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Superseded File

INSTRUCTION BOOK
FOR
ELECTRONIC MULTIMETER
TS-505A/U

Cover, pg. 1

Photostron Company

PREPARED FOR

THE SIGNAL CORPS ON

ORDERS NO. 35750-PHILA-53 AND 21210-PHILA-54

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29 April 1955
A.d

FORWARD COMMENTS ON THIS PUBLICATION DIRECTLY TO:

Commanding Officer

The Signal Corps Publications Agency

Fort Monmouth, New Jersey

ATTN: Standards Division

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 250-volt plate and power supply circuits, or on the 115-volt ac line connections.

DON'T TAKE CHANCES!

INSTRUCTION BOOK
FOR
ELECTRONIC MULTIMETER
TS-505A/U

PREPARED FOR

THE SIGNAL CORPS ON

ORDERS NO. 35750-PHILA-53 AND 21210-PHILA-54

INSTRUCTION BOOK

SIGNAL CORPS
ORDERS NO.
35750-PHILA-53
21210-PHILA-54

29 APRIL 1955

ELECTRONIC MULTIMETER TS-505A/U

CHAPTER 7. SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Figure 1. Electronic Multimeter TS-505A/U.

Note. This instruction book will be replaced by TM 11-5511A which, when published, will be listed in Department of the Army Pamphlet 310-4.

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

This manual contains instructions for the installation, operation, maintenance, and repair of Electronic Multimeter TS-505A/U. These instructions apply only to Electronic Multimeter TS-505A/U.

Note. Throughout this manual the word *multimeter* refers to the major component (par. 6) of the TS-505A/U.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army materiel and equipment and when performing preventive maintenance:

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army), Navy Shipping Guide, Article 1850-4 (Navy), and AFR 71-4 (Air Force).

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700-45-5.

c. DD Form 535, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700-45-5 and AF TO-00-35D-54.

d. DA Form 11-238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 6).

e. DA Form 11-239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 7).

f. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

a. Purpose. Electronic Multimeter TS-505A/U measures alternating-current (ac) and direct-current (dc) voltages and dc resistances in electrical and electronic equipments.

b. Use. The multimeter measures dc voltages from .05 volt to 1,000 volts and ac voltages from .05 volt to 250 volts root mean square (rms) at frequencies from 30 cycles per second (cps) to 5 megacycles (mc). With the radio-frequency (rf) adapter, used with the dc voltage measurement circuit, rf voltages may be measured from .05 volt to 40 volts rms at frequencies from 1 mc to 500 mc. Dc resistances from 1 ohm to 1,000 megohms may be measured.

4. Technical Characteristics

Dc voltage ranges	0 to 2.5 volts, 0 to 5 volts, 0 to 10 volts, 0 to 25 volts, 0 to 50 volts, 0 to 100 volts, 0 to 250 volts, 0 to 500 volts, 0 to 1,000 volts.
Dc zero center ranges	−1.25 to +1.25 volts, −2.5 to +2.5 volts, −5 to +5 volts, −12.5 to +12.5 volts, −25 to +25 volts, −50 to +50 volts, −125 to +125 volts, −250 to +250 volts, −500 to +500 volts.
Ac voltage ranges	0 to 2.5 volts, 0 to 5 volts, 0 to 10 volts, 0 to 25 volts, 0 to 50 volts, 0 to 100 volts, 0 to 250 volts.
Rf voltage range	0 to 40 volts.
Resistance ranges	0 to 1,000 ohms with 30 ohms at center scale; 0 to 10,000 ohms with 300 ohms at center scale; 0 to 100,000 ohms with 3,000 ohms at center scale; 0 to 1 megohm with 30,000 ohms at center scale; 0 to 10 megohm with 300,000 ohms at center scale; 0 to 100 megohms with 3 megohms at center scale; 0 to 1,000 megohms with 30 megohms at center scale.
Frequency range	30 cps to 5 mc, ac; 1 mc to 500 mc, rf.
Input impedance	At least 6 megohms shunted by 2 uuf at audio frequencies; 40 megohms on 1,000 volts dc range, and ±500 volts dc

	range (zero center scale); 20 megohms on all other dc ranges.
Accuracy	±5 per cent of full scale on dc voltage; ±6 per cent of full scale for ac sinusoidal input from 30 cps to 5 mc on A.C. range; ±6 per cent of full scale for rf sinusoidal input from 1 mc to 200 mc using rf adapter (error may exceed ±6 per cent of full scale for rf sinusoidal input from 200 mc to 500 mc using rf adapter); ±4 per cent of ohmmeter arc length on ohms scale.

Note. The meter scales are calibrated to indicate .707 of the peak voltage of a sine wave or a complex wave. In the case of a sine wave, the meter indication is the rms value of the sine wave. In the case of a complex wave, the meter indication is not the rms value of the complex wave.

Indicating meter	1 ma dc for full-scale deflection. Infinite damping factor.
Number of tubes	7.
Power requirements	98 to 132 volts, single-phase, 50 to 1,000 cps, approximately 21 volt-amperes.

5. Packaging Data

Electronic Multimeter TS-505A/U is packaged for either export or domestic shipment (fig. 4). For export shipment, the TS-505A/U is placed in an inner corrugated carton. The inner carton is protected by corrugated fillers and is placed, together with the spare parts box and two manuals, in an outer corrugated carton, thus comprising a unit package. Six unit packages are placed in a nailed and strapped wooden packing case. For domestic shipment, four unit packages are placed in a corrugated shipping carton. The dimensions and weights of the packages are listed in the table below.

TS-505A/U	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)
Unit package	15½	13½	10½	1.27	18
Packed for domestic shipment	16	27½	21	5.35	80
Packed for export shipment	16½	43	22	9.04	150

6. Table of Components

(fig. 2)

The following table lists the components of Electronic Multimeter TS-505A/U and gives their dimensions.

Component	Required No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Weight (lb)
Major component:						
Multimeter (fig. 3)	1	9¾	9	6⅛	.31	14
Minor components:						
Alligator clip	2	2	7/16	5/16		
Miniature probe tip (.040 in. dia tip)	3	⅞	¼			
Rf adapter (Test Prod MX-1797/U)	1	3⅜	⅝			
Spare parts (par. 8)	1 set					

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

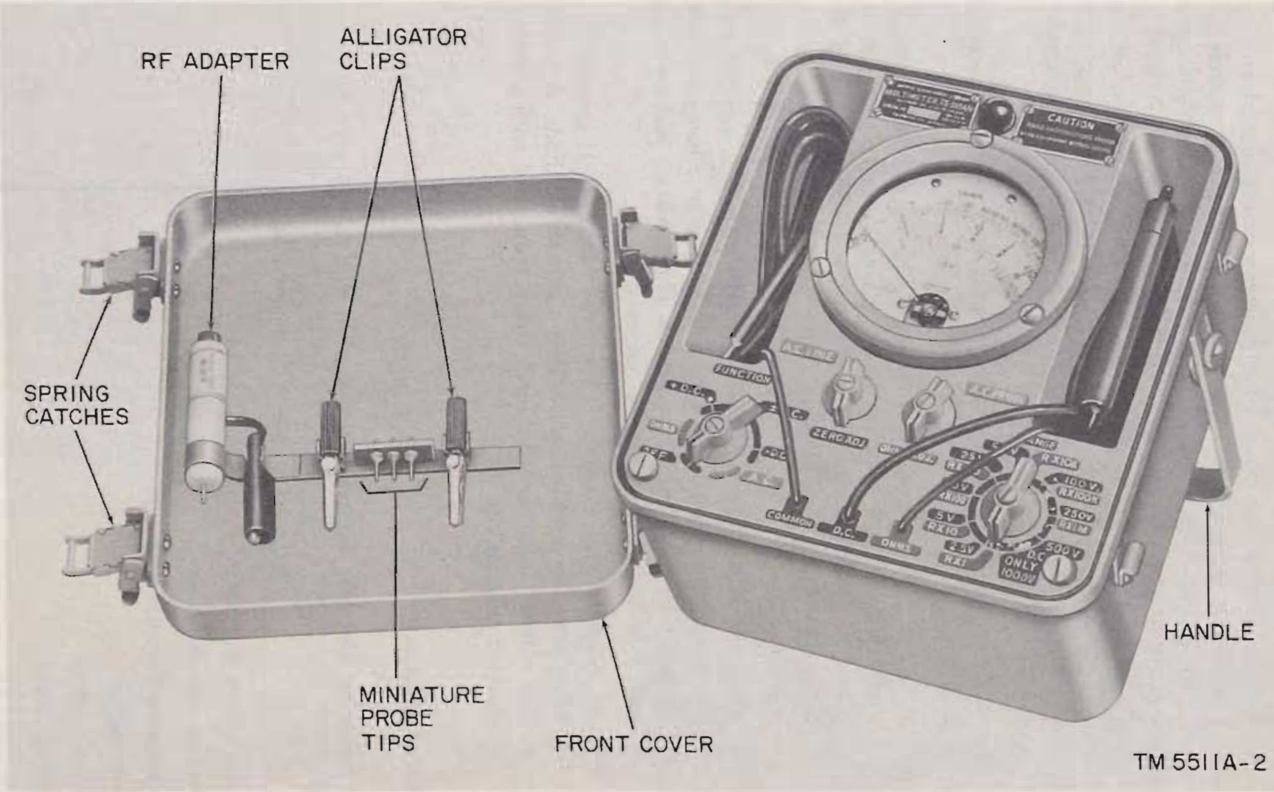


Figure 2. Electronic Multimeter TS-505A/U, cover removed.

7. Description of Components

a. Multimeter. The multimeter (fig. 3) consists of a panel chassis assembly contained in its case. A carrying handle attached to the case may be used as a stand when the multimeter is in use. A circuit label is mounted in the bottom of the case. A detachable cover (fig. 2), which protects the operating controls and the meter when the equipment is not in use, contains two jack-type alligator clips, three miniature probe tips, and the rf adapter (Test Prod MX-1797/U). All controls, the meter, and the pilot light indicator jewel are mounted on the front panel. The four test leads and the A.C. LINE cord extend through holes in the front panel and are stored in two recessed compartments. The multimeter is completely watertight.

b. Minor Components. The following minor components are supplied with the multimeter.

(1) *Alligator Clips.* The alligator clips (fig. 2) are each terminated in a pin jack designed to accommodate the multimeter probe tips. A plastic sleeve that surrounds the pin jack serves as an insulator. To aid in identifying the leads, one plastic sleeve is colored red and the other black.

(2) *Miniature Probe Tips.* The three miniature probe tips supplied with the multimeter are threaded at one end and are interchangeable with the probe tips attached to the probes. The miniature probe tips are used in miniaturized circuits or congested chassis.

(3) *Rf Adapter.* The rf adapter (Test Prod MX-1797/U consists of a teflon nose and carriage that contains a germanium diode. A ground lead extends from the teflon nose and is terminated with a rubber-shielded alligator clip.

8. Running Spares

The following table lists the spare parts supplied with the TS-505A/U.

Item	In rear of multimeter case	In spare parts carton
Fuse, 1-ampere, type 3AG	2	3
Lamp, 6.3-volt, .15-ampere		2
Diode, germanium, type 1N70	2	
Tube, type 5651		1
Tube, type 6AL5		1
Tube, type 6AU6		1
Tube, type 6X4		1
Tube, type 12AT7		1

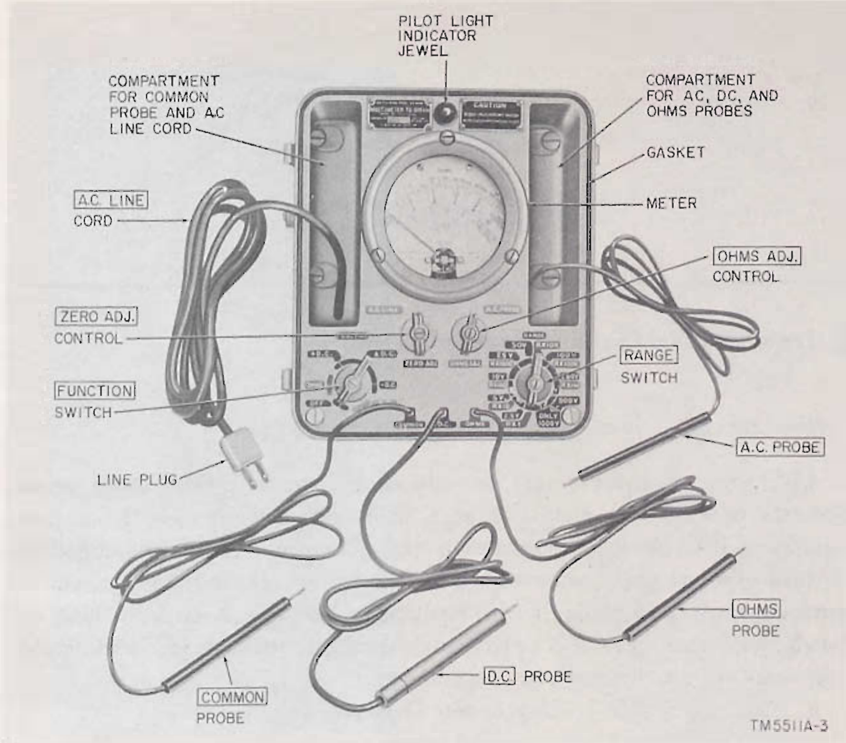


Figure 3. Multimeter, less cover, front view.

CHAPTER 2

INSTALLATION

9. Unpacking and Checking New Equipment (fig. 4)

Note. For used or reconditioned equipment, refer to paragraph 11.

a. General. Equipment may be shipped in oversea packing cases or in domestic packing cases and, sometimes, in its own carrying case. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent installation of the equipment. Use care when unpacking or handling the equipment. It is a precision measuring instrument, and mishandling will make the set inaccurate or inoperative.

b. Uncrating and Unpacking Export Shipments (fig. 4).

(1) Cut and fold back the metal straps.

(2) Using a nail puller, remove the nails from the wooden cover of the packing crate. Do not attempt to pry off the wooden cover; the equipment may become damaged.

(3) Lift off the wooden cover and remove the six unit packages from the wooden packing case.

(4) Open the outer corrugated carton and remove the two manuals and the corrugated fillers. Lift out the inner corrugated carton.

(5) Remove the lower corrugated fillers from the outer carton and remove the spare parts carton.

(6) Open the spare parts carton and remove the five paper envelopes. Open the envelopes and remove their contents. Remove the cellulose wadding surrounding the tube boxes; be careful not to drop the tubes. Remove the tubes from their boxes.

(7) Remove the TS-505A/U from its inner carton and place it on a workbench or near its final location.

(8) Inspect the multimeter and the spare parts for possible damage incurred during shipment.

(9) Check the contents of each unit package against the master packing slip.

(10) Repack the spare parts in their respective boxes or envelopes; rewrap the tube boxes in the cellulose wadding and repack in the spare parts box. Store the spare parts in a convenient location for future use.

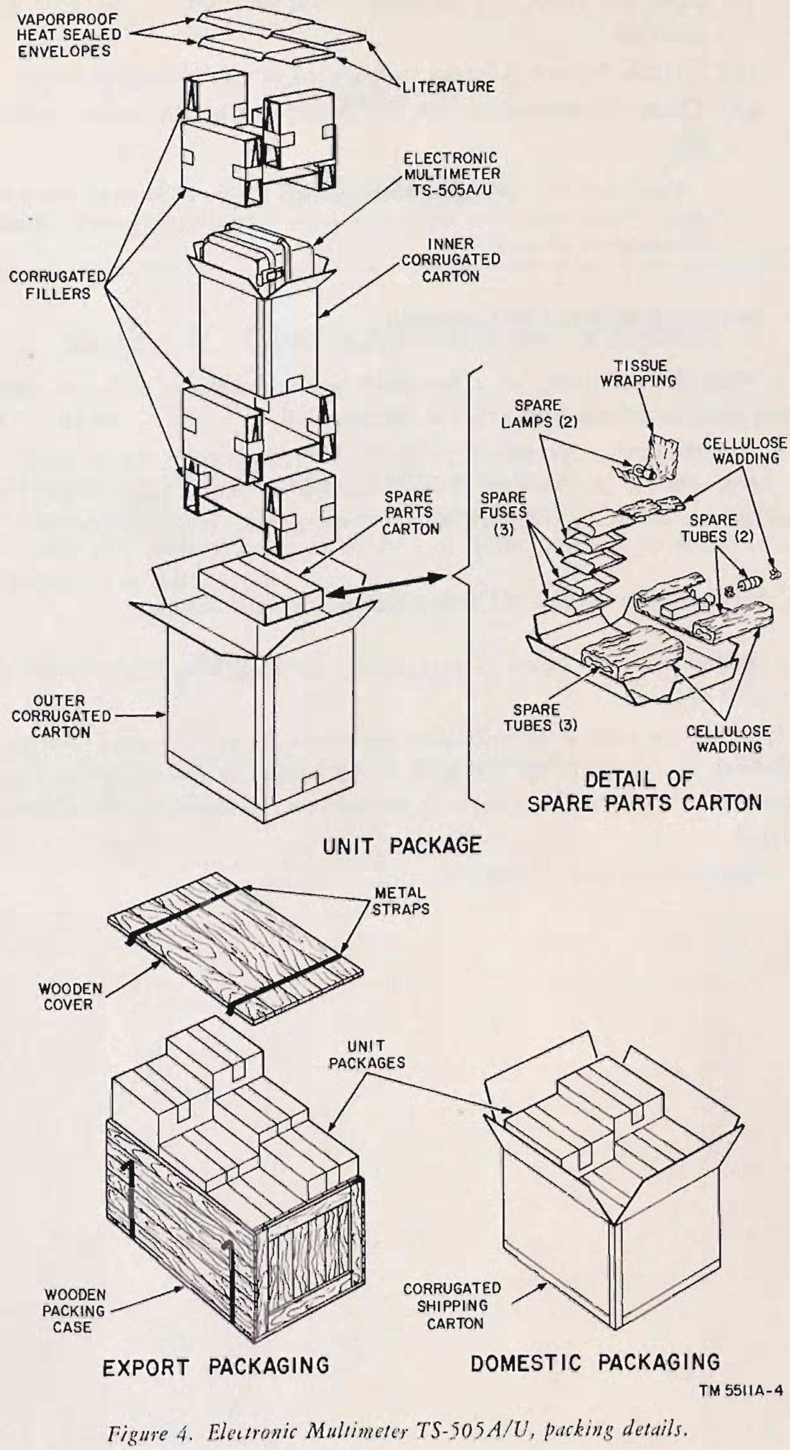


Figure 4. Electronic Multimeter TS-505A/U, packing details.

c. Unpacking Domestic Packing Cases (fig. 4).

(1) Open the corrugated shipping carton and remove the four unit packages.

(2) Unpack the unit packages as instructed in subparagraph *b* above.

(3) Check the contents of each unit package against the master packing slip.

Note. Save the original packing cases and containers for both export and domestic shipments. They can be used again when the equipment is repacked for storage or shipment.

10. Locating Equipment for Operation

a. Place the multimeter on a flat bench or firm base close to an ac outlet. There must be no strain or kinks in the line cord.

b. The multimeter operates on 98- to 132-volt, single-phase, 50- to 1,000-cps ac power. *Do not plug into any other power source.* Do not plug the line cord into the line before performing the operations specified in paragraph 14.

11. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 9 for unpacking and checking the TS-505A/U.

b. Check the used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment. If any changes in wiring have been made, note the changes in this manual, preferably on the schematic diagram.

c. Check the operating controls for ease of rotation.

CHAPTER 3

OPERATION

Section I. CONTROLS AND INSTRUMENTS

12. General

Haphazard operation or improper setting of the controls can cause damage to electronic equipment. For this reason, it is important to know the function of the meter and controls on the multimeter. Operating instructions are contained in section II of this chapter.

13. Controls and Their Uses
(fig. 5)

The following chart lists the controls and instruments of the multimeter and indicates their function:

13. Controls and Their Uses (cont)

Control or instrument	Function
FUNCTION switch (S1)	Selects the type of multimeter operation desired and turns the multimeter on or off.
RANGE switch (S2)	Selects various voltage or resistance measurement ranges.
ZERO ADJ. control (R15)	Controls pointer of indicating meter. Used to set the meter pointer at zero on the +D.C., −D.C. A.C., or OHMS scale, or to midscale on the ±D.C. scale.
OHMS ADJ. control (R8)	Controls pointer of indicating meter. Used to set the meter pointer at ∞ on the OHMS scale when the FUNCTION switch is set on OHMS position.
Meter (M1)	Indicates the value of voltage or resistance being measured.
A.C. LINE cord	Connects multimeter to ac power source.
COMMON probe	Connects the ground, or common circuit, of the multimeter to the equipment under test.
D. C. probe	Connects equipment under test to the dc measuring circuits of the multimeter.
OHMS probe	Connects equipment under test to the ohmmeter circuit of the multimeter.
A. C. PROBE	Connects equipment under test to the ac measuring circuits of the multimeter.
Pilot light indicator	Lights when power is applied to the multimeter.

