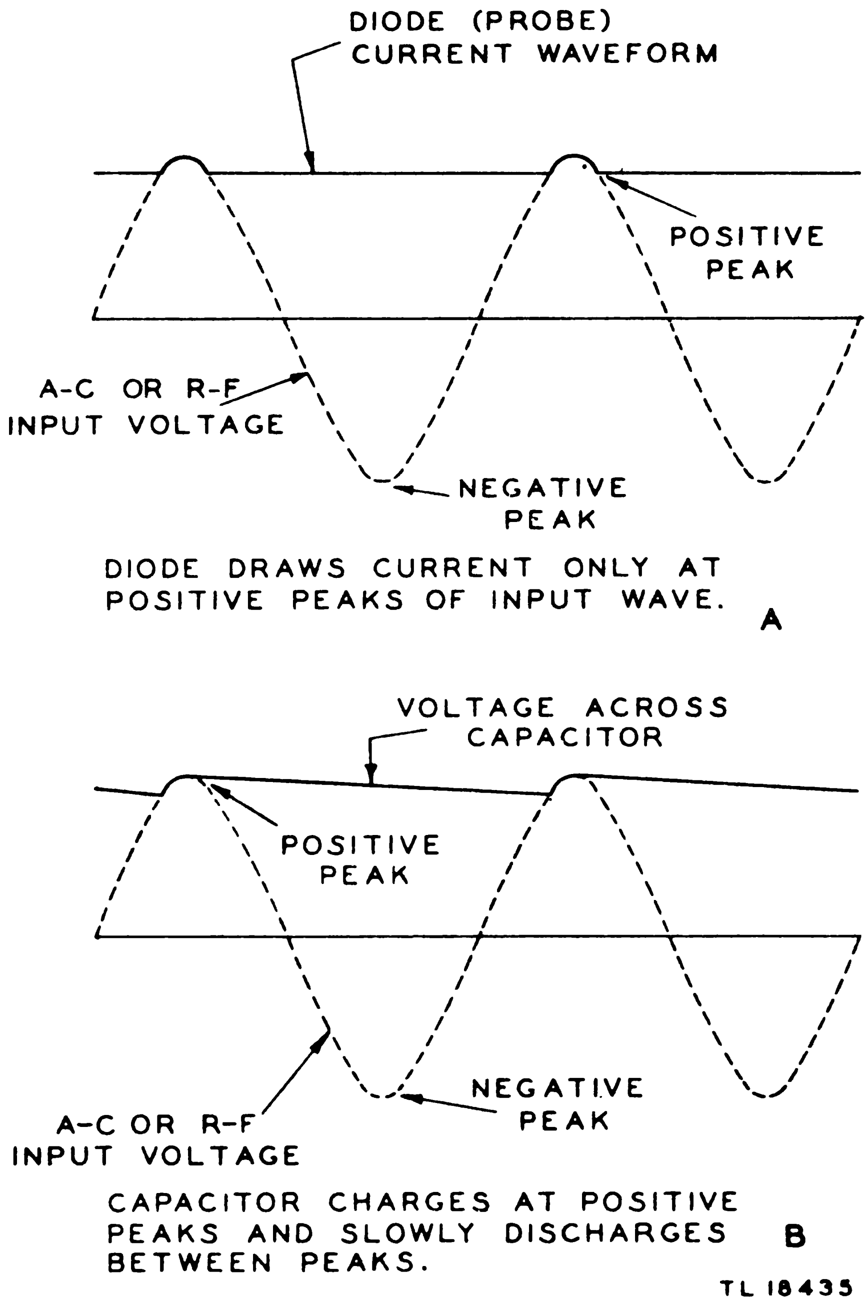


Figure 17. Diode waveforms.

In fact, at high frequencies the only loading imposed is due to the input capacitance of 6 micromicrofarads shunted by a resistance of approximately 15 megohms.

(*3*) A d-c current flow is caused by the discharge of capacitor C1 through the resistance network. Since the capacitor charges approximately to the peak value of the applied a-c or r-f voltage, the average current through these resistors will be approximately equal to the peak input voltage divided by the total resistance in the combination (Ohm's law, $I = \frac{E}{R}$).

(*4*) Capacitor C2 bypasses the a-c voltage around the voltage-divider network and in combination with the resistors serves as a smoothing circuit for the rectified current. Therefore, only a d-c component will appear at the grid of the input tube in the bridge circuit.

b. Voltage-divider Resistor Network. The voltage-divider resistor network performs the same function for the division of the rectified a-c or r-f voltage as it does for a d-c input to the D.C. VOLTS or D.C. VOLTS HIGH terminals. Resistors R2, R4, R24, and R25 are not used. Resistors R3 and R23 permit individual matching of the resistor network for the a-c or r-f voltage measurements circuit. This work is performed by the manufacturer at the time the initial instrument adjustments are made. The rectified output, being a negative voltage, is applied to the same grid of the bridge tube which accepts negative voltages when making d-c voltage measurements.

c. Meter Protection. Since a negative output is obtained from the rectifier, an increasing a-c or r-f voltage applied to the probe input causes an increasing negative d-c voltage to be applied to the control grid of the bridge tube. As a result, the limiting current through the meter is reached when the grid is driven sufficiently negative to cause plate current cut-off. This limiting current is only slightly greater than full scale current of the meter. Therefore, damage to the meter when measuring a-c or r-f voltages is impossible regardless of the magnitude of the voltage being measured or the voltage range being used.

d. Contact Potential Bucking Circuit.

(*1*) With *no* a-c or r-f input voltage at the probe tube, a zero-signal plate current of very small value flows in this tube. This current is normal for any diode and is caused by high-velocity electrons leaving the cathode and striking the plate even though no plate voltage is applied. As a result of the flow of this zero-signal plate current through the voltage-divider resistor network, a potential of approximately 1¼ volts is obtained at the output of the diode. This is called a contact potential.

(*2*) If some means were not provided to correct this condition, a percentage of this contact potential would be applied to the control grid of the voltmeter bridge and a zero reading would not be obtained unless an adjustment of the BALANCE control were made. In addition, a readjustment of this control would be necessary each time VOLTAGE RANGE switch S3 were changed. To compensate for the presence of this contact potential, a bucking circuit is incorporated. This circuit consists of a contact potential bucking tube VT1 (JAN-6SN7GT) and a resistance network which has identical resistor values as has the d-c voltage-divider resistor network.