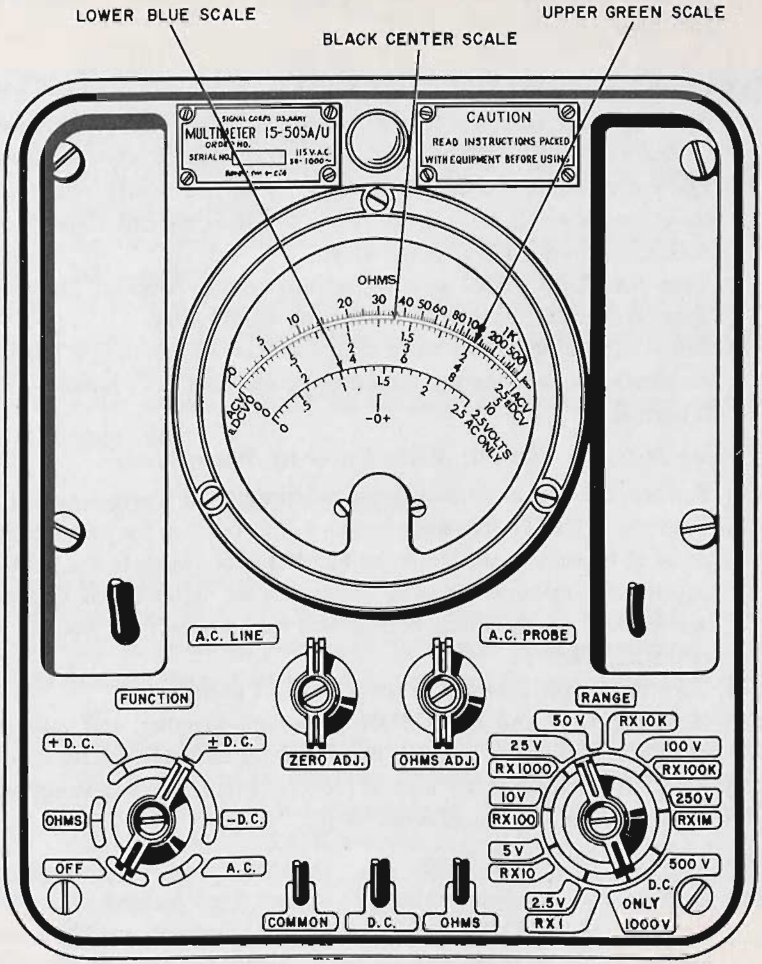


Figure 5. Multimeter, front panel.

Section II. OPERATION UNDER USUAL CONDITIONS

14. Starting Procedure

a. Preliminary. Before using Electronic Multimeter TS-505A/U, carefully read the operating instructions. *Obey all cautions.* The instructions detailed below include the adjustments necessary to permit the multimeter to function efficiently. Large errors in voltage and resistance measurements will be encountered unless the multimeter is properly adjusted.

b. Starting.

(1) Remove the front cover of the multimeter by manually opening the four spring catches (fig. 2).

(2) Turn the FUNCTION switch to the OFF position (fig. 5).

(3) Check the voltage and the frequency of the ac power source to which the A.C. LINE cord will be connected. The voltage must be between 98 and 132 volts, single-phase; the frequency must be between 50 and 1,000 cps. If the voltage and frequency of the power source are correct, remove all leads from both compartments and connect the A.C. LINE cord to the ac power source.

(4) Turn the FUNCTION switch clockwise to any position. The pilot light on the front panel above the meter should glow.

(5) Allow the multimeter to warm up for at least 10 minutes. While the multimeter is warming up, the meter pointer may drift rapidly. This is normal.

c. Zeroing Meter for Plus Dc, Minus Dc, or Rf Measurements.

(1) Perform the operations outlined in subparagraph *b* above.

(2) Turn the FUNCTION switch to the +D.C. position for making plus dc or rf measurements. Turn the FUNCTION switch to the −D.C. position for making minus dc measurements. After the multimeter has warmed up, the meter pointer will probably be near, but not at, zero scale reading.

(3) Turn the RANGE switch to the 2.5V-RX1 position.

(4) Hold the D.C. and COMMON probe tips together, and turn the ZERO ADJ. control until the meter pointer indicates exactly 0 volt.

(5) Refer to paragraphs 15 and 17 for directions for measuring and reading dc and rf voltages respectively.

d. Zeroing Meter for ±D.C. Range.

(1) Perform the operations outlined in subparagraph *b* above.

(2) Turn the FUNCTION switch to the ±D.C. position. The meter pointer should be at midscale within plus or minus one scale division.

(3) Turn RANGE switch to the 2.5V-RX1 position.

(4) Hold the D.C. and COMMON probe tips together and turn the ZERO ADJ. control until the meter pointer is at exact midscale.

(5) Refer to paragraph 15(a)7 and (b)2 for directions for using this range.

e. Zeroing Meter for Ac Measurements.

(1) Perform the operations outlined in subparagraph *b* above.

(2) Turn the FUNCTION switch to the A.C. position and hold the A.C. PROBE and COMMON probe tips together. The meter pointer should read to within one scale division of zero.

(3) Set the meter pointer by rotating the ZERO ADJ. control.

(4) Refer to paragraph 16 for directions for measuring and reading ac voltages.

f. Zeroing Meter for Resistance Measurements.

(1) Perform the operations outlined in subparagraph *b* above.

(2) Turn the FUNCTION switch to the OHMS position. The meter pointer should deflect to, or near, full-scale reading (∞).

(3) Turn the OHMS ADJ. control to set the meter pointer at full scale reading (∞).

(4) Hold the OHMS and COMMON probe tips together and turn the RANGE switch to the 2.5V-RX1 position. The meter pointer should indicate approximately zero.

(5) Set the meter pointer to exact zero reading by turning the ZERO ADJ. control.

(6) Recheck the ∞ setting by separating the OHMS and COMMON probes. Readjust the meter pointer, if necessary, by turning the OHMS ADJ. control.

(7) Refer to paragraph 18 for directions for measuring and reading dc resistances.

15. Measuring and Reading Dc Voltages
(fig. 5)

a. Measuring Dc Voltages.

(1) Turn the FUNCTION switch to the +D.C. or −D.C. position, depending on the polarity of the dc voltage to be measured.

(2) Recheck the zero setting of the meter pointer as specified in paragraph 14*c*.

(3) Turn the RANGE switch to an appropriate position such that the voltage indicated on the panel marking exceeds the value of voltage to be measured. If the magnitude of the voltage to be measured is unknown, turn the RANGE switch to the 1000V-DC ONLY position.

(4) Connect the COMMON probe tip to the nearest ground-potential point of the voltage to be measured. Connect the D.C. probe tip to the other point. The alligator clips, stored in the multimeter cover, may be slipped over the probe tips and used to connect the probes to the test points.

(5) If the meter pointer deflects below zero, turn the FUNCTION switch to the −D.C. position if it was previously in the +D.C. position, or to the +D.C. position if it was previously in the −D.C. position.

(6) Turn the RANGE switch counterclockwise, one position at a time, until the on-scale deflection of the meter is within the upper one-third portion of the meter scale. This is the most accurate portion of the scale.

(7) Turn the FUNCTION switch to the ±D.C. position to determine the polarity of an unknown voltage, or to determine a zero voltage output during alignment of certain electronic equipment. Before using the multimeter for this purpose, recheck the zero setting of the meter pointer as specified in paragraph 14*d*.

Caution: The maximum dc voltage which may be applied to the multimeter when the FUNCTION switch is set at ±D.C. position is one-half of the voltage indicated by the panel marking opposite the RANGE switch setting.

b. Reading Dc Voltages.

(1) Read positive or negative dc voltages on the black center scale of the meter (fig. 5). The most accurate readings are obtained when the meter pointer is within the upper one-third portion of the meter scale.

(2) When the FUNCTION switch is turned to the ±D.C. position, the meter pointer reads zero at the center of the scale. Deflection of the meter pointer to the right of zero center indicates positive voltage; deflection of the meter pointer to the left of zero center indicates negative voltage. *Voltage measurements cannot be read directly on the meter scale when the FUNCTION switch is set at the ±D.C. position.* The purpose of the ±D.C. position (zero center scale) is to determine the polarity of an unknown dc voltage or to indicate a zero dc voltage input to the multimeter.

16. Measuring and Reading Ac Voltages

Note. The procedures specified in this paragraph apply to measurements of ac voltages at frequencies from 30 cps to 5 mc. For procedures covering measurement of higher frequency voltages, refer to paragraph 17.

a. Measuring Ac Voltages.

(1) Turn the FUNCTION switch (fig. 5) to the A.C. position.

(2) Check the zero setting of the meter pointer as specified in paragraph 14*e*.

(3) Turn the RANGE switch to an appropriate position such that the voltage indicated on the panel marking exceeds the value of voltage to be measured. If the magnitude of the ac voltage to be measured is unknown, turn the RANGE switch to the 250V-RX1M position.

Caution: The maximum ac voltage which can be measured by the multimeter is 250 volts rms. The 500V-DC ONLY and 1000V-DC ONLY RANGE switch panel markings apply to dc voltage measurements only.

(4) Connect the COMMON probe tip to the low potential point of the voltage to be measured. Connect the A.C. PROBE tip to the opposite point of the voltage to be measured. The alligator clips, stored in the multimeter cover, may be slipped over the probe tips and used to connect the probes to the test points.

(5) Turn the RANGE switch counterclockwise, one position at a time, until the largest on-scale deflection of the meter pointer is obtained.

b. Reading Ac Voltages. Read all ac voltages except those in the 0- to 2.5-volt range on the black center scale of the meter (fig. 5). When the RANGE switch is in the 2.5V-RX1 position, the voltages are read on the lower blue scale of the meter. The most accurate readings are obtained when the meter pointer is within the upper one-third portion of the meter scale.

Note. The meter scales are calibrated to indicate .707 of the peak voltage of an ac wave or a complex wave. In the case of a sine wave, the meter indication is the rms value of the sine wave. In the case of a complex wave, the meter indication is not the rms value of the complex wave.

17. Measuring and Reading Rf Voltages

Note. The procedures specified in this paragraph apply to measurement of rf voltages of frequencies between 1 mc and 500 mc.

a. Measuring Rf Voltages.

(1) Turn the FUNCTION switch (fig. 5) to the +D.C. position.

(2) Check the zero setting of the meter pointer as specified in paragraph 14*c*.

(3) Turn the RANGE switch to an appropriate position such that the voltage indicated on the panel marking exceeds the value of voltage to be measured. If the value of rf voltage to be measured is unknown, turn the RANGE switch to the 50V-RX10K position.

Caution: Do not attempt to measure rf voltages greater than 40 volts rms. The rf adapter will be damaged if greater voltages are applied.

(4) Remove the rf adapter from the clips inside the multimeter cover (fig. 2). Connect the D.C. probe tip to the end of the rf adapter.

(5) Connect the alligator clip lead of the rf adapter to the low potential point of the voltage to be measured. Do not add extra length to the alligator clip lead; extra length will tend to cause rf loop effects.

(6) Connect the rf adapter tip to the high potential side of the rf voltage to be measured.

(7) Turn the RANGE switch counterclockwise, one position at a time, until the largest on-scale deflection of the meter pointer is obtained.

b. Reading Rf Voltages. Read rf voltages on the black center scale of the meter (fig. 5). The most accurate readings are obtained when the meter pointer is within the upper one-third portion of the meter scale.

Note. The meter scales are calibrated to indicate .707 of the peak voltage of an ac wave or a complex wave. In the case of a sine wave, the meter indication is the rms value of the since wave. In the case of a complex wave, the meter indication is not the rms value of the complex wave.

18. Measuring and Reading Dc Resistance

Caution: Be certain that the equipment being tested is turned off or disconnected from the power source before attempting to measure resistances. Any external voltages which are applied to the ohms circuit of the multimeter will cause damage to the multimeter.

a. Measuring Dc Resistances.

(1) Turn the FUNCTION switch (fig. 5) to the OHMS position.

(2) Turn the RANGE switch to the 2.5V-RX1 position.

(3) Adjust the meter pointer for maximum scale reading and for zero scale reading as specified in paragraph 14*f*.

(4) Connect the COMMON probe to the end (nearest the ground point) of the unknown resistor, and connect the OHMS probe to the other end of the resistor. For example, in measuring the resistance of the plate load resistor of an amplifier tube, connect the COMMON probe to the end nearest B+, and connect the OHMS probe to the end nearest the plate of the tube.

(5) Turn the RANGE switch clockwise, one position at a time, until the meter pointer is closest to center scale.

b. Reading Dc Resistances. Read resistance on the uppermost green scale of the meter (fig. 5). The most accurate resistance readings are obtained when the meter pointer is in the center portion of the meter scale. The resistance reading is determined by multiplying the meter reading by the panel marking opposite the RANGE switch setting. For example, if the meter reading is 30 and the RANGE switch is at the 50V-RX10K position, the resistance being measured is 30 times 10,000, or 300,000 ohms.

19. Stopping Procedure

a. Turn the RANGE switch (fig. 5) to the 1000V-D.C. ONLY position.

b. Turn the FUNCTION switch to the OFF position.

c. Remove the A.C. LINE plug from the power source.

d. If no immediate use for the multimeter is contemplated, replace the rf adapter and the alligator clips in the multimeter cover. Stow the A.C., OHMS, and D.C. probes and leads in the right-hand recessed compartment; stow the A.C. LINE cord and the COMMON probe and lead in the left-hand recessed compartment. Replace the front cover of the multimeter and close the spring catches (fig. 2).

Section III. OPERATION UNDER UNUSUAL CONDITIONS

20. General

Electronic Multimeter TS-505A/U operates under severe climatic conditions, such as extreme heat, cold, humidity, or sand conditions without appreciable change in performance. Paragraph 21 describes the general precautions to be observed under any unusual climatic conditions.

21. General Precautions

Instructions and precautions for operation under arctic, tropical, or desert conditions follow:

a. Operation in Arctic Climates. Handle the multimeter carefully in extremely cold climates. Inspect the rubber gaskets on the front panel, behind the meter and surrounding the front controls, for air leaks and brittleness. Check for cold air leaking through the rubber gaskets as it cools the amplifier tubes or it may crack the envelopes of the tubes. When the multimeter is not in use, replace the multimeter cover and fasten the spring catches securely (fig. 2).

b. Operation in Tropical Climates. The multimeter operates without trouble in the tropics. Periodic inspection of the rubber gaskets on the front panel behind the meter and surrounding the front panel controls is necessary. Check the rubber gaskets for air leaks. These leaks will allow moisture condensation which is harmful to the operation of the meter. When the multimeter is not in use, replace the multimeter cover and fasten the spring catches (fig. 2) securely.

c. Operation in Desert Climates. Conditions similar to those in the tropics prevail in the desert. Use the same measures to insure proper operation of the multimeter. Sand, dust, and dirt leak through worn rubber gaskets and foul the meter movement. Check the rubber gaskets and keep the multimeter cover fastened on with the spring catches when the multimeter is not in use.

CHAPTER 4

ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

22. General

a. Usually, a number of tools, materials, or tool equipment kits are either furnished with the equipment or supplied to the organization for use with the equipment.

b. The actual allowable organizational maintenance that can be performed on Electronic Multimeter TS-505A/U is dependent to a large extent on the existing military regulations (Standard Operating Procedure), the existing tactical situation, and on the tools and other test equipment issued.

23. Tools and Materials

Tools, materials, and test equipment used but not supplied with Electronic Multimeter TS-505A/U are listed below. These tools, materials, and test equipments are necessary to perform preventive maintenance and for use in organizational trouble shooting.

Tool Equipment TE-41
Tube Puller TL 201
ELECTRON Tube Test Set TV-7/U
Orange stick
Bleached, lint-free, cheesecloth
Sandpaper #0000
Dry Cleaning Solvent (SD)
Carbon tetrachloride

Section II. PREVENTIVE MAINTENANCE SERVICES

24. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working condition so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair since its object is to prevent certain troubles from occurring.

25. General Preventive Maintenance Techniques

a. Use #0000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If further cleaning is necessary, moisten the cloth or brush with dry cleaning solvent (SD); after cleaning, wipe the parts dry with a cloth. Do not use solvent (SD) on electrical contacts.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a clean cloth.

Caution: Repeated contact of carbon tetrachloride with skin or prolonged breathing of the fumes is dangerous. Make certain adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places; be careful, however, or mechanical damage may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 178, Preventive Maintenance Guide for Radio Communication Equipment.

26. Use of Preventive Maintenance Forms
(fig. 6 and 7)

a. The decision as to which items on DA Forms 11-238 and 11-239 are applicable to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communication officer/chief or his designated representative, and, in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of the form.

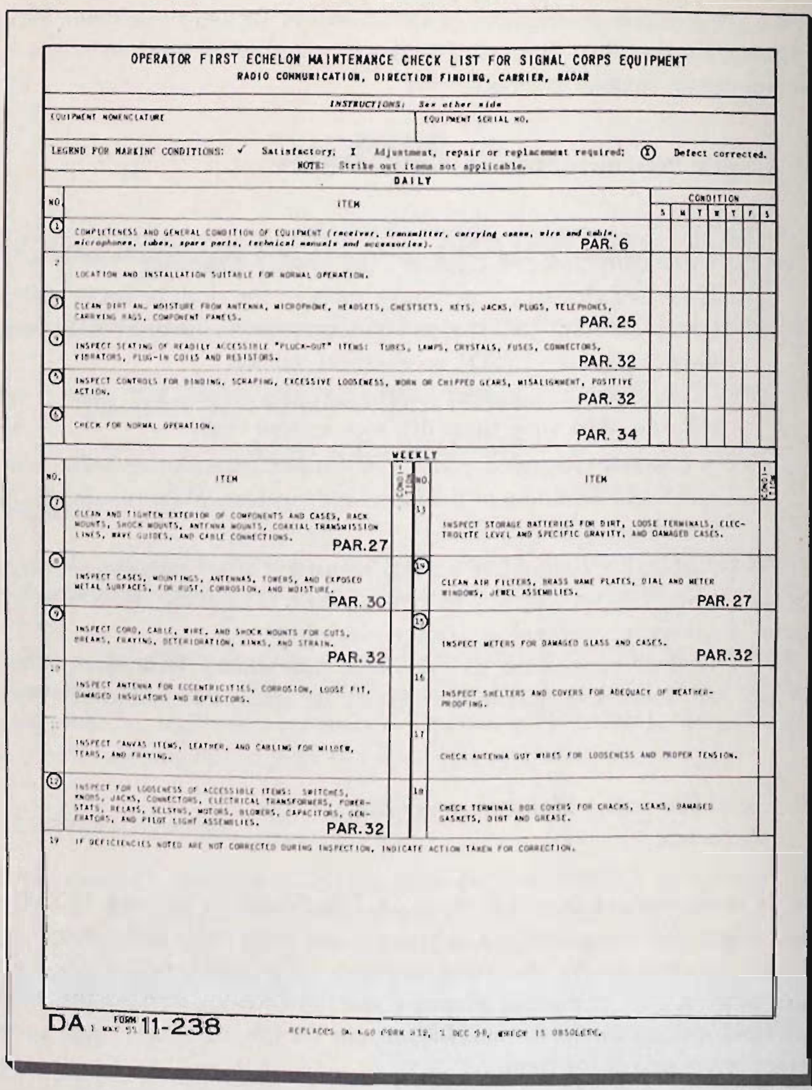
b. Circled items in figures 6 and 7 are partially or totally applicable to Electronic Multimeter TS-505A/U. References in the ITEM column refer to paragraphs in the text that contain detailed or additional maintenance information.

27. Preventive Maintenance, Exterior Items

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Check for completeness and general condition of the multimeter. The components of the multimeter are listed in paragraph 6.

b. Clean dirt and moisture from the case, front panel, A.C. LINE cord and line plug, test probes and leads, rf adapter, and alligator clips.



OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	S	M	T	W	T	F	S
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR. 6							
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.							
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 25							
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 32							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 32							
6	CHECK FOR NORMAL OPERATION. PAR. 34							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 27		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 30		14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 27	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 32		15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 32	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 32		18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 55 11-238 REPLACES DA AGO FORM 412, 1 DEC 50, WHICH IS OBSOLETE.

TM 5511A-6

Figure 6. DA Form 11-238.

c. Inspect the controls for binding, scraping, excessive looseness, and positive action.

d. Check the multimeter for normal operation (par. 34).

e. Clean the gasket around the front panel (fig. 3); tighten the panel mounting bolts and handle screws. Clean and tighten the test probe tips.

f. Inspect the exposed metal surfaces of the multimeter case and front panel for corrosion.

g. Inspect the A.C. LINE cord and test lead cords for breaks, deterioration, and loose connections.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO	ITEM	CONDI-TION	NO.	ITEM	CONDI-TION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 6		19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES. PAR. 28 & 47	
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.		20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 25		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR. 28	
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 32		22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 32		23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.	
6	CHECK FOR NORMAL OPERATION. PAR. 34		24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR. 28	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 27		25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS. PAR. 28	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 30		26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR. 25	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 32		27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR. 28	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		28	CHECK SETTINGS OF ADJUSTABLE RELAYS.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 32		30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR. 28	
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 27		32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR. 28	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 32		33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.		34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.		35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.		36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS. PAR. 27	
			37	MOISTURE AND FUNGIPROOF. PAR. 29	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 53 11-239 REPLACES DA AGO FORM 11-239, 1 DEC 52, WHICH IS OBSOLETE.

TM 55.1A-7

Figure 7. DA Form 11-239.

h. Inspect for looseness of accessible items, such as switch and control knobs, meter flange, test probes and rf adapter.

i. Clean meter glass, name plates, and pilot light indicator jewel.

j. Inspect meter M1 for damaged glass or deteriorated meter gasket (fig. 16).

28. Preventive Maintenance, Interior Items

Caution: Disconnect all power from the multimeter before performing the following operations. Upon completion, reconnect the power and check for satisfactory operation of the multimeter.

a. Inspect tubes for loose pins, improper seating, and insufficient spring tension on tube shields. Test the tubes for normal emission.

Note. Label tubes V1 and V2 to insure replacement in the same socket.

b. Inspect capacitors C8 and C9 (fig. 18) for discoloration or bulging. Inspect other capacitors for broken case or leads.

c. Inspect potentiometer R18 (fig. 17) for dirt or loose contact arm.

Note. Do not disturb the setting of this potentiometer. To do so, will result in loss of calibration of the multimeter.

d. Inspect resistors for cracks, chipping, discoloration, or broken leads.

e. Tighten the packing glands surrounding the A.C. LINE cord and the test leads on the back of the front panel; tighten the terminal board and chassis mounting screws.

f. Clean and tighten the connections and mountings for transformer T1, capacitors C8 and C9, selenium rectifier CR2, and resistor R44 (fig. 17).

g. Inspect transformer T1, selenium rectifier CR2, and resistor R44 for overheating.

h. Check moistureproof and fungiproof varnish for cracks and chipping.

i. Inspect case grounding spring for cleanliness and adequate tension (fig. 16).

Section III. LUBRICATION AND WEATHERPROOFING

Note. Electronic Multimeter TS-505A/U requires no lubrication.

29. Weatherproofing

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical

Maintenance of Ground Signal Equipment. The equipment is given the moistureproofing and fungiproofing treatment at the factory, and it is necessary to use this treatment only when parts are replaced or repaired.

c. Arctic Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66, Winter Maintenance of Signal Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

30. Rustproofing and Painting

a. When the finish on the case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use #00 or #000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.

b. When a touch-up job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with dry cleaning solvent (SD). In severe cases, it may be necessary to use this solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLE SHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

31. General

a. The trouble shooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation.

b. Paragraphs 31 through 34 help in determining which of the circuits is at fault and in localizing the fault in the circuit to the defective stage or part, such as a tube or fuse.

32. Visual Inspection

a. Failure of the multimeter to operate properly usually will be caused by one or more of the following faults:

(1) Improperly connected A.C. LINE cord, or no volttge at the outlet into which the A.C. LINE cord is plugged.

(2) Burned-out fuses.

(3) Wires broken because of excessive vibration.

(4) Defective tubes (open filaments).

(5) Worn, broken or disconnected leads or probes.

(6) Worn or dirty switch contacts.

b. When failure is encountered and the cause is not immediately apparent, check as many of the items (subpar. *a* above) as practicable before starting a detailed examination of the individual parts of the circuit. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

33. Trouble Shooting Using Equipment Performance Check List

a. General. The equipment performance check list (par. 34) will help the operator to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the operator can take. *To use this list, follow the items in numerical sequence.*

b. Action or Condition. For some items, the information given in the *action or condition* column consists of various switch and control settings under which the item is to be checked. For other items, it represents an action that must be taken to check the normal indication given in the *normal indications* column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator should perceive when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those the operator can make. If the multimeter is completely inoperative or if the recommended corrective measures do not yield results, trouble shooting is necessary. However, if the tactical situation requires that the equipment be kept in operation and if the multimeter is not completely inoperative, the user must maintain the equipment in operation as long as it is possible to do so.

Note. A preferred type electron tube, type 5726/6AL5W, has been developed as a direct replacement for tube type 6AL5. These tubes may be used interchangeably as the balancing diode (V6B) and ac signal rectifier (V6A). The older type tube should be used until stocks are exhausted.

34. Equipment Performance Check List

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	FUNCTION switch (S1).	Set to OFF position.	Meter pointer should be within ½ scale division of zero.	Turn in equipment for repair of meter.
	2	A.C. LINE cord.	Connect to 98- to 132-volt, single-phase, 50- to 1,000-cps ac power source.		
START	3	FUNCTION switch (S1).	Set to +D.C. position.	Pilot lamp lights.	Check A.C. LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp. Turn in equipment for repairs.
			Allow equipment to warm up (minimum of 3 minutes).	Meter pointer deflects rapidly and gradually settles at or near zero.	Check tubes V1, V2, V3, V4, and V5. Check meter M1. Turn in equipment for repairs.
	4	RANGE switch (S2).	Turn to 2.5V-RX1 position.		
	5	D.C. and COMMON probes.	Short tips together.		
	6	ZERO ADJ. control (R15).	Rotate until meter indicates zero (par. 14*c*).		Turn in equipment for repairs.
	7	FUNCTION switch (S1).	Set to ±D.C. position.	Meter pointer deflects to midscale within plus or minus one scale division on dc scale.	Turn in equipment for repairs.
	8	ZERO ADJ. control (R15).	Rotate until meter pointer is at midscale postion (par. 14*d*).		Turn in equipment for calibration or repairs.

34. Equipment Performance Check List (cont.)

	Item No.	Item	Action or condition	Normal indications	Corrective measures
	9	FUNCTION switch (S1).	Set to —D.C. position.	Meter pointer rests on zero.	Turn in equipment for repairs.
	10	D.C. and COMMON probes.	Separate tips.		
	11	FUNCTION switch (S1).	Set to OHMS position.	Meter pointer deflects to, or near, full scale reading (∞).	Turn in equipment for repairs.
	12	RANGE switch (S2).	Rotate sucessively to all seven resistance positions.	Meter pointer reads at, or near, full scale reading at each RANGE switch resistance position.	Turn in equipment for calibration or repairs.
START	13	OHMS ADJ. control (R8).	Rotate until meter pointer is at full scale reading (∞) (par. 14*f*).	Meter pointer at ∞.	Turn in equipment for calibration and repairs.
	14	RANGE switch (S2).	Turn to 2.5V-RX1 position.		
	15	D.C. and COMMON probes.	Short tips together.	Meter pointer rests at or near zero.	
	16	ZERO ADJ. control (R15).	Rotate until meter pointer is at zero.		Turn in equipment for calibration and repairs.
	17	D.C. and COMMON probes.	Separate tips.		
	18	FUNCTION switch (S1).	Set to A.C. position.	Meter pointer reads to within one scale division of zero.	Turn in equipment for calibration and repairs.
	19	A.C. PROBE and COMMON probe.	Short tips together.		

	20	ZERO ADJ. control (R15).		Turn until meter pointer rests at zero (par. 14*e*).		Turn in equipment for calibration or repairs.
EQUIPMENT PERFORMANCE		Switch setting				
		FUNCTION	RANGE			
	21	+D.C. ±D.C. −D.C.	Depends on applied voltage.	Apply dc voltage between D.C. and COMMON probes.	Meter indicates dc voltage.	Turn in equipment for repairs.
	22	A.C.	Depends on applied voltage.	Apply ac voltage between A.C. PROBE and COMMON probe.	Meter indicates ac voltage.	Turn in equipment for repairs.
	23	+D.C.	Depends on applied voltage.	Connect rf adapter to D.C. probe. Apply rf voltage.	Meter indicates rf voltage.	Turn in equipment for repairs.
	24	OHMS	Depends on resistance selected.	Connect OHMS and COMMON probes across resistance.	Meter indicates resistance.	Turn in equipment for repairs.
STOP	25	FUNCTION switch (S1).		Turn to OFF position.	Pilot light goes out. Meter pointer is within one-half scale division of zero.	
	26	RANGE switch (S2).		Turn to 1000V-D.C. ONLY position.		
	27	A.C. LINE cord.		Disconnect from ac power source.		

CHAPTER 5

THEORY

35. Block Diagram

The block diagram (fig. 8) for Electronic Multimeter TS-505A/U is described in subparagraphs *a* through *v* below. For detailed circuit information, refer to figure 27.

a. FUNCTION Switch. The FUNCTION switch (S1) selects the particular circuit in the multimeter which will be used to measure the input voltage. In the OFF position, the switch disconnects the multimeter circuits from the power source.

b. RANGE Switch. The RANGE switch (S2) selects the proper voltage from a voltage dividing resistance network.

c. Dc Amplifiers. The dc amplifiers (V1 and V2) function as an impedance matching network to convert the high input impedance to a low impedance for the meter circuit. The gain of these amplifiers is unity.

d. Coarse Zero Adjustment. The coarse zero adjustment control (R18) compensates for large variations between the dc amplifier tubes (V1 and V2) and accomplishes coarse balancing of these tubes. Coarse balancing sets these tubes within the range of the ZERO ADJ. control.

e. ZERO ADJ. Control. The ZERO ADJ. control (R15) adjusts the zero setting of the meter pointer with no voltage input by balancing the outputs of the two dc amplifiers (V1 and V2).

f. Meter Coupling. The meter coupling tube (V3) is a twin-triode which couples the output from the plates of the dc amplifiers to the meter with negligible loading.

g. Voltage Regulators. The voltage regulator tubes (V4 and V5) provide a low resistance coupling from the meter coupling tube (V3) to the meter (M1).

h. Dc Calibration. The dc calibration control (R10) regulates the voltage drop across the meter when measuring +D.C. or −D.C. voltages, thus providing for coarse zero adjustment of the meter pointer.

i. Zero Centering Control. The zero centering control (R6) regulates the voltage drop across the meter when measuring +D.C. voltages, thus providing for coarse zero adjustment of the meter pointer.

j. Power Supply. The power supply (V7) furnishes the necessary operating potentials to the other tubes in the circuit and to the selenium rectifier (CR2) which supplies a dc voltage to the ohmmeter circuit.

k. D.C. Probe. The D.C. probe is a test prod that contains an isolating resistor (R3) to prevent capacitive loading by the multimeter of the circuit under test.

l. Rf Adapter. The rf adapter is used with the dc voltage measurement circuit to measure rf voltages of frequencies between 1 mc and 500 mc. A germanium diode and a coupling capacitor within the rf adapter rectifies the applied rf voltage into a dc voltage.

m. A.C. Probe. The A.C. PROBE is a test prod that contains an isolating resistor to prevent capacitive loading by the multimeter of the circuit under test. Ac voltages at frequencies between 30 cps and 5 mc may be measured through the A.C. PROBE.

n. Ac Signal Rectifier. The ac signal rectifier (V6A) rectifies the input ac voltage being measured and supplies a pulsating dc voltage input to the dc amplifiers.

o. Balancing Diode. The balancing diode (V6B) supplies a voltage, proportional to the ac input voltage being measured. This voltage bucks out the contact potential of the ac signal rectifier (V6A).

p. Ac Zero. The ac zero control (R45) varies the amount of bias applied to the dc amplifier (V2) from the action of the balancing diode (V6B).

q. Ac Calibration. The ac calibration control (R12) regulates the voltage drop across the meter when measuring ac voltages, thus providing for coarse zero adjustment of the meter pointer.

r. OHMS Probe. The OHMS probe is a test prod which provides an external connection to the ohmmeter circuit.

s. Selenium Rectifier. The selenium rectifier (CR2) provides a source of constant dc voltage to the ohmmeter circuit. This dc voltage is applied across the unknown resistance to be measured. The voltage drop across the unknown resistance is indicated by the meter as a resistance reading.

t. OHMS ADJ. Control. The OHMS ADJ. control (R8) adjusts the meter pointer to full-scale reading ∞ on the OHMS scale by varying the amount of resistance in series with the meter.

u. COMMON Probe. The COMMON probe is a test prod which provides an external connection for the ground, or common, circuit of the multimeter.

v. Meter. The meter (M1) is a 0 to 1 milliampere movement (infinite damping factor) with the appropriate measurement scales (fig. 5) printed on the face.

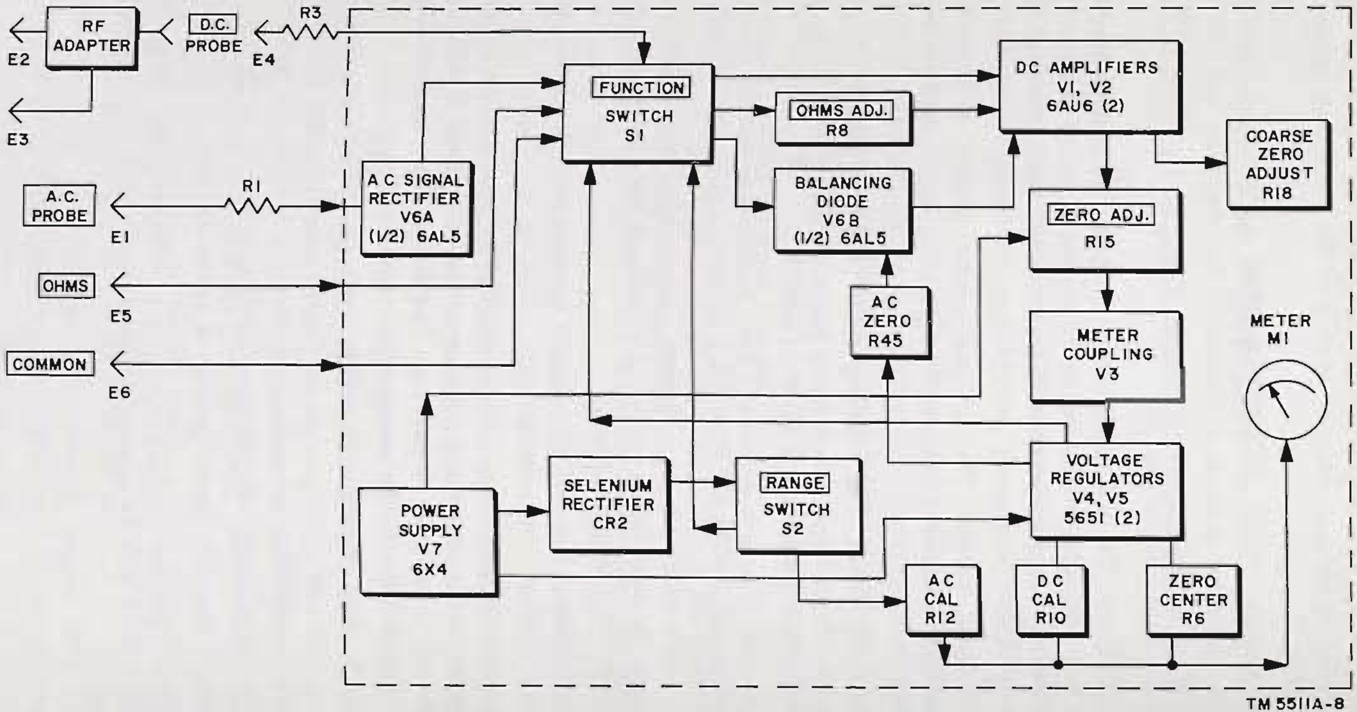


Figure 8. Electronic Multimeter TS-505A/U, block diagram.

36. Amplifier.

a. The amplifier portion of the multimeter which consists of tubes V1, V2, V3, V4, and V5, will be understood more easily if the following analysis of the circuit shown in figure 9 is read: If the coupling batteries are removed, the screen grid, plate, and cathode of one tube will be so phased with the corresponding elements in the other tube that the two tubes will act as a multivibrator. Since the circuit would be in a state of oscillation, high gain is theoretically available from the amplifier because any minute voltage input would be greatly amplified. However, this circuit cannot be used because it would be unstable. If the coupling batteries are replaced by a similar circuit, the action from plate to grid would be degenerative, and the output voltage would be equal to the input voltage. Thus, a high input resistance and, at the same time, a low output resistance necessary to operate the meter exists. The magnitude of the voltage from the coupling battery should be such as to give the proper bias to the tube.

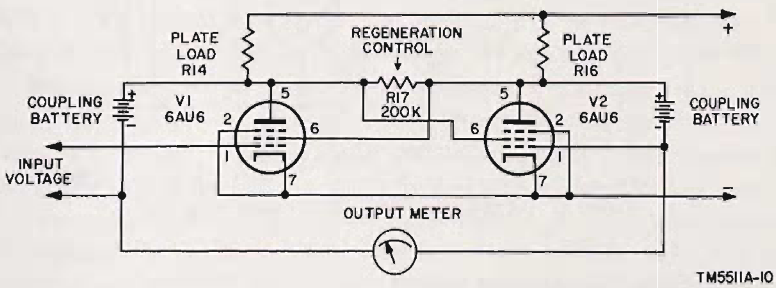


Figure 9. Simplified circuit diagram illustrating amplifier operation.

b. The circuit in figure 10 is a simplified schematic diagram of the amplifier portion of the multimeter. The coupling batteries in figure 9 have been replaced by tubes V3, V4, and V5. Using tube V3 for coupling permits operation of the plates of tubes V1 and V2 without any loading. Loading occurs if voltage regulator tubes V4 and V5 are connected directly to the plates of tubes V1 and V2. The voltage regulator tubes provide a low resistance coupling from tube V3 to the meter. Plate resistors R14 and R16 determine the gain of tubes V1 and V2. Resistor R17 sets the amplifier gain to unity. Potentiometer R15 is the ZERO ADJ. control which is used for setting the meter pointer at zero with no input voltage applied. Potentiometer R15 varies the value of plate load resistance for each dc amplifier tube (V1 and V2), and thus provides a balanced output. Resistors R46 and R47 provide a resistance across which the output voltage is developed. Resistor R19 is the biasing resistor for tubes V1 and V2. The schematic diagram indicates an open circuit in the control grid of V1; actually, a resistance appears across this grid at all times. Note that the negative point of the power supply is not connected directly to one terminal of the input voltage being measured.

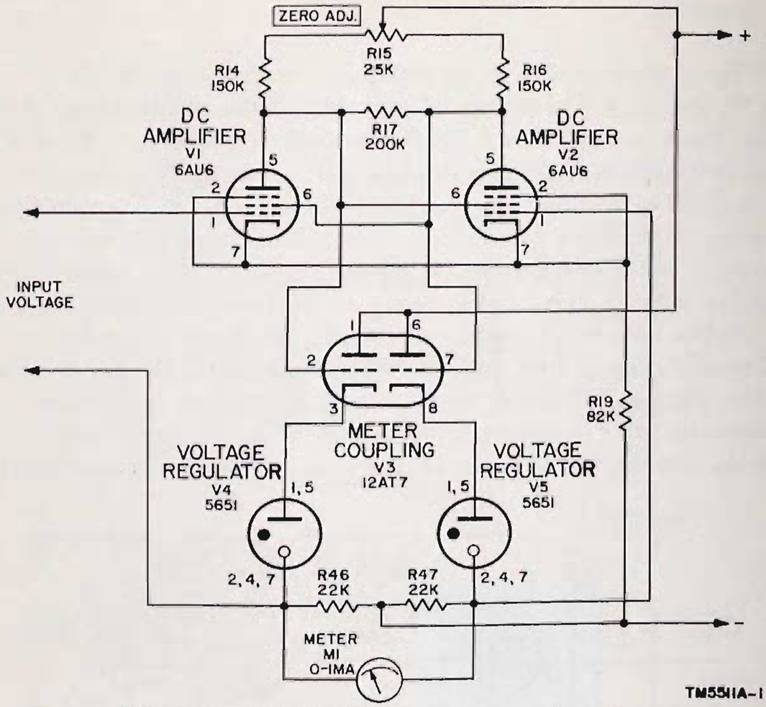


Figure 10. Amplifier, simplified schematic diagram.