(*3*) The two triodes of the bucking tube are connected in parallel and, in addition, the grids of the tubes are connected to the plates making the tube perform as a single diode (fig. 16). A zero-signal plate current also flows in this diode and because the resistance in the circuit is identical with the resistance in the d-c voltage-divider network, the currents through these two networks may be made equal. Likewise, the voltages appearing across the two networks as a result of contact potential may also be made equal. A potentiometer is inserted in one of the heater leads of the bucking diode for this purpose. This control regulates the amount of electron flow in the tube and, when properly adjusted, allows the zero-signal plate current in the bucking tube to have the same value as the zero-signal plate current of the probe tube.

(*4*) Since the contact potentials so developed are equal, balance in the bridge is maintained by applying the potential obtained from the bucking diode to one grid of the bridge tube and the potential obtained from the probe diode to the other grid of the bridge tube. Furthermore, because VOLTAGE RANGE switch S3 is a multiple switch and controls the position of the contact arms for each resistor network simultaneously, the voltages applied to the grids are always equal regardless of the range being used.

e. Selector Switch. A separate potentiometer P1 is used for meter calibration on the a-c or r-f ranges. Switch S2, the SELECTOR switch, inserts this potentiometer and connects the probe and bucking circuits to the proper grids of the bridge tube when in the A.C. position. When this switch is in the OFF position (figure 18) the meter is disconnected from the circuit and the pointer of the meter may be set at zero by adjustment of the zero-set screw on the meter. This position may be used as a safety precaution when performing service or repair operations on the instrument itself if a meter indication is not necessary.

f. Meter Scale. The rectified a-c or r-f voltage measured is the peak voltage of the a-c input but the meter scale is calibrated in rms values.

41. REGULATED RECTIFIER.

Rectifier Tube JAN-6X5GT (VT4) is used as a full-wave rectifier for the power supply which furnishes the plate voltage for the bridge tube. The output voltage is held constant at 150 volts through operation of the gas voltage regulator Tube JAN-0D3/VR-150 (VT3).

a. Transformer T1 has two primary and two secondary windings. When the two primary windings are connected in parallel as shown in figure 4A, operation of the equipment on a 50- to 70-cycle, 105- to 125-volt a-c power input is obtained. When these two windings are connected in series, a 220-volt a-c input may be used (fig. 4B). The 6.3-volt secondary winding supplies heater voltage for all tubes. The 300-volt secondary supplies the a-c voltage to the plates of the full-wave rectifier tube.

b. The use of gas voltage regulator tube VT3 and the fairly constant current drain on the rectifier permits the use of a filter consisting of capacitor C4 and the resistance in the circuit. The RC time constant is sufficiently high to hold a charge almost in its entirety during the negative-going excursions of the 120-cycle ripple input.

c. The gas voltage regulator tube in combination with resistor R22 maintains the output voltage at 150 volts. The operation of this circuit is relatively simple:

(*1*) As the voltage across the tube tends to increase, the internal resistance of the tube decreases; thus more current is drawn through series resistor R22, and the voltage across the tube is held at a constant level.

(*2*) Conversely, if the voltage across the tube tends to decrease, less current is drawn through R22, and again the voltage across the tube remains constant. The starting voltage necessary to bring the tube to the point of conduction is somewhat higher than the operating voltage. The tube has upper (40 milliamperes) and lower (5 milliamperes) limits of current flow through it.

d. The common connection of resistors R15 and R16 is placed at ground potential. This arrangement allows a positive 80-volt and a negative 70-volt output to be obtained. The negative voltage is fed to the cathode circuit of tube VT2 and the positive output supplies plate voltages for this tube.

SECTION XI. TROUBLE SHOOTING

42. INTRODUCTION.

No matter how well equipment is designed and manufactured, faults occur in service. When such faults occur, the repairman must locate and correct them as rapidly as possible. This section contains general information to aid personnel engaged in the important duty of trouble shooting.

a. Trouble-shooting Data. Take advantage of the material supplied in this manual to help in the rapid location of faults. Consult the following trouble-shooting data when necessary:

(*1*) Block diagrams of the vtvm (fig. 13).

(*2*) Complete schematic diagram (fig. 18).

(*3*) Simplified and partial schematic diagrams (section X).

(*4*) Voltage and resistance data for all socket connections (pars. 46 and 47).

(*5*) Illustrations of components. Front, top, and bottom views which aid in locating and identifying parts.

(*6*) Pin connections. Pin connections on sockets are indicated on the schematic diagrams. Seen from the bottom, pin connections are numbered in a clockwise direction around the sockets. On octal sockets the first pin clockwise from the keyway is the No. 1 pin.

b. Precautions Against High Voltage. Certain precautions must be followed when measuring voltages above a few hundred volts. High voltages are dangerous and can be fatal. When voltages to be measured are greater than 200 to 300 volts, turn off the power before making any test connections. After the power has been turned off, proceed with the test as follows:

(*1*) Connect the test leads to the proper terminals on the meter.

(*2*) Connect the opposite ends of the test leads to the points at which the voltage test is to be made.

(*3*) Step away from the voltmeter and leads, turn on the power and note the reading of the voltmeter. Do not touch any part of the voltmeter or leads during the period the power is turned on.

(*4*) When the reading has been noted or the test completed, turn off the power before removing any connections.

43. TROUBLE-SHOOTING PROCEDURES.

The trouble-shooting procedures for the vtvm are given in paragraph 44.

a. Starting Procedure Analysis. When an abnormal condition is observed during the starting procedure described in paragraph 9, the defect may be quickly located by referring to the starting procedure analysis given in paragraph 45.

b. Voltage and Resistance Measurement Analysis. When trouble exists and the cause of trouble is unknown, the starting procedure analysis is not used because of possible damage to the meter. In this case, voltage and resistance measurements are made to determine the abnormal condition.

c. Other Data. Paragraph 44 gives pertinent data which will assist the repairman in his work. Read this paragraph thoroughly before trouble shooting on the equipment.

44. GENERAL TROUBLE-SHOOTING DATA.

a. Power Supply. Before applying power, measure the resistance between socket No. 8 of tube VT4 and socket contact No. 2 of tube VT3. The normal value is approximately 600,000 ohms. If this measurement is low, capacitor C4 is either leaky or shorted or some other defect is present. If this measurement is normal, power may be applied to the instrument and voltage measurements made, provided the SELECTOR switch is in the OFF position.

b. Tubes. Check the tubes before making extensive measurements. A tube tester may be used but the best test for a defective tube is the replacement method, that is, substituting a known good tube for each tube to be checked. After testing, return each tube to its original socket unless a poor tube is found.

c. Precision Resistors. The resistors in the voltage-divider resistor networks are matched at the time of production. The accuracy of the instrument may be affected if a replacement is attempted in the field. In case of emergency, however, a defective resistor may be temporarily replaced with one having the value shown in the schematic diagram (fig. 18). Resistors R15 through R22, potentiometers P1 through P4, and rheostat P5 are not precision units.

d. Potentiometers P1, P2, and P3. The position of these controls governs the accuracy of calibration. For this reason, do not disturb their position unless it is known that one is defective. Paragraph 51 explains the manner in which these controls are adjusted when calibration is necessary.

e. Bridge Circuit. If voltage measurements at the socket contacts of tube VT2 are normal, the SELECTOR switch may be moved from OFF to any other position, and the starting procedure analysis given in paragraph 9 used.

f. Meter Circuit. If voltage and resistance measurements (pars. 46 and 47) fail to show an abnormal condition, the meter circuit should be checked. Disconnect the meter from the circuit and check capacitor C3 and potentiometers P1, P2, and P3. Also check for a loose, dirty, or broken connection. The meter is tested by substituting a known good meter in the circuit (see sub. e above before throwing SELECTOR switch from OFF position).

g. Potentiometers P1, P2, and P3. The position of these controls governs the accuracy of calibration. For this reason, do not disturb their position unless it is known that one is defective. Paragraph 51 explains the manner in which these controls are adjusted when calibration is necessary.

h. Bridge Circuit. If voltage measurements at the socket contacts of tube VT2 are normal, the SELECTOR switch may be moved from OFF to any other position, and the starting procedure analysis given in paragraph 9 may be used.

45. STARTING PROCEDURE ANALYSIS.

The following chart is based on the starting procedure given in paragraph 9.

a. Steps 1, 2, 3, 4, 5, and 6. The first six steps of the starting procedure are preparatory.

b. Step 7. Throw POWER switch to ON.

NORMAL INDICATIONS

(*1*) The red pilot light on the panel will go on.

(*2*) The meter will read approximately zero after the tubes have warmed up. (During the first minute, the meter pointer will swing perceptibly and then become stationary near the zero mark.)

Abnormal indications	Probable causes of trouble
(*a*) The meter pointer jumps off-scale.	(*a*) Use trouble-shooting procedure explained in paragraph 44.
(*b*) The meter pointer does not remain within a few divisions of the zero mark after tubes warm up.	(*b*) See subparagraph c, step 8 on opposite page.

Abnormal indications	Probable causes of trouble
(*c*) The pilot light does not go on and no movement of the meter pointer is perceptible as the tubes warm up.	(*c*) Plug of line cord is not inserted into "hot" socket. See subparagraph c, step 8 below chart.
(*d*) The meter pointer swings about normally but the pilot light does not light.	(*d*) Burned out pilot light bulb. Defective pilot light socket or broken connection in pilot light circuit.
(*e*) After approximately one minute has elapsed the meter pointer continues to wiggle.	(*e*) Poor tube VT2. Loose, dirty, or corroded condition of potentiometer P3 or P4. Loose, dirty, or corroded contacts of switch S2 or S3. Poor connection, or defective part in circuit. Make voltage and resistance measurements at socket contacts (pars. 46 and 47).

c. STEP 8. Rotate BALANCE control to bring meter pointer to zero.

NORMAL INDICATIONS

(*1*) Clockwise rotation of control will cause meter pointer to swing to the right (upscale).

(*2*) Counterclockwise rotation of control will cause meter pointer to swing to the left.

(*3*) The meter will read approximately zero when control rests at zero.

Abnormal indications	Probable causes of trouble
(*a*) The rotation of control does not cause any movement of pointer. Pilot light does not go on.	(*a*) Defective line cord or plug. Defective power switch S1. Defective transformer T1. Broken connection between plug of line cord and secondary of transformer T1.
(*b*) Any possible adjustment of control fails to bring meter pointer to zero.	(*b*) Poor tube VT2. Defective part or connection. Make voltage and resistance measurements at socket contacts (pars. 46 and 47).
(*c*) Control must be set higher than ten divisions to bring meter reading to zero.	(*c*) Same as (b) above. Make certain that control knob has not slipped on shaft.

Abnormal indications	Probable causes of trouble
(*a*) Pointer does not remain within one division of zero.	(*a*) Improper adjustment of rheostat P5 (see par. 9k). Defective tube VT1 or VT5. Abnormal voltage or resistance measurement at socket contacts of VT1, VT2, or VT5. See paragraphs 46 and 47 for normal measurements.

SECTION XII. TEST AND ANALYSIS DATA

46. RESISTANCE MEASUREMENTS FROM TUBE PINS TO CHASSIS.

NOTE: All values given are approximate. K = 1,000 ohms.

a. Chart No. 1. This set of resistance measurements shows normal values when the BALANCE control is set at 0, VOLTAGE RANGE switch is at 1,000, SELECTOR switch is at OFF, and the a-c probe plug is inserted into its socket.

Pin No.	Tube			
	VT1	VT2	VT3	VT4
1	8 meg	∾	No connection	0
2	8 meg	340K	270K	0
3	0	310K	No connection	280K
4	8 meg	∾	No connection	No connection
5	8 meg	340K	330K	280K
6	0	310K	No connection	No connection
7	0	0	No connection	0
8	5*	0	No connection	332K

*Depends on setting of rheostat P5.

∾indicates an open circuit. Ohmmeter will show an infinitely high reading.

b. Chart No. 2. This chart shows normal resitance values for tube VT5 when BALANCE control is at 0, VOLTAGE RANGE switch is at 1,000, SELECTOR switch is at A.C., and the a-c probe plug is inserted into its socket.