37. Dc Voltage Measurement Circuit (fig. 11)

a. All dc voltages to be measured are applied across the D.C. and COMMON probes. The D.C. probe is electrically shielded to prevent pick-up of stray rf voltages near or at the test point. Resistor R3 is located at the point of measurement (within the D.C. probe) to prevent capacitive loading by the multimeter of the circuit under test.

b. The voltage being measured is coupled to the dc measurement circuit through section 1 of FUNCTION switch S1. Capacitor C5 bypasses to ground ac components of the voltage being measured.

c. The voltage being measured is applied across a precision attenuator which consists of resistors R21 through R29. Section 2 of RANGE switch S2 picks off an appropriate value of voltage from the precision attenuator (R21 through R29) and connects this voltage to the control grid of dc amplifier V1. All voltages being measured within any range are attenuated by the precision attenuator (resistors R21 through R29) to provide a voltage between 0 and 1.875 volts at the grid of tube V1. Application of 1.875 volts to the control grid of tube V1 causes the meter pointer to deflect to full scale. Note that the voltage being measured is attenuated by resistor R3 as well as resistors in the precision attenuator (resistors R21 through R29). Specific resistors and resistances used to attenuate voltages being measured within each RANGE switch position are listed on figure 11.

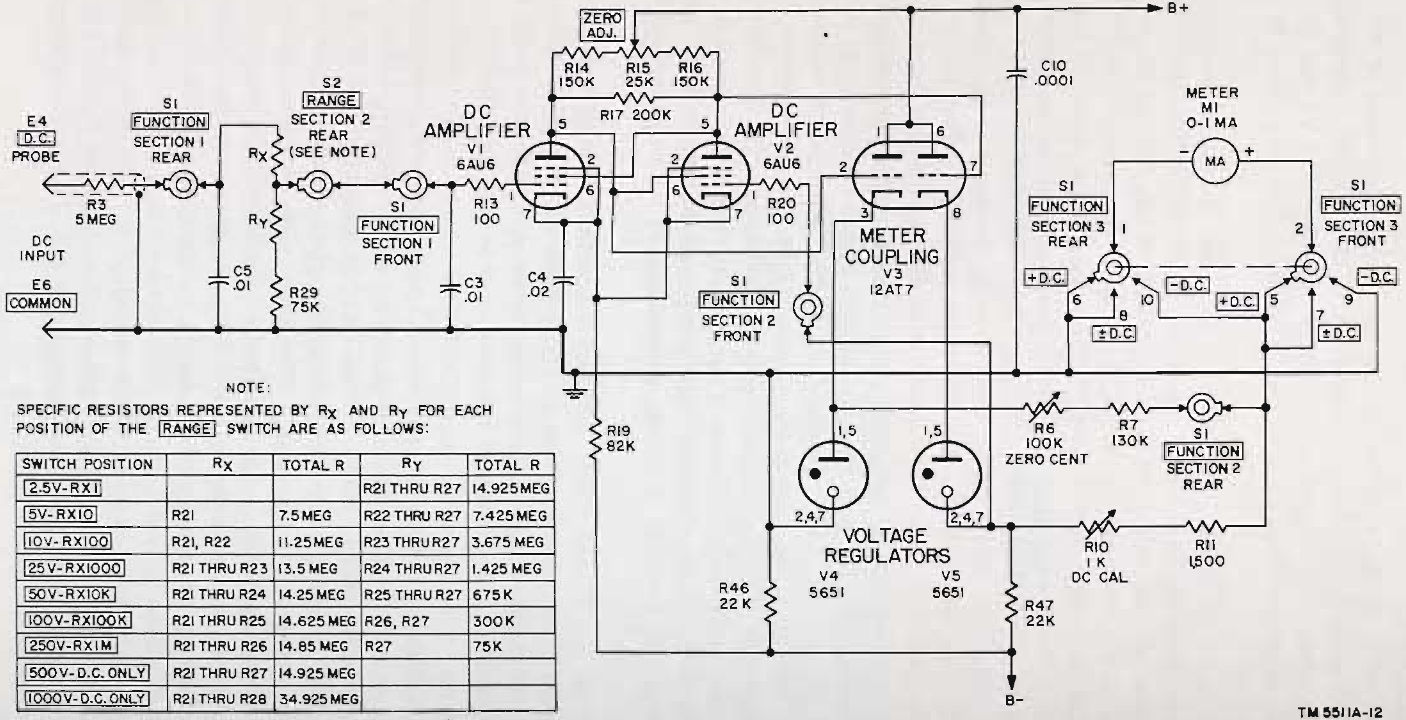
d. By action of the amplifier circuit, any voltage impressed at the high impedance input is applied to the control grid of tube V1 and is reproduced as a voltage across a low impedance at voltage regulator tubes V4 and V5. The operation of the amplifier circuits, tubes V1 through V5, is explained in paragraph 36.

e. Section 3 of FUNCTION switch S1 controls the connection of input voltage to the meter. In the +D.C. position, the FUNCTION switch connects the positive terminal of the meter to the cathode of tube V5 and the negative terminal of the meter to ground. With no input (or measurement) voltage applied to the control grid of tube V1, the voltage at the cathode of tube V5 is 0 volt with respect to ground. When a positive input voltage is applied to the grid of tube V1, the cathode of tube V5 becomes positive with respect to ground. Current is drawn from ground through the meter to the cathode of tube V5. This current flow causes the meter pointer to deflect upscale. The amount of deflection is directly proportional to the magnitude of input voltage.

f. When a negative dc voltage is being measured, the input voltage at the control grid of tube V1 is negative, producing a negative voltage at the cathode of tube V5. In the −D.C. position, the FUNCTION switch connects the negative terminal of the meter to the cathode of tube V5 and the positive terminal of the meter to ground, thus reversing the connection of the meter terminals with respect to the +D.C. position. Current is drawn from the cathode of tube V5 through the meter to ground, causing the meter pointer to deflect upscale. The amount of deflection is directly proportional to the magnitude of input voltage.

g. In the +D.C. and −D.C. positions of the FUNCTION switch, potentiometer R10 is in the meter circuit. This potentiometer is the dc calibration control and regulates the deflection of the meter pointer for any given input voltage by varying the amount of resistance in series with the meter.

h. In the ±D.C. position, the FUNCTION switch connects the positive terminal of the meter to the plate of tube V4 and the negative terminal of the meter to ground. With no input voltage applied to the control grid of tube V1, the voltage at the plate of tube V4 is such that 500 microamperes of current are drawn from ground through the meter to the plate of tube V5, causing the meter pointer to deflect to midscale. The meter pointer is positioned at exact midscale by action of zero centering potentiometer R6 which varies the amount of resistance in series with the meter and thus varies the current flow. A positive input voltage at the control grid of tube V1 increases the potential at the plate of tube V4, thus increasing current flow through the meter and causing the meter pointer to deflect to the right (above midscale). A negative input voltage at the control grid of tube V1 decreases the potential at the plate of tube V4, thus decreasing current flow through the meter and causing the meter pointer to deflect to the left (below midscale).



NOTE:

SPECIFIC RESISTORS REPRESENTED BY R_X AND R_Y FOR EACH POSITION OF THE RANGE SWITCH ARE AS FOLLOWS:

SWITCH POSITION	R_X	TOTAL R	R_Y	TOTAL R
2.5V-RX1			R21 THRU R27	14.925 MEG
5V-RX10	R21	7.5 MEG	R22 THRU R27	7.425 MEG
10V-RX100	R21, R22	11.25 MEG	R23 THRU R27	3.675 MEG
25V-RX1000	R21 THRU R23	13.5 MEG	R24 THRU R27	1.425 MEG
50V-RX10K	R21 THRU R24	14.25 MEG	R25 THRU R27	675 K
100V-RX100K	R21 THRU R25	14.625 MEG	R26, R27	300 K
250V-RX1M	R21 THRU R26	14.85 MEG	R27	75 K
500V-D.C. ONLY	R21 THRU R27	14.925 MEG		
1000V-D.C. ONLY	R21 THRU R28	34.925 MEG		

Figure 11. Dc voltage measurement circuit, simplified schematic diagram.

38. Rf Voltage Measurement Circuit

a. Except for the addition of the rf adapter, the rf voltage measurement circuit is identical with the dc measurement circuit described in paragraph 37 and illustrated in figure 11. Rf voltages are measured with the FUNCTION switch in the +D.C. position.

b. A simplified schematic diagram of the rf adapter is shown in figure 12. When in use, the rf adapter is mechanically and electrically connected to the D.C. probe. The rf adapter functions as a half-wave rectifier to convert the rf voltage being measured to a pulsating dc voltage which is applied to the control grid of tube V1. Terminal E2 represents the rf adapter probe tip; terminal E3 represents the alligator clip attached to the adapter. When in use, terminal E2 of the rf adapter is connected to the high potential side of the voltage being measured; terminal E3 is connected to the low potential side. The shield around the rf adapter parts is connected to the multimeter ground, or common, circuit through the shield around the D.C. probe. Both terminal E3 and the negative side of germanium diode CR1 are thus connected to the multimeter ground circuit.

c. The negative pulses applied to terminal E2 cause germanium diode CR1 to conduct, thus charging capacitor C1. Positive pulses applied to terminal E2 cause capacitor C1 to discharge through R2, D.C. probe resistor R3, and precision attenuator (R21 through R27 and R29) to ground, producing a positive pulsating dc input voltage at the control grid of V1. Resistor R2 is a matching resistor which adjusts the total resistance of the precision attenuator (resistors R21 through R27 and R29) for rf voltage measurement.

d. Because the voltage from the rf adapter to the control grid of tube V1 is pulsating dc, the meter reads the equivalent dc voltage, which is rms volts for a sine wave input, or .707 of the peak value of a complex wave. If the input wave form is not sinusoidal, the meter will not indicate an equivalent voltage. However, the meter can be used to determine the peak value of the positive applied input. Thus, if the input is known to be other than a sine wave, multiply the meter reading by 1.414 to obtain the peak value. For any random phase distribution of harmonic components in the applied wave form, the maximum error will not exceed the sum of the percentages of the harmonics. For example, if the input voltage has a harmonic content of 5 per cent, the error in reading may be from +5 to −5 per cent.

e. Use of the rf adapter is limited to measurement of rf voltages not exceeding 40 volts rms. Higher voltages will damage capacitor C1.

39. Ac Voltage Measurement Circuit
(fig. 13)

a. Ac voltages at frequencies from 30 cps to 5 mc may be applied across the A.C. PROBE and COMMON probe and measured by the ac voltage measure-

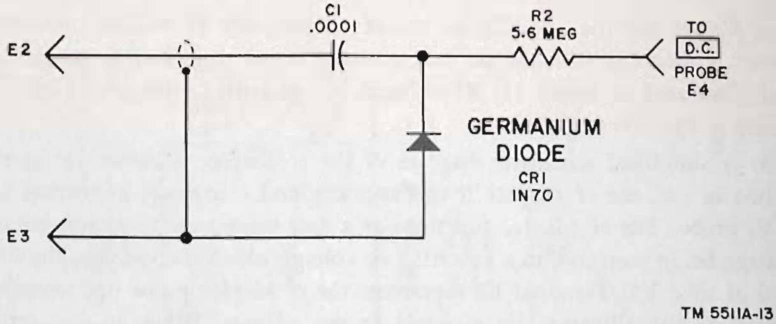


Figure 12. Rf adapter, simplified schematic diagram.

ment circuit shown in figure 13. The A.C. PROBE contains resistor R1 which is located at the point of measurement to prevent capacitive loading of the circuit under test.

b. Ac signal rectifier V6A, capacitor C1, and precision attenuator resistors R21 through R27 and R29 function as a half-wave rectifier to convert the ac voltage being measured to a pulsating dc voltage which is applied to the control grid of tube V1. Positive pulses applied to the A.C. PROBE charge capacitor C2 through the conduction of V6A. Negative pulses applied to the A.C. PROBE cause capacitor C2 to discharge through resistor R5 and precision attenuator (resistors R21 through R27 and R29) to ground, produce a negative pulsating dc input voltage at the control grid of V1. Resistor R5 is a matching resistor which adjusts the total resistance of precision attenuator (resistors R21 through R27, and R29) for ac voltage measurement.

c. When in the A.C. position, section 1 of FUNCTION switch S1 couples the pulsating dc input voltage from the precision attenuator (resistors R21 through R27 and R29) to the control grid of tube V1. Section 2 of RANGE switch S2 selects an appropriate value of voltage from precision attenuator (resistors R21 through R27 and R29) and connects this voltage to the control grid of tube V1. All ac voltages being measured within any range are attenuated by precision attenuator (resistors R21 through R27 and R29) to supply a voltage of between 0 and minus 1.875 volts to the control grid of tube V1. Specific resistors and resistances used to attenuate voltages being measured within each RANGE switch position are listed on figure 13.

d. Because of the nonlinear characteristics of the dc amplifier at small ac voltages, a special scale is provided on the meter dial for measurement of ac voltages in the 0- to 2.5-volt range. Voltages measured on all ranges other than 2.5 volts are read on the same scale as dc voltages. Resistors R4A and R4B are connected in parallel with precision attenuator resistor R21 to improve the linearity of the low voltage being measured.

e. By action of the amplifier circuit, a dc voltage applied to the control grid of tube V1 is reproduced as a voltage across the low impedance at regulator tubes V4 and V5. The operation of the amplifier circuit, tubes V1 through V5, is explained in paragraph 36.

f. Ac signal rectifier V6A is always conducting, even with no voltage applied to the A.C. PROBE, because of the contact potential in the tube. Current flows through tube V6A, resistor R5, and the precision attenuator (resistors R21 through R27 and R29) to ground, applying a constant negative voltage to the control grid of tube V1. In order that the meter pointer read 0 volt with *no* ac voltage applied to the A.C. PROBE, it is necessary to counteract the effect of this negative voltage on the control grid of tube V1. Balancing diode V6B supplies a constant positive dc voltage, a selected portion of which is applied to the control grid of tube V2, to counteract, or buck out the negative voltage on the control grid of tube V1 by balancing the outputs of dc amplifiers V1 and V2. Section 1 of RANGE switch S2 selects the amount of bucking voltage applied to the control grid of tube V2 from the precision attenuator (resistors R30 through R36) so that the bucking voltage is always equal to the negative voltage on the control grid of tube V1. Specific resistors used to attenuate the bucking voltage supplied by tube V6B at each RANGE switch position are listed on figure 13.

g. Ac zero potentiometer R45, the plate load of balancing diode V6B, develops the bucking potential. The potentiometer is adjusted to provide a voltage equal to the contact potential of tube V1; this voltage keeps the meter pointer at zero. Since the contact potential of tube V1 is a function of filament voltage, balancing diode V6B will tend to keep the meter pointer at zero as the line voltage is varied.

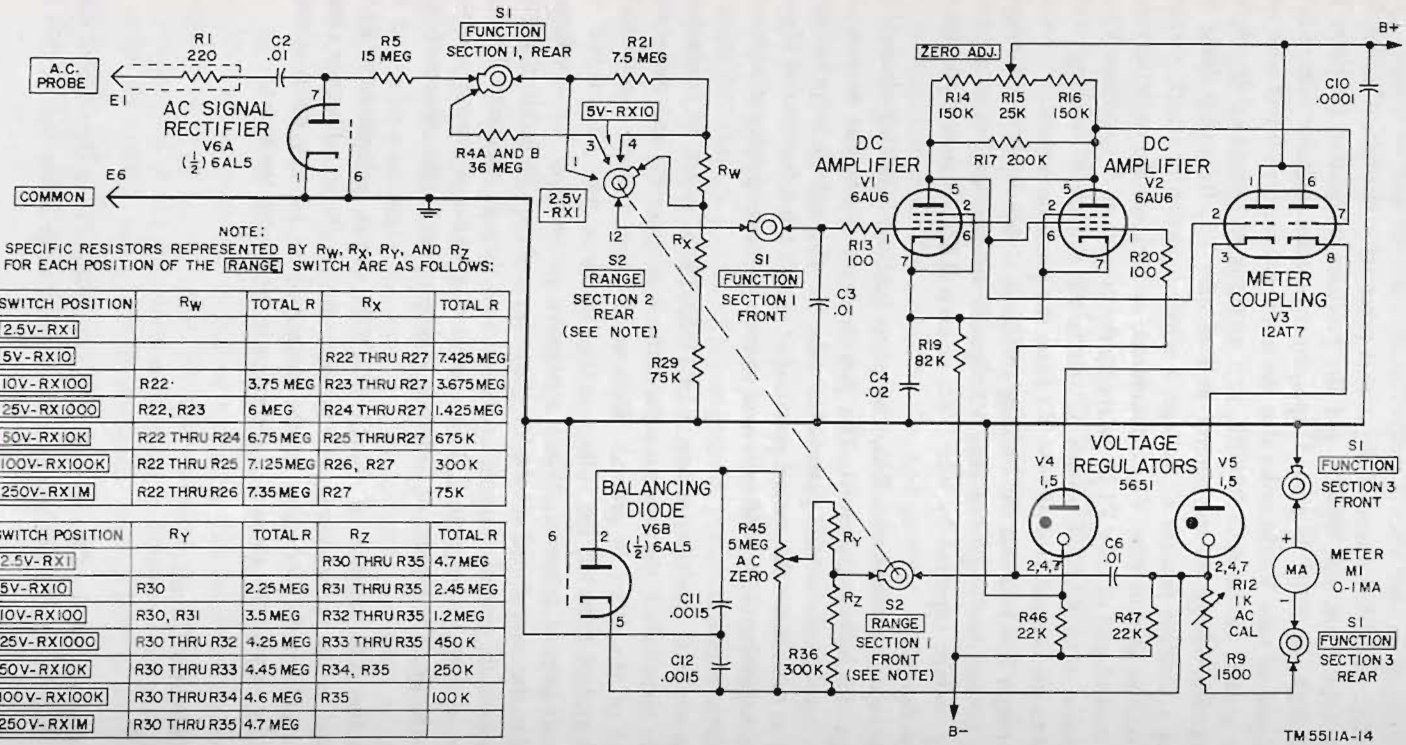
h. In the A.C. position, section 3 of FUNCTION switch S1 connects the negative terminal of the meter to the cathode of tube V5 and the positive terminal of the meter to ground. With no dc input voltage applied to the control grid of tube V1, the voltage at the cathode of tube V5 is 0 volt with respect to ground potential. When a negative pulsating dc input voltage is applied to the control grid of tube V1, the cathode of tube V5 is driven negative with respect to ground. Current is then drawn through the meter from the cathode of tube V5 to ground. This current flow causes the meter pointer to deflect upscale. The amount of deflection is proportional to the amount of input voltage.

i. In the A.C. position of the FUNCTION switch, potentiometer R12 is connected in the meter circuit. Potentiometer R12 is the ac calibration control which regulates the deflection of the meter pointer for any given ac input voltage by varying the amount of resistance in series with the meter.

40. Ohmmeter Circuit

(fig. 14)

a. Selenium rectifier CR2 receives a 6.3-volt ac input from the filament winding of transformer T1 and produces dc output voltage across resistor R44 and



NOTE:
SPECIFIC RESISTORS REPRESENTED BY R_W, R_X, R_Y, AND R_Z FOR EACH POSITION OF THE RANGE SWITCH ARE AS FOLLOWS:

SWITCH POSITION	R_W	TOTAL R	R_X	TOTAL R
2.5V-RX1				
5V-RX10			R22 THRU R27	7.425 MEG
10V-RX100	R22	3.75 MEG	R23 THRU R27	3.675 MEG
25V-RX1000	R22, R23	6 MEG	R24 THRU R27	1.425 MEG
50V-RX10K	R22 THRU R24	6.75 MEG	R25 THRU R27	675 K
100V-RX100K	R22 THRU R25	7.125 MEG	R26, R27	300 K
250V-RX1M	R22 THRU R26	7.35 MEG	R27	75 K

SWITCH POSITION	R_Y	TOTAL R	R_Z	TOTAL R
2.5V-RX1			R30 THRU R35	4.7 MEG
5V-RX10	R30	2.25 MEG	R31 THRU R35	2.45 MEG
10V-RX100	R30, R31	3.5 MEG	R32 THRU R35	1.2 MEG
25V-RX1000	R30 THRU R32	4.25 MEG	R33 THRU R35	450 K
50V-RX10K	R30 THRU R33	4.45 MEG	R34, R35	250 K
100V-RX100K	R30 THRU R34	4.6 MEG	R35	100 K
250V-RX1M	R30 THRU R35	4.7 MEG		

Figure 13. Ac voltage measurement circuit, simplified schematic diagram.