Tube VT5	
Plate pin	16 meg
Prod	0
Ground terminal	0

c. Chart No. 3. The normal resistance values at the grids of tube VT2 are given in this chart for different positions of SELECTOR switch. BALANCE control is set at 0 and VOLTAGE RANGE switch at 1,000 position.

SELECTOR switch	Pin No. 1	Pin No. 4
—D.C.	0	20K
D.C.+	20K	0
A.C.	20K	20K

d. Chart No. 4. The normal resistance values at the grid of tube VT2 (pin No. 1) given in this chart for different positions of VOLTAGE RANGE switch. BALANCE control is set at 0 and SELECTOR switch at D.C.+ position.

VOLTAGE RANGE switch	Pin No. 1
2.5	8 meg
10	2 meg
50	400K
250	80K
1000	20K

e. Chart No. 5. This chart shows normal resistance values at the grid (pin No. 4) of tube VT2 for different positions of VOLTAGE RANGE switch. BALANCE control is set at 0 and SELECTOR switch at —D.C. position.

VOLTAGE RANGE switch	Pin No. 4
2.5	8 meg
10	2 meg
50	400K
250	80K
1000	20K

f. Chart No. 6. This chart shows normal resistance values at the grid (pin No. 1) of tube VT2 for different positions of VOLTAGE RANGE switch. BALANCE control is set at 0 and SELECTOR switch at A.C. position.

VOLTAGE RANGE switch	Pin No. 1
2.5	8 meg
10	2 meg
50	400K
250	80K
1000	20K

47. VOLTAGE MEASUREMENTS FROM TUBE PINS TO CHASSIS.

The normal voltage measurements are given in the following chart. All voltages are measured between the point specified and the chassis using a 20,000 ohm-per-voltmeter. Voltages are approximate. The BALANCE control was set at 0 and the SELECTOR switch at the D.C.+ positions when these measurements were taken.

Pin No.	Tube			
	VT1	VT2	VT3	VT4
1	-0.25	0	No connection	0
2	-0.25	58	-70	0
3	0	2.9	No connection	300 ac between pin No. 3 and pin No. 5
4	-0.25	0	No connection	No connection
5	-0.25	58	80	See pin No. 3 above
6	0	2.9	No connection	No connection
7	6 ac	6 ac	No connection	6 ac
8	2.5 ac*	0	No connection	110

*Depends on setting of rheostat P5.

NOTE: The voltage at the plate pin of tube VT5 is 0.5; the heater voltage is 6 volts ac.

SECTION XIII. REPAIRS

48. SERVICING.

Be careful in maintaining and servicing this equipment. Servicing and repair other than the replacement of tubes should be performed only by competent personnel supplied with adequate tools and instruments. An inexperienced operator attempting to locate and repair troubles may damage the equipment to such an extent that shipment to a higher repair echelon will be necessary. This is particularly true of indiscriminate adjustment of the calibrating potentiometers.

49. GENERAL REPAIR.

Removal and replacement of defective parts and circuit elements in this equipment are very difficult, and great care must be taken to avoid further damage to the equipment or to the part being replaced. Before attempting repairs make every effort to obtain the proper tools for the job.

a. Identification of Leads. Often it may be necessary to remove other circuit elements to gain access to the defective part. To insure proper reinstallation, make record of the connections to each removed element and of the position of the element in the equipment.

b. Electrical Connections. When replacing leads clip them as short as possible for satisfactory connection and avoid using more solder than necessary to make a secure connection. A very slight amount of excess solder dropped accidently inside the equipment may cause other circuits or circuit elements to be short-circuited. Some clearances are very small, and extreme care must be exercised in soldering. Do not heat the lug or connection more than is absolutely necessary because of possible damage to nearby elements, such as capacitors, resistors, and wiring. When a wire is connected to a tube socket, the connecting wire should be long enough to prevent pull on the socket. Save time and trouble by making a thorough electrical check of any part that appears to be defective *before* removing it from the equipment.

50. RUSTPROOFING AND REPAINTING.

When the finish on the cabinet has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surface as follows:

a. Clean the scarred surface down to the bare metal. Use No. 00 or No. 000 sandpaper to obtain a bright, smooth finish.

CAUTION: The use of steel wool instead of sandpaper is not recommended. Minute particles of the metal frequently enter the cabinet and cause harmful internal electrical shorting or grounding of circuits.

b. When a touch-up job is necessary, apply paint with a small brush. When numerous scars and scratches warrant complete repainting, remove the radio set chassis and spray paint over the entire cabinet. Remove rust from the case by cleaning corroded metal with dry-cleaning solvent (SD). In severe cases it may be necessary to use dry-cleaning solvent (SD) to soften the rust and sandpaper to complete the preparation for painting. Paint used will be authorized and consistant with existing regulations.

SECTION XIV. CALIBRATION

51. CALIBRATION.

a. —D.C. Position. When it is known or suspected that calibration is necessary, take the following steps:

(*1*) Turn on and check the equipment using the procedure given in the starting procedure of paragraph 9.

(*2*) Set SELECTOR switch at —D.C. position.

(*3*) Rotate VOLTAGE RANGE switch to the 1,000 position.

(*4*) Apply a d-c voltage of *known* value to the d-c test leads.

(*5*) Rotate VOLTAGE RANGE switch to the proper setting for measuring the applied voltage (par. 10). If the meter pointer swings to the left when voltage is applied, reverse the test leads.

(*6*) Note the meter reading. If the indicated voltage is normal, calibration is not necessary, If, however, the reading shows an error in excess of 3%, adjust potentiometer P3 until the correct reading is obtained.

b. D.C. + Position. The D.C. + voltage calibration is obtained by following the procedure explained in subparagraph a above, with the following exceptions:

(*1*) The SELECTOR switch is set at D.C.+ position.

(*2*) If calibration is necessary, adjust potentiometer P2 instead of potentiometer P3.

c. A.C. Position. When it is known or suspected that calibration is necessary, take the following steps:

(*1*) Turn on and check the equipment using the starting procedure given in paragraph 9.