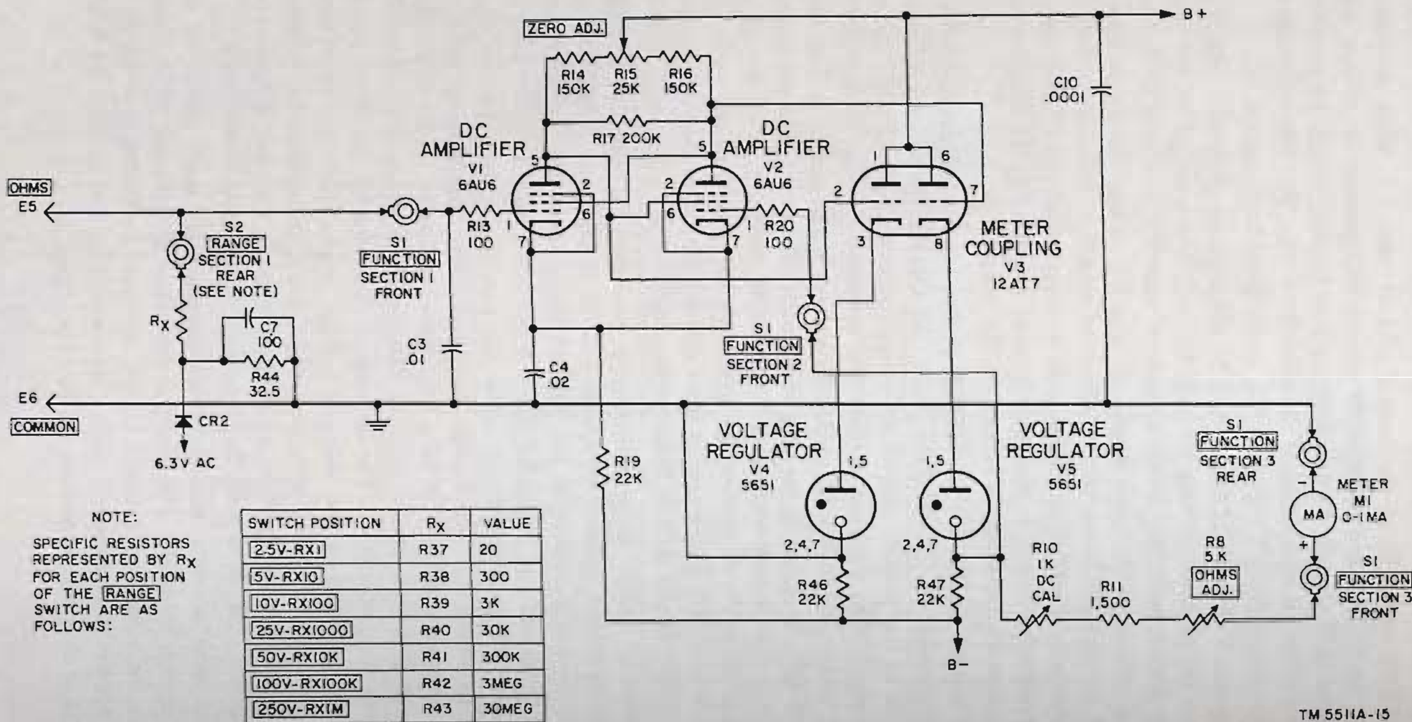
filter capacitor C7. This filtered positive dc voltage is connected through one of seven precision resistors, section 1 of RANGE switch S2, and section 1 of FUNCTION switch S1 to the control grid of tube V1. With no connection between the OHMS and COMMON probes, this positive dc voltage input to the control grid of tube V1 constitutes a bias voltage which, by action of the amplifier circuit, is reproduced at the cathode of tube V5. The operation of the amplifier circuit, tubes V1 through V5, is discussed in paragraph 36.

b. Section 3 of FUNCTION switch S1 connects the positive terminal of the meter to the cathode of tube V5 and the negative terminal of the meter to ground. A positive voltage at the cathode of tube V5, produced by the positive dc input voltage at the control grid of tube V1, causes current to flow from ground, through the meter, to the cathode of tube V5. This current flow causes the meter pointer to deflect to full-scale reading ∞ on the OHMS scale. The meter pointer is adjusted to read exactly ∞ by rotating OHMS ADJ. control R8 which varies the resistance in series with the meter.

c. When the OHMS and COMMON probes are shorted, current flows from ground, through the COMMON probe, the OHMS probe, and section 1 of switch S2 to the positive end of the resistor selected by switch S2. All of the voltage supplied by selenium rectifier CR2 is dropped across the resistor (Rx in fig. 14) selected by switch S2, so that the voltage at the control grid of tube V1 is now 0 volt. By action of the amplifier circuit, the potential at the cathode of tube V5 is also 0 volt with respect to ground potential. With 0 volt at the cathode of tube V5, no current flows through the meter and the meter pointer deflects to zero. The meter pointer is set at exact zero scale reading by adjusting ZERO ADJ. control R15 to balance the output of dc amplifiers V1 and V2.

d. When a resistor to be measured is connected between the OHMS and COMMON probes, current flows from ground, through the COMMON probe, the resistor being measured, the OHMS probe, and the precision resistor selected by section 1 of switch S2. This current flow causes a voltage drop across the resistor being measured and across the precision resistor (Rx in fig. 14) selected by switch S2. The voltage drop across the resistor being measured is applied to the control grid of tube V1, causing deflection of the meter pointer, since only a portion of the positive voltage from selenium rectifier CR2 is applied to the grid of V1. The amount of deflection of the meter pointer is directly proportional to the value of voltage applied to the control grid of tube V1. Resistances being measured which are high compared to resistor Rx will have a higher voltage drop across them, causing a greater deflection of the meter pointer. The meter will therefore read a high value of resistance.

e. The most accurate resistance measurements are made when the meter pointer is near midscale. Therefore, as the value of resistance to be measured increases, the value of Rx should also be increased by RANGE switch S2. The specific resistor and resistance value (represented by Rx) selected by RANGE switch S2 at each switch position are listed on figure 14.



NOTE:

SPECIFIC RESISTORS REPRESENTED BY R_X FOR EACH POSITION OF THE RANGE SWITCH ARE AS FOLLOWS:

SWITCH POSITION	R_X	VALUE
2.5V-RX1	R37	20
5V-RX10	R38	300
10V-RX100	R39	3K
25V-RX1000	R40	30K
50V-RX10K	R41	300K
100V-RX100K	R42	3MEG
250V-RX1M	R43	30MEG

Figure 14. Ohmmeter circuit, simplified schematic diagram.

41. Power Supply
(fig. 15)

a. The power supply uses a full-wave rectifier tube 6X4 (V7) to supply 310 volts at 12 ma for the amplifier plate supply. Power transformer T1 operates over a frequency range of 50 to 1,000 cps and requires approximately 21 volt amperes at 115 volts.

b. Power transformer T1 steps up the line voltage to approximately 500 volts. This voltage is applied to the plates of tube V7. Transformer T1 also steps down the line voltage to 6.3 volts for the heaters of the tubes, for the pilot light (I1), and for selenium rectifier CR2. The function of the electrostatic shield is to bypass interference from the power source to ground so that the operation of the meter is not affected.

c. The output of rectifier V7 is filtered by capacitors C8 and C9 and resistor R48. This supply differs from conventional power supplies in that the center tap of the high-voltage transformer winding is not connected to the common bus (ground). With respect to the common bus, the positive voltage is 165 volts dc and the center tap of transformer T1 is −103 volts dc.

d. Fuses F1 and F2 are placed in the primary circuit of transformer T1 to prevent damage to the transformer if abnormal currents are required from the multimeter. These fuses are rated at 1 ampere.

e. Switch S1, section 4, is a double-pole, single-throw snap switch, used to turn the multimeter on or off. It is part of FUNCTION switch S1 and is actuated when the switch is rotated clockwise to turn on the multimeter.

f. Selenium rectifier CR2 converts the 6.3 volts ac from transformer T1 to a pulsating dc voltage. The output of selenium rectifier CR2 is filtered by capacitor C7 and resistor R44 and is applied to the ohmmeter resistance network attenuator through RANGE switch S2.

g. Pilot light I1 indicates whether the multimeter is on. The light is covered by a colored lens.

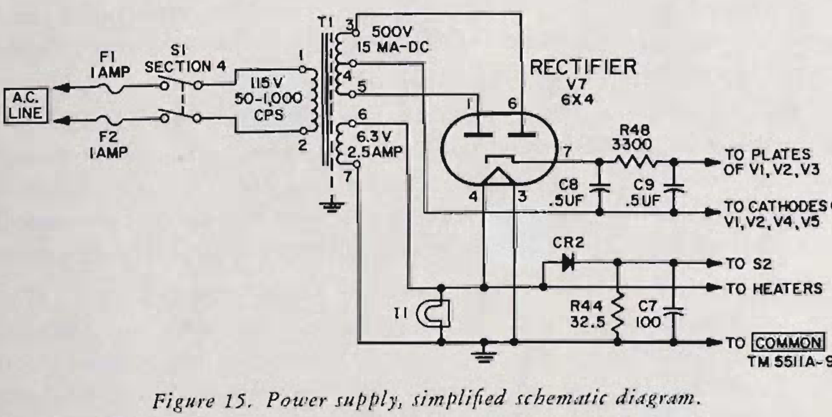


Figure 15. Power supply, simplified schematic diagram.

CHAPTER 6

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. TROUBLE SHOOTING AT FIELD MAINTENANCE LEVEL

Warning: Certain points located throughout the chassis of the multimeter operate at voltages above 250 volts. Do not touch these points while power is applied to the multimeter. Be very careful when handling or testing any part of the multimeter while it is connected to the power source.

42. Trouble-shooting Procedures

a. General. The first step in servicing a defective multimeter is to sectionalize the fault. Sectionalization means tracing the fault to the circuit responsible for the abnormal operation of the multimeter. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors, arcing, shorted transformer, leaky capacitors, or broken wires often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistances.

b. Component Sectionalization and Localization. Listed below is a group of tests arranged to simplify and reduce unnecessary work and to aid in tracing a trouble to a specific part. The simple tests are used first. Those that follow are more complex. Follow the procedure in the sequence given. Care must be exercised to cause no further damage to the multimeter while it is being serviced.

(1) *Visual Inspection.* The purpose of visual inspection (par. 32) is to locate any visible trouble. Through this inspection alone, the repairman frequently may discover the trouble or determine the circuit in which the trouble exists. This inspection is valuable in avoiding additional damage to the multimeter which might occur through improper servicing methods and in forestalling future failures.

(2) *Checking for Shorts.* The B+ and filament supply circuits should be checked (par. 46) for possible shorts before the equipment is tested with power applied. These measurements prevent further damage to the equipment from possible short circuits.

(3) *Operational Test.* Operational tests frequently indicate the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. To utilize this information fully, all symptoms must be interpreted in relation to one another. To perform an operational test on the multimeter, use the equipment performance check list (par. 34).

(4) *Trouble-Shooting Chart.* The trouble symptoms listed in this chart (par. 48) will aid greatly in localizing trouble.

(5) *Intermittent Troubles.* In all these tests, possibility of intermittent conditions should not be overlooked. If present, this type of trouble often may appear by tapping or jarring the equipment. It is possible that some external conditions may cause the trouble. Test wiring for loose connections and move wires and components with an insulated tool, such as a pencil or fiber rod. This will show where a faulty connection or component is located.

43. Trouble-shooting Data

The material supplied in this manual will help in the rapid location of faults. Consult the following trouble-shooting data:

Fig. or par. No.	Title
Fig. 27	Schematic diagram.
Fig. 28	Wiring diagram.
Fig. 8	Block diagram.
Fig. 11	Dc voltage measurement circuit.
Fig. 13	Ac voltage measurement circuit.
Fig. 14	Ohmmeter circuit.
Fig. 22	Tube socket, voltage and resistance diagram.
Fig. 23	Terminal board voltage and resistance diagram.
Fig. 17	Rear view of chassis.
Fig. 18	Top view of chassis.
Fig. 19	Components removed from panel.
Fig. 20	Exploded view of rf adapter.
Par. 32	Visual inspection.
Par. 34	Equipment performance check list.
Par. 48	Trouble-shooting chart.
Par. 49	Dc resistances of transformer.

44. Test Equipment Required for Trouble Shooting

The test equipments required for trouble shooting Electronic Multimeter TS-505A/U are Electron Tube Tester TV-2/U and Multimeter TS-352/U. The TV-2/U is covered by TM 11-2661; the TS-352/U is covered by TM 11-5527. If these test equipments are not obtainable, equipments with similar characteristics may be substituted.

45. General Precautions

Observe the following precautions very carefully whenever servicing the multimeter:

a. Be careful when the multimeter is out of its case; dangerous voltages are exposed.

b. If the multimeter has been operating for some time, use a cloth when removing the metal tube shields. Use a tube puller to remove the tubes to prevent burning the hand or fingers. Label tubes V1 and V2 to insure replacement in the same tube socket.

c. When removing parts from the panel, remove all packing glands that secure connecting leads. Be careful not to kink or strain any wires or leads.

d. Do not overtighten screws or packing glands when assembling mechanical couplings.

e. When changing a component that is held by screws, always replace the washers. Be sure that the rubber *O* rings are installed before installation of packing glands.

f. Careless replacement of parts often makes new faults inevitable. Note the following points:

(1) Before a part is unsoldered, note the position of the leads. If the part, such as a wafer switch or power transformer, has a number of connections, tag each lead before removing it.

(2) Be careful not to damage other leads by pushing or pulling them out of the way.

(3) Do not use a large soldering iron when soldering small resistors or ceramic capacitors. Overheating of small parts may damage the part or change its value.

(4) Do not allow drops of solder to fall into parts of the chassis because they may cause short circuits.

(5) A carelessly soldered connection may create new faults. It is very important to make well-soldered joints because a poorly soldered joint is one of the most difficult faults to find.

(6) When a part is replaced in a high-frequency circuit, it must be placed exactly in the position occupied by the original part. A part which has the same electrical value but different physical size may cause

trouble in high-frequency circuits. The multimeter contains a number of precision resistors which must be replaced by identical replacement parts. Give particular attention to proper grounding when replacing a part; use the same ground as in the original wiring. Failure to observe these precautions may result in improper operation or instability.

(7) *Do not disturb* the setting of potentiometer R6, R10, R12, R18, or R45 (fig. 16) unless it definitely has been determined that the trouble is caused by misadjustment of one or more of these potentiometers.

46. Checking Filament and B+ Circuits for Shorts

a. Trouble within the multimeter often may be detected by checking the resistance of the filament and high-voltage circuits before applying power to the equipment. This will prevent damage to the power supply.

b. Check the filament and B+ circuits before attempting to put the multimeter into operation. For these measurements, be sure that the A.C. LINE cord is disconnected from the power source, the FUNCTION switch is set at the +D.C. position, and the RANGE switch is set at 2.5V-RX1 position.

c. Check the resistances between the plate and filament tube socket pins and ground. If the measured resistance values differ more than 10 per cent from those specified in figure 22, check the circuit being measured for shorted components or wires. If a short in the B+ circuit is suspected, check capacitors C8 and C9 for shorts, and test all tubes for shorted elements. Refer to the schematic diagram (fig. 27) to aid in locating shorted components.

47. Gas Checks

a. The performance and accuracy of the multimeter largely depends on the degree of balance between the two dc amplifiers, V1 and V2. Small variations in the characteristics of tubes V1 and V2, which will cause unbalance, may be compensated for by the coarse zero adjust control (R18) and the ZERO ADJ. control (R15), provided that the tubes are not gassy.

b. Check for gas in tubes V1 and V2 as follows:

(1) Connect the multimeter A.C. LINE cord into the ac power source (98 to 132 volts, 50 to 1,000 cps). Turn the FUNCTION switch to the +D.C. position and allow the multimeter to warm up for 10 or 15 minutes.

(2) Turn the ZERO ADJ. control (R15) to its mechanical center. Turn the RANGE switch to the 2.5V-RX1 position. Connect the D.C. and COMMON probe tips together.

(3) Loosen the lock nut on potentiometer R18 (fig. 16). Using a screw driver, turn potentiometer R18 until the meter pointer is within

one-half scale division of zero. Wait approximately 1 minute between settings, since the action of this control is sluggish.

(4) After the adjustment has been made, tighten the lock nut on potentiometer R18. Be careful not to disturb the setting of the meter pointer and the setting of the potentiometer.

(5) Set the meter pointer at zero by turning the ZERO ADJ. control.

(6) Turn the FUNCTION switch to the −D.C. position. The meter pointer should read zero within plus or minus one scale division.

(7) If the meter pointer has shifted more than plus or minus one scale division from zero, allow the multimeter to operate for several hours; then repeat the instructions in subparagraphs (1) through (6) above. If the shift of the meter pointer is still greater than one division from zero, replace tubes V1 and V2. Check the replacement tubes by repeating the instructions in subparagraphs (1) through (6) above.

48. Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the multimeter. It lists the symptoms the repairman observes, either visually or audibly, while making tests. The chart also indicates how to localize trouble quickly to a particular stage or circuit. After the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurements of this stage or circuit ordinarily should be sufficient to isolate the defective part. Resistance and voltage readings are given in figures 22 and 23.

48. Trouble-shooting Chart (cont)

No.	Switch position		Symptom	Probable trouble	Correction
	FUNCTION switch	RANGE switch			
1	Any except OFF.	Any.	Pilot light does not go on; no movement of meter needle; line voltage normal.	*a.* A.C. LINE cord plug is not properly inserted in socket. *b.* Burned-out fuse F1 or F2. *c.* Defective A.C. LINE cord disconnected from plug. *d.* Defective switch S1, section 4. *e.* Defective transformer T1 (par. 49). *f.* Short across filament winding of transformer T1 (par. 49). *g.* Pilot lamp I 1 burned out.	*a.* Insert correctly. *b.* Replace defective fuse (fig. 17). *c.* Replace or repair cord. *d.* Replace or repair switch (fig. 19 and par. 50*b*). *e.* Replace transformer (fig. 17). *f.* Locate and remove short (fig. 17). *g.* Replace pilot lamp I 1 (fig. 19).

48. Trouble-shooting Chart (cont)

No.	Switch position		Symptom	Probable trouble	Correction
	FUNCTION switch	RANGE switch			
2	+D.C.	Any.	Meter pointer does not move during initial warm-up period; pilot light is on.	*a.* Bad tube V1, V2, V3, V4, V5, or V7.	*a.* Check tubes; replace defective tube or tubes (fig. 17).
				b. Poor contact at tube socket X1, X2, X3, X4, X5, or X7.	*b.* Clean and tighten contacts of sockets; replace defective socket or sockets (fig. 19).
				c. Meter M1 burned out.	*c.* Replace meter (fig. 19 and par. 50*e*).
				d. Defective potentiometer R10.	*d.* Replace potentiometer (fig. 19 and par. 50).
				e. Defective or dirty switch deck.	*e.* Clean or replace defective switch (par. 25*b*).
				f. Line voltage low.	*f.* Apply correct line voltage.
				g. No voltage at cathode of tube V7.	*g.* Check transformer T1 (par. 49); replace if defective (par. 45*f*(1) and fig. 18).

3	+D.C.	2.5V-RX1	Meter pointer is near zero but cannot be adjusted to zero with ZERO ADJ. control R15.	*a.* Potentiometer R18 improperly calibrated or defective.	*a.* Calibrate as outlined in 54*a* through *e*; replace potentiometer R18.
				b. Potentiometer R15 defective.	*b.* Replace potentiometer R15 (fig. 19).
				c. Line voltage too high or too low.	*c.* Apply correct line voltage.
				d. Defective tube, V1, V2, V3, V4, or V5 (fig. 17).	*d.* Check tubes; replace defective tube or tubes.
				e. Resistor R14 or R16 open or shorted; resistor R11 shorted.	*e.* Replace defective resistor (fig. 19 and par. 50).

48. Trouble-shooting Chart (cont)

No.	Switch position: FUNCTION switch	Switch position: RANGE switch	Symptom	Probable trouble	Correction
4	+D.C.	*a.* 1000V-D.C. ONLY.	Meter pointer drifts until off scale.	*a.* Resistor R29 open (control grid of tube V1 to ground should measure 75,000 ohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*a.* Replace resistor R29; clean switch contact or replace switch (fig. 17 and par. 50*b*).
		b. 500V-D.C. ONLY.		*b.* Same probable fault as in subparagraph *a* above.	*b.* Same correction as in subparagraph *a* above.
		c. 250V-RX1M.		*c.* Resistor R27 open (control grid of tube V1 to ground should measure 150,000 ohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*c.* Replace resistor R27; clean switch contact or replace switch (fig. 17 and par. 50).
		d. 100V-RX100K.		*d.* Resistor R26 open (grid of tube V1 to ground should measure 375,000 ohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*d.* Replace resistor R26; clean switch contact or replace switch (par. 50 and fig. 17).
		e. 50V-RX10K.		*e.* Resistor R25 open (control grid of tube V1 to ground should measure 750,000 ohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*e.* Replace resistor R25; clean switch contact or replace switch (par. 25*b*, *c*, 50 and fig. 17).

	f. 25V-RX1000.		*f.* Resistor R24 open (control grid of tube V1 to ground should measure 1.5 megohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*f.* Replace resistor R24; clean switch contact or replace switch (par. 25*b*, *c*, 50 and fig. 17).
	g. 10V-RX100.		*g.* Resistor R23 open (control grid of tube V1 to ground should measure 3.75 megohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*g.* Replace resistor R23; clean switch contact or replace switch (par. 25*b*, *c*, 50 and fig. 17).
	h. 5V-RX10.		*h.* Resistor R22 open (control grid of tube V1 to ground should measure 7.5 megohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*h.* Replace resistor R22; clean switch contact or replace switch (par. 25*b*, *c*, 50 and fig. 17).
	i. 2.5V-RX1.		*i.* Resistor R21 open (control grid of tube V1 to ground should measure 15 megohms); dirty or open contact on switch S1, section 1, or switch S2, section 2.	*i.* Replace resistor R21; clean switch contact or replace switch (par. 25*b*, *c*, 50 and fig. 17).

48. Trouble-shooting Chart (cont)

No.	Switch position		Symptom	Probable trouble	Correction
	FUNCTION switch	RANGE switch			
5	+D.C.	2.5V-RX1.	Application of 2.5 volts ±1 per cent to meter results in error greater than 5 per cent.	*a.* Potentiometer R10 set incorrectly or defective. *b.* Resistor R17 open. *c.* Resistors R21 through R29 are not within 1 per cent of correct value. *d.* Meter M1 error greater than ±2 per cent.	*a.* Refer to paragraph 54*q* through *u*; replace potentiometer R10 (fig. 19). *b.* Replace resistor R17 (fig. 19). *c.* Find defective resistor or resistors and replace (fig. 17). *d.* Replace meter (par. 50*e*).
6	+D.C.	500V-RX100K.	Apply approximately 500 volts between D.C. and COMMON probes and then turn FUNCTION switch to 1000V position. Meter pointer does not read 500 volts on 1000V range.	Resistor R28 short-circuited.	Repair or replace switch S2, replace resistor R28 (par. 50*b* and fig. 17).
7	±D.C.	Any.	Meter pointer not at midscale.	*a.* Potentiometer R6 set incorrectly or defective. *b.* Resistor R7 open or shorted.	*a.* Refer to paragraph 54*g* through *j*; replace potentiometer R6 (fig. 19). *b.* Replace resistor R7 (fig. 19 and par. 50).

8	±D.C.	See item 4 above.	Meter pointer drifts until off scale.	See item 4 above.	See item 4 above.
9	−D.C.	See item 4 above.	Meter pointer drifts until off scale.	See item 4 above.	See item 4 above.
10	−D.C.	2.5V-RX1.	Meter pointer set to zero on −D.C. indicates negative when switched to −D.C. and cannot be set to zero with ZERO ADJ. control (R15).	Tube V1 or V2 gassy.	Refer to paragraph 47 (fig. 17).
11	+D.C., ±D.C., or −D.C.	Any.	No deflection of meter pointer with dc voltage applied.	*a.* Resistor R3 open. *b.* Loose mechanical connection between resistor R3 lead and D.C. probe tip. *c.* Test lead open. *d.* Dirty or open contact on switch S1 or S2.	*a.* Replace resistor R3 (par. 50). *b.* Inspect resistor lead and tighten probe tip. *c.* Replace test lead. *d.* Clean switch contact or replace defective switch (fig. 17 and par. 50*b*).
12	+D.C., ±D.C., or −D.C.	Various.	Meter pointer shifts when changing setting of RANGE switch.	Tube V1 or V2 gassy.	Refer to paragraph 47 (fig. 17).
13	+D.C., ±D.C., or −D.C.	Any.	Meter pointer deflects in wrong direction.	Meter leads reversed	Reverse meter leads.

48. Trouble-shooting Chart (cont)

No.	Switch position: FUNCTION switch	Switch position: RANGE switch	Symptom	Probable trouble	Correction
14	+D.C., ±D.C., or −D.C.	Any.	Meter pointer unstable; for constant input voltage, meter indication keeps changing.	*a.* Tube V1 or V2 gassy. *b.* Resistor R17 open.	*a.* Refer to paragraph 47 (fig. 17). *b.* Replace resistor R17 (fig. 19 and par. 50).
15	+D.C., ±D.C., or −D.C.	Any.	Application of low frequency (approx 30 cps) to D.C. probe causes meter pointer to vibrate.	Capacitor C3 or C5 open.	Replace capacitor C3 or C5 (fig. 17).
16	+D.C.	Any up to 50V-RX10K.	Apply rf voltage up to 40 volts, 1 to 500 mc. No deflection of meter pointer.	*a.* Capacitor C1 open or shorted. *b.* Germanium diode CR1 open or shorted. *c.* Resistor R2 open.	*a.* Replace capacitor C1 (par. 50*f* and fig. 21). *b.* Replace germanium diode CR1 (fig. 21 and par. 50*f*). *c.* Replace resistor R2 (fig. 21 and par. 50*f*).
17	A.C.	2.5V-RX1.	Meter pointer cannot be set to zero with potentiometer R15 or R45 (no input voltage to A.C. PROBE).	*a.* Potentiometer R12 incorrectly set or defective. *b.* Potentiometer R15 or R45 defective. *c.* Resistor R21, R22, R23, R24, R25, R26, R27, or R29 open or shorted or of incorrect value.	*a.* Refer to paragraph 54*v* through *z*; replace potentiometer R12 (fig. 19). *b.* Replace potentiometer R15 or R45 (fig. 19 and par. 50). *c.* Replace defective resistor (fig. 17 and par. 50).

18	A.C.	Any.	No meter pointer deflection with ac voltage applied to A.C. PROBE.	*a.* Capacitor C2 open. *b.* Tube V6 burned out. *c.* Resistor R1 open. *d.* Dirty or open contact on switch S1 or S2. *e.* Defective test lead.	*a.* Replace capacitor C2 (fig. 19). *b.* Replace tube V6 (fig. 17). *c.* Replace Resistor R1 (par. 50*b*). *d.* Clean switch contact or replace defective switch (fig. 19 and par. 50*b*). *e.* Replace test lead (fig. 3 and par. 50*b*).
19	A.C.	Any.	Meter pointer deflects with dc voltage applied to A.C. PROBE.	Capacitor C2 defective.	Replace capacitor C2 (fig. 19).
20	A.C.	Any.	Potentiometer R12 will not adjust meter for calibrating.	Potentiometer R12 defective.	Replace potentiometer (fig. 19).
21	A.C.	Any.	Meter pointer deflects positive with no input voltage; rotation of potentiometer R45 has no effect.	*a.* Tube V6B inoperative. *b.* Capacitor C11 or C12 shorted. *c.* Resistor R21, R22, R23, R24, R25, R26, R27, or R29 open or shorted or of incorrect value.	*a.* Replace tube V6 (fig. 17). *b.* Replace defective capacitor (fig. 19 and par. 44*f*(3)). *c.* Replace defective resistor (fig. 17 and par. 50).
22	A.C.	Any.	Meter pointer deflects negative with no input voltage; rotation of resistor R45 has no effect.	*a.* Tube V6A inoperative. *b.* Resistor R5 open. *c.* Resistor R45 defective.	*a.* Replace tube V6 (fig. 17). *b.* Replace resistor R5 (fig. 19 and par. 50). *c.* Replace resistor R45 (fig. 19 and par. 50).

48. Trouble-shooting Chart (cont)

No.	Switch position		Symptom	Probable trouble	Correction
	FUNCTION switch	RANGE switch			
23	OHMS	Any.	Meter pointer does not deflect toward full scale.	*a.* Capacitor C3 or C7 shorted.	*a.* Replace capacitor C3 or C7 (fig. 17).
				b. Dirty or open contacts on switch S1 or S2.	*b.* Clean switch contact or replace switch (fig. 17 and par. 50*b*).
				c. Selenium rectifier CR2 defective.	*c.* Replace selenium rectifier CR2 (fig. 17).
24	OHMS	*a.* 2.5V-RX1.	Meter pointer drifts upscale.	*a.* Resistor R37 open.	*a.* Replace resistor R37 (fig. 18 and par. 50).
		b. 5V-RX10.		*b.* Resistor R38 open.	*b.* Replace resistor R38 (fig. 18 and par. 50).
		c. 10V-RX100.		*c.* Resistor R39 open.	*c.* Replace resistor R39 (fig. 18 and par. 50).
		d. 25V-RX1000.		*d.* Resistor R40 open.	*d.* Replace resistor R40 (fig. 17 and par. 50).
		e. 50V-RX10K.		*e.* Resistor R41 open.	*e.* Replace resistor R41 (fig. 17 and par. 50).
		f. 100V-RX100K.		*f.* Resistor R42 open.	*f.* Replace resistor R42 (fig. 17 and par. 50).
		g. 250V-RX1M.		*g.* Resistor R43 open.	*g.* Replace resistor R43 (fig. 17 par. 50).
		h. Any.		*h.* Resistor R44 open.	

25	OHMS	Any.	Full clockwise rotation of OHMS ADJ. control does not bring meter pointer to ∞.	*a.* Selenium rectifier CR2 defective. *b.* Line voltage too low. *c.* Potentiometer R10 defective. *d.* OHMS ADJ. potentiometer R8 defective.	*a.* Replace selenium rectifier CR2 (fig. 17). *b.* Apply correct line voltage. *c.* Replace potentiometer R10 (fig. 19). *d.* Replace potentiometer R8 (fig. 19).
26	Any except OFF.	2.5V-RX1.	No B+ at cathode of tube V7; pilot light glows.	*a.* Tube V7 defective. *b.* Capacitor C8 shorted. *c.* High-voltage winding of transformer T1 open or shorted.	*a.* Replace Tube V7 (fig. 17). *b.* Replace capacitor C8 (fig. 18). *c.* Replace transformer T1 (fig. 18 and par. 45*f*).
27	Any except OFF.	2.5V-RX1.	No B+ at plates of tube V3; pilot light glows.	*a.* Capacitor C9 shorted. *b.* Resistor R48 open. *c.* Tube V7 defective.	*a.* Replace capacitor C9 (fig. 18). *b.* Replace resistor R48 (fig. 17 and par. 50). *c.* Replace tube V7 (fig. 17).

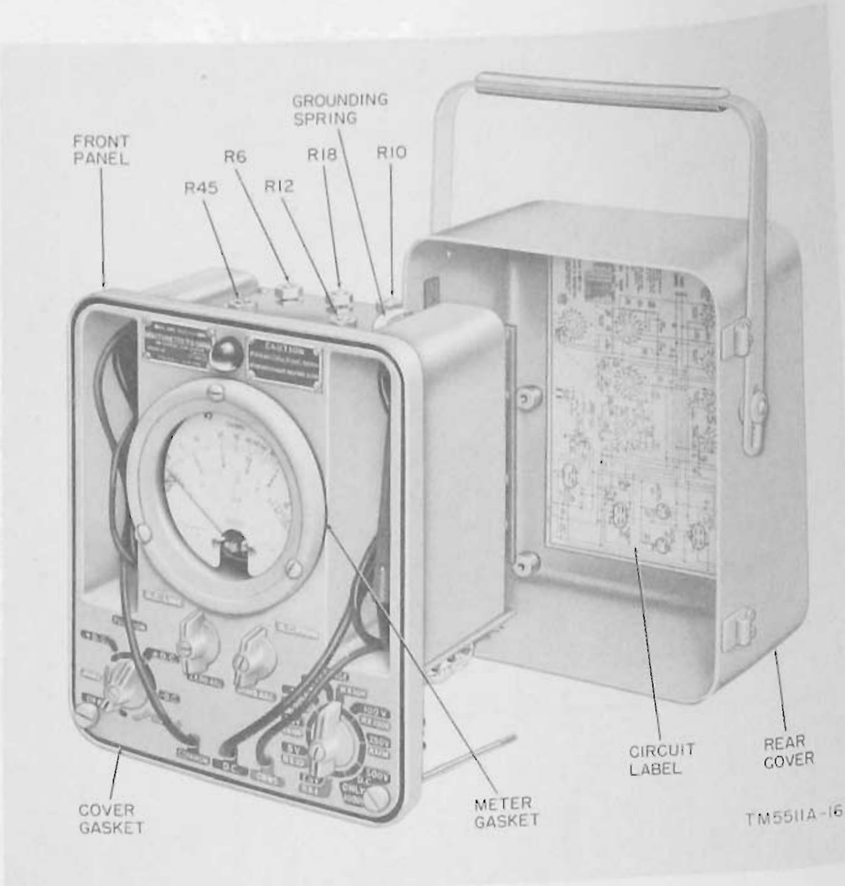


Figure 16. Multimeter, removed from its case.

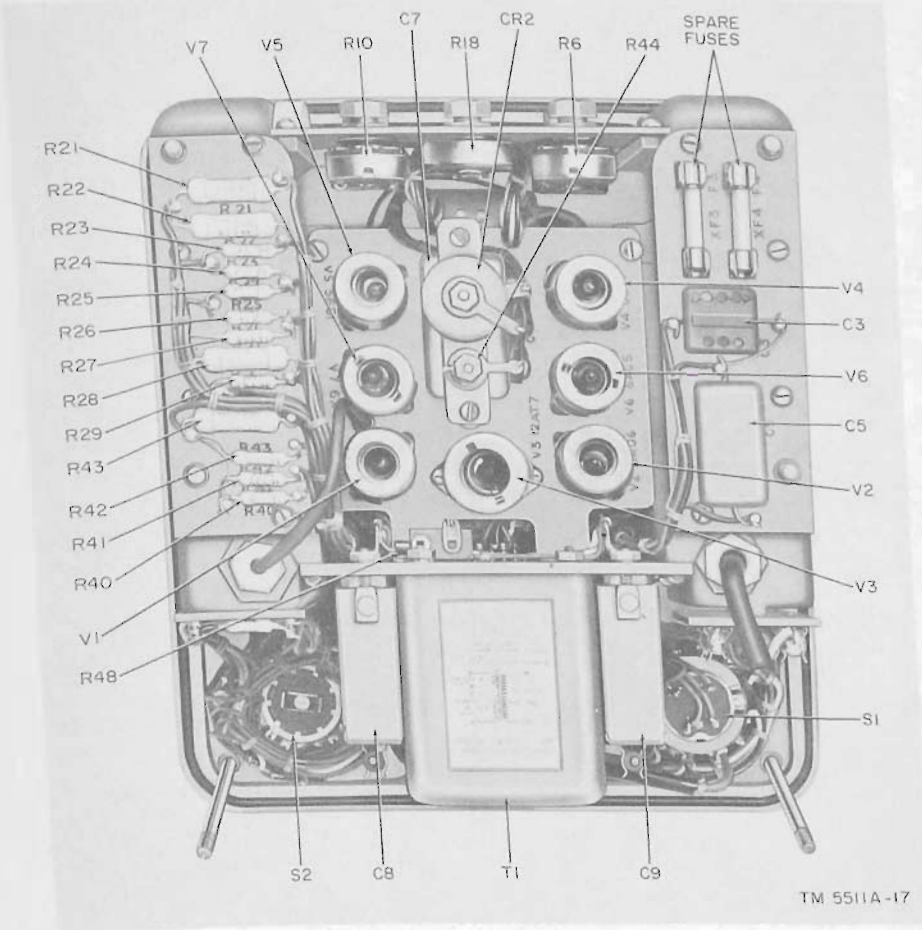


Figure 17. Multimeter, case removed, rear view.

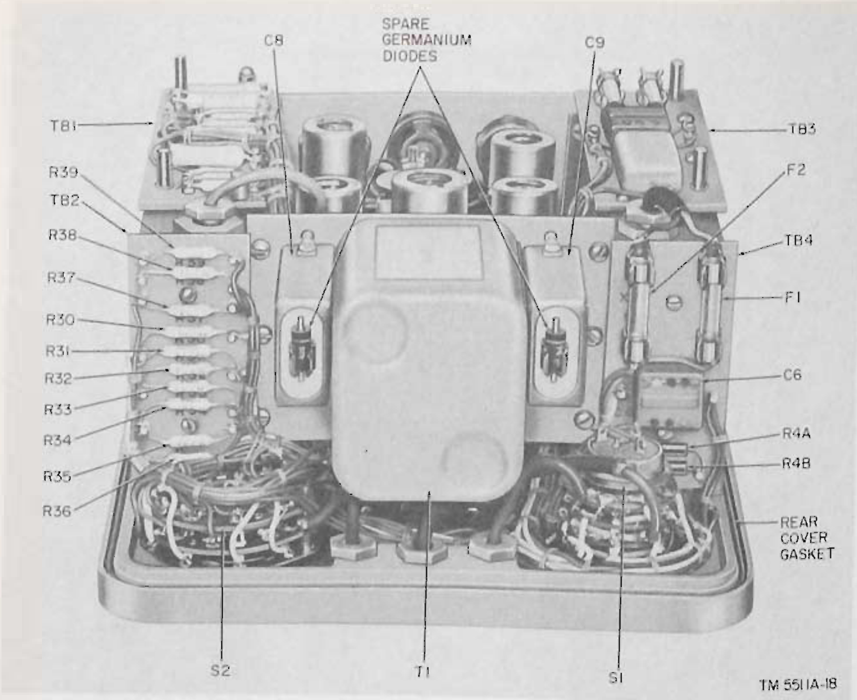


Figure 18. Multimeter, case removed, top view.

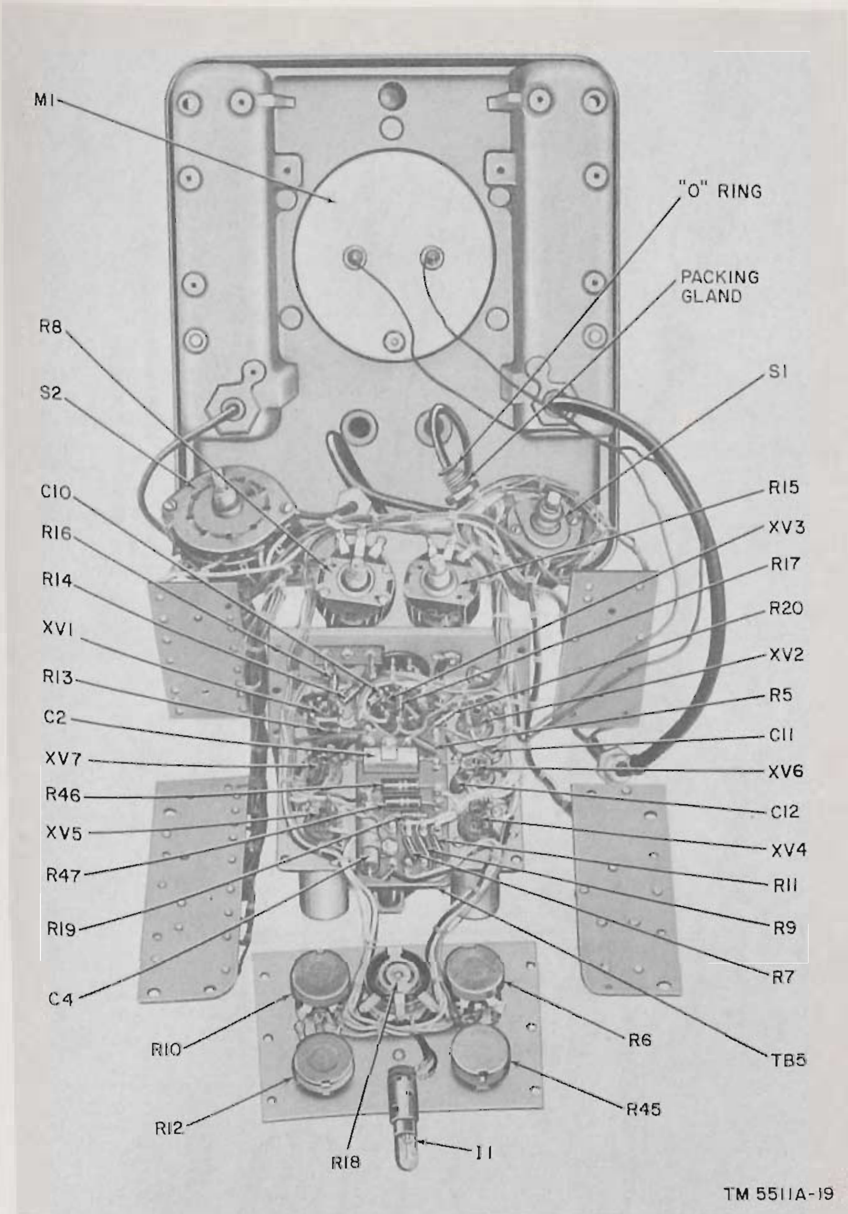


Figure 19. Multimeter, showing parts and subassemblies removed from panel.