(*2*) Set SELECTOR switch at A.C. position.

(*3*) Rotate VOLTAGE RANGE switch to the 1000 position.

(*4*) Apply an a-c voltage of *known* value to the probe input terminals.

(*5*) Rotate VOLTAGE RANGE switch to the proper setting for measuring the applied voltage (par. 11).

(*6*) Note the meter reading. If the indicated voltage is normal, calibration is not necessary. If, however, the reading of the meter shows an error in excess of 3%, adjust potentiometer P1 until the correct reading is obtained.

52. UNSATISFACTORY EQUIPMENT REPORT.

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report, W.D., A.G.O. Form No. 468 should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D.C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form No. 54 should be filled out and forwarded through channels.

c. If either form is not available, prepare the data according to the sample form reproduced in figure 12.

SECTION XV. DIAGRAMS

53. COMPLETE SCHEMATIC DIAGRAM OF VACUUM TUBE VOLTMETER (Hickok model 110-B).

See figure 18.

APPENDIX

SECTION XVI. REFERENCES

NOTE: For availability of items listed, check FM 21-6, and ASF Catalog SIG 2. Also see FM 21-6 for applicable technical bulletins, supply bulletins, modification work orders, and changes.

54. ARMY REGULATIONS.

AR 380-5	Safeguarding Military Information.

55. SUPPLY PUBLICATIONS.

SIG 1	Introduction to ASF Signal Supply Catalog.
SIG 3	List of Items for Troop Issue.
SIG 4-1	Allowances of Expendable Supplies.
SIG 4-2	Allowances of Expendable Supplies for Schools, Training Centers, and Boards.
SIG 5	Stock List of All Items.
SIG 10	Fixed Plant Maintenance Lists.
SB 11-6	Dry Battery Supply Data.
SB 11-10	Signal Corps Kit and Materials for Moisture and Fungi-Resistant Treatment.
SB 11-17	Electron Tube Supply Data.

56. TECHNICAL MANUALS ON TEST EQUIPMENT.

TM 11-303	Test Sets I-56-C, -D, -H, and -J.
TM 11-307	Signal Generators I-72-G, -H, and -J.
TM 11-321	Test Set I-56-E.
TM 11-472	Repair and Calibration of Electrical Measuring Instruments.
TM 11-2613	Voltohmmeter I-166.
TM 11-2626	Test Unit I-176.
TM 11-2627	Tube Tester I-177.

57. PAINTING, PRESERVING, AND LUBRICATION.

TB SIG 13	Moistureproofing and Fungiproofing Signal Corps Equipment.

58. CAMOUFLAGE.

FM 5-20	Camouflage, Basic Principles.

59. SHIPPING INSTRUCTIONS.

U. S. Army Spec. No. 100-14A.	Army-Navy General Specification for Packaging and Packing for Overseas Shipment.

60. DECONTAMINATION.

TM 3-220	Decontamination.

61. DEMOLITION.

FM 5-25	Explosives and Demolitions.

62. OTHER PUBLICATIONS.

TB SIG 66	Winter Maintenance of Ground Signal Equipment.
TB SIG 72	Tropical Maintenance of Ground Signal Equipment.
TB SIG 75	Desert Maintenance of Ground Signal Equipment.
TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TM 1-455	Electrical Fundamentals.
TM 11-310	Schematic Diagrams for Maintenance of Ground Radio Communications Sets.
TM 11-453	Shop Work.
TM 11-455	Radio Fundamentals.
TM 11-4000	Trouble Shooting and Repair of Radio Equipment.
TM 37-250	Basic Maintenance Manual.

63. FORMS.

W.D., A.G.O. Form No. 468.
Army Air Forces Form No. 54.

64. ABBREVIATIONS.

The following abbreviations are used in this manual:

a-c	alternating-current (adj)
ac	alternating current (noun)
a-f	audio-frequency (adj)
af	audio frequency (noun)
a-v-c	automatic-volume-control
amp	ampere
d-c	direct-current (adj)
dc	direct current (noun)
h-f	high-frequency
JAN-	Prefix designation for radio electron tubes procured under joint Army-Navy Specification JAN-1A.
K	1,000 ohms
l-f	low-frequency
ma	milliampere
RC	resistance capacitance
r-f	radio-frequency (adj)
rf	radio frequency (noun)
vtvm	vacuum-tube voltmeter
∞	infinity

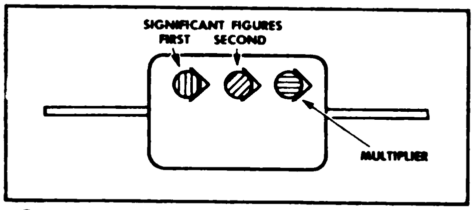
65. GLOSSARY.

See glossary in TM 11-455, Radio Fundamentals.

66. COLOR AND DESIGNATION CODES.

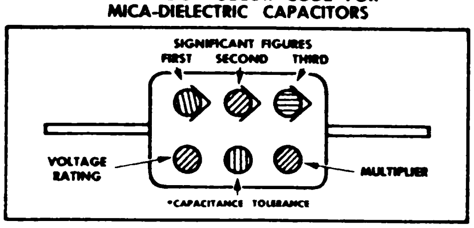
CAPACITOR COLOR CODES

RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS

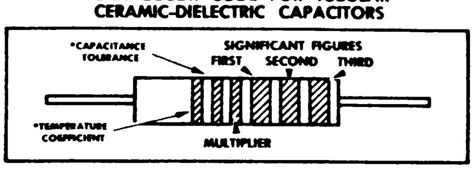


Capacitors marked with this code have a voltage rating of 500 volts.

RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS



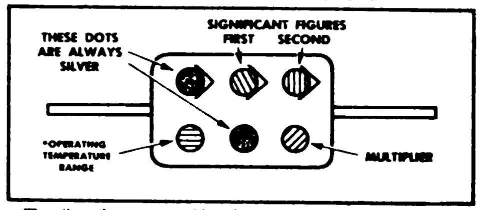
Capacitors marked with this code have a voltage rating of 500 volts.