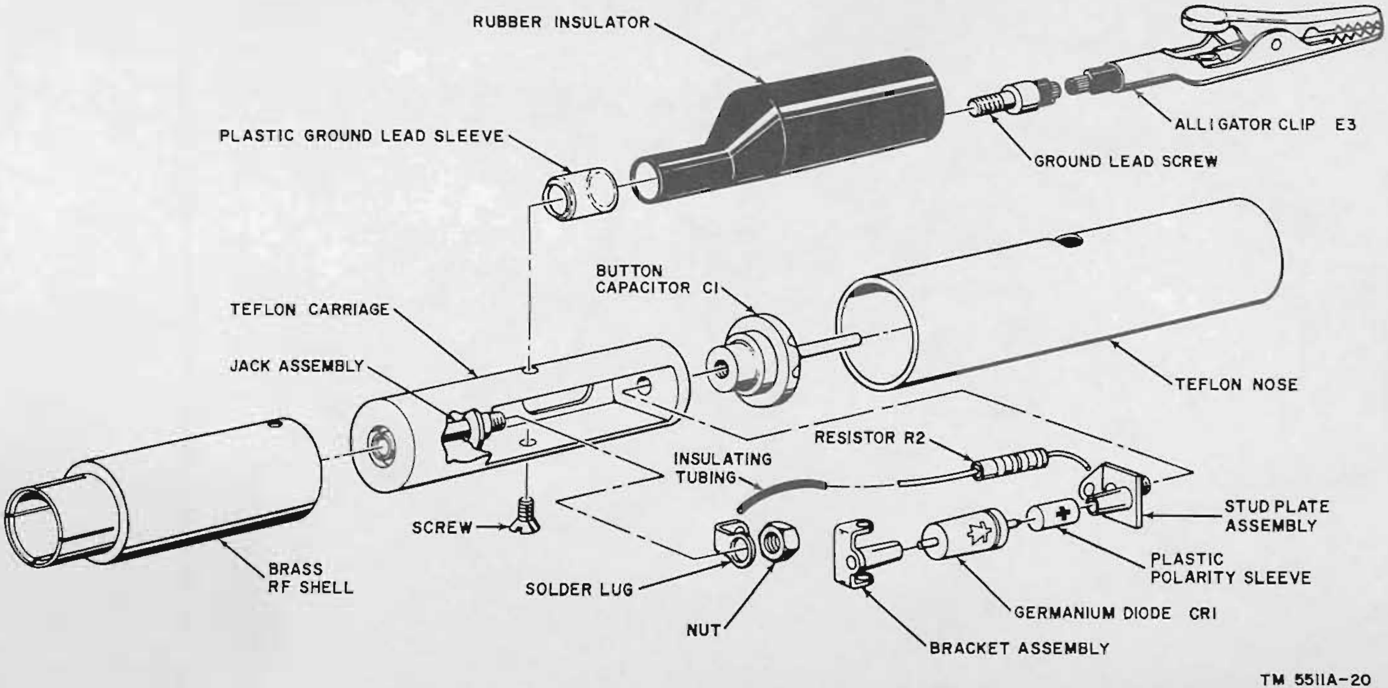


Figure 20. Rf adapter, exploded view.

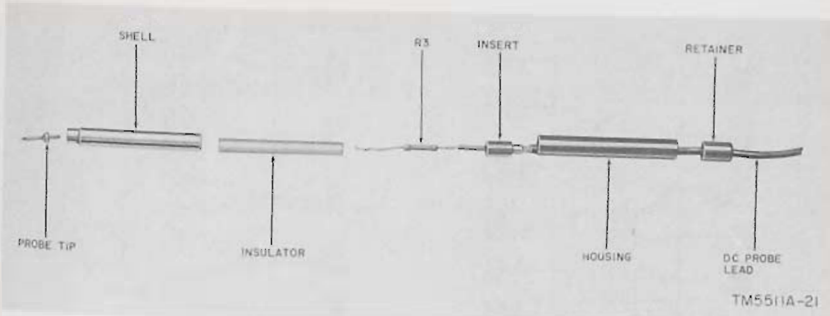
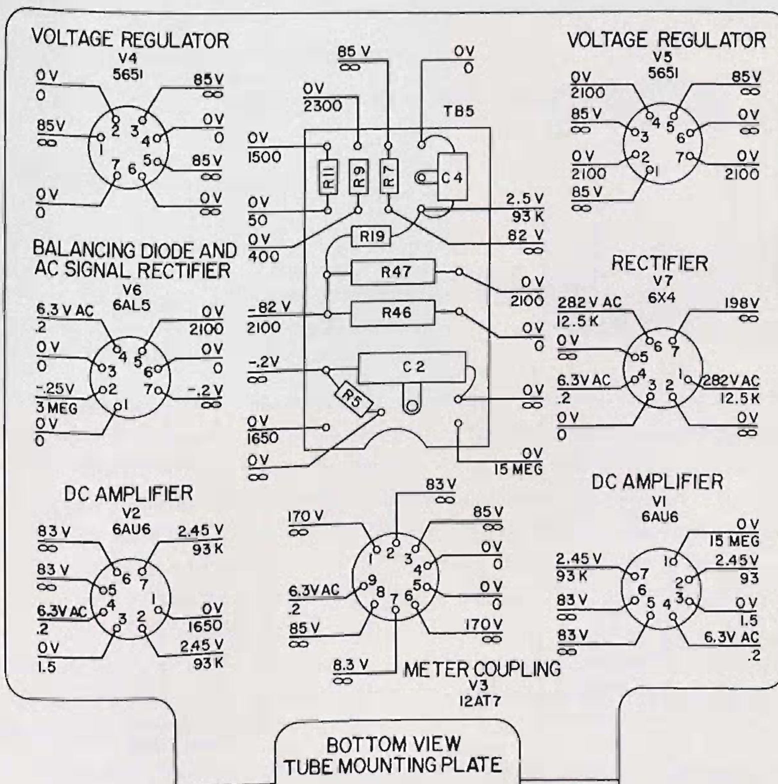


Figure 21. Dc probe, exploded view.

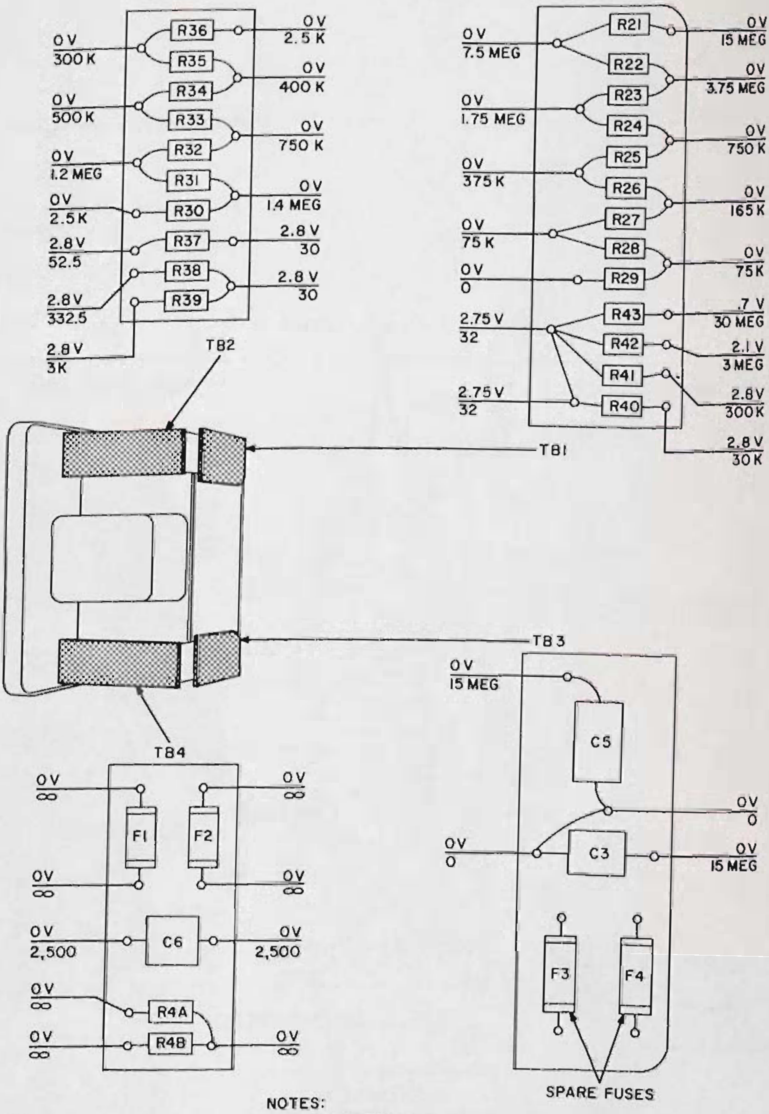


NOTES:

1. TUBE SOCKETS VIEWED FROM BOTTOM.
2. ALL POTENTIOMETERS AT MECHANICAL CENTER.
3. MEASUREMENTS MADE BETWEEN DESIGNATED POINTS AND CHASSIS GROUND.
4. RANGE SWITCH POSITION 2.5 V-RX1, FUNCTION SWITCH POSITION +D.C.
5. ALL MEASUREMENTS MADE WITH 20,000 OHMS-PER-VOLT METER.
6. VOLTAGE MEASUREMENTS DC EXCEPT AS NOTED.
7. LINE VOLTAGE 115 VOLTS AC 60 CYCLE.
8. ∞ INDICATES INFINITE RESISTANCE.
9. RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED.
10. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.

TM 5511A-22

Figure 22. Multimeter, tube socket voltage and resistance diagram.



NOTES:

1. RANGE SWITCH POSITION 2.5V-RX1, FUNCTION SWITCH POSITION +D.C.
2. MEASUREMENTS MADE BETWEEN DESIGNATED POINTS AND CHASSIS GROUND.
3. ALL MEASUREMENTS MADE WITH 20,000 OHMS-PER-VOLT METER.
4. VOLTAGE MEASUREMENTS DC.
5. LINE VOLTAGE 115 VOLTS AC 60 CYCLES.
6. ∞ INDICATES INFINITE RESISTANCE.
7. RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED.
8. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.

TM 5511A-23

Figure 23. Terminal board voltage and resistance diagram.

49. Dc Resistances of Transformer

The dc resistances of transformer T1 (fig. 18) are listed in the following table:

Terminals	Resistance (ohms)
1 - 2	34
3 - 4	740
4 - 5	740
6 - 7	.2

Section II. REPAIRS

50. Replacement of Parts

Note. Many resistors used in the multimeters have smaller tolerances than those used in most electronic equipments. Resistors R1, R3, R21 through R29, and R31 through R44 are precision resistors with a tolerance of ± 1 per cent. If these resistors require replacement, use the *exact* value of the part removed. If even slightly different values are used, calibration of the multimeter will be inaccurate.

a. In general, the components of Electronic Multimeter TS-505A/U are readily accessible and are replaced easily. The terminal boards, mounting plates, and tube chassis are secured to the panel casting by means of screws which mate with tapped holes in the casting. Studs on the power transformer and power supply filter capacitors engage with nuts on the underside of the mounting plate and may be removed easily by first removing the mounting plate from the casting and then removing the holding nuts.

b. If any of the switch wafers require replacement, carefully mark the wires connected to the wafer with tags to avoid misconnection when the new wafer is installed. Follow this practice whenever replacement of a part requires the disconnection of many wires.

c. All control knobs are held by a screw through the center of the knobs. The shafts of the controls are straddle milled; therefore, the knobs must be installed in the correct position so that they point in the proper direction in relation to the controls they are turning. When removing a knob, make a note of the position of the pointer and shaft and replace the knob under the same conditions.

d. To gain access to the underside of the tube chassis, all components except the meter must be removed from the panel casting (fig. 19). Remove the potentiometer plate and the four terminal boards by removing the mounting screws. Remove the four front panel control knobs and the nuts that hold the controls to the front panel. Remove the five packing glands from the panel casting and pull the leads through the panel to allow ample slack. Remove the two screws that hold the tube chassis to the panel casting and remove the six screws that hold the transformer and capacitor plate to the panel casting; lift the panel and chassis assembly away from the casting. Before reassembly, inspect the *O* rings in back of the packing glands and those surrounding the shafts of the four front panel controls for cracking, peeling, or signs of deterioration. Replace these *O* rings if necessary.

e. The meter is secured to the front panel by a flange held with three screws. When this flange is removed, the meter may be pulled forward and out of the panel. The meter glass may be removed by removing the 12 screws that hold a flange to the meter body.

Note. Other than replacement of the glass, repair of the meter should not be attempted. If the meter is defective, replace the entire meter.

f. Disassembly of the rf adapter is necessary to replace button capacitor C1, resistor R2, and germanium diode CR1. To disassemble the rf adapter, proceed as follows (fig. 20):

(1) Unthread the ground lead screw by rotating the alligator clip and lead counterclockwise. Be careful not to lose the plastic ground lead sleeve; tape the sleeve to the alligator clip after removal to prevent its loss.

(2) Slide the nose forward and off the rf shell and carriage assembly.

(3) Remove the screw on the side of the rf shell and slide the shell back and off the carriage assembly.

(4) Unscrew button capacitor C1 from the front of the carriage.

(5) Using a small pointed tool, such as an awl, press on the stud through the hole in the front of the carriage and push the stud plate assembly rearwards until it can be withdrawn from the side of the carriage. Be careful not to break the leads on resistor R2 when removing components from the carriage.

(6) Remove the bracket assembly from the end of germanium diode CR1. Remove the germanium diode and the polarity sleeve from the stud plate assembly.

(7) Remove the nut from the threaded portion of the jack assembly and withdraw the solder lug. If replacement of resistor R2 is necessary, unsolder the leads from the stud plate assembly and the solder lug and remove the insulating tubing; do not cut the resistor leads.

(8) If replacement of resistor R2 is necessary, trim the leads on the replacement resistor to the exact length of those on the original part to insure proper fit upon reassembly. Be certain to install the insulating tubing before soldering a lead to the solder lug.

(9) When replacing germanium diode CR1, be certain that the arrow printed on the side of the diode points toward the stud plate assembly. Two spare germanium diodes are located inside the multimeter case, held by clips on top of capacitors C8 and C9 (fig. 18).

(10) Reassemble the rf adapter in the reverse order of disassembly. Be careful not to force or strain the parts or leads. When installing button capacitor C1, tighten fingertight only; do not use a tool for tightening or damage will result.

g. To disassemble the D.C. probe, proceed as follows (fig. 21):

(1) Unscrew the probe tip by turning it counterclockwise.

(2) Use long-nosed pliers to grasp the end of the wire which is exposed by removal of the probe tip and pull gently to straighten the wire.

(3) Unscrew the retainer and withdraw the retainer and housing, pulling them back onto the probe lead.

(4) Unscrew the shell from the threaded insert and withdraw the shell and the insulator.

(5) Reassemble the D.C. probe in reverse order of disassembly. Before installing the probe tip, make a loop in the end of the wire which protrudes through the end of the shell. Use long-nosed pliers to arrange the loop so that it will surround the threaded shank of the probe tip when the probe tip is installed. Install the probe tip and tighten snugly, using a pair of pliers, to insure good mechanical connection between the probe tip and the looped wire. Avoid damaging the probe tip when tightening.

h. The construction of the A.C. PROBE and the OHMS and COMMON probes is identical, except that the A.C. PROBE contains precision resistor R1. To disassemble these probes, unscrew the probe tips and slide the barrels back on their leads. When replacing resistor R1, use an exact replacement part.

51. Stripping

Many of the components of Electronic Multimeter TS-505A/U will be salvaged if the equipment will not be repaired (fig. 17, 18, and 19).

a. The terminal boards (fig. 17 and 18) can be removed by unfastening the screws which hold them in place. Remove defective components on the terminal boards and place the boards in stock for re-use.

b. If the terminal boards are broken, salvage parts from the boards if they are in good condition. In general, the fixed capacitors and resistors on the boards are not worth salvaging because the leads would be too short. However, salvage precision resistors R21 through R29 and R31 through R43 even though the leads are short so that some precision resistors are readily available for replacement.

c. The metal plate that contains the five calibration potentiometers and the pilot light socket should be placed in stock if it is in good condition. If the plate is damaged, remove the components which are in good condition and place them in stock for future use.

d. The tube chassis and transformer and capacitor plate assembly should be removed and placed in stock if in good condition. If the chassis and plate are so badly damaged that they cannot be salvaged, remove the transformer, capacitors C7, C8, and C9, selenium rectifier CR2, resistor R44, the terminal board and the tube sockets and place these items in stock for re-use.

e. Meter M1, the A.C. LINE cord and plug, the test probes and leads, switches S1 and S2, potentiometers R8 and R15, the control knobs, pilot light indicator jewel, and six panel mounting screws are all located on the front panel. Place these items in stock for re-use if they are in good condition. Be careful not to lose the rubber *O* rings, the mounting nuts and screws, and the control knobs.

f. The front and rear covers may be placed in stock if they are in good condition. The rf adapter, alligator clips, and miniature probe tips stored in the front cover should be salvaged unless they are badly damaged. Note that the cables in the multimeter have enough slack (fig. 19) so that they may be cut close to the soldered end and re-used.

52. Refinishing

Badly marred panels or other portions of the multimeter which show evidence of wear should be refinished before the equipment is returned to service. Instructions for refinishing badly marred panels on exterior cabinets are given in TM 9-2851, Painting Instructions for Field Use.

Section III. CALIBRATION

53. General

a. Electronic Multimeter TS-505A/U is calibrated during manufacture. After calibration, potentiometers R6, R10, R12, R18, and R45 are locked in place. Recalibration is not required unless the tubes are replaced or it is definitely known that adjustments must be made. For example, recalibration is required if rotating the ZERO ADJ. control does not bring the meter pointer to zero scale reading, even though the control is available.

b. The calibration controls (fig. 16 and 24) are mounted on a single potentiometer plate.

54. Calibration Procedures

a. Connect the A.C. LINE cord plug of the multimeter into the power line socket (98 to 132 volts, single-phase 50 to 1,000 cps). Turn the FUNCTION switch to the +D.C. position and allow the multimeter to warm up for 10 to 15 minutes.

b. Set the ZERO ADJ. control to its mechanical center. Connect the D.C. and COMMON probe tips together. Turn the RANGE switch to 2.5V-Rx1 position.

c. Loosen the lock nut on coarse zero adjust potentiometer R18 (fig. 24).

d. Turn potentiometer R18 until the meter pointer is within one-half scale division of zero. Wait approximately 1 minute between the settings, since the action of this potentiometer is sluggish.

e. Tighten the lock nut on potentiometer R18. Be careful not to disturb the setting of the control.

f. Set the meter pointer to zero scale reading by turning the ZERO ADJ. control on the front panel.

g. Turn the FUNCTION switch to the ±D.C. position.

h. Loosen the lock nut on zero centering potentiometer R6.

i. Turn potentiometer R6 until the meter pointer is at midscale.

j. Tighten the lock nut on potentiometer R6. Be careful not to disturb the setting of the control.

k. Turn the FUNCTION switch to the −D.C. position. The meter pointer should be within one scale division of zero. If the meter pointer cannot be set at zero by rotating the ZERO ADJ. control on the front panel, refer to paragraph 47 for corrective procedure.

l. Turn the FUNCTION switch to the OHMS position. The meter pointer should read upscale. Adjust the meter pointer to ∞ by turning the OHMS ADJ. control on the front panel.

m. Turn the FUNCTION switch to A.C. position. Turn the RANGE switch to the 2.5V-Rx1 position.

n. Loosen the lock nut on ac zero potentiometer R45.

o. Turn potentiometer R45 until the meter pointer is within one-half scale division of zero.

p. Tighten the lock nut on potentiometer R45. Be careful not to disturb the setting of the control.

q. Turn the FUNCTION switch to the +D.C. position. Turn the RANGE switch to the 2.5V-Rx1 position.

r. Loosen the lock nut on dc calibration potentiometer R10.

s. Apply 2.5 volts dc ±1 per cent across the D.C. and COMMON probes.

t. Turn potentiometer R10 until the meter pointer reads full scale.

u. Tighten the lock nut on potentiometer R10. Be careful not to disturb the setting of the control.

v. Turn the FUNCTION switch to the A.C. position. Turn the RANGE switch to the 5V-Rx10 position.

w. Loosen the lock nut on ac calibration potentiometer R12.

x. Apply 15 volts ±1 per cent at 50 cps across the A.C. PROBE and COMMON probe.

y. Turn potentiometer R12 until the meter reads full scale.

z. Tighten the lock nut on potentiometer R12. Be careful not to disturb the setting of the control.

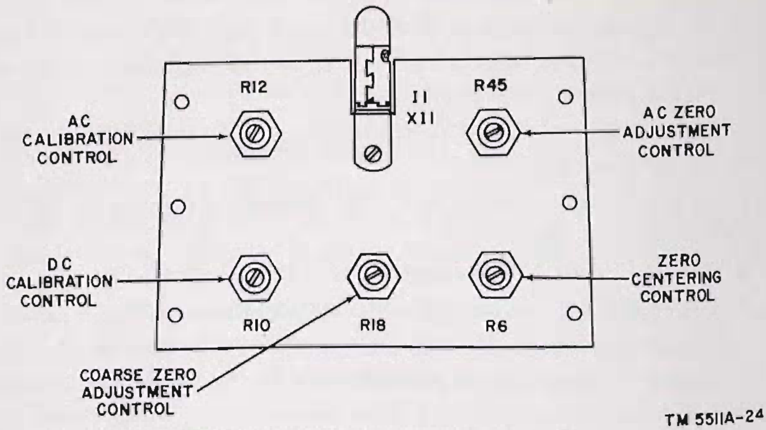


Figure 24. Electronic Multimeter TS-505A/U, calibration adjustment controls.

Section IV. FINAL TESTING

55. General

This section is intended as a guide to be used in determining the quality of a repaired Electronic Multimeter TS-505A/U. The minimum test requirements outlined in paragraphs 57 through 60 below may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

56. Test Equipment Required for Final Testing

The following test equipment is required for final testing of Electronic Multimeter TS-505A/U:

Test equipment	Technical manual
Meter Test Equipment AN/GSM-1B	TM 11-2535A
Electron Tube Test Set TV-2/U	TM 11-2661
Multimeter TS-352/U	TM 11-5527

57. Testing Dc Voltage Measurement Circuit

a. Connect the multimeter, set the controls, and zero adjust the meter pointer as described in paragraph 14*c*.

b. Apply 2.5 volts dc ±1 per cent across the D.C. and COMMON probes. The meter pointer should read full scale within plus or minus 5 per cent.

c. Repeat the procedure in subparagraph *b* above for each position of the RANGE switch and apply maximum voltage for each range setting (that is, 5 volts on the 5V-Rx10 position, 10 volts on the 10V-Rx100 position, etc.). In all instances, the meter pointer should read full scale ±5 per cent.

58. Testing Rf Adapter

a. Connect the multimeter, set the controls, and adjust the meter pointer as described in paragraph 14*c*.

Note. Test the dc voltage measurement circuit as described in paragraph 57 before attempting to test the rf adapter.

b. Plug the D.C. probe tip into the end of the rf adapter.

c. Apply 2.5 volts ±1 per cent at 5 mc between the rf adapter tip and the alligator clip. The 5 mc must have less than .5 per cent distortion. The meter pointer should read full scale within ±6 per cent.

d. Repeat the procedure in subparagraph *c* above for the 5V-Rx10, 10V-Rx100, and 25V-Rx1000 positions of the RANGE switch and apply maximum rated voltage for each range setting. In all instances the meter should read full scale within ±6 per cent.

e. Turn the RANGE switch to the 50V-Rx10K position and apply 40 volts ±1 per cent at 5 mc between the rf adapter tip and the alligator clip. The meter pointer should read 40 volts ±3 volts.

59. Testing Ac Voltage Measurement Circuit

a. Connect the multimeter and zero adjust the meter pointer as described in paragraph 14*e*.

b. Turn the RANGE switch to the 2.5V-Rx1 position.

c. Apply 2.5 volts ±1 per cent at 60 cps across the A.C. PROBE and COMMON probe. The 400 cps must have less than .5 per cent distortion. The meter pointer should read full scale ±6 per cent.

d. Repeat the procedure in subparagraph *c* above for the following positions of the RANGE switch: 5V-Rx10, 10V-Rx100, 25V-Rx1000, 50V-Rx10K, 100V-Rx100K, 250V-Rx1M. Apply maximum voltage for each range setting. In all instances, the meter pointer should read full scale ±6 per cent.

60. Testing Ohmmeter Circuit

a. Connect the multimeter and adjust the meter pointer as described in paragraph 14*f*.

b. Check the accuracy of the ohms calibration by measuring standard resistors known to be accurate within 1 per cent. Measure a standard resistor on each resistance setting of the RANGE switch, using an appropriate resistor within the range of each switch setting. In all instances, the meter reading should be accurate within 4 per cent of full scale (total arc length).

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

61. Removal from Service

a. Disconnect the multimeter from the power supply.

b. Place the test probes and leads in their respective compartments. Place the A.C. LINE cord in its compartment.

c. See that all tubes are seated firmly in their sockets.

d. Fasten the covers in place.

62. Repacking for Shipment or Limited Storage

a. The exact procedure in repacking for shipment or limited storage depends on the material available and the conditions under which the equipment is to be shipped or stored. Refer to paragraph 9*b* and figure 4, and follow the instructions in reverse order.

b. Whenever possible, place a dehydrating agent such as silica gel inside the equipment. Protect the equipment with a waterproof paper barrier. Seal the seams of the paper barrier with waterproof sealing compound or tape. Pack the protected equipment in a padded fiberboard box.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

63. General

The demolition procedures outlined in paragraph 64 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

64. Methods of Destruction

a. Smash. Smash the controls, panel chassis, resistors, capacitors, tubes, tube shields, transformer, and other interior parts; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut cords and wiring; use axes, handaxes, or machetes.

c. Burn. Burn cords, resistors, capacitors, wiring, and manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend mounting plates and tube chassis.

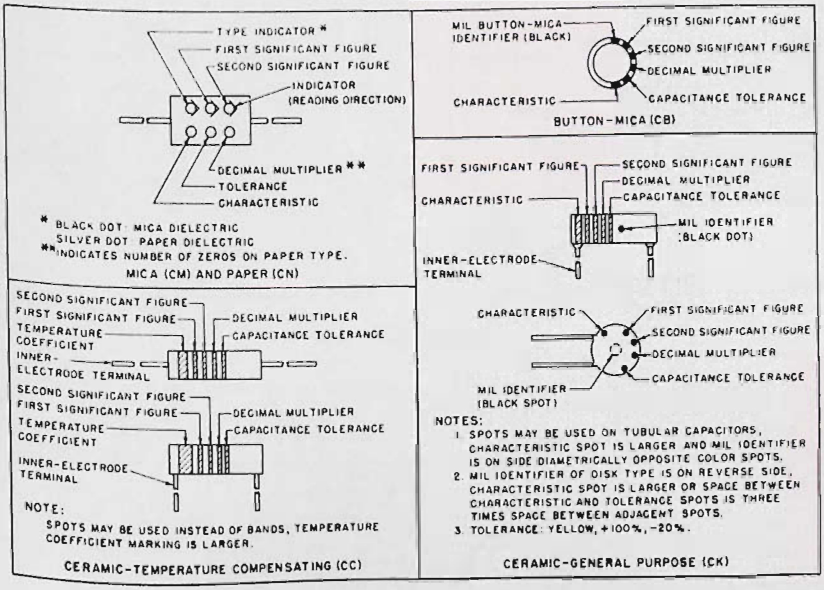
e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches, foxholes, or other holes, or throw them into streams.

g. Destroy. Destroy everything.

CAPACITOR COLOR CODE MARKING

(MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC OVER 10UUF	CC 10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		K	2		2	2		-80
ORANGE	3	1,000	3	D	J	O			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

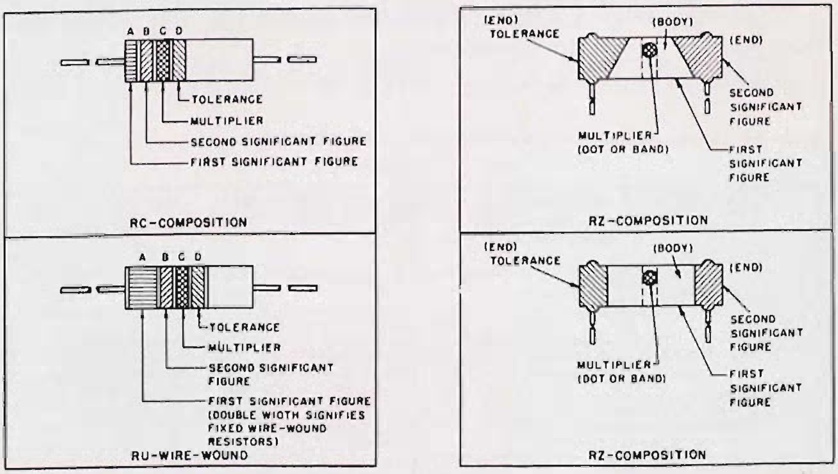
1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 25. Capacitor color codes.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED) — RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

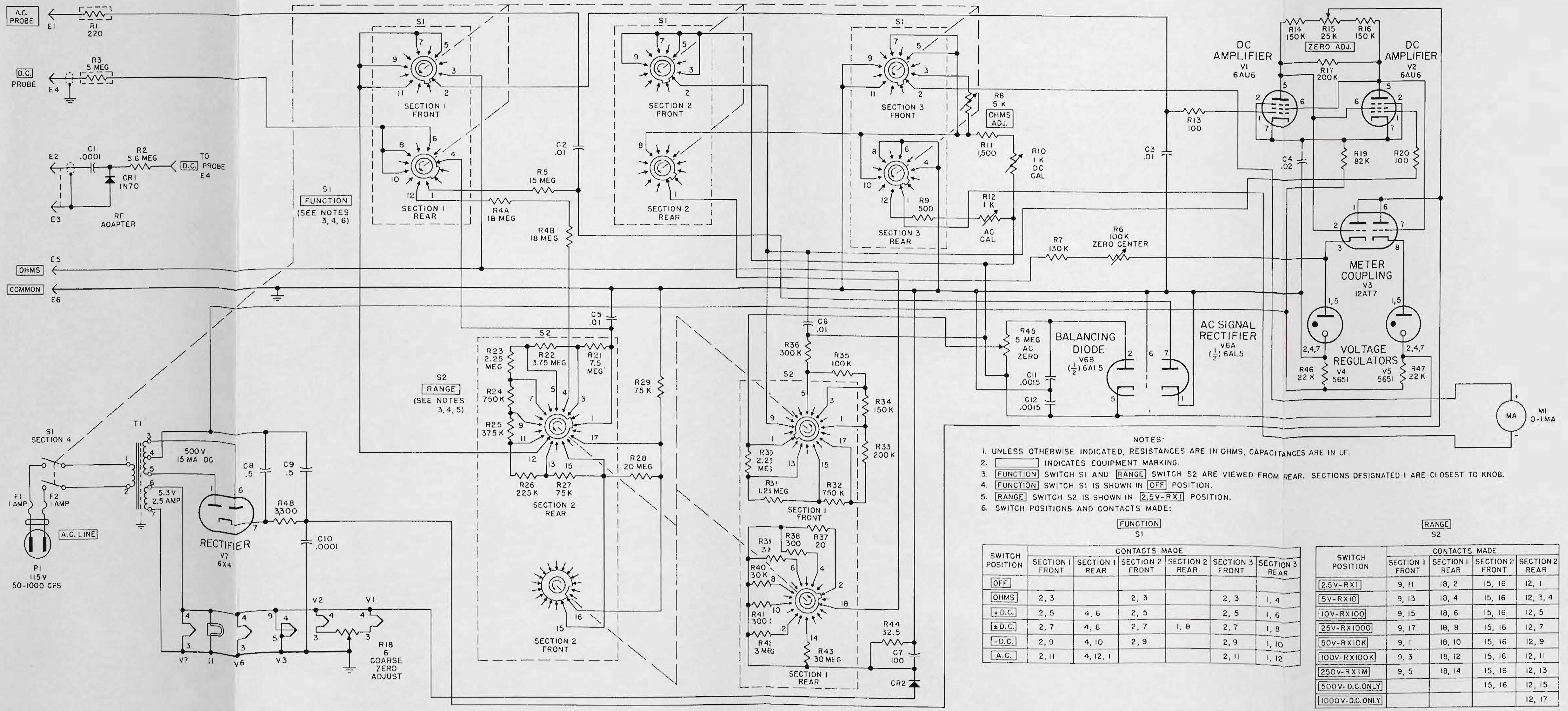
*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B, BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY, BLACK END, BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY, BLACK END, RED DOT OR BAND; SILVER END.

STD-R1

Figure 26. Resistor color codes.



NOTES:

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF.
2. [ ] INDICATES EQUIPMENT MARKING.
3. [FUNCTION] SWITCH S1 AND [RANGE] SWITCH S2 ARE VIEWED FROM REAR. SECTIONS DESIGNATED 1 ARE CLOSEST TO KNOB.
4. [FUNCTION] SWITCH S1 IS SHOWN IN [OFF] POSITION.
5. [RANGE] SWITCH S2 IS SHOWN IN [2.5V-RX1] POSITION.
6. SWITCH POSITIONS AND CONTACTS MADE:

[FUNCTION]
S1

SWITCH POSITION	CONTACTS MADE					
	SECTION 1 FRONT	SECTION 1 REAR	SECTION 2 FRONT	SECTION 2 REAR	SECTION 3 FRONT	SECTION 3 REAR
OFF						
OHMS	2, 3		2, 3		2, 3	1, 4
+D.C.	2, 5	4, 6	2, 5		2, 5	1, 6
±D.C.	2, 7	4, 8	2, 7	1, 8	2, 7	1, 8
-D.C.	2, 9	4, 10	2, 9		2, 9	1, 10
A.C.	2, 11	4, 12, 1			2, 11	1, 12

[RANGE]
S2

SWITCH POSITION	CONTACTS MADE			
	SECTION 1 FRONT	SECTION 1 REAR	SECTION 2 FRONT	SECTION 2 REAR
2.5V-RX1	9, 11	18, 2	15, 16	12, 1
5V-RX10	9, 13	18, 4	15, 16	12, 3, 4
10V-RX100	9, 15	18, 6	15, 16	12, 5
25V-RX1000	9, 17	18, 8	15, 16	12, 7
50V-RX10K	9, 1	18, 10	15, 16	12, 9
100V-RX100K	9, 3	18, 12	15, 16	12, 11
250V-RX1M	9, 5	18, 14	15, 16	12, 13
500V-D.C.ONLY			15, 16	12, 15
1000V-D.C.ONLY				12, 17

TM 5511A-27

Figure 27. Electronic Multimeter TS-505A/U, schematic diagram.

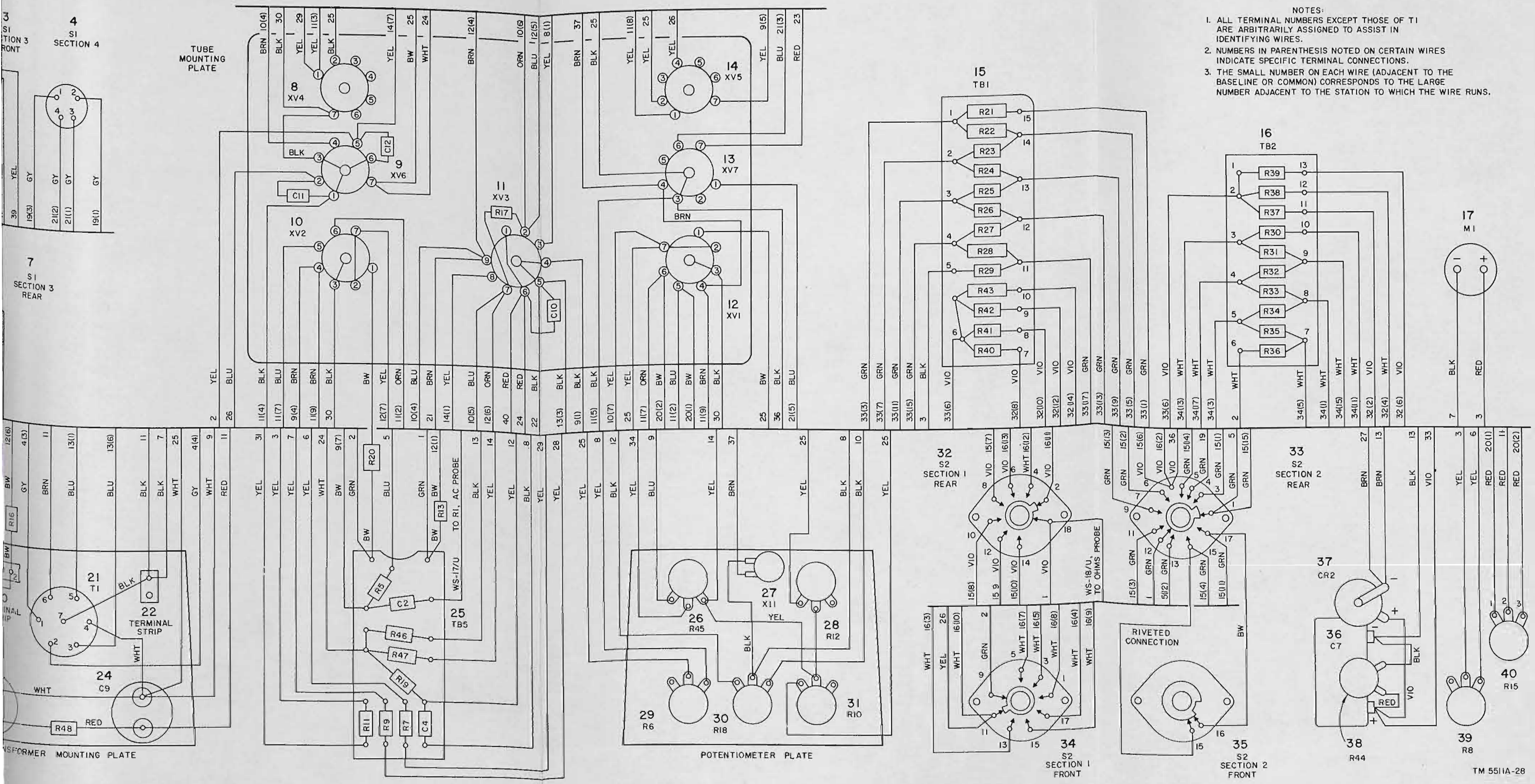


Figure 28

Figure 28. Electronic Multimeter TS-505A/U, wiring diagram.

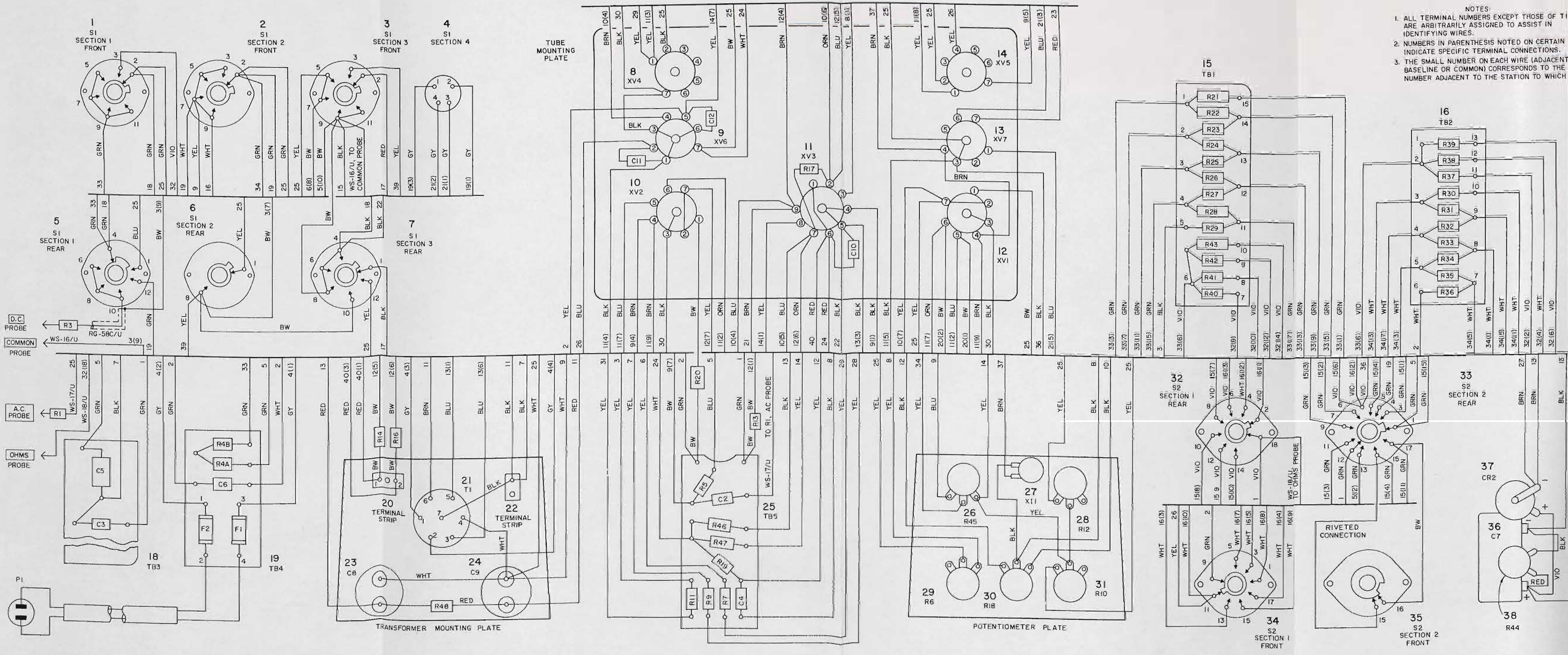


Figure 28. Electronic Multimeter TS-505A/U, wiring diagram.

INDEX