RMA Radio Manufacturers Association JAN Joint Army-Navy

Note These color codes give all capacitances in micro-microfarads

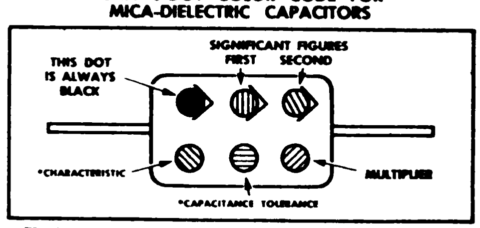
*Items marked with an asterisk are of interest primarily to depot and higher echelon repair personnel

JAN 6-DOT COLOR CODE FOR PAPER-DIELECTRIC CAPACITORS



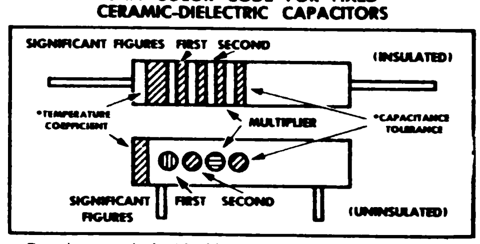
The silver dots serve to identify this marking. For working voltages see JAN type designation code

JAN 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



The black dot serves to identify this code. For working voltages see JAN type designation code.

JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS



Capacitors marked with this code have a voltage rating of 500 volts. Either the band or dot code may be used.

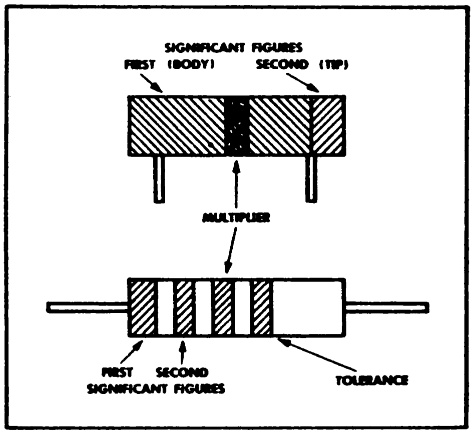
COLOR	SIGNIFICANT FIGURE	MULTIPLIER			RMA VOLTAGE RATING
		RMA MICA-AND CERAMIC-DIELECTRIC	JAN MICA-AND PAPER-DIELECTRIC	JAN CERAMIC-DIELECTRIC	
BLACK	0	1	1	1	
BROWN	1	10	10	10	100
RED	2	100	100	100	200
ORANGE	3	1,000	1,000	1,000	300
YELLOW	4	10,000			400
GREEN	5	100,000			500
BLUE	6	1,000,000			600
VIOLET	7	10,000,000			700
GRAY	8	100,000,000		0.01	800
* WHITE	9	1,000,000,000		0.1	900
GOLD		0.1	0.1		1,000
SILVER		0.01	0.01		2,000
NO COLOR					500

TL 13417 A

Capacitor color codes.

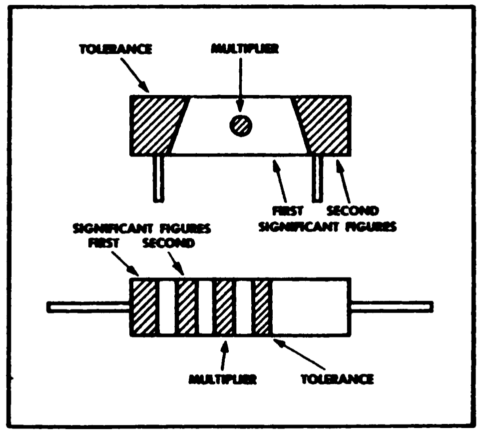
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS



Insulated fixed composition resistors with axial leads are designated by a natural tan background color. Non-insulated fixed composition resistors with axial leads are designated by a black background color.

JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS



Resistors with axial leads are insulated. Resistors with radial leads are uninsulated.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	
RED	2	100	
ORANGE	3	1,000	
YELLOW	4	10,000	
GREEN	5	100,000	
BLUE	6	1,000,000	
VIOLET	7	10,000,000*	
GRAY	8	100,000,000*	
WHITE	9	1,000,000,000*	
GOLD		0.1*	5
SILVER		0.01*	10
NO COLOR			20

*JAN ONLY

Example: A 50,000-ohm resistor with a standard tolerance of 20 percent (no color) would be indicated by a green ring (5), a black ring (0), and an orange ring (000)

RMA: Radio Manufacturers Association
JAN: Joint Army-Navy

TL 13418 A

Resistor color codes.

JOINT ARMY-NAVY TYPE DESIGNATION CODES FOR ELECTRICAL COMPONENTS

INTRODUCTION: Fixed and variable resistors and fixed capacitors manufactured under JAN specifications may be labeled with a *type designation code* instead of a color code or actual electrical value. For resistors and capacitors marked with the JAN type designation code, electrical values and other data can be determined by consulting the following information.

RESISTORS

FIXED, COMPOSITION

RC 10 AE 153 M

COMPONENT — STYLE — *CHARACTERISTIC — RESISTANCE — *TOLERANCE

COMPONENT: RC signifies *fixed, composition resistor.*

STYLE: A two-digit symbol indicates power rating and physical size.

Resistor style	Wattage
RC10, RC15, RC16	¼ WATT
RC20, RC21, RC25	½ WATT
RC30, RC31, RC35, RC38	1 WATT
RC40, RC41, RC45	2 WATTS
RC65	4 WATTS
RC75, RC76	5 WATTS

RESISTANCE: A three-digit symbol indicates the resistance value in ohms. The first two digits give the first two figures of the resistance value; the third digit gives the number of zeros which follow the first two figures.

RESISTORS

VARIABLE, WIRE-WOUND

RA 15 A 1 RH 103 A K

COMPONENT — STYLE — SWITCH — *TORQUE — *SHAFT — RESISTANCE — *TAPER — *TOLERANCE

COMPONENT: RA signifies *variable, wire-wound resistor.*

STYLE: A two-digit symbol indicates power rating and physical size and shape.

SWITCH: Symbol A indicates no switch. Symbol B indicates a switch turned ON at start of clockwise rotation.

RESISTANCE: A three-digit symbol indicates the resistance value in ohms. The first two digits give the first two figures of the resistance value; the final digit gives the number of zeros which follow the first two figures. The letter *R* may be substituted to represent a decimal point; but when *R* is used, the last digit of the group becomes significant.

RHEOSTATS

WIRE-WOUND, POWER-TYPE

RP 35 2 FD 252 KK

COMPONENT — STYLE — OFF POSITION — *SHAFT — RESISTANCE — *TOLERANCE

COMPONENT: RP signifies all *rheostats.*

STYLE: Same as for variable, wire-wound resistors.

OFF POSITION:

Numeral	OFF position
1	None.
2	At end of counterclockwise rotation.
3	At end of clockwise rotation.

RESISTANCE: Same as for variable, wire-wound resistors.

---

*Items starred are of interest primarily to depot and higher echelon repair personnel.

TL 18141

Joint Army-Navy type designation codes.

CAPACITORS

FIXED, MICA-DIELECTRIC

CM	20	B	511	K
COMPONENT	CASE	*CHARACTERISTIC	CAPACITANCE	*TOLERANCE

COMPONENT: CM signifies *fixed, mica-dielectric capacitor.*

CASE: A two-digit symbol identifies a physical case size and shape.

CAPACITANCE: A three-digit symbol indicates the capacitance value in micromicrofarads. The first two digits give the first two figures of the capacitance value; the final digit gives the number of zeros which follow the first two figures. When more than two significant figures are required, additional digits may be used, the last digit always indicating the number of zeros.

D-C WORKING VOLTAGE FOR CAPACITANCE RANGE

Case	Capacitance range	Vdcw
CM20	5-510 mmf	500
CM25	5-1,000 mmf	500
CM30	470-3,300 mmf	500
CM35	470-6,200 mmf	500
	6,800-10,000 mmf	500
CM40	3,300-8,200 mmf	500
	9,100-10,000 mmf	300

NOTE: Working voltages for capacitors above CM40 are stamped on the case.

The d-c working voltage of a capacitor can be determined from the above table when the case size and value of capacitance are known.

CAPACITORS

FIXED, MOLDED, PAPER-DIELECTRIC†

CN	36	A	302
COMPONENT	CASE	*CHARACTERISTIC	CAPACITANCE

COMPONENT: CN signifies *fixed, molded, paper-dielectric capacitor.*

CASE: Same as for fixed, mica-dielectric capacitors.

CAPACITANCE: A three-digit symbol indicates the capacitance value in micromicrofarads. The first two digits give the first two figures of the capacitance value; the third digit gives the number of zeros which follow the first two figures.

D-C WORKING VOLTAGE FOR CAPACITANCE RANGE

Case	Capacitance	Vdcw
CN35	3,000 mmf	800
	6,000 mmf	600
	10,000 mmf	400
CN36	3,000 mmf	400
	6,000 mmf	400
	10,000 mmf	300
CN40	3,000 mmf	400
	6,000 mmf	300
	10,000 mmf	300
CN41	3,000 mmf	600
	6,000 mmf	600
	10,000 mmf	400

The d-c working voltage of a capacitor can be determined from the above table when the case size and value of capacitance are known.

CAPACITORS

FIXED, CERAMIC-DIELECTRIC •

CC	20	AH	100	G
COMPONENT	CASE	*CHARACTERISTIC	CAPACITANCE	*TOLERANCE

COMPONENT: CC signifies *fixed, ceramic-dielectric capacitor.*

CASE: Same as for fixed, mica-dielectric capacitors.

CAPACITANCE: Same as for fixed, molded, paper-dielectric capacitors.

NOTE: All fixed, ceramic-dielectric capacitors have a working voltage of 500 volts, d-c.

---

*Items starred are of interest primarily to depot and higher echelon repair personnel.

†This is not a JAN specification. These capacitors are covered by AWS C75/221.

TL 18142

Joint Army-Navy type designation codes (contd).

SECTION XVII. MAINTENANCE PARTS

67. MAINTENANCE PARTS FOR VACUUM TUBE VOLTMETER (HICKOK MODEL 110-B).

The following information was compiled on 12 July 1945. The appropriate pamphlet of the ASF Signal Supply Catalog for Vacuum Tube Voltmeter (Hickok Model 110-B) is:

Fixed Plant Maintenance List

SIG 10-422.3 Vacuum Tube Voltmeter 110-B.

For the latest index of available catalog pamphlets, see ASF Signal Supply Catalog SIG. 2.

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
	3F13750.2	**METER, multimeter:** electronic; portable; 100-130 v 40-60 cps; 7 d-c ranges, 0-2.5-10-50-250-1,000-2,500-10,000-v; 4 a-c ranges, 0-1.5-3-50-150-v.	110B (H23)
	3F13750/B1	**ABSORBERS AND RIVETS:** consists of 1 bumper, black rubber; 1 rivet, hollow brass; 1 washer, brass, ⅛" ID, 5/16" OD, 0.021" thk.	0S-1463 (H23)
C2	3DA25-17	**CAPACITOR, paper:** 0.025 mf; 400 vdcw.	S (S5)
C3	3DB15-22	**CAPACITOR, electrolytic:** 15-mf, 25 vdcw.	M-015 (S5)
C4	3DA500-57.6	**CAPACITOR, paper:** 0.5-mf, 400 vdcw.	S-0263 (S5)
	2Z8674.1	**CONNECTOR, chassis type:** 4-cont; for a-c probe.	PC4F (A13)
	6ZK4920-12	**GROMMET, rubber:** ⅜".	22-2 (A13)

67. MAINTENANCE PARTS FOR VACUUM TUBE VOLTMETER (HICKOK MODEL 110-B) (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
	3G1837-72.1	**INSULATOR, feedthru:** lucite.	0S-1767 (H23)
	2Z5822-81	**KNOB, bar:** 2″ pointer, black bakelite.	S-293-1L (K6)
	2Z5822-80	**KNOB:** No. 10 binding post; round; bakelite; for 10-32 shaft.	S-76-3 (K6)
	2Z5925	**LAMP, pilot:** 6.3-v; 0.15-amp; miniature screw base.	S-40 (G3)
	3E7234-1	**LEAD:** spcl d-c.	12450-68 (H23)
	3E7174-10	**LEAD:** d-c ground connector.	110AC1 (H23)
	3F13750.1	**METER:** d-c; 0-200 μa; 0-2.5, 10-50, 100, 250, 2-500-10,000 v scale.	50-110B
	3E7174-5	**PROBE AND CABLE ASSEMBLY:** spcl a-c probe.	16970-2 (H23)
C1	3DA30-49	**CAPACITOR:** paper; 0.03-mf; 300 vdcw.	OS-2425 (H23)
	3F48250	**COVER:** probe.	3825-4 (H23)
	3F48980	**HOUSING:** a-c probe.	3140-44 (H23)
	3F13750/S1	**KNOB:** No. 6 binding post and stud; bottom for prod; brass.	2074-5 (H23)
	3E7174-4	**PROBE:** low term lead.	16970-2 (H23)
	3F3705-6	**PROBE, test:** high term extension.	16975-2 (H23)
R1	3RC20BE105M	**RESISTOR:** carbon; 1-meg; ½-w.	RC20BE 105M
	2Z8677.3	**SOCKET, tube:** miniature polystyrene.	54-7P (A13)

67. MAINTENANCE PARTS FOR VACUUM TUBE VOLTMETER (HICKOK MODEL 110-B) (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
	2Z7114.24	**SOCKET**: cable connector; 4-prong; moulded bakelite; brass shell.	MC4M (A13)
VT-5	2J9006	**TUBE**: type 9006.	JAN 9006
P1,2,3	2Z7280-63	**RESISTOR**: wire-wound; potentiometer; 3,000-ohm; 1-w; screwdriver slot shaft.	802 (W10)
P4	2Z7269.96	**RESISTOR**: potentiometer; carbon; 3,000-ohm.	33-010 229 (M1)
P5	3Z7010-7.1	**RESISTOR**: potentiometer; wire-wound; 10-ohm, screwdriver slot shaft.	C10R (M1)
R2	3Z6890	**RESISTOR**: carbon; 90-meg; 1-w.	65X (W46)
R3	3RC21BE475M	**RESISTOR**: carbon; 5-meg; ½-w.	BT ½ (I2)
R4	3RC31BE305J	**RESISTOR**: carbon; 3-meg; 1-w.	RC31BE 305J
R5,6	3Z6960-20.11	**RESISTOR ASSEMBLY**: carbon; 6-meg, ±2%; ½-w (consists of two BT-½ resistors matched in series to total of 6 megohms).	46 (I2)
R7,8	3Z6960-12	**RESISTOR ASSEMBLY**: carbon; 1.6-meg, ±2%; ½-w (consists of 2 BT-½ 0.8-megohm resistors matched in series to 1.6 megohms).	90 (I2)
R9,10	3Z6960-12.2	**RESISTOR ASSEMBLY**: carbon; 320,000-ohm, ±2%; ½-w (2 matched resistors in series to total 0.32 megohm).	91 (I2)
R11,12	3Z6960-12.3	**RESISTOR ASSEMBLY**: carbon; 60,000-ohm, ±2%; ½-w (2 matched resistors in series to total 60,000 ohms).	65 (I2)
R13,14	3Z6960-12.5	**RESISTOR**: carbon; 20,000-ohm, ±2%, ½-w (2 matched resistors in series to total 20,000 ohms).	10 (I2)
R15	3RC21BE334J	**RESISTOR**: carbon; 330,000-ohms; ½-w.	RC21BE 334J

67. MAINTENANCE PARTS FOR VACUUM TUBE VOLTMETER (HICKOK 110-B) (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
R16	3RC21BE274J	**RESISTOR**: carbon; 270,000-ohm; ½-w.	RC21BE 274J
R17,18	3RC21BE222J	**RESISTOR**: carbon; 2,200-ohm; ½-w.	RC21BE 222J
R19,20	3RC21BE182K	**RESISTOR**: carbon; 1,800-ohm; ½-w.	RC21BE 182K
R21	3RC21BE333K	**RESISTOR**: carbon; 33,000-ohm; ½-w.	RC21BE 333K
R22	3RC41BE222M	**RESISTOR**: carbon; 2,200-ohm; 2-w.	RC41BE 222M
R23	NSNR	**RESISTOR**: carbon; (value determined in production, varies from 0 to 5 megohms).	
R24	NSNR	**RESISTOR**: carbon; (value determined in production, varies from 15 to 25 megohms).	
R25	NSNR	**RESISTOR**: carbon; (value determined in production, varies from 0 to 2 megohms).	
	2Z8650.1	**SOCKET tube**: octal; moulded bakelite.	9919 (C6)
	2Z5882-6	**SOCKET**: jewel light assembly, red jewel; miniature screw base.	20S (D5)
S1	3Z9858-8.81	**SWITCH, toggle**: SPST.	20994-DA (A17)
S2	3Z9825-58.57	**SWITCH**: 4-pole; 4-position; 3-sect.	3BHX7503 (G15)
S3	3Z9825-58.56	**SWITCH**: 2-pole; 5-position; 2-sect.	3BHX7504 (G15)
T1	2Z9613.153	**TRANSFORMER, plate and fil**: pri 110/220 v 60 cps, secd No. 1, 300 v CT, secd No. 2, 6.3 v.	TR-2458 (T30)
VT1,2	2J6SN7	**TUBE**: type 6SN7.	JAN 6SN7

67. MAINTENANCE PARTS FOR VACUUM TUBE VOLTMETER (HICKOK MODEL 110-B) (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
VT3	2JVR150-30	**TUBE**: type VR-150-30.	JAN VR-150-30
VT4	2J6X5GT/G	**TUBE**: type 6X5GT.	JAN 6X5 GT

68. LIST OF MANUFACTURERS.

Code	*Name*
A13	American Phenolic Corp.
A17	Arrow, Hart & Hegeman Electric Co.
C6	Cinch Mfg. Corp.
D5	Drake Mfg. Co.
G3	General Electric Co.
G15	Globe Union, Inc.
H23	Hickok Electrical Instrument Co.
I2	International Resistance Co.
K6	Kurz-Kasch, Inc.
M1	Mallory, P. R., & Co.
S5	Solar Mfg. Corp.
T30	Transformer Engineering Corp.
W10	Wirt Electric Co.
W46	S. S. White Dental Laboratories.